DEVELOPMENT AND IMPLEMENTATION OF A STRATEGY FOR THE PROMOTION OF SOLAR WATER HEATING IN CARICOM COUNTRIES

December 2011

Submitted to the Caribbean Community Secretariat

Delivery under

The Caribbean Renewable Energy Capacity Support (CRECS) Project

Funded by The European Union

Author: Dr. Devon Gardner
REPORT
ON
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Author: Dr. Devon Gardner

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Executive Summary

Despite its considerable potential within CARICOM household, domestic and industry sectors, the possible contribution of solar water heat is often neglected in many energy projections and scenarios. This is best explained by the frequent failure to distinguish heat and (electrical) work as two different forms of energy transfers. As a result, policy makers in most countries have tended to pay lesser attention to solar thermal technologies than they do to renewable energy technologies, which generate electricity. Solar thermal technologies offer a great potential for providing a low carbon response to the increasing regional energy demand, much of which is required as heat. After decades of development, solar water heaters in particular have now reached a degree of technical maturity that makes them reliable and solar water heating is cost-effective compared to conventional methods. Other related technologies, including active solar cooling are also economic viable, but are somewhat more dependent on various local conditions, alternate energy resource availability to the annual cooling and hot water demand.

The fact is that the cost of electricity within the majority of CARICOM states averages around 38 US cents per KWh and is among the highest in the world; this is a major drag on the competitiveness of the respective economies. Consumers largely blame this state of affairs on the electric utilities; the energy sectors within the region have been slow to adopt and exploit new technological opportunities within the renewable energy sector, including the prospects available through solar water heating. Typically, the focus is on large-scale renewable energy projects on the grid as part of a fuel diversification strategy.

Numerous barriers impede expansion of the regional solar water heating market. Though most technical barriers have now been fixed, some technical limitations persist; unfortunately, past failures have left some distrust in the public and policy makers’ opinion within some territories. Other barriers such as: high investment costs; failure to link SWH to national energy security and the environmental benefits thereof; insufficient training of professional installers; “split incentives”; and other institutional barriers, legislation barriers such as a lack of incentives or regulations that promote the industry and lack of awareness of the potential by customers as well as policy makers, continue to inhibit its growth.

The uneven level of solar thermal markets within CARICOM countries, which have similar climate and energy conditions, highlights the importance of public policies to overcome the barriers to their use. The average penetration of solar water heating within the region is around 7.6 per cent. This is around 220,000 m² of installed collector area or 170 MWth of capacity. Placed into perspective, this represents per capita installed capacity of
approximately 48.9 kilowatts thermal (KWth) per 1,000 inhabitants – compare Cyprus (527 KWth) and Israel (371 KWth). The calculations include Barbados whose penetration is exceptionally high (313.9 KWth) and accounts for nearly 55 per cent of the installed solar water heating capacity within the region. As a result of a deliberate mix of tax incentive policies and regulations, which seek to promote solar water heaters and inhibit conventional heaters, Barbados has one of the world’s highest per capita rates of SWH penetration. It is estimated that there are 35,000 – 40,000 installed systems providing at over 40 per cent of households and 50 per cent of hotels with SWH services. Elsewhere in Jamaica, the “stop and go” policies of the government resulted in a comparatively low penetration; the per capita installed capacity (6.1 KWth per 1,000 inhabitants) falls well below the regional average (48.9 KWth).

This Study finds that there is significant potential for expanding the solar water industry within the region. In so doing, the installed capacity may be reliably increased from 170 MWth (2011, estimate) to around 840 MWth (2016, projection) within a five-year period. This requires a mix of “coherent” policies and incentives at the national levels, in particular and the regional level, in general that address: (i) Energy planning; (ii) Technology financing; and (iii) Greenhouse gas abatement. The experience of Barbados, as well as other global leaders in solar water heating deployment, points toward a need to link solar water heating market expansion to renewables promotion policies within the member respective states, as well as the fact that solar water heating market expansion is likely to be enhanced through national target-setting. Also, the deliberate timing of government support for the industry that coincides with the proliferation of new housing and hotel construction seems to be a common thread among the highest per capita users of solar water heaters. The cost of a solar installation is three times that of a standard water heater and despite the potential energy savings which results from the former, consumers will continue to adopt the lowest initial cost electric water heating solutions if the choice is simply left open to a “free market arrangement”. It is clear that market reform is necessary but not sufficient to deliver the expansion in the regional market that will provide the benefits of lower prices and better hot water service to consumers.

There is cognizance of the fact that the energy economics and socio-political dynamics within the respective CARICOM states are different and consequentially, solutions for regional market expansion consider the individual country situations. For instance, legislation barriers vary widely from country to country in which different CARICOM states are at varying stages in the development of National Energy Policies. Nonetheless, there are some broad-based recommendations that are applicable, in general, across the region. These are programmes and policies to overcome the previously mentioned barriers and include, inter alia:
● Finalization of modern **National Energy Policies**, which include renewable energy acceleration strategies, for the respective member states and associate member states

● Expansion of **Energy Planning** – especially for *electricity demand and supply expansion* – to include solar water heating and other renewables portfolios

● Introduction of **Generation Offset Legislation**, which provide direct incentive to SWH end-user through tax rebates on account of the value of the technology to grid stabilization, within CARICOM states

● Introduction of **Solar Ordinance Laws**, which mandate the use of solar water heaters in new buildings (especially hotels, hospitals and collective dwellings), as a part of a regional Sustainable Energy Building Code within CARICOM states

● Introduction and harmonization, through the regional standards body (CROS-Q), of regional **Minimum Energy Performance Standards, Codes and Labelling** for solar water heaters, as well as training and certification programmes for installation technicians

● Introduction of legislation and incentives to promote and facilitate the development of **Pay-as-You-Save (PAYS) third-party financing** for solar water heaters within the respective – member and associate member – states

● Development of a “**CARICOM Solar Bank**” as a regional *seed-financing* portfolio (from multilateral Blended Grant-Loan Mechanisms and CDM Financing) for capitalizing third-party financing schemes for small-scale solar technologies, including solar water heaters and PV/thermal systems, within the respective states

● Enhancement of existing **Outreach and Public Awareness Programmes**, including demonstration projects for *emerging* solar water heating technologies (such as solar cooling and PV/thermal); co-operative private and/or governmental procurement may be useful for accelerating dissemination and government agencies can, for instance, *lead by example* by installing solar water heaters on government buildings

Indeed, given the nature of the industry, ill-advised or improperly sequenced decisions can lead to medium and long-term adverse effects from which recovery is difficult. A proper vision of the future state of the industry requires **consistency in political will** accompanied by **effective** impact assessment and decision-making mechanisms; these are all critical to the long-term good of the sustainable energy sector within the region at large.
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</tbody>
</table>
NEVLEC  Nevis Electricity Company Limited
NHT    National Housing Trust
NREL   National Renewable Energy Laboratory
OAS    Organization of American States
OECS   Organization of Eastern Caribbean States
OPEC   Organization of Petroleum Exporting Countries
PV     Photovoltaic
PV/T   Photovoltaic/Thermal
R&D    Research and Development
RER    Renewable Energy Rider
RET    Renewable Energy Technology
SEFB   Sustainable Energy Framework for Barbados
SIDS   Small Island Developing States
SKED   St. Kitts Electricity Department
SME    Small and Medium Enterprises
ST     Solar Thermal
SURALCO Suriname Aluminium Company
SWH    Solar Water Heating
T&TEC  Trinidad and Tobago Electricity Commission
TTBS   Trinidad and Tobago Bureau of Standards
TTMA   Trinidad and Tobago Manufacturers’ Association
UNDP   United Nations Development Programme
USD    United States Dollars
VAT    Value-added Tax
VINLEC St. Vincent Electricity Services Limited
XCD    Eastern Caribbean Dollars
1. INTRODUCTION

1.1. HISTORICAL CONTEXT OF SOLAR WATER HEATING

Throughout human history, solar energy has been utilized for domestic use in heating and cooking; the Greeks and Romans documented their use of solar power in Europe over two millennia ago. In the early eighteenth century, specific solar technologies were introduced to concentrate the sun’s energy and put it to use in high-temperature processes. The development of a 1,700 °C solar furnace by Antoine Lavoisier in the mid-1700s is an excellent early example of human progress in harnessing solar energy. In general, its ubiquitous nature and usability over a range of scales make solar a popular choice among renewable enthusiasts today.

1.1.1. Technology Design

The story of solar water heating began in the 1760s in Geneva, Switzerland, where Horace-Bénédict de Saussure, a Swiss naturalist, observed that it is always hotter when sun rays pass through a glass-covered structure, whether in a coach or a building, than into a site unprotected by such material. To put his hypothesis to scientific scrutiny, in 1767 he built an insulated box, its bottom painted black to absorb as much sun energy as possible, with two panes of glass covering the top — the prototype for all solar water heaters. De Saussure found that when he exposed the box perpendicular to the sun, the inside heated to temperatures far above the boiling point of water. He had demonstrated, for the first time, the greenhouse effect.

De Saussure speculated that: “Someday some usefulness might be drawn from this device for it is actually quite small, inexpensive and easy to make.” But more than a century passed before de Saussure’s hope was realized.

In 1891, Clarence Kemp, an American plumbing and heating manufacturer, placed a black-painted water tank inside a glass-covered box with a similar design to de Saussure’s. As the bottom of the box heated, the colder water inside the tank absorbed the heat and became hot enough to be drawn for bathing or dishwashing. Here was the first commercial solar water heater. Kemp called it the Climax. The Climax had one drawback: The water was heated and stored in the tanks, which were exposed to the elements at night and during bad weather. Under such conditions, they cooled down sometimes to such a degree that the benefit of hot water use was not available to customers.

In 1909, William J. Bailey found a way out of the dilemma: separating the solar heating of the water from its storage. His solar collector consisted of water pipes attached to a
black-painted metal plate inside a glass-covered box and connected to an insulated remote storage tank located above the collector. As the sun heated the water, it became lighter than the heavier, cooler water entering from the bottom, forcing the hotter water to naturally rise into the storage tank and remain warm during the night and the following morning. Bailey called his company the *Day and Night Solar Water Heater Company* to emphasize his product’s advantage.

Day and Night solar water heaters soon drove the Climax out of business to dominate the burgeoning solar water heater market that had begun to take hold in California, Arizona, Hawaii and later, in Florida. And though the discovery of plentiful oil and natural gas during the 1920s decreased the attractiveness of solar water heater business, Bailey’s configuration that utilizes separation of solar water heating and storage — later referred to as thermosiphon systems — lived on to become the design of choice for millions throughout the world who rely on the sun to heat their water.

### 1.1.2. Industry Development

When the Second World War broke out in 1939, the United States Government exercised control over the use of copper — a principal element required by solar water heater manufacturers. This essentially forced the industry, which was centred in North America, to shut down. After the war, the industry in North America was never revived as public utilities launched “counter programmes” to promote electric water heaters. Nonetheless, the industry proliferated elsewhere: The new Jewish state, Israel, had so little electricity that government heavily regulated its use. As a consequence, astute entrepreneurs studied the American design of William Bailey and soon adapted it for Israel’s needs.

With the capture of oil fields in Egypt’s Sinai Peninsula during the Six-Day War, Israelis had sufficient fuel supplies to run electric water heaters cheaply, driving solar water heaters nearly out of business. Six years later, with the Arab oil embargo, the subsequent loss of Sinai and the rise of an unfriendly government in Iran turning off its oil supplies to Israel, the solar water heater business returned to centre-stage. The government mandated the use of solar water heaters on all buildings less than 27 metres in height; this law coincided with a huge influx of immigrants who required immediate housing, which set off an unprecedented boom for both the construction and the solar industries. Currently, Israel shares with Cyprus the highest per-capita use of solar water heaters in the world, and more than 90 per cent of Israeli households heat their water with the sun. Interestingly, neither nation provides *direct monetary incentives* to customers for using solar water heaters.

Cyprus, like Israel, has only one natural energy resource: the sun. Otherwise, like Israel, it totally depends on imported oil for its energy needs. The knowledge of solar water heating came to Cyprus from Israel in the 1960s. To set an example to its citizens, the national
government committed to installing solar water heaters on all state buildings. Unexpectedly, the government's role in promoting solar became paramount when, in 1974, the Turks invaded the island, uprooting thousands of Greek Cypriots from their homes. The government had to house nearly one-third of the island's population and, since it built the homes, made the decision to install solar water heaters. When the remaining population saw how well the heaters worked, they too soon became users.

Elsewhere – in Barbados – local entrepreneurs began adapting a Canadian solar water heater design to suit the island's situations and began a “niche” solar water heating market in response to the increase in water heating bills that resulted after the two oil shocks of the 1970s. Prime Minister Tom Adams had a locally manufactured solar water heater placed on the roof of his residence in the mid-1970s. Impressed by its performance, Adams had Parliament pass a series of laws to encourage solar water heating, which included: (i) removal of duties on imports specifically directed to the island's solar water heater industry; (ii) tax breaks for those buying solar water heaters; and (iii) taxation on electric water heaters. Later on, rebates were added to reward those making the change from electric to solar heaters. The number of solar units on the island increased over the last 30 years by a factor of nearly 3,000, making Barbados the third highest per-capita user of solar water heaters in the world. As was the case for Israel and Cyprus, the industry development came at a time of significant construction boom in the island.

In a seeming break with the pattern of the previously mentioned successes of Israel, Cyprus and Barbados, the environmental consciousness of Austrians drove the local market for solar. In 1978, a referendum whether to turn to nuclear power jump-started a national discussion on solar. A “grassroots movement” emerged with local communities developing do-it-yourself networks that supplied the initiative, know-how and training for the construction and installation of solar water heaters: Lobbying by citizens groups resulted in the Austrian government providing direct subsidies. The observation of solar water heaters on neighbours' houses started a “snowball effect” and manufacturers that had been producing electric water heaters jumped into the solar business. Under these conditions, the use of solar heating grew ten-fold since 1984.

The real Goliath of solar water heaters, based on the absolute numbers, is China: More than 30 million Chinese households rely on the sun to heat their water. Over the last six years, the number of solar consumers has grown six-fold. The motivation is simple. A solar water heater in China costs less than USD 200. Without one, a family wishing for hot water would have to buy an electric water heater for about the same price and pay up to USD 120 per year for electricity. The payback is almost instantaneous.
Huang Ming, the founder of the solar water heater business in China, built a prototype so his aging mother would avoid having her rheumatism aggravated through washing the dishes and floor with cold water. Word spread, and soon everyone in his neighbourhood wanted a solar water heater. Huang listened and built what became the largest solar water heater business in China. The largest city in the region where Huang lives also got the message: Rizhao, a city of 3 million people, provided funding to Huang’s firm to bring down the price and increase its efficiency and simplicity. The municipality also informed the public by holding educational seminars and conducting advertising campaigns in the old Communist tradition of parades and mass gatherings. Today, almost every household in Rizhao, which is located in the oil-rich Shandong province, uses a solar water heater.

In general, solar water heaters saved, in 2009, the consumption of almost 90 million barrels of oil and cut carbon emissions by 37 million tons. Their energy production dwarfs photovoltaics (PV) by a factor of 30 and equals the electrical capacity of wind, which is typically believed to be the most widely used renewable energy source. The fact that solar water heaters are not an electricity producing technology often times results in it frequently being overlooked in a world where electricity is the primary source of domestic, commercial and industrial energy services.

1.2. CARICOM SCENARIO

"To provide dynamic leadership and service, in partnership with Community institutions and groups, toward the attainment of a viable, internationally competitive and sustainable Community, with improved quality of life for all"
- Caribbean Community (CARICOM) Mission Statement

1.2.1. Background
The Caribbean Community (CARICOM) is a project of regional integration which comprises fifteen (15) states and territories in the wider Caribbean Basin. The members are: Antigua & Barbuda; The Bahamas; Barbados; Belize; Dominica; Grenada; Guyana; Haiti; Jamaica; Montserrat; St. Kitts & Nevis; St. Lucia; St. Vincent & The Grenadines; Suriname; and Trinidad & Tobago. The economic dimension of the CARICOM integration can be characterised by the following figures: (i) Overall population of 16.5 million; (ii) Average GDP per capita of USD 5,725; (iii) Taken together, the CARICOM countries account for 0.1 per cent of world export of goods. Evidently, the region is very small as a market as well as a trading partner and within the context of the liberalized global economy, Caribbean economies are extremely open.
In order to better understand CARICOM, it may be useful to attempt a characterisation of the region and member countries. CARICOM members are mainly islands (except for Suriname, Guyana and Belize) and the majority of them are very small. All members are classified by international organisations as developing countries. The CARICOM Secretariat distinguishes between least developed countries (LDCs) and more developed countries (MDCs).

**LDCs**
- Antigua and Barbuda
- Belize
- Dominica
- Grenada
- Montserrat
- St. Kitts and Nevis
- Saint Lucia
- St. Vincent and the Grenadines

**MDCs**
- Barbados
- Guyana
- Jamaica
- Suriname
- Trinidad and Tobago

According to the UNDP Human Development Index (HDI), the economies of the countries show significant variance, ranging from The Bahamas (USD 28,700) to Haiti (USD 1,200); this reflects the significant differences in the average standard of living between the CARICOM member states. The same heterogeneity can be detected with regard to population size. Population ranges from around 5,000 in Montserrat and Nevis up to nearly 10 million in Haiti. The economies are not very diversified however and agriculture, though losing importance, still accounts for a high proportion of GDP in most CARICOM countries. Manufacturing constitutes only a small part of industrial production and its share has been declining in most countries over the last twenty years. Because the Caribbean is a very attractive region for tourism, the service sector is well developed in most countries and still growing in many of them.

### 1.2.2. CARICOM Trade Relations

Trade within CARICOM is focused on a few exported goods which differ between the countries. As far as trade relations are concerned, both intra-regional imports and intra-regional exports have become more important over the period of integration. The more developed countries among the CARICOM member states account for roughly two thirds of all intra-regional imports by CARICOM countries; the lesser developed countries in the region account for only one third of the intra-CARICOM imports.

A comparison of CARICOM regional trade with data for other trading blocs reveals the following: (i) although there has been a reasonable increase in intra-regional trade, the level of intra-CARICOM trade is very low when compared with the European Union or NAFTA blocs for example; (ii) intra-regional trade is distributed unevenly across the region.
with heavy dominance from the MDCs. Except for solar water heaters, Trinidad and Tobago is the main source of intra-regional imports for the other CARICOM countries.

1.2.3. CARICOM Energy Scenario
For CARICOM states, renewable energy is estimated to contribute only about 3 per cent of the regional energy supply mix. Renewable energy potential (Biomass, Solar, Wind, Ocean, Hydro, Geothermal, etc.) is great but unevenly distributed; development of the resources may be stymied by the small size of the markets at the national level. A further defining characteristic of the national energy situations across the region is the high inefficiency in the use of energy resources; it is estimated that the region wastes more than half the available energy in the imported fuels, which results in a very high energy per unit of GDP.

Every year, the Caribbean region spends a significant portion of scarce foreign exchange to import liquid petroleum fuels to provide energy services. Except for Trinidad and Tobago, all Caribbean countries import petroleum products for more than 90 per cent of commercial energy consumption. In recent years, there has been growing concern that higher global oil prices during the period 2006-2008, and which precipitously declined in response to the global economic downturn in mid-2008, will impair the Caribbean economies, as the vast majority of them are highly dependent upon petroleum for their energy needs. Currently, the price of oil on both sides of the Atlantic has hit its highest level since the financial crisis and continues to hover around USD 100 per barrel after this year reaching its highest levels since October 2008: The current oil price is already significantly above the levels experienced prior to 2007. During 2007-08, oil and most other commodities were subject to a speculative bubble that pushed the price of Brent crude up to USD 147.50 at its peak in July 2008.

It is estimated that some 85 per cent of all electric power in the Caribbean is still generated with liquid fuel. As a consequence of disparate energy scenarios between member states, electricity prices vary significantly across the region. Nonetheless, there is general cognizance of the unsustainability of maintaining a hydrocarbon economy. Consequently, a number of the island nations have been exploring the use of renewable energy sources to better integrate their energy sectors into the overall economy. Energy is the driving force for the development of national economies, promoting social and economic development. Solar water heating has been demonstrated to be technically feasible and economically viable within the Caribbean and provides an immediate opportunity for providing a significant energy service, which is currently mostly support by fossil-based electricity, from a renewable source. In many countries within the region, as much as 15 per cent of the electricity consumption within the domestic (household) sector has been attributed to water heating.
Due to the size of their economies and population, the islands of the Caribbean have made only minor contributions to the increased amount of greenhouse gas (GHG) in the atmosphere; nevertheless, they are at high risk of suffering the negative impacts of high GHG concentrations. Further, with the exception of Trinidad and Tobago, high oil prices requires increasing amounts of foreign exchange to pay for imports and the increasing demand for foreign exchange reduces the financial resources available to the region to plan for and undertake needed adaptation to the impacts of climate change. This is especially significant given the fact that the region’s very high vulnerability to climate change, as stated in the Inter-governmental Panel on Climate Change Fourth Assessment Report (IPCC- FAR), requires spending of significant financial resources on adaptation.

1.2.4. Solar Water Heating Potential
Solar water heating (SWH) is one of the simplest and oldest ways to harness renewable energy and can contribute both to climate protection and sustainable development efforts within CARICOM. Solar thermal technology has existed since at least the time of the ancient Greeks, who designed their homes to foster “direct capture” the energy from the sun. Over one-third of homes in Barbados are equipped with SWH systems, and increasingly, hot water is seen as a fundamental aspect of a healthy and hygienic life, and demand for it is growing steadily. Nonetheless, penetration of SWH systems within the rest of CARICOM states remain low (less than 7 per cent) as a consequence of barriers which prohibit mainstreaming of markets for renewable energy technologies.

The CREDP (2004) was designed to significantly increase contribution of renewable energy by removing barriers (in the areas of policy, finance, awareness and capacity); though some measure of success was achieved, the barriers still mostly remain. Though many member states of CARICOM have commenced development of their national energy policies (three states having finalized and approved same) with an objective to provide significant focus on renewable energy and energy efficiency, there is still very limited investments in renewable energy within the region.

Water heating end-use area is considered to be one which can significantly benefit from the increased use of RE in the form of solar water heating technology. This, given the high cost associated with production of hot water from conventional energy forms as well as the significant water heating demand in tourism, hospitality, institutional health sectors as well as domestic sector, coupled with the fact that there is an abundance of solar energy in all CARICOM countries. Barbados has been recognized globally for achieving high penetration level (over 40 per cent) of solar water heaters and has for many years developed an industry encouraged by supportive government policies.
By studying carefully what has been done before, by demonstrating a commitment through regulations, and have leaders set an example, a government can go far to make solar water heating successful, and sustainable. The lessons of Barbados, the third-highest per capita user of SWH (313.9 KWth per 1,000) – behind Cyprus (527 KWth) and Israel (371 KWth) – can serve as a critical plank for guiding other CARICOM member states.

Despite the obvious opportunities, other member states have struggled to reproduce the results achieved by the “Barbados Model”. Within the existing respective national energy policies, there are clear and present options for solar water heating; in pursuance of same, there is nonetheless the opportunity to learn from the Barbados experience despite the unique energy situation in each member state, which requires that interventions should be “surgical”. Application of the technology must be done within the context of existing energy sources, end-use pattern, socioeconomics and the sociopolitical culture of the respective countries. The ultimate goal therefore is to develop a regional model that uses the best practices of the Barbados and other regional territories, but nonetheless, considers the specificities of individual member states for the promotion and use of solar water heating.
2. METHODOLOGY

2.1. OBJECTIVE OF THE STUDY

The primary objective of this project is to design strategies and mechanisms to accelerate commercialization and sustainable market transformation of solar water heating in CARICOM states, thereby reducing the current use of electricity and fossil fuels for hot water preparation in residential, private service sector and public buildings and, when applicable, industrial applications. It will build on the encouraging market development rates already achieved in some member states, especially Barbados, and seek to further expand the market in other states, where the potential and prerequisites for market uptake seem to exist.

More specifically, study sought to establish a roadmap through which CARICOM may seek to mainstream SWH into the energy economy and energy policies in the respective member states in light of different factors that include: the general policy framework; dominant paradigms and priorities; socioeconomic indicators; institutional arrangements; demography; and political culture. The lessons and practices of Barbados provide a platform towards developing same.

2.2. SCOPE OF WORK

The scope of work for the project required:
(i) Analysis of the present practices in energy sector policies, strategies and planning processes within the member states;
(ii) Identification of issues and gaps that mitigate the pursuit of solar water heating (SWH) initiatives in the member states;
(iii) Recommendations on steps for bridging the gaps where they exist; and
(iv) Recommendations on processes for improving policy formulations that support the mainstreaming of SWH into the respective national, as well as the overall regional, energy sector.

The work gives particular attention to financing, procurement, regulatory and capacity building issues; the role of quality control is also given significant treatment.
2.3. METHOD

The assignment was divided into three phases for which specific tasks have been outlined:

(i) Secondary information collection or desk assessment
(ii) Stakeholder consultations
(iii) Assessment of SWH potential

Phase I: Secondary Information Collection (Desk Assessment)
In this phase, secondary information on the solar water heating sector within CARICOM member states, as well as five (5) associate member states, was collected. This information consisted of information on manufacturers, products, policies, barriers and markets. This information was collected through literature survey and the information used toward planning the subsequent phases of the project.

Also, Case Studies on previous experiences of SWH applications within the most successful member state, Barbados, as well other countries of global significance were conducted. This was done so as to glean insight into the policies, strategies and circumstances that either supported (Israel and Cyprus) or hindered (South Africa) development of a thriving SWH market industry.

In consultation with the CARICOM Energy Unit during the Project Inception meeting held on 26 October 2011, four member states were selected for “in-country” stakeholder meetings and site visits. These were, inter alia: (1) The Bahamas; (2) Barbados; (3) Jamaica; and (4) Trinidad and Tobago. These states were selected for the following reasons:

(1) **The Bahamas:** This archipelago of islands has the largest SWH potential as a consequence of high electric water heating penetration (around 85 per cent) and high electricity pricing (USD 0.45 per kWh).
(2) **Barbados:** The country is the only member state to have achieved significant SWH market development – around 40 per cent SWH penetration – and the study will serve to guide other member states on best practices.
(3) **Jamaica:** This country has the largest potential SWH market based on sheer size. When Haiti is excluded, Jamaica accounts for around 42 per cent of households and 32 per cent of hotel rooms within the CARICOM states; though penetration remains low, Jamaica has demonstrated some degree of affinity towards SWH technology.
(4) **Trinidad and Tobago:** The twin-island republic has the potential to on the one-hand, develop a thriving SWH market if driven by government levers in support of SWH use as a clean development mechanism; on the other-hand, low energy costs and a “long tradition of manufacturing” within the islands means the potential for manufacturing cheaper, regionally produced SWH may exist in that country.
Phase II: Stakeholder Consultations
Survey instruments were designed and dispatched to targeted stakeholders within the respective member states. The primary purpose of the survey and stakeholder interviews was to collect information on the following:

- Hot water demand (present state, as well as growth trends);
- Electricity supply and demand details;
- Current status of solar water heater markets;
- National policies and mechanisms for their enforcement;
- State of various technical issues that are relevant for application of SWH (water quality, resource available, space availability, etc.);
- Previous in-country experiences of SWH applications and the profile of the end-users; and
- Knowledge, attitude and practice among SWH end-users.

For conducting the primary survey, three stakeholder groups were targeted. These were, inter alia: (i) electric utility companies; (ii) energy desks within the respective national governments; and (iii) SWH manufacturers and distributors within the respective countries.

Phase III: Assessment of SWH potential
Through the CARICOM Energy Unit, the work under this phase sought to provide regional operatives with the following:

- An appreciation of sector-level issues concerning installation of SWH and implications of these in terms of SWH market prospects. This is based on the primary survey and stakeholder interviews done.
- Development of hot water requirement norms based on literature survey, primary survey and stakeholder consultations.
- A reasonable outlook on the existing SWH stock for different sectors in CARICOM member states and expected growth until 2020.
- Recommendations for enabling policy to support sustainable development of the SWH market, including building regulations, financial and/or fiscal incentives and/or voluntary or mandatory quality control, as well as certification and labelling schemes.
- Suggestions for enhancing the awareness of the key stakeholders on the use of SWH systems as a part of buildings’ HVAC systems.
- Programmes for increasing consumer access to SWH financing options offered through local financial institutions, electric utility demand side management (DSM) programme, etc.
- Programmes for building the capacity of the supply chain, including training and certification of installers.
2.4. STAKEHOLDERS’ WORKSHOP

The Stakeholders’ Workshop was held on Thursday December 8, 2011 at the Amaryllis Beach Resort in Hastings, Barbados.

The workshop was organized into three (3) sessions, to include a site visit that highlighted the SWH manufacturing operation within the small island state of Barbados. The site visit was preceded by a presentation on the Barbados SWH Experience and the intent is to link the details thereof with the “concept proof”. General objectives of the workshop are, inter alia:

- Exploration of strategies for supporting expansion of Solar Water Heating manufacturing and systems’ use in CARICOM countries;
- Identification of effective, supportive legislative and regulatory frameworks for enhancing the expansion of Solar Water Heating manufacturing and systems’ use in CARICOM countries;
- Analysis of the Barbados experience, thereby furnishing a suitable template for other CARICOM countries; and
- Examination of the status and requirements for capacity building, product performance, and quality assurance along the value chain for Solar Water Heating systems in CARICOM countries.
- Network for facilitating regional information exchange and cooperation on the experiences, results, lessons learned and best practices across countries.

2.5. LIMITATIONS OF THE STUDY

The study’s primary research data was significantly weighted towards the household (domestic) SWH use and far less towards the industrial use; this was a consequence of the limited availability of public data for the latter. Also, the fast growing number of property (residential) developments and the absence of mandatory reporting mechanisms for SWH sales means that the Consultant was dependent on the voluntary furnishing of data by technology manufacturers, distributors and retailers.

The Consultant was seriously constrained by the lack of details related to renewable energy, particularly SWHs, within CARICOM states. Though significant due-diligence was performed to obtain primary information, where such could easily be obtained, most usually the Consultant had to rely on secondary information from the stakeholders involved in this Study as well as extrapolation of said data. As a consequence, much of the data presented within this report are very crude and should be treated at best, as reasonable estimates.
3. SITUATION ANALYSIS

The use of solar energy in the Caribbean is widely known and disseminated, but only on a local scale or for domestic uses. Photovoltaic (PV) electricity generation, solar water heating and solar cooling systems are suitable for much of the Caribbean region, with current deployment primarily in off-grid locations.

The current solar energy potential in the Central American and Caribbean region is shown in Figure 3.1 and Table 3.1 below. At a glance, it can be seen that the CARICOM member states are among the best location to use solar energy; the average solar radiation (insolation) is between 4.0 and 5.0 KWh per m² per day for the region.

**Figure 3.1: Solar Insolation Map: Mexico, Central America and the Caribbean**
Source: National Renewable Energy Laboratory (NREL). 2010
Table 3.1: Daily Solar Insolation (KWh/m²) and Average Temperatures for CARICOM states
Source: NASA Langley Research Centre, Atmospheric Science Data Centre, 2010

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>GEOGRAPHIC LOCATION</th>
<th>INSOLATION/ KWh/m²/day</th>
<th>AVERAGE TEMPERATURE/ ºC</th>
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<td>St. Lucia</td>
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<td>4.98 (Dec)</td>
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<td>5.10 (Dec)</td>
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<td>Suriname</td>
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<td>Associate members</td>
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</table>

**3.1. GENERAL OVERVIEW**

Despite the huge potential for solar-based and other indigenous energy sources, CARICOM countries spend a significant portion of “scarce” foreign exchange to import liquid petroleum fuels to provide energy services. The fifteen CARICOM states are almost entirely dependent on imported oil and gas and it is estimated that as much as 95 per cent of commercial energy consumed in the CARICOM region is derived from fossil fuels, primarily oil. That figure represents about 90 millions of barrels of oil equivalent in a year. CARICOM countries are essentially net importers of crude oil and refined products - the exception of Trinidad and Tobago and lesser degree Suriname – which are derived largely from extra-regional sources. The unstable and unpredictable cost of energy has been, and will continue to be, a major concern to countries dependent on petroleum resources for the generation of electricity. In recent times, high oil prices have forced electric utility companies to pass on the cost of generation to their customers – with the exception of EBS in Suriname and T&Tec in Trinidad and Tobago – CARICOM utilities currently include a per KWh fuel surcharge in their tariff structure to compensate for changes in fuel cost. On the
basis of the foregoing, electricity prices in CARICOM member states are typically rather high (See Figure 3.2). Charges – when fuel surcharge is included – are mostly above US 20 cents per KWh and the average cost across the region is around USD 40 cents per KWh. Higher oil prices inevitably lead to higher electricity bills and a subsequent increase in the overall cost of living. Also, paying the energy bills is becoming more difficult and continues to divert funds from other needs related to maintaining the level of economic status and to the addressing the never-ending demand for growth and development.

3.1.1. Status of Electricity Generation and Use
Like other island nations, CARICOM member states and their associates are caught in the middle of the energy crunch. The region’s large dependence on diesel generation technologies for electricity has resulted in considerable price increases that are affecting the ability of the consumer and governments to maintain economic stability. Persistent instability in the world’s oil producing regions and the forecast for more devastating tropical storms that impact the delivery of petroleum resources to the Caribbean are not helping the situation or providing any hope of lower fuel prices in the near future. In addition, fuel imports and electricity demand increase in response to explosive residential and resort development throughout the region; as a consequence, utilities (and at times, governments) are forced to expand generation capacity, slow the rate of growth, or turn to alternative solutions to meet the growing demand for electricity.

The need for growth and economic development, combined with the desire to continuously improve the quality of life, necessitate new thinking about the role for renewable energy. Based on the current state of maturity of the available conversion technologies renewable energy sources, two main areas have been identified in which renewables have immediate potential to replace petroleum for energy services provision; these are, inter alia, electricity generation and water heating.

With the exception of Barbados, solar water heating is hardly utilized within CARICOM member states despite the commercial maturity of the technology and the very favourable climatic conditions (high solar radiation). By any standards, the economically-feasible potential for increased use of solar thermal applications for hot water preparation is huge and comparable to any other form of renewable energy. As demonstrated by the experiences in China, it is a technology that can provide cost-effective energy solutions to the lower income segment of the population and as further demonstrated, in Cyprus, Israel and Barbados, can become a mass product leading to permanent market shift at the national level for the benefit of both the end-users and technology suppliers. This Report will focus on mechanisms to accelerate commercialization and sustainable market transformation of solar water heating, thereby reducing the current use of electricity and fossil fuels for hot water preparation within CARICOM member states.
Figure 3.2: Average Electricity Tariff (USD per KWh) in CARICOM States
Source: CARILEC Tariff Survey, 2010
3.1.2. Solar Water Heating Penetration

Solar thermal energy as applied to heating domestic hot water – an idea that has been around for a long time – offers what many CARICOM countries have been articulating as a part of their energy efficiency strategy; distributed generation is a key element in de-centralizing the production of electricity for the security of predictable generation that simultaneously reduces load impacts on the grid, as well as reducing transmission line losses. By generating heat energy at the customer’s site, the utility is reducing the capacity needed for the electricity distribution system, improving the reliability, and increasing the quality of the power. Instead of using electricity from the grid to heat water, the abundant “free” energy of the sun is harnessed by the solar system to generate the electric equivalence necessary to provide hot water to the end-user or the heat required to operate other systems used for manufacturing, process heat and air-conditioning.

Solar thermal systems directly reduce consumption of electric grid power in exactly the same way as solar electric generation technologies (such as PV and CSP) increase useable energy at the customer’s site. Nonetheless, the potential contribution of solar water heating industry to the energy sector in the Caribbean has been largely under-utilized. Crude estimates place the penetration of solar water heaters in CARICOM member and associate member states at around 7.6 per cent: This is around 220,000 m² installed collector area or 170 MWth of capacity. Placed into perspective, this represents per capita installed capacity of approximately 48.9 kilowatts thermal (KWth) per 1,000 inhabitants – compare Cyprus (527 KWth) and Israel (371 KWth). The calculations include Barbados whose penetration is exceptionally high (313.9 KWth) and excludes Haiti and Montserrat for whom data was not available. It should be noted Barbados accounts for around 55 per cent of the solar water heating capacity within CARICOM member and associate member states (Figure 3.3).

When Barbados is omitted from the calculations, penetration drops to around 5.2 per cent or 33.4 KWth per 1,000 inhabitants. The suggested reasons for this low penetration include limited retailer presence and the associated lack of product offerings and support in a majority of member states and associate member states. This argument may be substantiated on the basis that, with the exception of Barbados, the countries with the highest per capita penetration (per 1,000 inhabitants) are St. Lucia (111.4 KWth), Grenada (85.5 KWth) and Dominica (46.2 KWth) respectively. This is attributable to the significant presence of Barbadian-based SWH giants, Solar Dynamics Limited, within these territories. In fact, Solar Dynamics (EC) Limited, a joint venture of Solar Dynamics Limited with local companies Minvielle and Chastenet Limited manufactures and installs SWH in St. Lucia – hence the relatively high penetration (15.6 per cent) in that country. Also, both Solar Dynamics Limited and its subsidiary, Solar Dynamics (EC) Limited have a significant distribution presence in Grenada and supply as much of 1,000 SWH units to that country on an annual basis (Figure 3.4).
When disaggregated, the solar water heating penetration in CARICOM member states is 8.5 per cent or alternately, 54.5 KWth per 1,000 inhabitants. In comparison, the associate member states of CARICOM have average penetration of around 5.4 per cent or 34.5 KWth per 1,000 inhabitants, which is somewhat indicative of the limited market operatives within those countries. This is especially significant considering that the hot water demand is high in the latter territories – significant number of households (in most instances, over 80 per cent) own conventional water heaters; the hot water demand is attributable to the relatively high standard of living within these territories where the average per capita GDP is just over USD 50,700. In CARICOM member states, excepting Haiti and Montserrat for which data is not available, conventional water heaters are present in just around 18 per cent of household and the average per capita GDP for these territories is USD 13,600.

The general principle however is that for the majority of CARICOM states, hot water is not a priority in poor households when compared with other energy-related applications. In fact, it has also been reported that: “in general, access to hot water in low-income households is a secondary requirement, after the requirement for additional space within the home”.¹

¹ Douglas, Guy. 2004
In addition to the foregoing, perceived or real issues with aesthetics and reliability and a lack of familiarity and knowledge about the technology have combined to limit consumer adoption. The primary driver however remains the high initial cost – the lifecycle benefits often do not greatly exceed the capital cost of the system and benefits, such as reduced reliance on fossil fuels and reduced carbon dioxide emissions, are in many instances external to the consumer and difficult to quantify. Methods to increase SWH penetration within CARICOM therefore requires strategies that attract a strong retail presence within the respective member and associate member states, as well as mechanisms for facilitating the affordability of solar water heaters to the end-users.
3.1.3. Barriers to SWH Market Expansion within CARICOM States

Energy is the driving force for the development of national economies, promoting social and economic development. Solar water heating has been demonstrated to be technically feasible and economically viable within the Caribbean and provides an immediate opportunity for providing a significant energy service, which is currently mostly support by fossil-based electricity, from a renewable source. In many countries within the region, as much as 15 per cent of the electricity consumption within the domestic (household) sector has been attributed to water heating. There are however, many factors that currently mitigate the mainstream deployment of SWH across the Caribbean. Some of the main factors (barriers) are summarised below.

1. **High Capital Cost of Solar Water Heaters**

The main barrier to the general uptake of solar water heating within the Caribbean is financial. Solar water heaters are considered high cost when compared to the price of conventional (electric and LPG) water heaters. Within CARICOM states, the average price of a 66-gallon system is around USD 2,000; in contrast, the average cost of an equivalent (50-gallon) electric water heater is USD 600 and a gas (LPG) equivalent is around USD 800 (See Figure 3.5 below). Though credit facilities for SWH purchase are available in some member states, low- and lower-middle income households may not qualify for same. In fact, studies in Jamaica have shown that many low-income households do not even have proper water and electricity facilities and so solar water heating is not a concern to them. In some low-income households, hot water is obtained by the primitive method of heating water in metal containers over a wood fire.

Loan facilities for SWH typically target middle-income households but as a consequence of the relatively high interest rates (around 7 per cent), such facilities are unattractive and other energy-related items (such as refrigerators, televisions, computers, etc.) frequently take precedence. This barrier is enhanced in member states such as Trinidad and Tobago where electricity pricing is low and the payback period for SWH investment is, as a consequence, relatively long (around 7 years). In other CARICOM territories, electricity costs between USD 20 – 40 cents per KWh; this is rather high compared with the global average of around USD 16 cents per KWh. The payback period for investment in SWH in most CARICOM states is typically less than two years. Nonetheless, it is the initial investment, rather than the economic return, that is the biggest determinant for consumers. The cost of a solar installation is three times that of a standard water heater and the bottom-line remains the bottom-line; despite the potential energy savings which results from SWH, consumers will continue to adopt the lowest initial cost electric water heating solutions if the choice is simply left open to a “free market arrangement”.

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Figure 3.5: Capital Cost (USD) of Various Water Heating Technologies within CARICOM States

The technologies compared are the most commonly utilized, *inter alia*, Electric (Tank), Electric (Tankless), LPG (Tank) and Solar Thermosiphon; the comparisons are done for 60 gallon capacity in the tank systems

Source: Consultant Generated. 2011
2. Lack of Awareness (Perception Barrier)

The most basic obstacle to the spread of solar water heating is lack of knowledge. When most persons think of solar energy, they envision photovoltaic panels on rooftops or, sometimes, vast fields of mirrors in concentrating solar power (CSP) plants. These technologies generate electricity and represent an important tool for reducing dependence on fossil fuels but are rather expensive; as a result, there is a perception that solar technologies are for the rich and very rich. But solar energy technology extends beyond the generation of electricity and can also be utilized for the direct provision of heat-based energy services, such as to heat water for domestic, commercial or industrial use. Moreover, there is very little awareness towards the ability of solar technology to deliver multiple energy services, such as PV/thermal (electricity and hot water) and solar cooling (air conditioning and hot water).

The decision-making process regarding investments in SWH technologies is shaped by national cultures and the individual’s perception of its level of cost-benefit and reliability. Lack of knowledge or the limited ability of SWH producers and retailers to reliably research and evaluate information on their technologies and practices retard technology uptake. Consumers or businesses are frequently unaware of how to go about integrating solar water heating into their buildings and practices, or of how much energy and money solar technologies can save. The information provided by SWH retailers is usually, at best, generic and cliché sales statements that are frequently not based on empirical data. Although SWH technology exists within CARICOM states, there is limited communication promoting the technology; promotion programmes are typically market-driven.

3. Split Incentive Barrier

Split incentives happen when those responsible for paying energy bills are different than those making capital investment decisions. The most common form of split incentives is in rented housing (domestic) and leased buildings (commercial) where tenants pay the energy bills, but owners pay for upgrades; owners do not make renewable energy and energy efficiency investments because it is the renters who pay the electricity bills. And renters do not make investments in property they do not own. The result is buildings in which energy costs are more than it could be.

Within CARICOM states, residences account for as much as 28 per cent or ca. 6,300 GWh of electricity use. It is further estimated that electric water heaters account for around 12 per cent or 750 GWh of domestic electricity-use. In the specific case of solar water heating, the issue of split-incentive has played a significant role in retarding market penetration. The fact is that the incentive to save energy is often in the wrong place; the people who can make the investment happen (substitute or replace conventional water heaters with SWH) are not the ones who will realize the electricity savings. The owners will typically therefore
invest in the lower cost electric water heaters (which are around 25 per cent the cost of a SWH) as they are not burdened with the responsibility for the energy bills.

<table>
<thead>
<tr>
<th>Building occupied by</th>
<th>SCENARIO 1</th>
<th>SCENARIO 2</th>
<th>SCENARIO 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity bill paid by</td>
<td>Owner</td>
<td>Tenant</td>
<td>Tenant</td>
</tr>
</tbody>
</table>

Within CARICOM states, a significant number of housing units (around 28 per cent) are rented and though limited data is available, it is clear that a substantial amount of energy consumption may be affected if misaligned incentives between landlords and tenant lead to underutilization of sustainable opportunities, such as solar water heating. The possibility of split incentives between landlords and tenants was first noted in the realm of energy consumption not long after much of the economic theory of the principal-agent problem was being developed. Since, landlord-tenant split incentives have been discussed primarily in the context of market failures that impede energy efficient investments by renters, usually as one of a long list of possible market failures, as well as in a variety of other circumstances related to energy-use; the likelihood of investment in renewable energy and energy efficiency technologies increases for buildings in which the electricity bill is paid by the owner (Scenario 1 and Scenario 2 above). In instances where the bill is paid by the tenant (Scenario 3), the investment is less likely; a consequence of the differing landlord-tenant (split) incentives. For SWH, this barrier is highest for existing buildings in which conventional water heaters are already installed as owners frequently do not upgrade existing technology in which they have already invested.

**Figure 3.6: Split-incentive in SWH Technology Implementation**

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2 Blumstein, Krieg, Schipper, and York. 1980
The split-incentive barrier also applies in other circumstances, such as in the case of the differing developer-owner (split) incentives for large residential and some commercial projects, such as hotels. In most instances, the project developer is not the end-user and therefore does not pay the electricity bills. As a consequence, building design and the choice of energy technologies (in this case, water heating devices) is influenced by factors that are deemed more expedient to the developer; these include project cost and aesthetics.

Within the majority of CARICOM states, there is neither the requirement nor incentive for project developers to include building operating and maintenance cost in bid tenders. Frequently, construction projects are primarily focussed on (up-front) capital costs, design aesthetics and construction time and as a consequence, the developer is usually interested in the lowest possible capital cost that is compatible with the building codes.

4. Technical Barriers
Numerous barriers still impede the dissemination of these technologies. Most technical barriers have now been fixed, although technical limitations persist; unfortunately, past failures have left some distrust in the public and policy makers’ opinion in many countries. Solar thermal technologies are often viewed as “low tech”. Yet they currently provide a greater contribution to global and regional energy demand than solar electricity – photovoltaic (PV) and concentrating solar power (CSP) altogether – and have the potential to contribute much more toward meeting future energy demand.

Designs: Theories for optimal design and sizing of SWH have become rather reliable and most technical strategies now translate into cost issues; in fact, there are concerns among some stakeholders which suggest that regionally-manufactured SWH are “over-designed” and do not provide low cost options to consumers.

Installation: Another technical barrier that continues to persist is also the lack of trained and competent installers in most markets. The fact is simply that the public frequently ignores that most products are now technically reliable and it takes little time for the market to lose confidence in the benefits of solar water heating technologies on account of poor installation by incompetent installers. The lack of craftsmen properly trained to install and maintain solar thermal systems can is a key barrier to growth. This is particularly relevant for the main market segment of single-family houses as installers can often decisively act as the decision-maker. If installers know solar thermal systems, they may motivate potential users to buy them. If they are not specifically trained, they may discourage consumers or even provide a poor installation, with a negative impact on the functionality of the system and on the image of the technology.
Standards and Minimum Performance: Development of the SWH market is a balanced process in which the increased demand must be matched by the availability of decent quality products; a lack of quality control can often undermine consumer confidence as people associate SWH with mediocre or low quality equipment. Within CARICOM, CROSQ has responsibility for harmonization of quality control standards within member states. Solar water heaters and other renewable technologies have not been items of focus however as standards and codes have typically been utilized for “mainstream” articles such as refrigeration and HVAC equipment, as well as electrical appliances. Further, there are limitations to the capability of national standards bodies which do not have the capacity to conduct performance testing in their present state. In order to maintain market confidence, some Barbados manufacturers conduct voluntary testing through the FSEC; imported technology are not subject to quality assurance measures however and there is much concern within the industry that “inferior” technology from Asia is entering the CARICOM market.

Cross-integration: All the points mentioned above mainly hold for production of domestic hot water. The main technical barrier however has to do with more widespread applications beyond hot water production, i.e., for heating, cooling and industrial process heat, which are still on both the component and system level. For a broader application of solar water heating, greater integration of solar thermal technologies into the various energy matrices is required. There is, for instance, much scope for application in cooling and air-conditioning of buildings (commercial buildings, offices, hotels, etc.). For such applications, custom engineering designs are required – that is, small scale heat driven chillers and/or air handling units have to be developed and system concepts have to be designed and tested. For industrial processes, heat-reliable, stagnation-safe, medium-temperature solar collectors working in the temperature range of 80 – 250 °C are required; these collectors are also beneficial for application with heat driven cooling and refrigeration technology. This therefore requires a shift in focus from the current “cookie-cutting” paradigm that dominates the CARICOM market towards a more solutions-based approach.

5. Institutional and Legislative Barriers
In general, the present SWH situation in CARICOM states can be described as “business as usual” with limited growth reported by the SWH sector in recent years. The residential sector, especially in Barbados, has been the main driver of growth in the industry; it is estimated that despite the potential within the commercial (hotel and hospital) and industrial (especially food processing) sectors, around 70 – 80 per cent of the SWH sales within CARICOM states occur within the household sector. Much of the failure to disseminate SWH technology within CARICOM states is institutional: Barbados aside, governments have largely failed to do enough to stimulate the industry. In many instances,
supportive policies for renewable energy (including solar water heating) technologies have been largely absent. In cases where policies exist, they have neither been translated into action nor have they been sufficiently integrated into the overall energy economy.

**The lack of a champion:** Within CARICOM, there is no institutional ownership of the benefits of an expanded SWH programme. Currently, different member states attempt to set their own national agenda with, excepting in the case of Barbados, limited success. Much of the benefits of a successful regional SWH market, such as energy security derived through use of an indigenous resource and the environmental benefits of cleaner energy, being external to the end-user. Nonetheless, the current scenario is such that the regional market is largely investor-driven as SWH manufacturers and retailers seek to exploit the available opportunities. As a consequence, there is very little policy or activity coordination for SWH within the region.

**A lack of political continuity:** There is frequently not enough “follow-through” on policies that are engendered for SWH. Usually, this results in no definitive policy decisions and thus little implementation of SWH promotion measures. Though there is no “single magic bullet” that has accounted for the successful promulgation of SWH markets, the continuity of government policies through successive political administrations is critical. This provides stability for an industry that is continually gauged against global oil (and electricity) prices.

**Not enough performance data:** There is a paucity of data that is available on SWH use in the region. Consequently, there has not been enough information that is geared towards presenting a clear picture of the microeconomic benefits of SWH to end-users, nor of the macroeconomic benefits to decision-makers in government. Consequently, analysis on SWH benefits within the region has been semi-quantitative at best.
3.2. OPPORTUNITIES FOR SOLAR WATER HEATING END-USE

The Caribbean Community (CARICOM) consists of many small island developing states (SIDS) and low lying coastal states, all of which exhibit unique characteristics, including, varying topographies, limited natural resources, small populations and fragmented markets with different energy product specifications. CARICOM states face the two-fold challenge of energy and environmental security; more than 90 per cent of power supplies in the region are dependent on imported fossil fuels. With the exception of Trinidad and Tobago and to a lesser extent Suriname, CARICOM states have little or no oil, natural gas or coal resources. Analyses of renewable resources in the region indicate excellent potential for wind-, solar-, biomass- and, in some instances, geothermal- energy use. A confluence of factors – commercial maturity, industry experience, potential electricity savings and short payback period – make low- to medium- temperature solar thermal technologies (solar water heaters) appropriate for mainstream utilization within the region. Nonetheless, the SWH potential has been largely underutilized. By any standards, the global, economically-feasible potential for increased use of solar thermal applications for hot water preparation is huge and comparable to any other form of renewable energy.

As demonstrated by the experiences in China, it is a technology that can provide cost-effective energy solutions also to lower income part of the population and as further demonstrated, for instance, in Cyprus, Israel and Barbados, can become a mass product leading to permanent market shift at the national level for the benefit of both the end-users and the environment. In summary, it is an economic, commercially viable and available technology, which due to the different market barriers, however, has not reached the market penetration rate that it could reach on simply economic grounds.

3.2.1. Household (Residential) Sector
Haiti and Montserrat aside, it is estimated that there are over 2 million households across CARICOM states. At present, the residential (household) sector accounts for approximately 6,300 GWh or roughly 28 per cent of electricity use within the territories. The single largest electricity consuming appliance in many households is usually the electric water heater, accounting for as much as 30 per cent of the total electricity used. With a penetration of around 26 per cent, electric water heaters account for 4 per cent or approximately 850 GWh of electricity-use per year within CARICOM member and associate states. Household domestic hot water penetration varies from as low as 1.1 per cent in Suriname to over 85 per cent in The Bahamas, Bermuda, Cayman Islands and The Turks and Caicos Islands (Figure 3.7). Except for Barbados, electric water heaters dominate the domestic hot water landscape and account for 68.3 per cent of residential water heaters; solar and gas (LPG) water heaters constitute 24.1 per cent and 7.6 per cent respectively.
Figure 3.7: Domestic Hot Water (DHW) Penetration, CARICOM States
Domestic hot water use (total and disaggregated) per 1,000 households
Source: Consultant Generated. 2011
When taken into context, the opportunities for solar water heating within the residential sector can be disaggregated as follows:

A. Replacement of electric with solar water heaters: The high penetration of electric water heaters (26 per cent) versus the relatively low SWH penetration (7.6 per cent) presents a clear and present opportunity for a paradigm shift towards the latter technology. Large-scale replacement of electric water heaters with solar water heaters would result in significant and quantifiable displacement of electricity within various CARICOM states and consequently slow the rate of increase in electricity demand as well as reduce greenhouse gas emission. When taken into context, the replacement of each electric with solar water heater: (i) reduces electricity consumption by around 4,000 KWh per annum; and (ii) reduces CO₂ emissions by approximately 2.2 tons per annum. This translates into 40,000 KWh and 22 tons of CO₂ over the “conservative” 10-year lifecycle of a single SWH and would save nearly 75 barrels of oil imports. In microeconomics terms, the individual household would save as much as USD 1,250 and USD 2,900 per annum in electricity bills in Jamaica and Bermuda respectively.

An aggressive approach that replaces 100,000 (46 per cent) of the estimated 215,000 electric water heaters in CARICOM member and associate member states could save around 4,000 GWh of electricity (7.3 million boe) and 2.2 million tons CO₂e over 10 years. At current global carbon pricing of around 10 euros per ton, there is an interesting potential to derive as much as 20 per cent of the technology cost from carbon financing.

Though the economic and environmental benefits for replacing electric with solar water heaters are substantial, there are a number of mitigation factors. The primary barriers of: (i) High capital cost; (ii) Lack of awareness; and (iii) Split-incentive would require particular attention. In addition, the existing plumbing infrastructure would require modification in order to facilitate roof-based hot water storage systems. As a consequence of the foregoing, upgrade of water heating technology is not a common feature among households and would require either multilateral or state-driven programmatic approaches. In terms of absolute numbers, The Bahamas, Jamaica, Trinidad and Tobago, and Bermuda are high impact states for electric water heater substitution as together, they account for around 68 per cent of the electric water heaters installed within CARICOM member and associate member states.

B. Retrofitting of existing households with solar water heaters: It has been stated elsewhere in this report that for the majority of CARICOM states, hot water is not a priority in many households. Crude estimates suggest that, Haiti aside, there are over 1.4 million residences within CARICOM member and associate member states that are currently
without domestic water heating technology. Even for households with modest financial resources, SWH can be a wise investment.

With the exception of Haiti, the majority of households within CARICOM member and associate member states are grid-connected; electricity penetration is over 90 per cent. Nonetheless, many are significantly challenged by the high price of electricity. Though hot water technology is not a priority among low- and low-middle income households, limited hot water access is important in households with children and the elderly; hot water is an important feature of paediatric and geriatric care. Consequently, many households utilize stove top kettles and pots to provide hot water for bathing and other domestic uses.

The demand for hot water for bathing shows significant variation across CARICOM states and within various types of households; demand for hot water not only depends on climatic factors but also depends on human behaviour (which is influenced by culture and traditional practices). While hot water is a mainstream commodity in countries such as The Bahamas, Bermuda, The Cayman Islands and The Turks and Caicos Islands, across CARICOM states in general, domestic hot water technology is widely regarded as a luxury when compared to other energy-related technology, such as refrigerators and televisions. Seemingly, DHW demand is a related to economic progress – there is a relatively strong correlation between GDP and domestic hot water penetration (Figure 3.8) – and this suggest a likely increase in hot water demand as the economic well-being of Caribbean-folk improves. It is therefore important for a proactive programme, which shifts water heating installation from conventional to solar technology, to be developed. Further, there is scope for SWH to provide domestic hot water to households in deep-rural and hinterland communities, which do not have grid access, as a social commodity.

**Figure 3.8: Correlation Between Per Capita GDP and DHW Penetration, CARICOM States**

Source: Consultant Generated, 2011
Solar water heaters provide a realistic opportunity for affordable DHW services to low- and low-middle income households within CARICOM states as it avoids the burden of high and unpredictable electricity bills. Barriers such as: (i) Lack of awareness; (ii) Public perception towards SWH; (iii) Split incentive; and most importantly, (iv) High investment cost for SWH will again, have to be suitably addressed in order to realize the “full” potential of this market. Also, the existing plumbing infrastructure would require modification in order to facilitate roof-based hot water storage systems and hot water pipes. The lack of reliable, piped water supply, which is a common issue among a significant number of low- and low-middle income households in CARICOM states, will simultaneously need to be addressed. A realistic regional implementation plan can successfully target the installation of SWH in 10 per cent (or 140,000) of the existing stock that is now without water heating technology. The high impact states for this project would be Belize, Dominica, Guyana, Jamaica, and Trinidad and Tobago; such an initiative would require clean development rather than economics as the driver and may also be “bundled’ as part of a carbon financed programme.

C. Installation of solar water heats in new houses: In 1980, the Israeli Parliament (Knesset) passed a law requiring the installation of solar water heaters in all new homes (except high towers with insufficient roof area). As a result, Israel is a world leader in the use of solar energy per capita with 85 per cent of the households today using solar thermal systems; this is 3 per cent of the primary national energy consumption and is estimated to save the country 2 million barrels (320,000 m³) of oil a year, the highest per capita use of solar energy in the world. SWH implementation is typically most effective in new housing developments. Within the region, the Barbados Model provides a suitable reference frame; the initiative began during a period (the late 1970s) when the housing construction industry in Barbados was "mushrooming". Importantly, a market for solar water heating was created with the “construction wave” that posited water heating as a necessary energy service for the modern Barbadian households – high oil and electricity price, as well as government incentives, made solar the technology choice for domestic hot water services.

The fact is that it is far easier and consequently, more cost-effective to integrate solar water heating into construction projects at the design stage than to retrofit later as building infrastructure and passive designs (such as roof angle and orientation) makes it cheaper. For a typical family of four, three-bedroom house, solar water heating adds 1 – 2 per cent to the construction cost and does not therefore impact the building investment cost in a significant way. There is significant opportunity to either design houses: (i) with SWH installed; or (ii) that are “SWH ready”. This will require appropriate regulatory and incentive schemes within respective territories. Already, there is significant move towards
modernizing Building Codes and Practices to reflect the moves towards a “low carbon” economy within a number of member states.

The role of the regional standards body, CROSQ, will be significant for the harmonization towards, and dissemination of, an appropriate regional code that supports SWH and other sustainable building designs. It is widely acknowledged that the region experienced its most significant “construction boom” during the 1990s (Figure 3.9); during this period, growth in housing stock within CARICOM member and associate member states was estimated to be at a rate of around 3 per cent or 45,000 households per annum. Since, the industry has slowed considerably on account of the global oil crisis of 2008 and concomitantly, the economic recession that has severely impacted many CARICOM states. Crude estimates suggest that the current rate of growth is circa 1.1 per cent or 17,000 – 20,000 houses per annum; recent population censuses within a number of states is expected to provide more refined data on the current state of construction within the housing sector.

The targeting of new housing construction for SWH installation may be done through a mix of "push" (solar ordinances and building codes) and “pull” (government fiscal and tax incentives) factors. As the global and regional economies continue to recover, 20,000 – 30,000 new houses are expected to be constructed on an annual basis in CARICOM states. The correct mix of policies can reasonably result in a penetration of around 60 per cent in these households (12,000 – 18,000 per annum). Over 10 years, SWH can reasonably be installed in preference to conventional technologies in 120,000 – 180,000 households; this would avoid 4,800 – 7,200 GWh of electricity-use and 2.6 – 4.0 million tons of CO₂ emissions compared to the “business as usual” scenario.

When compared to the previous scenarios, the use of SWH in new housing construction has the highest potential for success. The high impact countries are Jamaica and Trinidad and Tobago who together, constructed more than 200,000 houses during the 1990s and continue to dominate the housing construction market within the region. Trinidad and Tobago presents a very interesting case as the government, through the Housing Development Corporation (HDC), participates extensively in the development of low- and middle-income housing projects. In any case, regulatory levers are an interesting tool towards this initiative. There is also significant scope for carbon financing support.
Figure 3.9: New Housing Construction in CARICOM States
The number of houses has been disaggregated according to the decade during which they were constructed.
Source: CARICOM Capacity Development Programme, 2000 Round of Population and Housing Census Sub-Project Reports

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<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&amp;B</td>
<td>1,598</td>
<td>10,546</td>
<td>12,310</td>
</tr>
<tr>
<td>BAH</td>
<td>2,640</td>
<td>15,627</td>
<td>5,038</td>
</tr>
<tr>
<td>BDS</td>
<td>3,537</td>
<td>6,662</td>
<td>8,797</td>
</tr>
<tr>
<td>DOM</td>
<td>20,353</td>
<td>137,900</td>
<td>43,892</td>
</tr>
<tr>
<td>GRN</td>
<td>99,659</td>
<td>3,499</td>
<td>154,471</td>
</tr>
<tr>
<td>GUY</td>
<td>1,201</td>
<td>2,154</td>
<td>14,654</td>
</tr>
<tr>
<td>JAM</td>
<td>1,201</td>
<td>2,154</td>
<td>14,654</td>
</tr>
<tr>
<td>SKN</td>
<td>4,371</td>
<td>8,253</td>
<td>8,436</td>
</tr>
<tr>
<td>SLU</td>
<td>3,499</td>
<td>5,563</td>
<td>46,482</td>
</tr>
<tr>
<td>SVG</td>
<td>44,210</td>
<td>46,689</td>
<td>1,041</td>
</tr>
<tr>
<td>T&amp;T</td>
<td>474</td>
<td>728</td>
<td>1,433</td>
</tr>
<tr>
<td>ANG</td>
<td>2,562</td>
<td>2,985</td>
<td>1,685</td>
</tr>
<tr>
<td>BER</td>
<td>692</td>
<td>1,095</td>
<td>1,757</td>
</tr>
<tr>
<td>BVI</td>
<td>1,200</td>
<td>1,730</td>
<td></td>
</tr>
<tr>
<td>TCI</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Since the energy crisis of the 1970s, SWH markets within CARICOM member states experienced some level of commercial growth. In countries such as Barbados, growth has been prolific and has been fuelled by government incentives that include tax credits. In other territories, poorly designed incentives and lack of standards led to sale of very expensive, poorly performing systems installed by inexperienced and sometimes unscrupulous firms. The result of this is that there has been a significant level of market retardation as market barriers continued to hurt the reputation and proliferation of the regional SWH industry. Though there are no detailed figures available, there is indication that when oil prices were low during the 1980s and 1990s, governments within the region (with the exception of Barbados) paid very little or no attention towards developing a “low carbon” economy. As a consequence, opportunities for mainstreaming and expanding the SWH market within the region were missed during the economic boom of the 1990s and the industry served a “niche” segment of the populations. Today, the world is dominated by high oil prices and renewable options are of renewed interest to governments and citizens alike. Although market penetration within the CARICOM states as a whole has remained low, SWH firms within the region have established a record of high-quality products and good service. Improvement in the quality of life of Caribbean folk seemingly promotes domestic hot water demand, which (as electricity prices continue to increase) has resulted in recent increases in demand for SWH.

The member and associates states of CARICOM are characterized by high solar insolation (Figure 3.1 and Table 3.1) and, with the exception of Suriname and Trinidad and Tobago, high electricity prices (Figure 3.2). Assessments show that for all territories, except Suriname and Trinidad and Tobago, significant economic savings accrue to the household if SWH are used in preference to the conventional technologies. The analysis compares the up-front investment as well as the fuel and operation costs for the respective water heating technologies – solar, electric (tank), electric (tankless) and LPG – over a conservative 10-year cycle (Figure 3.10). Again with the exception of Suriname and Trinidad and Tobago, the savings are highest when compared to tank water heaters and are especially significant in Antigua and Barbuda, as well as the associate member states where electricity tariffs are highest.

The payback period for SWH in the respective territories and is less than 12-months when compared to electric heaters in 12 territories; except for Suriname and Trinidad and Tobago, the payback period is less than 24 months across the region (Figure 3.11). The barrier of low-electricity cost is therefore peculiar to these two territories where the payback is over 6 years and requires specific attention.
Figure 3.10: Financial Saving Scenarios for SWH v Conventional Water Heating Technologies (in USD), CARICOM States
Savings have been calculated on a 10-year technology lifetime based on substitution of electric (tank and tankless) and LPG technologies with SWH
Source: Consultant Generated. 2011
Figure 3.11: Payback Scenarios for SWH v Conventional Water Heating Technologies (in USD), CARICOM States
Payback periods have been calculated based on substitution of electric (tank and tankless) and LPG technologies with SWH
Source: Consultant Generated. 2011
The household sector is a major consumer of power within the region and accounts for nearly 6,300 GWh of the 22,300 GWh (around 28 per cent) of electricity end-use. Analysis of the SWH potential for the household (domestic) sector may be disaggregated as follows:

Table 3.2: Macroeconomic overview of SWH potential in the household sector, CARICOM states

The calculations herein are based on a conservative 10-year lifecycle.
Source: Consultant generated

<table>
<thead>
<tr>
<th>Case</th>
<th>No. of Households</th>
<th>SWH Collector Area/ m²</th>
<th>Installed Capacity/ MWth</th>
<th>Fuel Savings/ million boe</th>
<th>Electricity Savings/ GWh</th>
<th>GHG Reduction/ million tons CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100,000</td>
<td>300,000</td>
<td>225</td>
<td>7.30</td>
<td>4,000</td>
<td>2.20</td>
</tr>
<tr>
<td>B</td>
<td>140,000</td>
<td>420,000</td>
<td>315</td>
<td>10.22</td>
<td>5,600</td>
<td>3.08</td>
</tr>
<tr>
<td>C</td>
<td>120,000</td>
<td>360,000</td>
<td>270</td>
<td>8.76</td>
<td>4,800</td>
<td>2.64</td>
</tr>
<tr>
<td>TOTAL</td>
<td>360,000</td>
<td>1,080,000</td>
<td>810</td>
<td>26.28</td>
<td>14,400</td>
<td>7.92</td>
</tr>
</tbody>
</table>

A= Replacing existing EWH with SWH  
B= Retrofitting existing households with SWH  
C= Installation of SWH in new houses

There is significant potential for enhancing the penetration of SWH within the regional household sector. This will require a mix of policies and demonstrations that target the respective territories in a deliberate and strategic way that considers the peculiarities of energy economics as well as the socio-political dynamics therein. Analysis indicate that initiatives which target SWH market expansion within the domestic sector can increase SWH penetration almost five-fold within a 10-year period, increasing SWH collector area from under 0.25 to over 1.3 million m² and installed solar thermal capacity from 171 to 981 MWth. This would save over USD 2.5 billion in oil imports to the region and reduce GHG emissions by nearly 8 million tons of CO₂ equivalent.

From macro-perspective, reduction and avoidance in electricity use due to domestic solar water heating will have the following benefits:

- **Reduction in residential power use**, which will improve the energy security of the respective countries, as there is less power required from the grid to supply household energy services (Table 3.2).
- **Reduction in demand**, during peak times in particular (Figure 3.12), from the residential sector, which translates into a delay of power supply expansion as the rate of increase in electricity demand will slow – SWH can play a major role in utilities’ demand side management (DSM) programme.
- **Creation of jobs** within the solar water heater industry – in manufacturing, system installation and support services; employment creation is a huge priority in many territories.
3.2.2. Commercial and Hotel Sectors
This section covers three important types of commercial and institutional buildings. These are, *inter alia*: (i) Guesthouses; (ii) Hotels; and (iii) Hospitals. Hot water draw profiles can affect solar thermal water heating systems, but the extent to which this is true for commercial systems is not well-defined. Within CARICOM states, commercial hot water consumption data is sparse and where available, is typically outdated. Nonetheless, the following sections shall seek to delineate the hot water demand within the commercial, especially hotel, sector; the potential for solar water heating will be analysed.

A: Guesthouses and Hotels: Tourism is a major consumer of power in the region; hotels and guesthouses consume nearly 2,200 GWh, or approximately 10 per cent of the total electricity consumption, per annum. Estimates suggest that electric water heaters consume around 200 GWh per annum, which is 9 per cent of the electricity consumed by the industry (See Figure 3.13). Though there is some amount of SWH utilization, the most significant contribution is from conventional technologies, *inter alia*, electric water heaters and gas-fired boilers.
It is generally accepted that the SWH potential within the regional sector is grossly underutilized. It is unclear however, whether or not there is an accurate way to predict hotel hot water consumption; in order to maximize a system’s performance, the hot water draw profile for that particular hotel must be known. Gaining insight into the hot water consumption pattern of hotels will allow for accurate engineering design and economic optimization of a solar water heating system for a given hotel. The optimum system will be more economically feasible than a system designed based on rules of thumb.

The Caribbean Hotels Energy Efficiency Action Programme (CHENACT) was designed as a mechanism to “improve the competitiveness of small and medium sized hotels (less than 400 rooms) in the Caribbean Region through improved use of energy with the emphasis on Renewable Energy and Micro-Generation”. The project includes energy audits within a number of CARICOM member states – The Bahamas and Jamaica in the north and Barbados and the OECS in the south. Much of the studies carried out so far have been in Barbados and analyses have focussed primarily on lighting, HVAC and refrigeration. As a consequence, hot water demand has been largely overlooked and the studies failed to generate hot water draw profiles for the various hotels; the recommendations for SWH use has so far been qualitative. Importantly, SWH may be suitably integrated with other energy efficiency and renewable energy technologies for cooling and refrigeration, as well as PV electricity generation.
A US Department of Energy (DOE) study found that on average, hotels use around 28 gallons of hot water per room per day; small hotels and guesthouses of 121 rooms or less used 49 gallons per room per day, and the larger facilities of 390 rooms or more used around 13 gallons per room per day. The energy mix within the hotel sector varies on the basis of type and more importantly, size. Whereas electricity accounts for nearly 90 per cent of the energy mix in small and large hotels, electricity provides less than 75 per cent of the energy within medium hotels (Table 3.3). There is significant scope for the replacement of significant portions of electric with solar water heating. Engineering designs that utilize a mix of solar and LPG technologies are capable of supplying the hot water demand for medium and large hotels; small hotels may be supplied exclusively by solar technologies.

**Table 3.3: Hotels' Energy End-use by Source**
Source: Fichtner Report. The Bahamas. 2010

<table>
<thead>
<tr>
<th></th>
<th>Energy Consumption/ GWh</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Large Hotels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>133.79</td>
<td>89.11</td>
</tr>
<tr>
<td>LPG</td>
<td>7.62</td>
<td>5.08</td>
</tr>
<tr>
<td>Diesel</td>
<td>8.73</td>
<td>5.81</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>150.14</td>
<td>100</td>
</tr>
<tr>
<td><strong>Medium Hotels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>12.54</td>
<td>72.99</td>
</tr>
<tr>
<td>LPG</td>
<td>3.96</td>
<td>23.05</td>
</tr>
<tr>
<td>Diesel</td>
<td>0.68</td>
<td>3.96</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17.18</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Small Hotels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>2.12</td>
<td>87.24</td>
</tr>
<tr>
<td>LPG</td>
<td>0.28</td>
<td>11.52</td>
</tr>
<tr>
<td>Diesel</td>
<td>0.03</td>
<td>1.24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2.43</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Within CARICOM states, there are around 90,000 rooms and oversimplified calculations indicate that hot water demand is around 2.5 million gallons per day. There is around 30,000 m² of installed SWH capacity (22.5 MWth) within the hotel sector, which provides around 600,000 gallons of hot water (just under 25 per cent of the existing demand) per day; this results in approximately 40 GWh in annual electricity savings.

Larger properties tend to utilize collectors measuring about 300 m², with large tanks of up to 25,000 litres (around 6,600 gallons), which allow for preheating from such sources as the central air conditioning or refrigeration system; smaller properties typically use thermosiphon systems. Solar water heating has the potential to provide as much as 60 – 70
per cent of the hot water demand within the hospitality industry; at present, SWH accounts for 24 per cent (half of which is installed in Barbados). The highest potential is in The Bahamas and Jamaica that constitutes 47 per cent of the rooms within the region (Figure 3.14). The opportunities for same may be clearly delineated under the upcoming CHENACT project phases that are fortuitously scheduled for those very countries (The Bahamas and Jamaica); this will require inclusion of water heating under the scope of work for the energy audit activities.

On the basis of the foregoing, SWH has the potential to provide an additional 60 GWh in annual electricity savings through installation of 45,000 m² of new collector area; this would also result in annual GHG reduction of 33,000 tons of CO₂ equivalent.

Figure 3.14: Distribution of Rooms (Hotels and Guesthouses), CARICOM States
Source: CHENACT. 2011

B. Hospitals: In addition to hotels and guesthouses, solar water heaters can be used effectively in other commercial applications; there is significant potential in hospitals, clinics and old age homes. A well-designed solar thermal system can contribute 100 per cent of the energy required for the production of domestic hot water in smaller facilities (small private hospitals, clinics and old age homes) and as much as 70 per cent in larger facilities (general hospitals).
When Haiti is included, there are approximately 25,000 hospital beds serving a population of over 16.5 million within CARICOM member states (Figure 3.15). On the basis of an assumption that hot water demand is approximately 8 gallons per day per bed, the predicted demand for the hospital sector within the region is 195,000 gallons per day. As for the case of hotels, larger hospitals can suitably utilize engineering designs with collectors measuring up to 300 m$^2$ and large tanks of up to 6,600 gallons, which allows for preheating from such sources as the central air conditioning or refrigeration system; smaller hospitals and health centres, etc. can suitably use thermosiphon systems.

**Figure 3.15: Distribution of Hospital Beds, CARICOM States**

Source: WHO, World Health Statistics. 2005

Jamaica is the regional leader in SWH use within hospitals and as much as 50 per cent or 16,000 gallons of the daily hot water demand is provided by solar thermal technology. This is the result of a deliberate, government-led project during the last 5-years that targeted the installation of SWH in public hospitals.

Conservative estimates suggest that regionally, SWH account for around 15 per cent (29,000 gallons) of daily hot water demand within the health sector; this corresponds to an installed collector area of around 1,500 m$^2$ and 1.1 MWth in solar thermal capacity and saves nearly 2 GWh electricity use per annum. There is potential for realistically increasing SWH penetration within the sector to 70 per cent. This increases the hot water produced on a daily basis via solar thermal technology from 29,000 gallons to 136,000 gallons. This initiative requires substitution of electric and LPG water heaters with solar thermal technology. In so doing, additional installation of 5,300 m$^2$ of collector area or 4 MWth of
thermal capacity would be required, which would result in electricity savings of over 9 GWh and GHG reduction of 4,000 tons of CO\textsubscript{2} equivalent per annum.

In general, there is significant potential for SWH use within the commercial (hospitality and health) sector. The penetration of SWH is estimated at around 25 per cent for guesthouses and hotels and 15 per cent for hospitals and health centres respectively; the majority of the hot water demand is provided by electric heating.

Despite the high hot water demand, a number of barriers – chief among which is the split-incentive barrier (previously identified in Section 3.1.3) – have limited the utilization of SWH within the hospitality and health services sector. Conservative estimates suggest that there is already around 31,500 m\textsuperscript{2} (23.6 MWth) of flat plate collector area installed within the commercial (tourism and health) sector and that there is immediate scope for additional installation of just over 50,000 m\textsuperscript{2} (37.8 MWth). This has the potential to reduce electricity use by an additional 670 GWh, thereby saving around 1.25 million barrels of oil imports, over a 10-year period (Table 3.4).

Table 3.4: Overview of SWH potential in the commercial sector, CARICOM states

The calculations herein are based on a conservative 10-year equipment lifecycle.

<table>
<thead>
<tr>
<th>Case</th>
<th>Additional SWH Collector Area/ m\textsuperscript{2}</th>
<th>Additional Installed Capacity/ MW\textsubscript{th}</th>
<th>Additional Fuel Savings/ million boe</th>
<th>Additional Electricity Savings/ GWh</th>
<th>Additional GHG Reduction/ tons CO\textsubscript{2}e</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>45,000</td>
<td>33.8</td>
<td>1.10</td>
<td>600.0</td>
<td>325,800</td>
</tr>
<tr>
<td>B</td>
<td>5,350</td>
<td>4.0</td>
<td>0.13</td>
<td>71.3</td>
<td>38,715</td>
</tr>
<tr>
<td>TOTAL</td>
<td>50,350</td>
<td>37.8</td>
<td>1.23</td>
<td>671.3</td>
<td>364,515</td>
</tr>
</tbody>
</table>

A= Guesthouses and hotels
B= Hospitals

Importantly, there is significant potential for, and much health-related benefit to be derived from, the introduction of SWH in small, often rural, guesthouses and hospitals that do not currently have domestic hot water technologies; this allows for greater availability of hot water for domestic sanitary needs. Many common water-borne diseases can be prevented with proper washing, and hot water provides an additional level of disinfection over cold or room-temperature water. Using solar heat and radiation to treat water is also an effective way to minimize exposure to some waterborne microbes, which can cause diarrheal diseases. Even when solar thermal energy is not adequate to purify water, its use will drastically cut down on the amount of conventional fuels needed to reach the higher temperatures that are required for sterilization.
3.2.3. Industrial Applications

The major share of the energy, which is needed in industrial companies for production processes, is below 250 °C (482 °F). In fact, the low temperature processes are less than 80 °C (176 °F) and are congruent with temperature level that can easily be reached with commercial-scale solar thermal collectors; the principles of operation of the existing SWH systems and their components can apply directly to industrial process heat applications. The unique features of these applications, however, may be found in the degree to which the system configurations (and the controls needed to meet the industrial process requirements) are integrated with the SWH system, as well as with other auxiliary energy sources and the industrial process. Custom-engineering designs and manufacturing is frequently therefore required for application of solar thermal technologies to provide hot water or pre-heating for industrial processes.

The favourable conditions for industrial application of solar water heating are: (i) mean process temperatures that are less than 212 °F; (ii) processes that need a constant amount of energy during sunlight hours; and (iii) high energy prices within the existing operation. The suitable processes within CARICOM states are many and some opportunities for SWH application are delineated below:

<table>
<thead>
<tr>
<th>INDUSTRY</th>
<th>REQUIRED TEMPERATURE/ °F</th>
<th>APPLICABLE TECHNOLOGY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning; Sterilization</td>
<td>140 – 200</td>
<td>Evacuated tube collectors</td>
<td>Cleaning of bottles, cans, kegs and process equipment is the most energy consuming activity within the food industry. Within the textile industry and laundries, hot water clean fabrics and within service stations, clean cars. Storage and integration into the existing heat supply system is rather easy since reliable storage tanks have “relatively low” heat loss.</td>
</tr>
<tr>
<td>Textile</td>
<td>190 – 220</td>
<td>Evacuated tube collectors</td>
<td>The major application of water in the textile industry is in dyeing process. Water is required, not only at normal temperature but also, at temperature as high as 190 °F (90 °C). Heating the quantity of water that is required to above ambient temperatures consumes considerable energy, which is typically produced from electric, diesel- or gas-fired boilers.</td>
</tr>
<tr>
<td>Baking</td>
<td>190 – 220</td>
<td>Evacuated tube collectors</td>
<td>All bakeries requires hot water to clean the utensils used in production process as fat is a major ingredients in bakery product. Solar water heating give bakeries an alternative source of energy for heating water (that is typically produced by electric or gas-fired boilers), thereby reducing cost of fuel.</td>
</tr>
<tr>
<td>INDUSTRY</td>
<td>REQUIRED TEMPERATURE/ °F</td>
<td>APPLICABLE TECHNOLOGY</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
<td>------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Dairy</td>
<td>165 – 220</td>
<td>Evacuated tube collectors</td>
<td>Within the dairy industry, there is significant potential for SWH use in sterilization and pasteurization; pasteurisation can be performed in heat exchangers, in which there is a need for a heat transfer medium (typically water, air or steam). Solar water heating can provide between 70 – 100 % of the heat required for the process and may be used in conjunction with other heat capturing processes such as boiler stack heat recovery.</td>
</tr>
<tr>
<td>Brewing</td>
<td>165 – 220</td>
<td>Evacuated tube collectors</td>
<td>On a daily basis, breweries needs to heat water daily to about 165 °F. Solar thermal technology may be used to preheat the water to around 135 °F degrees, after which it is heated by conventional fuel sources. Again, this process is best used with other heat capturing processes such as boiler stack heat recovery.</td>
</tr>
<tr>
<td>Food Processing</td>
<td>170 – 220</td>
<td>Evacuated tube collectors</td>
<td>The food processing industry comprises a gamut of segments like fruits and vegetables, and grain processing, packaged or convenience food and packaged drinks. There is significant hot water demand for such processes as cooking, extraction, sterilization, etc., which requires temperatures of 170 – 220 °F. Solar thermal technology is typically used to preheat the water to around 135 °F degrees, after which it is heated further by conventional fuel sources.</td>
</tr>
<tr>
<td>Meat Processing; Seafood Processing</td>
<td>210 – 240</td>
<td>Evacuated tube collectors; PV/Thermal</td>
<td>Within the meat and seafood processing industries, refrigeration is the largest user of electricity followed by boilers producing steam and hot water. There is significant scope for using solar water heaters to preheat the water for steam conversion, thereby reducing the electricity requirement for the process. There is also scope for engineering designs that utilize “combi-systems” such as PV/Thermal for refrigeration and hot water services.</td>
</tr>
<tr>
<td>Preheating boiler feed</td>
<td>130 - 150</td>
<td>Flat-plate collectors</td>
<td>As a low temperature heat sink, solar energy is suited very well to preheating boiler feed water. In some territories (such as Trinidad and Tobago where there is natural gas and the Eastern Caribbean States where there is geothermal heat) other heat sources may be available to the process at lower costs.</td>
</tr>
<tr>
<td>Solar cooling</td>
<td>190 - 200</td>
<td>Evacuated tube collectors</td>
<td>Solar cooling with absorption systems is a very special application of solar heat in industry. Integrated into the whole energy system of the industrial plant, it might offer opportunities for hot water production, which is useful especially within the food processing industry.</td>
</tr>
</tbody>
</table>
Despite the substantial environmental, economic and social benefits of investing in industrial solar thermal applications, the regional situation is characterized by numerous untapped opportunities; available technologies could save an additional 5–15 per cent in production and operating costs. Often, potential users are not aware of the advantages and opportunities from investments in the respective technologies. And when they are, they cannot easily obtain the funding to acquire the new equipment or make the necessary plant modifications. Decision-makers in firms do not always benefit directly from their decisions, and moreover, it is difficult to estimate all the costs, benefits and risks of projects. Furthermore, government subsidies that lower conventional energy prices (such as in Suriname and Trinidad and Tobago) can make these investments less attractive.

Examination of the current state within CARICOM territories shows, for instance:

(i) **Soft-drink manufacturing companies** in eleven member states – Antigua and Barbuda; The Bahamas; Barbados; Dominica; Grenada; Haiti; Jamaica; St. Kitts; St. Lucia; St. Vincent; and Trinidad

(ii) **Water bottling companies** in six member states – The Bahamas; Dominica; Grenada; Jamaica; St. Lucia; and Trinidad

(iii) **Breweries** in nine member states – Barbados; Grenada; Haiti; Jamaica; St. Kitts; St. Lucia; St. Vincent; Suriname; and Trinidad

but no known utilization of solar thermal applications within their operations despite the obvious fit. In addition, there are a significant number of bakeries, dairies and food, including meat and seafood, processors. It is difficult to arrive at a definitive account of the size of the processed foods sector in CARICOM due to the unavailability of accurate official statistics in some cases, and the lack of a uniform reporting structure across the region. Crude estimates using opinions of food distribution services leaders across the region identify around 15,000 small and medium firms. The fact that the majority (over 60 per cent) of these businesses are in Trinidad and Tobago, where there is natural gas availability and industrial electricity rates are 3.5 US cents per KWh, is somewhat responsible for the current state of low SWH penetration; nonetheless, there is opportunity for macroeconomic saving to be derived through reducing the use of “royalty gas” through the pre-heating of process water with low-temperature solar thermal technologies.

The regional food industry can be broadly categorised as consisting of two groupings: large and medium enterprises (LMEs) and small and micro enterprises (SMEs). LMEs are, in general, involved in the production of sugar, soft drinks, beer, rum, and a diversity of processed products, from the local raw material base, as well as from imported raw and semi-processed materials. There is much opportunity for integrating custom-engineered SWH designs into such companies. SMEs, on the other hand, produce a diversity of products of variable quality, primarily from the local raw material base. Many are cottage industries and may utilize “turn-key” thermosiphon solar water heating.
3.3. OPPORTUNITIES FOR MANUFACTURE, ASSEMBLY AND DISTRIBUTION OF SWH

"In concrete terms, if a domestically based business (whether locally owned or originating outside the region) is organised to produce articles of personal consumption (clothing, household appliances, consumer electronics, etc.) it must be connected to the global distribution chain as represented by retailers such as Wal-Mart and Target. This further implies that production must conform to the standards that are imposed by the global consumer system. This last point serves to reinforce the argument we made earlier that there is no 'Chinese Wall' between the local and the global market."


Solar water heating contributes to economic development in a number of ways and domestic solar water heaters for residential and commercial applications are among the simplest and most cost-effective renewable energy technologies. Without the need for highly capital-intensive manufacturing equipment, SWH systems are made in many developing nations, small and large alike. In contrast to wind and photovoltaics, SWH offers opportunity for immediate, substantial employment opportunities to local semi-skilled artisans, both in manufacturing and installation. As such, substantial job opportunities in manufacturing, retail sales, and business administration, as well as system design, installation, and maintenance can result from greater adoption of SWH technology.

Within CARICOM states, there are already three major manufacturers of SWH. All are Barbados-based and were borne out of the “Golden Period of SWH” within that country (1974 – 1983), when a mix of high global oil prices and deliberate government policies encouraged an industry that produced in excess of 1,000 SWH per annum for local use. Since, SWH production within Barbados has exceeded 2,000 per annum and the major manufacturers have looked to the rest of the Caribbean for supplemental markets. Currently, the supply-side of the SWH market is “mix” of regional products (from Barbados) and external imports (primarily from Israel, Greece and China) that are distributed by manufacturers and dedicated retailers within the respective territories. Though there is much debate surrounding the “quality” of the imports and the “price” of regional products, the promotion of SWH uptake may perhaps be best served by maintaining a good balance between imported systems and local manufacture.

A multitude of barriers impede the broader adoption of SWH systems in markets around the world. These generally include high up-front system costs compared to conventional alternatives, a lack of available financing for SWH businesses and consumers, a lack of awareness about the favourable lifecycle economics of SWH technology and a lack of quality control, which often undermines consumer confidence as people associate SWH with mediocre or low quality equipment. Development of the SWH market is a balanced process in which the increased demand must be matched by the availability of decent
quality products, and along with it an infrastructure of sufficiently trained installers. Consistency in market stimulation programs (whether they are the development of legislation, building codes, tax credits, subsidies or other) is essential to create a long-term basis for investment in these new activities. The identified steps in the supply chain are:

- Availability of hardware (collectors, tanks, and systems components like controls, pumps, etc.) through local manufacturing or imports;
- Distribution structure (wholesalers or warehousing and distribution network); and
- Trained installer and engineering base for SWH installation.

3.3.1. Supply Chain Development

The supply chain, which developed within the emerging CARICOM SWH market, started with a small group of suppliers (local manufacturers and importers), who were based mainly in Barbados and, to a lesser extent, Jamaica. These entities took responsibility for the whole supply chain, including products, distribution and installation work. Though the supply base has been expanding to meet the steady market-demand for SWH products and installation services, the model has essentially remained unchanged. Local retailers of imported products have emerged within a number of territories and continue to function throughout the entire supply chain. Though some regional manufacturers have taken steps towards delinking production from distribution and installation activities, their success have been somewhat limited.

Currently, there is around 220,000 m² (170 MWth) of installed solar thermal collector area within CARICOM member and associate member states. There is clear and present opportunity for six-fold expansion of the existing capacity to around 1.4 million m² (1,000 MWth) through implementation of a programmatic approach within a ten-year period. There is also significant capacity expansion within the global markets, including Latin America and the non-CARICOM Caribbean states.

With the increasing sales volume that is predicated, the market is perhaps best served by a gradual separation of the three elements within the supply chain and different actors would therefore take-on specific (defined) roles as suppliers, wholesalers or installers. At present, the wholesale activities (warehousing and logistics) remain in the hands of the suppliers. The typical character of the SWH systems (bulky and fragile because of the glass), may not be particularly liked by either wholesalers in the installation sector, who are used to pipes and fittings or by wholesalers in the building industry, who are used to brick, concrete, wood, etc. As a consequence, there is need to inform and train entrepreneurs on the business opportunities that are available once the market mechanisms have been clearly defined. Marketing and quality issues, and the related capacity building, need to be integrated into the supply chain development.
3.3.2. Capacity Building of Hardware Suppliers
In order to build the basic capacity either in manufacturing or at the level of importers in the respective countries, local interests should build up their expertise based on the technical knowledge of more experienced exporting companies, therein reducing the learning curve barrier. The experiences of Barbados and, to a lesser extent, Jamaica are useful in this regard.

Manufacturing will require some economies of scale; although there is no single rule available, it is generally believed that once a supplier can sell more than 5,000 m$^2$ per year (or 2,000 systems), it can be more economical to start local production or assembling. Nonetheless, many companies (including the Barbados manufacturers) start with smaller size turnover levels. For companies to become active in the supply or manufacturing of SWH, the barriers to get them started must be kept as low as possible. The Jamaican experience shows that complicated import procedures or high duties will frustrate the process and retard capacity building.

3.3.3. Capacity Building in the Distribution Structure
Apart from activating installation capacity, there are no specific unique elements, which would need to be addressed to cover this issue. Normally the physical distribution structure will follow normal patterns once the market size develops. The lack of craftsmen properly trained to install and maintain solar thermal systems can, however, become a key barrier to growth. This is particularly relevant for the main market segment of single-family houses, as installers can often act as the decision maker. If installers know solar thermal systems, they may motivate potential users to buy them. If they are not specifically trained, they may discourage consumers or even provide a poor installation, with a negative impact on the functionality of the system and on the image of the technology. Overcoming this barrier to growth requires proactive measures in partnership between the solar industry and public authorities. The market is currently still too small for the respective territories to build a dedicated network of installers and as a consequence, the industry has to rely on the craftsmen, usually plumbers and roof specialists, who work directly with suppliers.

One major problem is that most installers are reluctant to invest time and money to attend courses, which are of limited value to them as a result of the market not reaching a critical mass. As with the suppliers of the hardware, it is important to promote the development of installation companies and make them part of the overall capacity building process; this may include the creation of some form of incremental value for these installers through a label of recognition such as “Authorised Solar Installer”. Once this is done on a regional basis and is open to all installers, this approach can allow the participants to get the proper training programmes whilst setting the criteria for entry. Care must be taken however as
such a scheme has the potential to back-fired by creating a “chicken and egg” problem: if there are only few installers who qualify, potential investors may find it difficult to find and contact them. As such, a measure like this must be carefully examined in collaboration with industry experts, as it may not work well at the initial phase of market development. It is suggested that in the beginning solar thermal training should be strictly voluntary and the training should be subsidised in order to lower the barrier for the installers to attend these courses.

**Domestic market:** The availability of trained installers is crucial for market expansion. Regional initiative to provide a dedicated training programme for installers may be undertaken through the Continuing Vocational and Education Training (CVET)/ Caribbean Vocational Qualification (CVQ) Programme and may link to the CARICOM Single Market and Economy (CSME) Certification for Free Movement of Skill and Labour within the region.

**Commercial market:** The commercial market requires, apart from trained installers, knowledgeable solar engineers to make the proper solar designs for commercial applications. The installers in this segment are typically larger companies with experience in large air conditioning and heating installations; the typical solar installation skills for these larger systems are more in line with general large HVAC systems and will be adequately engineered and specified by the consulting engineer who is responsible for the project. The need for this segment therefore is the transfer of knowledge to mechanical engineers; the cadre of professionals required for same is relatively easy to identify within a given territory and dedicated training modules may be offered to them.

**3.3.4. Quality Control and Certification**

The issue of quality of products, systems and installation have had a “checkered” within the region. In Jamaica, locally manufactured products showed quality defects during the early stages of market development when there was increase in the volume of products produced and installed; the local manufacturing sector has since given way to imported products. On the other hand, Barbados managed to largely “avoid” the problem through an appropriate “mix” of local and imported parts and components. Though the regional market has largely remained self-regulated, product quality has been rather high on account of competition among suppliers within a limited market space. This is particularly noticeable in Barbados where manufacturers conducted voluntary testing through the Florida Solar Energy Centre (FSEC) in order to enhance consumer confidence in their product; the third-party quality certificate was deemed to be a critical marketing tool within a contracting marketing space that is shared by three major manufacturers.
In countries like China, Turkey and Nepal with a solid and stable market development, the establishment of quality criteria is considered as being important: (i) for **creation of a level playing field** internally; (ii) towards **limiting malfunctioning systems**; and (iii) for **stimulation of exports** from these countries based on internationally accepted standards. Regional markets will benefit similarly and CARICOM-based manufacturers will require similar quality certifications for entry into some export markets. The well-developed European Union (EU) product standards and Solar Keymark certification scheme can perhaps form the basis of an assessment towards (and may be utilized for) developing a CARICOM standard. This will require, however, that regional dynamics are also taken into account\(^3\) and that there is harmonization towards the development of a “common” standards and certification scheme. Also, the availability of testing facilities to national or regional standards bodies and the creation of links between these and the already well-established testing facilities in more advanced countries are necessary for the reducing the cost for regional suppliers to get the products and systems tested.

**Certification mechanism:** The certification mechanism must serve the purpose of guaranteeing the constant quality of the products supplied in the market, thus providing the basis for consumer confidence. Many certification schemes are dedicated for the hardware only. However, there is need for developing a certification schemes for installers as well and this can be addressed and further developed as part of the capacity building of the CVET.

The development of the certification scheme will normally imply a **procedure to guarantee the evaluation of conformity of the supplier** and will ensure that products surpass a set of defined minimum performance criteria. To avoid bureaucratic mechanisms, which could frustrate the supply-side of the market instead of stimulating it, the certification scheme must be pragmatic and affordable to avoid excessive cost in the system.

**3.3.5. Trade Associations**

In order to effectively build up the capacity in the supply chain as well as create a broad support from the industry for quality programs, an essential step is that the supply side will be organised in some sort of solar trade association.

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\(^3\) It needs to be recognized that some standards may be specifically developed for the European and other temperate climate zone and also for the sophisticated installation sector with such countries. For CARICOM countries both the climate conditions as well as the typical state of the art in the installation sector are different. Therefore, the standards cannot be duplicated exactly but will require a review of the various technical requirements of the standards to match the local climate and technical capabilities.
3.4. INDIVIDUAL COUNTRY ANALYSIS

CARICOM Member States

- Antigua and Barbuda
- The Bahamas
- Barbados
- Belize
- Dominica
- Grenada
- Guyana
- Jamaica
- St. Kitts and Nevis
- St. Lucia
- St. Vincent and The Grenadines
- Suriname
- Trinidad and Tobago

CARICOM Associate Member States

- Anguilla
- Bermuda
- British Virgin Islands
- Cayman Islands
- The Turks and Caicos Islands
3.3.1. Antigua and Barbuda

1. Energy Scenario
Antigua and Barbuda relies almost exclusively on fossil fuels for electricity generation transportation and cooking; there are no natural resources of fossil fuels in Antigua and Barbuda. Secondary fuels including gasoline, jet kerosene, gas, oil/diesel, heavy fuel oil (bunker fuel oil) and LPG, are also imported for local consumption. In 2010, the average generation cost before transmission was 0.204 USD/KWh (0.55 XCD/KWh), and the average electricity sales price across sectors was 0.326 USD KWh (0.88 XCD/KWh). Fuel surcharge was an additional 0.23 USD/KWh (0.621 XCD/KWh) and as a consequence, the average electricity price paid by the end-user was 0.556 USD/KWh (1.501 XCD/KWh). The largest single electricity consumers in Antigua during the period January 1 to December 31, 2010 were the commercial sector, including tourism, with some 101,463 MWh; the domestic sector with some 86,502 MWh; the governmental sector with about 20,860 MWh; followed by the industrial sector with about 6,104 MWh. In Barbuda, over the same period, the largest consumers were the domestic sector with some 1,385 MWh; the commercial sector with 355 MWh; and the governmental sector with about 186 MWh.

2. Renewable Energy Legislation and Planning
Currently, Antigua and Barbuda does not have the necessary policies or regulations in place to foster the development of the various renewable energy technologies, improve the efficiency of non-renewables or to foster the application of emerging technologies which have the potential to improve the energy sector. An enabling policy is required to accelerate the growth of renewable energy technologies. As a consequence, the government created an Energy Desk within the office of the Prime Minister and tasked the Desk with developing a National Energy Policy (NEP) – the second draft of the National Energy Policy
(NEP) was prepared with the assistance of the recently established National Energy Task Force (NETF). With respect to solar water heating, the Draft NEP indicates an intention by government to: “legislate the mandatory use of solar passive systems (conversion of solar radiation into thermal energy for utilization of hot water supply, air conditioning and industrial heat sources)”. It should be noted that warm water is not an essential requirement among households, with many having no DHW system at all. There is much applicability however, within the hotel sector.

The existing energy sector planning appears to be focusing only on the supply of electricity and the importation of petroleum fuels. Other areas such as the promotion of energy efficiency, conservation measures and renewable energy sources only receive attention on an ad hoc basis, and such efforts are generally spearheaded by non-governmental organizations such as the Environmental Awareness Group (EAG).

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Antigua and Barbuda, in general, do not offer tax exemptions on solar water heater purchase and the nominal sales tax of 15 per cent applies equally to all DHW technologies. Moreover, the general conditions to investors that are codified under the Fiscal Incentives Act include “waiver of all import duties and consumption tax on the importation of materials and equipment used in the operations of the company”. On the one-hand, this general rule may encourage supply-side investments in SWH such as manufacturing and assembly that utilizes imported raw material and components. It simultaneously however, creates a disincentive on the demand-side by generating tax credits for non-renewables resources such as the use of electric water heaters in the hotel industry. Incentives for targeting the utilization of renewable resources are being developed under the NEP; in particular, the NEP states that “Government will mandate and provide appropriate incentives for the installation of solar water heating systems in the tourism sector”.

There is no direct financing scheme or low-interest loan facility for solar water heater purchase in Antigua and Barbuda. Consequently, end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH.

4. Technology Suppliers and Installers
Solar water heating technology and services in Antigua and Barbuda are provided by 2 – 3 major retailers (including an agent of Solar Dynamics Limited); installation and maintenance services are provided by the retailers. In Antigua and Barbuda, SWH penetration is around 5 per cent (32 KWth per 1,000 inhabitants) and the DHW market is still dominated by electric heaters. There is potential for installing around 1,000 SWH units per annum over a 10-year period within residences and hotels, thereby increasing the penetration to around 45 per cent or 288 KWth per 1,000 inhabitants.
3.3.2. The Bahamas

1. Energy Scenario

Renewable energy sources and technologies represent a negligible contribution to the energy mix of The Bahamas. Two main players, Bahamas Electricity Corporation (BEC) and Grand Bahama Power Company (GBPC), supply virtually all the power needs for the islands. International oil companies supply the fossil-derived fuels and lubricants that are utilized in the electricity and transport sectors. A critical and important fact is that like most Small Island Developing States (SIDS), The Bahamas is almost completely dependent on oil for its energy needs but is not a producer of oil. The Bahamas uses some 26,000 barrels of imported petroleum, daily to meet energy needs. Imports of gasoline, diesel oil, and heavy fuel amounted to about 5.5 million barrels. This provided fuel for transportation and electricity generation; around 1.9 billion KWh of electricity per annum is provided to drive economic growth and provide modern energy services for the population. In mid-2008, global oil prices reached as high as around USD 150 per barrel; this translated into BEC having to add fuel surcharge to its tariffs. Currently, this charge adds around US 18 cents per kWh to its customers’ bills and the result is that electricity prices reached are high as US 45 cents per kWh. This has significantly affected the cost of producing goods and services for residents and the tourism industry alike.

2. Renewable Energy Legislation and Planning

Currently, The Bahamas does not have the necessary policies or regulations in place to foster the development of the various renewable energy technologies, improve the efficiency of non-renewables or to foster the application of emerging technologies which have the potential to improve the energy sector. In recognition of the need for an enabling policy to support the mainstreaming of sustainable energy activities, a preliminary National Energy Policy (NEP) has been drafted and a number of sustainable energy
initiatives are being developed that could significantly reshape the fossilised energy sector of The Bahamas, which is growing at 8 per cent a year.

The second draft of the National Energy Policy (2010) reports that: “government is committed to aggressively re-engineering legislative, regulatory and institutional frameworks, re-tooling human resources and implementing a diverse range of sustainable energy programmes”. The document goes further to outline a series of short-, medium- and long-term policies that target development of alternative energy sources, expanding financial opportunities in the energy sector, increasing energy efficiency and managing the demand for fossil fuels. The most immediate goals range from phasing out the use of incandescent light bulbs, building energy efficiency into low-cost housing and cutting energy use in public buildings, to generating electricity from a variety of renewable technologies, offering incentives for more fuel-efficient vehicles, and mandating the use of solar hot water systems.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The government is in the process of passing the requisite legislation to provide tax incentives for promoting fuel and energy efficiency in lighting, vehicles, and solar water heaters to reduce the average energy load in Bahamian homes. The Customs Import Duty Regulations (2011/2012) have been revised to include duty exemptions for a number of renewable energy and energy efficiency equipment, including: “solar water heater panels, tanks and all associated equipment”. The government does not have levers for enacting other tax incentives, such as the tax rebates used in Barbados, as there is no income tax, capital gains tax, purchase or sales tax, VAT or capital transfer tax within The Bahamas.

There is no direct financing scheme or low-interest loan facility for solar water heater purchase in The Bahamas. Consequently, end-users must either access traditional commercial loans in order to meet the up-front cost of SWH.

4. Technology Suppliers and Installers
Solar water heating technology and services in The Bahamas are provided by a number of major retailers (including an agent of Solar Dynamics Limited), as well as a number of off-shore manufacturing companies (located mainly in neighbouring Florida). Installation and maintenance services are, in most instances, provided by the retailers. Recent studies\(^4\) have estimated the solar water heating potential of The Bahamas at 200 GWh per annum; current energy production from SWH is around 25.1 GWh or 12 per cent of the overall potential. There is significant opportunity for replacing electric with solar water heaters.

3.3.3. Barbados

1. Energy Scenario
Barbados currently produces slightly more than 1,000 barrels of oil and 1.7 million cubic feet of natural gas per day; the oil is exported to Trinidad where it is refined and shipped back as refined product. Barbados relies on imported refined product to meet approximately 95 per cent of its power and transport fuel needs; domestic natural gas provides less than 5 per cent of total energy needs. Electricity demand in the domestic and commercial sectors has grown steadily since the 1970s. In recent years, electricity demand has grown at an average annual rate of more than 4 per cent. Currently, total annual electricity consumption is about 960 GWh or slightly less than 3,350 kWh per capita; this consumption is higher than other countries within the region with the exception of Trinidad and Tobago. Electric rates charged by the Barbados Light and Power Company (BL&P) include a base rate (31 US cents per KWh) and a fuel adjustment charge (16 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil. Currently, domestic consumers pay about 47 US cents or roughly (94 BDS cents) per KWh.

2. Renewable Energy Legislation and Planning
Some 36 years ago, the government of Barbados instituted a number of fiscal policies to support renewable energy initiatives. The Fiscal Incentive Act of 1974 grants import benefits and tax exemptions to solar water heater producers. Under the 1984 Income Tax Amendment, tax payers were allowed to directly and fully deduct solar water systems from their taxes. In addition, all electric water heaters were subject to 60 per cent consumption tax, which makes conventional water heaters financially unattractive. The consistency of successive government administrations in maintaining and strengthening these policies for SWH has been fingered as a critical element in the success of the Barbados Model.
Currently, renewable energy deployment in Barbados is guided by the National Energy Policy (NEP), with support from the Sustainable Development Policy. The NEP intends to broaden the scope of mainstream renewable technology use in Barbados from SWH to other technologies and include such issues as distributed generation of electricity and grid integration. The utility (BL&P) recently implemented a Renewable Energy Rider (RER), which is applicable to the integration of PV into the grid and remunerates customers a fee of 1.8 times the avoided fuel cost for energy supplied. The upper limit for this supply is set at 5 KW for residential and 50 KW for commercial customers and can provide significant boost towards usage PV/Thermal installations as an alternative to traditional SWH.

Many of the policies within the NEP are still not entrenched in law and, via the IDB-supported Sustainable Energy Framework for Barbados (SEFB), government is seeking to “execute the renewable and energy efficiency policies through the necessary legislation”. The policies have already received cabinet ratification.

Despite the significant progress, the SWH industry in Barbados (like elsewhere in CARICOM) suffers from a lack of utility planning. Electric utilities traditionally plan for generation capacity based on projected growth – typically on a 20 year-cycle; investment in additional capacity that is made by the utility to supply projected demand may turn out to be a stranded investment if demand side reduction isn't integrated into the supply side planning. Currently, BL&P is not involved in many demand side initiatives related to micro-generation and solar water heating.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The SWH programme in Barbados is perhaps the best known and successful of all renewable energy programmes in the Caribbean. The industry was boosted by the Fiscal Incentives Act (1974), which allowed the manufacturers to benefit from import preferences and tax holidays. Later, the introduction of the Homeowners Tax Benefit (1984), which allowed the homeowner to claim the cost of the solar water heater as an income tax rebate, increased SWH demand and this end-use incentive continue to boost the local industry. On the commercial side, the Barbados Income Tax Act (BITA) provides incentives for renewable including SWH use in businesses, such as hotels and guesthouses. For instance, BITA makes provision for businesses to be entitled to an annual allowance of 20 per cent of the capital expenditure incurred for the purpose of an energy audit and the retrofitting of a building or the installing of a system to reduce electricity use or to produce electricity from sources other than fossil fuels. This deduction is taken over a period of 5 years.

There is however, no state-run financing facility for SWH in Barbados. It is still widely believed that the initial costs for SWH are still too high, especially among low- to middle-
income households who do not qualify for significant income tax rebates, and this has acted to retard the rate of penetration growth. Most end-use financing have been commercial in nature and in the past, hire purchase arrangements were available through many appliance stores. Currently, the majority of the financial instruments for SWH are available through the commercial banks but market rate interests and collateral requirements make them unattractive to many potential end-users.

4. Technology Suppliers and Installers
Barbados is the leading provider of SWH within the regions and its three major manufacturers account for much of the installed capacity within CARICOM (See Chapter 5). With the Barbados market fast-approaching saturation, there is significant effort from manufacturers, with government backing, to replicate the Barbados Model in other CARICOM countries; Barbadian manufacturers would, in such a case, facilitate technology and knowledge transfer to avoid the learning curve barrier within the respective countries.

Currently, the Barbados market is supplied exclusively by local products. There are 3 major manufacturers – Solar Dynamics Limited, Sun Power Limited, and Solaris Global Energy (formerly AquaSol) Limited – who take responsibility for the whole supply chain, including product manufacturing, distribution and installation work. A number of small (cottage) manufacturers, who are typically ex-employees of the major manufactures, also operate within Barbados. There is very little diversification of products within the industry with companies characterized by an over-reliance on the SWH market though recently, some have begun to explore options in photovoltaic retail and installation.
1. Energy Scenario
Belize acquires its energy from four main sources, specifically, imported fossil fuels (66 per cent), biomass – traditional biomass and bagasse (26 per cent), hydro (3 per cent) and imported electricity (5 per cent); Belize currently imports 100 per cent of fossil fuels used. Although there is evidence of petroleum deposits, oil has, so far, not been discovered in commercial quantities.

Approximately 50 per cent of electricity produced in Belize is imported from Mexico. Of the remaining 50 per cent, Belize Electricity Limited (BEL) generates the majority from a mix of hydro- (25 per cent) and diesel- (20 per cent) and the private sugar companies generate the remainder from sugarcane bagasse (5 per cent). In 2010, total consumption was over 384 GWh – peak demand was just over 80 MW. The electricity consumption in Belize may be disaggregated as follows: 56 per cent for residential application; 31 per cent for commercial application; 8 per cent for street lights; and 5 per cent for industrial application. In 2010, the weighted average electricity rate to consumers was 23 US cents per KWh. As a part of its socioeconomic package, government created a “social tariff” as a part of their formal electricity pricing structure whereby profits from mid- and higher-end electricity consumers were used to cross-subsidise costs associated with the social tariff.

2. Renewable Energy Legislation and Planning
Energy consumption is rapidly increasing in Belize and to satisfy burgeoning demand, policymakers often choose the most expedient option or adapt traditional practices without an appreciation of the alternate choices or the long term cost-effectiveness of the selected options. The development of a renewable economy in Belize is being retarded by
the lack of an explicit national policy that encourages the use of renewables (where feasible) and the status quo continues to encourage the continued use of imported fossil fuels as the most expedient energy supply option for an oil poor nation.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Belize, in general, do not offer tax exemptions on solar water heater purchase. As is the case in many other CARICOM states, domestic hot water is not a priority in Belize households and focus on the application of renewable energy technologies have been largely centre on electricity-generation devices. Moreover, subsidies on electricity and LPG are an existing barrier to the deployment of SWH within the country; though there is limited hot water demand within the country, especially within the hotel sector, electric water heaters have been typically chosen in preference to SWH.

Also, there is no direct financing scheme or low-interest loan facility for solar water heater purchase in Belize and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH; higher purchase of Solar Dynamics SWH is available through Courts (Belize) Limited.

As a consequence of the foregoing, the installed SWH capacity in Belize is 6.3 KWth per 1,000 inhabitants and is well below the regional average of 48.9 KWth per 1,000 inhabitants (Figure 3.4).

4. Technology Suppliers and Installers
Solar water heating technology and services in Belize are provided by a limited number of retailers (including Courts Limited, who are a distribution agent for Solar Dynamics Limited). There is a lack of specialist installation technicians for SWH in Belize and this function is typically carried out by plumbers; properly installing a solar water heating system requires an installer with knowledge and experience in the plumbing, roofing, and electrical trades. Belize does not have sufficient human and institutional capacity to promote SWH. Additionally, some of the SWH projects undertaken in the past were of poor quality, due in part to unreliable components, as well as inappropriate design, improper installation and poor maintenance. Unarticulated or poor standards persist and many Belizeans purchase SWH equipment in Mexico without the requisite quality assurance or technical support.
3.3.5. Dominica

1. Energy Scenario
Dominica is known as "The Nature Island of the Caribbean" due to its abundant plant and animal life, extensive park system, volcanic peaks, lava craters, waterfalls, rivers, and lakes. The island has no indigenous sources of coal, oil and natural gas. Its power sector is therefore based on a mixture of imported fossil fuels and locally produced hydroelectric power; the imported petroleum products make Dominica susceptible to swings in the international oil market. Total energy production in 2010 was 80.9 GWh, of which 32.5 per cent was generated by hydropower and the remainder by diesel generators; the system peak demand was 17 MW. The electricity consumption in may be disaggregated as follows: 46 per cent for residential application; 49 per cent for commercial application (including 8 per cent for hotels, in particular); 2 per cent for street lights; and 3 per cent for industrial application. Electric rates charged by the Dominica Electricity Company (DOMLEC) include a base rate (33.7 US cents per KWh) and a fuel adjustment charge (10.7 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil. Currently, domestic consumers pay about 44.4 US cents per KWh; this is among the highest tariffs within the Eastern Caribbean.

Studies dating back to 1969 concluded that Dominica has excellent potential to generate geothermal power; it has been estimated that fully developed geothermal fields in Dominica could provide electric power generation of up to 300 MW. As a consequence, Dominica is part of a sub-regional geothermal energy project – a GEF-financed, OAS-coordinated sub-regional initiative encompassing also St. Lucia and St. Kitts & Nevis – for the purpose of analysing and developing the geothermal resources. The commercial development of geothermal electricity production is expected to reduce the base electricity rate from 33.7 to around 6 US cents per KWh.
2. Renewable Energy Legislation and Planning
Dominica currently has no national energy policy or law, or renewable energy policy or statement, although an integrated plan for development is currently in the works and will include energy aspects. The lack of an energy plan is viewed as a significant impediment to development of the country's renewable energy resources and energy efficiency programmes. The government is therefore formulating a National Energy Policy (NEP), as well as a revised Sustainable Energy Plan (SEP), with technical assistance provided by CARICOM, the Organisation of American States (OAS) and the German Technical Assistance (GTZ). Work on the NEP is currently in progress and is being done under the Global Sustainable Energy Islands Initiative (GSEII) and the Caribbean Sustainable Energy Programme (CSEP). A draft NEP was finalized in November 2009 and submitted to the Government for review; as part of this initiative, draft Geothermal Resources Development Bill and draft Environmental and Planning Regulations for Renewable Energy were produced.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The government is in the process of passing the requisite legislation to provide tax incentives for promoting renewable energy use and energy efficiency within Dominica. Examination of the Final Draft of NEP (2010) suggests that: “Consideration has been given to the incentives which will promote investment in renewable energy and energy efficiency system.”

The Government of Dominica has indicated a willingness to take the lead role in the creation of a dedicated renewable energy and energy efficiency fund. This fund will provide concessional financing for renewable energy projects, including SWH, and is expected to enhance the opportunities for renewable energy use.

4. Technology Suppliers and Installers
There is one company (a subsidiary of Solar Dynamics Limited) on the island manufacturing, selling and installing solar water heaters, but there has been no formal public awareness campaign or promotion of the technology. Nonetheless, the installed capacity within the island is 46.2 KWth per 1,000 inhabitants, which is slightly lower than the regional average (48.9 KWth). Given the high cost of electricity, and the significant load required for water heating, which show the cost-effectiveness and relatively quick return on investment required for solar water heating systems, the potential for its use is considerable. The short payback period – 9 to 10 months – makes the installation of SWH feasible despite the imminent development of geothermal heating, which will require significant infrastructural work before reaching commercial readiness. The implementation of low-interest government financing is expected to increase SWH end-use.
1. Energy Scenario
In 2010, 92 per cent of all gross supply allocated to the transportation, industrial, residential, and commercial sectors’ energy needs was primarily from imported oil products; biomass completed the other 8 per cent of that supply. This over-reliance on oil imports makes Grenada extremely vulnerable to global oil price shocks and as a consequence, Grenada has to spend as much as half its export revenues on imported fossil fuels.

Currently, total annual electricity consumption is about 177 GWh; all electricity produced is derived from thermal power. Electricity consumption in Grenada is dominated by the commercial sector, which accounted for 57 per cent of all electricity sold in 2010, followed by the domestic sector, which consumed 38 per cent. The balance is made up of industrial usage (3 per cent) and street lighting (2 per cent). Electric rates charged by the Grenada Electricity Services Limited (GRENLEC) include a base rate (35.1 US cents per KWh) and a fuel adjustment charge (18 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 53.1 US cents per KWh.

2. Renewable Energy Legislation and Planning
A Sustainable Energy Action Plan (SEP) was drafted in 2001, as part of the Global Sustainable Energy Islands Initiative (GSEII). The plan provides for a renewable energy promotion strategy, but was not been adopted by the government and, as a consequence, the measures it proposed have only been implemented in isolated cases, on an ad-hoc basis, or not all.
Since, government has been formulating a National Energy Policy (NEP), as well as a revised Sustainable Energy Plan (SEP), with technical assistance provided by CARICOM, the Organisation of American States (OAS) and the German Technical Assistance (GTZ). A draft NEP was finalized in December 2010 and submitted to the Government for review.

Though government does not yet have an official energy policy, it does offer an incentive to use renewable sources of energy; alternative energy products, including solar and wind energy systems, as well as energy efficiency technologies are exempted from the general consumption and other taxes.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The government is in the process of passing the requisite legislation to provide tax incentives for promoting renewable energy use within Grenada. The Draft NEP (2010) suggests that: “The Government of Grenada acknowledges the great indigenous renewable energy potential Grenada possesses and the need to properly assess the renewable energy resources development potential (including wind, solar, geothermal, and other future alternatives) to allow tailoring specific incentives and regulations to accelerate the introduction and deployment of renewable energy technologies (RETs).” The government has indicated a willingness to provide fiscal incentives (e.g. tax rebates, subsidies, feed-in tariffs, etc.) based on objective cost-benefit analysis to all sectors of the economy and society (considering equitable access to such) to encourage increased use of renewable energy and energy efficiency technology and systems, including SWH.

There is no direct financing scheme or low-interest loan facility for solar water heater purchase in Dominica and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH. The Grenada-Caribbean Solar Finance Programme (CSFP) has however been promoting private-sector financing for Solar Hot Water Systems in Grenada through a training program for lending officers, as well as pilot lending operations, within the commercial banking system.

4. Technology Suppliers and Installers
Solar energy is mainly used for water heaters in hospitals and residences. Solar water heating technology and services in Grenada are provided by a limited number of retailers. Regional manufacturers – Solar Dynamics Limited and Solar Dynamics (EC) Limited, operating out of neighbouring Barbados and St. Lucia respectively – have a significant presence within Grenada. This is believed to be partially responsible for the relatively high installed SWH capacity, viz. 85.5 KWth per 1,000 inhabitants.
1. Energy Scenario
Guyana is almost totally dependent on imported fossil fuel, the result of which is relatively high electricity costs. The electricity sector in Guyana is dominated by Guyana Power and Light Limited (GPL), the state-owned vertically integrated utility. Although the country has a large potential for hydroelectric and biofuel-based power generation, most of its 226 MW of installed capacity correspond to inefficient thermoelectric diesel-engine driven generators.

In 2010, total consumption was around 688 GWh; while the consumption of electricity has increased substantially in the past few years, the installed generation and distribution capacity has increased at a slower pace. Consequently, self-generation (mainly from small diesel generators) has played an important role in filling the gap between consumption and generation of electricity. It is estimated that the electricity grid in Guyana services only about 60 per cent of the population (the CARICOM average is 92 per cent) and electric rates charged by the GPL ranges from 26.8 US cents per KWh for domestic customers to 34.7 US cents per KWh for commercial consumers.

2. Renewable Energy Legislation and Planning
In Guyana, the government’s renewable energy and energy efficiency “policy position” is embedded within the Low Carbon Development Strategy (LCDS) which aims to convert the power sector to renewable energy sources by 2020; in this regard, emphasis has been on developing two major hydro-electric schemes. The “official” Energy Policy of Guyana (1994) is rather outdated but nonetheless advocates the replacement of imported petroleum, as far as possible, by indigenous renewable energy sources. More recently, the
System Development Plan prepared by GPL (2000), as well as its Development and Expansion Programme (2007-2011), reflect the official government position toward the utilizing Guyana’s renewable energy resources such as biomass and hydropower. Though programmes have provided over 11,000 households with stand-alone photovoltaic (PV) panels in the rural hinterland, solar water heating has been largely ignored due to the low priority of DHW within the country – only 1.7 per cent of households have access to water heating technology. Much of the growth within the SWH industry has been “private sector driven” and has is not officially supported through legislation nor included in energy planning.

Within Guyana, there is need for greater coordination and collaboration amongst stakeholders to allow for more cogent and cohesive planning, as well as better assessment of risks involved with the energy sector and revision of energy policy to make it more current and appropriate to the existing paradigm.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Guyana, in general, do not offer tax exemptions on solar water heater purchase. As is the case in many other CARICOM states, domestic hot water is not a priority in Guyanese households and government strategies focus on the application of renewable energy technologies for electricity-generation; the per capita GDP of Guyana is rather low (USD 7,200) and other energy-related appliances are more important than SWH. Even so, much of the fiscal applications for solar PV assistance have been project-oriented rather than programmatic.

Also, there is no direct financing scheme or low-interest loan facility for solar water heater purchase in Guyana and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH.

4. Technology Suppliers and Installers
There is one company on the island retailing (selling and installing) solar water heaters and there has been no formal public awareness campaign or promotion of the technology. The majority of SWH heaters in Guyana are imported from Barbados and mainly serve hotels and upper-income households. As a consequence of the high focus on solar-based distributed generation, especially within the remote hinterlands, there is significant opportunity for PV/Thermal “co-generation systems” that produce both electricity and domestic hot water.
1. Energy Scenario
Over the 10-year period 1998-2007, the consumption of electricity in Jamaica, measured by growth in residential and non-residential consumption (KWh/capita), grew by 11.0 and 7.0 per cent for residential and non-residential, respectively. Currently, annual electricity consumption (when the large self-generators such as the bauxite companies are included) is around 6,839 GWh; the peak demand was around 640 MW.

Electricity generation from renewable sources was 4.8 per cent of total electricity generated in 2010. Hydroelectric power accounted for the largest portion with 3.4 per cent of total electricity generation and has increased steadily since 2001; the remainder was generated from wind farms. In 2010, electricity generation consumed 6.7 million barrels of oil or 33.6 per cent of total petroleum consumption. Jamaica’s residential, commercial, and industrial electricity prices are among the highest in the region. This is partly because 95 per cent of the electricity generated uses expensive imported petroleum coupled with the inefficiency with which the fuel is converted to electricity. Jamaica’s dependence on petroleum resulted in erratic swings in the price of electricity, as seen over the last tariff period (2004-2009), when prices reached a record high of 38 US cents per KWh for household customers in July 2008. The current domestic electricity rate, charged by the Jamaica Public Service Company (JPS), is 31.3 US cents per KWh; other rates are 29.9 US cents per KWh for industrial customers and 35.5 US cents per KWh for commercial consumers.

2. Renewable Energy Legislation and Planning
Following the oil crisis of 1973, Jamaica adopted a programme of energy conservation and increased use of alternative energy. Since that time, energy conservation has been “promoted” in Jamaica as an official position of the GOJ. In 1995, the first “formal” energy
policy was approved by Cabinet and focused mainly on the structure and organisation in the electricity sector, while “encouraging” energy conservation and efficiency (ECE) measures, including electricity supply and demand side management. In 2004, the Government started a new energy policy approach, this time focusing on the opening of the electricity generation market, on fuel diversification and renewable energies, as well as on energy efficiency.


3. Fiscal Incentives and Financing Instruments for Solar Water Heaters

The Jamaican government reduced the import duty on SWH from 30 per cent to 5 per cent and zero-rated the government consumption tax on renewable energy equipment, including SWH. Despite significant private sector interest, no concessions are, however, available to SWH manufacturers and many of the parts and components required for SWH manufacturing and assembly continue to attract duties and tax. Also, there are no clear incentives targeted at attracting local manufacturing and assembly.

With respect to end-use financing, special financing arrangements were made available to SWH purchasers under a World Bank funded Demand Side Management (DSM) project. The success of this programme has since influenced other financing programmes for renewable energy and energy efficiency technology, including SWH, purchase and installation.

The National Housing Trust (NHT) offer SWH loans of up to USD 3,000 for “qualified contributors”. This Homeowner’s Loan is offered at an interest rate of 3 per cent per annum (over a maximum period of 5 years) and is intended to cover system purchase and installation costs. Also, an Energy Fund was set up in May 2008 as a means for financing large projects for sustainable energy. The Fund targeted primarily: (i) commercial and industrial energy users; (ii) energy service companies (ESCos); and (iii) manufacturers of energy efficiency equipment and devices. The loans are being retailed by approved financial institutions (AFIs) at an annual interest rate of 12.5 per cent, with oversight provided by the Development Bank of Jamaica (DBJ).
Jamaica has the third-highest installed SWH capacity (17.5 MWth) within the region; only Barbados (90 MWth) and St. Lucia (18 MWth) are higher. The penetration of SWH in Jamaica, however, is fairly low with the per capita installed capacity (6.1 KWth per 1,000 inhabitants) falling well below the regional average (48.9 KWth). It is believed that this is partially because the funding facilities have not done enough to attract interest due to insufficient awareness among homeowners on the economic benefits to be derived from SWH, as well as the fact that many individuals are either unable or unwilling to meet the collateral requirements. Taken into context, the NHT Homeowners Loan for SWH has been accessed by less than 1,500 Jamaicans over a five-year period.

4. Technology Suppliers and Installers
The Jamaican experience in Solar Water Heating has been somewhat “checkered” and has certainly not been as prolific as the Barbados experience. Though SWH manufacturing and assembly began as early as the 1970s, there are currently no manufacturers within the country. Solar water heating is supplied through a mix of Israeli, European, Asian and Barbados technology that is distributed and installed by local retailers. There is much scope for a return to SWH manufacturing and assembly in Jamaica, which is the largest potential market within the region. On the engineering design side, Jamaica has had a distinguished history in engineering custom SWH solutions for the hotel sector. Analysis of the short-term energy policies and actions taken by the Jamaican government in the last years however reveals that most of the initiatives and investment have been expected from the private sector, given some government guidelines and, in some cases, financial incentives. Several of these expectations, however, did not materialize and there is perhaps need for government to play a more pro-active role in facilitating the SWH market expansion; the “market will deliver” philosophy is wishful thinking.

In 2010, SWH covered only about 1 per cent of the domestic market (private houses); the total number of solar water heaters was estimated to be around 7,800, mainly in the form of small-scale passive thermosiphon systems with integrated water storage tanks directly attached to and above the glazed flat-plate collector; only a few large scale applications are active systems using a collector circulation pump and a remote storage tank. Potentials for solar water heating exist in particular in medium- and high-income households and in the tourism sector. The hotel industry alone provides for about 14,000 rooms with 30,000 beds across the island and has an occupancy rate of well above 50 per cent, indicating that there is a hot water need throughout most of the year. In this specific case solar water heating has to compete against LPG, since this is the common energy source for hot water generation in hotels. Other niche market potentials can be found in the industrial sector, mainly in food-processing, and for sporting facilities. Also, market research shows that about 45,000 residential customers of JPSCo currently spend about one third of their electricity bills for hot water generation.
1. Energy Scenario

In St. Kitts and Nevis, electricity is produced entirely by diesel-fueled generators. This places the twin-island state in a vulnerable position as the islands are fully dependent on imported fossil fuel for electricity generation and transportation. St. Kitts and Nevis is a net energy importer; the country has no indigenous sources of oil, coal, natural gas or hydropower. Secondary liquid fuels including natural gas liquids, gasoline, and jet fuel are imported for local consumption. Oil imports are about 1,000 barrels a day. Significant geothermal potential is available within Nevis however and the feasibility of commercial development is being examined.

Two utilities on either island, St. Kitts Electricity Department (SKED) in St. Kitts and Nevis Electricity Company (NEVLEC) in Nevis, manage the production, transmission, and distribution of electricity. The installed capacity at SKED amounts to 28.5 MW, using diesel gen-sets, with a peak demand of 25.3 MW and a base load of about 16 MW. The utility has, since late 2009, been dealing with a shortage of capacity and relies on rented diesel generator sets with an accumulated capacity of 7.5 MW. The installed capacity of NEVLEC is 13.2 MW. Though total capacity of St. Kitts and Nevis is 41.7 MW, the system is not interconnected and each island must independently meet its own demand. Currently, total annual electricity consumption is about 121 GWh; all electricity produced is derived from thermal power. Average rates charged by the electric utilities include a base rate (33.9 US cents per KWh) and a fuel adjustment charge (11 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 44.9 US cents per KWh.
2. Renewable Energy Legislation and Planning
St. Kitts and Nevis currently has no national energy policy or law, but government is formulating a National Energy Policy (NEP) with technical assistance provided by CARICOM, the Organisation of American States (OAS) and the German Technical Assistance (GTZ). Work on the NEP is currently in progress and is being done under the Global Sustainable Energy Islands Initiative (GSEII) and the Caribbean Sustainable Energy Programme (CSEP). A draft National Energy Policy and Action Plan was finalized in February 2010 and submitted to the Government for review; as part of this initiative, draft Nevis Geothermal Resources Development Ordinance (2008) was produced. Much of the energy planning within St. Kitts and Nevis is being based on development of the geothermal resources, which would make the twin-island nation energy-independent and the first non-fossil economy within CARICOM.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The Ministry of Energy, of Commerce and the Chamber of Commerce is in the process of developing an incentive scheme to attract local and foreign investments in renewable energies. The discussions so far have looked at, inter alia, tax exemption for investments in renewable energy projects, removing import duties, soft-loan programmes for residential applications as solar hot water systems and solar PV home systems. As a means of attracting private financing schemes from commercial institutions, such as banks and credit units, the government is proposing to reinsure the loans with financing from multilateral bodies and the central bank.

Currently however, there is no direct financing scheme or low-interest loan facility for solar water heater purchase in St. Kitts and Nevis and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH.

4. Technology Suppliers and Installers
Government have called for increased uptake of solar water heating in households and public buildings in an effort to improve energy efficiency. This will hopefully be supported by the adoption of policy that will provide the requisite incentives to drive market expansion. Currently, there is one main SWH retailer within St. Kitts and Nevis selling systems that are imported from Barbados. Most of the installations have been in middle- to high- income residences and, despite its potential, there has been very limited application in the hotel sector. The installed solar thermal capacity in St. Kitts and Nevis is 1.4 MWth – this is more than the 1.1 MW of wind installation. The per capita installation is 29.1 KWth per 1,000 inhabitants and is less than the regional average (48.9 KWth). Like many other CARICOM states, electric water heaters are more common than SWH due to the cheaper purchase and installation cost.
1. Energy Scenario

St. Lucia is a net importer of fossil-based energy, with the power and transport sectors relying exclusively on imported oil-derivates. Consequently, all economic sectors have been affected by increasing oil prices in recent times, which has had negative impacts on the country’s balance of trade. The effects of energy supply interruptions and oil price shocks on economic performance are therefore of major concern to successive governments. St. Lucia is involved in the Eastern Caribbean Geothermal Development Project (Geo-Caraibes), funded by the Organization of American States (OAS), as it seeks to examine the potential of its geothermal resources toward electricity generation – if successful, this would reduce its oil-dependence.

Currently, total annual electricity consumption is about 310 GWh; all electricity produced is derived from thermal power. Electricity consumption in St. Lucia is dominated by the residential and hotel sectors, which together accounted for 67 per cent of all electricity sold in 2010; each account for just over 33 per cent respectively. Electric rates charged by the St. Lucia Electricity Company Limited (LUCELEC) include a base rate (25.2 US cents per KWh) and a fuel adjustment charge (3.7 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 28.9 US cents per KWh.

2. Renewable Energy Legislation and Planning

In 2001, the Cabinet of Ministers approved a Sustainable Energy Plan, by Cabinet Conclusion No. 695. One of the goals identified by the Plan was to enhance the security of energy supply and use for all sectors of the economy; successful implementation of the Plan
has been impeded however by the absence of an appropriate regulatory and policy framework. Government is formulating a National Energy Policy (NEP) with technical assistance provided by CARICOM, the OAS and the German Technical Assistance (GTZ). Work on the NEP is currently in progress and is being done under the Global Sustainable Energy Islands Initiative (GSEII) and the Caribbean Sustainable Energy Programme (CSEP). A draft National Energy Policy and Action Plan was finalized in January 2010 and submitted to the Government for review.

The Draft NEP asserts that: “Solar water heaters (SWH) have a large economic potential; therefore current fiscal incentives for the purchase of SWH will be maintained and promotion activities will be established to encourage their use. The use of electrical water heaters for any purpose will not be exempted from regular taxation. The use of SWH for new large consumers of hot water such as tourist resorts will be made mandatory through appropriate legislation, except for such cases where hot water is provided by co-generation plants.” Through the NEP, the Government of St. Lucia is seeking to utilize a mix of regulation and incentives (push and pull factors) to promote the local SWH market. Also, the Government is intending to promote the use of other renewable energy technologies in buildings, including photovoltaic and solar cooling, which also provide opportunities for integrated systems such as PV/Thermal that provides electricity and hot water.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The Government of St. Lucia has supported its sustainable energy rhetoric with tangible policies. So far, incentives which are aimed at attracting end-users have been implemented. In May 1999, the Government passed Cabinet Conclusion No. 464, thereby removing all import duties and consumption taxes on renewable energy equipment and materials (including SWH and components thereof. Further, in April 2001, the purchase of solar water heaters was made tax-deductible.

Solar water heating holds much scope for use in both the domestic and hotel sectors; currently thermosiphon SWH, which are applicable for domestic use in households, guesthouses and small hotels, costs in the range of USD 1,500 – 2,600. There is some financial support for purchasing, such as hire purchase schemes and financing through banks and credit unions. Moreover, the government has instituted concessions for SWH, which allows first time purchasers to claim up to USD 2,400 (XCD 6,500) on their income tax returns. The result of these support mechanisms is that St. Lucia has the second-highest per capita installed capacity of 111.4 KWth per 1,000 inhabitants, which is more than double the CARICOM average (48.9 KWth).
4. Technology Suppliers and Installers

Government support for SWH in St. Lucia extends beyond the end-use; incentives on the supply-side have attracted Barbados SWH manufacturers, Solar Dynamics Limited. A local manufacturing company, Solar Dynamics (EC) Limited, was formed through a partnership between Solar Dynamics Limited and local companies Minvielle and Chastenet Limited. The company currently manufactures as much as 1,000 units per annum, which are distributed and installed in St. Lucia and other Eastern Caribbean countries. Recent growth in the number of technicians entering the field also shows that there is scope for expansion of the sector locally. Importantly, this partnership stands as the most successful case of technology and knowledge transfer within the CARICOM SWH industry.
3.3.11. St. Vincent and the Grenadines

1. Energy Scenario
Like most other CARICOM SIDS, St. Vincent and the Grenadines (SVG) is heavily dependent on imported petroleum products for electricity generation, transportation, cooking, and other energy requirements. The country has no indigenous sources of oil, coal and natural gas but has an “energy mix” of more than 96 per cent petroleum-based fuels and around 3 per cent hydropower; energy imports are about 1,600 barrels of oil equivalents per day. In 2010, the state-owned utility St. Vincent Electricity Services Limited (VINLEC) had almost 49 MW of installed capacity, of which 40.5 MW are operated on the main island of St. Vincent alone; 11.5 per cent of the installed capacity is from small hydropower stations in St. Vincent. As hydro power is not available at full scale on a year-round basis, some diesel plants work only as back-up systems; consequently, the firm capacity is therefore only around 40 MW. Geothermal power offers the potential to supply all of the base load electricity demand on mainland St. Vincent and, through interconnections, to the Grenadine islands and to other neighbouring islands. Although the Government has undertaken a number of preliminary investigations of geothermal resources in St. Vincent over the last 15 years, the actual potential is yet to be proven by drilling.

Residential and commercial sectors, including the government, are the largest consumers of electricity; there are few industrial activities on the island, and consumption for street lighting is minimal. Nonetheless, electricity demand has been increasing and consumption went from 74.6 GWh in 1998 to 122.9 GWh in 2008 – a 70 per cent increase in 10 years. Currently, total annual electricity consumption is about 122.7 GWh, the slight dip resulting from the contraction in the economy on account of the recent global recessions.
Electricity consumption in St. Vincent and the Grenadines is dominated by the commercial sector and residential sectors, which accounted for 48 per cent and 45 per cent of all electricity sold in 2010, respectively. The balance is made up of industrial usage (5 per cent) and street lighting (2 per cent). Electric rates charged by VINLEC include a base rate (30.8 US cents per KWh) and a fuel adjustment charge (12.4 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 43.2 US cents per KWh.

2. Renewable Energy Legislation and Planning
In 2008, an Energy Unit was established in the Prime Minister's Office with a mandate to assist with the formulation and implementation of energy policy issues, particularly in the areas of renewable energy and energy efficiency. In 2009, a National Energy Policy (NEP) was approved by the Cabinet. The guiding principles upon which this policy was prepared include: “strengthening of the national economy by reducing the dependence on import of fossil fuels; stabilizing and possibly reducing the energy consumption per capita in the medium and long term; and reducing the dependence on imported energy through continued and expanded exploitation of indigenous resources and improvement of energy efficiency and/or conservation of energy use.”

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Renewable energy, including SWH, technologies generally show relatively high up-front investment costs, but require far lower operation and maintenance costs than conventional technologies. Therefore, to overcome the obstacle of high initial costs and stimulate the market the government as indicated, through the Draft NEP, a willingness to: “provide financial (grants or soft-loans) or fiscal (tax credits, reduction or exemption from duty taxes and consumption taxes etc.) incentives.” Currently, electric water heaters are taxed with 100 per cent excise tax and 15 per cent Value Added Tax (VAT), while SWH are fully exempted from excise tax and VAT. The Ministry of Energy has also indicated, through the Draft NEP, the intent to initiate a programme to be managed by VINLEC for improvement in demand side management (DSM) by: “offering low- or no-cost services for energy audits to major electricity consumers.” It is envisioned that VINLEC will function as a utility-based ESCO and consequently, offer, whenever this is feasible, low-interest loans for the purchase of energy efficient devices, or pre-payment schemes for the purchase of such goods as solar water heaters, where credits are repaid through the cost savings on the electricity bill.

4. Technology Suppliers and Installers
The use of solar water heaters is not widespread. The systems are imported from Barbados and are commonly found in large, upscale residential buildings. Regional manufacturers – Solar Dynamics Limited and Solar Dynamics (EC) Limited, operating out of neighbouring Barbados and St. Lucia respectively – have a significant presence within St. Vincent.
1. Energy Scenario

Suriname produces crude oil, which is used in refineries to produce a range of petroleum products. With the domestic oil production unable to meet demand, petroleum products still have to be imported. No natural gas or coal is produced or imported. Electricity, primarily for industry, is supplied by the 189 MW hydroelectric power station at Afobaka, south of Brokopondo. The plant, which was built by Alcoa, is owned and operated by the Suriname Aluminum Company (SURALCO). Suriname’s energy sector and bauxite industry are closely linked; Suralco also owns and operates a 47 MW oil-fired turbine plant.

Presently, the energy supply system of Suriname consists of more than 70 per cent fossil fuels. The fossil fuels are mainly consumed by the main electricity supplier, Energie Bedrijven of Suriname (EBS), as well as the transport sector. The total installed electricity generating capacity in Suriname was 389 MW in 2010 (51.4 per cent was from fossil fuels and 48.6 per cent from hydropower) and total annual consumption is about 1,440 GWh. Electric rates charged by EBS are highly subsidized and among the lowest in the Caribbean; domestic consumers pay about 5.5 US cents per KWh and only Trinidad and Tobago (4.5 US cents) is lower.

2. Renewable Energy Legislation and Planning

Though Suriname has significant renewable potential, there is no national energy policy or law, or renewable energy policy or statement. The lack of an energy plan has been a significant impediment to development of the country’s renewable energy resources and energy efficiency programmes. Energy planning is Suriname is primarily done by EBS and the technologies management tools utilized typically include investments, planning and
scenario building. Further, insufficient financial resources in the face of growing demand, has exacerbated the electricity power supply issue and investments usually target electricity generation and grid-reliability; SWH is not considered to be an important supply-side technology. There is also need for greater coordination and collaboration amongst stakeholders to allow for more cogent and cohesive planning, to include better assessment of risks and variability of the energy sector.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Suriname, in general, do not offer tax exemptions on solar water heater purchase. As is the case in many other CARICOM states, domestic hot water is not a priority in Suriname households and government strategies focus on the application of renewable energy technologies for electricity-generation in remote villages; the per capita GDP of Suriname is rather low (USD 9,700) and other energy-related appliances are more important than SWH. Moreover, the subsidize cost of electricity acts as a disincentive to SWH end-use.

Also, there is no direct financing scheme or low-interest loan facility for solar water heater purchase in Suriname and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH.

4. Technology Suppliers and Installers
The use of solar water heaters is not widespread. The systems are imported from St. Lucia and are commonly found in large, upscale residential buildings. Regional manufacturers – Solar Dynamics (EC) Limited, have a significant presence within Suriname and distribute, as well as install, the majority of SWH in that country. There is also a limited amount of Dutch SWH technology installed, especially for hot water production in small hotels.

A recent policy of the government is to supply all households with electricity, including the new households in the public housing program of Suriname. This requires an expansion of the generation capacity in the very short term, and also expansion of the transmission and distribution network. It is likely that many new households may demand energy services, such as hot water, and individuals may opt to use electric water heaters due to the relatively low investment cost (when compared with SWH), as well as the affordability of electricity cost. Though, at present, Suriname has the lowest per capita installation of SWH, viz. 1.37 KWth per 1,000 inhabitants, a proliferation of new households may provide the “perfect opportunity” for development of a thriving SWH market in Suriname.
1. Energy Scenario
Trinidad and Tobago is unique among Caribbean nations in that it is the leading producer of crude oil and natural gas in the region and its economy is significantly dependent upon these resources for revenue and foreign exchange; during the “oil-price spike” of 2008, the oil and gas industry contributed 57 per cent of government’s revenue or 21 per cent of GDP. The country is the world’s largest exporter of methanol and ammonia and the seventh largest exporter of liquefied natural gas (LNG). There is also a significant manufacturing industry built around the energy sector such that the country is among the leading suppliers of manufactured goods, such as food and beverages, cement, etc. to the region.

Trinidad and Tobago’s energy balance shows complete dependence on crude oil and natural gas – there is insignificant renewable energy use. Crude oil is typically exported or processed into liquid fuels at the refinery while natural gas is used as fuel and feedstock in the manufacture of petrochemicals for export or for direct export as LNG. Domestically, natural gas is the primary fuel for electricity generation. As a result of its favourable energy balance, Trinidad and Tobago has the enviable position of having the second lowest electricity rates (around 4 – 6 US cents per KWh) in the LAC region and by far, the lowest in the Caribbean. This has however served as a significant barrier towards adaptation of renewable energy and energy efficiency activities as there is seeming complacent dependence on the existing hydrocarbon economy.

The installed electricity capacity in Trinidad and Tobago is around 1,691 MW. Currently, total annual electricity consumption is about 7,562 GWh, which is the highest of all
CARICOM member and associate member states. Disaggregation of the electricity use by sector shows that heavy industry accounts for the largest share (38 per cent), followed by residential (28 per cent) and light industry (23 per cent). Electricity demand continues to grow as it is an essential commodity that is “heavily correlated” with socio-economic growth and development. The electricity rate charged by the Trinidad and Tobago Electricity Commission (T&TEC) is the lowest in the Caribbean – 4.5 US cents per KWh for domestic customers.

2. Renewable Energy Legislation and Planning
Trinidad and Tobago bases its economic growth on its large natural gas reserves and relies exclusively on its hydrocarbon economy to create a competitive electricity and gas market in the region. Consequently, the twin-island republic currently has no national energy policy or law, or renewable energy policy or statement. The lack of an energy plan is viewed as a significant impediment to development of the country’s renewable energy resources and energy efficiency programmes.

The Government of Trinidad and Tobago has become conscious of the need to engage in a “lessened hydrocarbon-based economic development model” and has strongly committed to clean energy solutions including energy efficiency and renewable energy. In 2009, the Cabinet launched a Renewable Energy Committee (REC) to develop a Framework for Development of a Renewable Energy Policy that will support the development of renewable energy sources in the twin-island republic. Though a number of draft framework documents have been produced, a National Energy Policy (NEP) has still not been drafted. As a consequence, energy planning is based on the oil, gas and petrochemical sectors and do not consider renewables. A Draft Energy Vision 2020 Report was thin on renewable energy technologies and energy conservation, only: “recognising that national institutions were not yet prepared to dedicate the time and resources needed for engaging these challenging issues, given the high importance of oil and natural gas production to the national economy.”

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Trinidad and Tobago, in general, do not offer tax exemptions on solar water heater purchase and duties, as well as the nominal sales tax of 15 per cent, applies equally to all DHW technologies. In 2010, The Annual Budget outlined incentives such as duty and VAT free imports of solar water heating equipment and tax allowance of 25 per cent on solar water heating equipment valued at USD 1,500 for households. To date, the implementation of these stated policies have been rather slow and has consequently, not influenced the market in any way.
Also, there is currently no direct financing scheme or low-interest loan facility for solar water heater purchase in Trinidad and Tobago and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH.

There is however, scope for project-financing for SWH under the Green Fund; this facility has “unfortunately” been limited to NGOs, government agencies and community organizations. Nonetheless, the fact that the Government of Trinidad and Tobago, through the Housing Development Corporation (HDC), develops and owns significant portion of the housing stock provides immediate opportunity for project-based financing under the facility. This project-based approach is required as the low price of electricity is a significant barrier towards solar water heating uptake under the “traditional” market arrangements.

4. Technology Suppliers and Installers
The use of solar water heaters is not widespread in Trinidad and Tobago. The systems are mostly imported from Barbados and are commonly found in large, upscale residential buildings. Regional manufacturers – Solar Dynamics Limited and Solaris Energy Limited – have recently established a significant presence within the twin-island republic. In fact, Solaris Energy Limited is a joint-venture partnership between Mora Ven Holdings Limited (MVH), a Trinidad and Tobago-based oil company, and Barbadian AquaSol Limited; MVH has 60 per cent shares in the partnership.

Given the significance of the Trinidad and Tobago manufacturing sector to CARICOM states, as well as the advantage of low energy costs and highly-skilled workforce, it is anticipated that the twin-island republic may become a major player in the supply-side of a regional SWH market. Trinidad and Tobago has abundant potential for the utilization of solar thermal energy for residential and industrial purposes, especially for preheating within the food processing industry. Given the widespread availability of cheap natural gas, SWH will continue to be the more expensive option for industrial heating. It is likely therefore that the more immediate market uptake will be within the residential sector and Trinidad and Tobago will not become a major player in the demand-side.
3.3.14. Anguilla

1. Energy Scenario
Anguilla currently depends on imported fossil fuels for electricity generation and the transportation sector. A significant aspect of fossil fuel use is price volatility, which makes economic planning difficult. The ramifications for small island nations such as Anguilla are serious. In the face of escalating oil prices and increasing competition to access a limited supply in the region, Anguilla has little bargaining power relative to larger island nations.

Currently, total annual electricity consumption is about 79 GWh; all electricity produced is derived from thermal power. Electric rates charged by the Anguilla Electricity Company Limited (ANGLEC) include a base rate (3.57 US cents per KWh) and a fuel adjustment charge (10 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 45.7 US cents per KWh.

2. Renewable Energy Legislation and Planning
In 2006, a group of public and private sector individuals got together and formed the Anguilla National Energy Committee. With support from the government and the electric utility (ANGLEC), the committee went on to draft a “National Energy Policy for Anguilla”. The draft was finalized and adopted by cabinet in 2008. Among the main goals of the NEP are: “the development of policies, legislation, regulations, standards and incentives that promote energy efficiency, foster the use of renewable energy resources, and facilitate the transition to and adoption of renewable energy technologies”, as well as: “the integration of sustainable energy strategies into national sustainable development planning and programming.”
Thereafter, the Anguilla Renewable Energy Office (AREO) was formed; the mission of AREO was to fast-track implementation of the NEP through what has been termed The Anguilla Model. The initial goals of the Model are, inter alia: (i) to seek energy efficiencies opportunities nationwide; and (ii) to establish substantial renewable energy production on Anguilla within the shortest possible timeframe, with early deployment beginning within one year. This first phase deployment will focus on solar-, wind-, and waste-to-energy technologies.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Anguilla is a British overseas territory in the Caribbean and derives much of its income from the financial sector. Like many other tax havens in the Caribbean region, Anguilla is truly a tax-neutral jurisdiction; there are no income, capital gains, estate, profit or other forms of direct taxation on either individuals or corporations, whether resident in Anguilla or not. As a consequence, tax incentives are not available as a government lever for attracting SWH end-use and market expansion. There is however scope for reducing the cost of SWH technology through the removal of Customs Tariffs, in order to encourage the importation of the products.

Also, there is no direct financing scheme or low-interest loan facility for solar water heater purchase and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH. On account of the potential market size of approximately 4,000 households and 600 hotel rooms, there is scope for a manageable all-island SWH installation drive that is financed through a mix of multilateral grant/loans and carbon financing.

4. Technology Suppliers and Installers
Anguilla has a number of companies that install solar PV and solar thermal, including SWH, systems. On account of its size, the potential SWH market in-country is small and the available capacity is adequate to meet consumer demand. Anguilla does not produce SWH and most of the units in the country are imported from North America and, to a lesser extent, Barbados. Under The Anguilla Model, there is much interest in micro-generation from PV systems and government is currently examining Net-Metering and Net-Billing issues with the electric utility (ANGLEC). The NEP stated government’s desire to “create a legislative framework for customer-generated renewable power” and an appropriate mechanism that leads to the proliferation of solar PV within Anguilla would provide an excellent opportunity for solar cogeneration through utilization of PV/Thermal systems for electricity and hot water in the residential and hotel sectors.
1. Energy Scenario
Like most other CARICOM SIDS, Bermuda is heavily dependent on imported petroleum products for electricity generation, transportation, cooking, and other energy requirements. The country has no indigenous sources of oil, coal and natural gas but has an “energy mix” that is completely based on petroleum fuels, inter alia, diesel and heavy fuel oils. Energy imports are about 4,900 barrels of oil equivalents per day. In 2010, the state-owned utility Bermuda Electric Light Company (BELCO) had around 180 MW of installed capacity. Currently, total annual electricity consumption is approximately 630 GWh; all electricity produced is derived from thermal power. Electric rates charged by the BELCO include a base rate (59.2 US cents per KWh) and a fuel adjustment charge (13.5 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 72.7 US cents per KWh. This is the highest tariff within CARICOM member and associate member states.

2. Renewable Energy Legislation and Planning
Faced with the challenges of rising global oil prices and an economy that is characterized by complete dependence on imported oil, the Bermuda Government, in 2008 established the Department of Energy in to direct the country strategy for reducing fossil fuel dependency, thereby enabling energy security and encouraging greenhouse gas emissions reductions. In 2009, the Department drafted a National Energy Policy for Bermuda; the Energy Green Paper (2009). After twelve months of public consultations and cabinet considerations, the policy was adopted by government as the National Energy Policy for Bermuda; the Energy White Paper (2011). This was Bermuda’s first energy policy and is
intended to “guide the small-island community to use energy in an increasingly sustainable manner.” The NEP is driven by the government’s commitment to “reducing emissions to less than 1 metric tonne of CO\textsubscript{2} equivalent per capita by 2050” as part of its small but exemplary contribution towards global climate change mitigation efforts. Currently, Bermuda’s per capita emission is 14.44 metric tonnes per capita, which is more than twice the worldwide average, and is the only country within the CARICOM member and associate member states to adopt direct GHG emission cuts as part of its sustainable energy strategy.

As part of the on-going development of legislation to promote a “low carbon economy”, the Bermuda government has signalled an intention to: “Establish a legal framework to specifically outline how landlords bill their tenants for energy consumption”, which will have significance toward reducing the split-incentive barrier. Also, (i) Micro-financing for investments in small-scale renewable energy and energy efficiency; and (ii) Customs tariff incentives for energy efficient and renewable energy technologies, have been legislated as part of its ambitious and aggressive programme.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
In 2009, the Bermuda Government introduced various changes to the Customs Tariff to encourage the importation of products that produce or use energy in a more sustainable manner. To encourage the uptake of renewable energy technologies, the duty was removed entirely for complete solar water heating systems, as well as wind and solar photovoltaic electric generating sets. The Government continued this theme into 2010 by removing the duty for ocean swell powered electric generating sets, inverters for solar photovoltaic systems and most replacement parts of solar hot water systems.

In addition, the Solar Water Heater Rebate Initiative (SWRI) was launched in September 2010 to provide a rebate of up to USD 1,500 for residents who have SWH systems installed on their properties. The purpose of the SWRI was to complement the Solar Photovoltaic Rebate Initiative (SPRI) and to encourage industry diversification into solar hot water systems; The (SPRI) was launched in September 2009 to provide a rebate of USD1 per installed Watt up to a maximum of USD 5,000 for residents who have solar PV generating systems installed on their properties. The latter incentive (SPRI) is applicable toward the purchase of PV/Thermal systems.

4. Technology Suppliers and Installers
There are around thirty SWH companies in Bermuda but only around have since registered to participate in the SWRI. Many are small retailers who import North American and EU technology for installation and there is scope for direct involvement by some regional manufacturers and installers. Bermuda has a high domestic hot water demand (86.3 per cent), most of which is currently satisfied by electric water heaters (Figure 3.7).
3.3.16. British Virgin Islands

1. Energy Scenario
The British Virgin Islands is heavily reliant on imported fossil fuels and utilizes imported petroleum products for electricity generation, transportation, cooking, and other energy requirements. The country has no indigenous sources of oil, coal and natural gas but has an electricity sector that is completely based on diesel.

In 2010, the state-owned utility, BVI Electricity Corporation (BVIEC), provides all of the island’s electricity and had around 44 MW of installed capacity; peak demand was approximately 32 MW. Currently, total annual electricity consumption is around 42 GWh; all electricity produced is derived from thermal power. Electric rates charged by the BVIEC include a base rate (23.4 US cents per KWh) and a fuel adjustment charge (14.8 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 38.2 US cents per KWh.

2. Renewable Energy Legislation and Planning
Though The British Virgin Islands have significant renewable potential, there is no national energy policy or law, or renewable energy policy or statement. The lack of an energy plan has been a significant impediment to development of the country’s renewable energy resources and energy efficiency programmes. Like many SIDS, The British Virgin Islands is facing several challenges in the energy sector that may impede the future development and success of the Islands’ economy and society.
Existing electricity legislation prevents the implementation of alternative energy sources from contributing to the main power supply in areas served by BVIEC. Also, import duties and a lack of tax incentives contribute to making alternative energy technologies expensive. Although efforts have been made by civil society to begin the process of drafting a National Energy Policy (NEP) for the British Virgin Islands, the government has *neither acknowledged nor endorsed* initiatives toward same. Meanwhile, the status of renewable energy development within the islands remains retarded and allowable technologies, such as Solar Water Heating, continue to rely on the will of private interests.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The British Virgin Islands is a British overseas territory in the Caribbean and derives much of its income from the financial sector. Like many other tax havens in the Caribbean region, The British Virgin Islands is truly a tax-neutral jurisdiction; there are no income, capital gains, estate, profit or other forms of direct taxation on either individuals or corporations, whether resident in the territory or not. As a consequence, tax incentives are not available as a government lever for attracting SWH end-use and market expansion. There is however scope for reducing the cost of SWH technology through the removal of Customs Tariffs, in order to encourage the importation of the products.

Also, there is no direct financing scheme or low-interest loan facility for solar water heater purchase and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH.

4. Technology Suppliers and Installers
The British Virgin Islands have very few companies that retail and install solar PV and solar thermal, including SWH, systems. Domestic hot water demand in The British Virgin Islands is rather moderate when compared to other CARICOM associate member states; only around 15 per cent of all households have water heaters installed. The penetration of SWH is also low (10.6 KWth per 1,000 inhabitants); hot water is not a priority in BVI households.

The use of solar water heaters is not widespread. The systems are imported from North America, as well as Barbados, and are commonly found in large, upscale residential buildings. There is opportunity for utilization in the hotel sector where hot water is mostly provided by conventional (electric and LPG) heaters. This will require capacity support from countries, such as Barbados and Jamaica.
3.3.17. Cayman Islands

1. Energy Scenario
Like most other CARICOM SIDS, The Cayman Islands is heavily dependent on imported petroleum products for electricity generation, transportation, cooking, and other energy requirements. The country has no indigenous sources of oil, coal and natural gas but has an electricity sector that is completely based on petroleum fuels, *inter alia*, diesel and heavy fuel oils. In 2010, the state-owned utility Cayman Utilities Company (CUC) had around 137 MW of installed capacity. Currently, total annual electricity consumption is approximately 537 GWh; all electricity produced is derived from thermal power. Electric rates charged by the CUC include a base rate (41.4 US cents per KWh) and a fuel adjustment charge (22.8 US cents per KWh) that varies monthly and is indexed to the world price of Brent Sea crude oil; consequently, domestic consumers pay about 64.2 US cents per KWh, which is among the highest electricity tariff within the region.

2. Renewable Energy Legislation and Planning
Though The Cayman Islands have significant renewable potential, there is no national energy policy or law, or renewable energy policy or statement. The lack of an energy plan has been a significant impediment to development of the country’s renewable energy resources and energy efficiency programmes. Like many SIDS, The Cayman Islands is facing several challenges in the energy sector that may impede the future development and success of the Islands’ economy and society. Accordingly, under the auspices of the Ministry of District Administration, Works, Land and Agriculture (DAWLA), the government appointed a National Energy Policy Committee (NEPC) in June 2010, tasked with developing a National Energy Policy (NEP). A final document outlining a
comprehensive approach to energy policy development is expected to be submitted by the NEPC to Cabinet within the first quarter of 2012.

It has been recommended that the NEP should underpin government policies on economic development, transportation, resource management, climate change, and research and development; it must also support wider government objectives for sustainable development and economic transformation for The Cayman Islands.

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
Cayman, like Anguilla and the British Virgin Islands, is a British overseas territory in the Caribbean and also derives much of its income from the financial sector. Like the other tax havens in the Caribbean region, Cayman is a tax-neutral jurisdiction; there are no income, capital gains, estate, profit or other forms of direct taxation on either individuals or corporations. As a consequence, tax incentives are not available as a government lever for attracting SWH end-use and market expansion. There is however scope for reducing the cost of SWH technology through the removal of Customs Tariffs, in order to encourage the importation of the products. Much is expected under the anticipated NEP.

Though there is no direct financing scheme or low-interest loan facility for solar water heater purchase in the Cayman Islands, end-users are mostly capable to either pay up-front or access traditional commercial loans in order to meet the investment cost of same.

4. Technology Suppliers and Installers
The Cayman Islands have a number of companies that retail and install solar PV and solar thermal, including SWH, systems. Domestic hot water demand in The Cayman Islands is rather high; nearly 90 per cent of all households have water heaters installed. Despite the obvious opportunities, electric water heating dominates the landscape (Figure 3.7) and SWH penetration is like the rest of the region, relatively low (43.8 KWth per 1,000 inhabitants).

There is significant opportunity within the residential sector for the replacement of around 12,000 electric water heaters with solar technology. On account of its size, the potential SWH market in-country is significant and the available capacity within the country is not adequate to facilitate market expansion. The country does not produce SWH and most of the units are imported from North America and Europe.
1. Energy Scenario
The Turks and Caicos Islands currently depend on imported fossil fuels for electricity generation and the transportation sector. A significant aspect of fossil fuel use is price volatility, which makes economic planning difficult. The country has no indigenous sources of oil, coal and natural gas but has an “energy mix” that is completely based on petroleum fuels. In 2010, The Turks and Caicos Island had a total electricity generation capacity (all diesel-powered) of 56.7 MW; peak demand in that year reached 29.6 MW. Total electricity consumption over a five-year period grew steadily at an average 11.5 per cent per year, from 85 GWh in 2004 to 161 GWh in 2010. Current consumption is estimated at around 173 GWh. The electric rate, charged by the main electric utility company – Provo Power Company (PPC), is around 44 US cents for domestic consumers and 50 US cents per KWh for commercial and industrial interests.

2. Renewable Energy Legislation and Planning
Though The Turks and Caicos Islands have significant renewable potential, there is no national energy policy or law, or renewable energy policy or statement. The lack of an energy plan has been a significant impediment to development of the country's renewable energy resources and energy efficiency programmes. A recent strategic analysis of the country's energy sector recommended the development of a National Energy Policy (NEP) and suggested that the Policy “should create a framework where market participants have the incentive and ability to develop renewable energy and energy efficiency projects that benefit the country, regardless of technology.” It is anticipated that SWH will be supported in the policy, which is currently being developed.
Meanwhile, energy planning in The Turks and Caicos Islands is primarily done by PPC and the technologies management tools that are utilized include investments, planning and scenario building. Further, an excess in generation capacity causes the electric utility to favours the *expansion of electricity-use* over *electricity-reduction* mechanisms so as to avoid being left with a “stranded investment”; peak demand (29.6 MW) is just over 50 per cent of the installed capacity (56.7 MW).

3. Fiscal Incentives and Financing Instruments for Solar Water Heaters
The Government of the Turks and Caicos Islands adopted a new Customs Tariff Order in 2010. The order imposes a standard 30 per cent duty on most imports and also establishes exemptions to promote sustainable energy equipment and technologies, such as Photovoltaic and Solar Water Heating systems. The duty for clothes dryers, electric water heaters, and electric heating resistors has been increased from 30 to 40 per cent; this is expected to act as a disincentive to traditional energy appliances and technologies, including electric water heaters. It is too early to determine whether these recent provisions are effective to increase the uptake of Solar Water Heaters in the islands.

Like many other CARICOM states, there is no direct financing scheme or low-interest loan facility for solar water heater purchase and end-users must either pay up-front or access traditional commercial loans in order to meet the investment cost of SWH.

4. Technology Suppliers and Installers
The use of solar water heaters is not widespread. The systems are predominantly imported from North America or Asia and are commonly found in large, upscale residential buildings. Almost no water heating is done with solar energy in either the commercial (hotel) or industrial sectors – electric boilers are predominant, with limited LPG is used. The Turks and Caicos Islands has a high DHW demand (93.1 per cent), most (81.1 per cent) of which is currently satisfied by conventional water heaters (Figure 3.7).

The Turks and Caicos Islands have a number of companies that retail and install solar PV and solar thermal, including SWH, systems. Though the available capacity with is adequate to meet current consumer demand, any serious market expansion will require additional capacity. The country does not produce SWH and most of the units are imported from North America and Asia. Recent surveys⁵ revealed some degree of skepticism towards solar water heaters; this negative reputation is a consequence of sub-standard units that were being distributed and installed over the past ten years. As a consequence, further market expansion within the Turks and Caicos Island will require a careful mix of public awareness programmes and quality control procedures.

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⁵ Castilla. Conservation Policy and Implementation Strategy for the Turks and Caicos Islands. *February 2011*
| ATG | BHS | BRB | BLZ | DMA | GRD | GUY | JAM | KNA | LCA | VCT | SUR | TTO | AIA | BMU | BVI | CYM | TCA |
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Country name abbreviations are based on the International Organization for Standards (ISO) 3-alpha code for member states.
4. CURRENT STATE OF SWH TECHNOLOGIES

The sun is a continuous fusion reactor in which hydrogen is turned into helium and consequently, generates sunlight (solar energy that radiates outwards in all directions). Solar thermal technologies are concerned with trapping sunlight as heat. Because of the low energy density of sunlight, the required end-use temperature determines the complexity and cost of the applicable technology; the higher the required temperature, the more complicated and expensive the system will be.

Depending on the range of temperature use, solar thermal applications are divided into the three broad categories. These are, *inter alia*:

a. **Low-temperature applications** that are below 100°C (212°F), such as solar cooking, solar drying and solar water heating;
b. **Medium-temperature applications** that are between 100°C – 150°C (212 °F – 302°F), such as solar refrigeration and solar space cooling; and
c. **High-temperature applications** that are above 150°C (302 °F), such as electricity generation through Concentrating Solar Power (CSP) plants.

This report focusses on low-temperature (below 212 °F) applications, which have the potential to provide swimming pool heating, domestic hot water and industrial water pre-heating services (See Figure 4.1 below). For these *low-temperature* applications, the standard products that can be used are Solar Water Heaters. Some of the applications under investigation are:

- **Hot water for bathing application** in households, hospitals, hotels, guesthouses and other commercial establishments – solar water heating systems based on *flat plate solar collector* technology and *evacuated tube collectors* are used for bathing applications;
- **Hot water for washing application** such as: (i) the washing of clothes in commercial laundromats; (ii) laundry services and sanitization of toilets in hospitals, hotels and guesthouses; and (iii) the washing of kitchen utensils in hotels, hospitals and factory canteens;
- **Hot water for cooking application** in households, hospitals, hotels, guesthouses and factory canteens; and
- **Pre-heated hot water feed to steam generation boiler** in various industries as part of their energy efficiency programmes.
Figure 4.1: Low-temperature (below 212 °F) Solar Thermal Applications and Technologies
Source: Consultant generated. 2011

Swimming Pool
70 – 100 °F

Absorber
(Plastics)

Domestic Hot Water
100 – 140 °F

Flat Plate Collector

Insulated Backing

Storage Collector

Industrial Applications
140 – 200 °F

Vacuum Collector

Vacuum Tube Collector

Direct Flow Tube
with reflector
without reflector

Heat-pipe
Dry connection
Solar water heating is a tried and tested technology that has been used for more than a century. Small-scale solar water heaters are ubiquitous in countries such as Israel and Barbados, and are being installed by the millions in China. Solar water heaters use captured solar thermal energy to heat water in a storage tank. SWH systems may be direct (uses water from the main) or indirect (uses a working fluid), active (electric pump) or passive (thermosiphon). SWH systems can be backed up with a grid-tied electric water heater.

Hinged on the rapid global expansion in solar water heating demand, the technology has recently expanded to include a range of vacuum insulated collectors (in both flat-plate and tubular form), solar boosted heat pumps and a range of concepts to reduce the cost and improve product performance of pumped circulation systems. The most common forms of solar water heaters are integrated solar pre-heaters and stand-alone thermosiphon systems.

4.1. DOMESTIC SOLAR WATER HEATER DESIGNS

The solar domestic hot water system consists of three main components: a solar collector panel, a storage tank, and a circulation system to transfer the heat from the collector panel to the storage tank. Solar DHW systems for households range in size, because of differences in hot water demands and climate conditions. The majority of domestic solar water heaters use thermosiphon circulation of water between the solar collectors and the storage tank. This requires the storage tank to be mounted above the collector to produce thermally driven circulation between the collector and the tank. The advantage of these systems is that they do not require an electrical connection and have very low maintenance.

4.1.1. Thermosiphon (Passive) Solar Water Heating Systems

The principle of the thermosiphon system is that cold water has a higher specific density than warm water, and so being heavier will sink. Therefore, the collector is always mounted below the water storage tank, so that cold water from the tank reaches the collector via a descending water pipe. If the collector heats up the water, the water rises again and reaches the tank through an ascending water pipe at the upper end of the collector (See Figure 4.2 below). The cycle of tank-water pipe-collector ensures the water is heated up until it achieves an equilibrium temperature. The end-user can then make use of the hot water from the top of the tank, with any water used being replaced by cold water at the bottom. The collector then heats up the cold water again.

Due to higher temperature differences at higher solar irradiances, warm water rises faster than it does at lower irradiances. Therefore, the circulation of water adapts itself almost perfectly to the level of solar irradiance. A thermosiphon system's storage tank must be
positioned well above the collector, otherwise the cycle can run backwards during the night and all the water will cool down. Furthermore, the cycle does not work properly at very small height differences. In regions with high solar irradiation, such as the Caribbean, storage tanks are usually installed on the roof as in Figure 4.3 below.

Figure 4.2: Operation of a thermosiphon (passive) SWH system

Figure 4.3: Flat plate thermosiphon solar water heater on a residence in Kingston, Jamaica
Source: Alternative Power Sources Limited
Thermosiphon systems operate very economically as domestic water heating systems, and the principle is simple, needing neither a pump nor a control. However, thermosiphon systems are not suitable for large commercial systems, *inter alia* those with more than 10 m² of collector surface. It is usually therefore the system of choice for most domestic, as well as small commercial SWH systems.

### 4.1.2. Active Solar Water Heating Systems

Alternately, some households use “pump-circulated” systems in which the storage tank is ground or floor mounted and is below the level of the collectors; in these *active systems*, a circulating pump (electric or solar powered) moves water or heat transfer fluid between the tank and the collectors (Figure 4.4). Active systems may utilize controllers (usually two temperature sensors) that monitor the temperatures in the solar collector and the storage tank. If the collector temperature is above the tank temperature by a critical value (usually between 5°C and 10°C), the control starts the pump, which moves the heat transfer fluid in the solar cycle; if the temperature difference decreases below a second threshold, the control switches off the pump again.

*Figure 4.4: House with “pump circulated” system*
4.2. SOLAR COLLECTORS

At the heart of a solar thermal system is the solar collector. It absorbs solar radiation, converts it into heat, and transfers useful heat to the solar system. There are a number of different design concepts for collectors: besides simple absorbers used for swimming pool heating, more sophisticated systems have also been developed for higher temperatures, such as flat-plate collectors, evacuated flat-plate collectors and evacuated-tube collectors.

4.2.1. Flat Plate Collectors

The majority of solar collectors that are sold in many countries are of the flat-plate variety. The main components of these are a transparent front cover, collector housing and an absorber. The absorber, inside the flat-plate collector housing, converts sunlight to heat and transfers it to water in the absorber tubes. As the collector can reach “stagnation temperatures“ of up to 200°C (when no water flows through), all the materials used must be able to resist such heat and the absorber is usually made of metal materials such as copper, aluminium and more recently, titanium.

Commercial collector housings are usually made of a non-corrosive metal – typically aluminium - and a glass front cover that must be sealed so that heat does not escape and dirt, insects or humidity do not get into the collector itself. The cover is typically transparent and allows the sun’s rays to pass through to the absorber and conversely prevents some of the rays from escaping out of the collector once they have entered; this condition is referred to as glazing. Many collectors also have controlled ventilation, so as to avoid condensation inside the glass front cover. The collector housing is highly insulated at the back and sides, keeping heat losses low (See Figure 4.5 below).

Figure 4.5: Flat plate collector
The important parts of a typical flat-plate solar collector are the “black” solar energy-absorbing surface, which is the means for transferring the absorbed energy to the circulating fluid. The heat transfer fluid (HTF) for the absorber may be the hot water from the tank – open system – but more recently, (at least, in active systems) a separate loop of fluid is utilized to deliver heat to the tank through a heat exchanger (commonly a coil of copper tubing within the tank) in what is referred to as a closed system. The closed system, though more expensive than the open system, has the advantage of negligible maintenance as the open system is prone to “pipe fouling” – the precipitation and accumulation of salts (typically carbonates and sulphates of calcium and magnesium) on the inner walls of the circulation pipes. This is especially prevalent in the limestone regions of the Caribbean, such as Jamaica and The Bahamas.

4.2.2. Evacuated tubular (Vacuum tube) collectors

Evacuated tube collectors consist of parallel rows of evacuated glass tubes (Figure 4.6a). There are two main types of evacuated tubes in commercial use; heat pipe and direct flow collectors. An evacuated tube collector consists of an evacuated glass tube with a (copper) heat pipe inside (See Figure 4.6b), which contains a temperature-sensitive medium such as methanol. The sun heats up and vaporizes this heat pipe fluid, and the vapour then rises to the condenser and heat exchanger at the end of the pipe. There, the vapour condenses, and transfers heat to the heat carrier of the solar cycle, typically water. The condensed fluid flows back to the bottom of the heat pipe where the sun begins heating it up again. To work properly, the pipes must have a minimum angle of inclination, in order for the vapour to rise and the fluid to flow back.

Figure 4.6: (a) Evacuated tubular collector; and (b) Heat pipe scheme
Extensive development of evacuated (vacuum) tubes has led to the introduction of a range of evacuated tubular collectors and evacuated integral water heaters. Vacuum insulated collectors range from the “widely adopted” flooded Dewar-tube collectors in China to the “high performance” vacuum insulated collectors in Japan. Collectors incorporating pressure tubing inside all-glass evacuated tubes are also in wide use. Overheating of solar water heaters in summer is a problem in many parts of the world, particularly with pressurized water tanks attached to evacuated tubular solar collectors, due to the high efficiency of evacuated tubes at temperatures above 100 °C; robust storage is therefore important for evacuated tube systems.

A significantly higher energy gain can be obtained with evacuated tube collectors than flat-plate collectors; Figure 4.7 shows the relative thermal efficiencies of a variety of solar collectors. Thus, evacuated tube collectors provide higher efficiencies and as a consequence, are capable of providing consistently higher temperatures than flat plate collectors. Also, a solar system using evacuated tube collectors requires a smaller collector area than one using standard flat-plate collectors. On the other hand, the specific collector price for evacuated-tube collectors is higher than that for flat-plate systems and the former are therefore typically favoured for low-temperature commercial and industrial applications; flat-plate collectors continue to dominate the residential market as they are believed to provide the best cost/performance ratio for domestic hot water production.

*Figure 4.7: Relative efficiencies of solar water heating collectors*
4.3. STORAGE TANKS

To compensate for periods when the solar gain is too low to produce water of the required temperature, storage tanks are designed larger than for the conventional (electric or gas-fired) systems. In many instances also, tanks include an auxiliary energy source (electric heating element), which acts as a back-up heater when the water temperature falls below the desired temperature (usually 120 - 140 °F).

Sizing of residential solar water heating systems is generally easy: the rule of thumb is **20 gallons per person** for the first two people and 15 gallons for each additional person in the household. Commercial systems however require professional engineering design and sizing; the hot water load of the facility must be determined as the application may be different from those for residential hot water. Manufacturing processes, commercial laundries, hotel kitchens and restaurants will require higher temperatures and consequently there is need to customize the appropriate sizing to ensure the best economics for the system and the end-use requirement.

4.4. SOLAR WATER HEATERS FOR THE HEALTH AND HOTEL SECTORS

Solar water heaters can be used effectively in several commercial applications (especially hotels), as well as in hospitals, clinics and old age homes where hot water demands are high. Though the desired temperature is typically similar as that for households, these two markets require a very different approach in the design and implementation plans. For starters, there is a much higher demand in health and hotel facilities than in residential buildings but “smart engineering design” may serve to optimize the advantage of an increased roof area and these buildings typically allows for more collectors to be installed. Depending on size and end-use requirement, the system design ranges from a serial arrangement of individual thermosiphon systems in smaller facilities to a collection of roof-mounted collectors with central storage in larger facilities.

Most usually, the dominant design in hospitals and hotels are flat-plate solar collectors mounted on the roof of buildings so as to provide a large percentage of the hot water required. Such systems are usually active (uses controllers and pumps) and are integrated into back-up sources such as electricity or gas; see Figure 4.8 below. Solar water heating systems are ideal appliances for hospitals, hotels and guesthouses as the load demand frequently complements the peak operation of the solar system.
Figure 4.8: Solar Water Heating installation at St. Anns Bay Hospital, Jamaica
Source: Alternative Power Sources Limited
4.5. INDUSTRIAL WATER HEATING APPLICATIONS

Solar thermal systems do not only provide heat and hot water for direct use but also for pre-heated water to boilers that generate steam. Factories use hot water or steam to prepare processed foods, clean equipment, facilitate chemical reactions, and for many other purposes. Solar water heaters are not suited to replace boilers and other high temperature water apparatus in industry. However they can be used for preheating purposes, so that at a large percentage of the heating operation draws on solar, rather than carbon-based, energy.

Like the commercial case, industrial buildings are also likely to have more flat roofs than residential buildings, increasing the share of rooftops that could host solar collectors. In addition, the higher-efficiency heat collectors often used for industrial solar heating applications (vacuum tubes) can be installed in large numbers and coupled with mirrors to enhance their effectiveness (See Figure 4.9). These measures can reduce the cost per square foot of these high-efficiency collectors to 50 per cent or more below the average cost of residential units. Unlike the case of domestic (and some commercial) applications, industrial SWH systems are not ubiquitous features that are readily available as “off the shelf” solutions. Because of the peculiarities thereof, industrial applications typically require “customized engineered” SWH systems.

**Figure 4.9: Heat pipe energy transfer from parabolic trough concentrating collectors**

The process heat that is typically required for industrial application is between 100 and 400 °C. Solar water heating applications can provide water heating services for helping to meet the requirements of most industries and is typically most efficient for process that require water at temperatures of 250 °C or less (medium heat). Consequently, solar water heating is extremely useful for certain key industries – food processing, textile and paper manufacturing – as more than 60 per cent of the required process heat is below 250 °C.
4.6. DISTRICT WATER HEATING

A district heating system is one in which steam or hot water from a central plant is piped to residential and commercial buildings in a city, neighbourhood, industrial park or college/university campus. In other words, instead of each individual building having its own, all the buildings receive hot water from one central system. The provision of hot water from these systems requires use of a central collector area and have been realised in countries such as Denmark, Germany, and Sweden. In these systems, rooftop solar collectors heat water, which is then piped to a central storage tank. The storage tank is typically designed with thick concrete walls and buried underground so that it can retain heat for use in times of day (and night) when the sun is not shining.

Figure 4.10: A solar district heating system
4.7. INTEGRATED SOLAR WATER HEATING SYSTEMS

Integrated SWH systems combine two solar technologies into one integrated energy management system. Within the context of the Caribbean, the two most applicable solutions are: (i) **Solar cogeneration or PV/Thermal** – electricity and hot water; and (ii) **Solar cooling** – air conditioning and hot water.

4.7.1. Solar Cogeneration

A solar cogeneration system produces both hot water and electricity. It combines the high-efficiency water heating technology with photovoltaics to create a total energy solution with a payback period that is substantially less than a typical PV installation. In this system, the heat is drawn off the back of the PV modules and is ducted to the nearest roof-top air handler where it is channelled into a heat exchanger to pre-heat water for hot water service (See Figures 4.11 and 4.12).

The solar cogeneration or PV/Thermal (PV/T) hybrid system boosts the overall system efficiency to over 50 per cent - compare with 10 to 15 per cent efficiency for the PV module alone. This is because the PV modules are cooled as the “waste heat” is removed and used for other energy services such as domestic water heating or industrial water pre-heating and the system is estimated to generate 200 to 300 per cent more energy (in the form of heat and electricity) than a standalone PV system for approximately 25 per cent more cost. This combination of the two solar technologies in one footprint offsets both heating and electricity costs, and addresses two of the main energy requirements in the building sector.

*Figure 4.11: Rooftop PV/Thermal application*

*Source: Conserval Engineering Inc.*
4.7.2. Solar Cooling

All refrigerators and air conditioners cool by evaporating a refrigerant, a process that absorbs heat. It is no surprise therefore that solar water heating can help to cool buildings. Absorption chillers use heat energy – which can be provided by hot water from a solar water heating system – to drive an evaporation/condensation cycle that produces chilled water. Fans then blow across pipes containing the chilled water to provide refrigerated air. Commercial solar cooling systems are not very common but nonetheless, represent a useful way to maximize the benefits of solar water heating. Though solar cooling is currently still one of the less well-known technologies, the idea is in fact very simple: In areas (or periods) when there is an increased demand for cooling because of the solar radiation that occurs, the energy is captured and used to drive a thermal refrigerating machine provides the necessary cooling (See Figure 4.13).

This technology can be used in any building type to operate the cooling circuits and therefore to provide air conditioned rooms. The “cooling capacity” is usually available if solar energy is available and likewise, the “cooling demand” of a building is approximately equivalent to the solar radiation. Consequently, the match between the plants performance profile and the consumption profile allows for an extremely efficient energy supply system without the need for a large store. Hot water is invariably produced as a by-product of this process and can be used as part of the building hot water supply in an integrated system that produces air conditioning and hot water services.
Figure 4.13: Simplified diagram of a solar cooling system

1 Collector Plates  2 Heat Exchanger  3 Buffer Store
4 Back-up Heating System  5 Refrigerating Machine  6 Cooling Towers

4.8. NON-SOLAR WATER HEATING TECHNOLOGIES

For the vast majority of homes, hot water comes from one appliance: the large tank hot water heater. It runs on a constant cycle to ensure that hot water is ready for when we need it. This section examines the conventional tank, tankless and geothermal water heating systems.

4.8.1. Conventional Tank Water Heaters
The large tank hot water tanks typically hold around 50 gallons. In electric versions heating elements are suspended in the tank. The heat produced from the electric elements is transferred directly to the water in the tank. A gas version works similarly, but by heating the water from below with a gas burner (Figure 4.14 below).

The temperature of the water inside the tank is usually regulated and, through blending with cold water, the desired end-use temperatures can be reached. The biggest drawback to this type of hot water heater is that it must constantly monitor the temperature of the water and run a cycle to ensure that the temperature is always at the desired setting. This is a rather inefficient means to heat water, especially at times when it is not in use, and is costly in countries where electricity and LPG prices are high.
4.8.2. Tankless Water Heaters

The tankless hot water heater system (Figure 4.15) solves many of the problems that are inherent in the conventional tank hot water heater. The concept is that as the demand for hot water is created (by turning on the faucet, etc.), the unit will immediately begin *heating the water as required*. These units do not have to store 50 gallons of heated water to meet the demands of a household, and the removal of this tank-size limit causes the supply of hot water to be virtually endless.

Figure 4.15: Diagram of an electric demand (tankless) water heater system
Source: Engineering.com Technology Review. February 2012
4.8.3. Geothermal Water Heaters

While geothermal systems are typically used for HVAC applications, many manufacturers also have options to provide heated domestic hot water through the system. The temperature in the earth is a constant once you reach a certain depth. In a geothermal hot water system, this heat is absorbed into a coolant that is often under extreme pressure. The combination of the heat absorption and increased pressure can produce enough heat to handle both the cooling requirements of a house, as well as most hot water demands. Though this technology provides a free source of consistent energy, installation is typically rather expensive.

Figure 4.16: Geothermal water heating system
Source: Engineering.com Technology Review. February 2012
5. BARBADOS CASE STUDY

5.1. COUNTRY DETAILS

Barbados, the most easterly of the islands of the Lesser Antilles, is a small island developing state of area 431 km\(^2\) (it is 34 kilometres in length and as much as 23 kilometres in width), located in the Caribbean at 13° 4’ north latitude and 59° 37’ west longitude. It is bordered by the Caribbean Sea on the west coast and the Atlantic Ocean on the east, with a coastline of 97 km, and an exclusive economic zone of about 167,000 km\(^2\). On a clear, sunny day during the dry season, Barbados receives an equivalent of around 3 billion KWh in solar radiation, which translates to almost 1.9 million barrels of oil equivalent (BOE).\(^6\)

The country has an estimated population of 284,589 people, with around 80,000 living in or around Bridgetown, the largest city and the country’s capital. The inhabitants of Barbados already benefit from an estimated 40,000 solar water heating systems for private, public and commercial buildings on Barbados; two out of five households on the island use solar energy to heat their water. This is a remarkable success for a solar market and, on a per capita basis, Barbados ranks third in the world – behind Cyprus and Israel – in installed capacity for solar water heating, which accounts for around 8 per cent of the country’s energy sources.

Figure 5.1: Solar Water Heaters on the roof of the Oistins Police Station in Barbados.  
Source: Solar Dynamics Limited

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\(^6\) Energy Information Administration (EIA). Barbados Energy Profile. **March 2011**
5.2. DEVELOPMENT OF THE INDUSTRY

The first known solar water heater in Barbados is believed to have been constructed by Sir Frank Hutson in as early as 1935. Later, in around 1964, Anthony Hoad and D.A. Sinson built solar water heating units at the Brace Research Institute of McGill University in Canada. It was this design (by Hoad and Sinson) that was introduced into Barbados by Professor Tom Lawand during 1965 when he was stationed at the Brace Experiment Station in St. James. The “Brace Design”, as constructed by Lawand, utilized locally available material and was therefore “low cost” (See Figure 5.2 below).

![Early solar water heater that utilized the Brace Design.](image)

Figure 5.2: Early solar water heater that utilized the Brace Design.

This solar water heating unit however, like many other early ones which immediately followed, did not quite meet the requirements and expectations of homeowners, in terms of performance and appearance. Beyond the need to overcome the mistrust of a new and untried product, and to incorporate mechanisms to compensate for the occasional lack of sunshine or overcast conditions, there were the technical issues to be settled such as the placement of the storage tank. It would take another ten (10) years – after the introduction of the “Brace Design” by Lawand – for commercial production of solar water heating units in Barbados.

In 1973, the first in a number of global oil crises took root. This was on account of:

(i) An “oil-price shock” as a consequence of a re-balancing of oil prices against gold in response to deregulation of the US dollar, the currency in which oil was priced; and
(ii) More significantly, an oil embargo that was imposed by the Arab members of the Organization of Petroleum Exporting Countries (OPEC) in response to US assistance to Israel during the Yom Kippur War.

These events bore significance as until then, the price of oil was *low, stable* and *predictable* but became rather *volatile* thereafter (Figure 5.3). As the price of oil on the global market soared, a small industry with a strong commitment to solar thermal technology emerged in Barbados and took advantage of the paradigm shift towards energy solutions that were alternate to oil. The Caribbean Conference of Churches was, at the time, mandated to establish technology transfer training workshops in the region and seized the opportunity to establish training in the manufacture of solar water heaters in Barbados. From this technology transfer initiative, a group of entrepreneurs set up a company for manufacturing solar water heaters.

**Figure 5.3: Average Annual Oil Prices (Nominal and Real), 1861 – 2008**

Source: Energy Information Administration (IEA), 2010

It has been reported that the SWH industry in Barbados started as a venture initiated by Canon Andrew Hatch to provide jobs for boys at one of the local churches; Andrew Hatch was also an associate director of the Christian Action for Development in the Eastern Caribbean (CADEC), the ecumenical organization that was charged by the Caribbean Council of Churches to assist with development projects. To start the assembly of the solar water heaters, a company – Solar Dynamics Limited – was established in 1974 by Reverend Hatch to which CADEC provided a USD 4,2007 loan as seed capital for the project. The critical expertise to develop the solar water heating concept at Solar Dynamics into *marketable* and *functional* product was provided by James Husbands and the technical

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7 USD 4,200 (1974) is approximately USD 22,000 (2011) when adjusted for inflation.
expertise to produce and install the systems was provided by Lindsay Greaves. The challenge to Solar Dynamics was the development of a solar water heating unit that met the requirements and expectations of homeowners, in terms of performance and appearance. In this regard, a model domestic unit was expected to:

- Deliver water at approximately 135°F
- Cope with the salt air, which is a component of the moisture content of prevailing winds over the island
- Tolerate the calcium-laden hard water of Barbados
- Withstand hurricane conditions
- Compensate for the occasional lack of sunshine or overcast conditions and be aesthetically pleasing

An important “plank of support” came from the Barbados Government, which was beginning to explore the use of solar water heaters in state-led housing developments. In 1975, the housing development at Oxnards, St. James was the first development earmarked for the installation of solar water heating units and Solar Dynamics manufactured and installed eighty-four (84) units. As with most entrepreneurial start-up initiatives, the local banking industry was initially reluctant to invest in the manufacture of such a new and untried product. It was the intervention of the Barbados Institute of Management and Productivity (BIMAP) which allowed Solar Dynamics to raise sufficient capital for financing the material and components required for the project.

Meanwhile, the government also put policies in place which persisted even as energy prices went down again. Prime Minister Tom Adams (1976-1985) installed a SWH unit on his residence and was favourably impressed with the performance and the potential energy savings of the technology. This favourable impression is believed to have underlined his administration’s support of the initial fiscal incentives that helped to stimulate the SWH market. The industry benefitted from the Fiscal Incentives Act (1974), which allowed the manufacturers to benefit from import preferences and tax holidays. In addition, government sought actively to promote the competitiveness of solar water heaters, by placing a 30 per cent consumption tax on imported gas and electric units. In so doing, the Barbados Government strategically managed a dynamic mix of “push and pull” factors in support of the industry. Later, the Homeowners Tax Benefit (1981) was introduced. Except for a break in 1993, this incentive allowed Barbadian homeowners to claim the cost of the solar water heater on income taxes, fuelling growth of solar water heating to such an extent that there was an annual major surge in sales in December as people try to beat the “end-of-year deadline” in order to qualify for the rebate.

Apart from Solar Dynamics, other companies also entered the solar water heating industry. The most notable among these are, *inter alia*, Sun Power in 1978 and AquaSol in 1981;
these companies were founded and managed by Peter Hoyos and Vincent McLean respectively. In August 2010, Mora Ven Holdings Limited – a company incorporated in Trinidad and Tobago – formed a subsidiary, Solaris Energy Limited through which controlling shares in AquaSol (60 per cent) were acquired. AquaSol has since evolved to become Solaris Global Energy Limited, and remains a subsidiary of Solaris Energy Limited.

Figure 5.4 below provides a summarized graphical chronology of annual SWH installations in Barbados, with the more important events affecting the sale of SWHs noted. With the exception to the early to mid-1980s, sales of SWHs increased steadily from 1974 when 12 units were sold to 1989 when more than 2,800 units were sold. In the early to mid-1980s growth in SWH sales slackened considerably despite the promulgation of the homeowner SWH tax deduction in 1980. The lessening in sales during this period was no doubt due to the economic recession following the second oil price shock in the late 1970s. With the onset of the major economic recession in 1990 installations declined precipitously to under 1,000 units in 1993. As the economic recovery began, SWH sales started increasing toward 2002 and estimates suggest that they have continued increasing since. Unfortunately, SWH sales figures have not been reported since 2002.

**Figure 5.4: Annual Solar Water Heater Installations in Barbados, 1972 – 2002**
5.3. CHRONOLOGICAL DETAILS

A chronological summary of what are believed to be the more important events that influenced the present state of the SWH industry in Barbados is given below:

<table>
<thead>
<tr>
<th>TIMEFRAME</th>
<th>EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973 - 1974</td>
<td>First OPEC oil embargo leading to a quadrupling of world oil prices.</td>
</tr>
<tr>
<td>1974</td>
<td>CADEC loan to help establish Solar Dynamics Limited as a means to develop and market SWH units.</td>
</tr>
<tr>
<td>1974</td>
<td>Active involvement of an informed government in seeking ways to reduce oil dependency.</td>
</tr>
</tbody>
</table>
| 1974            | Promulgation of the Fiscal Incentives Act:  
- **Exemption of SWH raw materials** (e.g., tanks and collectors) from the 20% import duty; this lowered the installed cost of a SWH by 5 to 10%.  
- A **30% consumption tax** placed on conventional electric water heaters.                                                                                                                                  |
| 1975 - 1977     | Government purchase of 84 units for a housing development project (Oxnards project).                                                                                                                                                                                      |
| 1978            | Launch of SunPower Limited by Peter Hoyos; provided the first *direct competition* to Solar Dynamics.                                                                                                                                                                  |
| 1978 – 1980     | Second world oil price shock brought about by the Iranian Revolution and the Iran-Iraq War leading to a doubling of prices.                                                                                                                                             |
| 1980            | Income Tax Amendment provided a specific line item to deduct the full-cost of a SWH installation. SWH deduction was in-place from 1980 through June 1992.                                                                                                                   |
| 1980 - 1985     | International economic recession brought on by the second oil crisis.                                                                                                                                                                                                    |
| 1988 – 1992     | Government purchase of 300 units for a housing development project (Venezuela project).                                                                                                                                                                                  |
**Tax deduction programme suspended as part of IMF structural reforms.**                                                                                                                                   |
| 1993-1995       | Suspension of tax deduction for SWHs. Tax deduction suspended as part of Structural Reform Programme.                                                                                                                                                                   |
| 1996 - present  | Reinstatement of SWH deduction as part of a personal home improvement allowance deduction of up to BBD 3,500 per year for mortgage interest, repairs, renovations, energy or water saving devices, solar water heaters, and water storage tanks. |

5.4. TECHNOLOGICAL INNOVATIONS

The great majority of SWHs in Barbados operate on the basis of a thermosiphon system: The thermosiphon system relies on natural convection to circulate water through the collector and to the storage tank for which, the operation requires that the tank is installed above the collector. Significant innovations in the system’s design included the following:

- The use of glass with a greater heat tolerance in the construction of solar panels
- Improved welding techniques for a more professional finish
- Improvements in the flow pattern of water through the solar collectors with larger headers to compensate for the calcium build-up, thereby prolonging collector life
- The provision of different tank sizes and collector combinations to match end-user hot water demand preferences
- Improved modular component designs (reducing the number of parts to be fitted together) so as to increase the ease of installation and expedite installation time
- Product standardization to guarantee the desired output temperature on hot water emerging from its systems

Figure 5.5: Solar water heating units from Solaris (left) and Solar Dynamics (right).
As mentioned in the previous section, there were three major manufacturers of solar water heaters – Solar Dynamics, Sun Power and AquaSol – in Barbados by 1981. As competition within the industry grew and each manufacturer sought to enhance the sustainability of its business within a limited market environment, mechanisms to: (i) reduce the price of solar water heaters; and (ii) improve end-user confidence in the units became the main factors that drove technological innovation. Over time, the companies improved efficiency and performance of solar water heaters by increasing collector efficiency and reducing heat loss from the storage tanks. In fact, systems performance is currently a major marketing tool within the Barbados solar water heating industry and companies have been able to provide guarantees, and third-party verification, on water temperatures and heat loss.

5.4.1. Solar Dynamics

Figure 5.6: Solar Dynamics® Solar water heater design. 
Source: http://www.solardynamicsltd.com

Collector
- Selective copper absorber coating, with fusion bonding technology
- Copper tubing
- Aluminium enclosure with aluminium bottom plate
- Tempered glass light window
- Fibreglass insulation; 1.5"
- 150 psi pressure rating

**Storage Tank**
- Porcelain-lined (*inner and outer surface*) stainless steel
- Recommended pressure of 150 psi (Suggested upper limit of 300 psi)
- Electrical *back-up* heating element
- Corrosion resistant aluminium jacket
- Polyurethane insulation – *mould casted*

### 5.4.2. Sun Power

**Figure 5.7:** Sun Power® Solar water heater design.  
Source: [http://www.sunpowr.com](http://www.sunpowr.com)

**Collector**
- Copper absorber coating
- Copper tubing
- Aluminium enclosure
- Tempered glass light window
- Fibreglass insulation; 2”
- 150 psi pressure rating
Storage Tank
- Porcelain-lined (inner and outer surface) stainless steel
- Recommended pressure of 150 psi (Suggested upper limit of 300 psi)
- Electrical back-up heating element
- Corrosion resistant aluminium jacket
- Polyurethane foam insulation

5.4.3. Solaris Energy (formerly AquaSol)

Figure 5.8: Solaris Energy® Solar water heater design.
Source: http://www.solarisenergy.co

Collector
- Titanium (BLUE T) absorber coating
- Copper tubing
- Aluminium enclosure with aluminium bottom plate
- Tempered glass light window
- Fibreglass insulation; 1.5"
- 150 psi pressure rating
Storage Tank

- Porcelain-lined (inner and outer surface) stainless steel
- Recommended pressure of 150 psi (Suggested upper limit of 300 psi)
- Electrical back-up heating element
- Corrosion resistant aluminium jacket
- Polyurethane foam insulation

Starting in 1973 with the “Brace Design”, Solar Dynamics based their technology on a tried and tested solution. The design was not without its problems and, as mentioned in Section 5.2. above, suffered from problems related to performance and aesthetics. As a starting point: (i) The 55-gallon oil drums that were used for storage in the original design was replaced by imported stainless steel cylindrical tanks; (ii) The wooden casing that was used for the collector frame was changed to aluminium; and (iii) Galvanized pipes gave way to copper tubing. Gradually, the company worked to improve the efficiency of solar hot water systems, which led to a reduction of the collector area required to heat the water to a specified temperature. With modification of the collector design, a 42 ft² of collector area was no longer necessary and 33 ft² became sufficient; this represented a reduction of 21 per cent, which lowered the production and installation price. Solar Dynamics also established and maintained a policy of installing only “right-sized” systems suitable for the respective end-use of the customer and most recently, in response to criticisms from a competing entity, renewed market confidence in its products through the voluntary testing of a 66 gallon unit at the Florida Solar Energy Centre (FSEC); others have since followed.

In the environment of competitiveness that ensued from the 1980s onward, the three manufacturing companies have consistently learnt from each other and a cursory perusal of the design features for the collectors and tanks show much similarity among them. Solaris recently broke from the pack with its collector design by using titanium (Blue T) as the heat absorber and consequently promises more efficient heat transfer and higher water temperatures; the other major companies continue to use copper. Solar Dynamics predices its competitive advantage on the polyurethane mould that is used for tank insulation and consistently boasts of a lower heat loss – 3.2 Btu per hour – than its rivals who use polyurethane foam as a wrap. Sun Power chooses to improve insulation on the collector plate by using 2 inches of fibre glass as a means of retaining the heat captured; its rivals uses 1.5 inches. In the final analysis, all three companies continue to vary design parameters that are aimed at the efficient delivery of hot water (120 - 140 °F) to consumers and the technology innovation in the Barbados market, though close to optimization, is nonetheless dynamic.
5.5. CAPACITY BUILDING AND TECHNICAL SUPPORT

According to some reports, the SWH industry in Barbados started as a venture initiated by Canon Andrew Hatch to provide jobs for boys at one of the local churches. Capacity building was therefore at the heart of the industry, even in its inception stage. Development of the SWH market is a balanced process in which the increased demand must be matched by the availability of *decent quality products*, and along with it an infrastructure of *sufficiently trained installers*. In the case of Barbados, supply chain development in the emerging SWH markets started with a small group of suppliers (local manufacturers), who have been largely responsible for the whole supply chain, including products, distribution and installation work. Largely, there has been significant focus on the building of technical capacity within the respective companies, wherein they invest in training engineers, technicians and sales personnel for servicing their own customers; this has been largely achieved through *on-the-job* training and experience.

During the 1980s, the Barbados Government managed and maintained a successful public awareness programme. Coupled with the marketing thrust of the individual companies, and in particular James Husbands of Solar Dynamics, a culture of general acceptance of the technology and its benefits was engendered among the population of Barbados: The fact that the country has one of the highest literacy rates in the world – *circa* 98 per cent – certainly made the *technicalities* and *benefits* of solar water heating easier to explain. As interest in solar water heaters increased, so too did the need for relevant capacity to support the industry. Capacity building at the national level has been limited to the training of technicians for utilization in the manufacture, installation and maintenance of solar water heaters for the domestic market; the Barbados Vocational Training Board (BVTB) currently offers a course for SWH technicians – this is a programme that includes *on-the-job training*. The result is that the country has a cadre of craftsmen properly trained to install and maintain solar thermal systems. Installation and maintenance of SWH is still the domain of the manufacturing companies however and there are few third-party installation and maintenance technicians. There is no national scheme for certification of technicians and skill verification is informal and industry-based.

On the other-hand, policy-makers, financiers and bankers, project developers and civil engineers, architects and other stakeholder groups typically participate in capacity building seminars and workshops which are, on occasion, held by government or multilateral institutions. There have been no known *sustainable training programmes* available for such targeted groups and consequentially, many of the “soft skills” required for supporting the industry are usually self-taught, experiential or both. Companies tend to be owner-managed and many activities are typically limited to a select few.
5.6. FISCAL INCENTIVES AND TAX EXEMPTIONS

The solar water heating industry in Barbados would likely not have succeeded without the particular involvement and participation of the Government of Barbados. The government initially used two main policies in 1974 to promote the use of solar water heaters in the country. These were: (i) The elimination of import tariffs on raw materials that are used in the manufacture of solar water heaters; and (ii) The imposition of a 30 per cent consumption tax on electric water heaters. In 1980, government implemented another policy, this time in the form of another fiscal incentive; this “new” incentive allowed homeowners to deduct the full-cost of a SWH installation up to a maximum of BBD 3,500. This tax deduction was eliminated in 1993 under the Structural Reform Programme\(^8\) and reintroduced in 1996 as part of a broader homeowners allowance deduction, which allowed the deduction (which remained at BBD 3,500) to be utilized for mortgage interest, repairs, renovations, energy or water saving devices, solar water heaters, and water storage tanks.

A common concern regarding the use of fiscal incentives and other government programmes to stimulate the diffusion of renewable energy technologies is whether these incentives are a prudent and justifiable use of taxpayer’s money. The report from a 1985 World Bank Consultancy suggested that the benefits of the retention of the incentives far outweighed the loss of government revenue. Additionally, the report argued that although installation and system costs had a short payback period of approximately three years, the incentives should be kept in place to ensure the success of the “fuel-switching and energy saving programme” that were deemed critical to the country’s balance of payments position. Later (in 1994), Solar Dynamics chief, James Husbands estimated that the SWH systems installed between 1974 and 1992 produced a total energy savings of USD 50 million while costing the government around USD 6.6 million in revenue.

Figure 5.9 below summarizes an estimate by Perlack and Hinds\(^9\) of the cost of the fiscal incentives to Barbadian taxpayers. In estimating the tax cost of the incentives, a number of assumptions were made regarding income distribution, the impact of the duty-free raw material exemption on the installed system cost, and the fraction of systems installed in dwellings as opposed to hotels. For the period 1980 to 1992, the income distribution was, \(\text{inter alia}:\) (a) 20 per cent of the population with no taxable income; (b) 40 per cent with taxable incomes up to BBD 15,000 and a tax of 20 per cent; (c) 20 per cent of the population with taxable incomes up to BBD 25,000 with a tax rate of 30 per cent; and (d)
20 per cent with taxable incomes greater than BBD 25,000 with a tax rate of 40 per cent. For the period after 1992, assumptions were changed to reflect income tax reform and the reduced number of tax brackets (0, 25, and 40 per cent). In addition, it was assumed that the effect of the duty-free importation of raw materials lowered installed costs by about BBD 200 and further that 80 per cent of the SWHs were installed in dwellings as opposed to hotels and other tourist accommodations.

Figure 5.9: Annual Cost of SWH Tax Incentives for Barbados, 1972 – 2002

As expected, the estimated cost of the incentives to the Barbadian taxpayer generally follows that of the installation data presented in Section 5.2. Perlack and Hinds indicated in their seminal report that about two-thirds of the tax cost of the incentives is due to the homeowner deduction and one-third due to the manufacturer tariff exemption on raw materials. The tax cost of the incentive reached a maximum of nearly BBD 1.8 million in 1989; the consumer deduction cost about BBD 1.2 million and the duty-free importation of raw materials about BBD 0.6 million.

In 2002, the cost of the tax incentives was about BBD 1.1 million and was rather small when compared to government revenues of BBD 1,740 million. Industry interests have consistently argued that although no recent analysis have been done, there is still significant benefit to be derived from government foregoing less than 0.1 per cent of its annual revenue to maintain the current programme of incentives for solar water heating. Cumulatively, the tax cost of the SWH incentives from 1974 to 2002 was estimated at about BBD 21.5 million or less than USD 11 million (an average of USD 0.4 million per annum). On
this basis, the cumulative tax cost of the SWH incentives from 1974 to 2012 is being estimated at around BBD 29.2 million (less than USD 15 million).

Figure 5.10: Cumulative Cost of SWH Tax Incentives for Barbados, 1972 – 2002

5.7. MARKETING AND EXPORT PENETRATION

During the early days of the Barbados solar water heating industry, much marketing was “door to door”; Solar Dynamics, in particular, expended significant time and resources to simultaneously engage project developers and householders, as well as policy-makers on the benefits of solar water heating to the country. Other manufacturers also adopted a similar model. Later, they participated in seminars, workshops and exhibitions and demonstrated their *cognizance of the latest advancements in manufacturing and installation techniques* for both domestic and commercial designs (particularly for the hotel industry - a major user of hot water services in Barbados). Associated with those activities too were video recordings of “success stories” demonstrating tangible energy and operating cost-savings, derived through application of solar water heating technology to diverse customers. The marketing strategy was enhanced through the collaboration of solar water heater manufacturers with distributors, credit unions, and commercial banks to provide credits to end-use consumers over a two-year period. This move not only made the system more affordable to a wider cross section of the population but added significant public
awareness support through “broadening of the stakeholder base” within the marketing and sales industry for solar water heating.

The solar water heating programme in Barbados is perhaps the best known renewable energy technology programme in the Caribbean. It stands to reason therefore that the region has much to learn from the “Barbados Experience”. In the face of a limited local market – Barbados has less than 82,000 households and around 5,500 hotel rooms – and a competitive local manufacturing industry, it is understood that expansion into the regional market is a necessary requirement for sustainability of the Barbados Model. Nonetheless, the companies have had only moderate success in operating beyond the island’s borders. Solar Dynamics has been the most successful of the companies to venture overseas and started the production of solar water heaters in St. Lucia through a joint venture in 1993. That subsidiary, Solar Dynamics EC Ltd. exports to the islands of the Eastern Caribbean and in 2006, won the Export Award of the St. Lucia Chamber of Commerce, Industry and Agriculture. The company has had the assistance of the electric utility in that country, LUCILEC, which advises its consumers through their bills on the benefits of solar water heating use to offset – either reduce or avoid increasing – electricity consumption. Apart from its plants in Barbados and St Lucia, Solar Dynamics has a distribution centre in Jamaica, agents in Antigua and Barbuda, Belize, Dominica, Grenada, Guyana, Montserrat, St Lucia, St Vincent and the Grenadines, and Tortola. The company is also actively working to establish other bases, especially in The Bahamas and Trinidad and Tobago.

In 2006, AquaSol formed a 50-50 joint venture partnership with the Nigerian state of Akwa Ibom. The partnership was intended to make use of the “Barbados Experience”, thereby enabling Akwa Ibom to raise the level of solar water heating usage in Nigeria. A USD 1.2 million deal was facilitated through the Commission for Pan-African Affairs within the Barbados Prime Minister’s office and the expectation at the time was that a Nigerian subsidiary, Akwa Sol Nigeria Limited, would produce around 10,000 solar water heating units per year. But the deal went sour and the project never “got off the ground”. This somewhat stymied government’s willingness to further participate directly in the establishment of overseas businesses as the loan, which came from a fund that was “created to encourage development within the manufacturing sector, through the provision of concessionary financing to facilitate retooling and expansion of the industrial base” was never repaid. AquaSol, under its new brand Solaris Energy, have only now revisited the strategy to expand its market Barbados and now has agents in Grenada and Jamaica.

The fact that Barbados accounts for nearly 60 per cent of the solar water installations within the Caribbean and 80 per cent of the solar water heaters in the English-speaking Caribbean is believed to have originated from Barbados-owned factories suggest that the marketing strategy have had reasonable success.
5.8. CURRENT STATE

Currently, there are an estimated 35,000 to 40,000 SWH units installed on the island. Over 25,000 systems are installed in homes and the remainder in hotels and other tourist accommodations. The current Barbados market is estimated at about 2,000 systems per year split unevenly among three companies – Solar Dynamics, SunPower, and Solaris. Solar Dynamics has about 55 to 60 per cent of the Barbadian market with the remaining amount divided more or less equally between other two. It is worth noting also that there are over ten (10) small “backyard” manufacturers operating in Barbados; Solar Apex and Solar Solutions are the two most well-known. These companies typically comprise former employees of Solar Dynamics or AquaSol (now Solaris) and it is estimated that together, they control as much as 5 per cent of the Barbados market.

5.8.1. Data Availability

During the initial stages of the industry development, manufacturers were required to report production data to the Barbados Government. On account of the intense rivalry that has arisen in recent years as the established market approaches saturation, manufacturers have become rather “cagey” with data and have suspended their participation in the voluntary reporting procedure since 2002. As a consequence, data reliability has declined significantly since and information is typically derived from extrapolations and estimates.

5.8.2. Technology Design and Affordability

Progress was slow during the first years, on account of defects in design, which led to low efficiency, high cost and operational difficulties such as leakage. However, with engineering developments and rationalisation of production, defects were eliminated and the cost kept at constant level, leading to an impressive increase in production.

Today, Barbadian manufacturers utilize high performance designs for household solar water heating systems; the technologies are considered to be mature but nonetheless continue to improve. Nonetheless, there are now questions regarding the ability of the respective companies to match the performance gain with further innovation that leads to significant cost price reduction; there is a widely-held belief that local systems are “over-designed” as a consequence of the competition among the three major manufacturers and this may have prohibited the lowering of prices of the Barbados product. Consequently, Barbados manufacturers are unable to compete with other countries, such as Greece and China, on pricing; countries, such as The Bahamas and Jamaica, are already looking to the “cheaper, imported products” in preference to the “more expensive, regional products” as a means of addressing the price barrier.
Also, the relatively high cost of the Barbadian product may be responsible for “slowing down” of new installations as this impact the affordability of solar water heating among the lower and lower-middle income groups within the local population. Figure 5.11 below shows that solar water heaters are more prevalent within concrete dwelling structures and almost completely absent in wooden dwellings – this may be taken as indication of the low penetration of solar water heating among the lower income groups. It is believed that these groups will preferentially choose electric water heaters, which has a lower initial cost, when they require water heating services. It can be seen from the figure that an increase in the proportion of concrete dwellings resulted in an increase in the number of installed solar water heaters within Barbados, a trend that is believed to be relevant even now.

Figure 5.11: Water Heater Use in Barbados Dwellings, 2000 and 2010
5.8.3. Government Incentive Scheme

The promotion of solar water heating systems in Barbados resulted from concessions granted by the Ministry of Finance, which enabled manufacturers to import materials duty-free, and provide consumers with partial or full tax deductions for the cost of the heaters. As previously articulated (Section 5.6. above), the government’s incentive scheme was critical to the development of the industry and is therefore an important “limb in the anatomy” of the Barbados Model.

There is some indication however that the SWH industry was already starting to grow at a relatively fast pace prior to the passage of the Homeowner Tax deduction. It should not necessarily be construed that the tax incentives were entirely responsible for the relatively high penetration of SWHs in Barbados. Clearly, there is some measure of free-ridership – tax deductions taken by homeowners who would have installed a SWH without the incentives. However, without conducting extensive surveys it would be impossible to tell how much effect the tax incentives had in a homeowner’s decision to install a water heater.

The financial returns to government from the SWH industry as a result of the incentive schemes in which potential revenue was traded for the potential returns on the industry has been studied and articulated but never reliably investigated. This may have had some influence on government’s decision to lower the taxation incentive scheme, which at one time was altogether removed. More recently, the Barbadian government has implemented several schemes to further stimulate the use of renewables in newly constructed houses – this scheme is also applicable to solar water heaters. For example, from the USD 5,000 allotted per year under the 2008 modified Income Tax Allowance for Home Improvement, up to USD 1,000 may be used for energy audits. Also, under the Energy Conservation and Renewable Energy Deduction, a reduction of 50 per cent of the cost of retrofitting a residence or installing a system to produce electricity from a source other than fossil fuels has also been proposed. This has significant implications for hybrid technologies such as solar cogeneration (PV/thermal) technologies.

5.8.4. Marketing and Regional Export

In the 1980s to the early 2000s, the marketing initiatives of solar water heater manufacturers in Barbados were centred on the creation of a distribution network to propel its growth and ensure its sustainability. As the domestic market grew more competitive, they began to form strategic alliances with some of the leading distributors of household goods on the island, many of whom offered hire-purchase rates of 12 – 15 per cent: Solar Dynamics, for instance, entered into distribution arrangements with Modern Living®, Cave Shepherd®, Courts® and Home Centre®. Though the partnership with distributors did increase sales, the manufacturers experienced lower profit margins on their products.
The mainstreaming of the solar water heating industry in Barbados during the 1980s meant that credit unions and banks were willing to participate in customer financing; they offered relatively low interest (7 – 8 per cent) loans over two years and consequently, manufacturers were able to sell direct to consumers who no longer had to depend on hire-purchase financing from distributors. The ability of the manufacturers to efficiently and reliably maintain direct sales was significantly enhanced with the emergence of internet and e-commerce tools which has almost completely removed the requirement for domestic distribution partnerships. All three major manufacturers today maintain and manage a very robust internet marketing and sales presence:

- Solar Dynamics http://www.solardynamicsltd.com/
- Solaris Global Energy http://solarisenergy.co/
- Sun Power http://www.sunpowr.com/

As penetration in Barbados grew, demand slowed and competition became fierce among rivals who fought to maintain their share in a shrinking market; the “wars” between Solar Dynamics and Sun Power have become infamous. Though the respective companies now base their domestic marketing strategy around technology efficiency, it was the “virgin territories” within the regional overseas market that proved more lucrative. The opportunities that are available within the CARICOM market continue to drive the export-centred model of Solar Dynamics and more recently, Solaris Energy. There has never been a significant effort however to compete in a more global market that extends to North America, Latin America and wider Caribbean.

### 5.8.5. Solar Water Heating End-use within the Hotel Sector

In Barbados, there are around 73 hotel properties – an estimated total of 5,506 rooms. Of these properties, around 50 use solar water heating methods with large-scale integrated designs that cover the hotel roof with solar collectors. The typical arrangement in the larger properties utilize collectors measuring about 300 m², with large tanks of up to 6,600 gallons (25,000 litres), which allow the heat from the central air-conditioning system to preheat the water; the smaller properties used thermosiphon systems. For tourism, which is now the biggest industry in the country, hot water is essential, and solar water heaters are even more cost-effective for this industry than for households. It is estimated that there is an installed solar water heating capacity of just around 300,000 gallons per day in the Barbadian hotel sector. This is believed to provide around 53 per cent of the total hot water demand in the hotel sector; around 21.4 million of 40.5 million gallons on an annual basis, which represents around 350,000 KWh in annual electricity savings. Solar water heating currently saves around 6 per cent on electricity bills in the hotel sector. Further increase in the penetration of solar water heating in the hotel sector has been inhibited by issues related to split-incentives.
The Caribbean Hotel Energy Efficiency Action (CHENACT) Programme in conjunction with several other agencies, have recently been investigating alternative ways of incorporating energy-efficient practices within the tourism sector; the hotel sector in Barbados accounts for at least 9 per cent of the overall electricity consumption in the country. Under the programme, energy audits were conducted within 35 hotels; opportunities for energy savings were examined but focussed on: (i) Lighting; (ii) Building Envelope and Air Conditioning; (iii) Guestroom Equipment; (iv) Office Equipment; (v) Kitchen Equipment; and (v) Pool Pumps.\(^{10}\) A unique opportunity was missed to capture data on and opportunities for water heating that utilize solar and other alternate technologies during this audit; on average, hot water services account for 9.1 per cent of energy-use in hotels.

Though no *quantitative assessment* was done towards hot water use and demand, the CHENACT audits provided *qualitative reports* on solar water heating use in the industry. Significantly, the findings suggested that there was a *lack of maintenance* of collector plates and the accumulation of limescale on the surface reduced its efficiency (Figure 5.13). Hot water pipes were also poorly maintained and significant breach in the integrity of the

\(^{10}\) Private discussions with Loretta Duffy-Mayers, Project Manager for CHENACT. **December 2011**
insulation material was frequently observed. Seemingly, there is a lack of willingness on the part of hotel operators to include maintenance contracts for solar water heater installations and many systems are either being inefficiently operated or have become completely inactive. There was also evidence of poor operation practices; many properties seemed unaware of how back-up electrical heating should be used and it was not uncommon for electrical switches to remain on for days, or instances weeks, at-a-time. It is believed that there is insufficient integration of energy management into overall property management practices and so efficiency measures tend to be focussed on the higher demand – lighting and air conditioning – devices.

Figure 5.13: Limescale deposits on solar collectors in a Barbados hotel.
Source: CHENACT

Also, some hotel designers are unwilling to include solar water heating technology in new hotel designs as on the one-hand, modular thermosiphon systems do not have aesthetic appeal and on the other-hand, the preferred custom-designed active systems are deemed too expensive. The economics that allowed electric water heaters to remain somewhat competitive with solar technologies within the hotel sector in Barbados was the result of a policy flaw; hotel operators were allowed duty-free import for goods and equipment under the Tourism Development Act (2002). Through this “loophole”, electric water heaters were imported without the 30 per cent duty that was applicable to other sectors. The Act has now been amended to give preference to clean energy technologies, including solar water heaters.
Solar water heaters represent a large initial expense, especially for large hotel projects. Although solar water heating options can provide positive life-cycle returns through lower operating costs, the additional cost above the base expense for more conventional (electric and gas) water heaters represents a financial commitment that many hotel developers are either unwilling or unable to make; construction cost has been an important feature in contract awards. The outcome of this is that the developer has an interest in the lowest capital cost that is possible within the terms of reference of the project, as well as the building codes and the benefit of a lower operating cost (maintenance and energy bills) usually accrues to the owner. This is referred to as the “split incentive” in which the decision-maker on technology selection is not the property owner, who pays the utility bills and is typically not sufficiently knowledgeable on the technology options and benefits. Moreover, property owners operate on the basis of a profit mark-up and operating costs are usually passed unto customers.

5.9. BENEFITS OF THE SOLAR WATER HEATING INDUSTRY TO BARBADOS

5.9.1. Economic Benefits
Barbados has a total installed electricity generating capacity of 239 MW. According to the Barbados Light and Power Company (BL&P), the base demand is around 110 MW – the demand peaks at around 160 MW during the course of the day as the use of air conditioning units rise, commercial businesses open and industrial operations increase. Electricity demand in the domestic and commercial sectors has grown steadily since the 1970s and in recent years, electricity demand has grown at an average annual rate of a little over 3 per cent – this is less than the Caribbean average of around 5 per cent per annum. It may be reasonably inferred that the widespread use of solar technology for domestic hot water is partly responsible for the lower rate of increase in electricity demand and consequently, will serve to delay the addition of new generation capacity by BL&P.11

In 2002, an estimated 35,000 solar water heaters were installed – this saved around 130,000 barrels of oil valued at USD 3 million (BBD 6 million). Presently, there are around 40,000 solar water heaters in use. Assuming that these units have replaced conventional electric heaters, there is electricity savings of around 160 GWh per year. The corresponding oil reduction is just under 150,000 barrels which cost USD 15 million (BBD 30 million) at current price of around USD 100 per barrel. Perlack and Hinds showed in 2002 that significant economic benefits accrued from the use of solar water heaters in preference to the electric equivalent. Figure 5.14 and Figure 5.15 below show economic benefit scenarios

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11 Private discussions with Stephen Worme, Vice-President of BL&P. December 2011
for 50 per cent and 70 per cent electric water heater replacement between 1972 and 2002. The economic benefits of SWH have increased five-fold since, mainly as a consequence of higher global oil prices.

Figure 5.14: Energy Savings Due to Solar Water Heating, 1972 – 2002

Figure 5.15: Primary Petroleum Savings Due to Solar Water Heating, 1972 – 2002
The return-on-investment for families using solar water heaters is also very appealing. In 2002, analyses showed that net return of the investment was reached after less than two years – in contrast to the average electricity use of 4,000kWh/year that a family would have to pay for if it purchased an electric water heater. The minimum savings over the 15-year lifecycle of a solar water heater was estimated at BBD 36,000. At today’s electricity rate (USD 0.469 per KWh), calculations show that the “popular” 66 gallon SWH has a payback period of just under 13 months when purchased without incentives – compare with 25.2 months in 2002. With tax deduction incentives, the payback is less than a year – 9.6 months (25 per cent tax deduction) and 7.6 months (40 per cent tax deduction).

The bottom-line is that the both the macro- and micro- economics of solar water heating is extremely attractive in Barbados. The initial investment still acts a debilitating factor among individuals within the lower income segment as commercial facilities (banks, credit unions and hire-purchase distributors) are still the only source of loans for solar water heaters. In many instances too, many residences are not owned by the occupants and the issue of split incentives pervade: Owners do not make SWH investments because it is the renters who pay the electricity bills and renters do not make investments in property they do not own.

5.9.2. Environmental Benefits

Figure 5.16 below shows the carbon emissions reduction due to the replacement of conventional electric heaters by solar water heaters; the carbon savings are based on a composite carbon emission coefficient of 20 metric tons/Billion Btu, which reflects the percentage of fuel oil, diesel and gas that is used by BL&P to generate electricity. These results show that carbon savings in 2002 were 15,000 metric tons of CO₂ equivalent; this was 4.3 per cent of emissions from all Barbadian carbon sources (the main sources being the power generation and cement manufacturing sectors). The carbon emissions reduction is estimated to be over 17,000 metric tons based on current technology use.

The local environmental benefits due to the reduction of other emissions (SO₂, NOₓ, particulate, VOC, etc.) as a consequence of the avoided electricity generation was not analysed but is nonetheless relatively significant.
5.10. CRITICAL LESSONS LEARNT

The SWH systems used in Barbados are usually domestically manufactured thermosiphon systems. Most consist of a flat plate collector and separate tank, though some integrated collector systems are on the market; all are open loop systems. Household systems are typically 66 gallons and cost approximately USD 2,000 or USD 30.30 per gallon of capacity. With a Gross National Income in Purchasing Power Parity (GNI PPP) per capita of over USD 15,000, many Barbadians are relatively well equipped to pay the up-front costs of SWH systems. Furthermore, affordability is usually not an issue for most buyers of SWH systems who pay income taxes, as they can take advantage of homeowner tax rebate incentive. To keep costs down, the government offers preferential import tax treatment to local manufacturers for fabrication materials, in addition to the above mentioned income tax rebate to buyers of domestic SWH systems.

As a result of these very favourable tax policies, Barbados has one of the world’s highest per capita rates of SWH penetration; it is estimated that there are 35,000 – 40,000 installed systems providing at over 40 per cent of households and 50 per cent of hotels with SWH services. This high rate of SWH adoption is due to several factors, including the country’s relatively high rate of insolation, extremely high electricity tariffs, and very active government pro-SWH incentive programs. Despite the robust SWH market, there are still a significant number of electric systems. Otherwise, it has been estimated that Barbados accounts for as much of 60 per cent of the solar water heater usage in the entire Caribbean.
and that as much as 80 per cent of the solar water heaters within the Caribbean are from Barbados-owned manufacturing companies. Crude estimates suggest that the penetration of solar water heating within the Caribbean is around 8 per cent. It stands to reason therefore that the rest of the region is a long way off from the approximately 40 per cent penetration that is currently being achieved in Barbados. The Barbados model may not be perfect but there is nonetheless much wisdom to be gleaned from it.

5.10.1. Seven Best Practices
There have been a “confluence of factors” that has driven the Barbados Model to its current state and there is no single magic bullet that accounts for its success. The following are the factors that are deemed to be important to the model:

1. There was recognition of the potential benefits of SWH technology to Barbados at the highest level of government – then PM, Tom Adams, actively utilized and supported the technology.
2. The sector was driven by innovative entrepreneurship that drove product development and market dynamics.
3. There was a rollout of the industry at a time of rapidly rising electricity cost – this gave clear rationale for its importance.
4. The provision of key fiscal incentives by government lowered manufacturing cost and enhanced affordability of SWH to the end-user.
5. The implementation of appropriate regulation discouraged electric water use – government promoted the competitiveness of solar water heaters, by placing a 30 per cent consumption tax on imported gas and electric units.
6. The institutionalization of government policies by successive political administrations have continuously provided stable, dedicated support for the solar water heating industry since 1974 – aggressive support for SWH continued even when oil and electricity prices were low.
7. Most important, there were deliberate and timely government procurement programmes for solar water heating housing projects.

5.10.2. Seven Inhibiting Practices
Despite its successes, there have been a number of factors that have retarded further growth of the industry. The following are deemed to be relevant:

1. System designs should be optimized for contribution and cost – efficiency is not the only factor and ought to be balanced with quality, durability, service and cost.
2. Accurate accounting of the solar water heating capacity in Barbados has been lost without the requirement for mandatory reporting of sales by manufacturers – this should be demanded by government as a basis for continued fiscal support as the availability of reliable data supports scientific decision-making.
3. There was some degree of incoherence in government policies – the Tourism Development Act permits duty free import of equipment for use in the hotel and tourism sector and consequently, hotel developers have imported “tax-free” electric water heaters, a situation which has recently been addressed.

4. Capacity building programmes should transcend the entire value chain to include marketing agents, facilities managers, finance experts rather than the current single-focus on technicians.

5. There is a clear and present gap for ESCo-type financing for customers who are either unable or unwilling to make the investment in solar water heating – this would be significant in removing cost and split-incentive barriers.

6. There is need therefore for congruence among government, the electric utility (BL&P) and other relevant stakeholders in energy planning with appropriate target-setting for solar water heating and other renewable technologies – currently, utilities are asked to support Demand Side Management (DSM) and renewable generation projects after significant investment has already been made in the supply side through generation capacity expansion.

7. Solar water heating has not been sufficiently integrated into the sustainable energy economy and should form part of an overall solar policy within the Sustainable Energy Framework for Barbados (SEFB) – solar water heating is currently not considered under the programme that is seeking to “measure the potential for renewable energy sources”.

The Barbados Solar Water Heating expansion took place at a time when there was mass conversion of sugarcane lands into housing during the 1970s to 1990s. This “new wave of housing construction” in combination with high-electricity costs, which was a consequence of high global oil prices, supported the proliferation of solar water heaters in Barbados as the technology experienced mass application in newly constructed buildings.

Importantly, consumer acceptance of this technology in Barbados is quite high – a result perhaps of the early concept proof provided by government’s investment in application of the technology.
6. GLOBAL SWH EXPERIENCES

6.1. GLOBAL OVERVIEW

Solar hot water technologies are becoming widespread and contribute significantly to hot water production in several countries. World solar thermal capacity has increased four-fold since 2000 with two emerging country profiles. On one-hand, countries with a long-term promotion policy have a high share of systems installed per capita (Austria, Germany, Turkey, Barbados, etc.) and in some cases reaching saturation (Cyprus and Israel). On the other-hand, new market for solar water heaters (SWH) is developing for many countries, in particular in emerging countries, such as China and Brazil.

Cyprus is the world leader in terms of capacity per capita, followed by Israel, due to high solar radiation and support policies: More than 90 per cent of households are equipped with SWH. China ranks first in terms of installed capacity, with almost 2/3 of the world's capacity. Over the last few years, China has been the leader in solar water heater system additions, with 11 million m² installed in 2009. In comparison, the three countries that had massively invested in capacities during 2009 lagged far behind China with Turkey “only” installing 380,000 m² in 2009, Australia, around 200,000 m² and Portugal, 88,000 m².

Figure 6.1: Existing Solar Water Heating Capacity, Top Ten Countries/Regions, 2009
Source: Renewables 2010 Global Status Report
According to preliminary estimates, the SWH market is estimated to have risen to about 185 GWth in 2010, of which 70 per cent of new capacities were installed in China and 10 per cent in the European Union. The European market for SWH contracted again in 2010, by almost 13 per cent after a 10 per cent drop in 2009 due to the global economic crisis (slowdown in construction in countries with legislative promotion such as Spain or Greece, stop-and-go policy for subsidies in Germany and the Czech Republic, preference for solar PV incentives in France, etc.). In the European Union, the development of SWH systems is included in the National Renewable Energy Action Plans by member states and most of EU countries have set targets for solar heat by 2020.

In 2009, existing solar water heating capacity increased by an estimated 21 per cent to reach about 180 gigawatts-thermal (GWth) globally, excluding unglazed swimming pool heating. China alone added more than 29 GWth, or about 42 million m² – an increase of 34 per cent over its 2008 additions and representing more than 80 per cent of the global market. Chinese demand was driven in large part by the central government’s programme of “home appliances going to the countryside,” which accounted for about 58 per cent of newly installed capacity.

The European Union accounted for most of the remaining global added capacity, installing an estimated 2.9 GWth (about 4 million m²) in 2009. Although the European market was at its strongest in 2008, it was down 12 per cent in 2009. Germany’s new installations were slightly lower in 2009, after a record year in 2008, at an estimated 1.1 GWth (1.6 million m²). This brought its total domestic capacity to about 9 GWth (12.6 million m²), with annual solar heat output increasing by 14 per cent to 4.7 GWh. Markets also declined in France, Greece, Italy, and Spain relative to 2008 due to the economic crisis, but many smaller markets experienced significant growth in 2009. And while Germany remains Europe’s largest installer, its importance is declining as others step up installations and as new markets emerge due in large part to supportive policies in an increasing number of countries.

There is some evidence that the Turkish solar heating market is shrinking due to lack of government support, a VAT tax on solar thermal systems, and the introduction of new natural gas pipelines. At the same time, use of solar thermal in remote villages in Turkey

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12 Estimate for 2009 based on China data from Li and Ma, which, along with other estimates for 2009 additions in Brazil (0.5 GWth), the EU (2.9 GWth), and the United States (0.2 GWth), and extrapolating 2008 additions for other countries and estimating retirements (3–4 per cent annually), yields a 2009 world total estimate of 180 GWth.
13 Share of market derived from estimates for gross additions in 2009.
14 Over 4 million m² of solar thermal panels were sold in the EU during 2009, per European Solar Thermal Industry Federation (ESTIF), “Solar Thermal Markets in Europe: Trends and Market Statistics 2009” (Brussels: June 2010).
is increasing rapidly thanks to zero-interest government loans. In India, an estimated 20,000 solar hot water systems are installed each year; Brazil’s capacity increased 14 per cent in 2009, bringing its total existing capacity to nearly 3.7 GWth (5.2 million m²). The US market for solar hot water systems (excluding unglazed swimming pool heating) is still relatively small but is gaining ground – especially in California – and total capacity increased 10 per cent in 2009 to some 2.1 GWth. Interest is also up in Africa, with markets expanding in Ethiopia, Kenya, South Africa, Tunisia, and Zimbabwe, among others.

On a per capita basis, Cyprus remained the world solar heating leader with 527 kilowatts thermal (KWth) per 1,000 inhabitants, followed by Israel (371 KWth), where more than 80 per cent of households heat their water with the sun. Austria, which had 285 KWth per 1,000 inhabitants in 2008, remains the leader in continental Europe. Palestine has the highest installed capacity across the Middle East and North Africa region: about 68 per cent of all households use solar water heaters, which are routinely installed on new buildings.

The market for solar-assisted cooling, a related technology, remains small to date but is growing quite rapidly, particularly in Europe where demand has risen 50 – 100 per cent annually over the past five years. By the end of 2009, an estimated 450 to 500 systems were in operation worldwide, most of them in Europe. An increase in sales of small-sized systems has been observed in recent years, mostly in Spain and other southern European countries. In general, data on such systems are limited.

### 6.2. CYPRUS

The island of Cyprus is situated in the eastern Mediterranean, at the geographical latitude of 35°N and has an area of 9,251 km²; the population is estimated at around 1.12 million inhabitants (2011). The economy of Cyprus is prosperous, driven by the tourism and services sectors. Cyprus does not have any indigenous fossil-fuel resources: It is almost totally dependent on imported energy products, mainly crude oil and refined products. Solar energy is the only indigenous source of energy in Cyprus. The contribution of solar energy to the energy balance of the country is about 4 per cent.

Solar energy is utilized extensively by households and hotels for the production of hot water. Indeed, Cyprus is a leading country in installed solar collectors per capita (0.86 m² of solar collector per capita); solar water heaters were first fabricated and installed in

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17 Epp, Baerbel. "40,000 'Forest Villagers' in Turkey Heat Water with the Sun." 21 April 2009
18 Weiss, Werner. Arbeitsgemeinschaft Erneuerbare Energie, Institut für Nachhaltige Technologien. March 2010
1960. Since, a remarkable expansion in the utilization of solar water heaters has taken place rendering the country among the leaders on the basis of total number of solar water heaters in use per person.

6.2.1. Progress
Progress was slow, during the first years, on account of the defects in design, which led to low efficiency, high cost and operational difficulties (e.g. leakage). With engineering developments and rationalization of production, the defects were eliminated to a large extent and the cost kept at constant level, witnessing an impressive increase in production. Today, there are about ten (10) major and twenty (20) smaller manufacturers of solar water heaters in Cyprus, employing about 300 people and producing about 35,000 m² of solar collectors annually. The estimated penetration of solar water heating systems in the different categories of buildings is 92 per cent for houses and 53 per cent for hotels.

The estimated current area of solar collector in working order in Cyprus is 600,000 m² and the annual solar thermal energy production is 336,000 MWh/year. As a result of the extensive use of solar heaters, 10 per cent of total CO₂ emissions are avoided (285,600 tones CO₂/year) when compared with the business as usual scenario.

6.2.2. Technology
The majority of solar domestic hot water heaters, put up on individual houses are of thermosiphon type. Two solar collectors, with a total glazed area of 3 m², are connected in series to a hot water tank, placed at a height, just above the top of collectors. Since the city water supply is not continuous, a cold-water storage tank is located above the hot water storage tank. The hot water tank is also fitted with an auxiliary electric 3 KW heater, which can be operated manually or automatically. The solar collectors are invariably of the flat plate type glazing.

6.2.3. Market Sustainability
A number of factors have contributed to the wide scale use of solar energy in Cyprus. The most important factor, contributing to this phenomenon is the enterprising industry. The industry identified correctly the prime application of solar water heaters and boosted the improvement of technology and promotion of product with vigour. Hot water is a primary need and solar water heaters can meet the need economically with an investment, which most Cypriot house owners can make, without significant inconvenience. The sunny climate has tended to make solar heating more competitive. In hotels, the maximum demand in summer matches very well with the flux of solar radiation, which makes water heating systems more efficient and economic. The government, through the Applied Energy Centre of the Ministry of Commerce, Industry and Tourism helped the promotion of solar energy by:
Providing technical support, consisting of testing of collectors, advice to industry for improvement of products and to consumers for efficient utilization. The provision of technical support to industry proved to be very critical at the initial stages, but even now, the provision of technical support is necessary because most local solar water heater firms on account of their size cannot support research and development activities.

- Making the material used for fabrication of solar water heaters duty-free
- Providing technical support for the preparation of relevant standards
- Making the installation of solar water heaters compulsory on state-built housing

The main lesson to be learnt from Cyprus is that nothing succeeds like the exploitation of a properly identified application of solar energy, in this case solar water heating, by an enterprising industry, backed up a cooperating government. An important factor has been the institutionalization of the industry through government support procedures.

6.3. ISRAEL

Not counting annexed or occupied territories, Israel covers 21,121 km². It lies at the geographic latitude 31°N on the Mediterranean Sea and has borders with Lebanon to the north, Syria to the northeast, Jordan and the West Bank to the east and Egypt and the Gaza Strip to the south; the population is estimated at around seven million. Israel has a technologically advanced market economy with substantial government participation. It depends on imports of crude oil, grains, raw materials, and military equipment. Despite limited natural resources, Israel has intensively developed its agricultural and industrial sectors over the past twenty (20) years.

Like most of the world, Israel has adopted plans to shift towards the use of renewable energy and has set its target at 5 per cent by 2014 and 10 per cent by 2020. In seeking to meet its goals, Israel is poised to become a leader in the global solar energy market. Historically, Israel was the first country, in 1980, to introduce a regulation about the use of solar energy in new buildings for reasons of energy security. This legislation has had a great success and made solar water heaters a mainstream technology.

6.3.1. Progress

Israel has historically led in the use of solar energy for domestic purposes. The most obvious testaments to this history are the thousands upon thousands of solar water heaters on roofs in Jerusalem and other cities. Israel’s interest in solar water heaters began even before Israel gained independence in 1948. Israel’s first Prime Minister David Ben-Gurion
had a solar water heater in his home. In 1953, the early interest turned into an active commercial pursuit. The Yissar family with support from Ben-Gurion created the Neryah Company – the first Israeli solar water heater company.

In the 1950s, there was a fuel crisis in Israel that resulted in increased use of solar water heaters. The solar water heater industry continued to grow, and in the period from 1957 to the beginning of the 1967 Arab-Israeli war, 50,000 solar water heaters were sold. The 1967 Arab-Israeli War produced short-term resolution to Israel’s fuel dependency, as Israel conquered several Egyptian oil fields, but with the return of Sinai as part of the Camp David Accords the need for more restrained fuel use resurfaced. To encourage energy efficiency, the Israeli government passed a law requiring installation of solar water heaters in newly constructed buildings. The outcome of this requirement was successful and today, 85 per cent of Israel’s 1,650,000 households use solar water heaters. The solar water heaters save 1.6 billion kilowatt hours each year, which would have otherwise accounted for 21 per cent of the domestic electricity use and makes Israel “one of the largest per capita user of solar energy in the world.” The widespread use of and confidence in solar water heaters have produced a situation where the difference in cost between an electric and solar heater can be recouped in less than four years.

6.3.2. Industrial Solar Water Heating Application
Despite success in domestic solar use, Israel did not adopt large-scale industrial solar power in the initial stages. Failure to internalize the environmental and other externalized costs of fossil fuel resulted in solar energy costing 2 to 3 times as much as energy from coal or natural gas. The lack of precedent for solar development produced uncertainty that increased the costs of investment in solar energy utilization within Israel’s industrial sector; even the use of solar water heaters for non-residential purposes was stymied. Businesses could write off the use of fossil fuel for tax purposes, but shops and industrial plants were excluded from the solar water heater requirement.

6.3.3. Market Sustainability
The very first commercial solar water heaters in Israel was based on a tried and tested design - William Bailey’s Sun Coil design. By using the same type of metal for the tubing in both the collector and the storage tank, the disastrous electrochemical corrosion problems experienced in the US were avoided; in Miami, it was observed that when iron tanks and

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copper piping was used, the water tanks burst about ten years after they had been installed. The Israeli government took steps to ensure that the solar water heaters were of adequate quality, particularly for export. Most importantly, unlike many countries where the solar water heating industry was allowed to die when cheap energy suddenly became available, in 1980 the government made the use of solar water heaters compulsory in new private dwellings and hospitals, elderly citizens' homes, hotels, dormitories and educational institutions. Besides regulations, leaders also led by example; one of the first persons in Israel to have a solar water heater installed in his home was David Ben-Gurion. Experience has shown that when political leaders set the example, others are more inclined to follow, regulations or no regulations.

By careful selection of suitable and reliable technology, demonstration of government commitment through regulations, and demonstrated political-will through example-setting from the political leadership, Israel was able to create a successful, sustainable solar water heating market.

The main lesson from Israel is the **power of government regulation**, such as was enacted under the planning and construction law in 1980, requiring the placing of solar water heating systems in new private dwellings, in advancing the solar water heating industry.25

### 6.4. SOUTH AFRICA

South Africa is located at the southernmost region of Africa, with a long coastline that stretches more than 2,500 km and along two oceans (the South Atlantic and the Indian). At 1,219,912 km² South Africa is the 25th-largest country in the world; the country lies between latitudes 22 and 35 °S. The interior of South Africa is a vast, flat, and sparsely populated scrubland, the Karoo, which is drier towards the northwest along the Namib Desert. In contrast, the eastern coastline is lush and well-watered, which produces a climate similar to the tropics.

South Africa has one of the highest insolation (hours of sunshine) rates in the world. Despite this less than 1 per cent of households across the country have solar water heaters; this is in stark contrast to countries such as Cyprus, which has installation rates of 92 per cent, and Israel, which is around 60 per cent.

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25 The regulation, promulgated in 1986, mandated that all domestic residences, up to nine storeys high, must make use of solar water heating.
6.4.1. Progress
South Africa was a world leader during the early phases of SWH development; there was already a fledging market during 1961 when government doubled the rail rates on all manufactured goods. This move resulted in extremely high transport tariffs on solar water heaters and their price soared beyond what was either affordable or acceptable to the market. The local manufacturing firm that had been the leading producer of Solar Water Heaters since 1954 was forced out of business that same year (1961) and for a while the industry lied in abeyance.

Later (in around 1980), the government supported the promotion of SWHs. The Centre for Scientific and Industrial Research (CSIR) developed effective communication strategies and projects, which motivated homeowners to install them. Homeowners would pay, either with a home improvement loan, or paying cash. The SWH market grew, and six major companies manufactured, marketed and/or installed SWHs, focusing on middle- to high-income customers. The average heater cost around R 3,500 (USD 500) for a 200-litre (50-gallon) system, which most houses installed. The industry flourished, and in 1983 about 27,000 m² of solar collectors were produced. In that year, the SWH communication project came to an end, and following the discontinuation of the CSIR promotion, the market collapsed and has not yet recovered since although there are encouraging signs of an industry revival more recently.

There has been perennial cognizance of the fact that the residential sector in South Africa consumes around 17 per cent of the country’s electricity; the largest electricity consuming appliance in many middle- to high-income households is usually the electric water heater, which typically accounts for around 30 per cent of the total electricity used in these households. Estimates suggest that this translates to around 5 per cent of the country’s energy consumption and the oil price peaks of the 1973, 1980 and, more recently, 2008 have on occasion renewed interest in the industry.

6.4.2. Market Sustainability
The enthusiasm for the industry has however been kept in check by later experiences with product performance – corrosive water and clogging of direct thermosiphon systems. In fact, some of the major players withdrew from the market after those experiences. A combination of lacking awareness, lacking sustained government initiatives, vested interests, lacking standardisation and cost effective test procedures, as well as the lack of industry cooperation in promotion and training led the situation where the glazed SWH market has continually stagnated. The advantages of mass markets never materialised.

In keeping with global trends, South Africa’s domestic water heating market is moving away from traditional water heating methods, such as electric and LPG water heaters,
towards solar water heaters. Recently, the number of suppliers of solar water heaters in South Africa expanded from less than 20 in 1997 to 400 at the beginning of 2011. Within the last four years (between 2007 and 2011), this flurry of activity within the market produced volatile growth which was plagued by malfunctioning products, “fly-by-night” companies, and incorrect installation and application of the products. Nevertheless, market growth continued, albeit slower than expected, as many suppliers experienced a hush after this initial boom: The market began to stabilize somewhat during the second half of 2010 as many “fly-by-night” companies selling cheap, imported, turnkey products left the market or changed their strategy, while established companies with developed reputation formed efficient distribution networks, franchises and partnerships.26

The government intends to provide regulatory support through features such as new building codes which, when officially instated, will require new buildings or those undergoing refurbishments to account for at least 50 per cent of their hot water consumption through solar water heaters or heat pumps. Current and potential future manufacturers are preparing for this legislation-driven demand and are set to compete with foreign imports, which are categorized either by low price, large quantity (and often inappropriate technology) products on the one hand, or reputable, global solar water heater manufacturers with developed global distribution networks and more expensive products on the other. Government has set ambitious targets, such as that of reaching 1 million households within 15 years and have commenced a series of initiatives and projects in support of this drive.

The key challenge facing the development of the solar water heater market in South Africa will no doubt be the available capacity for installation and maintenance, as solar water heaters require a mix of plumbing and electrical skills, as well as unique solar installation skills, which must be learned.

The main lesson from the South African experience is that even in an environment where there is enterprising industry and mainstream public interest, bureaucratic measures can serve to kill the industry’s economic appeal. Further, it is also important to note that over-zealous signals, if left unregulated, can kill market confidence. The failure of government to sufficiently support the South African SWH industry has been identified on three distinct occasions, all with the same outcome – the market collapses.

6.5. TRENDS, PATTERNS AND INDICATORS

As demonstrated by the experiences in South Africa, solar water heating is a technology that can provide cost-effective energy solutions also to lower income part of the population and as further demonstrated, for instance, in Cyprus and Israel, can become a mass product leading to permanent market shift at the national level for the benefit of both the end users and the environment. In summary, it is an economic, commercially viable and available technology, which due to the different market barriers has not reached the market penetration rate that it could reach on simply economic grounds.

It has been noted however that the main constraint in the adoption of solar water heaters is purely economic. With its relatively high initial investment costs, the adoption rates are closely linked to promotion policies and regulations. The countries with the largest capacity per capita are Cyprus (government incentives – pull factors) and Israel (where SWH are mandatory on new buildings – push factors). The experiences suggest that tax credit and direct subsidies are appropriate for promoting solar water heaters. In Greece, tax reductions contributed in raising the capacity per thousand of inhabitants from 20 m² in 2005 to 360 m² in 2009. In Spain, subsidies and mandatory SWH on new buildings raised the capacity per thousand of inhabitants from 13 m² in 2005 to 47 m² in 2010.

Table 6.1: Promotion policies for solar water heating, European (selected) Countries.
Source: ENERDATA, from National Renewable Energy Action Plans, IEA and REN21

<table>
<thead>
<tr>
<th>Country</th>
<th>Type of measures</th>
<th>Target</th>
<th>Expected CO₂ emission reduction (ktCO₂)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Rebates Subsidies</td>
<td>169 ktoe by 2020</td>
<td>1,000</td>
</tr>
<tr>
<td>Cyprus</td>
<td>Subsidies</td>
<td>90 ktoe by 2020</td>
<td>1,000</td>
</tr>
<tr>
<td>France</td>
<td>Tax credit Investment grants</td>
<td>927 ktoe by 2020</td>
<td>3,100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 million homes equipped with SWH by 2020</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>Preferential loans Subsidies</td>
<td>1,245 ktoe by 2020</td>
<td>4,400</td>
</tr>
<tr>
<td>Greece</td>
<td>Tax reductions Minimum solar contribution to the hot water supply</td>
<td>355 ktoe by 2020 60% of hot water needs from solar</td>
<td>1,100</td>
</tr>
<tr>
<td>Italy</td>
<td>Tax credit Subsidies</td>
<td>1,586 ktoe by 2020</td>
<td>5,000</td>
</tr>
<tr>
<td>Portugal</td>
<td>Subsidies Tax reductions Preferential Loans Mandatory SWH system on new buildings</td>
<td>160 ktoe by 2020 + 100,000 m²/year until 2020 1 m²/occupant in new buildings</td>
<td>510</td>
</tr>
<tr>
<td>Spain</td>
<td>Minimum solar contribution to the hot water supply</td>
<td>644 ktoe by 2020 10 million m² by 2020</td>
<td>2,300</td>
</tr>
</tbody>
</table>

¹ CO₂ emission reduction in tonnes of CO₂ equivalent.
Outside Europe, China and India are implementing ambitious solar thermal policies, setting targets of 300 million m² by 2020 and 20 million m² by 2022, respectively. Subsidies are currently the main lever being used to promote solar water heating, but other incentives are under consideration. Some towns like Kunming (Yunnan) and Dezhou (Shandong) in China have set targets to accelerate the development of solar water heating (50 per cent of buildings with solar hot water by 2010), while Shenzhen mandated SWH in all new residential buildings. India is planning to offer preferential loans and to make solar water heaters mandatory on new buildings. In the USA, where the market is still underdeveloped, SWH systems now benefit from a 30 per cent federal tax credit, while some States have also implemented credits and rebates.

Table 6.2: Promotion policies for solar water heating, Non-European (selected) Countries.
Source: ENERDATA, from National Renewable Energy Action Plans, IEA and REN21

<table>
<thead>
<tr>
<th>Country</th>
<th>Type of measures</th>
<th>Target</th>
<th>Expected CO₂ emission reduction (ktCO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morocco</td>
<td>Subsidies</td>
<td>1.7 million m² by 2020</td>
<td>450</td>
</tr>
<tr>
<td>Tunisia</td>
<td>Subsidies, Preferential loans</td>
<td>2.5 million m² by 2020</td>
<td>670</td>
</tr>
<tr>
<td>South Africa</td>
<td>Tax reductions, Rebates</td>
<td>4 million homes equipped by 2020</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>Mandatory SWH system on new buildings</td>
<td>1.05 million m² by 2020</td>
<td>290</td>
</tr>
<tr>
<td>Israel</td>
<td>Tax credit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>Tax credit</td>
<td>15 million m² by 2015</td>
<td>3,700</td>
</tr>
<tr>
<td>Brazil</td>
<td>Subsidies</td>
<td>1.8 million m² by 2012</td>
<td>500</td>
</tr>
<tr>
<td>Mexico</td>
<td>Subsidies, Investment grant</td>
<td>15 million m² by 2017, 20 million m² by 2022</td>
<td>4,100, 5500</td>
</tr>
<tr>
<td>India</td>
<td>Subsidies</td>
<td>300 million m² by 2020</td>
<td>54,500</td>
</tr>
<tr>
<td>China</td>
<td>Subsidies</td>
<td>6 million m² by 2020</td>
<td>1,100</td>
</tr>
<tr>
<td>Taiwan</td>
<td>Subsidies</td>
<td>342 ktoe by 2020, 1,882 ktoe by 2030</td>
<td>1,100, 6,000</td>
</tr>
<tr>
<td>Australia</td>
<td>Renewable energy certificates, Tax credits, Rebates, Subsidies</td>
<td>12% of homes equipped with SWH by 2020</td>
<td></td>
</tr>
</tbody>
</table>
6.6. CRITICAL LESSONS LEARNT

6.6.1. Solar water heater adoption is closely linked to state promotion policies
World solar water heating capacity has increased four-fold since 2000. The growth is closely linked to promotion policies and countries with a long-term promotion policy have a high share of systems installed per capita (Austria, Germany, Turkey, etc.) and in some cases reaching saturation (Cyprus and Israel). Within the Caribbean, Barbados and St. Lucia provides clear evidence on the role of government promotion policies in market penetration.

6.6.2. Solar water heating adoption is enhanced by national target setting
Some countries set mandatory national targets for renewable energy shares of final energy consumption. Many of the successful cases for solar water heating deployment have been driven by target setting – within the European Union, Austria, Cyprus, Germany and Greece have been highlighted. Important too is the role of interim targets, which are crucial monitoring devices for progress. In many instances, targets have been linked to clean development and provide clear goals to which government promotion policies may be aligned. South Africa’s target of solar water heaters in 4 million homes by 2020 recently resurrected interest in the technology within that country.

6.6.3. Timing is critical to solar water heating market expansion
If there was ever an adage that defines the most critical elements required for boosting the solar water heating industry in any country, it would be timing, timing, timing.

In Israel, the expansion of the industry coincided with a huge influx of immigrants who required immediate housing, which set off an unprecedented boom for both the construction and the solar industries. In Cyprus, the 1974 invasion by the Turks, which uprooted thousands of Greek Cypriots from their homes, required that government house nearly one-third of the island’s population. Since it built the homes, government made the decision to install solar water heaters. Barbados also owes the expansion of its solar water heating market to the mass conversion of sugarcane lands into housing during the construction boom of the 1970s to 1990s. The deliberate timing of government support for the industry that coincides with the proliferation of new housing construction seems to be a common thread among the highest per capita users of solar water heaters.

6.6.4. The “market will deliver” philosophy is wishful thinking
Experience has shown that the market does not care enough for the environment nor the security of the energy supply and project developers typically pursue the cheapest, most proven (which is often the most traditional) means of hot water production – electricity and gas. Consequently, penetration of solar water heating worldwide remains relatively (around 5 per cent) low despite the maturity and simplicity of the technology.
The supply chain created by enterprising entrepreneurs will find little progression to end-use unless government levers work to either push consumers (through appropriate regulations) or pull them (through attractive incentive packages) from the more conventional to solar water heating technologies. Table 6.3 below show that within the most successful countries, the industry is supported by either regulations (Israel) or incentives (Cyprus, Australia, Germany and Barbados); these are institutionalized within the framework of renewable energy policies. Important also is the role of public awareness programmes that communicates the opportunities to the market.

The market needs the right investment framework and incentives; countries that have exhibited the greatest success in solar water heating market deployment have used push or pull factors. The countries with the largest capacity per capita are Cyprus (high subsidies and government incentives) and Israel (where SWH are mandatory on new buildings); Barbados, which is has the third-highest capacity per capita, uses a mixture of push and pull factors in the form of consumption taxes on conventional heaters and tax deductions toward solar water heater purchase.

**Table 6.3: Critical Parameters for Promotion of a Successful Solar Water Heating Industry.**
Source: Consultant generated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cyprus</th>
<th>Israel</th>
<th>Australia</th>
<th>Germany</th>
<th>Barbados</th>
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</thead>
<tbody>
<tr>
<td>Financial Incentives for Project Developers</td>
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<tr>
<td>Tax Incentives for Manufacturers</td>
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<tr>
<td>Consumer Financing Programme</td>
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<tr>
<td>SWH Regulation in Building Code</td>
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<tr>
<td>Detailed Demand Assessment</td>
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<tr>
<td>Business Development Grants</td>
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<tr>
<td>Broad-based Customer Education</td>
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<tr>
<td>Government Support for Marketing</td>
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<tr>
<td>Government R&amp;D Support</td>
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<tr>
<td>Capacity Building Programme</td>
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<tr>
<td>Renewable Energy Policy</td>
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<tr>
<td>Integration of SWH into Energy Economy</td>
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</tbody>
</table>
Barbados has been recognized globally for achieving high penetration level (over 40 per cent) of solar water heaters and has for many years developed an industry encouraged by supportive government policies. Despite the obvious opportunities however, other CARICOM member states have however struggled to reproduce the results achieved by the “Barbados Model”. In order to identify, understand and develop mechanisms for the removal or minimization of the barriers that mitigate the mainstreaming of solar water heating within CARICOM member states, stakeholder surveys and dialogues were conducted. There are many factors that currently mitigate the mainstream deployment of SWH across the Caribbean. Three factors that are already worth mentioning are, inter alia:

- Insufficient knowledge on the opportunities for SWH;
- High initial investment costs – relative to gas-fired or electric water heaters; and
- Split-incentives in regard to landlords/project developers and tenants/buyers; frequently, those who make decisions on the investment are not the final users who pay the energy bill.

Key stakeholders within the region include public service commissions and other state agencies, local government agencies, energy service providers and public utilities, potential developers and financiers, potential manufacturers and merchants, regional and national standards bodies, consumer group representatives, and others; they were engaged during the project in order to help in the establishing of criteria for identification and evaluation SWH options in the respective CARICOM member states.

Stakeholder Analysis is a methodology used to facilitate institutional and policy reform processes by accounting for and incorporating the needs of those who have a “stake” or an interest in the reforms under consideration. The model of Stakeholder Analysis applied in the case of this project relied on a variety of tools – based on both qualitative and quantitative data – to understand stakeholders, their positions, influence with other groups, and their interest in a particular reform. Significantly, these activities were able to capture the attitude of people within the region on the level of expectation in behavioural change toward sustainable energy use and the role that SWH may play toward same.

Four member states (The Bahamas, Barbados, Jamaica and Trinidad and Tobago) were selected for particular focus on the basis of their historic, current and perceived future importance to the development of a regional SWH market.
### 7.1. THE BAHAMAS

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>INTEREST</th>
<th>INFLUENCE</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government Energy</td>
<td>SWH as an alternative to electric water heating, especially in new housing developments.&lt;br&gt;Interest is <strong>high</strong>.</td>
<td>Energy is a part of the portfolio responsibility of the Ministry of Environment.&lt;br&gt;Influence is <strong>moderate</strong>.</td>
<td>Wants to see legislation to incentivize SWH and prohibit electric water heating.&lt;br&gt;<strong>High</strong> importance.</td>
</tr>
<tr>
<td>Government Communication</td>
<td>Public awareness for RE opportunities within The Bahamas.&lt;br&gt;Interest is <strong>high</strong>.</td>
<td>The Bahamas Information Service (BIS) has very limited capacity for producing public awareness packages.&lt;br&gt;Influence is <strong>very low</strong>.</td>
<td>SWH is very important to the Bahamas energy strategy and technical assistance is required for enhancing public awareness programmes.&lt;br&gt;<strong>Low</strong> importance.</td>
</tr>
<tr>
<td>Public Utility Electricity</td>
<td>Cursory interest in SWH as a Demand Side Management (DSM) tool, especially in households.&lt;br&gt;Interest is <strong>low</strong>.</td>
<td>The Bahamas Electricity Corporation (BEC) is the state-owned electric utility operator.&lt;br&gt;Influence is <strong>high</strong>.</td>
<td>BEC does not have the capacity to become seriously involved in SWH implementation; the belief is that such should be consumer-driven rather than utility-led.&lt;br&gt;<strong>Moderate</strong> importance.</td>
</tr>
<tr>
<td>Public Utility Water</td>
<td>Utility-based ESCo for SWH technology in households and small hotels.&lt;br&gt;Interest is <strong>moderate</strong>.</td>
<td>The Water &amp; Sewerage Corporation (WSC) is the state-owned water utility operator.&lt;br&gt;Influence is <strong>low</strong>.</td>
<td>WSC does not have the financial resources to participate in the financing of SWH but is willing to do so if external financing is available.&lt;br&gt;<strong>Low</strong> importance.</td>
</tr>
<tr>
<td>SWH Distributor Importer</td>
<td>Expanding market-base for SWH and PV technology within The Bahamas, to include operation as an ESCo.&lt;br&gt;Interest is <strong>very high</strong>.</td>
<td>There is one major player (Alternative Power Sources Limited).&lt;br&gt;Influence is <strong>moderate</strong>.</td>
<td>Legislation to facilitate the operation of ESCo should be pursued; consider incentives that are aimed at reducing payback period, such as tariff removal.&lt;br&gt;<strong>High</strong> importance.</td>
</tr>
<tr>
<td>Hotel Sector Management</td>
<td>Cost reduction through appropriate mix of energy efficiency and renewable energy technologies, including SWH.&lt;br&gt;Interest is <strong>moderate</strong>.</td>
<td>Hotels account for over 20 per cent of electricity use in The Bahamas and the tourism sector accounts for 60 per cent of GDP.&lt;br&gt;Influence is <strong>very high</strong>.</td>
<td>For large properties, most investment is being made on the efficiency rather than the renewables side as the costs seem to be more reasonably justified in the latter; believes there is nonetheless some potential for SWH in small hotel properties.&lt;br&gt;<strong>High</strong> importance.</td>
</tr>
</tbody>
</table>
### 7.2. BARBADOS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>INTEREST</th>
<th>INFLUENCE</th>
<th>POSITION</th>
<th>Importance</th>
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</thead>
<tbody>
<tr>
<td>Government Energy</td>
<td>Replicating the “Barbados Model” in other CARICOM countries with Barbadian manufacturers facilitating technology and knowledge transfer to fast-track the industry.</td>
<td>Though Government continues to tangibly support the local SWH manufacturing industry, the Ministry of Energy is not a significant player. There is enhanced role to be played via SEFB.</td>
<td>The regional market is being threatened by “cheaper, inferior” Asian technology products; the market should be centred around regionally manufactured goods rather than external imports.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Government Trade &amp; Investment</td>
<td>Enhancing the international competitiveness of local SWH manufacturers.</td>
<td>BIDC facilitates such activities as international (including regional) trade missions and has provided over USD 250,000 to SWH manufacturers in 2011.</td>
<td>The exportation of SWH from Barbadian manufacturers to other CARICOM member states will be important to regional market development.</td>
<td>High</td>
</tr>
<tr>
<td>National Standards Body (BNSI)</td>
<td>Reviewing the current (outdated) codes that guide technology design in the Barbados SWH industry.</td>
<td>The BNSI is not a regulatory but rather an advisory body. It therefore does not enforce standards but rather, recommends best practice codes.</td>
<td>SWH testing is being done (via FSEC) as a marketing tool as there is no policy requirement in Barbados; BNSI wishes to develop the capability for testing.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Regional Standards Body (CROS-Q)</td>
<td>Providing a platform from which national standards bodies, engineering and architect bodies, and SWH manufacturers can work to develop regional MEP for the technology.</td>
<td>CROS-Q is however an implementing agency of CARICOM and is directed by the COTED through which member states advance recommendations.</td>
<td>Minimum Energy Performance Standards and Testing, as well as Manufacturers’ Code, may be developed under the CROS-Q/IDB/MIF project.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Public Utility Electricity</td>
<td>Finding appropriate mechanisms to fit DSM into the utility business model.</td>
<td>BL&amp;P is a privately owned utility (mostly owned by AMERA) and has monopoly over the electricity sector.</td>
<td>There is scope for study to examine: (i) Water Heating Demand; and (ii) The Market for Substitution of Electric Water Heater with SWH in Barbados; BL&amp;P is willing to support such study but will neither initiate nor finance same.</td>
<td>Moderate</td>
</tr>
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<td>GROUP</td>
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<tr>
<td>SWH Distributors</td>
<td>Manufacturing SWH from Barbados designs via</td>
<td>Local SWH technology dominates the Barbados industry –</td>
<td>The regional market is being threatened by “cheaper, inferior” Asian</td>
<td></td>
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<tr>
<td>Manufacturers</td>
<td>technology and knowledge transfer in other</td>
<td>there are no imported SWH. Also, Barbados manufacturers</td>
<td>technology products; the market should be centred-around regionally</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CARICOM member states.</td>
<td>may have supplied as much 80 per cent of the installed</td>
<td>manufactured goods rather than external imports.</td>
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<tr>
<td></td>
<td></td>
<td>regional capacity.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Interest is <strong>very high</strong>.</td>
<td><strong>very high</strong>.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering &amp; Architects</td>
<td>Designing capacity building programmes on</td>
<td>There is very little or no discussion with SWH</td>
<td>Among local architects, there is no integration of SWH into architectural</td>
<td></td>
</tr>
<tr>
<td>Associations</td>
<td>Integration of sustainable energy design,</td>
<td>manufacturers and consequently, there is no influence</td>
<td>designs; appropriate SWH technology is typically selected during the</td>
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<td></td>
<td>including SWH, for architects.</td>
<td>by architects on SWH design; most custom-built features</td>
<td>construction phase of most projects.</td>
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<td></td>
<td></td>
<td>are designed to fit architecture rather than integrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest is <strong>high</strong>.</td>
<td>into early-stage design for optimization.</td>
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<tr>
<td></td>
<td></td>
<td><strong>moderate</strong>.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hotel Sector</td>
<td>Conducting hotel energy audits in Barbados</td>
<td>Audits focused on energy efficiency opportunities and</td>
<td>The opportunity to capture hot water demand, as well as currently</td>
<td></td>
</tr>
<tr>
<td>Energy Consultants</td>
<td>and the OECS.</td>
<td>unfortunately did not look at opportunities for energy</td>
<td>installed SWH capacity in the hotels in The Bahamas and Jamaica</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>service provision, such as SWH.</td>
<td>(the remaining project countries).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest is <strong>moderate</strong>.</td>
<td><strong>very high</strong>.</td>
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<td><strong>High</strong>.</td>
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### 7.3. JAMAICA

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<th>GROUP</th>
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<tbody>
<tr>
<td><strong>Government Energy</strong></td>
<td>Securing an appropriate policy mix (of incentives and regulations) for promoting SWH.</td>
<td>The Ministry of Energy has portfolio responsibility for the Petroleum Corporation of Jamaica (PCJ), and agency tasked with implementing demonstration projects for renewable technologies.</td>
<td>Wants to see legislation to incentivize SWH and prohibit electric water heating.</td>
</tr>
<tr>
<td></td>
<td>Interest is <strong>high</strong>.</td>
<td>Influence is <strong>high</strong>.</td>
<td><strong>High importance.</strong></td>
</tr>
<tr>
<td><strong>Government Finance</strong></td>
<td>Examining the economic case for SWH incentives.</td>
<td>The Ministry of Finance negotiates all incentive packages, especially within the constraints posed by the IMF Standby Agreement.</td>
<td>Wants sufficient proposal delineating the economic benefits of SWH incentives to GDP.</td>
</tr>
<tr>
<td></td>
<td>Interest is <strong>low</strong>.</td>
<td>Influence is <strong>very high</strong>.</td>
<td><strong>High importance.</strong></td>
</tr>
<tr>
<td><strong>Government Planning</strong></td>
<td>Enhancing the integration of sustainable energy, including SWH, into the energy economy – in keeping with Vision 2030.</td>
<td>The Planning Institute of Jamaica (PIOJ) is mandated to coordinate inter-agency planning but has very little direct oversight for planning implementation.</td>
<td>Wants to see SWH replace significant portion of the DHW services that are currently provided by electricity.</td>
</tr>
<tr>
<td></td>
<td>Interest is <strong>moderate</strong>.</td>
<td>Influence is <strong>low</strong>.</td>
<td><strong>Low importance.</strong></td>
</tr>
<tr>
<td><strong>National Standards Body (BSJ)</strong></td>
<td>Re-establishing the capability to conduct testing on solar and other renewable technologies.</td>
<td>The BSJ is the leading national standards body in CARICOM and is guides the establishing of regulatory codes in Jamaica.</td>
<td>The establishment of <strong>minimum energy performance</strong>, as well as <strong>performance rating</strong> is deemed critical to the protection of local consumers and the guarantee of returns on government investment in incentives.</td>
</tr>
<tr>
<td></td>
<td>Interest is <strong>very high</strong>.</td>
<td>Influence is <strong>moderate</strong>.</td>
<td><strong>High importance.</strong></td>
</tr>
<tr>
<td><strong>Public Utility Electricity</strong></td>
<td>Interested in public awareness activities that will, hopefully influence national behaviour towards the use of SWH.</td>
<td>JPSCo is a privately owned utility (mostly owned by Marubeni) and has monopoly over the electricity sector.</td>
<td>Focussing on supply side (generation) efficiency, to include fuel diversification; does not have the resources to engage in DSM.</td>
</tr>
<tr>
<td></td>
<td>Interest is <strong>low</strong>.</td>
<td>Influence is <strong>high</strong>.</td>
<td><strong>Moderate importance.</strong></td>
</tr>
<tr>
<td>GROUP</td>
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<tr>
<td>SWH Distributors Importers</td>
<td>Establishing local SWH manufacturing facility in Jamaica for supplying local and regional markets.</td>
<td>Currently, there are a number of SWH distributors; thus far, most projects have been market-driven (in the absence of incentives or regulatory policies).</td>
<td>Legislation to facilitate the operation of sustainable SWH manufacturing should be pursued; consider incentives that are aimed at removing tariff on raw material, etc.</td>
</tr>
<tr>
<td>Electrical Engineering Association</td>
<td>Implementing engineering design projects for SWH in commercial facilities, especially hotels and hospitals.</td>
<td>Jamaican engineers were among the earliest group to design commercial SWH systems within the Caribbean; there is still available technical capacity.</td>
<td>There is opportunity for looking at integrated solutions for energy service provision that includes DHW or industrial water pre-heating; consider PV/T, solar cooling, etc.</td>
</tr>
<tr>
<td>Hotel Sector Owners</td>
<td>Cost reduction through appropriate mix of energy efficiency and renewable energy technologies, including SWH.</td>
<td>The umbrella body that represents hotels, Jamaica Hotel &amp; Tourism Association (JHTA) galvanizes the support of significant portion of the industry.</td>
<td>There is interest in any mechanism that may contribute to the reduction of energy bill. SWH is highly desirable but investment costs are prohibitive.</td>
</tr>
<tr>
<td>Consumer Organization Household</td>
<td>Understanding consumer demand for DHW services, as well as technology options that are available for SWH.</td>
<td>The Consumer Affairs Commission (CAC) is a statutory body that monitors and evaluates the cost-effectiveness of consumer goods and services.</td>
<td>There is no data that suggests DHW is a significant service in the majority of low- to middle-income households.</td>
</tr>
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### 7.4. TRINIDAD AND TOBAGO

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<tbody>
<tr>
<td>Government Energy</td>
<td>Implementing pilot/demonstration projects for SWH use within Trinidad &amp; Tobago.</td>
<td>The Ministry of Energy is largely focussed on activities in the oil, gas and petrochemical sector but has available financing for project implementation.</td>
<td>Wants to introduce renewable technologies as concept proof in order to prepare the country for transition to the clean energy economy. Moderate importance.</td>
</tr>
<tr>
<td>Government Finance</td>
<td>Encouraging the use of non-fossil energy sources, such as SWH.</td>
<td>The Ministry of Finance has the ability to both utilize incentives to enhance SWH use on both the supply and end-use sides, as well as to provide government financing for projects.</td>
<td>Influence is moderate. Very high importance.</td>
</tr>
<tr>
<td>Government Housing</td>
<td>Developing “green” housing projects for low- and middle-income groups.</td>
<td>The Ministry of Housing, through the HDC, controls significant portion of existing housing stock and is also largely responsible for future developments.</td>
<td>Wants to see SWH replace significant portion of the DHW services that are currently provided by electricity as part of clean development mechanism; intend to access carbon financing for same. Very high importance.</td>
</tr>
<tr>
<td>National Standards Body (TTBS)</td>
<td>Participating in the development of MEP codes for SWH technologies in the region.</td>
<td>The TTBS is not significantly influential in the energy sector as its activities are mainly geared toward traditional goods; not enough capacity for renewable technologies monitoring and testing.</td>
<td>Willingness to work with CROS-Q and NSB (such as BSJ) that are sufficiently endowed with capacity to develop and implement regulatory code(s). Low importance.</td>
</tr>
<tr>
<td>Public Utility Electricity</td>
<td>Utility of natural gas for direct water heating services – natural gas is viewed as the preferred fuel source and SWH as uneconomical.</td>
<td>The electric utility, T&amp;TEC, has monopoly over transmission and distribution of electricity. Supply side investments are largely state-financed and there is little incentive for clean energy projects.</td>
<td>Willingness to participate in DSM project for SWH if externally-driven (by CDM financing, etc); belief remains that SWH is not sufficiently economical to compete with electric heating. Low importance.</td>
</tr>
<tr>
<td>GROUP</td>
<td>INTEREST</td>
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</tr>
<tr>
<td>SWH Distributors Manufacturers</td>
<td>Establishing local SWH manufacturing facility in Trinidad for supplying local, regional and Latin American markets.</td>
<td>Two companies with SWH manufacturing plants in Barbados already operate in Trinidad; one company is majority-owned by Trinidadian investors.</td>
<td>Wants to pursue model that places Trinidad as a major manufacturing centre for SWH collectors and PV panels for integration into regional business and for export to North and Latin America.</td>
</tr>
<tr>
<td>Energy Service Company (ESCo)</td>
<td>Establishing energy efficiency and renewable technology provision as part of a thriving regional model.</td>
<td>Despite the low status of energy efficiency in Trinidad, the most prolific ESCo type company in the region is Trinidadian. The model currently on offer is not a full ESCo as there I no financing component.</td>
<td>Willingness to pursue complete ESCo model, especially for commercial sector; this requires both government incentives to encourage SWH end-use, as well as regulations to legitimize the establishment of ESCo.</td>
</tr>
</tbody>
</table>

7.5 GENERAL OVERVIEW

The countries selected – Trinidad and Tobago, Jamaica, The Bahamas and Barbados – are the four largest economies in CARICOM and account for more than approximately 70 per cent of the aggregate regional GDP (when based on nominal 2010 estimates). These economies, it is believed, will form the critical limbs in the anatomy of a regional SWH market. The analysis shows that the groups of highest importance are typically from Government ministries (Finance, Energy or Trade and Industry); SWH manufacturers/distributors; and the hotel sector. The role of the electric utility, in all cases, is deemed to be at best moderate.

The following descriptions hold:

- **Interest** The level of interest exhibited by stakeholder toward the mainstreaming of a regional SWH market
- **Influence** The level of power held by the stakeholder regarding ability to influence the critical parameters required for market deployment
- **Position** The positioning of the stakeholder as a key player toward the mainstreaming of a regional SWH market, to include what the stakeholder is prepared to do towards facilitating same.

The various attributes are ranked according to five levels: *inter alia*, Very Low, Low, Moderate, High, and Very High.
8. IMPLEMENTATION STRATEGY AND ROADMAP

8.1. MARKET BARRIER REMOVAL FOR SOLAR WATER HEATING

Although strong market development for SWH has been evidenced in some CARICOM countries, notably in Barbados and to a lesser extent in St. Lucia, solar water heating is hardly utilized in most other countries despite the most favourable climatic conditions and economic benefits. By any standards, the economic feasibility and greenhouse gas reduction potential for increased use of solar thermal applications for hot water preparation is huge and comparable to any other form of renewable energy. Despite the opportunity to significantly accelerate market uptake of solar water heating with comprehensive and well-designed barrier removal activities, there have been very few projects dealing specifically with solar water heating among the hundreds of medium- and full-size renewable energy projects within the region.

A number of barriers to the development of commercially, institutionally and technically sustainable solar water heating systems in CARICOM states have been identified and discussed within the framework of the CARICOM Renewable Energy Capacity Support (CRECS) project. The principal barriers to be addressed are typical for an underdeveloped market and relate to four principal marketing elements: **product, price, promotion and policy**. Solar Water Heating is an economic, commercially viable and readily available technology, which due to the different market barriers has failed to reach the desired market penetration rate. In the absence of the suggested strategic initiative to stimulate the SWH market and to remove the related barriers simultaneously in several CARICOM countries, the regional SWH market development will not reach the level that is expected despite the technical maturity and cost-efficiency of the SWH systems.

The barriers identified by this study are consistent with those previously reported by CREDP for renewable energy in general. These were, inter alia: (i) **Policy** (legislation and regulation): A lack of consistent energy policies hampers private sector participation in the business side of the energy sector; (ii) **Finance**: Relatively low international credit-rating of most CARICOM countries results in a lack of investor confidence for project financing and the resulting feature is excessive collateral requirement and high-interest terms for loans; (iii) **Capacity**: Limited skill-base for developing energy policies, as well as for energy planning and forecasting; (iv) **Awareness**: Limited knowledge among the populations regarding the commercially-developable renewable energy resources and technologies for CARICOM states, as well as the cost-benefits to end-users. Despite much effort, these barriers seem to have persisted and are also applicable to SWH deployment.
8.1.1. Policy-related Barriers

In many cases, solar thermal technologies seem to have been somewhat forgotten by policy makers – the policies to support them seem to be “less developed” than for other renewable energy technologies. Solar thermal technologies are often viewed as “low tech”. Nonetheless, they currently provide a greater contribution to the global energy demand than solar electricity – photovoltaic (PV) and concentrating solar power (CSP) altogether and have the potential to contribute much more toward meeting a significant portion of the energy demand than other renewable energy technologies (Figure 8.1). The same is also true within CARICOM states. The total installed solar thermal capacity due to solar water heaters is around 175 MW, which translates to a displacement in electricity generation capacity of just under 300 MW when generation and transmission and distribution losses are factored. This is almost equivalent to the combined capacity of other renewable sources, circa 310 MW. Taken into context, wind and hydro account for around 30.7 MW and 235 MW respectively.

Figure 8.1: Cumulative Capacity and Annual Energy Output for Renewable Energy Technologies
Source: Weiss et al. 2006
1. Legislation and institutional barrier

Within the majority of CARICOM states, there is a lack of supportive legislation and institutional capacity for solar water heating project development. Despite some move towards the preparation of modern NEPs, development of financial mechanisms that encapsulate the requisite “financial” criteria for the private sector, financial institutions and end-user groups are typically absent. There is general cognizance within CARICOM states of the need for enabling policies to accelerate the growth of renewable energy technologies. The pace of development has been nonetheless, modest at best and the current state of energy legislation varies among CARICOM states. Despite efforts from the CARICOM Secretariat (through the Energy Unit), CARILEC and the OAS (through CSEP), only five of twenty CARICOM member and associate member states have National Energy Policies that have been approved by their respective governments; in the instance of Guyana, the policy is outdated (nearly 20 years old) and is in urgent need of revision. Another eight have already produced Draft NEPs while the remaining seven are in varying stages of developing same. A number of case analyses have shown that a modern energy policy, with renewable energy support mechanisms, is necessary for a thriving SWH market (Table 6.3).

Recommendation 1: The finalization (and in cases, revision and modernization) of National Energy Policies for CARICOM states should be prioritized as this is an important precursor to the successful deployment of renewable energy, including SWH, technologies.

Much of the current thrust towards renewable energy legislation within the region focuses on grid-scale renewable energy generation. In instances where small-scale renewable applications are considered, there seem to be an “overwhelming focus” on electricity generation applications and as a consequence, much more attention and detail is paid to issues such as distributed generation and grid interconnection issues, to include net-metering, net-billing and feed-in-tariff. As a consequence, only three of twenty CARICOM member and associate member states either have, or are examining policies that provide direct incentives for the implementation

Instead of using electricity from the grid to heat water, the abundant free-energy of the sun is harnessed by the solar system to generate the electric equivalence necessary to provide hot water to the end-user or the heat required to operate other systems used for manufacturing, process heat and air-conditioning. Solar thermal systems will directly reduce consumption of electric grid power in exactly the same way as solar electric generation technologies increase useable energy at the customer's site. For example, where a solar water heater is used in place of an electric water heater, a solar water heater that offsets 4,000 KWh of electricity per year has the same impact on grid power consumption as a PV system that produces 4,000 KWh.
of SWH to end-users; Barbados, Bermuda and St. Lucia provide tax rebates of USD 1,500 to 3,000 as a means of incentivizing investment in SWH. The relationship between SWH and electricity generation is underestimated and the “avoided electricity use” should be suitably rewarded.

**Recommendation 2:** Develop Generation Offset Legislation as a common law across CARICOM states so as to provide direct incentive to SWH end-user through tax rebates on account of the value of the technology to grid stabilization. The value of this incentive may be calculated based on delayed expansion, oil import savings and other country-specific features.

While the majority of countries with the highest penetration rates have regulations making installation of solar water heating systems mandatory for select types of buildings, many countries have continued to trust voluntary action. The disadvantage of the latter is that in the absence of strong regulations, there are more needs for fiscal and financial incentives, such as tax breaks, investment grants, low interest loans etc. to make the SWH systems more attractive to the customers, especially during the initial market stage. Many CARICOM states are limited in their ability to provide fiscal and tax incentives as a consequence of their current economic situations and in some instances, conditions imposed by multilateral lending agencies. Further, evidence – Israel, Cyprus and Barbados – shows that SWH industry development is typically enhanced at times of significant construction boom; hence, the requisite need for regulation to “push” the choice of water heating technology from conventional to solar, especially for new construction.

The stability of financial incentives is a key condition for a sustainable growth of the solar thermal market. For this reason, regulation or incentives based on law have stronger effects than short-term incentive programs based on ad-hoc budget lines. The latter have been often applied, at national or regional level, but their short-term success has often turned into a barrier to growth in the long-term. If the budget of the incentive program is not enough to cover the demands, the funds have often been disbursed long before the end of the budget period. In this case, potential users often expect a reactivation of the incentive program and postpone the purchase of a solar system. This leads to short-term “overheating” followed by breakdown of the market, when incentives are temporarily stopped. The impact of such a stop-and-go dynamic is particularly negative, as the long-term growth of solar thermal relies on the development of a strong network of specialized distributors, system designers and installers, which is rather discouraged by the instability of the political framework. The suggestion is that whatever incentives are applied, they should be set on the long-term.
**Recommendation 3:** Solar Ordinance Legislations, which are harmonized across CARICOM member and associate member states, should be used to promote the use of SWH for hot water services in: (i) off-grid areas; (ii) commercial production, tourism and health facilities; and (iii) new hospital, hotel and large residential developments.

The ordinance should form part of the **sustainable energy requirement** of a regional Building Code that is to be deployed through the regional standards body, CROSQ. As a minimum, new buildings should be made “solar water heating” ready with relevant plumbing infrastructure that can, whenever desired, facilitate roof-based hot water storage systems. It is especially important for the ordinance to make it compulsory for government housing, hospital and hotel constructions as the participation of government in the market sends the right signal to other developers and also provide “proof of concept” for the technology. In essence, where government owns or develop buildings, it is important to lead by example.

A mix of “push” and “pull” factors are **necessary but not sufficient** for promulgation of a successful and sustainable SWH market. Integrated resource planning, including the subsets of **regional, national, and local** energy planning are necessary “stepping stones” in SWH market transformation. The mainstreaming of SWH into energy conservation, energy efficiency and renewable energy planning is necessary for optimizing the benefits and market opportunities thereof. With the exception of Barbados, current planning and institutional practices commonly hinder growth in the respective national SWH markets. Frequently, conflicting policies and programmes from different government ministries and agencies results in a policy environment that is neither conducive for nor supportive of the development and promotion of the market for solar water heaters. In the case of Barbados – and in many CARICOM states – government have policies that remove or reduces customs tariff for the purchase of imported goods and equipment within the hotel sector. Typically however, there is no requirement for preferential purchasing, to include energy efficiency and renewable energy options (such as SWH) and consequently, procurement is done on the basis of the lowest investment cost.

**Recommendation 4:** Develop an **Energy Planning Division** within the appropriate ministry or agency with responsibility for planning in the respective member states. This Office should have the authority to identify and engage energy sector stakeholders, including electric utility operators and regulators, as well as renewable energy (including SWH) project developers and technology suppliers, for **periodic planning activities** for the energy sector. One outcome of this approach is the harmonization of national activities that are related to strategies for supply- and demand-side management; it is especially important to shift expansion planning from the electricity to the energy sector, to include heat demand.
With conventional water heaters overwhelmingly dominating the market in most locations, consumers wishing to adopt SWH technology often encounter difficulty in finding retail outlets or system design and installation businesses with adequate knowledge to properly size, install, and maintain solar water heating systems. Linkages between the various parties involved in the SWH industry are often underdeveloped, and there is often little or no coordination between the public and private sectors to promote alternative energy technologies. In contrast, electric or gas water heaters may be purchased and installed by most neighbourhood hardware and household appliance stores.

**Recommendation 5:** Develop and institutionalize the capacity for the SWH industry through the creation and maintenance of a Regional Training and Certification Programme for industry workers. Most activities, so far, have focussed mainly on installers but there is need for capacity development related to the engineering, marketing, financing, and economic modelling of SWH. The HEART/NTA and BVTB may be utilized as sub-regional centres within the North and South Caribbean respectively to provide “polytechnic-type” training for the industry. Certification, which is recognized as a part of the CVQ programme, can facilitate the movement of skills throughout the region so as to fill “capacity gaps” that may exist in select member states.

### 2. Split-Incentive Barrier
A typically under-rated but critical barrier is probably the “split incentives” problem, which arise for solar thermal technologies both in the new construction and rental markets. Property developers and buildings owners renting their properties have little incentive to invest in energy saving equipment, including SWH, while the returns on investments will go to actual occupants. In theory it is possible to conceive of financial arrangements between builders and homeowners or between landlords and tenants where the costs and benefits of energy efficiency investments are shared. In practice this is very difficult to achieve due to inadequate information, high transaction costs, and market inertia.

**Recommendation 6:** Consideration should be given to third-party financing, such as Pay-as-You-Save (PAYS) systems; this is a market infrastructure that enables either the building owner (landlord) or tenant to install energy efficient products (including solar water heaters) with no capital expenditure and no debt, through a third party vendor. This can then be paid for on a periodic basis through an energy service charge that is lower than the savings realized by the bill-payer. This is an energy service charge mechanism that ensures that whoever gets the savings pays the bill, a mechanism which is transferable to the subsequent tenant should the tenant who used a PAYS solar water heating product re-locates.
The use of PAYS systems have had some degree of success for energy efficiency, including solar water heating technologies in Hawaii, New Hampshire and other limited US locations. There are however, some essential components that are necessary for them to work successfully. These include, inter alia, a third-party who verifies the savings of the products, a local utility that provides the billing and transfer of charges to the provider of the PAYS product and the provision of capital to the vendor in order to finance the capital costs of the PAYS products. The role of government as a “facilitator” in the process cannot therefore be overstated.

Split incentives also exist in large companies or administrations, such as hospitals and hotels, when the resources for investment and running costs are separated and the decision-maker may not benefit from the fuel savings resulting from investment in solar equipment. Other split incentive examples arise in existing “collective dwellings”. It would be a coincidence if everyone feels the need to modify the installations within the building to, for instance, replace an existing electric with solar water heating system, though there is a chance for adoption if majority decision or unanimity is not required. Moreover, some flats might be rented, in which case the “split incentives” issue for some may become a barrier for all. If one dweller in the building wants to act in isolation, the installation of a single device may become technically very complex and, for example, an occupant within a multi-story building will still require permitting from a majority of co-owners. As a consequence of the many permutations and combinations that exist in such facilities, experts typically consider solar technologies for multi-dweller buildings only in new constructions and complete retrofitting processes.

As there is no simple panacea for solving the split incentives problem to date, obviating the problem may be the best way to address it in the future. Designing, legislating, and enforcing building codes, energy codes, and energy-related appliance selection so as to promote high energy performance in the built environment would obviate the tenant-landlord investment problem over time, as new buildings would be legally required to be energy efficient initially.
**Recommendation 7:** The inclusion of new large commercial facilities such as hospitals and hotels, as well as “collective dwellings”, under the Solar Ordinance Legislation is necessary for optimizing the installation of solar water heaters in the construction of facilities that would have otherwise been limited by the “split incentive” barrier. Design engineers and architects must be trained and certified in order to provide reliable implementation and performance, in order to derive the anticipated cost-savings from same.

### 8.1.2. Promotion-related Barriers

**Lack of Awareness**

When many within the Caribbean think of solar energy, they envision photovoltaic panels on rooftops. Though this technology of electricity generation represents an important tool for reducing the region’s dependence on fossil fuels however, solar energy can do much more than generate electricity – it can also be used to heat water for domestic, commercial or industrial use.

Within CARICOM states, there is insufficient empirical knowledge on the costs and benefits of solar water heating technologies; this is mostly due to a lack of performance evaluation and monitoring for demonstration projects, as well as very little reporting requirement for SWH manufacturers, distributors and retailers. The consequence is limited awareness on the potential of solar water heating for public, residential and private commercial sectors among key decision-makers, architects and engineers, and various end-user groups.

**Recommendation 8:** Outreach programmes are necessary for raising awareness among potential customers of the possibilities of solar thermal technologies and is especially useful for informing them of the state of maturity reached by solar water heaters, integrated systems (such as PV/Thermal) and other related systems (such as solar cooling). Demonstrations that provide “concept proof” are also useful.

Training, especially of engineers and installers, is also a key component in the awareness programme as in many instance, these individuals provide guidance to potential clients and are highly influential in the decision-making process. Comprehensive support programmes for market deployment, can also reduce the lack of solar competence among professionals in the energy service industry, HVAC installers, architects and building developers. This training should not focus only on the technical aspects. Sales and marketing people, for example, should be able to use other economic criteria than “payback time” to support the profitability of their products and also delineate the environmental benefits more substantively.
8.1.3. Price-related Barriers

High Capital Cost
The rapidly rising international market prices of fossil fuels have significantly improved the attractiveness of solar water heating and other renewable energy resources during the past few years, but the financial barriers have not yet disappeared. Although SWH systems are now available in many territories, they are capital intensive and represent a significant one time expenditure for most customer segments.

Recommendation 9: Best practices have shown that fiscal measures have a structural impact on SWH market development. These typically include tax-deduction for private home owners or corporate tax incentives for companies or non-profit organizations. Fiscal incentives should be used to promote SWH use by those governments that have the necessary “fiscal space” to support same.

Options for Financing
Without access to financing options, most SWH markets will remain small. A major criterion for market expansion must be the development of mechanisms to encourage the finance sector within the respective countries to create new credit instruments for the residential and commercial/industrial SWH markets, which will require direct government intervention. The support of multilateral funding facilities require government backing and Blended Grant/Loan Mechanisms that provide capital to financial institutions or third-party financers (such as ESCOs) require serious consideration. In addition, tax-incentives for financial institutions and energy service companies engaged in SWH consumer loans or third-party financing should be utilized where possible.

The fact is that solar water heating system financing can come in various forms. A mix of options is advisable as various stakeholders will have different loan access abilities and loan portfolio preferences. Financing mechanisms to be considered include:

- **Retailer financing**, where the customer pays the vendor in monthly installments
- **Commercial loans**, through commercial and mortgage banks, credit unions or building societies, structured as:
  - Corporate loans, where loans are secured by company assets
  - Secured personal loans, where loans are secured by client assets or revenue streams, such as a salary, car or home
  - Unsecured personal loans, usually referred to as a consumer loan
  - Micro credit (group lending)
  - Supplier credit, where the customer takes a loan, which is paid directly to the supplier and both share repayment risk
Third-party financing, structured as:
  - Leasing
  - Pay-as-You-Save (ESCO service) contract

**Recommendation 10:** Most of the financing within CARICOM states thus far have focussed on banking products in target markets, including corporate finance, secured personal loans, consumer loans, and supplier credit. Except for the case of Barbados, and to a lesser extent St. Lucia, there have been very little direct incentives such as tax rebates for solar water heater purchase. The fact is that many national governments do not have the “fiscal space” within which to provide incentives that will affect traditional revenue streams (such as property and personal income taxes) and consequently, are limited in their options. The most significant potential for financing is perhaps third-party financing that is capitalized through a revolving fund derived through a “mix” of Blended/Grant Loans from the World Bank/IDB and carbon financing.

A USD 600 million project, executed over ten years, would serve to produce around 15,000 GWh of thermal heating over ten-years, thereby eliminating around 27.48 million barrels of oil, save around USD 2,748 million of foreign exchange from avoided oil-imports and lower GHG emissions by around 8.2 million CO₂ equivalents compared to the BAU scenario. A number of sub-regional ESCOs may be developed to function within defined regional zones in order to derive maximum impact from same. Focus should be on the hotel, hospital and industrial sectors, as well as new housing construction in the first instance. It has been estimated that the project can earn as much as USD 80 million in carbon financing (See Chapter 9) and would require an additional USD 200 million in start-up financing through Blended Grant/Loan multilateral funds. The facility may then be administered through a “revolving process” that involves utility companies, credit unions, mortgage banks, hotel and tourism associations, and energy service companies.

**Capacity Development for the Financial Sector**
For the financial inflows to provide the desired market expansion, a range of subsidiary activities will need to be undertaken in support of the development of the financial instruments that promote solar water heaters. These should include: (i) general awareness raising and loan officer training; (ii) technical support for setting-up and administering dedicated loan instruments; and (iii) financial support mechanisms to reduce specific front-end barriers that hinder the development of SWH credit markets. These activities are described in detail below:
1. **Banker Training/Awareness Raising:** The goal of this area of activity would be to get banks to see SWH systems as an economically and technically sound product, worthy of dedicated credit instruments both for residential and commercial/industrial markets, including the following:
   a. **Awareness Raising and Outreach:** Produce relevant, practical, timely information on SWH products and customer profiles, tailored to the financial audience. Provide banking institutions with the information, tools and training needed to gain awareness of, and experience with, SWH systems and in so doing to influence their willingness to begin lending or managing loan portfolios to the sector.
   b. **Programme Training and Capacity Building:** As needed, work with bank training staff or institutes to develop and/or integrate SWH loan product curricula into normal loan officer training programmes. Develop a standardized “train the trainer” SWH package to facilitate this process. For smaller financial institutions that lack in-house training programmes, offer dedicated SWH training programmes and materials to loan officers.
   c. **Loan Marketing Activities:** Assist participating banks in preparing marketing campaigns for dedicated SWH loan products. Assist in the customer segmentation process, for instance using behavioural scoring systems to identify the most suitable customer profiles for commercial advertising and mailings.

2. **Loan Programme Technical Support:** Provide technical support to domestic credit institutions in setting up and managing dedicated SWH loan programmes to include:
   a. **Solar Water Heating Technical Standards:** Stipulate minimum technical specifications for products eligible for commercial financing, revised from time to time depending on changes in technologies, operating experience and customer preferences. The regional standards body, CROSQ, is required to work closely with local national standards bodies, laboratories and testing institutes to define the applicable technical specifications.
   b. **Vendor Qualification Support:** Vendor qualification support will help the financing institutions to establish qualification processes to ensure that vendors satisfy technical criteria, in terms of their products, and are able to provide the required after-sales service and suitable warranty support. Vendors would be added and deleted from the qualifications panel from time to time depending on audits of their performance and their compliance with qualification criteria.
   c. **Investment Evaluation Support:** For larger SWH financing activities in the commercial or industrial sectors, banks and financiers should be provided with targeted expertise and support to evaluate investment proposals and to help these institutions develop the skills to evaluate such projects independently. The support provided could come in the form of partial grant or contingent grant funds for the contracting of expert consultants to advise on first-time transactions in a particular sector and cover incremental costs and advisory work for SWH projects. A broad range of activities could be eligible for support, ranging from project technical reviews, third party assessments and financial risk analysis.
Activities supported would generally focus on evaluating incremental risk issues related to these new technologies.

3. **Specific financial support mechanisms (credit enhancements):** These can be introduced to reduce risk for the local lending institutions or to facilitate increased demand for their loans. Credit enhancements are a variety of approaches for softening loan financing, either for the lender or the borrower. The concessions come in the form of interest-rate reductions or risk sharing.

a. **Interest Rate Softening:** Interest rate softening lowers the cost of financing for the borrower and can be an effective means of helping banks build loan portfolios in specific target sectors. By assuming the entire credit risk, the bank’s interests are fully aligned with those of the donor, both in terms of minimizing defaults and continuing lending activity after the donor support has been phased out. However this approach is subtle and therefore will only work in larger national SWH markets where banks can be confident building sizeable loan portfolios quickly. In less developed, smaller markets, transaction costs might outweigh the benefits for the bank; hence, this should be applied to the larger markets such as Jamaica, Trinidad and Tobago, and Barbados only.

b. **Guarantees:** Guarantees, another form of credit enhancement, are most effective at addressing elevated banker perceptions of risk; once a bank has gained experience managing a portfolio of renewable energy loans, they are in a better position to evaluate true project risks. Partial risk guarantees ensure debt-servicing payments to selected lenders or other investors in a project, usually for specific time periods or exposure levels. Partial credit guarantees act to extend loan repayment periods, thus improving the project’s cash flow. Both forms of guarantee can motivate banks to lend for projects they perceive as risky, thereby protecting the initial capital investment and ensuring sustainability of the revolving loan facility.

8.1.4. **Product-related Barriers**

**Technical Barriers**

In order to develop the SWH market, the local supply chain must develop in parallel. It is a balanced process in which the increased demand from the market must be matched with the availability of decent quality products and along with it an infrastructure of sufficiently trained installers.

Also, the establishment of a training and certification system for and supporting the actual training of the SWH installers is envisaged. The approach is that two centres of excellence – HEART/NTA in Jamaica and the BVTB in Barbados – should be identified and developed for supporting training in the Northern and Southern CARICOM states respectively. Regional
certification should be developed and linked to the CVQs, thereby enabling skilled installers to work throughout the region through the CSME Skills Certificate arrangement. Non-CSME territories, such as The Bahamas and the associate member states would require alternate arrangements.

**Recommendation 11:** A key component of the strategy require that the region build the capacity of the manufacturers to improve their product quality and design as well as the business skill of the distribution chain to offer better quality and more attractive services to the targeted end user. While there is significant scope for technology transfer from the Barbados manufacturers to potential partners in other territories, similar to the example of St. Lucia, there is also scope for promoting cooperation with foreign manufacturers as a means of diversifying product offering and perhaps reducing cost within the region. The reality is that the price of the Barbados technologies are higher than the global average and a coordinated mechanism is required for further design enhancements that are geared towards cost-reduction without compromising the existing high quality and performance.

The region currently suffers from an absence of norms, standards, certification, “codes of practice” and performance contracts for solar water heating systems and consequently misses a key element for market development; the ability to base technology supply and financing support on quality as determined through Minimum Energy Performance (MEP). Though the Barbados products currently dominate the market, any significant expansion may require the development of additional supply chains. The financing of SWH products (through incentives and loans) will be based upon anticipated product performance and lifecycle assessment. The lack of MEPs poses a risk to market expansion as mediocre technology may enter the regional market and less-than-expected performance can erode consumer confidence in SWH.

**Recommendation 12:** CROSQ should work with national standards bodies to develop product standard and labelling rules for SWH. There is need for the establishment of at least two sub-regional centres – Bureau of Standards, Jamaica (BSJ) and the Trinidad and Tobago Bureau of Standards (TTBS) – for performance testing. It is anticipated that as the regional market expands, Trinidad and Tobago will perhaps overtake Barbados as the leading manufacturers of SWH within the Southern Caribbean.

### 8.2. INDUSTRIAL APPLICATIONS FOR SOLAR WATER HEATING

The challenge of developing an energy sector that will promote sustainable development requires the development of institutional capacity to plan and implement an energy strategy in an integrated manner, as it requires transferring concepts of sustainable development at the global level into livelihood at the local level.
The principal business of an industrial facility is production of goods, not *energy production* or end-use efficiency. This is the underlying reason why market forces alone will not achieve industrial solar water heating use on regional basis, “price signals” notwithstanding. High energy prices or constrained energy supply will motivate industrial facilities to try to secure the amount of energy required for heating operations at the lowest possible price. But price alone will not build awareness within the corporate culture of the industrial firm of the potential for the energy savings, maintenance savings and production benefits that can be realized from the systematic pursuit of industrial solar water heating applications. In Jamaica, for instance, industrial electricity tariff is 30 US cents per KWh and the country has significantly lost much of its competitive advantage against Trinidad and Tobago, whose electricity price is almost an order of magnitude less (See Table 8.1). Nonetheless, industries in Jamaica have failed to embrace the use of SWH applications to reduce their energy costs despite the obvious opportunities. It is this lack of awareness and the corresponding failure to manage energy use with the same attention that is routinely afforded production quality, waste reduction and labour costs that is at the root of the opportunity.

Table 8.1: Comparative Costs of Key Inputs into Manufacturing
Source: JMA Competitiveness Study (2010)

<table>
<thead>
<tr>
<th>Input</th>
<th>Unit</th>
<th>COST/USD</th>
<th></th>
<th></th>
<th>Jamaica Comparative Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>JAMAICA</td>
<td>COSTA RICA</td>
<td>TRINIDAD &amp; TOBAGO</td>
<td></td>
</tr>
<tr>
<td>Middle Manager</td>
<td>Per annum</td>
<td>35,000</td>
<td>39,348</td>
<td>24,000</td>
<td>1.11</td>
</tr>
<tr>
<td>Professional Personnel</td>
<td>Per annum</td>
<td>20,000</td>
<td>14,700</td>
<td>12,750</td>
<td>1.46</td>
</tr>
<tr>
<td>Supervisor</td>
<td>Per annum</td>
<td>12,000</td>
<td>10,152</td>
<td>8,900</td>
<td>1.26</td>
</tr>
<tr>
<td>Skilled Labour</td>
<td>Per annum</td>
<td>5,200</td>
<td>2,787</td>
<td>4,524</td>
<td>1.42</td>
</tr>
<tr>
<td>Unskilled Labour</td>
<td>Per annum</td>
<td>2,500</td>
<td>2,028</td>
<td>2,100</td>
<td>1.22</td>
</tr>
<tr>
<td><strong>Electricity</strong></td>
<td><strong>Per KWh</strong></td>
<td><strong>0.30</strong></td>
<td><strong>0.10</strong></td>
<td><strong>0.04</strong></td>
<td><strong>7.50</strong></td>
</tr>
<tr>
<td>Factory-space Rental</td>
<td>Per Sq. Ft.</td>
<td>4.25</td>
<td>4.0</td>
<td>4.75</td>
<td>0.97</td>
</tr>
<tr>
<td>Telephone Call to US</td>
<td>Per Minute</td>
<td>1.14</td>
<td>0.80</td>
<td>0.90</td>
<td>1.34</td>
</tr>
</tbody>
</table>
Companies that actively manage their energy use seek out opportunities to upgrade the efficiency of equipment and processes because they have an organizational context that supports doing this wherever cost effective, while companies without energy management policies do not. Experience has shown that the provision of technology-based financial incentives for SWH in the absence of energy management will not result in significant enough market shifts because there is no organizational context to respond to and integrate the opportunity into on-going business practice (See Figure 8.2).

**Recommendation 13:** A portfolio of industrial policies is needed that is designed to assist companies in developing the organizational context for supporting industrial solar water heating, while also providing *consistency, transparency, engagement of industry in programme design and implementation*, and, most importantly, *allowance for flexibility of industry response*. The opportunities for SWH applications in the regional food processing industries (including breweries) should be pursued as priority.
Figure 8.2.: Organization Mechanism for Promoting Industrial Solar Water Heating

Consultant generated

**CAPACITY BUILDING (Outputs) PHASE**

- **Team of system optimization experts**
  - Provide system optimization training
    - Develop highly skilled core practitioners
  - Develop & test tools to support sustainability
    - System optimization library documentation

- **Governments**
  - Hire experts to conduct initial training & develop supportive policy package
    - Management standards, target setting, tax incentives, minimum performance, etc.

**IMPLEMENTATION (Outcomes) PHASE**

- **Industrial Plant Engineers**
  - Conduct plant assessments
    - Train factory personnel, develop & document projects

- **Manufacturers’/Distributors/ESCOs**
  - Sell system optimized services
    - Develop & document projects

- **Technical educational institutions**
  - Train future generations of skilled practitioners

- **Trained system optimization experts**
  - Use training, library & methodologies to develop projects

- **Industrial Plant Managers**
  - Use trained system experts to develop & document system projects

- **Bureaus & National Standards Institutes (BNSI)**
  - Recognize documentation and integrate into certification process

- **Governments**
  - Promote standards & other policies for system projects

**INTEGRATION (Objectives) PHASE**

- **Solar Water Heating in industrial system becomes “business as usual”**

- **Recognize documentation and integrate into certification process**

- **Train future generations of skilled practitioners**

- **Use training, library & methodologies to develop projects**

- **Use trained system experts to develop & document system projects**

- **Promote standards & other policies for system projects**

- **Technical educational institutions**

- **Trained system optimization experts**

- **Industrial Plant Managers**

- **Bureaus & National Standards Institutes (BNSI)**

- **Governments**
8.3. ROADMAP FOR REGIONAL SWH MARKET EXPANSION

The expansion of the SWH market within CARICOM states will occur most readily if driven by renewable and energy efficiency, and the related carbon reduction, targets rather than through a stand-alone programme. Consequently, the strategic direction that is provided by the respective NEPs, as well as the tax and other incentives for renewables – and in some instances, subsidies – that are offered through the respective national governments are deemed to be critical for success.

The fact is that the cost of electricity within the majority of CARICOM states averages around 38 US cents per KWh and is among the highest in the world; this is a major drag on the competitiveness of the respective economies. Consumers largely blame this state of affairs on the electric utilities; they feel the power companies, with the help of “lax” regulators within the respective countries, have not invested sufficiently or wisely in generating capacity and continually abuse their transmission and distribution monopolies within the respective markets. Unfortunately in most CARICOM countries, profits to the (private and government-owned) electric utilities are guaranteed. Also, regulation of the sector is usually weak and competition is non-existent and consequently, the electricity sectors have been slow to adapt and exploit new technological opportunities within the renewable energy sector, including the prospects available through solar water heating. Typically, the focus of resources and effort is on large-scale renewable energy projects on the grid as part of the fuel diversification strategy.

Despite the lack of data on installed hot water technology within the region, it can be verified that within the residential sector the main source of energy – covering almost all households – is electricity. In the commercial and public sectors, the choice is essentially the same as in the residential sector, with a mix of “more or less mix” tanked gas (LPG). In the industrial sector, the fuel choice change, and (except for Trinidad and Tobago) fuel oil, diesel oil and biomass appear as the main inputs for water heating, followed by electricity. Solar water heating, in part, addresses electric utility issues such as demand side management, distributed generation and supply-side planning. The “decoupling” of hot water heating from the electric grid may be achieved through expansion of the market for solar water heaters, which serves to on the one-hand reduce electricity end-use and on the other-hand delaying or avoid new power generation infrastructure that would be required to match rising electricity demand. Also, there are benefits to be derived from enhanced energy security and the significant carbon emissions reduction. The roadmap for solar water heating market expansion will require coordinated policy and planning support; to include: (i) the completion of NEPs for CARICOM states; (ii) the drafting and adoption of Solar Ordinance Laws; (iii) the design and adoption of training and awareness programmes; and (iv) the development of suitable financing facilities, which promote the industry.
The Roadmap for accelerating SWH market expansion within CARICOM requires as a starting point, the fast-tracking of NEP adoption within the respective territories. Global Case Studies have shown that ALL successful SWH markets are supported by clearly defined energy policies (Chapter 6); NEP’s provide the necessary framework for policies – incentives or regulations - in support of SWH deployment. The Case Studies have shown that either regulations requiring SWH use (push factors) or incentives that encourage same (pull factors) are necessary tools for market expansion.

It has been estimated that the current installed SWH capacity within CARICOM states is around 170 MWth. With the right mix of policies and demonstrations, this may increase five-fold (to around 840 MWth) by 2016. There is significant scope for carbon financing as a consequence of the 6.5 million tons of “bundled” CO₂ emissions, which may be derived over a ten-year project cycle from a deliberate programmatic regional approach that yields the aforementioned expansion in SWH use. The immediate identification of a regional implementation organ to drive the process is critical for its success – one possible option is the CARICOM Climate Change Centre.

This is necessary for addressing the required mechanisms, such as “Pay as You Save” third-party financing, which are critical for removal of price, split-incentive and capacity barriers. All this is, of course, promulgated on the addressing of the legislation and technical barriers for quality control by governments.

- Complete and adopt NEP’s for CARICOM member and associate member states
- Conduct regional SWH audit to determine “firm” solar thermal capacity; this is a pre-requisite for CDM financing
- Conduct regional market assessment
- Develop PDD for CDM Project Financing

- Replace 30,000 electric water heaters in existing households with SWH
- Retrofit 8,000 households with SWH
- Install 12,000 SWH in new households
- Install 1.2 MWth SWH capacity in hotels
- Develop Ordinance Laws for SWH

- Replace 30,000 electric water heaters in existing households with SWH
- Retrofit 18,000 households with SWH
- Install 12,000 SWH in new households
- Install 2.0 MWth SWH capacity in hotels
- Install 0.4 MWth SWH capacity in hospitals

- Replace 20,000 electric water heaters in existing households with SWH
- Retrofit 52,000 households with SWH
- Install 12,000 SWH in new households
- Install 1.0 MWth SWH capacity in hotels
- Install SWH in breweries

- Replace 20,000 electric water heaters in existing households with SWH
- Retrofit 62,000 households with SWH
- Install 12,000 SWH in new households
- Install SWH in food processing plants

- Install 12,000 SWH per annum in new households
- Install SWH in new hotels and hospitals
- Develop SWH export market to service North America and LAC region – to include French and Spanish Caribbean territories
9. INTEGRATION OF SWH INTO THE SUSTAINABLE ENERGY ECONOMY

9.1. ENERGY PLANNING

Energy planning is the process of developing long-range policies to help guide the future of national and regional energy systems. Within CARICOM states, energy planning is often conducted through a “top-down” approach and is mainly driven by “vertically-integrated” electric utility companies, with limited input from government regulators; planning is largely characterized by supply-side considerations. The utility traditionally plans its generation capacity based on projected growth – typically 20 years in advance – and fuel choice, as well as conversion technology is based on least cost expansion mechanisms.

The role of governments continues to be mainly focused on setting the framework for regulations in the electricity sector (for example, influencing what type of power plants might be built or what prices are electricity). The fact is however that most governments within the region have suffered critically from a lack of human resources – a deficit that has affected the quality of deliberation that feeds into making complex decisions about energy. As a consequence, the requisite level of analysis and modelling of key outcomes that is often required for successful sustainable energy planning is usually forgone for more expedient decision-making in which energy planning is grid-based and utility-led.

The aims of sustainable energy action planning are: (i) optimal energy-efficiency; (ii) low carbon energy supply; and (iii) affordable, accessible, equitable and good energy service provision to end-users. Such planning is based on consideration of the broader concerns of the whole economy, environment (particularly carbon mitigation) and society, not just a ‘least financial cost’ focus. And, it is led by the demand for energy services. Key characteristics of sustainable energy action planning are as follows:

- All energy sources and energy-related activities are considered as a whole system
- Carbon mitigation is a key determinant in the development of the plan and choice of project options
- The demand for energy services, rather than what energy can be supplied, is the basis for planning
- Energy conservation, energy efficiency and demand-side management are considered in preference to supply-side solutions
- Environmental and social costs are clearly considered
- Energy sector linkages with the economy are included
- The plan is flexible and can anticipate and respond to change
Good energy planning needs to be informed by the right kind of information. It is fairly easy to gather supply information (how much electricity is used by a city, etc.), but it is more difficult to gather information on who uses what energy sources, how they use these and why. This kind of energy information is very important for sustainable energy planning because in the new paradigm, the focus shifts to meeting the needs of the energy users in the best way possible. There are very significant economic, social and environmental benefits which can be gained by planning according to the needs of people and industries and these should be considered in national and regional energy plans. The needs of the electric utility and, in more recent cases, independent power producers and the energy sources from which they derive supply often dominate energy planning and end-use issues, such as hot water demand, are either not known or not considered.

Solar water heating is an “off-grid” technology but should be included in energy planning and target setting within the CARICOM energy sector. This is somewhat difficult however due to the limited available details on SWH installations. While information on the installed thermal, hydro, solar PV and wind generation capacity within the region are readily available, this Report represents a first attempt at “guessing” the installed solar thermal capacity (that is due to SWH) – around 170 MWth. Disaggregated renewable energy targets should contain solar thermal contributions. The mainstreaming of SWH into sustainable energy planning within CARICOM states will no doubt, send the correct signal to potential investors and boost the opportunities for commercial project financing.

A good demand-side database is important in order to develop energy action strategies and evaluate implementation; there is urgent need to address the data availability barrier, which continues to mitigate the expansion of the solar water heating market within the region. This requires audit of the available regional solar thermal capacity, as well as a market assessment to determine the full potential of the industry. This feature is especially important for the establishment of baselines for carbon financing under the CDM facility, as well as for the calculation of cost-benefit details for commercial financing.
The role of the utility is especially important as utility investment in additional capacity to supply demand may turn out to be a stranded investment if demand-side reduction is not properly integrated into the supply side planning; where ESCOs are involved, this cross-cooperation is critical towards ensuring that the benefits to all parties are realized. Currently, the participation of utilities in demand side management, such as solar PV, solar water heating and energy efficiency projects, is either limited or non-existent. Utilities frequently resent projects that seek to reduce electricity sales revenue once significant investment has already been made in the supply side through generation expansion. The incorporation of demand side projects, such as a solar water heating, into generation expansion planning is an important part of the new paradigm.

There is significant scope for utilities to shift their role from being electricity providers to becoming energy service providers, thereby delivering energy efficiency, solar water heating and other sustainable energy activities to customers through Pay-as-You-Save (PAYS) mechanisms. This may be most useful for instances in which there is sufficient available capital for energy service investment by the utility. Further, terms for energy service – including solar water heating – provision can be negotiated as a part of electric utility licences within the respective CARICOM states. There is also scope for, in some member states, “vertical separation” of potentially competitive segments (for instance, generation, marketing and retail supply) from segments that will continue to be regulated (distribution, transmission, system operations). This would enable more direct access of mainstream energy service providers to the sustainable energy, including solar water heating market.

In further considering possible solutions, the question must be posed as to what factors contribute to the shortfall of human capital within the public sector for energy planning. Undoubtedly, the existing constraints around compensation and the negative perceptions of the public service, fostered by pervasive criticism of an outmoded bureaucracy, are two such factors. As a result, not enough of our talent pool enters the sector, and when they do, they are often frustrated by organisational structures, which are not in keeping with their ideal of employment. The solution requires the private sector to “lend significant resources” to governments, specifically through secondments and

The implementation of broad-based steering committees or task teams that brings all the necessary players together will help build commitment and keep everyone on the same page. This team or committee should also be made up of government staff (in decision-making positions) and political champions who will be able to support and drive the process on-the-ground and act so as to ensure that a common vision and clear goals are agreed on, while allowing a flexible platform for diverse groupings to unite and combine tools and resources.
extra-curricular service, and for the governments in turn to adopt flexible structures that allow these resources to be brought to bear.

9.2. PROJECT FINANCING

Recent increases in electricity tariffs within CARICOM states have motivated householders and companies alike, to look for new energy products and services in order to decrease their costs. A clear and present opportunity lies in the use of solar thermal technology for DHW services in the residential, commercial and industrial sectors. Nonetheless, the regional market, except in Barbados, has remained largely under-developed. One of the reasons for this may be the complexity of the market infrastructure for solar water heating. The technology in itself is not the complicating factor, but the decentralized applications, requiring a widely developed infrastructure of SME’s is a critical success factor. Creation of a sustainable market infrastructure requires a consistent strategy and stable financial support mechanisms, which most countries are presently lacking.

Most countries are trapped in a “vicious cycle”. On the one-hand, CARICOM states are predominantly characterized by an over-dependence on imported oil, which drives an electricity generation sector that is mainly based on thermal generation from diesel and heavy fuel oil. The on-going escalation of crude oil and energy prices and the current dependence on petroleum is neither sustainable for supplies nor affordable in the long-term. The high level of expenditure on oil significantly reduces the financial resources available to invest in social development, environmental protection, adaptation to climate change and improving food security. Paradoxically, the region’s vast renewable energy resources, including its solar thermal potential, remain largely underdeveloped. Transforming the inefficient and fossil fuel-based energy sector is expected, over time, to significantly reduce the quantum of foreign exchange exported to pay for petroleum fuels. Many countries, such as Jamaica, are however burdened with high indebtedness and the substantial investments required for transformation of the energy economy are not usually available in-country. With limited access to consumer financing for SWH, upfront payments have been a common mechanism for SWH sales in many countries. However, typical household budgets and lack of accumulated savings among the majority of households in most developing countries severely restrict large capital expenditures and the requirement for up-front cash payments limits the SWH market to the wealthiest households or commercial enterprises.

Recently, governments (with technical assistance from multilateral organizations such as the OAS) have been instituting policies, such as tariff exemptions and tax rebates, to attract project financing for solar water heating. Meanwhile, financing institutions (banks, credit
unions, etc.) have been taking note and in instances, developed instruments for financing technology purchase and installation through loans to end-users. Despite capacity building within these institutions however, the time involvement and overhead costs related to providing small loans for domestic solar water heaters continues to keep the transaction costs for loans high. Hence, financing is usually more readily available for larger projects and, in the case of small projects, the project financing gap (Figure 9.1) arise.

Figure 9.1: The Project Financing Gap for Solar Water Heating Deployment
Source: Consultant generated

The fact is that this new reality in the energy market can create suitable opportunities for retail sale of new products and services. The “bundling” of small loans into a package may become necessary for financial institutions to become sufficiently involved in project financing. The inability to offer an “aggregate” package to a designated institution hampers
involvement from the banks which are unable, due to a lack of capacity, to sufficiently monitor and evaluate the project development, preparation and implementation activities for solar water heaters. Direct consumer loans enable term payments over a period of years and can increase affordability to the point where monthly or other periodic payments are comparable to the cost of conventional alternatives during the loan repayment period. This will serve to enhance the expected emergence in some markets of lease (rental) or “fee-for-service” (Pay-as-You-Save) operations that may provide the significant thrust that is required to overcome the financing barrier for SWH.

**Figure 9.2: The ESCO Model for Solar Water Heating Deployment**

Source: Consultant generated
The electric utility is faced with a number of difficult challenges: providing base load and meeting the peak demand in the evenings, expanding the grid to provide services to new development, and finding ways to increase their environmental stewardship. Privately-owned electric utilities must do all of this while returning a profit to the shareholders and keeping energy costs from rising, which directly impacts the host nation’s ability to attract investment, foster tourism and further economic development. Government run national utility companies face similar pressures. To say these conditions are challenging would be an understatement. To complicate the situation even more, utilities are being asked to allow consumers, both commercial and residential, to generate their own electricity with private generators and renewable energy technologies like wind and solar PV. Private generation is not new, but is increasingly seen as competition and lost revenue by the utility. Moreover, many utilities are under pressure to allow net-metering or to allow the customer to install wind and PV energy generation systems on their homes and businesses and feed renewable energy into the grid when the electricity produced by the renewable energy system is greater than the customer’s demand. Net-metering allows the customer to store energy credits on the utility’s grid for later use, banking their reserves or asking the utility to pay for their excess generation at the same retail rate the utility charges. Net-metering is often seen as direct competition to the utility.

It may seem surprising that solar thermal energy as applied to domestic hot water production – an idea that has been around for a long time – offers what electric utilities and their residential customers may want most in a new product and service. But distributed generation is a key element in de-centralizing the production of electricity for the security of the generation facilities, simultaneously reducing load impacts on the grid and reducing line losses. By generating energy at the customer’s site, the utility is reducing the capacity needed for the distribution system, improving the reliability, and increasing the quality of the power. There is significant scope for the provision of PAYS services through the utility company, dedicated energy service companies, or a partnership between both.

In some countries local/customer generation is not legal, but due to the perceived need to reduce their dependence on imported oil and to guarantee electricity supply, governments are under pressure to change the laws in an attempt to encourage greater use of renewable energy. Net-metering is a valuable tool for integrating renewable energy into the energy mix but as seen in the United States, it may take prolonged legislative processes or very “forward-thinking” utilities before it can be established throughout the region. Utilities must integrate new products and services to increase revenues, improve customer loyalty and retention, and establish barriers to market erosion. In many countries, business expansion via new products and services is now a central goal for utilities. The following are some service options:
**Leasing:** Leasing equipment is common in the business sector and is used as a method of financing equipment purchases. In the US and some other jurisdictions, a leased item is owned or financed by a third party who will typically realize a tax advantage by depreciating the item while receiving a fair price for the use of the product being leased by the customer. Commercial SWH systems may be financed in this way.

**Sale of Energy:** Sale of energy programmes can be applied to any type of water heating customer. Applications can include residential, commercial and industrial users of hot water. These Pay-as-You-Save (PAYS) programmes do not require capital investment by the customer; the utility company or another energy service provider owns, installs and services the SWH system. A third party might also own the equipment, with the utility or ESCo managing the administration. The owner/utility sells the energy generated by the solar thermal system to the customer. These arrangements can be structured as a “shared savings” or “performance” contract whereby the utility will charge a rate lower than the conventional electricity costs for the solar energy generated and supplied to the customer.

**Flat fee:** The “flat-fee” approach may be the best option for a PAYS program within CARICOM states, especially for the residential sector. Under this option, the utility would own, install and service the SWH system located at the customers’ home, hotel or business facility. The customer is charged a flat monthly fee for the use of the system. No metering equipment is installed in the system and the customer is responsible for any electricity used for supplemental heating of hot water. As with the sale-of-energy approach, third party ownership is also possible, with the utility managing the programme’s administration.

A PAYS programme can provide significant benefits to a utility company, including revenue and profits from the service fees charged to solar thermal customers and revenue from the sale of environmental attributes such as emission reductions (covered in the following section, 9.3) as well as reduced peak demand and fuel cost savings. Energy for water heating within an expanded CARICOM market may cost as little as 4 – 8 US cents per KWh, which is far less than the typical cost for diesel generation and also offers a very low risk as it relates to fuel cost stabilization, production and resource reliability. Successful examples include Hawaii Electric Company, Lakeland Electric and Jacksonville Electric Authority.

Finally, the International Finance Corporation (IFC) of the World Bank Group has been actively seeking to finance a greater number of renewable energy and energy efficiency projects and is developing special initiatives to accelerate the market penetration and commercialization of these technologies. Mechanisms may be explored for developing suitable financing arrangements for the aforementioned activities through the IFC, with some amount of carbon financing also considered.
9.3. GREENHOUSE GAS ABATEMENT

When SWH systems supplement or replace conventional water heaters, they displace some or all of the fuel that would have been used in those systems. While carbon intensity of baseline fuels for water heating varies, it is generally high within the majority of CARICOM states on account of the predominance of diesel and heavy fuel oil in their respective electricity generation mix. Consequently, emissions of greenhouse gases (GHG) and other pollutants are reduced through the use of SWH, helping to mitigate climate change while often improving local air quality, and sometimes indoor air quality as well.

Markets for international trade in GHG reduction credits offer important opportunities to overcome barriers and help advance SWH technology. Since global efforts to fight climate change began in earnest, GHG trading has been considered a practical way to control emissions while enabling compliance-flexibility and cost-efficiency to participants. Today, numerous voluntary and regulatory GHG trading programs are in operation. Despite the expiry of the Kyoto Protocol in 2012, and recent failed attempts toward securing a successor agreement, the carbon market still remains fairly active. This is partly as a result of European Union commitments to “significant reduction of GHG emissions” before 2020.

For developing nations, the Clean Development Mechanism (CDM) continues to provide an opportunity for carbon trading to support environmental protection and economic development. The CDM enables trade in GHG reductions between developing and industrialized nations for activities that contribute to sustainable development.

Environmental benefits aside, the emission reduction revenue that is derived from the CDM can help to surmount a multitude of barriers for SWH technology. Foremost, carbon finance can help to increase system affordability to end-users and enhance the viability of SWH projects and businesses. Financial arrangements that address constraints on SWH affordability, such as third-party financing and Pay-As-You-Save (PAYS) operations, could gain substantially by leveraging underlying and additional finance where project participants establish emission reduction purchase agreements with creditworthy CER buyers. Carbon trading can also help to overcome institutional, technical and other barriers to the development of SWH markets. In this context, SWH projects could potentially use carbon reduction revenue for market

With stringent project review and verification requirements and laborious procedures structured to safeguard environmental objectives, participation in the CDM can be arduous and costly, especially for less developed countries that are more likely to utilize low volume, small-scale projects. In response, the CDM now incorporates “special rules” for small-scale project developers, which are designed to enhance the chances of their participation in the scheme.
development, training, awareness-raising, and other activities to overcome barriers that constrain broader SWH dissemination, including the establishment and enforcement of quality standards.

The “bundling” of small-scale projects can help address the transaction costs associated with CDM participation and enable the attainment of common minimum size requirements. At the time of this report’s publication, there were few precedents where bundled projects involving SWH applications had completed validation for the CDM, but some projects were working their way through this process.

This Study provides the basis for two overarching conclusions: (i) Solar water heating can contribute substantially to carbon abatement while supporting the achievement of economic development goals; and (ii) Carbon finance can help overcome barriers to the broader adoption of solar water heaters. The degree to which SWH systems abate carbon is a function of several factors, such as baseline emission factors for conventional water heating, average insolation rates, SWH system efficiency, and total system volume.

We have estimated that the carbon abatement from residential and commercial SWH systems within CARICOM member states is slightly less than 500,000 tons of CO₂ equivalent per year. Further, our calculations and models indicate a potential for installation of around 850 MWth of solar thermal capacity, which can contribute further GHG abatement of around 800,000 tons of CO₂ equivalent per year or around 8 million tons of CO₂ equivalent over a ten-year project cycle.

The fact is that: “The overriding concern of developing countries is economic growth and poverty eradication.” Like other SIDS, CARICOM states are expected to engage on the question of climate change without harming the overriding development objectives and consequently, a “balancing act” is required. The region has the potential and available opportunity to generate meaningful quantities of GHG emissions reduction and CER revenue from clean energy projects involving SWH technology.

Even with streamlined procedures for small-scale projects, such as the envisioned regional SWH effort, the transaction costs of CDM participation remain substantial. These include the cost of establishing baselines, developing and implementing monitoring and verification plans, and addressing and documenting other prerequisites for CDM participation. There are additional costs to identify buyers, negotiate an emissions reduction purchase agreement, pay an Operational Entity to validate the Project Designed Document, and pay CDM registration fees; these costs may be as high as USD 200,000 and may require small grant financing to facilitate same.
10. CONCLUSIONS

The Study seeks to identify mechanisms for accelerating the commercialization and sustainable market transformation of solar water heating in CARICOM states, thereby reducing the current use of electricity and fossil fuels for hot water preparation. It will build on the encouraging market development rates already achieved in some member states – in particular, Barbados – and seek to further expand the market in other territories, where the potential and necessary prerequisites for market uptake seem to exist. Large-scale implementation of solar water heaters can result in significant and quantifiable displacement of electricity and hence significantly reduce GHG emission. Past assessment of solar water heater performance has been directed at the value for individual consumers and little consideration has been given to the value of capacity displacement and pollution reduction on a utility scale.

It should be noted that warm water is not an essential requirement among a significant number of CARICOM households, with many having no water heating technology. Domestic hot water penetration varies from as low as 1.1 per cent in Suriname to over 85 per cent in The Bahamas, Bermuda, Cayman Islands and The Turks and Caicos Islands. Yet, the growing numbers of electric heating devices are contributing significantly to the daily evening load peaks in the public electricity system, especially within The Bahamas. There is also significant scope for solar water heating use in the commercial and public sector (in particular, hotels and hospitals), as well as for industrial applications. Analysis that disaggregates the respective market segments is required however as much of the details required for data-driven decision-making is either limited or non-existent.

Recently, solar technology has been becoming increasingly popular, particularly in the use of water heating. This has been driven mainly by high electricity costs as global oil-prices continue to hover around USD 100 per barrel. While energy costs and incentive programs can be drivers for adoption of solar thermal systems however, other factors such as stable, sustained governmental policy and targeted educational and marketing campaigns are deemed critical for spurring market growth. Building on the analysis of several renewable energy projects, such as the CREDP, as well on consultations within select member states and a regional stakeholders’ workshop, the key barriers to market growth can be summarized as follows:

- High upfront costs and often higher overhead costs (related to marketing information, procurement and installation) of SWH systems compared to conventional water heating
- Lack of established market infrastructure
- Lack of attractive and specifically tailored financing mechanisms for customers considering high up-front costs as a barrier
- Lack of experience of the banking sector with SWH investments
- Lack of awareness, or adequate incentives, for the power grid operators to consider SWH as a technology to manage the electricity demand
- Solar water heating is not yet perceived as a standard option by planning professionals (architects, HVAC engineers, etc.)
- Low awareness of energy savings and environment benefits for solar water heating systems
- Lack of motivated and specifically skilled installers
- Lack of customer confidence on the technical performance of the solar water heating systems in the market
- Lack of internationally recognized and harmonized standards, certification and labelling schemes and testing procedures
- Applications with high potential (solar cooling; PV/Thermal, etc.) are not yet available on a mainstream basis
- Lack of incentives to support the early market development phase and the associated "learning costs"
- Split incentives, which happen when those responsible for paying energy bills are different than those making capital investment decisions
- In Suriname and Trinidad and Tobago, “subsidized” electricity rates make solar water heating economically unattractive, when compared to the rest of the region

While manufacturers and retailers traditionally sell solar heating systems within the region, there is significant opportunity for utility-based and dedicated energy service companies to offer solar heated water based on a “fee-for-service billing” or Pay-as-You-Save (PAYS) system. In this model, the cost per end-use will eclipse the clients' first objections connected to the value of initial investments, “split-incentive” issues that obfuscate the responsibility for the investment, and the fear of adopting a new and unknown technology. The likelihood is that financing required to capitalize the third-party process is derivable through a mix of Blended Grant-Loan Mechanisms, via the World Bank/IDB and other multilaterals, and carbon financing from the CDM. It has been noted elsewhere that the main constraint in the adoption of solar water heaters is economic and the relatively high initial investment costs of the technology requires that the adoption rates are closely linked to promotion policies and regulations of government.

It is anticipated that the expanded regional demand will drive the technology and skills supply-side. With the appropriate government signals, an enterprising industry will likely emerge; current manufacturers and retailers are expected to expand their operations to
take advantage of the market opportunities and other entrepreneurs will seek to enter both the manufacturing and import/retail sectors. There is a critical role for the backing of “supportive” governments that institutionalize the industry through an appropriate mix of regulatory and support procedures that will control product quality, thereby ensuring market confidence in solar water heaters, while simultaneously promulgating their use.

Of critical note is the fact that the countries which have been able to elicit significant contribution of solar water heating to their energy economies have all had one thing in common: bold leadership that motivated stakeholders to accept changes from the “business as usual” approach. In all cases, the use of policies (regulations and/or incentives) are leveraged, despite the fact that the outcomes of same could not have been guaranteed. Important also is the fact that in all instances, government played a significant role in the end-use market through the strategic procurement of SWH technology for public buildings, such as hospitals and state-funded housing developments.

The main misfortune within the region is that policy makers have typically had no agreed set of polices or agreed principles on which to devise sustainable strategies which can “pass the baton successfully from one runner to the next” with smooth continuity. Festina lente (make haste slowly) is the surest way to succeed in building a sustainable regional SWH market; the market will deliver philosophy is wishful thinking. This is perhaps the best lesson of the Barbados Model.
APPENDICES

1. Proceedings of the Stakeholders Workshop, Barbados
2. Mother Earth News Article, January/February 1984
3. Mother Earth News Article, November/December 1980
4. Applicable Conversion Factors
5. Generalized Cost of Solar Water Heaters
APPENDIX 1: WORKSHOP REPORT

DEVELOPMENT AND IMPLEMENTATION OF A STRATEGY FOR THE PROMOTION OF SOLAR WATER HEATING IN CARICOM MEMBER STATES

Proceedings of the Stakeholders’ Workshop BARBADOS
1. BACKGROUND TO WORKSHOP

Water heating end-use area is considered to be one which can significantly benefit from the increased use of RE in the form of solar water heating technology. This, given the high cost associated with production of hot water from conventional energy forms as well as the significant water heating demand in tourism, hospitality, institutional health sectors as well as domestic sector, coupled with the fact that there is an abundance of solar energy in all CARICOM countries. Barbados has been recognized globally for achieving high penetration level (over 40 per cent) of solar water heaters and has for many years developed an industry encouraged by supportive government policies.

Despite the obvious opportunities however, other CARICOM member states have however struggled to reproduce the results achieved by the “Barbados model”. Within the existing respective national energy policies, there are clear and present options for solar water heating and given the regional success story achieved by Barbados, mechanisms are being sought for other CARICOM countries to learn from the Barbados experience. The unique energy situation in each member state however requires surgical intervention that considers existing energy sources, end-use, country economics and the socio-political culture of the respective countries.

The purpose of this project is to develop a regional model that uses the best practices of the Barbados and other regional experiences, but nonetheless, considers the specificities of individual member states for the promotion and use of solar water heating. In partial fulfilment of this purpose, a Stakeholders’ Workshop was held in Barbados.

2. DATE AND LOCATION

The Stakeholders’ Workshop was held on Thursday December 8, 2011 at the Amaryllis Beach Resort in Hastings, Barbados.

3. WORKSHOP ORGANIZATION

The workshop was organized into three (3) sessions, to include a site visit that highlighted the SWH manufacturing operation within Barbados. The site visit was preceded by a presentation on the Barbados SWH Experience and the intent is to link the details thereof with the “concept proof”. General objectives of the workshop are, inter alia:

- Exploration of strategies for supporting expansion of Solar Water Heating manufacturing and systems’ use in CARICOM countries;
• Identification of effective, supportive legislative and regulatory frameworks for enhancing the expansion of Solar Water Heating manufacturing and systems' use in CARICOM countries;
• Analysis of the Barbados experience, thereby furnishing a suitable template for other CARICOM countries; and
• Examination of the status and requirements for capacity building, product performance, and quality assurance along the value chain for Solar Water Heating systems in CARICOM countries.

3.1. SESSION 1: PLANNING, REGULATING AND FINANCING

Objectives of Session 1

• The identification of governance processes to improve policy formulation that supports the mainstreaming of SWH into the energy sector, with focus largely on financing, procurement, regulatory and capacity building issues; the role of effective government incentive packaging and effective quality control are being highlighted towards same.

• The identification of individual national SWH potentials and aggregate the best potentials for regulatory, fiscal and other support and thereby developing the conceptual implementation plans; by identifying the potential SWH use within the respective territories, investors, developers and national regulators will be able to make more informed decisions about:
  o Cost of SWH implementation;
  o Regulations that are required to provide quality control for the manufacturing, installing and servicing of SWH components;
  o Financing mechanisms and incentives that are needed to move SWH to end-users; and
  o Where potential investors can maximize the available opportunities.

3.2. SESSION 2: MANUFACTURING, MARKETING AND QUALITY MANAGEMENT

Objectives of Session 2

• Identification of the capacity that exists regionally as well as in-country, for manufacturing, installing and servicing SWH components; this will allow for the design of mechanisms that effectively build up the capacity in the supply chain as well as create a broad support from the industry for quality programmes.
• Identification of the framework for a certification mechanism to serve the purpose of guaranteeing consistency in the quality of SWH products supplied in the market, thus providing the basis for consumer confidence; many certification schemes are dedicated for the hardware only, but there is also need for developing a certification schemes for installers as well.

• The provision of detailed information with regard to current global trends and best practices in SHW manufacturing and product issues, quality and certification and import related issues (either for complete systems or for hardware components to be used in manufacturing like glass, spectral selective material, etc.).

3.3. SESSION 3: THE BARBADOS SWH EXPERIENCE, PRESENTATION AND SITE VISIT

Essentially, countries wishing to introduce solar water heating have to get three things right simultaneously; otherwise the entire programme has a high risk of failure. While there have been many successes, there have also been many failures around the world and as the International Energy Agency (IEA) puts it, solar thermal technologies have a long history of disappointing customers with poorer-than-expected performance.

Barbados is a very small (431 km²) island in the Eastern part of the southern Caribbean, with a population of about 279,000. It is also the third highest per capita user of SWH in the world, after Israel and Cyprus. This session will seek to examine what the Barbadians have done right, as not only do they have a thriving solar water heating industry, but one that currently export its technology and expertise into nearby islands. A Case Study on the Barbados Solar Water Heating Experience was presented and thereafter, followed by site visit to the Solar Dynamics and Solaris SWH manufacturing facilities.
WORKSHOP REGISTRATION

Session 1
Planning, Regulating & Financing

Session 2
Manufacturing, Marketing & Quality Management

LUNCH

Barbados SWH Experience
Presentation & Site Visit
### 4. WORKSHOP PROGRAMME

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<tr>
<th>Time</th>
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<td>8.00 am – 8.30 am</td>
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| 8.30 am – 9.30 am | **OPENING SESSION**               | **Dr. Robert Stoddard**  
*Project Manager, CRECS*  
*CRECS Project Manager, CRECS*  
*CRECS Project Manager, CRECS*  |
|                | 8.30 am – 9.00 am | Opening Remarks  
*Joseph Williams, CARICOM Energy Programme Manager*  
Welcoming Remarks  
*Valerie Browne, Permanent Secretary, Division of Energy & Telecommunications*  
Context: CRECS Project  
Framework: CARICOM SWH Project  
*Robert Stoddard, CRECS Project Manager*  
Context: CARICOM SWH Stakeholders’ Workshop  
Outline: CARICOM SWH Project Report  
*Devon Gardner, SWH Project Consultant*  
  | 9.00 am – 9.30 am | **SESSION I: PLANNING, REGULATING & FINANCING**  
*Push-Pull Factors*: Government Rules and Incentive Schemes  
*Carol M. Lynch, Barbados Investment & Development Corporation (BIDC)*  
*Creative Financing*: Enabling Public and Private Financing Schemes for SWH  
*Allan Luke, Solaris Energy Limited*  
*Future Outlook*: Overcoming Implementation Barriers and Challenges  
*Eaton Haughton, Caribbean ESCO Limited*  
*Closing the Loop*: Parameters for Optimization of a Regional SWH Market  
*James Husbands, Solar Dynamics Limited*  
  | 9.30 am – 11.30 am | **SESSION I: PLANNING, REGULATING & FINANCING**  
*Push-Pull Factors*: Government Rules and Incentive Schemes  
*Carol M. Lynch, Barbados Investment & Development Corporation (BIDC)*  
*Creative Financing*: Enabling Public and Private Financing Schemes for SWH  
*Allan Luke, Solaris Energy Limited*  
*Future Outlook*: Overcoming Implementation Barriers and Challenges  
*Eaton Haughton, Caribbean ESCO Limited*  
*Closing the Loop*: Parameters for Optimization of a Regional SWH Market  
*James Husbands, Solar Dynamics Limited*  
<p>| 11.30 am – 12 noon | <strong>Summary: Session I</strong>            |                                            |
| 12 noon – 1.00 pm | <strong>LUNCH</strong>                         |                                            |</p>
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<th>Time</th>
<th>Session II: Manufacturing, Marketing &amp; Quality Management</th>
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| 1.00 pm – 2.00 pm | **Technology Selection:** Current and Future Trends  
*Damian Lyn, Alternative Power Sources (APS) Limited*  
**Closing the Loop:** Building Investor and Consumer Confidence  
*Stephen Worme, Barbados Light & Power (BL&P) Limited* | **Dr. Robert Stoddard**  
*Project Manager, CRECS* |
| 2.00 pm – 2.30 pm | **Summary: Session II**                                                                                                      |                                              |
| 2.30 pm – 3.00 pm | **Session III: The Barbados Experience**  
*Bobbi McKay, Barbados Manufacturers’ Association (BMA)* | **Dr. Robert Stoddard**  
*Project Manager, CRECS* |
| 3.00 pm – 3.30 pm | **Closing Discussions and Workshop Summary**                                                                                   | **Dr. Robert Stoddard**  
*Project Manager, CRECS* |
| 3.30 pm – 5.00 pm | **Site Visits: Assembly Facilities**  
- *Solar Dynamics*  
- *Solaris Energy (Aquasol)* | **Optional** |

Presentations highlighted in red text were done via Skype
5. PROCEEDINGS

5.1. OPENING SESSION

5.1.1. Robert Stoddard, Project Manager
The project aim is to **package a set of details to government** that the stakeholders believe are necessary and important to the success of “wide-scale” solar water heating deployment within the Caribbean. Moreover, the workshop and project are strategic – the results of same will not be seen until *long after* the workshop and project, as indicators are observed within the respective member states. Solar Water heating is an important part of the Sustainable Energy Framework for the region.

The project is under CRECS, which is funded under the EDF-9; the deadline of the project, which was originally scheduled for December 31, 2011 has been extended to December 31, 2012. The CRECS is a follow-up to the CREDP and is extremely critical to the Caribbean. There have already been workshops under the CRECS in Suriname (Renewable Energy) and in Haiti (Development of the Haiti Energy Sector) prior to this workshop in Barbados (Solar Water Heating Market Development).

5.1.2. Joseph Williams, Programme Manager
There have been many challenges over the past twelve (12) months in executing the CRECS project. A key objective of the CARICOM Energy Unit is to enable the region to attain a sustainable energy model that will assist member states towards energy security. CRECS was designed in 2006 as part of the CREDP. The key question of the workshop is: How can the “Barbados Experience” be replicated across the Caribbean?

The work of the CARICOM Energy Unit is primarily based around sustainable energy, of which renewable energy is a part, and seeks to look for *collective threads* across the region that can optimize some sustainable energy activities. Solar water heating is one option that is believed to have regional application and can therefore be driven through a collective framework, with appreciation for the country specific issues. The workshop is one that is therefore required to provide a platform of how to develop the SWH market in the Caribbean and so provide answers on *existing potential and opportunities, existing capacity, identifiable gaps, etc.*
5.1.3. Valerie Browne, Government of Barbados

Barbados has established itself as a world best practice state in respect of Solar Water Heating penetration, as well as the development of indigenous SWH technology. Barbados government policy has largely focussed incentives and policies toward sustainable energy, especially solar water heating. Successive political administrations have continuously provided stable, dedicated support through fiscal incentives, etc. and this is perhaps the best lesson to be gleaned by other territories – many countries tend to suffer from a lack of continuity in government policies. Government use the Fiscal Incentive Act to allow the tax-free importation of Solar Water Heater tanks and components to support the manufacturing sector. Otherwise, householders have been allowed income tax deductions of up to BDS 3,500 in lieu of Solar Water Heater purchase and installation.

Other solar technologies are important to Barbados and solar cooling is of significant interest. Member states need to recognize that fiscal incentives – though successful for Barbados – may not be necessary or sufficient for the promulgation of Solar Water Heater promotion in the region.

Important questions:

(i) Are we promoting regional manufacturing or will we also seeking imports from countries external to CARICOM?

(ii) What are the appropriate responses for the current landscape (technology selection, etc.) within CARICOM?

(iii) What lessons are to be learnt from the Barbados Model and how can these lessons be best applied to other CARICOM states, thereby avoiding the re-invention of the wheel?

5.1.4. Devon Gardner, Project Consultant

Solar Water Heaters are a technology tool for providing water heating services to various market segments within the Caribbean, as well as a potential sector for economic development through manufacturing. Solar Water Heating market already exists: the question is how do we accelerate the market expansion in a sustainable way?

Solar water heating should be integrated into the sustainable energy economy so as to deliver the full benefits to the respective national economies.

See Microsoft Powerpoint® presentation...

Solar Water Heating is, like most other energy issues, a multi-stakeholder issue and therefore requires broad-based participation from: (i) government and government
agencies, including national standards bodies; (ii) technology developers, manufacturers and suppliers; (iii) bankers and financiers; (iv) project developers, architects and engineers; (v) end-users, including hoteliers and householders; and (vi) educational institutions, including universities, community colleges and vocational institutions. It is also cross-sectoral with most focus on households, tourism, industrial (process heating) and health (hospitals and health centres).

Data Barrier was identified as the most significant issue facing widespread deployment within the Caribbean. Many decisions are not data-driven and so not enough effort have typically been placed on collection, management and assessment of data to justify the requirement for government support through fiscal incentives, policy support, etc.
5.2. SESSION I: PLANNING, REGULATING AND FINANCING

5.2.1. Push-Pull Factors: Government Rules and Incentive Schemes
Carol M. Lynch, Barbados Investment & Development Corporation (BIDC)

Interesting mix of government policies and private investments/innovation brought the Barbados industry to where it is today. The relevance of complementarity among the various interventions cannot be overstated. Such factors as the readiness of the national markets, ability of individual governments to provide and support incentives in their various forms, as well as the local capacity to regulate and manage the industry are critical.

Public-private sector collaboration on funding is important: Private sector must signal commitment to the industry as a means of driving government to providing incentives.

The point of disincentives for antagonistic, competing technologies must be dealt with: While government provides incentives for solar water heating technologies, taxes on conventional (fossil) products provide discouragement to such technologies. In Barbados, concession given to hotels for equipment purchase excluded electric water heating systems and is likely to extend to other items that are not in-keeping with sustainable energy trends. The current policy drive is for government support toward sustainable energy rather than single threads of energy solutions such as energy efficiency or particular renewable technologies. It may be perhaps useful to amalgamate policies and strategies for solar water heating, solar cooling and solar PV technologies under a “broad-based” solar policy.

5.2.2. Creative Financing: Enabling Public and Private Financing Schemes for SWH
Allan Luke, Solaris Energy Limited

Aquasol Limited, a Barbadian company, merged with Solaris Limited, a Trinidadian company, to create Solaris Energy Limited. The barrier of insularity that comes with over-focus of nationality must be addressed if regionalization of the sector is to be achieved. The vision of the sustainable energy economy must be integrated into the planning process within CARICOM; this will send the right signals to investors and encourage their participation within the sector.

Some important drivers for the SWH sector include:

- **Technology R&D:** How to constantly improve the existing technology to reduce price, increase performance, etc.?
- **Market research:** This is useful to drive decision-making and should be government-facilitated, with data captured as a part of the routine census and other economic statistics gleaning processes.
• Skilled workforce: This is not limited to the technical side but should transcend the entire value chain to include *marketing agents, facilities managers, finance experts, etc.*

• **Government incentive for manufacturing:** This cannot be over- emphasized and it is important that governments demonstrate a willingness to *give some of what it gains* back to the sector.

• **Policy-assisted public awareness:** Sustainable energy should be made to become a *lifestyle* among the upcoming generation through the requisite introduction of renewable energy and energy efficiency principles in school in a government-directed programme. The selection of renewable energy technologies for energy service provision should become almost instinctive among Caribbean folk within the next generation.

Customer-confidence will provide an important element for market expansion which in-turn, boosts profitability and consequently drives investor-confidence. Government must facilitate this vicious loop by putting the relevant regulatory mechanisms for quality control, to include *minimum performance* rules for solar water heaters.

### 5.2.3. Future Outlook: Overcoming Implementation Barriers and Challenges

Eaton Haughton, Caribbean ESCO Limited

The Jamaican experience in Solar Water Heating has been somewhat “checkered” and has certainly not been as prolific as the Barbados experience. We should however not lose sight of the successes even within a history of mixed-results. Jamaica has significant advancement in solar water heating processes within the commercial and hotel sector – much more than there is in the household sector.

In most of the Caribbean, there is a **lack of consistent policy** from governments; Barbados is perhaps the only case where there has been demonstrable continuity in policy from one administration to another.

*See PDF Presentation...*

There is a **lack of energy experts in the region, lack of public support, and lack of confidence in renewable energy technologies from the financial sector,** especially banks. Again, Barbados has been the exception rather than the rule.
How do we simplify the communication of information related to cost-benefits of solar water heating to the end-user?

In an environment where there are many options, the responsibility of engagement and communication with the end-user is critical. Government support is very important in this regard as many manufacturers still see themselves as product providers rather than the responsible party for regional market expansion; the market-oriented approach has been historically to make inroads to facilitate “own” rather than regional market success.

Other questions of significant note:

**What is the role of the electric utility in sustainable energy service provision and demand side management (DSM) principles, especially in a privatized, vertically integrated monopoly?**

**How do we integrate solar thermal systems into other energy services – refrigeration and space cooling (air conditioning) – that may produce hot water while impacting the most significant energy end-uses?**

### 5.2.4. Closing the Loop: Parameters for Optimization of a Regional SWH Market

James Husbands, Solar Dynamics Limited

There is need to understand the **history** of the Solar Water Heating industry within the Caribbean is very important if we are to understand where we are and how to get where we wish to go. Solar Dynamics have dominant markets in Barbados, Belize, Grenada, St. Lucia, Guyana, etc.; there is also some presence in countries as far Guatemala. Solar Dynamics has a high presence across the Latin America and Caribbean (LAC) region. Though the penetration has not been high in some countries, there is experience that will minimize the learning curve in such countries – one such is Trinidad and Tobago.

*See Microsoft Powerpoint® presentation...*

As early as 1935, Sir Frank Hutson built Solar Water Heating system in Barbados. It was the oil shock of 1973 that promulgated the solar water heating industry in Barbados. Andrew Hatch used a design by Professor Tom Lawand to build a Solar Water Heater from *readily available material*.

*See Microsoft Powerpoint® presentation for design features...*

Solar Dynamics started as a joint-venture partnership among CADEC Board Members, including Andrew Hatch, and with James Husband of BUILDEC. Solar Dynamics had difficulties in securing loans from commercial banks – *at that time they approached*
Barclays Bank – to develop a project for providing Solar Water Heating for an eighty-four (84) unit housing development (Oxnard). With leverage, the financing was obtained through the leverage of a guarantee provided by the Barbados Institute of Management and Productivity (BIMAP). Thereafter, another important turning-point was the contract to replace an existing Solar Water Heating unit on the house of then Prime Minister Tom Adams, whose plumber had designed a home-made system, with a Solar Dynamics unit; the rest is history. PM Adams realized significant reduction in his LPG use since transferring his water heating services from gas to solar technology and immediately introduced tax rebates as an incentive to attract solar water heater purchase among consumers.

It is important to note that incentives to attract Solar Water Heating systems should be twinned with disincentives toward conventional (fossil) water heating technologies. Also, pricing must be realistic as for a sustainable market environment to be maintained; the profitability of the business must be realized.

See Microsoft Powerpoint® presentation for some Solar Dynamics projects...

Important: significant issues were experienced with corrosion of steel – and other steel-based material – that was used as part of the collector design for Solar Water Heaters as a consequence of the saline island environment. Aluminium is now the preferred material of choice.

Replication of industry: transfer of technology and building of capacity have been successfully done in St. Lucia and Grenada. The issue is not whether the replication can be done, it’s a matter of whether the member states want to have it done and are willing to facilitate the enabling environment for same.

5.2.5 Discussion Forum

5.2.5.1. Leighton Waterman – Barbados Experience

Coherence of policies, or lack thereof
Solar Water Heating Incentive Act: Duty free solar water heater import

Tourism Development Act: Duty free import of any equipment for use in the hotel and tourism sector which allowed electric water heaters... only recently corrected.
**Data availability**

**Significant lack of data:**

Mostly intelligent guesses rather than scientific data – there is still uncertainty, for instance, on the installed SWH capacity in Barbados.

**Manufacturing platform**

**Policy regarding CET:**

Do we act in such a way as to facilitate regional manufacturing sector or do we aim more broadly to derive market penetration regardless of the technology source.

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**5.2.5.2. Clyde Griffith – Barbados Experience**

Policy formulation and articulation is a serious issue, even in Barbados... Regional Energy Action Plan for CARICOM (1983) that was drafted by then Minister of Energy for Trinidad and Tobago, Patrick Manning... *this had significant opposition from Jamaica.*

Estimate of solar water heaters in Barbados – ranges from 40,000 to 55,000 but no exact figure is known.

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**5.2.5.3. Ellsworth Dacon, St. Vincent & the Grenadines - The OECS Requirements**

The cost-benefits of solar water heating for Domestic Hot Water (DHW) services provision are questionable. In fact, hot water services are considered a “luxury item” among many households. The reality is that Solar Water Heating is more significant for hotel/tourism and industrial sectors.

Look at calculation to show the “real cost” of **solar water heating** vs. **intermittent electric water heating** vs. **tankless water heating**.

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**5.2.5.4. Beverly Quamina, Trinidad and Tobago – The CARICOM Market Dynamics**

*Supply side management*...

How do we ensure sustainable supply of solar water heating technology to meet the regional market demands that are anticipated?
5.2.5.5. **Ricardo Adams, St. Vincent & the Grenadines – Dealing With the Realities**

Explore the efficacy of credit unions vs. banks to provide end-user financing?
*What are the advantages/disadvantages of one model v. the other and how do we seek to maximize the opportunities for national/regional benefit?*

5.2.5.6. **Racquel Chambers, Jamaica – The Consumer Perspective**

How to identify and develop consumer market, especially in environments where domestic water heating is not viewed as important?
*Internet poll in Jamaica shows that 6/10 persons do not think water heating is an important commodity for households.*

Evaluation of the solar energy industry in the Caribbean: **What it means to the region?**
- Social impact
- Economic impact
- Environmental Impact

*This would guide the sectoral expansion and integration of solar technologies within the region...*
5.3. SESSION II: MANUFACTURING, MARKETING AND QUALITY MANAGEMENT

5.3.1. Technology Selection: Current and Future Trends

Damian Lyn, Alternative Power Sources Limited

Alternative Power Sources (APS) Limited is a company of design engineers and installers of renewable technologies solutions, including solar water heaters. Old technology: progressive tube, which are typically tank-less with large (1 – 2 inch) copper tubes that are located in collector; \textit{Heat loss is high and consequently there are storage issues.}

Other important systems: Thermosiphon systems and evacuated tubes. Evacuated tubes seem to be at a disadvantage due to the physical demands of the Caribbean region, \textit{including hurricane}. The unit integrity is however, typically compromised if a tube is broken.

\textit{See Microsoft Powerpoint® presentation...}

Thermosiphon system: open and closed

\textbf{Open system:} Cheaper and easier to install and has a single heat transfer system; consequently very efficient. The major problem with this system is that \textit{pipe fouling} has been identified in installations within Jamaica, especially after the integrity of municipal water supply has been breached during hurricanes and floods. There are also issues with respect to chlorination of water and calcification due to mineral presence – Jamaica has high limestone presence in its landscape and \textit{calcification is typically prevalent within the copper tubes}. The bottom-line is that open systems are cheaper to install but operating and maintenance costs are higher.

\textbf{Closed system:} Less maintenance is required but it is a heat exchange system; hence greater heat loss (though negligible relative to open systems) and the capital cost for purchase and installation is significantly higher than the open system.

Active system
These systems provide an aesthetic advantage due to non-presence of tanks on roof. They typically, use closed loop heat-exchanger and has a controller to manage fluid flow.

Evacuated tube system
Thermosiphon systems are suited to the Caribbean and give the required temperatures for DHW – typically around 140\textdegree F. Evacuated tubes give around 200 \textdegree F or higher and is more suited to industrial preheating than domestic hot water services. Many persons...
nonetheless seem to display preference for evacuated tube systems, even for domestic hot water services in households, because of aesthetics.

**Forced circulation system**

There is the option of installing modified thermosiphon systems where the tank is removed from the roof and placed, for instance, on the ground – *for aesthetic or engineering reasons*; the fluid dynamics managed by a solar DC circulation pump in what is referred to as a forced circulation system. This has been installed by APS and the costs are much less than the active system due to the elimination of the need for a controller.

**The future of the technologies**

*Hybrid PV/Thermal (PV/T) system*

Hybrid PV/T systems are photovoltaic and thermal cogeneration systems that produce both heat and electricity from a single technology. The way it works is that the PV panel sits on-top of a water circulation system that cools the panel and the water, which is now heated, provides the DHW for the end-user. Disadvantage was the price of PV panels but the cost of same is now trending significantly downward.

*Tank-less SWH system*

There are also tank-less SWH systems that use phase change materials to produce and store heat as is required.

The bottom-line is that there are many options that must be considered from a *technological* and *economical* standpoint. The future of SWH is one where different combinations should be made available to the market so as to match end-user preferences.

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**5.3.2. Closing the Loop: Building Investor and Consumer Confidence**

**Stephen Worme, Barbados Light & Power Limited**

Renewable energy and energy efficiency technology integration is a difficult question for the utilities. In Barbados, the utility did not play a significant role in Solar Water Heating development within the domestic sector as most households in Barbados did not electric water heating system prior to the promulgation of the solar technology. The electricity sales of the utility (BL&P) were therefore not affected by domestic solar water heater use as there was *creation of a new market* rather than *substitution of an existing one*. Had the
water heating demand been provided by the electric grid however, there would have been significant effects on the electricity supply dynamics of BL&P and so the avoided costs that resulted from the solar water heating industry were likely beneficial to the company and the Government of Barbados.

It is important to note that the Barbados Solar Water Heating expansion took place at a time when there was mass conversion of sugarcane lands into housing and it is believed, was promulgated by the “new wave of housing construction” at that time.

BL&P has recently implemented a Renewable Energy Rider, which reimburse customers 1.8 times the avoided fuel cost for energy supplied and is applicable to the integration of PV into the grid. This is done in recognition of the value of micro-generation to infrastructure expansion – micro-generation reduces the rate of demand increase and therefore delays generation capacity expansion. There is a limit of 5 kW for residential and 50 kW for larger customers; this is a pilot set-up and will be revised at the end of the process.

The role of the ESCo is to assist customers with the high up-front cost of purchasing and installing the technology in what is similar to a hire-purchase arrangement. Typically, the customer pays a periodic fee to the ESCo from the calculated energy savings. The difficulty has been however the determination of the level of customer savings in a low-risk manner; proving the savings from the intervention measure relative to the Business as Usual (BAU) scenario has been difficult due to externalities, such as shifting knowledge, practice and attitude of the end-user on the one-hand, and the “rebound effect” on the other-hand. Utilities are generally risk-averse in their business model and avoid practices that involve significant uncertainty – the projection of energy saving from energy efficiency and renewable energy interventions are deemed to be such. Many Caribbean utilities, including BL&P, are therefore not interested in “quasi-ESCo” activities; the fact that the Demand Side Management programmes of the utilities, particularly the IDB programme with JPSCo in Jamaica, did not result in any proposal for utility-based ESCo suggests not much is headed in that direction.

With respect to ESCo development, significant funding is required and many hedge-fund companies are averse to operating in the Caribbean due to what is referred to as “country risk”. The fact is that many investors do not know enough about the Caribbean and to invest significant capital in these countries would require much due diligence, which comes at a cost.
5.3.3. Discussion Forum

5.3.3.1. Eaton Haughton, Jamaica – Issues with ESCo development in Jamaica

Financing
Jamaica National Building Society (JNBS), a Jamaican mortgage bank, was providing finance for energy efficiency, and limited PV installation for households that were backed by ESCo guarantee. Caribbean ESCO, owned and operated by Eaton Haughton, was the main ESCo partner with whom the bank operated.

Government
Policy to support ESCo model has never been developed or articulated; the ESCo model have never received clear support from government through policy, financing or any other mechanisms.

Public Utility
It is the opinion that the project was unsuccessful as a consequence of the lack of interest from the public utility – this prohibited the installation of some devices as well as access to measurement and data... *Utilities need to be more proactive in facilitating demand side projects that are managed by ESCo...*

Deployment
The deployment of the project is weak because of the lack of defined rules and structures, as well as the weak capacity that is available on the regulatory and fund management side.

5.3.3.2. Joseph Williams – Experience in Demand Side Issues with the Utility

ESCo is essentially an instrument for financing *energy efficiency* and *renewable energy* activities through performance-contracting. *The challenge typically resides in the contractual issues.*

Monitoring and Evaluation
Independent third-party monitoring and evaluation companies exist in the US to ensure that the reported savings from *energy efficiency* and/or *renewable energy* intervention is accepted by customers and ESCo – there tend to be mistrust on the side of the customer towards the savings claim reported by the ESCo and the independent third-party removes the burden of proof from the ESCo. This service was never developed within the Caribbean.
Collection of Payments

The utility can play a substantial role in billing and collections, thereby ensuring that investments that have been made by the ESCo are recovered through utility billing as a part of a tripartite arrangement among the customer, ESCo and the utility. This significantly reduces the exposure of the ESCo to the risk of non-payment by the customer and also lowers the administrative cost of the finance side of the ESCo activities.

Institutional Customers

In many countries, including the UK, government and quasi-government institutions are the chief clients for ESCo type services. The fact that government agencies are large users of electricity provides an opportunity for government to participate directly in the market arrangement for the ESCo model so as develop and encourage the industry.

The Jamaican experience was not sufficiently structured and so the levels of success were stifled; CARICOM is working with Mexico to establish a pilot project with a Super-ESCo, a firm that has the requisite experience and will work with smaller firms in Caribbean.

5.3.3.3. Stephen Worme – Utility Planning

The utility traditionally plans its generation capacity based on projected growth – typically 20 years in advance. The utility investment in additional capacity to supply demand may turn out to be a stranded investment if demand side reduction isn’t integrated into the supply side planning. There is need therefore for congruence among government, utilities and the ESCo as a means of ensuring that the benefits to all parties are realized – currently, utilities, as in the Jamaica case, are asked to participate in DSM projects at the last minute, sometimes after significant investment has already been made in the supply side based on the projected demand and electricity sales. Any reduction in sales is going to significantly impact the return on the investment in the generation expansion. This is a very critical relationship that is missed by actors within the energy sector, including governments.

5.3.3.4. Joseph Williams – Manufacturing SWH within the Current Paradigm

In the context of pricing and the rate of technology advancement, is it still advantageous to produce regionally manufactured technologies for the regional market?

How do we realistically look at the cost-benefits of regional engineering design with global technology imports v. regional engineering design and technology manufacturing?
Most Chinese models are non-pressurized systems – a technology utilized in the Caribbean around 20 years ago: The experience of the pressurized systems suggests a distinct lifecycle advantage v the non-pressurized system.

Is there enough analysis to justify the suitability of much of the imported technology, inter alia, evacuated tubes, forced circulation, PV/T, etc., that is being used within the region? There is perhaps need for same at this juncture.

How do we institutionalize the research and development component of the industry so as to drive independent, third-party results on which much decision-making can be based?
5.4. SESSION III: THE BARBADOS EXPERIENCE

5.4.1. The Barbados Experience
Bobbi McKay, Barbados Manufacturers’ Association

Varying price of oil over the past 40 years has driven interest in renewable energy technologies. Between 1973 and 1976 in particular, oil-pricing was pain-fully high and interest peaked. Between 1986 and 2006, when prices were very low, renewable energy interest was very low and consequently, only a few countries continued to pursue this path. The most significant were: (i) Germany and Netherlands – wind; and (ii) Israel and Barbados – solar water heating.

First commercial solar water heater manufacturer in Barbados was Solar Dynamics; Father Andrew Hatch and James Husbands got together and started the company with USD 4,500 (around USD 22,000, 2011 value).

The Government began active participation in the SWH market in 1973: Then PM, Tom Adams installed a unit on his residence and thereafter (upon experiencing the concept proof) mandated all government buildings to have SWH units instead of electric, as well as incentive support for manufacturers and end-users.

See Microsoft Powerpoint® presentation...

The 1990-94 economic recession affected the rate of growth of the industry. Nonetheless, it is believed that the regional export market sustained the industry as Barbados experienced significant downturn in the construction industry.

The economic condition of Barbados seem to be the major issue that affects the local market at this juncture; there seem to be a de-correlation between SWH and electricity costs due to the mainstreaming of the technology into the practice, knowledge and attitude of citizens. Seemingly, Barbadians will typically choose SWH technology as long as they are in good economic standing.

See also Perlack-Hinds Report for more details...
There have been a “confluence of factors” that has driven the Barbados Model to its current state and there is no *single magic bullet* that accounts for its success. The following are the factors that are deemed to be important to the model:

- Recognition of the potential benefits of SWH technology to Barbados at the highest level of government – the then PM actively utilized and supported the technology;
- Innovative entrepreneurship that drove the product development and market dynamics;
- Rollout of the industry at a time of rapidly rising electricity cost – this gave clear rationale for its importance;
- The provision of key fiscal incentives for lowering manufacturing cost and enhancing affordability of SWH to the end-user; and
- Deliberate and timely government procurement programme for housing projects.

### 5.4.2. Discussion Forum

There wasn’t sufficient time for a full discussion on the presentation as there was need for participants to leave for the site visit. More importantly, it was believed that the presentation was a wrap-up that pulled the features from previous presentations into focus and the issues would have therefore been addressed in previous sessions.

### 5.5. CONCLUDING STATEMENTS

**Robert Stoddard, Project Manager**

The following are deemed to be the important take-away points from the workshop:

1. Mechanisms must be found to encourage project developers within member states through the creation of incentives for SWH systems that are integrated into supply-side planning;
2. There is need for a programme that encourages the development of ESCo’s within member states in order to drive the financing of *renewable energy technology*, including SWH and PV/T implementation; and
3. The strategies developed should encourage the integration of SWH into other sustainable energy development programmes within member states.
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Build a Solar Water Heater: An Integral Passive Solar Water Heater

Passive solar water heaters are easy to build, install and use.

by David Bainbridge
January/February 1984

The author’s "test-bed" — a tilted, three-tank integral passive solar water heater, provided his family with 70% of their total hot-water needs during a full year of monitoring.

For the do-it-yourselfer searching for an inexpensive, easy-to-build solar water-heating system, the integral passive solar water heater (IPSWH, pronounced ipswah) is a dream come true. All you need to get going on this down-to-earth water warmer is a discarded electric water heater tank rescued from the local dump, a homemade plywood box to house it in, a can of flat black paint, a sheet or two of used window glass or clear plastic, a few common plumbing fittings and some pipe and insulation. Combine all that with some spare hours of satisfying sawing, hammering and wrench-turning, and you'll have an ongoing supply of hot water provided virtually free from that friendly furnace in the sky.

But before we get into the nitty-gritty of integral passive solar water heaters, let's run through a quick review of the basics of solar heating for those who may be new recruits to this wonderful world of free energy.

We'll be discussing solar collection systems for heating purposes — not for charging photoelectric cells or for other power applications — and there are only two basic types: active and passive. The essential difference between them is the use of external power: While active solar heating systems employ fans or heat pumps to circulate the Btu they gather, passive setups don't. As their name defines them, integral passive solar water heaters work on the latter principle, and that lack of power dependency and resultant energy savings is one of the IPSWH's greatest selling points.
Passive solar heaters can be subdivided into two classes: units in which the functions of heat collection and storage are separate, known as thermosiphon flat-plate systems, and arrangements that combine collection and storage into one integrated unit, namely, integral passive solar water heaters.

Since the flat-plate passive solar water heater is the predominant type in use today, most folks think of such collectors as being the best available for solar water heating. But in fact, for many uses, especially owner-built applications, IPSWH’s outshine their flat-plate competition in almost every way — including ease and economy of installation, reliability and higher resistance to freezing.

**How Solar Water Heaters Work**

The design of all IPSWH’s is based on a tank (or a series of tanks) painted flat black to absorb heat from the sun and then transfer the tapped Btu to the water stored within. IPSWH's are sometimes called batch heaters, because the heart of the system is the "batch" of water stored in the tank(s). To increase heat collection and reduce heat loss, a combination collection/storage tank is enclosed in an insulated box covered on the south-facing side and top with a glazing material, usually glass or molded plastic.

The standard IPSWH brings cold water into a solar collection tank through an inlet near the bottom (or through a dip tube that enters the tank at the top and discharges unheated water near the bottom), heats it, then moves it along to a backup heater — which can be powered by gas, electricity or wood — through an outlet near the top. This system uses waterline pressure for circulation, eliminating the need for expensive pumps and/or controls. During the summer months, or where it is warm and sunny year-round, the backup heater can often be turned off or bypassed entirely, with the IPSWH providing for all of your hot water needs.

Incidentally, for those of you who may be looking for solar-related business opportunities, IPSWH’s have excellent potential for mass marketing/installation in tract housing areas, plus a growing array of commercial applications.

**The Evolution of Passive Solar Water Heaters**

Let’s look now at the history and evolution of the IPSWH, and at five of the many designs that have proved effective and popular with home-based handypersons.

The principles used in modern IPSWH’s are undoubtedly the same as those that were first applied to solar water heating. For example, Butch Cassidy’s roost in Utah reportedly still bears remnants of a passive solar water warmer: a black can filled with water and placed in the sun to heat. Similar primitive IPSWH’s are being used today in locations where people live without piped-in water and conventional energy sources such as gas and electricity.

The first commercial solar water heater, patented in 1891 by Clarence Kemp, was dubbed the Climax solar heater. Kemp’s Climax used four cylindrical water tanks housed in a pine box lined with felt paper and covered with single-pane glass. This system typically was mounted on a roof, with cold water from a reservoir entering the first tank and passing through the other two in series, with gravity carrying the heated liquid down to the tap. By the year 1900, more than 1,600 Climax units were in use in America, primarily in the sunny regions of California and Florida.

In 1898, Frank Walker of Pasadena, California applied for a patent on an improved IPSWH. Walker's model was recessed into the roof, instead of being exposed as were the Climax heaters. And more important, the Walker unit incorporated backup connections to a "wetback" woodstove. Thus, the Walker model was the direct forerunner of today's most usual IPSWH application, a polar preheater feeding into a standard gas or electric water heater located inside the louse.
But successful as these early IPSWH's proved to be, they were destined to gradually disappear as enticingly cheap natural gas became available and was aggressively promoted.

**A New Wave of Solar Hot Water**

Fortunately for us, the popularity of natural gas didn't bring solar water-heating research and development to a total standstill. In one valuable experiment conducted at the University of California at Berkeley in 1936, a researcher named F. A. Brooks tested several IPSWH designs and demonstrated that tank-type solar heaters were capable of producing water warmed to more than 120°F. He found, too, that upright tanks placed on an incline delivered hotter water than horizontally situated units. Brooks also concluded that IPSWH's could produce hot water at a cost consistently below that of flat-plate systems. The only shortcoming of the IPSWH was lower early morning temperatures as a result of nighttime heat loss.

Contemporary investigators have reduced nighttime cool-down in several ways, the most effective involving the use of manual or automatic lids on the heater boxes. These hinged lids are raised during the day, their reflective undersides catching and directing additional solar Btu onto the tanks. At night, the insulated lids are closed to retain the stored heat. A second method of heat-saving relies on an ultramodern, specially coated metal foil, tagged "selective surface tape." This expensive — $75 to $80 for a 4’ X 8’ sheet! — but effective material offers a combination of high absorbance (on the average, about the same as flat black paint, approximately 95%) and low emissivity (thereby cutting heat loss).

**Five Types of Solar Water Heating Systems**

Let's take a look at five of the many types of integral passive solar water heaters in use today.

The **single-tank IPSWH** is often dubbed a "breadbox" heater, because it looks a lot like an oversized breadbox (see the illustration in the Image Gallery at right). Overall, it's probably the most economical and least complicated of the permanent IPSWH's to build, requiring only easily scrounged materials and basic construction skills.

For the "econo-model" breadbox unit, a standard electric water heater tank is painted flat black and housed in an insulated plywood box. Glass or another transparent glazing material covers the top and the south-facing side of the box. (Glass is generally the most suitable glazing for owner-built heaters.) And, while not always absolutely necessary, an additional hinged, insulated lid will reduce nighttime cool-down and increase the collector's efficiency.

Incoming water enters the breadbox near the bottom of the tank, with the sun-warmed water being drawn off from near the top and routed on to the backup unit inside the house. A horizontally oriented IPSWH provides the lowest heat gain, but is the easiest to build and is less visible than a vertical one. By using tilted tanks — which can be attained by vertically flat-mounting the unit on a pitched roof — the stratification of the water is increased and the solar angle is improved, resulting in higher temperatures.

The **vertical three-tank IPSWH** has as simple a design as the breadbox, but it's constructed on a larger scale. For the triple-tanker, three glass-lined electric water heater cores are painted flat black (or are covered with selective surface tape) and enclosed in a large, well-insulated box. Glass or other glazing material covers the south-facing side and the top of the box, and shuttering in the form of a lid or interior insulated "drapes" can be installed to improve heat retention. The three tanks are plumbed in series, with the protected central tank serving as the final stage before the heated water is discharged (see the photo).

Naturally—because of the greater collection surface area and improved thermal layering—the tilted position of the tanks and the series hookup provide better heating than is offered by the smaller, horizontal, single-tank breadbox. To test the efficiency of the three-tank IPSWH, I installed and monitored one for a full
year at my home in north-central California... and found that it supplied an impressive 70% of my family's hot water!

A greenhouse IPSWH installation is the ticket for best performance and freeze protection in colder climates or during the winter months. Of course, you can increase the cold-weather efficiency of your solar water heater by locating it in virtually any protected, warm, sunlit enclosure... but an attached solar greenhouse is usually the best choice. Almost any IPSWH configuration can be used inside the plant room, with size and weight being the primary limiting factors. Usually, the heater is tucked up under the peak of the greenhouse roof to take advantage of the warm, rising air. And as with all IPSWH's, the collector tank should be painted flat black or coated with selective surface tape. For maximum efficiency and cold-proofing, an insulated box with top and south-facing glazing, and a hinged, insulated, after-hours lid is still recommended.

The inverted IPSWH offers another good method of reducing heat loss in colder climates and seasons, and is especially effective protection against after-dark cool-down. Visualize, if you will, a standard IPSWH with a black tank enclosed in an insulated box with south-facing and top glazing... and the whole works flipped on its lid! Now, the insulated portions of the heater box are looking at the sky, thereby significantly reducing nighttime heat loss. Sunlight gets to the collector tank(s) by way of one or a series of reflectors. At first, these upended heaters seem almost absurd. But they've performed quite well at sites throughout the country.

A low-cost IPSWH, which can be built for just a couple of bucks, was developed a few years ago by the Minimum Cost Housing Group at McGill University in Canada. This unit offers more Btu per dollar than any solar water heater designed to date, and should be useful to summer campers and owners of weekend homes with no conventional water-heating facilities. This budget water warmer can be built with a minimum of time, effort and cash by anyone in need of a little hot water for washing purposes, and requires only a plastic garbage bag, some PVC pipe and fittings, a few hand tools and a lighted cigarette for "welding" the plastic joints.

The heart of this heater is the common plastic garbage bag of 1.6-mil-thick, dark green polyethylene in a 26" X 35" size. The drain outlet is made of PVC pipe, washers and nuts, and is fastened to the bag mechanically (that is, by tightening the fittings over a hole punched in the plastic). Tests at McGill University demonstrated that a plastic bag of this type and size is strong enough to hold water to a depth of three inches, thus offering a capacity of about a dozen gallons. Temperatures of about 104°F were reached by just setting the bag of water out in the sun, and when the bag was placed inside an insulated box with a glass cover, the water temperature rose to a respectable 132°F!

**The Six Commandments of Designing a Solar Hot Water System**

A few basic principles and considerations govern the design, installation, use and maintenance of IPSWH's. If your heater's specifications and installation follow the six commandments listed below, it will work admirably and will provide you and your family with inexpensive solar-warmed water, no matter which specific design you decide to go with.

[1] _Locate your heater for maximum sunlight exposure._ Find a sunny, south-facing location for your IPSWH, preferably close to the conventional gas, electric or wood backup unit to minimize piping distance. You might have to indulge in a bit of calculating to be sure your solar collector will be exposed to the sun year round, but such an orientation is, after all, the single most important consideration.

[2] _Make the collector as effective as you can._ First, decide on the type of tank(s) you'll use for your heater. Tanks come in a wide variety of sizes and shapes, with most of them being usable. But long, thin cylinders are the most efficient (they have the greatest ratio of surface area to water volume), and by far the cheapest and easiest of these are used electric water heater cores.
If you prefer new tanks, out-of-the-carton, glass-lined electrical water heater cores — minus the heating element, outer insulation and sheet metal cover — can be ordered from several manufacturers. But if you plan to retrieve your cylinders from cast-off electric units, be sure to test them thoroughly for leaks and rust, and patch carefully where necessary. Never use a tank that you have doubts about.

One of the most suspect parts of any used electric heater core is the "sacrificial anode," a rod made of metal that has a low resistance to corrosion and is inserted into the tank from the top to attract and absorb any corrosive elements in the water. Examine the anode, and replace it if substantial corrosion and/or consumption is evident. A new anode costs only a few bucks, and it will add measurably to the longevity of your system.

Next, determine where your IPSWH will be installed — roof, platform, wall or ground — keeping in mind that a filled three-tank system tips the scales at a hefty 1,000 pounds or so. For most applications, it's best just to plop the heater right on the ground. This makes installation easier, eliminates the weight problem, and renders the manual raising and lowering of a night lid less of a chore. Finally, reflectors can be used to increase solar exposure, with a variety of materials being suitable for this purpose. (It's usually no problem to make a hinged lid serve double duty as a reflector when it's raised to its daytime position.)

[3] Insure that your water tank(s) will retain heat. There are a number of options for glazing the top and the south-facing wall of your IPSWH, including single- and double-paneled tempered glass, Du Pont Tedlar-coated fiberglass exterior with Teflon-film interior glazing, acrylic or polycarbonate plastics, and R-3.6 Heat Mirror. In most cases, you should use two layers of your chosen glazing material with an air space between, to provide maximum heat retention. Be sure to caulk and tightly seal each of the panes.

[4] Size your heater for its intended application. To determine what size IPSWH you need, allow 30 gallons of water capacity per person in your household. Davis Alternative Technology Associates suggests about 2.5 gallons of water per square foot of glazing as the maximum ratio for good heating, and a smaller water-to-glazing ratio will speed up heat gain considerably. Using those figures, you can plan around a requirement of 30 gallons of water capacity and about 12 square feet of glazing per user. But if you can't meet these desired measurements, don't lose heart. Even a drastically undersized system will preheat water well above ground or ambient air temperature, thus providing economical solar water warming, which will conserve nonrenewable energy sources and save cash.

[5] Make an efficient connection to the backup system. Try to locate your IPSWH close to its conventional mate, thus minimizing the amount of connecting pipe required. To be sure the pipe is properly sealed and insulated, consider using Armaflex and a coating, or urethane foam with aluminum jacketing. (Although it can take up to 72 hours to freeze a standard exposed water heater tank at 12°F, pipes — because of their restricted size — are far more sensitive to cold.) Any exposed pipes in particularly cold places should also be heat-taped.

Before hooking your IPSWH to its backup unit, bleed the air out of the tank. You can bleed through the temperature/pressure valve (if you install such an overheating safety feature), or just leave a plug out at the top of the tank until the system is full of water. As a final precaution when galvanized tank fittings are to be used with copper tubing, make sure that the two metals are separated with nonconducting, dielectric fittings to prevent accelerated corrosion. I've had very good luck using copper tubing, plastic dielectric connections and galvanized fittings on my tanks.

[6] Build your solar water heating system to last. Use the best materials you can afford or scrounge, and take proper care in the construction of your unit. And be safe: Make sure that the tank supports are strong enough to bear the load they'll carry, and consider adding a tempering valve near the backup heater.
Conventional Water Heater Maintenance

Once in a while, someone will install a solar water preheater, while simultaneously neglecting his or her conventional gas or electric unit, with the results reflected in unnecessarily high water-heating bills, in spite of the solar preheater!

Four common forms of neglect are [1] exposing the conventional water heater to the cold by improperly insulating the room in which it is housed, [2] failing to insulate that tank sufficiently (inexpensive and easy-to-install "thermal blankets" can be added in just minutes), [3] maintaining an unnecessarily high temperature setting (which is sometimes the fault of a bad thermostat), and [4] allowing sediment to build up on the bottom of the tank and act as insulation between the water and the heat source.

Check your backup heater at the time you install your IPSWH. In fact, even if your solar unit is only a dream at the moment, it makes good energy sense to tune up your conventional water heater right now.

A Bright Future for Solar Water Heating

More research is needed to determine methods of increasing the effective solar collecting surface area of tanks, as well as to improve means of insulating for year-round operation in colder climates. Currently, sheltered integral passive solar water heaters can be cost-effective even in 6,000-degree-day climates. But as IPSWH technology stands today, it definitely offers the energy-conscious do-it-yourselfer an attractive alternative to costly hot water and conventional energy dependence, and presents the solar professional with a low-overhead, uncrowded field of action.

Of course, you don't have to take my word for it. Look around, read around, shop around and — most important — build for yourself. I think you'll come to the same conclusion I did years ago, that integral passive solar water heaters provide the most economical, efficient, down-to-earth method of water warming under the sun.

Jamaica Takes the First Step

While many "experts" are still claiming that practical solar power is years away, effective energy-saving (and moneysaving) installations — a number of which are designed by do-it-yourselfers who just won’t listen to the gloomy projections of scientific pessimists — are popping up all over the place!

November/December 1980

[LEFT TO RIGHT] The hotel's staff cottages (the experimental heater is on the third roof from the left)... and the Hyatt's water heater ... with Eaton Haughton in the foreground) explaining his system.

In September of 1979, the Mallards Beach-Hyatt Hotel — in Ocho Rios, Jamaica — went "on line" with the first commercial solar water-heating system on that lovely tropical island.

The very fact that the prestigious hotel decided to enter the "solar age" is interesting, of course . . . but perhaps even more impressive is the story of just how the Hyatt's heating system came to be.

Mr. Eaton Haughton, who holds the position of Special Projects Engineer for Jamaica's National Hotels and Properties group, initiated the project. Haughton admits that he had no real training in solar theory at the time that he approached the hotel management with his idea. He did, however, feel a deep dissatisfaction with the slow rate at which his nation's public and private sectors were moving toward energy conservation . . . and he also had a shade-tree mechanic's knack for gathering information (from magazine articles, photographs, and conversations with solar experts) and then translating the scattered bits of data into real, working equipment.
The Mallards Beach-Hyatt Hotel

After making an analysis of the hotel’s hot water consumption, Eaton suggested a plan for meeting that demand — a step at a time — with inexpensive, renewable solar energy. The "powers that be" were cautious, he reports, but — after the engineer had proved his point by installing an experimental heater on the roof of one of the hotel’s staff cottages — he was given permission to go ahead with the project!

The completed "first step" solar conversion — which supplies hot water to the huge resort’s laundry department — cost a total of $20,000. (The financial figures given here are in terms of Jamaican dollars, each — at the time of this writing — worth about 56¢ U.S.).

Eaton originally estimated that the installation would pay for itself in three years. However, with the recent rises in the cost of conventional power sources, Haughton estimates that his small bank of collectors is already saving the establishment at least $12,000 annually . . . which, of course, means that the Hyatt Hotel's solar installation will be supplying "free and clear" energy within less than two years after its completion!
APPENDIX 4: APPLICABLE CONVERSION FACTORS

**Electricity**

1 GWh of electricity utilizes 1,832 barrels of crude oil

1 KWh of electricity produces 0.543 kg of CO₂ equivalent

**Water heater**

1. **Energy consumption**

   Electric (tank) 4,000 KWh per annum
   Gas (LPG) 300 gallons LPG per annum

2. **GHG emission**

   Electric (tank) 2,173 kg CO₂ equivalent per annum
   Gas (LPG) 1,500 kg CO₂ equivalent per annum

**Notes**

Energy system performance software models such as RETScreen® (Solar Water Heating Software) can be used to estimate the anticipated performance of solar water heating systems based on different configurations and on weather data for locations in the Caribbean region. Based on model runs for residential systems using weather data for Kingston, Jamaica, and various assumptions about system sizing and hot water consumption patterns, one could estimate a rough approximate average of the equivalent of 0.65 MWh of thermal energy delivered per year to the user per m² of solar thermal collector surface. To provide the same quantity of thermal energy to the end user using an existing electric water heater of 65 per cent efficiency would require 1.0 MWh of electricity, without accounting for line losses. Based on these assumptions, it is possible to estimate that each m² of solar thermal collector surface in a properly sized residential solar water heating system in the Caribbean region would displace about 0.8 tons of CO₂ per year, as a rough approximation.
APPENDIX 5: GENERALIZED COSTS OF SOLAR WATER HEATERS

The capital cost of a solar water heater depends not only on the installed capacity of the collector, but also on the capacity of the storage tank. Estimated generation costs for residential and commercial SWH systems are as low as US 12 and 13 cents per KWh, respectively. Since this is a mature technology, capital costs are unlikely to fall to a significant extent. However, a study by the International Energy Agency (IEA) suggests that costs decrease by 20 per cent when the total capacity of domestic solar water heaters doubles within a given country. For our assessment, we used cost figures collected from solar water heater manufacturers in Barbados (including Solar Dynamics, whose systems have been installed in the majority of CARICOM states).

**Solar Water Heater Costs**

Source: Based on data provided by solar water heater manufacturers in Barbados.

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<th>Capacity Factor (%)</th>
<th>Annual output (GWh/y)</th>
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