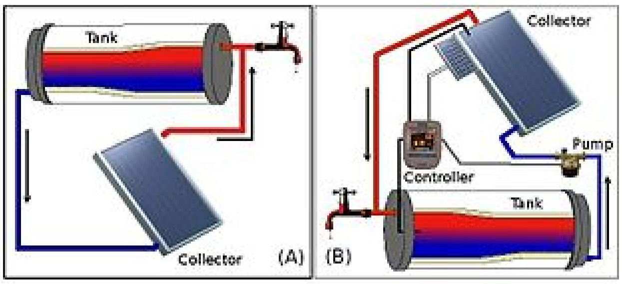
3. Solar Water Heater

<table>
<tr><td colspan="2">SECTOR: ENERGY
CATEGORY: Solar Thermal (Domestic and Commercial water heating)</td></tr>
<tr><td colspan="2">TECHNOLOGY: Solar Water Heater</td></tr>
<tr><td>Introduction</td><td>Solar Water Heating (SWH) is a proven technology that has been widely applied across residential, commercial and industrial sectors around the world (REN21, 2009). China and northern Europe have led the global SWH market in terms of total installed capacity, although island jurisdictions such as Barbados and Cyprus have some of the highest penetrations of SWH on a per capita basis. Solar water heating (SWH) takes advantage of the region’s abundant solar resource to provide a simple, cost-effective, and sustainable means of heating water

Solar water heating is a very recent technology for Belize but the country currently has poor incentives, information and awareness promoting solar thermal technologies for heating water. 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.

This technology transfer initiative under the TNA project will seek to install twenty-four (24) SWH in four municipalities across the country. Namely, Corozal Town, Belize City, Belmopan and Dangriga. The electricity bills for participants in this pilot project will be monitored over a 12-month period. Electricity consumption pre- and post-installation of the SWH will be compared to determine the real financial and environmental benefits and savings.</td></tr>
<tr><td>Technology characteristics</td><td>Solar water heating (SWH) is the conversion of sunlight into renewable energy for water heating using a solar thermal collector. [1]

Solar water heating collectors capture and retain sensible heat from the sun and transfer this heat to a liquid. Solar thermal heat is trapped in a way similar to the “greenhouse effect”; but in this case, it is the ability of a reflective surface to transmit short wave radiation and reflect long wave radiation. Heat and infrared radiation (IR) are produced when short wave radiation light hits a collector’s absorber, which is then trapped inside the collector. Fluid, usually water, in contact with the absorber collects the trapped, sensible heat and transfer it to storage. [2]



Direct systems: (A) Passive CHS system with tank above collector. (B) Active system with pump and controller driven by a photovoltaic panel [2]

(Source: (Wikipedia 2016) [2]</td></tr>
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	Heat transfer *Direct* *Direct* or *open loop* systems circulate potable water through the collectors. They are relatively cheap. I*ndirect* *Indirect* or *closed loop* systems use a heat exchanger to transfer heat from the "heat-transfer fluid" (HTF) fluid to the potable water. **Propulsion** *Passive* *Passive* systems rely on heat-driven convection or heat pipes to circulate the working fluid. Passive systems cost less and require low or no maintenance, but are less efficient. Overheating and freezing are major concerns. *Active* *Active* systems use one or more pumps to circulate water and/or heating fluid. This permits a much wider range of system configurations. Pumped systems are more expensive to purchase and to operate. Active systems operate at higher efficiency that can be more easily controlled. Do it Yourself (DIY) SWH systems are usually cheaper than commercial ones, and they are used both in the developed and developing world.
Costs, including	
Cost to implement adaptation options	Based on the three major SWH vendors in Belize, prices range from BZ$ 2,000 to BZ$ 4,000. The price varies depending on storage capacity and whether it is vacuum tubes or flat panel models being used.
Operational Cost	There are very few persons trained to install SWH in Belize. Most current installations are done by plumbers or even electricians. Installation costs about BZ$ 500, with a team of two persons and installation usually takes about half-a-day. Maintenance is minimal and mainly requires the cleaning of the glazed panel or tubes to ensure efficiencies are maintained. Maintenance also includes regular checks for leaks on the plumbing and occasional flushing of the system. Encapsulated tubes need to be replaced whenever they break or are damaged. According to one vendor's statistics, sales of vacuum tubes have been about 8 every year for every sale of 30 SWH unit, so a typical unit requires a single tube replacement every three year. Each tube costs about BZ$ 35.
Cost of not modifying the project	The cost of not implementing this project will see the gradual increase and reliance on non-renewable sources of energy for heating water.
Potential development impacts,	Most of Belize, especially the central and northern areas, receives medium to high solar intensity (4.5-5 kWh/m^2/day) that can sustain a reasonably good

benefits	power generation throughout most of the year. With 20% of Belize's households converting to SWH (approximately 17,060 SWH units) – the average use is equivalent to 119 MWh/day of thermal energy. Assuming that these would replace existing traditional electric water heaters, this would represent a 23,900 tCO_2 reduction per annum. Similarly, in the commercial sector (hotels) 9,889 KWh/day or 1,412 solar water heaters would reduce GHG emissions by 1,980 tons of CO2 per year.
Economic	Some of the economic benefits for Belize triggered by an increased uptake of SWH would include: i) Direct job creation for locals: Installation and maintenance of SWH systems would require technical and manual labour, which would increase the workforce for Belize. ii) Replacing existing electric or LPG water heaters with SWH would reduce the energy intensity and hence save money. Both domestic and commercial sectors can benefit from this, but hotels and resorts would be the biggest winners in SWH investments. iii) National Cost savings - due to reduced imports of total petroleum products Belize would retain currency. iv) Hotels and Resorts can benefit economically by promoting their regional or global green/environmental certifications.
Social	*Income, education, health, other* Electricity expenses make up a significant portion of operating expenses in the tourism industry, especially those providing accommodations, such as hotels and resorts. Solar water heaters can replace conventional thermal systems and drive down operating costs. Note that payback time on investments can be short term, as indicated by a recent study conducted by the International Renewable Energy Agency (IRENA) which states that the estimated payback period for SHW systems for hotels in the Caribbean can be as short as one year. The widespread adoption of renewable energy resources in the hotel sector of Belize can lead to increased demand for local trained personnel in installation, operation, and maintenance of SWH systems. An increase in investment in SWH can simultaneously benefit the environment and stimulate the local economy.
Environmental	*Local pollution, GHG emissions, other* Besides the reduction of GHG as mentioned earlier in the document, SWH is a clean technology and has the following additional environmental benefits: i. Solar water heating systems require no fuel or any inputs during operation and electricity production and does not contaminate any water since there are no waste products. ii. SWH systems are noise and vibration free which can be considered environmentally friendly. iii. SWH systems have a service life of over 20 years with minimal

	maintenance, and most parts can be recycled.
Status	Despite the favourable economic and climatic conditions, the SWH market in the Caribbean is still emerging. Average per capita deployment is relatively low, estimated at 48.9 kW_{th}/1000 people compared to the market leader of Austria at 430 kW_{th}/1,000 people (CREDP, 2013; Gardner, 2012; Mauthner & Weiss, 2015). However, this regional average is skewed by the high levels of SWH deployment in Barbados (319 kW_{th}/1000 people), Saint Lucia (111.4 kW_{th}/1000 people), and Grenada (80.0 kW_{th}/1000 people) (Gray *et al*., 2015). In Belize, SWH investment has the potential to reduce energy costs, stimulate local markets for clean energy technologies, mitigate GHG if the technology will replace electric and gas water heaters and hence improve the environmental performance of the tourism sector. Belize, in general, does 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 centred on electricity-generation devices.
Barriers	Most Caribbean countries face significant barriers to SHW technology and these are: - • **Financial Barriers** Despite the fact that a SWH investment has a short payback period of as little as 15 months and a generally high net present value, initial investments are very high, as much as US$ 1000 for a 40-gal unit. High upfront costs will discourage many homeowners from making this investment. • **Organizational/regulatory Barriers** Many organizations including hospitals, public facilities and government departments still do not see energy efficiency and energy management as priority and in many cases, see energy expenses as a fixed cost. Motivation to invest in SWH may be triggered by occasional increases in fuel or electricity cost and then shortly after, this drive to save energy dies off. Other barriers identified that can restrict the mainstreaming of this technology are: - Weak Enabling policy environments for SWH - Incumbent Technology - Information Barriers - Technical Barriers
Acceptability to local stakeholders	According to Belize's 2010 census, Belize had 79,492 households with an average of 4.1 persons per household. There is no data on how many of these households have access to hot water systems. In 2012 the estimated solar water heating technology installed capacity for Belize was estimated at 6.3 kW_{th} per 1,000 inhabitants and well below the regional average of 48.9 kW_{th} per 1,000 inhabitants [3]. The mid-year population estimate for Belize in 2013 was 349,728 with an estimated 85,300 households, so the estimated installed SWH capacity in 2013 was 2,205 kW_{th} or

	the equivalent of 315 SWH units of 80-gal capacity each. If Belize were to attain technology penetration level at least similar to the Caribbean region, the SWH installed capacity would be a total of 17.1 MW_{th}. Based on a typical Belizean household solar thermal requirement of 7 kWh/day per household [4], would represent about 2,445 households (2.9% of the households) or 2,445 solar water heater units of 80 gallons capacity each. On the commercial side, in 2010 Belize had 664 hotels with 6,849 rooms but this increased to 757 hotels with 7,377 rooms by 2013 with an average of 10 rooms per hotel [5]. The average hotel occupancy rate was 38.3% for the period of 2007-2010 [6]. Assuming a 38.3% occupancy rate this reflects 2,825 rooms, and assuming a two-person per room occupancy, this would represent a total water heating demand of 9,889 kWh/day or 1,412 solar water heaters of 80 gallons capacity each.
Endorsement by experts	Solar thermal energy can cover a substantial part of the world's energy use in a cost effective and sustainable way. Any long-term vision for economic development must include solar thermal technologies to save finite energy sources. Key to solar' s growth is the willingness by governments, industry and all Belizean for the transition from fossil fuels to renewables. [7]
Timeframe	Six (6) months to acquire and install all 24 systems. Assessment will take place over a 12-month period.
Institutional capacity	For the pilot tests, the required institutional capacity can be met by the existing local solar companies. However, as the need for SWH grows, there will be need for more institutional capacity in the form of trained personnel to install and maintain.
Adequacy for current climate	Solar PV has enormous energy potential in many countries in Central America and the Caribbean, and likewise in Belize. Most of Belize, especially the central and northern areas, receives medium to high solar intensity (4.5-5 $kWh/m^2/day$) that can sustain a reasonably good power generation throughout most of the year. Assuming that these would replace existing traditional electric water heaters, this would represent a 23,900 tCO_2 reduction per annum. It is possible to estimate that each m^2 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 CO_2 per year, as a rough approximation.
Size of beneficiaries group	The pilot project will benefit 24 households (six persons per household) evenly distributed among four municipalities in Belize.

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