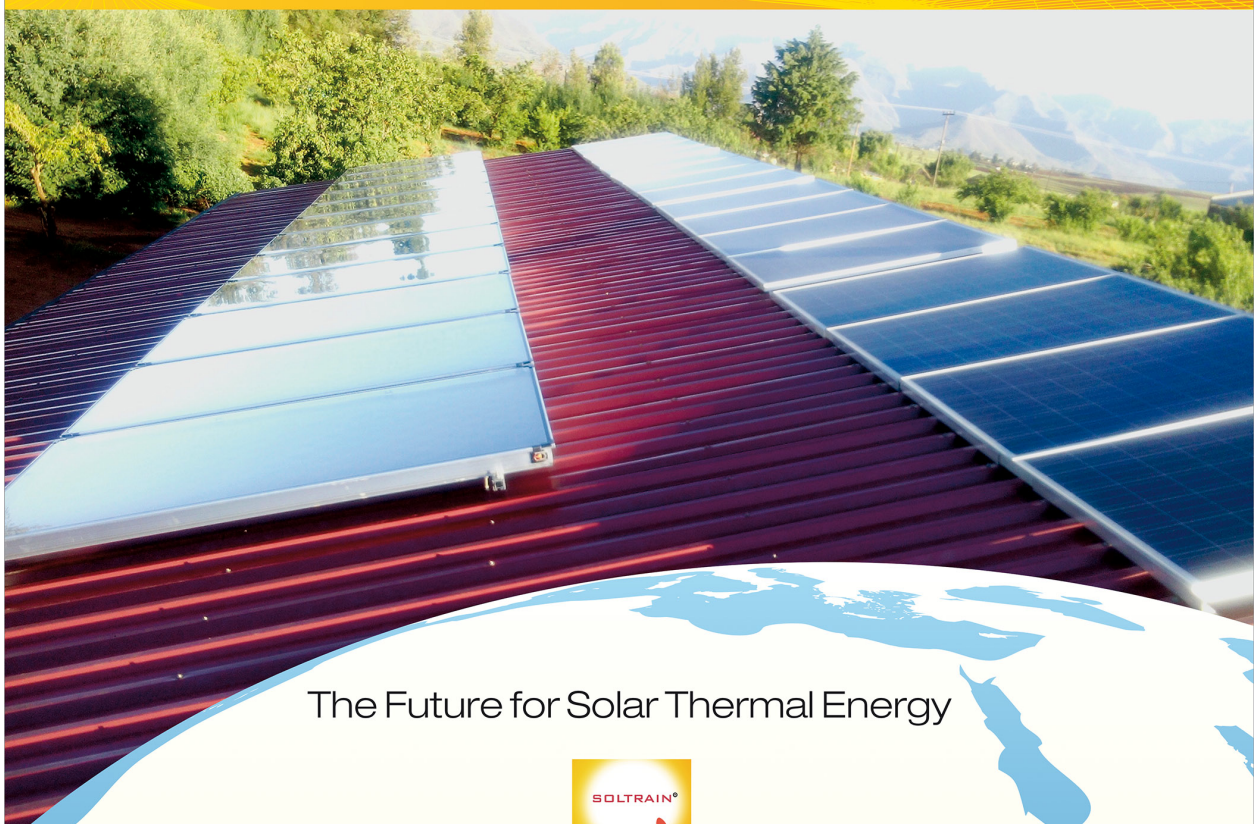
Solar Thermal Technology Roadmap and Implementation Plan



The Future for Solar Thermal Energy

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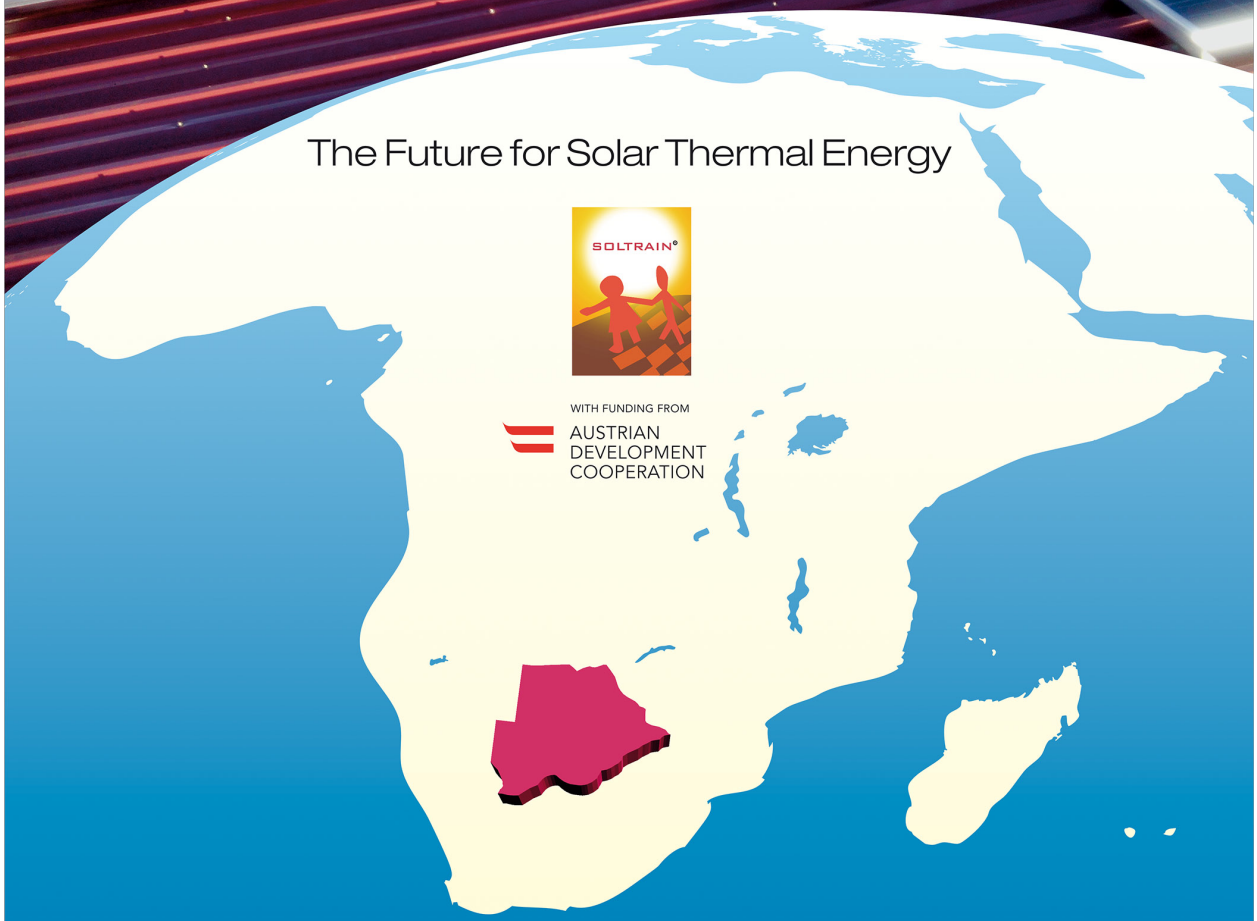

Botswana

REPUBLIC OF BOTSWANA

Solar Thermal Technology Roadmap and Implementation Plan for Botswana

Strategy for

Botswana's Solar Thermal Energy Vision

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Foreword

The Government of Botswana (GoB) is acutely aware of the significance and importance Energy plays in economic and social development of the country, through investments, policy and strategy. Accordingly, it has placed the oversight for development of the Energy sector under the portfolio of the Ministry of Minerals, Green Technology and Energy Security. The Department of Energy (DoE) which falls under the Ministry is directly charged with the responsibility of the development of the energy sector and has designed policies, strategies and regulation accordingly. The Department has navigated the development of the sector to meet the demands of national development through policies, strategies and plans which are based on international norms and constraints. In particular, the UN's strategy on climate change which requires the international community of nations to combat the production of CO_2 from generation of electricity using fossil fuels in order to protect the environment from climate change.

In this regard DoE has refocused its attention to the development of renewable as a major source of energy for powering socio-economic development. Starting with Energy, targets were set in the Energy Master Plan of 1996 with regard to the electrification of Botswana. The target aimed at an electrification rate of 80% by 2016 at the national level in tandem with a target of 60% for rural electrification. The National Development Plan (NDP) 10 on the other plans aimed to achieve an uptake of 15% in 2015 and 25% in 2030 in Renewable Energy.

Several instruments have been applied, or planned, to meet the targets, especially to push rural electrification forward, and to increase the share of renewable energy to meet the target sets. These plans are set against the backdrop of Electricity tariffs, which are not cost-reflective, but subsidized by the government, and applied by the partially government owned power utility, Botswana Power Corporation (BPC), to its customers.

In Rural Electrification, BPC Lesedi was set up to lead the renewable energy based rural electrification programme. Through BPC Lesedi, by 2013, over 12000 Solar Home Systems were installed. In addition a few mini-grids were realized. LESEDI has been instrumental in strengthening the public and private sectors working in the area of solar PV and renewable energy. Another instrument to increase the share of renewable energy in Botswana is the planned Feed-In-Tariff, FIT for short. Unfortunately, the planned FIT-scheme has not been realized, because subsidizing renewable power generation by price-uplifts would automatically increase power prices.

In view of the foregoing, the SOLTRAIN project which aims at consolidating and increasing the market share of solar thermal water heaters in Botswana through "the Botswana Solar Thermal Technology Roadmap and Implementation Plan" for new installations, repair and maintenance of existing systems from now till 2030, has come at the most opportune moment for the Ministry and indeed the Department of Energy.

The Department of Energy and the Ministry of Minerals, Green Technology and Energy Security, cognizant in their current role of increasing the share of renewable energy throughout the country, wholly support the roadmap. The Roadmap represents four elements from the viewpoint of the Department:

(i) As a national strategy document for planning the development and deployment of solar thermal technology systems for application in the areas of great need in Botswana – in the short to medium term. The Department is in the process of adopting the documents for strategy and policy requirements in renewable energy in general, and solar thermal systems in particular.

(ii) As an instrument for increasing the share of renewable energy technology application in Botswana

(iii) As an instrument for rolling out the Presidential Directive on Solar Water Heater (CAB 18(B)/2015) and Energy Efficiency

(iv) As a mechanism for reducing the demand on the electricity supply by offloading solar water geysers from the electricity network

In preparing the roadmap, consideration was given to commanding areas where the development and deployment of solar thermal technology systems (STTSs) were of immediate concern to Botswana: namely- Domestic Sector; public sector applications such as schools, hospitals, government infrastructure; police; the army; private sector: hotels, resorts; commercial and industrial sector.

The roadmap stipulates Botswana Solar Thermal Technology Platform (BSTTP) Vision that provides for a development path for achieving a STTS targets as follows:

(i) Achieve the installation of 910,000 m^2 of solar thermal technology collectors by 2030.
(ii) The target installation will be equivalent to have 0.3 m^2 of net solar thermal collector area for every member of the population by 2030 in Botswana.
(iii) This relates to an installed capacity of 637MW_{th} and annual electricity savings of 659,000 MWh, avoiding 182,000 tons of CO_2 every year.

The target covers the period from 2018 to 2030, giving a time span of 12 years. The programme shall be phased such that there is a yearly target to achieve, beginning 2018.

The total cost for realising the vision is EURO 461 million, with an annual average breakdown of EURO 21 million. The financial implications are huge and a strategy to invest in the project is of immediate concern if the roadmap is to be implemented. This investment should be viewed against the positive spin it has on reduction of generation from fossil fuels.

The electricity savings due to the investment on annual basis is Pula 141 million or EUR 11.4 million, which gives a payback time of about 3.4 years.

I invite you to read this document and hope that it will inspire us and provide us with the pathway for achieving a greater share of renewable energy in meeting our targets for our socioeconomic development.

Mr. K. Molosiwa
Acting Director – Department of Energy (DoE)

1.0 BACKGROUND

1.1 Current state of national Energy Supply and Demand

Botswana is faced with high and rising fuel prices; high cost of grid-connectivity in rural areas; the need to decrease the dependence on imported electricity and fossil fuels; and to reduce the country's emissions of green house gases (GHGs), including a reduction in use of non-renewable biomass. The Government has exerted national efforts to reduce Botswana's energy-related CO_2 emissions by promoting renewable energy and low GHGs technologies as a substitute for fossil fuels (fuel wood, paraffin, charcoal used countrywide).

Energy consumption in Botswana includes fire wood, electricity, gas, petrol and diesel. Botswana's electricity market is vertically integrated and controlled by the partially state-owned Botswana Power Corporation (BPC). Coal is the major source for domestic electricity production.

BPC reported maximum system demand of 578MW in its 2013 annual report. In the same year, the company's power imports amounted to 76% of total consumption and were sourced mainly from South Africa. According to the World Bank, 45.7% (2011 estimate) of the population has access to electricity; BPC's own and more recent estimate on the access rate is a little higher at 55% of the population.

Electricity generation for Botswana is based on coal, like the Morupule Power Station (Morupule A) with an installed capacity of 132MW. Morupule A provides 20% of the base load, with the rest (80%) being provided from imports mainly from Eskom of South Africa and Mozambican utility companies. Both locally generated and imported electricity are to meet the current demand of about 600MW (BPC, 2015). In addition Morupule B was commissioned in 2014 with an additional capacity of 600MW. However the plant has not been able to produce the expected output due to technical and operational problems. Currently, it produces less than 100 MW of the projected output and is under maintenance to achieve the planned output.

The electricity generated locally from Morupule A and Morupule B, is produced from coal fired thermal plants with conversion efficiency of 30%. This means that only 30% of the energy in coal ends up as useful electricity. The remaining 70% is lost due to process inefficiencies and heat losses. Many modern coal-fired power plants have conversion efficiencies greater than 35% and water-cooled plants, such as those located near rivers or oceans, have even higher efficiencies. The world's most efficient

coal plants have conversion efficiencies as high as 47%. One hopes that, as the operational problems are solved at the Morupule plant, attention will be focused on improving its conversion efficiency to above 30%.

The thermal plants coupled with their poor efficiency levels have led the Government to forge partnership with GEF and UNDP to mitigate against increased use of thermal generating plants in an a concerted effort to reduce CO_2 emission in response to global efforts at combating climate change.

The Government of Botswana (GoB) with its partners are pursuing policies and projects based on integrated approach to address solar energy barriers such as policies, financial, engineering, hardware demonstration, awareness, and public-private partnership to improve renewable energy access. The project has been integrated into the Government's National Development Plans 9 and 10 and has attracted both GoB and other partner donors such as Sweden for the mini-grid PV and Japan for the 1.3 MW PV projects.

These efforts are aimed at increasing the application of renewable energy to reduce reliance on fossil fuels in order to reduce its carbon emission.

1.2 SOLTRAIN

It is against this background that the Austrian Development Agency (ADA) through AEE Institute has initiated the support for development and deployment of solar thermal technology in Botswana as part of Government effort to reduce power from fossil fuels. The aim of ADA through IEE Institute is to support target countries (Botswana, Lesotho, Mozambique, Namibia, Zimbabwe and South Africa) in changing from largely fossil energy system to renewable energy system (Solar Thermal). The implementation agency is AEE INTEC, an Austrian institute active in solar thermal Energy Research, Training & Demonstration Plants.

AEE – Institute for Sustainable Technologies (AEE INTEC) is an independent research association and is a leading institute for applied research in the fields of solar thermal energy, low-energy and zero energy buildings as well as in energy efficiency in industry. The AEE INTEC research group in 'Solar Thermal Components and Systems' works in cooperation with industry partners and other research institutes on the further development of single components, as well as solutions for solar thermal systems. The preparation of the Botswana Solar Thermal Technology Platform (BSTTP) is the starting point. BSTTP is where different national stakeholders are assembled into an organized

structure to strategize and address the issues of solar thermal technology. This will lead to a planned implementation of the Solar Thermal Technology systems throughout Botswana. The preparation of BSTTP follows similar exercises that has already been achieved in South Africa, Mozambique, Zimbabwe, Lesotho and Namibia.

1.3 Rationale for a Solar Water Heating Roadmap and Implementation Plan

1.3.1 Energy Generation Shortage

The current installed capacity for electricity generation in Botswana is 892 MW, with operating capacity of 410 MW, a current peak demand of 610 MW and a current peak demand plus reserves of 698 MW. At current levels of demand, there is a capacity shortfall of 288MW. By 2025 it is forecast that Botswana demand will increase to 1017 MW (BPC, 2015). More critically, Botswana's major source of energy import, which is South Africa, is forecast to experience a shortfall of 5994 MW by 2025.

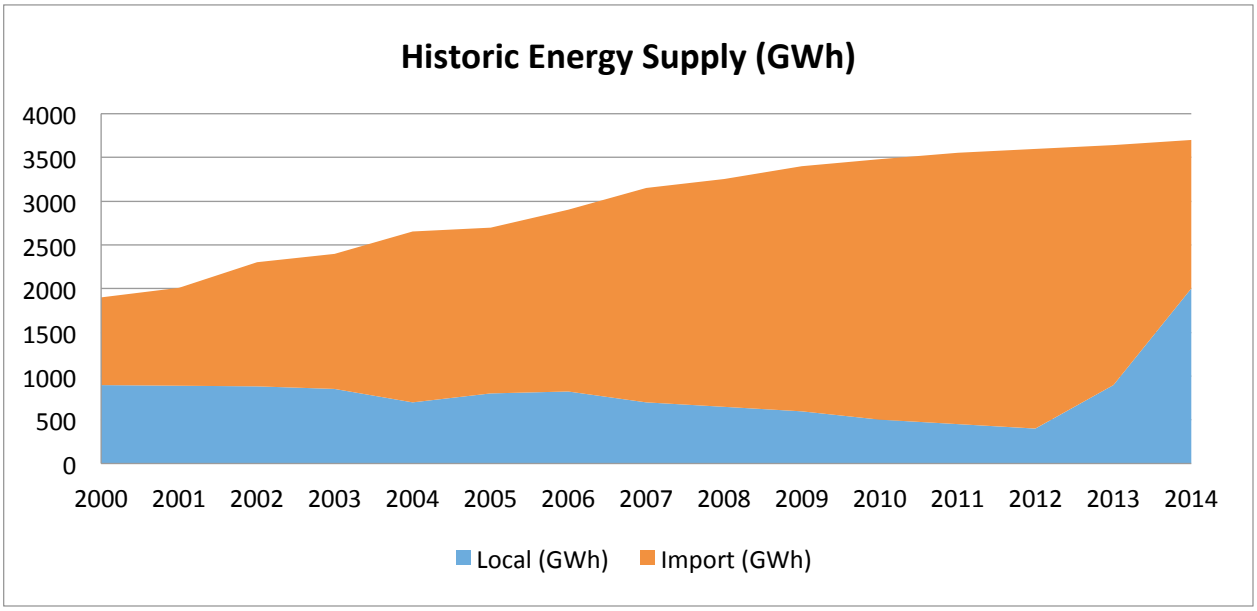

Figure 1: Current deficit in supply due to increasing demand (Source: Botswana Power Corporation, 2015)

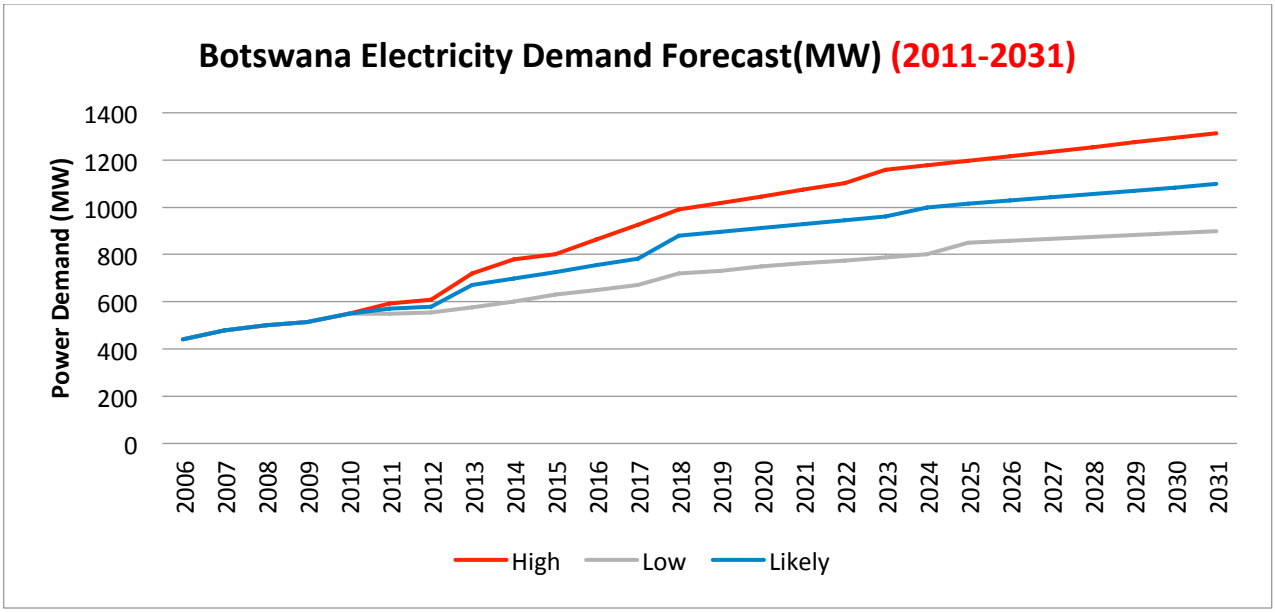

Figure 2: Projected electricity demand to 2031 (Source: Botswana Power Corporation, 2015)

The electricity demand has been increasing significantly over the years, energy at 6% & capacity at 8% annually in the last 5 years as in Figure 1. Botswana's reliance on power imports increased from 51% in 2000 to 94% in 2012 with the shutdown of Morupule A power station. The commission of Morupule B reduced the reliance of import power from 94% in 2012 to 48% in 2014. As evident from Figure 2 the deficit in generation will grow over time up to and beyond the roadmap target year of 2030. However, if the development and deployment of solar thermal systems is implemented as set out in this roadmap and implementation plan, that deficit will be curbed significantly with reductions in imports as well as cost savings and added financial benefits.

1.3.2 Population Growth and Energy Requirements

In the last census of 2014, the population of Botswana was recorded as nearly 2.2 million and the growth rate was estimated at 1.98%. By 2020, the Botswana Population is projected to trend around 2.5 Million in 2020, Figure 3, according to our econometric models. At the rate of 1.98%, the population of Botswana will rise to nearly 3 million, in the year 2030 and the energy demand will be nearly 1500 MW. As the population grows the proportion of renewable energy in the energy mix from different sources: fossil, biomass, solar should be significant for Botswana to offer meaningful contribution in combating the depletion of the ozone layer due CO_2 from fossil generation source. The solar thermal technology energy application will play a very important role in that case.

Figure 3: Population Growth for Botswana

1.3.3 Reduction in Carbon Emission through Renewable Energy

While the government has planned for increased electricity production to meet demand, there is the global concern of expanding access to energy services to meet the Millennium Development Goals while protecting the environment. This is especially pertinent at this time when the atmosphere is currently suffering from an ever rising concentration of carbon dioxide and other Green House Gases. The balance between the global demands for cleaner energy in the interest of humankind provides a key point in the development and deployment of solar thermal systems, as solar resource is abundant.

1.3.4 Solar Energy Resource Opportunity

Botswana has high potential to tap solar energy and has global horizontal annual irradiation (GHI) up to 2,300 kWh/m^2/year, which is among the highest in the world.

The area bordering Botswana, South Africa and Namibia is among the areas with the highest solar radiations. It is estimated that using less than 1% of the country area, Botswana could meet its current electricity consumption. Based on data recorded, high figures of global irradiation of 2350 KWh/m^2/year were identified on the western side of

a place called Kang, in the western region of Botswana and around Kalahari Gemsbok National Park, located 23°South, 20° East, at elevation 1240 m above sea level. The lowest figures of solar radiation are on the north eastern side of Botswana west of Francistown. Depending on the season, temperatures range from nearly 0°C in winter (May-July) to over 40°C in Summer (Nov-Feb).

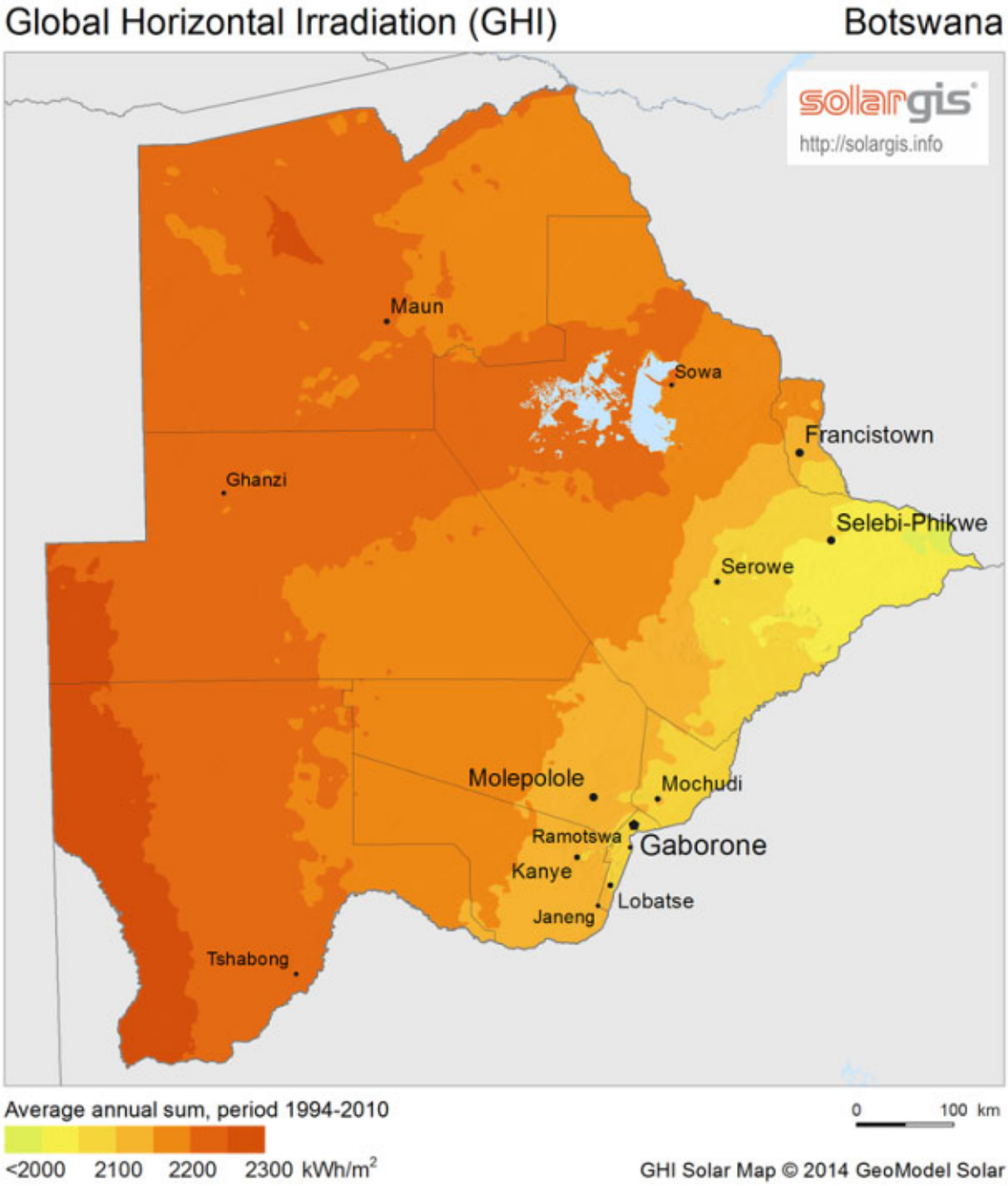

Figure 4: Solar Radiation Map for Botswana

1.4 Current Solar Water Heating and Cooling in Botswana

With the abundance of solar energy in Botswana, there is potential for solar water heating, passive solar designs, solar PV and solar cooling. Solar PV technologies are still too expensive to be adopted in large scale and hence can only be disseminated through a government subsidy or private investors.

Currently, there is also limited application of solar cooling and passive designs, due to limited expertise and cost of designs in those areas. There is potential to widely disseminate solar water heaters in the country by using the improved SWH technologies developed in-country and outside Botswana.

1.5 Barriers and Gaps in Accounting for Low Uptake of Solar Thermal Energy Technology

The key gaps and barriers for solar thermal energy technology and applications in Botswana for productive use are as follows (GEF):

i. Clear policy for solar thermal energy technology uptake, energy efficiency and productive use of Solar Thermal Energy Technology.
ii. Assessment of energy efficiency and renewable energy potential and capacities that can be achieved.
iii. Identification and costs and benefits of various Solar Thermal Energy Technologies.
iv. Instituting appropriate regulatory frameworks e.g. for technology standards, incentives to reduce costs to consumers
v. Having dedicated institutions that push for solar thermal technology and application
vi. Dedicated financing mechanisms with reduced cost of finance to enable the poor to afford Thermal Energy Technology
vii. Awareness of end users on Solar Thermal Energy technologies and their costs and benefits
viii. Monitoring and evaluation of set targets for energy access, energy efficiency and renewable energy
ix. Capacity of technology developers, designers, installers and maintenance of Solar Thermal Energy Technology
x. The availability of local financing from commercial banks and financial intermediaries, which can play a decisive role in the development of local markets.

1.6 Existing Legislation and Institutional Arrangements

The implementation of the Solar Thermal Roadmap will depend on current legal instruments, institutional arrangements, enabling policy, strategies, regulations and standards applicable to solar thermal technology, in particular, and renewable energy in general. Recently, the implementation of solar thermal technology and applications have come under sharp focus at the highest level of government, with the Presidential order directing that solar thermal technology should be fast tracked with regard to new installations, repair and servicing of old ones in government institutions and public buildings. The areas covered are as outlined below.

1.6.1 Institutional frameworks

Policy
The institutional framework consists of public and private sector organizations. At government level, there are two institutions involved in various aspects of renewable Energy:

i. Ministry of Mineral Resources, Green Technology and Energy Security (MRGTES)
ii. Department of Energy (DoE)

At the time of writing this document, the reorganization of the Department of Energy was being mooted. The MRGTES and the DoE are the lead institutions responsible for national energy policy formulation, coordination and implementation.

The key elements of the policy relate to goal and objectives, namely:

Policy goal
To provide affordable, reliable and adequate supply of energy for sustainable development, as well as to improve access to and efficient use of energy resources.

Policy Objectives

- Improve security and reliability of energy supply through renewable energy (RE) solutions.
- Increase the share of new and renewable sources of energy in the energy supply mix of the country.
- Provide effective institutional arrangement and governance for the RE energy sub-sector.

- Minimise energy related impacts on the environment.
- Establish an effective and sustainable RE
- Research and development programmes that addresses the country's RE development priorities.

Regulation

The Botswana Energy Regulatory Authority (BERA) was created in 2015 as an energy regulator. The key responsibilities of this body will encompass the following:

i. Establish licensing procedures, prescribe license fees and issuance of generation licenses;
ii. Establishment, approval, management and administration of feed-in tariffs;
iii. Overall monitoring, reporting and review;
iv. Supervision of licensed renewable energy generators/Independent Power Producers (IPPs);
v. Develop and enforce codes of conduct, performance and quality standards for operators in the energy sector;
vi. Development, management and review of appropriate regulations for grid connections and wheeling of renewable energy electricity;
vii. Review and updating of the avoided costs of the grid; and
viii. Mediation of disputes between generators, transmitters, distributors and consumers.

1.6.2 Current Trends on Legal, Policy, and Regulatory Instruments on SWH

Initiatives in Renewable Energy

i. Promotion of solar water heating - Presidential Directive CAB18 (B)/2015
ii. A number of RE initiatives are currently on-going, namely: energy policy, energy efficiency strategy, renewable strategies, and feasibility study on Mini-grids. Incidentally, none of these studies and initiatives cover Solar Thermal Technology programmes. Therefore, this is an opportunity for the BSTTP to come up with a robust Road map that will propel the country to high penetration of Solar Thermal Technology.
iii. Ratification of International Renewable Energy Agency (IRENA)
iv. Establishment of Renewable Energy Agency

1.6.3 Presidential Directive on Solar Water Heater CAB 18(B)/2015 and Energy Efficiency

The erstwhile Ministry of Minerals, Energy and Water Resources was instructed through a presidential directive to immediately implement energy saving measures. The directive covered the following areas of energy efficiency and SWH:

i. The banning of use, supply, import and sales of all inefficient lights such as incandescent and florescent lights are banned with immediate effect.
ii. To replace inefficient lights (e.g. incandescent lights, florescent lights) with efficient lights (e.g. LED technology);
iii. Install occupancy sensors in common areas and intermittently occupied rooms such as toilets, kitchen and conferences rooms;
iv. Set all Information Technology equipment to power saving mode and replace old cathode ray tube computer monitors to Liquid Crystal Display (LCD); and
v. To repair all Solar Water Heaters installed in public institutions and ensure that these systems are operating efficiently.
vi. Botswana Defense Force to undertake maintenance or replacement of some 600 SWH systems that were previously found defective as a way of kick starting the aspect on SWH maintenance as per the Directive .

The Department of Energy has begun the implementation of some energy efficiency and conservation measures at the DoE offices and at the headquarters of the Ministry in accordance with the directive.

1.6.4 Solar Thermal Cooling and Energy Efficiency for Botswana Building Regulation

Building regulations in Botswana are currently under review. The review has been necessitated by energy efficiency and passive solar thermal cooling considerations. The particulars of the review relate to:

i. Advocacy for sustainable and conservation of energy in building design
ii. Development of energy efficiency and conservation chapter by the Department of Energy for adoption in the Botswana Building Code
iii. To enforce compulsory installation of SWH in hotel and other building that house groups of tenants e.g hostels.

1.6.5 Establishment of the National Energy Fund

The Department of Energy through a consultancy shall establish a National Energy Fund. The process of establishing the fund will involve the following considerations:

i. Review of energy sector projects and programmes as well as their financing structures and mechanisms.
ii. Recommend optimal integrated financing solution and strategies for effective and efficient delivery of energy projects and programmes.
iii. Assess the possibility of consolidating existing energy funds (NPF and NEF) to create a single fund from which all energy projects and programmes will be funded including Solar Water Heating.
iv. Establishment of an integrated energy fund for delivery of the energy sector projects and programmes.

2.0 TECHNOLOGY ROADMAP PROCESS

2.1 Purpose of the Roadmap and Implementation Plan

The purpose of the report is to present the Botswana Solar Thermal Roadmap and Implementation Plan (BSTRIP). The BSTRIP aims to identify the primary actions and tasks that must be addressed to accelerate the residential, institutional, industrial solar thermal technology development and deployment nationwide, where the majority of users have only just started to consider or become aware of the potential offered by solar heating and cooling technology. The BSTRIP balances several diverse areas; namely policy, regulation and legal Issues; publicity, research, training and capacity development, standards quality and testing. Drawing from the foregoing synergies, the roadmap and implementation plan focuses on applications of thermal technology in the key areas of immediate attention to Botswana, namely domestic and public sector applications; *commercial and industrial applications like mining applications.*

2.2 Process

The approach embraced four phases:

i. Phase1: Launching of the BSTTP preceded by SOLTRAIN training
ii. Phase 2:Group Leaders Meeting
iii. Phase 3: Stakeholder Workshop
iv. Phase 4: Preparation of Draft to be discussed by the stakeholders.

Phase 1:
This phase of the approach followed first SOLTRAIN training in May 2016. The launching was primarily to inform trainers (main stakeholders) about the BSTRIP, its purpose and implications, and about the process for the preparation of the Platform. It was a publicity event about the BSTRIP and its implications. Group leaders were identified during this initial stage of discussions.

Phase 2:
The key stakeholders in the energy sector, namely representative from government (Department of Energy), the power Utility (Botswana Power Corporation), Solar Industries Association of Botswana, private organizations, Standard Bureau, public institutions, Solar Companies (currently in business) and NGOs were called to make preparations for the workshop. In all 29 stakeholders attended the leaders meeting. The outcome of the meeting was a formation of 5 strategic groups, each with a leader. Each group developed and prepared a working paper, which was discussed during Phase 3. The consolidated list of groups consisted of:

Group 1: Policy, Regulation and Legal Issues for Solar Thermal Technology

Group 2: Domestic and Public Sector Applications of Solar Thermal Technology

Group 3: Commercial Industrial and Mining Applications of Solar Thermal Technology

Group 4: Research, Technology and Capacity Building for Solar Thermal Technology

Group 5: Standards Quality and Testing for Solar Thermal Technology

Group 6: Publicity and Awareness for Solar Thermal Technology

The basis for group formation was dictated by the structure of the Energy Industry and sector in Botswana, the need to be as inclusive as possible, and knowledge about SWH industry of the participants in Botswana. The role of each group was clearly articulated. Each group prepared an industry\sector report related to the group responsibility. These reports were then in turn submitted to the coordinator SOLTRAIN workshop. Subsequently, the reports were then discussed and analyzed in the preparation for the BSTRIP.

Phase 3:
Workshop for BSTRIP: The workshop consisting of over 20 stakeholders and was held in September, 2016 to draft and prepare the final BSTRIP. Each paper prepared from each group was analyzed during the workshop to determine the issues and elements which would be included, rejected or modified for inclusion in the BSTRIP. The outcome of the workshop identified the key areas, elements and details that should be covered in the BSTRIP. The key aspects of the BSTRIP identified were:

Roadmap 1: Thermo-syphon systems for single family residential houses (High pressure residential \ low pressure residential applications) (2-4 m^2 collector area per system): Residential houses

Roadmap 2: Solar (pumped) combi-systems (10-20 m^2 collector area): Multi-story residential houses and lodges

Roadmap 3: Pumped SWH systems (20 -100 m^2 collector area per system) for government institutions: (hospitals and educational institutions) and multi-residential building

Roadmap 4: Large pumped thermal systems (50-500 m^2 collector area per system) for Industrial, Commercial and Mining applications of solar thermal technology

Roadmap 5: Large Pumped Solar Water Heating, Cooling and Air-conditioning (20-500 m^2 collector area per system) for larger offices and hotels

2.3 Scope of the Roadmap and Implementation Plan

The Roadmap and Implementation Plan represents a strategy document for planning the development and deployment of solar thermal technology systems for application in the areas of great need in Botswana – in the short to medium term. In preparing the roadmap, consideration was given to commanding areas where the development and deployment of solar thermal technology systems were of immediate concern to Botswana: namely- domestic sector; public sector applications such as schools, hospitals, government infrastructure; police; the army; private sector: hotels, resorts; commercial and industrial sector.

3.0 SOLAR THERMAL TECHNOLOGY ROADMAP

3.1 Roadmap – Solar Thermal Technologies

The statistics on solar thermal technology application, all types and sizes, was not available at the time of preparing the roadmap, for all categories of users. It is however known that there are many installations throughout the country that have solar thermal technologies of different types and sizes. Therefore, the thermal technology roadmap is based on inputs during the process and reports submitted by the leaders of the formed groups. The stakeholders were further informed about the types of technology available in the market, and the areas of application, and prevailing trends in the uptake of renewable energy technologies.

The Botswana solar thermal technology roadmap is driven and informed by the following applications:

i. Thermo-syphon system for single family residential houses (High pressure residential \ low pressure residential applications) (2-4 m^2 per systems): Residential houses.
ii. Pumped solar thermal systems (10-20 m^2): Multi-story residential houses and lodges in the tourism sector.
iii. Pumped SWH systems (20 -100 m^2 per systems) for government institutions: (hospitals and educational institutions) and multi-residential building.
iv. Large pumped thermal systems (50-500 m^2 per system) for Industrial commercial and mining applications of solar thermal technology.
v. Large Pumped Solar Water Heating, Cooling and Air-conditioning (20-500 m^2 per system) for larger offices and hotels.

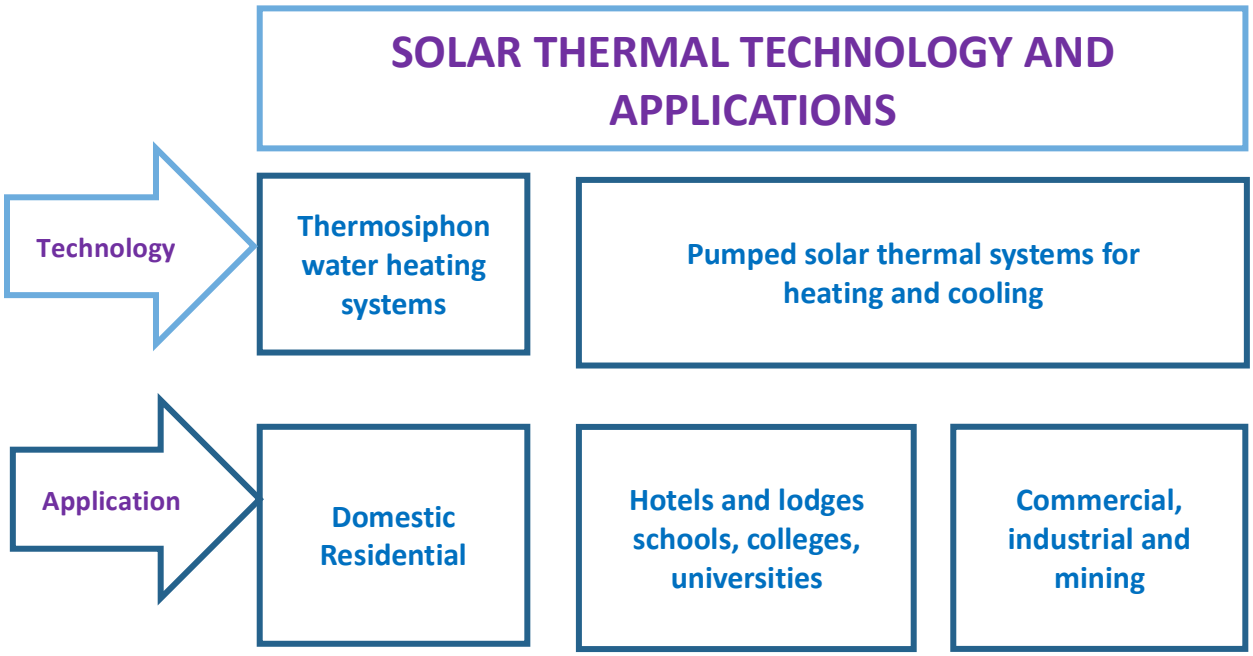

Figure 5: Roadmap Technology and Applications

3.2 Botswana Solar Thermal Technology Vision

The Solar Thermal Vision for Botswana provides a development path for achieving solar thermal technology targets as follows:

(iv) Achieve the installation of 910,000 m^2 of solar thermal technology collectors by 2030.
(v) The target installation will be equivalent to have 0.3 m^2 of net solar thermal collector area for every member of the population by 2030 in Botswana.
(vi) This relates to an installed capacity of 637MW_{th} and annual electricity savings of 659,000 MWh, avoiding 182,000 tons of CO_2 every year.

The target covers the period from 2018 to 2030, giving a time span of 12 years. The programme shall be phased such that there is a yearly target to achieve, beginning 2018.
The following table shows the annual solar collector installation targets between 2018 and 2030.

Table 1: Targets for annual solar collector installations in Botswana

Year	**Targets for annual solar collector installations [m²]**
Total estimated installed collector area by 2017	5,000
2018	500
2019	900
2020	1,500
2021	3,000
2022	5,000
2023	8,000
2024	14,000
2025	25,000
2026	44,000
2027	78,000
2028	137,000
2029	240,000
2030	348,000
Total installed collector area by 2030	**910,000**

The target for 2018, and for each successive year will be distributed between the different applications shown in Table 2.

Table 2: Targets for Solar Thermal Systems by sector

Sector	Options of SWH and/or Cooling Technologies	Estimate of systems to be installed [units]	Projected levels of collector areas to be installed to meet target projection [m^2]	Projected Solar yields and electricity savings [MWh/year]	Estimated Cost [Mill. EURO]	CO_2 Emissions Avoided [10^6*kg]
Residential houses for single family (including replacement)	Thermo-syphon systems 2-4 m^2	181,000	450,000	360,000	135	90,000
Multi-story Residential houses and Tourism Sector	Pumped Solar thermal -systems 10-20 m^2	11,000	230,000	115,000	184	46,000
Government Institutions (Educational institutions and Hospitals)	Pumped SWH systems 20-100 m^2	3,000	140,000	112,000	70	28,000
Industrial Commercial and Mining Sector	Large pumped SWH systems 50-500 m^2	500	45,000	36,000	27	9,000
Solar Water Heating, Cooling and Air Conditioning for hotels & lodges, and large offices	Large Pumped Solar Water Heating, Cooling and Air-conditioning Systems 50-500 m^2	500	45,000	36,000	45	9,000
TOTALS		**196,000**	**910,000**	**659,000**	**461**	**182,000**

3.2.1 Investment, Electricity Savings and avoided Carbon Emissions

The total cost for realising the vision is EURO 461 million, with an annual average breakdown of EURO 21 million. The financial implications are huge and a strategy to invest in the project is of immediate concern if the roadmap is to be implemented. This

investment should be viewed against the positive spin it has on reduction of generation from fossil fuels.

The electricity savings due to the investment on annual basis is Pula 141 million or EUR 11.4 million, which gives a payback time of about 3.4 years.

More significantly the deployment of solar thermal systems will lead to a reduction in CO_2 of 182,000 tons each year, which will be a major contribution from Botswana to the COP21 Agreement in mitigation of climate change.

3.3 Assumptions and Challenges of the Roadmap Vision

The development of the roadmap for Botswana has been complicated by many challenges:

(i) At the national level there has been a lack of attention to strategy for development and deployment of Solar Thermal Systems. This is in contrast to Solar PV – grid and off-grid where the government has undertaken a number of studies as development of strategies.

(ii) The bulk of installations in Botswana has been fragmented between government and the private sector, with eminent lack of coordination for effective development and deployment.

(iii) The lack of database on statistics from which to make predictable and realistic projections for the roadmap targets.

(iv) To a large extent, the target numbers for the vision, neglects significant number of installations currently in use. This is because many of them are in a state of malfunction and need repair or need replacement.

3.4 Implementation of the Roadmap

Immediate Implementation Challenges

At the onset it is important to recognize that the task of implementing the roadmap is difficult and fraught with many challenges. These challenges are:

i. The magnitude of the tasks involved- they involve several stakeholders who are not well coordinated.

ii. Lack of national strategy to guide the implementation of the roadmap. This is manifested in lack of resources, physical and financial; capacity and skills as well as structures to grow the technology

iii. Inadequate publicity regarding its importance in the energy mix for the country and the contribution to combating CO_2 emission

iv. Leadership to envision, plan and execute its implementation.

v. Near lack of reliable database and statistics from which to plan the development and deployment of the technology.

3.5 Processes for Implementation

3.5.1 Identification of Key Stakeholders

The key stakeholders comprise of:

i. Department of Energy, Ministry of Minerals, Green Technology and Energy Security- who are responsible for policy and regulations.

ii. The Botswana Power Corporation, a National Power Utility, who can benefit from offsetting planned new fossil generation.

iii. Research institutions- Botswana International University of Science and Technology (BIUST), and Botswana Institute of Technology and Research Innovation (BITRI) who are responsible for innovation, development of solar thermal systems applied to Botswana or market. Additionally, they offer advanced professional and academic training in solar thermal systems.

iv. The private sector who can play different roles: market agents; promoters of solar thermal systems; development of demonstration systems; investment agents

v. Banking institutions who can offer entrepreneurs investment funding

vi. Technical colleges who are responsible for training technicians and artisans to work in solar thermal field as maintenance personnel.

vii. Center for Clean Energy Research to Coordinate and lead activities for the development and implementation of BSTRIP.

3.5.2 Formation of a National Task Force on BSTRIP operating under CERC to draw out a strategy and plan of action for rolling out the BSTRIP.

The Task Force shall be formed from the key stakeholders who will determine the following:

i. Terms of Reference of the Task Force
ii. The scope of Work of the Task Force
iii. Outcome from the Task Force.
iv. Establishing procedure for monitoring and controlling of the implementation
v. Resourcing the implementation of the Roadmap.

3.6 Thermo-Syphon systems for Single family residential Houses

High-pressure and low-pressure systems for residential applications. Typical collector area per system is between 2 and 4 m².

Heating water for residential use is one of the most economical solar energy applications available. Most people are unaware that heating water is nearly as large a part of the electricity bill as air conditioning & heating are. While payback of the initial cost varies by system, climate, and use; a payback period of 4 to 5 years is typical with most systems continuing to provide savings for 20 or more years.

A thermo-syphon system requires neither a pump nor a controller. Water flows through the system when hot water rises as cooler water sinks. The collector must be installed below the storage tank so that hot water will rise into the tank. These systems are reliable, but careful attention should be directed at the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems. This system features a thermally operated valve that protects the collector from freezing. It also includes isolation valves, which allow the solar system to be manually drained in case of freezing conditions, or to be bypassed completely. For the active systems, there is the direct and indirect circulation systems. For the passive solar water heating system there are two alternatives: Integral collector-storage passive systems and Thermosyphon systems. There are also the direct system where the water is directly circulated to the collector, while in the indirect system it is most often installed in climates subject to hard freezing for extended periods. Its design is similar to a direct system except that a food grade antifreeze solution is heated in the collector in a closed loop system. The heated antifreeze is passed through a heat exchanger to transfer its heat into the conventional hot water tank.

Nationally, this is a very important and pervasive sector in Botswana and forms a large sector in comparison to other sectors when it comes to contribution to the national

capacity required to meet the 2030 target of 0.3 m^2 of solar thermal collector area for each citizen.

The results of the 2011 Population and Housing Census showed that Botswana's population was 2 038 228 persons enumerated during the study period, compared with 1 680 863 enumerated in 2001. The same census showed that there were 550,944 households. The majority (82%) of households had their walls made out of conventional bricks/blocks while the remaining shares were distributed amongst corrugated iron, asbestos, wood, stones and poles and reeds. Roof material is dominated by corrugated iron (74%), followed by roof tiles (13%), while the least share was for concrete (0.3%).

The Access to electricity stands at 66% and the target was to reach 80% by 2016.

The roadmap will target the following for the residential houses for single families:

i. Family houses with access to electricity;
ii. Family houses consuming electricity of 300 kWh per month or more
iii. Rural and town houses
iv. Family houses with no access to electricity

The savings from thermal generation will be 360,000 MWh_{th} by 2030.
The approach to meet the roadmap targets will be based on:

i. A database on statistics of new installations; replacements and repairs
ii. Plan for deployment of the systems countrywide, including scope, requirements of systems, and application.

Table 3: Industry and Government Roles in Supporting the Thermo-Syphon Systems (Road Map 1: Thermo-syphon system for single family residential houses (High pressure residential \ low pressure residential applications) (2-4 m^2 per systems): Residential houses)

Awareness and Marketing	
Industry Role	Promote uptake of thermo-syphoned systems. Their role is closely linked to publicity and outreach on: types of systems; system supply sources; standards; M&O; design and development; procurement; installation and commissioning; quality assurance mechanism for the systems; pricing; types of technology; and application. Main types of promotional media are: mobile adverts; posters; print media; radio broadcasts and social media.
Government Role	The government should promote the use of the solar thermo-system in government institutions of the system where applicable. Government should develop clear strategy for improving access on solar thermo-syphon systems for domestic and government uptake. Government ministry responsible for energy\renewable energy should have a portfolio for showcasing the importance of the system at a national level. Use financial schemes to encourage the use of solar thermo-syphon systems.

Research and Development	Communicate to the public effectively on the important technical attributes and characteristics which promotes the application of the system above the traditional methods of heating.

Institutional Issues	
Industry Role	To prompt self-regulation on issues which the government regulations does not provide for clearly. Promote fair competition among suppliers regarding pricing, quality, and safety. Encourage ethical practice involving the application of the system.
Government Role	Establish regulations on the application of the system relating to standards, quality and safety in promotional activities for the system.
Research and development	Monitor and publish results on system performance under local conditions which strengthens regulation. Identify areas where system performance can be improved under local operating conditions in terms of quality and environmental requirements.
Workforce Development	
Industry Role	Provide training programmes for their technicians, artisan, and professional engineers through accredited programmes relating to: maintenance and operations, design and installations of the system.
Government Role	Establish and support training programmes in government technical institutions and Universities in SWH. Sponsor students to take courses in the area of SWH at training\academic institutions.
Research and Development	Advanced training should be offered to Research class workforce at research in research organizations and Universities, namely BITRI and government Universities.
Research and Development	
Industry Role	Industry should have a network for collaborative research work with local universities (University of Botswana, BIUST) relating to field measuring and monitoring of system performance.
Government Role	Provide research funding to research institutions and Universities for research on application and optimization of SWH.
Research and Development	Undertake collaborative research on improvements to thermo-syphon systems for optimal performance in Botswana.

3.7 Pumped Solar Thermal Systems for Multi-family houses and the Tourism sector

The typical size of these systems is going to be between 10 and 20 m² collector area. These systems are targeted to multi-story residential houses and lodges in the tourism sector as follows:

i. Multi-family houses and lodges with access to electricity;
ii. Multi-family houses and lodges consuming electricity of 1000 kWh per month or more

iii. Rural and town houses

The approach to meet the roadmap targets will be based on:

i. A database on statistics of new installations; replacements and repairs
ii. Plan for deployment of the systems countrywide, including scope, requirements of systems, and application.

Table 4: Industry and Government Roles in Supporting the Pumped Solar (Thermal Systems (Roadmap 2: Solar (pumped) systems (10-20 m²): Multi-story residential houses and lodges in the tourism sector)

Awareness and Marketing	
Industry Role	Promote uptake of medium-sized pumped solar thermal-systems. Their role is closely linked to publicity and outreach on: types of systems; system supply sources; standards; M&O; design and development; procurement; installation and commissioning; quality assurance mechanism for the systems; pricing; types of technology; and application. Main types of promotional media are: mobile adverts; posters; print media; radio broadcasts and social media.
Government Role	The government should promote the use of the medium sized pumped solar thermal -systems in Multi-story residential houses and lodges as applicable. Government should develop clear strategy for improving access on pumped solar thermal-systems for Multi-story residential houses and lodge uptake. Government ministry responsible for energy\renewable energy should have a portfolio for showcasing the importance of the system at a national level. Use financial schemes to encourage the use of solar thermo-syphon systems.
Research and Development	Communicate to the public effectively on the important technical attributes and characteristics which promotes the application of the system above the traditional methods of heating.
Institutional Issues	
Industry Role	To prompt self-regulation on issues which the government regulations does not provide for clearly. Promote fair completion among suppliers regarding pricing, quality, and safety. Encourage ethical practice involving the application of the system.
Government Role	Establish regulations on the application of the system relating to standards, quality and safety in promotional activities for the system.
Research and development	Monitor and publish results on system performance under local conditions which strengthens regulation. Identify areas where system performance can be improved under local operating conditions in terms of quality and environmental requirements.
Workforce Development	
Industry Role	Provide training programmes for their technicians, artisan, and professional engineers through accredited programmes relating to: maintenance and operations, design and installations of the system.
Government Role	Establish and support training programmes in government technical institutions and Universities in SWH.

	Sponsor students to take courses in the area of SWH at training\academic institutions.
Research and Development	Advanced training should be offered to Research class workforce at research in research organizations and Universities, namely BITRI and government Universities.
Research and Development	
Industry Role	Industry should have a network for collaborative research work with local universities (University of Botswana, BIUST) relating to field measuring and monitoring of system performance.
Government Role	Provide research funding to research institutions and Universities for research on application and optimization of SWH.
Research and Development	Undertake collaborative research on improvements to thermo-syphon systems for optimal performance in Botswana

3.8 Pumped SWH systems for Governmental Institutions

The government has several of the following institutions that the Solar Thermal Roadmap has targeted:

i. 1500 educational institution comprising of: primary schools, junior secondary schools, senior secondary schools, colleges, technical colleges

ii. 500 Health Institutions comprising of: Hospitals, Clinics, Health Training Schools and institutes

iii. Botswana Defense Force: residential quarters and military facilities

iv. Botswana police and prison residential quarters and facilities

Overall the roadmap target is 3000 units with a total area of 140 000 m^2, spread across the country.

Over 90% of the Government Institutions are connected to the electricity grid. However their demand, electricity bills as well as the statistics on the systems currently installed, or requiring maintenance is not obtainable.

The approach in meeting the target will involve the following key processes:

i. Establishing the statistics on scope, requirements and area application

ii. Determination of statistics on systems requiring maintenance or replacement

iii. Developing a plan for the development and deployment of the system.

iv. Wide publicity among stakeholders

Table 5: Industry and Government Roles in Supporting the Pumped Systems (Roadmap Map 3: Pumped SWH Systems (20 -100 m2 per system) for Government Institutions: (hospitals and educational institutions) and multi-residential buildings)

Awareness and Marketing	
Industry Role	Promote the use of pumped thermal systems for government institutions. Develop manufacturing capacity for the systems locally. Use media to publicize availability and application of the system. Promote the use of large scale systems for Industries.
Government Role	Establish tax incentives, and rebates to make the system affordable and competitive. Establish a revolving funding mechanism to promote uptake of the systems.
Research and Development.	Monitor and publish operating characteristics of the systems. Develop and publish models for increasing uptake of the systems- particularly in the areas of funding, technology, and application.
Institutional Issues	
Industry Role	Develop mechanisms for maintaining ethical business models for design quality, procurement, installation and commissioning of the systems. Establish businesses for supply, maintenance, and servicing and operations business nation-wide. Establish industry association to support regulations for the system.
Government Role	Establish standards for testing and the quality of the product through Botswana Bureau of Standards. Provide policy, strategy and regulations for application of the system.
Research and Development	Monitor results of field operation and publish results. Build test plants for the system to evaluate and develop technical standards. These tasks can be undertaken in Universities, and Research Organizations (BITRI) locally.
Workforce Development	
Industry Role	Train artisans, technicians, and professional engineers who can design, install, commission and operate through short course training programmes. Employ qualified artisan, technicians and engineers to work on the systems. Collaborate with University and research institution in performance measurements and monitoring of systems installed.
Government Role	Establish training programmes in tertiary technical institutions for training for SWH. Fund students taking courses in SWH at all levels.
Research and Development	Research funding should be established for capacity development in SWH for training technicians, and engineers. The funding can be sourced from different institutions: government, international development partners, foreign donors and research institutions themselves.

Research and Development	
Industry Role	Collaborate with research institutions and Universities on monitoring and evaluating system performance from installations. Fund research in areas where they encounter problems in their systems. Design and develop home grown adaptation of large-scale pumped thermal to meet local needs.
Government Role	Provide funding research and development activities in SWH at local Universities and research institutions- in areas of optimization of operating system, design to meet local conditions.
Research and Development	Develop new components and systems well adapted to local conditions. Undertake field tests and monitoring of current installations to support improved designs. Build research and testing facilities for development of larger systems.

3.9 Large pumped Solar Thermal Systems for Industrial Commercial and Mining Applications

The Roadmap for Botswana will cover the following areas:

i. Mining and quarries, such as diamond, copper mines,
ii. Industrial Factories – Manufacturing: textiles, food and beverage
iii. Airports and Petrol Service Stations
iv. Commercial Centres and Shopping Malls

The statistics on current levels of application and requirements for SWH in these areas are not available. The prevailing view is that there are no thermal technology systems employed in the mining sector, industrial factories, airports and petrol service stations at the moment. It is however known that many of these industries use coal fired heating applications. However, the number connected to the electric grid are not known, including their consumption, and electricity bills.

The approach in implementation of the roadmap will be of necessity to involve the following processes:

- Determine the statistics on scope and requirements of SWH by application
- Preparation of a plan and programme for implementing the roadmap
- Replacement of the old coal fired applications to be employed with SWH
- To cover the broad range of industries and applications for this sector large solar thermal water pumping systems are proposed varying in collector areas from 50-500 m^2.

500 systems shall be deployed over the roadmap period, which will lead to a saving of 36 000 kWh of generation.

Table 6: Industry and Government Roles in supporting the Large Pumped Systems (Road Map 4: Large pumped thermal systems (50-500 m2 per system) for Industrial Commercial and mining applications of solar thermal technology)

Awareness and Marketing	
Industry Role	Promote the use of pumped thermal systems for industry and commercial enterprises. Develop manufacturing capacity for the systems locally. Use media to publicize availability and application of the systems. Promote the use of large scale systems for Industries.
Government Role	Establish tax incentives, and rebates to make large pumped system affordable and competitive. Establish a revolving funding mechanism to promote uptake of large pumped systems.
Research and Development.	Monitor and publish operating characteristics of the large pumped systems. Develop and publish models & methods for increasing uptake of the large pumped systems- particularly in the areas of funding, technology, and application.
Institutional Issues	
Industry Role	Develop mechanisms for maintaining ethical business models for design quality, procurement, installation and commissioning of the large pumped systems. Establish businesses for supply, maintenance, and servicing and operations business nation-wide. Establish industry association to support regulations for large pumped systems.
Government Role	Establish standards for testing and the quality of the product through Botswana Bureau of Standards for large pumped systems. Provide policy, strategy and regulations for application of large pumped systems.
Research and Development	Monitor results of field operation and publish results of large pumped systems. Build test plants for large pumped systems to evaluate to support development of technical standards. These tasks can be undertaken in Universities, and Research Organizations (BITRI) locally.
Workforce Development	
Industry Role	Support employees on short courses (artisans, technicians, and professional engineers) to design, install, and commission and operate large pumped systems. Employ qualified artisan, technicians and engineers to work on large pumped systems. Collaborate with University and research institution in performance measurements and monitoring of large pumped systems installed.
Government Role	Establish training programmes in tertiary technical institutions for training in

	large pumped systems. Fund students taking courses in large pumped systems at all levels.
Research and Development	Research funding should be established for capacity development in large pumped systems for training technicians, and engineers. The funding can be sourced from different institutions: government, international development partners, foreign donors and research institutions themselves.
Research and Development	
Industry Role	Collaborate with research institutions and Universities on monitoring and evaluating large pumped systems' performance from installations. Fund research in areas where they encounter problems in their large pumped systems. Design and develop home grown adaptation of large-scale pumped thermal to meet local needs.
Government Role	Provide funding research and development activities in large pumped systems at local Universities and research institutions- in areas of optimization of operating system, design to meet local conditions.
Research and Development	Develop new components and systems well adapted to local conditions. Undertake field tests and monitoring of current installations to support improved designs. Build research and testing facilities for development of larger systems.

3.10 Large pumped Solar Thermal Systems for Heating, Cooling and Air-Conditioning for larger Offices and Hotels

These large pumped systems for heating, cooling and air-conditioning will have a typical size in the range between 20 and 500 m² collector area.

The systems can be designed differently and can have the following functions:

- Active space heating.
- Passive space heating and cooling.
- Passive space ventilation.
- Space air conditioning

Under the roadmap the following areas of applications are covered:

i. Large office buildings- for the public sector or private sector

ii. Medium to large size hotels

iii. Conference facilities

iv. Large game lodges

Already some hotels have installed SWH in their hotels in many areas of the country. For example, Avani Hotel (formerly Sun Hotel) has a 320 m^2 for SWH and cooling system, which has now been operating for over 20 years. However, a number of hotels use electricity as a sole water heater or backup.

There are a number of challenges in meeting the target in this category of application because of:

i. Inadequate information in total numbers

ii. Their level of consumption of electricity for back-up

iii. Their electricity bills

iv. The types of systems deployed.

Like other sectors of application in Botswana, a satisfactory level of statistics on the range and requirements for SWH&C will be collected and a program of action will be prepared for implementation of the roadmap.

Table 7: Industry and Government Roles in Supporting the Cooling and Air-Conditioning of Hotels and Large Office Buildings (Roadmap 5: Large Pumped Solar Water Heating, Cooling and Air-conditioning (20-500 m² per system) for larger offices and hotels)

Awareness and Marketing	
Industry Role	Promote cooling and air conditioning technology as an option to enhance solar, either solar thermal or Solar PV systems. Both lead to a solution approach which is wholly clean and solar based. Identify and prioritize areas of application of great benefit in reducing electricity usage through passive solar cooling\energy efficient buildings. Private Architects should be motivated to design passive solar cooling\energy efficient buildings. An industry association needs to be set up to promote passive solar cooling\energy efficient buildings. Botswana's National Vision 2030 currently under formulation, need to consign passive solar cooling\energy efficient buildings as a priority vision in its official Vision 2030 document. Hotels should encourage use of passive solar cooling\energy efficient building technology.
Government Role	Apply passive solar cooling\energy efficient building technology for improvements to government buildings and offices Establish a mechanism to increase uptake of passive solar cooling through building regulations. This could be in the form of a revolving fund. Government architects should be empowered to publicise the uptake of passive solar cooling

Research and Development.	Monitor and publish the benefits of passive solar cooling\energy efficient buildings.
Institutional Issues	
Industry Role	Develop mechanisms for maintaining ethical business models for design quality, procurement, installation and commissioning passive solar cooling \energy efficient buildings. Establish businesses for supply, maintenance, and servicing and operations business nation-wide. Establish industry association to support regulations passive solar cooling \energy efficient buildings.
Government Role	Prepare strategies for increasing passive solar cooling. Establish standards for testing and the quality of passive solar cooling\energy efficient buildings through Botswana Bureau of Standards. Provide policy, strategy and regulations for passive solar cooling\energy efficient buildings. Empower government architects to implement building designs incorporating passive solar cooling.
Research and Development	Monitor and report results of field operation of passive solar cooling\energy efficient buildings and publish results. In particular energy efficiency of the buildings.
Workforce Development	
Industry Role	Train artisans, technicians, and professional engineers who can design, install, commission and operate systems for passive solar cooling\energy efficient buildings through short course training programmes. Train technicians and engineers in energy efficiency and energy audit and monitoring of systems installed. Employ trained technicians in operations and maintenance of passive solar cooling\energy efficient buildings.
Government Role	Establish training programmes in tertiary technical institutions for training for passive solar cooling\energy efficiency and energy audit. Fund students taking courses in passive solar cooling\energy efficiency and energy audit at all levels.
Research and Development	Evaluate how current governments buildings can be upgraded or altered to cater for passive solar cooling\energy efficiency and advise stakeholders.
Research and Development	
Industry Role	Collaborate with research institutions and Universities on monitoring passive solar cooling\energy efficient buildings. Design passive solar cooling\energy efficient buildings. Design and develop home grown adaptation of passive solar cooling\energy efficient buildings to meet local needs.
Government Role	Provide funding research and development activities in passive solar cooling\energy efficient buildings at local Universities and research institutions- in areas of optimization of operating system, design to meet local climatic conditions.

Research and Development	Develop models to quantify the benefits of passive solar cooling\energy efficient buildings in relation to energy savings, impact on carbon emission, economic and financial savings. Develop plans for converting the current stock of buildings to passive solar cooling\energy efficient buildings.

4.0 CONCLUSION

The final version of the BSTRIP is covered in this document. The rationale for the BSTRIP is therefore underpinned by the abundance solar resources that Botswana enjoys; the need for Botswana to contribute to a war against global warming by increasing its proportion of renewable component of its energy supply mix; reducing the sustained gap between supply and demand for electricity.

The Vision for the BSTRIP is to enable Botswana achieve 0.3 m^2 collector area per citizen by the year 2030. The immediate benefits of the Vision are: decrease the fossil generation of electricity; reduce carbon emissions; decrease the burden of building new fossil generation stations. The environment of preparing the BSTRIP has been challenging due to lack of credible statistics in the use of solar thermal systems in Botswana.

The implementation of the roadmap will depend on the stakeholders led by the Government on the one hand through policy and strategy and CERC on the other hand through coordinating structures. The main drawback for implementing the roadmap might come from sourcing funding.