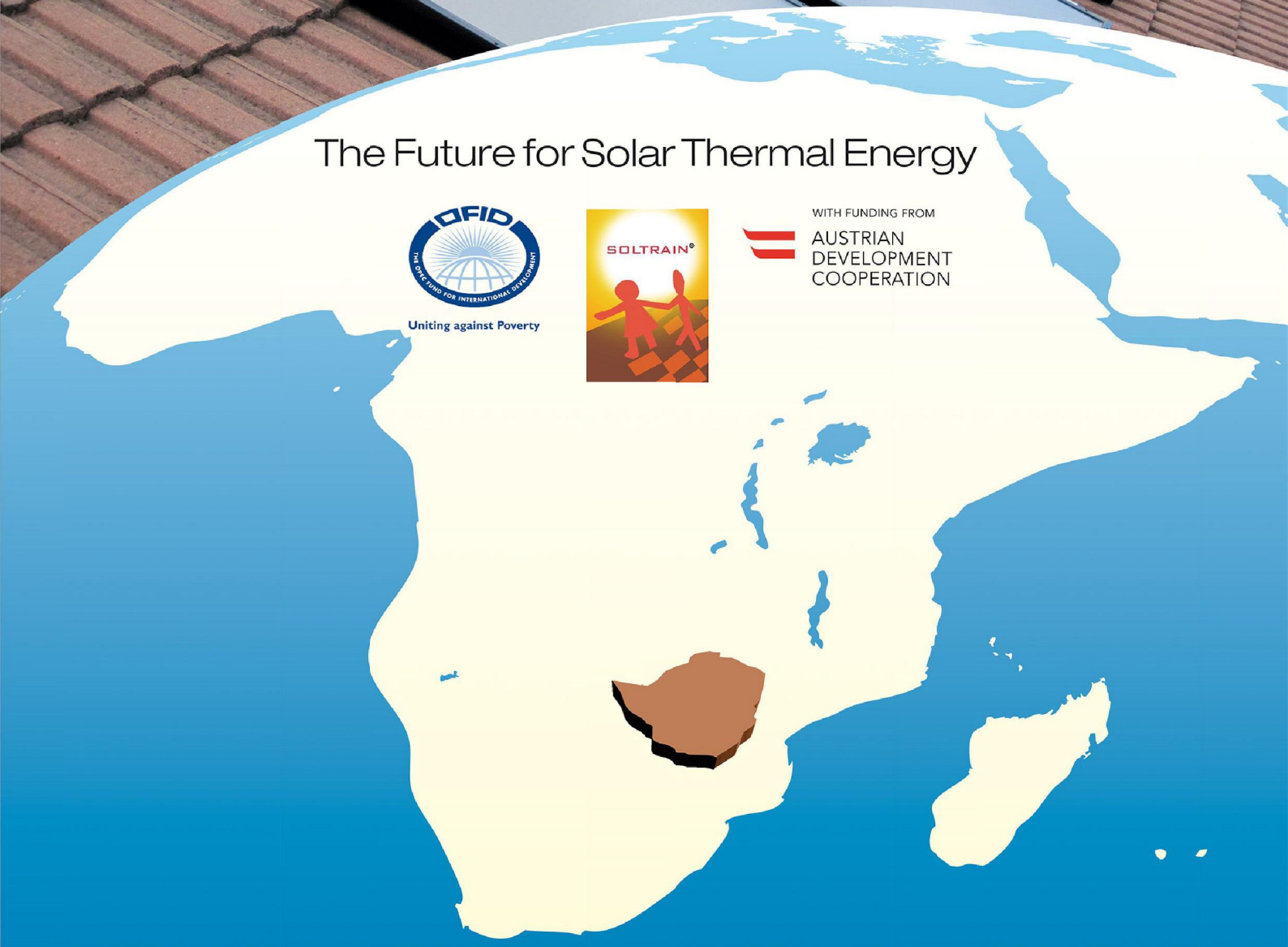
Solar Thermal Technology Roadmap and Implementation Plan

The Future for Solar Thermal Energy

OFID
THE OPEC FUND FOR INTERNATIONAL DEVELOPMENT
Uniting against Poverty

SOLTRAIN

WITH FUNDING FROM
AUSTRIAN DEVELOPMENT COOPERATION



Zimbabwe

Solar Thermal Technology Roadmap and Implementation Plan for Zimbabwe

Authors:

Samson Mhlanga, Antony Schwarzlmuller, Blessed Sarema,

Charles Murove, Millet Zviitwa, Malan Manyundo

TABLE OF CONTENTS

FOREWORD

This solar thermal technology roadmap and implementation plan seeks to support the Government of Zimbabwe's vision of making the country a middle-income economy by 2030. In order for the country to achieve the middle-income status by 2030, there's need to uplift the standards of living for the citizens and the gross national income per capita. Energy plays a pivotal role in the social and economic development and thus its availability will be critical for the country to achieve this vision.

Currently there is a gap between demand and supply of energy in the country and this deficit presents a threat in the achievement of the middle-income economy vision. The energy supply is dominated by fossil fuels that are also environmentally unsustainable. As the country pushes towards the middle-income status economy there is also need to decarbonise the energy supply.

The solar thermal technology roadmap and implementation plan is a result of collaborative efforts between the Government of Zimbabwe, the Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN) and all the Stakeholders to promote use of solar heating and cooling in the country. The roadmap foundation is anchored on the National Solar Water Heating Programme that the country has adopted to retrofit existing electrical geysers with solar water heating systems. The installations are expected to grow steadily with envisaged stimulated demand in new housing, public sector and commercial installations as well as industrial systems. The growth rate is expected to reach 0.1 m^2 of collector area per capita by 2030.

In order for this solar thermal technology roadmap and implementation plan to be successful, there's need for collaborative effort between the Government of Zimbabwe, Industry and Educational Institutions. The Educational Institutions will be responsible for driving research and development of solar thermal technologies locally with industry driving the commercialisation and financing models while the government will be responsible for policy development.

Harare, July 2019

Fortune Chasi (MP)
MINISTER OF ENERGY AND POWER DEVELOPMENT

MINISTER'S OFFICE
MINISTRY OF ENERGY AND POWER DEVELOPMENT
17 JUL 2019
P BAG 7758, CAUSEWAY
ZIMBABWE

1 INTRODUCTION

1.1 Background Note

According to the World Bank (2013), 25 countries in the Sub-Sahara Africa are facing an energy crisis evidenced by rolling electricity blackouts. These shortcomings in the power sector threaten Africa's long-term economic growth and competitiveness. The cost to the economy of load-shedding is equivalent to 2.1 % of GDP on average.

Solar energy could play a major role in reducing the stress on the security of electricity supply in Sub-Sahara Africa. In the six SOLTRAIN partner countries that are; Botswana, Lesotho, Mozambique, Namibia, South Africa, and Zimbabwe, Solar Water Heating Systems are being implemented not only for domestic uses but also for heating and cooling of hospitals, hotels, student hostels and also for providing heat for industrial processes.

Due to these reasons all partner countries of SOLTRAIN, phase III are pursuing policies that enhance security of supply, energy conservation and increases energy access. Furthermore, in all partner countries there are several national plans and policies on the support to increase the use of solar thermal systems in place.

Phase III of the project is therefore based on the national and regional governmental renewable energy targets as well as on the results and lessons learnt in the two previous phases of SOLTRAIN which were carried out from 2008 – 2016.

The project focuses on three main groups:

- Local implementation partners: Educational and research institutions like universities, vocational schools and other training centres

- Target groups: Installers of solar thermal systems but also policy, administration and the financial sector. For example, about 750 administrators, teachers, installers, designers, distributors, technicians, bankers, consultants etc. have participated in various training courses.

- Beneficiaries: Social institutions and other eligible entities such as small and medium enterprises, house owners, patients of hospitals, occupants of homes for elderly people, students of student hostels, guests of the accommodation sector (hotels, lodges), visitors of restaurants, "industrial processes". It is estimated that

about 7,000 persons will directly benefit from these demonstration systems by reducing their energy bills and by improving the hygienic living standard.

It is the aim of all measures taken in the project to anchor the results achieved during years of working relationship with the partner institutions and in governmental bodies of the partner countries and to initiate or to strengthen sustainable national solar thermal programs that are in place far beyond the duration of the project.

The Solar Thermal Roadmap for Zimbabwe is the brainchild of the SOLTRAIN project. It is expected to be in place far beyond the term of the intervention. Like in South Africa, Namibia and Mozambique in the 2nd phase of the project, Zimbabwe had to first establish a Solar Thermal Technology Platform (Z-STTP). The Z-STTP includes officials from relevant government ministries and parastatals' officials, representatives of industry and finance, staff members of universities, polytechnics and non-governmental institutions. They had to formulate the Vision Document and a National Solar Thermal Roadmap for the long-term replacement of electric geysers by solar water heaters.

A Founding Meeting was held when the first draft work programme and regulations of the STTP were defined. Three more workshops were required to facilitate broad discussions on the content and priorities of the Vision and the Roadmap. All relevant stakeholders involved in this process (companies, higher education as well as administration and policy) will be needed at a later stage for the Roadmap implementation.

Figure 1 illustrates the process starting with a Vision, thereafter charting the Roadmap to the Vision target and eventually making it a national effort to implement the Roadmap and to bring the Vision to fruition. Each one is the product of ideas, opinions and data inputs by various stakeholders. The stakeholders involved with the Vision may be different from the ones which are instrumental in the Roadmap Implementation exercise.

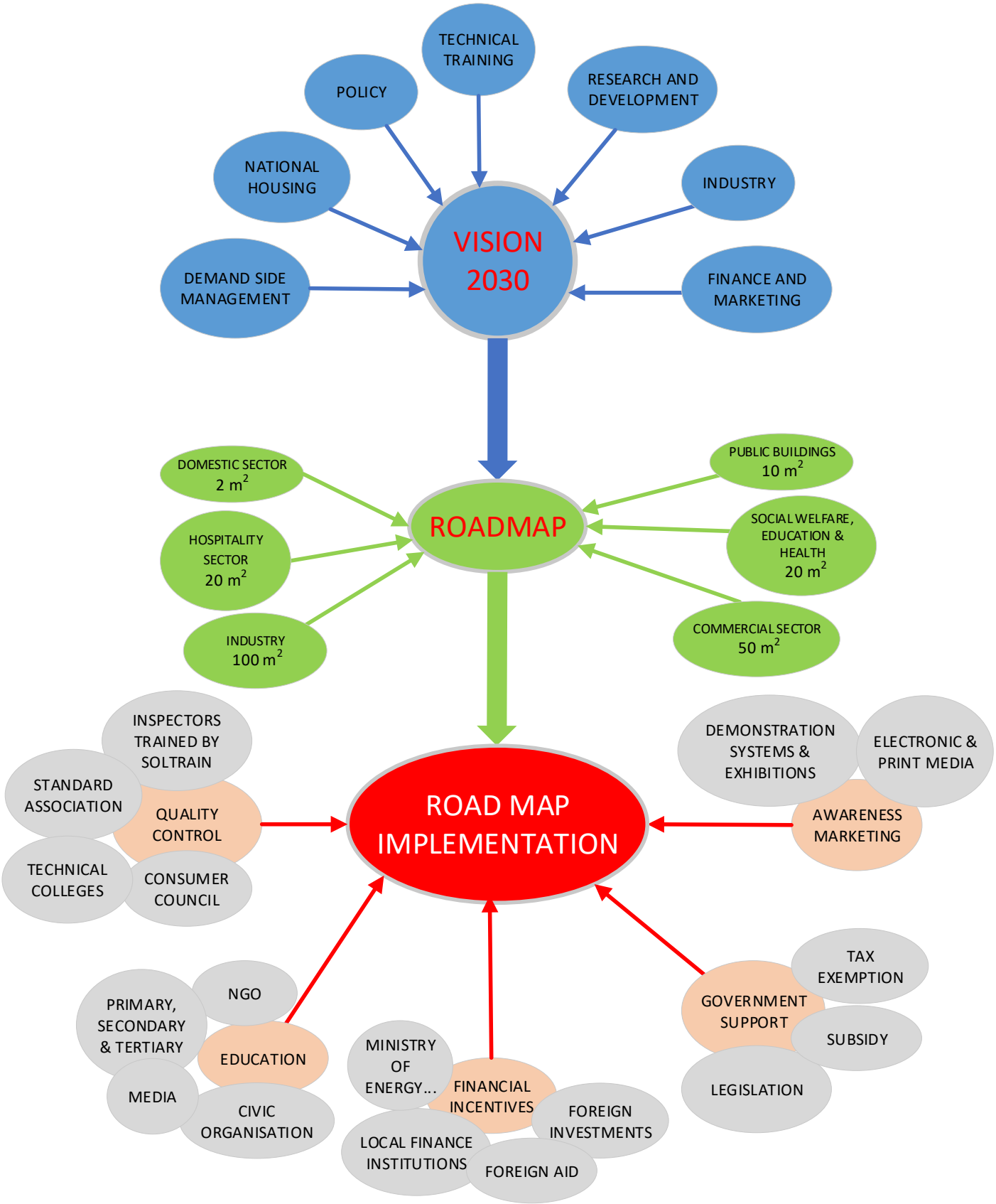


Figure 1: Vision, roadmap and implementation illustration

The Vision 2030 was shaped by:

- The National Energy Policy (NEP, 2012) and the National Solar Water Heating Programme launched by the government of Zimbabwe in September 2013.
- The draft National Renewable Energy Policy
- The expectation that the tertiary education system can train enough qualified solar artisans and solar engineers.
- Persuasion that the research and development institutions will come up with improved component and system designs meeting the requirements of the many different customers.
- The affirmation that the solar industry will be able to locally manufacture and assemble solar thermal components as required by the National Solar Water Heating Programme.
- The ability and willingness of finance institutions to provide loans to investors.
- The mastery of the marketing sector to recommend a solar hot water system as a must-have.
- The qualified assumption that a significant increase in public housing will lead to a remarkable growth of solar thermal installations.
- The expectation that demand side management in industry and commerce will ultimately lead to electricity and fossil fuel for water heating being substituted by solar heat.

Once there is consensus of how many square metres of collector surface area per inhabitant should be installed by 2030 the Vision expands into a Roadmap as shown in Figure 1. The Zimbabwe Roadmap comprises all sectors of the economy where Solar Thermal Technology (STT) may be employed. The extent of use of STTs in the various sectors can differ vastly from one another and also the sizes of installed systems will be different in each sector.

In Zimbabwe the implementation of this Roadmap is largely going to be dominated by the domestic sector. Domestic systems will contribute 90% to the vision while the other sectors will contribute an additional 10%. This is based on the statistics in the past 10 years of solar thermal heating installations, which has been more on domestic than Industrial installation.

For the purposes of this Roadmap, the Solar Water Heating Systems will be classified into three categories i.e. domestic sector - mainly small systems up to 2 to 4 m^2 collector area used for residential applications. **PUBLIC & COMMERCIAL SECTOR** – mainly installations of 10 to 60 m^2 collector area used in the hospitality, social welfare, health and education sectors. **INDUSTRIAL SECTOR** – where large amounts of heat are consumed, installations of 60 to 200 m^2 collector area are frequently found. The food and beverage, textile, chemical, mining, agriculture etc. are included in this category.

The most complex and work intensive part of the Roadmap is the ROADMAP IMPLEMENTATION hinging on the following pillars:

Governmental support through solar-friendly legislation and financial incentives.

Support from local finance institutions, foreign investment and foreign aid.

Marketing and awareness creation to generate and increase demand through demonstration systems and all forms of media.

Quality control by technical colleges, the Standards Association of Zimbabwe, the Consumer Council, Ministry of National Housing and by inspectors specifically trained for this job.

Solar education of the broad public by primary, secondary and tertiary schools, civic organisations, media and Non-Governmental Organisations.

1.2 Short history of solar water heating in Zimbabwe

Solar water heating systems in Zimbabwe have a history that dates back to the 1970s. There were mainly produced for the hospitality industry and high-income households. The growth in the number of installations was affected by poor performance of some designs in the 1980s, but there was renewed interest after the electricity shortages hit the country in the 1990s. Around 1992, low electricity prices then hindered further

development in the 1990s. However, a lot of interest in SWH remained in the mid- to late-1990s sharing the accomplishments of the successful promotion of solar PV of household and community use through the UNDP/GEF Solar PV Pilot project (Batidzirai et al, 2009).

Accelerated promotion of Solar Water Heating systems was listed as one of the priority projects under the government's National Renewable Energy Programme (1996-2005). The programme was born out of the World Solar Programme (1996-2005) to which Harare hosted the World Solar Summit in September 1996 (UNESCO, 1997). However, much emphasis was given to PV for lighting. Similarly the Rural Electrification Fund Act of 2001 passed in January 2002. The Act established the Rural Electrification Fund (REF), mainly responsible for grid extension in rural areas and for supplying specific institutions, such as schools, clinics, government offices, and community-initiated projects under the Rural Electrification Programme (AFDB, 2011). REF also dwells much on solar PV and only lists SWH as a potentially valuable technology.

Low activity was recorded in the Solar Water Heating Industry in the period between 2005 and 2012 largely due to economic recession. The National Energy Policy (2012) stimulated activities in the energy market. The activities included the formulation of a cocktail of Demand Side Management (DSM) strategies aimed at mitigating electricity shortages. The major relevant DSM initiative launched by the government of Zimbabwe in September 2015 is the National Solar Water Heating Program (NSWHP) (Herald, 2015). The NSWHP aims to replace the existing 250 000 to 300 000 electrical geysers in households in five years as well as installation of the solar geysers in all new buildings as guided by the new building by-laws. The programme seeks to install a solar thermal equivalent of 420 MW (NEP, 2012).

Most of the SWH systems in Zimbabwe are imported from Europe, America, Asia, Australia and South Africa. There is limited local production and assembling, only three local manufacturers were in operation in 1998 according to Batidzirai et al. (2009) and to date there are more than 25 companies listed by ZERA (2016). The bulk of the companies are importers and installers. Local producers still need to import some components. These are the companies that seem to be active in the supply and installation of SWH.

A number of initiatives have been undertaken in Zimbabwe to promote SWH. These include the Austrian supported projects, the Dutch/UNDP supported SADC FINESSE activities, the Zimbabwe government's own SWH program under the National Solar Water Heating Programme and other private initiatives.

The Austrian supported SWH programmes in Zimbabwe promoted the development and manufacture of affordable thermo-syphon SWHs. It has trained craftsmen and developed SWHs using mainly local materials.

About 600 SWH systems have been successfully installed to date in homes, schools and rural clinics through the programme, and the trained technicians are now carrying out installations on their own (Batidzirai et al, 2009).

1.3 Why solar thermal heating and cooling systems in Zimbabwe

Zimbabwe currently has a national electrification rate of 48 % according to ZimStat (2017) in the Inter-Censal Demographic Survey Report electricity has reached 86 % of the urban households, and reached 28% of rural household. The country has an estimated installed capacity of around 2 200 MW, with Zimbabwe Power Company (ZPC), a generation subsidiary of Zimbabwe Electricity Supply Authority (ZESA) contributing around 94 % of this with 58 % of the capacity from thermal based power plants and 36 % of the capacity from Kariba Hydro Project. Bagasse and small hydro based IPPs with an installed capacity of 114 MW constitute the remaining capacity and supply around 12 MW to the national grid. Against this, the actual capacity available is around 1 300 MW due to water availability issues and limited coal supplies according to the draft National Renewable Energy Policy.

One of the primary objectives of the Renewable Energy Policy is to achieve an installed renewable energy capacity of 1 000 MW (excluding large hydro) by 2025 with a generation mix of nearly 17% of the total electricity demand coming from renewable energy sources. This target is expected to meet the supply deficit in the country as well as to meet the emissions objective as per the Intended Nationally Determined Contribution (INDC) report according to the draft National Renewable Energy Policy.

Solar Water Heating and Cooling systems reduce carbon emissions and earn carbon credits which may earn the local manufacturers millions of dollars upon sell of the

same to companies or countries in Europe, Asia and North America failing to meet their Kyoto Protocol quota.

The earnings received may be a source of funding for many developmental projects in the country.

Zimbabwe has low electrification levels with a supply deficit of 38% in 2015. Among all the RE technologies, solar (including solar thermal/CSP and solar PV) has the highest potential of well over 140 GW (IRENA, 2015).

1.4 Climatic Conditions

Zimbabwe is a land locked country situated in the middle of Southern Africa. It is fortunate in its level of solar radiation which varies between 1700-2200 kWh/m^2 which will allow for the solar resource to become a reliable and modern energy source both for electricity and thermal purposes. With an average of 300 days of sunshine annually, Zimbabwe is one of the sunniest countries worldwide.

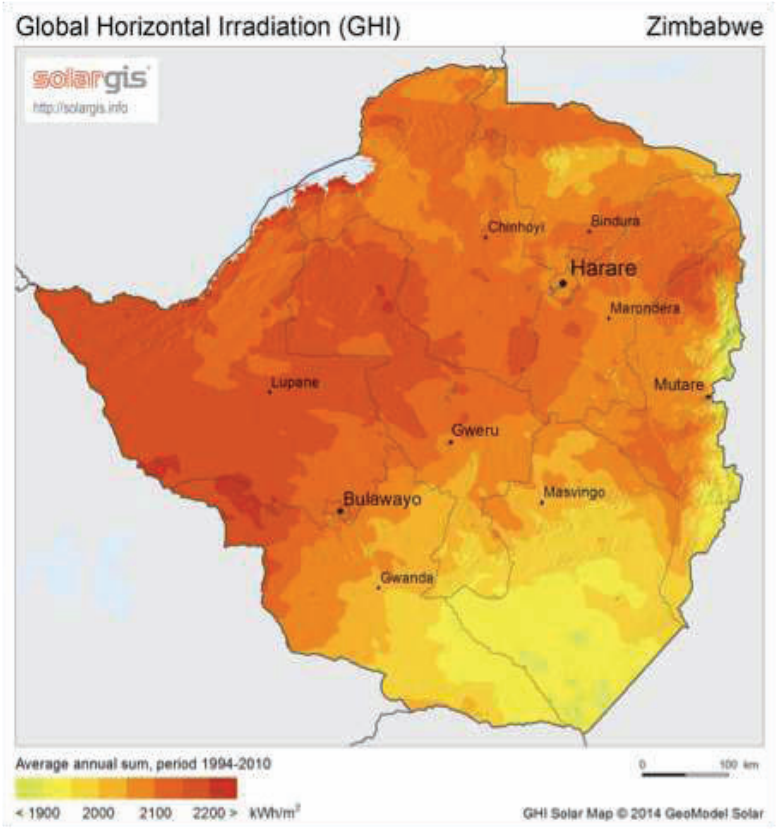


Figure 2- Zimbabwe global horizontal irradiation.
Source-Solargis solar resource maps

Solar thermal is a renewable source of energy which depends on climatic conditions of the area. It is therefore essential to have an overview of the prevailing climatic conditions in Zimbabwe. Detailed information on annual global radiation in Zimbabwe is shown in Figure 2

Zimbabwe lies wholly in the tropics, stretching from 15.5 to 22.5 degrees south latitude. The sun is overhead twice a year. The least angle of elevation of the sun is 45 degrees over the south most parts of the country. The summer season (rainy season) ranges from November to March. The wettest months are December, January, February and March which are characterized by torrential downpours in the afternoon and sometimes continuous rains for a couple of days. Temperatures are between 18 degrees Celsius in the morning and 32 degrees Celsius in the afternoon and the relative humidity ranges from 53 % to 96 %.

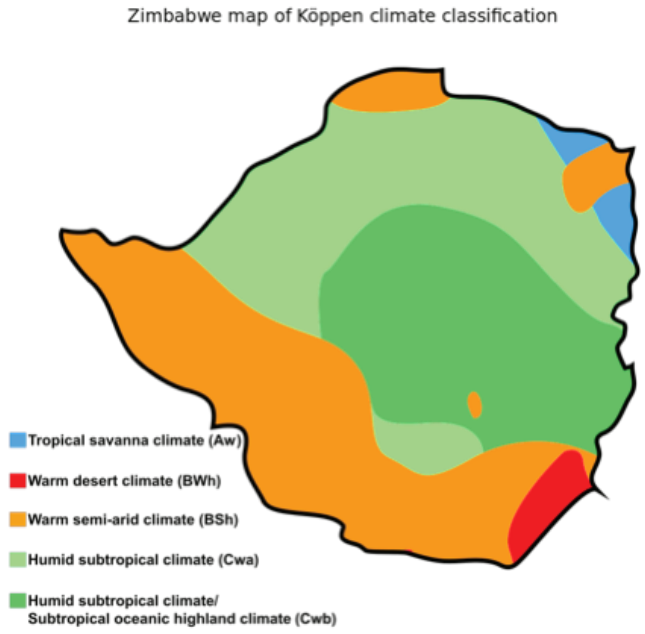


Figure 3-Koppen Climate Classification for Zimbabwe

The spring time comes immediately after the rainy season. It is a short season from April to early May marked by fresh early morning breezes. The temperatures are relatively cool, typically around 10 degrees Celsius in the morning and 28 degrees Celsius in the afternoon. The night time temperatures start to drop and by May the rain is almost gone. The winter season ranges from mid-May till August. The early morning of winter is characterized by chilly winds and sometimes there is a thin frost that covers the grass in many parts of the highveld. The coldest months are June and July with average morning temperatures of 6 degrees Celsius. The middle part of the day reaches 20 degrees Celsius on most days.

August and September mark the autumn period. The hottest season runs from October till mid-November with the temperature reaching its annual peak in October. Temperatures during the day all over the country reach 30 degrees Celsius and above. Figure 3 shows the Koppen climate classification for Zimbabwe.

1.5 Existing Legislation, regulations and government targets for Zimbabwe

The policies and programmes lay out the Government strategic direction and objectives of the sector and also provide targets to be met by implementing the

identified action plans. This Roadmap comes into effect to complement the already existing frameworks of legislation, regulations and targets set by the government of Zimbabwe. The following are some of the policy documents and programmes made reference to in the development of this Roadmap. A full list of these and other resource documents is available in Appendix 1.

1.5.1 National Solar Water Heating Programme

The National Solar Water Heating Programme launched by the government of Zimbabwe in September 2015 seeks to retrofit existing electrical geysers with solar geysers. The NEP (2012) estimates the number of electrical geysers to be between 250,000 to 300,000. The programme has a potential to save about 420 MW of electricity.

1.5.2 National Energy Policy (NEP)

The National Energy Policy (2012) recognises that renewable energy is a local resource that should be fully utilised, as it brings access to energy and both economic and environmental benefits. This includes the sustainable use of biomass resources (e.g. wood fuel, industrial waste such as bagasse, and pulp), hydropower, solar power and wind. The policy clearly states that it seeks to "Develop the use of other renewable sources of energy to complement conventional sources of energy (applicability and acceptability principles)."

The policy prescribes some implementation strategies for solar solutions in section 7.5.5.5 pp 25 in which the Minister, through the proposed Rural Energy Agency and the power utilities, will establish a fund to promote the use of solar energy as a short-term to medium-term strategy to address the electricity crisis. The immediate strategies and targets that can be implemented in the meantime are as follows (NEP, 2012):

a) Introduction of regulations by 2013 to mandate the installation of solar geysers in all new homes; penalties in the form of higher electricity prices or other methods can be imposed for non-compliance.

b) Provision of incentives and raising awareness of the benefits of retrofitting solar collectors on existing geysers.

c) Promotion of technology transfer and the expansion of local manufacturing; training of artisans and harnessing of the informal sector in the assembly and installation of solar geysers.

1.5.3 National Renewable Energy Policy (NREP) Backdrop

Government is developing many of the critical policies that will catalyse renewable energy use. In particular the National Renewable Energy Policy (NREP) is in the final stage of development and a validation workshop has been part of the final stages of consultation before the policy is promulgated by government tentatively in early 2017.

1.5.4 The Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZimAsset, 2013)

The economic blue print ZimAsset (2013) also promotes increased uptake of renewable energy. The energy sector comes under the Infrastructure and Utilities Cluster and it sets out targets for implementation over the period (2013 -2018).

1.5.5 SE4ALL Action Plan

A draft of the SE4ALL Action Plan which also identifies energy efficiency and renewable improvement targets has also been completed. SE4ALL (2012) targets to improve household access to modern energy from about 30 % to 90 % of all rural and urban households by 2030. The number of solar water heating systems installed will also be used as an indicator to measure progress towards the target.

1.5.6 National Integrated Energy Resource Plan (NIERP)

Another critical policy instrument, the National Integrated Energy Resource Plan (NIERP) is still under development. The plan is aimed to bring together and integrate sub-sector energy plans into one coherent least cost energy plan.

1.5.7 The Transitional Stabilisation Programme Reforms Agenda (TSP, 2018)

The economic blue print TSP (2018) also promotes increased uptake of renewable energy by making it mandatory for local authorities' requirements for all new housing development plans to embrace solar geysers. The Transitional Stabilisation Programme Reforms Agenda is a short-term programme running between 2018-2020, building towards Zimbabwe's vision 2030 of becoming an upper middle-class economy by 2030.

1.5.8 Gaps in the Existing Policies and Instruments

The renewable energy market in Zimbabwe is faced with a number of barriers and constraints inhibiting its rapid growth despite a huge renewable energy potential available in the country. It has been observed that the Ministry of Energy and Power Development (MoEPD) has set out through the new Renewable Energy policy long-term targets, clear action plans, timelines, and implementation strategies for renewable energy. More importantly, the need for reporting, monitoring, and evaluation frameworks to guide progress. Many policy and strategy initiatives have passed final consultation stage with a draft policy document awaiting debate by parliament. While the renewable energy policy framework conditions (policy ecosystem) evolve the MoEPD together with sister government ministries and parastatals departments have reviewed the existing standards and regulatory frameworks and are now concurrently in the process of developing and/or updating the existing standards and regulations.

1.6 Standards and Quality Control

The Solar Energy Market in the past seen to be largely unregulated, resulting in the importation of and manufacture of sub-standard products. These have led to reports of high failure rate of imported technology and installations, which gave the solar technology bad reputation. Apart from substandard products, the market has insufficient skilled and experienced system designers and installers, with the majority of plumbers and electricians claiming to be solar installers yet most are without formal focussed training in solar thermal installation.

After-sale service for solar is systems is almost non-existent and the situation needs to improve in order for consumers to have confidence in the technology. ZERA is building a dedicated solar PV equipment testing laboratory, which would check components such as solar modules, batteries, charge controllers and inverters. It is also funding the establishment of a test centre for solar thermal systems. They are also calling for mandatory standards for solar components and installations, as well as enforcement mechanisms for warranties and guarantees to safeguard consumers.

1.6.1 Available Standards

The Standards Association of Zimbabwe (SAZ) is responsible for standards development and administration in Zimbabwe. However, the Standards Association of Zimbabwe has no powers to enforce the standards. In an effort to enforce the standards, the Government through the Zimbabwe Energy Regulatory Authority (ZERA) is in the process of incorporating the SAZ standards in the solar water heating regulations. All the solar water heating standards and regulations have been developed.

Some of the existing standards include:

- ZWS 278: 2006-Domestic water heater
- ZWS 713: 2007-Domestic solar water heaters,
  Part 1: Thermal performance using an outdoor method
- ZWS 713: 2007-Domestic solar water heaters,
  Part 2: Thermal performance using an indoor method
- ZWS 744: 2003-Installation of solar water heaters
- ZWS ISO 9459: 1999-Solar heating systems,
  Part 2: Outdoor test methods for system performance characterisation and yearly performance prediction of solar system

1.6.2 Quality Control

To make sure that the products, which are manufactured locally or imported meet the specified requirements, the Ministry of Energy and Power Development through ZERA is sponsoring the establishment of a laboratory test centre at SAZ. In the meantime the Government since 2015 through Bureau Veritas, the French firm awarded a contract to administer consignment-based conformity assessment (CBCA) has been inspecting all imports including renewable energy supporting products[1].

The following tests shall be performed to check compliance on the part of suppliers:

- Internal pressure test for fluid channels
- High temperature resistance test

[1] http://www.veritaszim.net/node/1715

- Stagnation test
- Exposure and pre-exposure test
- External thermal shock test
- Internal thermal shock test
- Rain penetration test
- Freeze resistance test
- Mechanical load test

1.6.3 Quality assurance in skills development

The Ministry of Energy and Power Development is facilitating the following in order to control quality and promote continuous improvement:

- Training of installers on how to install and maintain the systems
- Registration and certification of plumbers or installers
- Establishment of holistic regulatory framework that governs the solar water heating industry, inclusive of all downstream activities that support the industry
- Training of local manufacturers in tendering procedures to stimulate competition

1.6.4 Enforcement Mechanism

The Enforcement mechanism to the standards is to be achieved through development of appropriate Statutory Instruments. Implementation of the standards may be achieved through the use of local authorities' by-laws. Inspections and authorisation will play a major role to ensure conformance to standards. The installed systems may go through the approval process before payment to the installer.

1.7 Housing Projects

World migratory trends show movement of people from rural to urban areas. This was true for Zimbabwe from 1982 to 2002 when the urban population increased by 9 %. The recent trends show a complete contrast with the rural population increasing by about 3 % from 2002 to 2017 according to ZimStat (2017) in the Inter-Censal Demographic Survey Report as shown in Figure 4 **[2].

[2] http://www.sundaymail.co.zw/rural-population-surges-puzzling-numbers-show-urban-to-rural-migration/

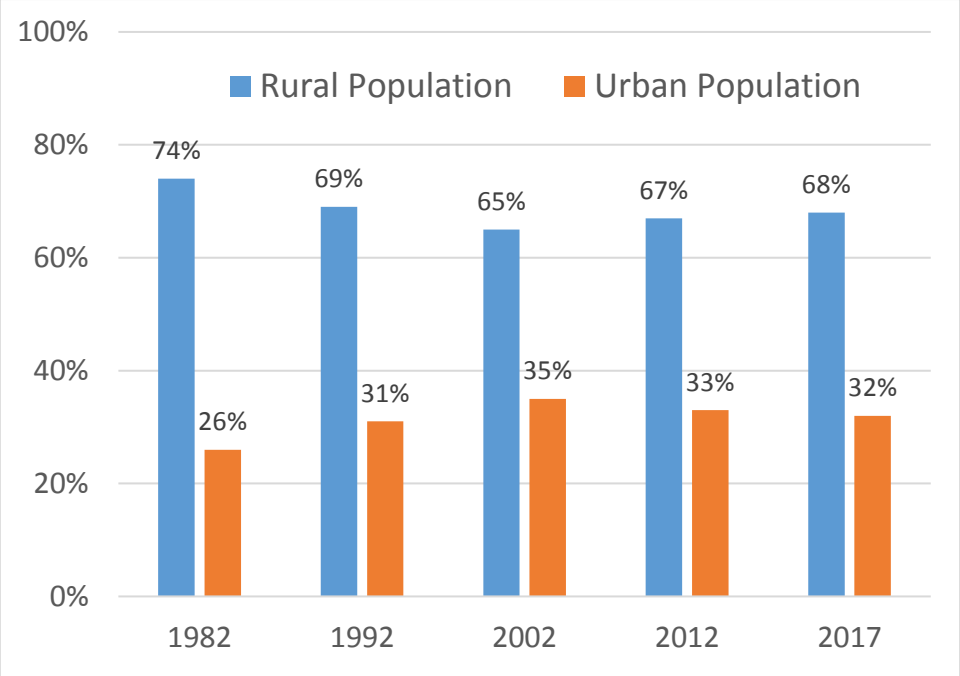


Figure 4: Rural vs Urban Population trend in Zimbabwe between 1982 and 2012.

While an analysis of the figures shows that the urban population increased from 2 million in 1982 to 3 million in 1992 before rising to 4 million in 2002, 4.3 million in 2012, and remaining stagnant at 4.3 million in 2017, overall statistics show that the urban population has not risen in levels proportional to the total population.

In order to cater for the backlog in housing in urban area[3] the government launched a National Housing Delivery Programme under ZimAsset (2013) (Housing Conference and Expo, 2016). The project has been superseded by the Transitional Stabilisation Programme Reforms Agenda (2018) which gives assurance to new housing developments and clearing of backlogs. Massive housing projects are expected to be financed by the National Social Security Authority's National Building Society (NBS), which offers housing schemes low cost mortgage loans, Infrastructure Development Bank of Zimbabwe (IDBZ) and the Urban Developmental Corporation (UDCORP). Other building societies like CABS, FBC etc. also offer loans for housing projects. Some financial institutions e.g. banks and land developers also offer assistance in construction of houses. The government and some local authorities have acquired more land for housing in urban areas. With a large workforce of civil servants, the government is working on a system whereby they require each civil servant to own a

[3] https://www.herald.co.zw/housing-backlog-needs-up-to-20-years-to-clear/

house with the assistance of the NBS. Some individuals have formed housing co-operatives aiming at building houses for each group member.

If all the suggestions for the proposed housing programmes mentioned above were to succeed the demand for electricity would increase sharply. Presently the country is facing challenges in power generation resulting in it importing electricity from neighbouring countries hence the need for the country to switch on to renewable energy especially solar energy.

Currently the government is working on a policy outlawing the installation of electric geysers in all new structures so as to promote the use of solar geysers. All new structures will be fitted with solar geysers, houses will be the major area of focus but all new buildings and existing structures will be expected to with time, replace their electric geysers with solar geyser.

Energy experts say electric geysers consume more than 40% power in households, so the installation of the solar geyser in households would save about 40% of the current domestic consumption. The solar thermal thermo-syphon systems would be most appropriate for domestic water heating systems.

In order for Zimbabwe to achieve its solar thermal vision for 2030 the country should have adequate manufacturing companies, which would manufacture solar geysers which matches with the population. Currently the country relies on importing solar geysers some of which are substandard. The government and industrialists should provide with credit facility schemes to those who cannot afford to purchase solar geysers. Solar geysers should also be installed in rural areas in order to reduce deforestation since wood is the main source of water heating in these areas. Government support is important for quick expansion of solar water heating installations.

1.8 Financing and Marketing

The major challenge with solar systems is the high up-front cost, which many low-income households cannot afford. Local assembling of imported components can help to lower costs. Several innovative solutions for subsidising access costs have been used elsewhere and can be tried here.

1.8.1 Grants

Non-profit making organisations may be funded using grants. Government, NGOs and international organisation may sponsor Solar Water Heating systems in institutions in the public sector such as schools, hospitals and homes. Carbon credits can be used as another source of funds for grant aided projects as shown by the REDD+ project[4].

1.8.2 Bank loans and Concessional loans

Prospective financiers of the NSWHP have expressed overwhelming interest in financing the project however have raised concerns about how they will recover their loans from beneficiaries of the project. It is hoped that the financing model be made sustainable after the duration of the NSWHP.

1.8.3 Grace period in loans

This scheme can be used to allow cost recovery to be made over an extended period using electricity-bill savings. Since the solar water heating systems will save on electricity the savings may be used to finance the purchase of the system when it is already installed.

1.8.4 Self-financing

The government may motivate people to fund their own solar thermal systems by offering subsidised procurement and installation costs of solar water heating systems. Penalties for energy inefficiency can assist in funding subsidies for a solar geyser roll-out programme.

1.8.5 Budgetary allocation

The power utility can fund this as a DSM investment through funding from Treasury or the programme can be awarded a national project status that can actually receive budgetary allocation.

1.8.6 Loans Recovery

ZETDC has been tasked by the Ministry of Energy Power Development using the 3E ZETDC prepayment vending platform to facilitate the recovery of loans availed to the beneficiaries of the locally manufactured solar geysers from local financiers so as to lower the risk to the financiers.

[4] https://www.reuters.com/article/us-zimbabwe-forest-idUSKBN16Z33Z

The Financiers together with ZETDC and the NSWHP beneficiary, will sign a memorandum of agreement indicating the loan amount and the loan repayment schedule, clearly stating the allowable deductions in percentage or otherwise of electricity purchase until the loan paid off. After signing of the MOU in triplicate by all parties involved, ZETDC will deduct a percentage or otherwise of every electricity purchase from the beneficiary of the NSWHP until the loan amount is paid off and remit the payment to the NSWHP beneficiary's financier.

Due to the cost incurred by ZETDC through third party vending which currently accounts to about 85%, ZETDC will reserve the right to collect a commission on all transactions relating to the recovery of the NSWHP loans upon advisement from the Ministry of Energy Power Development.

1.9 Education and awareness

Education is important for a country to grow, whether economically or socially, it plays a vital role in the growth of these two important factors. The world is focusing on the use of renewable energy particularly solar energy as compared to any other form of energy. Zimbabwe as a nation is not left behind in this race. It is through education that the solar technology can reach each individual.

In order to achieve the vision of this Roadmap, it is necessary to carry out awareness campaigns nationwide educating the population about solar thermal technology. Awareness campaigns can be done to primary school pupils, secondary schools, vocational and technical colleges, universities and the civil society. People should be educated on the use of solar thermal energy, its advantages and disadvantages as compared to any other form of energy.

At primary school level, teachers should be trained on solar thermal technology. This enables them to teach the topics on the elementary theory on solar thermal technology. The syllabus should include simple experiments on solar thermal energy and its applications. An example of a simple experiment would be to take two pans of different shades, one light and another one dark. Fill the pans with water and place them on sunshine. After some time let the pupils test the temperatures of the water in the pans. The pupils should be able to appreciate the use of solar energy for heating water. The government should provide primary school children with access to solar water heaters i.e. demonstration units on solar thermal systems should be made

available at each primary school. If possible each primary school should have a functional solar water heating system.

Regarding secondary education, it is essential that the educators be equipped with knowledge on solar thermal technology. The government should avail funds for the training of these educators. Workshops on training the trainers on solar thermal technology should be conducted in all districts nationwide so that the teachers would be equipped with relevant technology to impart to students. The school curricula should integrate solar thermal technology. At this level, this is the stage where the students need proper career guidance hence adequate information on solar thermal technology is required.

Each secondary school should have a laboratory to carryout experiments on solar thermal technology. The laboratories should have all the necessary apparatus, instruments, materials and equipment needed to perform practical work on solar thermal energy. Students can experiment on the applications of solar thermal energy e.g. on solar cookers, solar water heaters, solar driers etc. The government should distribute inspectors to each province who should monitor that the experiments will be done practically and not theoretically. Each secondary school whether boarding or day school should have a functional solar water heating system. By so doing the students should be able to appreciate the use of solar thermal energy as compared to any other form of energy.

At vocational/technical centres and universities, the government should organize and fund training courses on solar thermal technology. These institutions offer hands on training on various trades hence their curriculum should also incorporate solar thermal technology.

Training seminars should be carried out for trainers (lecturers & instructors) who will in turn disseminate the acquired knowledge to the students. Exchange programmes for lecturers/instructors are also important in order to improve their skills.

The curriculum should be designed in such a way that it offers basic and advanced courses in solar thermal technology. Under the basic course, students would be taught theory and practicals on domestic solar water heating systems i.e. the thermo-syphon systems. The solar water heater installers produced would be able to do system sizing, check in installation site, understand the layout requirement as per design and assess

precautionary measures to be taken. The advanced course should include the pumped solar water heating system, solar thermal air conditioning, solar thermal drying, space heating etc. The students should be able to do system designing and manufacture components of solar water heating systems. Components to be manufactured include the different collector types and storage tanks. The graduates from these courses include plumbers, installers, quality controllers and sheet metal workers. Students should go for on the job training on companies which manufacture products for solar thermal systems and also carry out installations for solar thermal systems.

Laboratories and demonstration units to be available on each vocational /technical centre. All students' hostels should have a solar water heating system. The government in conjunction with industry should construct a Solar Test Centre responsible for carrying out product tests as a basis for the quality labelling.

Universities should have research centres which research on new solar thermal technologies. The government should fund the projects which the researchers' carry out. Examples of projects would be the installation of concentrating solar thermal power into the National grid system, advanced solar thermal energy storage technologies, steam generating receivers for high concentration solar collectors etc. Courses on solar thermal technology should also be offered at universities and training workshops for the trainers conducted.

Awareness campaigns on solar thermal energy use should be conducted in both urban and rural areas so as to educate the civil society. Relevant stakeholders and interested population should be well informed about the different applications of solar thermal energy and the related impact on security of energy supply, employment and on the environment. When the civil society appreciates the use of solar thermal energy, for example in rural areas people would form cooperatives and work on income generating projects like manufacturing of solar dryers for farm produce, manufacturing of solar cookers etc. This would result in employment creation and poverty alleviation. Each household in urban areas should have a solar water heating system. Some private companies and NGOs should assist in the installation of these SWH systems. Private companies can provide with some credit facility schemes to assists household who wish to have SWH systems but having financial problems. Solar thermal technology Platform workshops should be conducted frequently by

NGOs who are into solar thermal technology. These would assist in mapping up the Roadmap for solar thermal technology for Zimbabwe and also as a strategic measure to support the achievement of the solar thermal vision for 2030.

Non-Governmental Organisations (NGO) can assist in funding some solar thermal projects in the country like what SOLTRAIN is embarking on. They can also assist in conducting outreach programmes nationwide spreading the gospel of solar thermal technology. There is a low penetration of solar thermal technology in Zimbabwe and a low level of consumer awareness leading to low market demand. The country relies on imported solar thermal equipment some of which are not up to standard, thus industrialists should manufacture and assemble solar thermal equipment locally.

Zimbabwe is facing power shortages despite the vast solar potential the country has. Industrialists should work on the establishment of solar thermal power stations in the country. There is need to focus more on renewable energy sources for sustainability and energy security. Industry should also participate in the production of the National Renewable Energy Policy which the government is currently drafting. Associations in solar thermal technology can be formed by interested stakeholders. These associations would work on research on new solar thermal technology.

If all the suggested views in this document are to be considered, Zimbabwe would definitely achieve its solar thermal vision for 2030.

1.10 Industry

The main task of industry is to supply the market with solar water heating systems to achieve the vision. The NSWHP is anchored on local manufacture of solar water heating components as well as local assembly. There are three major roles that the industry in Zimbabwe will have to play for this vision to be achieved. Awareness and Marketing, Retooling and Workforce development and Product Design and Manufacture / Research and Development. Table 1 gives a summary of the industry roles and associated activities.

Table 1: Identified roles and activities of industry to achieve the vision

Role	Activities
Awareness and Marketing	• Gather specific market requirements for the different market subsectors (e.g. amount of water used and temperatures) • To put up demonstration systems to create awareness and promote the use of solar water heating systems • Run awareness campaigns and promotions in partnership with educational institutions and government departments to provide information to potential buyers and users. • Provision of after-sales services
Retooling and Workforce development	• Develop or refurbish manufacturing facilities for solar water heating systems • Work with universities and colleges to determine current process capabilities • Training or retraining of workforce in production in partnership with universities and colleges • Ensure competent and qualified personnel for installations through certification by ZERA through Universities and Colleges
Product Design and Manufacture (Research and Development)	• Design and manufacture or assemble products required by the market • Develop low cost solutions applicable to all market segments in partnership with universities and colleges • Ensure maximum use of local resources • Use reverse engineering principles to produce components locally • Develop sustainable procedures for the manufacture, assembly, installation, commissioning, monitoring and maintaining solar water heating systems to ensure quality

Supplying the market with solar water heating systems will require industry to manufacture or assemble solar geysers or components locally for all the market segments. Already some companies have expressed interest to be manufacturers under the National Solar Water Heating Program being initiated by the government of Zimbabwe. Table 2 is a brainstorm of the perceived easy of manufacture for Solar Water Heating system components.

Table 2: Solar Water Heating System Components Complexity and Easy of Manufacture

Solar Water Heating System Component	Comments on complexity and ease of manufacture locally
Storage tank	• Easy to manufacture locally • Some local companies are already in the same line of business • Metal, or polymer tanks • Raw materials may have to be imported
Collectors: Unglazed	• Easy to manufacture locally • Some local companies are already in the same line of business • Raw materials will have to be imported • Small and Medium Entrepreneurs can fabricate
Collectors: Flat plate	• Easy to manufacture locally • Some local companies are already in the same line of business • Raw materials will have be imported, especially tempered glass • Investment into ultrasonic welding processes
Collectors: Vacuum tube	• Perceived to be complicated • Local companies to focus on other components of the system
Copper pipes	• Raw materials can be imported • Utilize region relationship e.g. SADC to purchase copper
Support structure	• Easy to manufacture locally • Local or imported raw materials
Controls	• Perceived to be complicated • Components may be imported • Universities and colleges can be used to develop these
Pumps	• May be imported

2 THE SOLAR THERMAL VISION FOR ZIMBABWE

Five countries in the SOLTRAIN project have completed their Solar Thermal Technology Roadmaps and have earmarked to install between 0.1 m^2 and 0.5 m^2 of solar collector area per inhabitant by the year 2030.

Botswana – 0.5 m^2 / inhabitant
Lesotho - 0.3 m^2 / inhabitant
Mozambique - 0.1 m^2 / inhabitant
Namibia - 0.5 m^2 / inhabitant
South Africa – 0.5 m^2 / inhabitant

Figure 5-Stakeholders who contributed to the vision

During the three Zimbabwe Solar Thermal Technology Platform (Z-STTP) workshops held at the University of Zimbabwe in 2016 the installation targets as spelled out in the roadmaps of Mozambique, Namibia and South Africa were debated by representatives from government, academia, industry, NGOs and other interested parties and stakeholders shown in Figure 5.

It was agreed that the vision for 2030 must be realistic and achievable and for some time a range between 0.1 and 0.3 m^2 collector area per inhabitant until 2030 was favoured.

Looking at the proposed range from different perspectives, like solar industry, marketing and finance, awareness creation, demand side management, quality control and policy first doubts were raised whether anything of the size above **0.1 m^2** is workable.

In principle, the participants to the 3rd Z-STTP endorsed the use of the National Solar Water Heating (NSWH) program as the basis of determining the target. New housing developments underpinned by the fact that all new buildings should be fitted with a solar geyser. Some penetration will be required in the rural and non-electrified homes.

In roads into industrial applications of solar thermal energy is envisaged in this Roadmap.

2.1 National Solar Water Heating Programme (Retrofitting)

The NSWH programme seeks to replace existing electric geysers with solar geysers. The National Energy Policy estimates the number of electrical geysers installed to be in the range of **250 000 to 300 000** units (NEP, 2012). Using the upper limit and assuming each geyser to have a heating element of approximately 2 kW the power consumed by these electric geysers is given by;

$$300\,000 \times 2\,kW = \mathbf{600\,MW}$$

At the Z-STTP workshops stakeholders agreed to factor a load shifting of about 70 % to indicate that all the geysers will not be switched on simultaneously. Therefore, the estimated amount of electricity that can be saved by replacing or retrofitting with solar geysers is given by;

$$600MW \times 0.70 = 420\ \text{MW}$$

Hence the plenary session adopted to use **420 MW** as a target to be replaced by a solar thermal equivalent 2030. This will be an enormous success, if the full conversion of electrical geysers to solar water heaters can be achieved in the next ten to fifteen years.

The solar collector area equivalent to capacity is given by 0.7 kW_{th}/m^2, therefore for 420 MW the corresponding collector area is given by;

$$\frac{420\,000\,kW}{0.7\,kW/m^2} = \mathbf{600\,000\,m^2}$$

With each unit having a collector area measuring between 2 and 2.5 m^2 the number of single systems will be between **240 000 and 300 000** systems

Comment: There are some urban hot water users who do not have electrical geysers, these heat their water using electricity, gas or by burning biomass. Most of these residents are in high density areas and will be a potential market as the economy improve. Unreliable water supply stifles the desire for investment into solar water heating.

2.2 New urban houses development

The government also targets to introduce regulations that mandate the installation of solar geysers in new buildings (NEP, 2012). The Zimbabwe Agenda for Sustainable Socio-Economic Transformation (Zim-Asset, 2013) a policy roadmap for the country that ran from October 2013 to December 2018. The policy was superseded by the Transitional Stabilisation Programme Reforms Agenda (TSP, 2018) which is a policy roadmap for the country running from October 2018 to December 2020, the government targets to address the housing backlogs, provision of new housing stands and the requisite social amenities. The government also pledges the complete all outstanding institutional accommodation projects that had stalled due to the economic challenges in the past years. Some of the institutions earmarked to finance housing under the TSP include the Infrastructure Development Bank of Zimbabwe (IDBZ), the Urban Development Corporation (UDCORP) and the National Social Security Authority (NSSA). For the purposes of this roadmap, it is presumed that a total of 425 000 new households will be constructed by 2030. This will about 850 000 m^2 collector area of solar water heating systems will be installed as solar water heating systems have become mandatory for new buildings.

2.3 Rural and non-electrified urban households

The population especially in rural areas has not been exposed much to the benefits of solar thermal technology and will in some years to come contribute very little to the Vision. ZimStat (2017) reports that 68 % of the Zimbabwean population live in rural areas. Ninety-four percent of Rural households meet their primary energy requirements using wood and 20 %of the households in urban areas also use wood (NEP, 2012). This population is facing energy poverty owing to a looming wood shortage following clearing land for agriculture and unsustainable firewood harvesting. Zimbabwe has joined the global effort to eliminate energy poverty by 2030 under the United Nation's Sustainable Energy for All (SE4ALL) initiative (SE4ALL, 2012). Though the government has electrified 13% of rural households to date through the Rural Electrification Fund (REF), the effort to end energy poverty in rural areas needs to be complemented by designing indigenous solar water heaters that are socio-culturally accepted in rural areas. REF has achieved an 18% penetration rate on photovoltaic home systems, and assuming a half penetration rate (9%) for the solar

water heating systems in rural areas and non-electrified urban households over the period to 2030 requires installation of about 185, 000 systems.

Comment: The people are mainly interested in solar lighting, solar cooking and solar refrigeration. Solar water heating ranks relatively low in the list of priorities. Naturally, lack of piped water is a serious barrier to the dissemination of solar water heaters. A high percentage of the rural population has to fetch water from sources more than 500 metres away (ZimStat, 2012).

Of all applications of solar thermal technology solar fruit and vegetable drying and solar cooking attract the strongest interest. Solar cooking, if widely promoted and financially supported, would have the highest potential of reducing the consumption of firewood and arresting deforestation. Government has supported programmes of biogas through REF in a way of conserving fast-dwindling wood resources.

Parabolic reflectors may be used for both cooking food and for heating bathing and laundry water. A parabolic dish of 1.5 metre diameter intercepts around 1.7 square metres of solar radiation and concentrates more than 1 kW onto the pot. One hundred thousand units of these cookers sold, subsidised or donated until 2030 would contribute to the target.

2.4 Public and Commercial Sector

Applications of solar thermal technology at hotels, hospitals, homes, schools, etc. will gain a higher share of the solar heater market as soon as more local installers learn how to design and install thermo-syphon and pumped systems of up to 50 and more square metres. For the purposes of this roadmap high volume of hot water users were classified in the commercial and public sector. Commercial takes care of institutions like players in the hospitality and tourism industry including hotels. The public sector has social institutions like schools, colleges, caring homes and universities among other institutions that have hostels. Hospitals and Clinics were also considered in this class. Generally this sector has similar requirements for pressurised setups and high volumes of water.

Most of these hospitals, hotels and hostels are already connected to the grid and some of them use electricity to meet their hot water demand. Hove et al (2007) identified 278 primary and secondary boarding schools; 125 private hospitals and clinics; 50 government hospitals of size District hospital and larger (estimate); 42 Children’s

homes; 23 Old people's homes and 16 Rehabilitation, Aids/Orphan Centres across Zimbabwe. Though the list was inconclusive and was prepared about 10 years ago the study gave a good picture of the demand for solar water heating systems at institutional level. Installations in this sector will be about 7.25% of the total vision target yielding 145 000 m^2. However, there have been a few installations of medium-size SWH at schools, homes and hospitals in the past but for the commercial sector to play a major role in making the roadmap vision happen efforts will be required to multiply the installation figures.

2.5 Industrial and Agriculture Sector

In Zimbabwe the adoption of solar thermal technologies for industrial process heating, cooling and drying has stalled because industrialists doubt whether they would realise benefits as they are not aware of the ability of solar and absence of local case studies were the technology has been successfully utilised (SIRDC-SNV, 2012). In this regard, demonstration systems will help in creating awareness towards the adoption of solar thermal for process applications. To help the development of this cause a target of 1.75% of the total vision has been set to be installed in this sector translating to 35 000 m^2 by 2030. Huge potential for solar process heating also exists in industry and mining.

Agriculture run on a commercial or industrial scale also requires large amounts of low and high-temperature heat for food processing and crop drying and could create a high demand for many square metres of water and air collectors. As long as industry and industrial agriculture can gain cheap heat from coal and from biomass, solar heating will mainly be favoured by environment-conscious persons. Solar technology employed in commercial farming can at the most reach a solar fraction of 30 percent, the other 70 percent inevitably coming from fossil or biomass fuels.

3 THE SOLAR THERMAL TECHNOLOGY ROADMAP

3.1 The Approach to the Roadmap

To reach the envisaged target of 0.1 m^2 / inhabitant of solar thermal collector area in Zimbabwe by 2030 an additional 2 million square metres of collector area has to be installed for a population of about 20 million people countrywide. This is up from the 39,000 m^2 currently installed for the 14 million inhabitants to date. Table 3 shows the estimated targets for the different sectors.

Table 3: Solar water heating market segmentation for Zimbabwe (Approach to roadmap 2030)

Sector	Specific Target	Number of Systems	Estimated solar collector area to satisfy demand	Percentage of Overall Vision
Domestic (Thermo-syphon and pressurised systems)	Existing electrified urban households (retrofitting)	300,000	600,000 m^2	30.00 %
	Existing non-electrified urban households and rural households	185,000	370,000 m^2	18.50 %
	New urban houses	425, 000	850,000 m^2	42.50 %
Public and Commercial (pressurised systems)	Hostels, Hospitals and Hotels	4,800	145, 000 m^2	7.25 %
Industrial (process heating and cooling)	Food & Beverages, Textile, Chemical, Mining , Agriculture etc.	350	35, 000 m^2	1.75 %
TOTAL			**2,000,000 m^2**	**100.00 %**

Some of the discussion on the approach suggested towards the achievement of this target is shown in detail in section 2 of this document.

3.1.1 Thermo-syphon systems for domestic sector (2-4 m^2 per system)

Domestic sector installations in the roadmap will be largely driven by the thermo-syphon systems though, some upmarket consumers would prefer the pressurised system. The roadmap targets retrofitting or replacement of existing electrical geysers. This is in line with the National Solar Water Heating Program (NSWHP) launched by

the government of Zimbabwe in September 2015 (Herald, 2015). Besides retrofitting of the currently available electrical geysers, installations in new housing projects is also targeted in line with the Transitional Stabilisation Programme Reforms Agenda (2018) and also making inroads into rural areas. Together the households will contribute 90 % of the overall target. Table 4 shows the pivotal roles that the Government of Zimbabwe and industry have to play to support installations in residential households.

Table 4a: Industry and Government Roles in supporting Thermo-syphon systems

Awareness and Marketing	
Industry Role	Determine specific market requirements for households e.g. hot water consumption patterns in terms of volumes and temperature Design appropriate and affordable solutions for the determined market requirements Run advertising campaigns to promote the adoption of solar water heating technologies Raise awareness on the financial benefits of adopting solar water heating technologies
Government Role	Promote the development of information dissemination platforms for public and free consultations on available solar water heating solutions and technology suppliers Promote the use of thermo-syphon systems especially in rural areas and low income households using government agencies like the Rural Electrification Fund (REF)
Institutional Issues	
Industry Role	Develop or refurbish manufacturing facilities for local production of solar water heating system components Offer high quality product and customer service to build customer confidence in solar water heating technologies Form professional body or bodies that represents interests of the whole supply chain for solar water heating products with government, in order to influence policy, standards and regulations formulation
Government Role	Develop clear and consistent policy, standards and regulations that apply to the supply (manufacture or import), installation and maintenance Develop tools for enforcing conformity e.g. Municipalities and Power Utility Company may be used to enforce laws on Solar Water Heating Systems Support the development of quality control testing centres

Table 4b: Industry and Government Roles in supporting Thermo-syphon systems

Workforce development	
Industry Role	Develop the workforce to acquire the necessary skills for design, manufacture of components, installation and maintenance of Solar Water Heating Systems
Government Role	Ensure competent and qualified personnel for installations through certification of installers by regulatory authorities, universities and colleges
Research and Development	
Industry Role	Engage universities and colleges to develop low cost solutions particularly applicable to rural areas focusing on the use of locally available resources
Educational Institutions	Work with industry, government and the market to develop mass-customised systems for the diverse market needs
Government Role	Promote and fund research and development work through universities and colleges as well as other government research institutions

3.1.2 Pressurised systems for the commercial and public sector (10-60 m^2 per system)

Hove et al (2007) identified 534 social institutions in this section that included hospitals, homes and boarding schools. The study concluded that the demand for solar water heating systems exists but however, there is no market owing funding constraints. For hotels Batidzirai et al (2009) discovered that water heating contributes 54 % of energy consumption in a hotel. With a bit of grant aided installations for socials services and awareness campaigns to hotels to reduce the 54% consumption with solar, the envisaged 145 000 m^2 of collector area in this sector is achievable by 2030. Table 5 shows key roles for industry and government to make the target attainable.

Table 5a: Industry and Government Roles in supporting pressurised systems for commercial and public sectors

Awareness and Marketing	
Industry Role	Classify users according to their consumption patterns of hot water Design appropriate solutions for each class of users Coordinate with bodies that represent the classes of users for awareness and marketing of solar water heating product and services e.g. The Ministry of Primary and Secondary Education for schools, Ministry of Tourism and Hospitality for hotels, Ministry of Public Service, Labour and Social Welfare for caring homes and Ministry of Health and Child Welfare for Hospitals and Clinics
Government Role	Promote the initiatives for dissemination of technical knowledge on solar water heating solutions using line ministries

Table 5b: Industry and Government Roles in supporting pressurised systems for commercial and public sectors

Institutional Issues	
Industry Role	Develop or refurbish manufacturing facilities for local production of solar water heating system components Offer high quality installations and provide after sales services Engage in Private-Public Partnership to fund large scale installations in institutions
Government Role	Develop clear and consistent policy, standards and regulations, including Green Label Certification for Hospitality operators that adopt Solar Water Heating Ensure adherence to standards using certification system of quality for suppliers, local and imports to protect the users Support the development of quality control testing procedures at every level of installation Consolidate government to government agreements for institutional heating systems like the ones already installed at United Bulawayo Hospitals and Harare Institute of Technology through the assistance from South Korea
Workforce development	
Industry Role	Develop the workforce to acquire the necessary skills for design, manufacture of components, installation and maintenance of Solar Water Heating Systems Standardise, maintain and appraise best work practices during installation, including ergonomics and safety during work, environmental protection and productivity
Government Role	Ensure competent and qualified personnel for installations through certification of installers by regulatory authorities, universities and colleges Enforce the banning of electrical geysers to institutions in the commercial and public sectors
Research and Development	
Industry Role	Engage in Private-Public Partnerships with universities, colleges and the target market sector to develop improved systems in terms of efficiency
Educational Institutions	Work with industry, government and the commercial and public sector to develop customised systems for the diverse needs of this sector
Government Role	Promote and fund research and development work through universities and colleges as well as other government research institutions like the Research Council of Zimbabwe

3.1.3 Pressurised systems for industrial process heating and cooling (50-200 m^2 per system)

Participants to the SIRDC-SNV Workshop on uptake of solar thermal technology in industry held in Harare on 11 December 2012 noted that Industrialists seem not to be

aware of the potential of solar thermal applications to industrial processes (SIRDC-SNV, 2012). Food and Beverages, Textile Chemical, Agriculture are some of the industries that require low temperature heat. Solar water pre-heating can also be used to offset some significant energy costs for industry. This Roadmap just set a target of 1.75 % of the overall, translating to 35 000 m^2 by 2030. This is an entry level figure backed by extensive awareness and marketing as shown in the roles of government and industry shown in Table 6.

Table 6a: Industry and Government Roles in supporting Industrial process heating and cooling

Awareness and Marketing	
Industry Role	Target specific industries were process heating and cooling is applicable and create awareness e.g. food and beverages, textile, chemical and agriculture Install exemplary systems Conduct thermal energy audits and encourage companies to keep statistics of thermal energy usage in industries Develop different solar water heating and cooling integration points to existing processes
Government Role	Promote use of solar thermal energy for industrial applications as part of demand side management thus an equivalent of the National Solar Water Heating Program for Industry Promote the use of Solar Thermal Technologies to the new farmers e.g. solar drying for tobacco, tea, fruits and vegetables Coordinate the Ministry of Energy and Power Development to carry out awareness campaigns for key decision makers in the targeted industries
Institutional Issues	
Industry Role	Develop or refurbish manufacturing facilities for local production of solar water heating system components Offer high quality installations and provide after sales services Engage in Private-Public Partnership to fund large scale installations in industry or demonstration units
Government Role	Develop clear and consistent policy, standards and regulations that apply to the supply (manufacture or import), installation and maintenance Develop a policy of implementation for application of Solar Thermal Technologies in industrial processes Support the development of quality control testing centres

Table 6b: Industry and Government Roles in supporting Industrial process heating and cooling

Workforce development	
Industry Role	Develop the workforce to acquire the necessary skills for design, manufacture of components, installation and maintenance of Solar Thermal Systems Standardise, maintain and appraise best work practices during installation, including ergonomics and safety during work, environmental protection and productivity Specialised courses for industrial integration of solar thermal to existing process for engineers and technicians
Government Role	Support the training of competent and qualified personnel for installations through certification of installers by regulatory authorities, universities and colleges
Research and Development	
Industry Role	Engage in Private-Public Partnerships with universities, colleges and the target market sector to develop systems with different integration points for Solar Thermal Use of simulation packages to indicate comparisons and future energy savings
Educational Institutions	Work with industry, government and the market to develop customised systems for the diverse market needs Research into a wider range of industrial applications for Solar Thermal Technologies in heating and cooling Monitor, analyse and publish results from industrial solar thermal installations
Government Role	Promote and fund research and development work through universities and colleges as well as other government research institutions like the Research Council of Zimbabwe

4 ROADMAP IMPLEMENTATION

The implementation of this roadmap depends upon support given by five key pillars namely; government support, education, financial incentives, quality control and awareness marketing. This pentagon support is illustrated as shown in Figure 6. The implementation process starts with identification of stakeholders followed by the formation of a task force that is responsible for strategy formulation for implementing the roadmap.

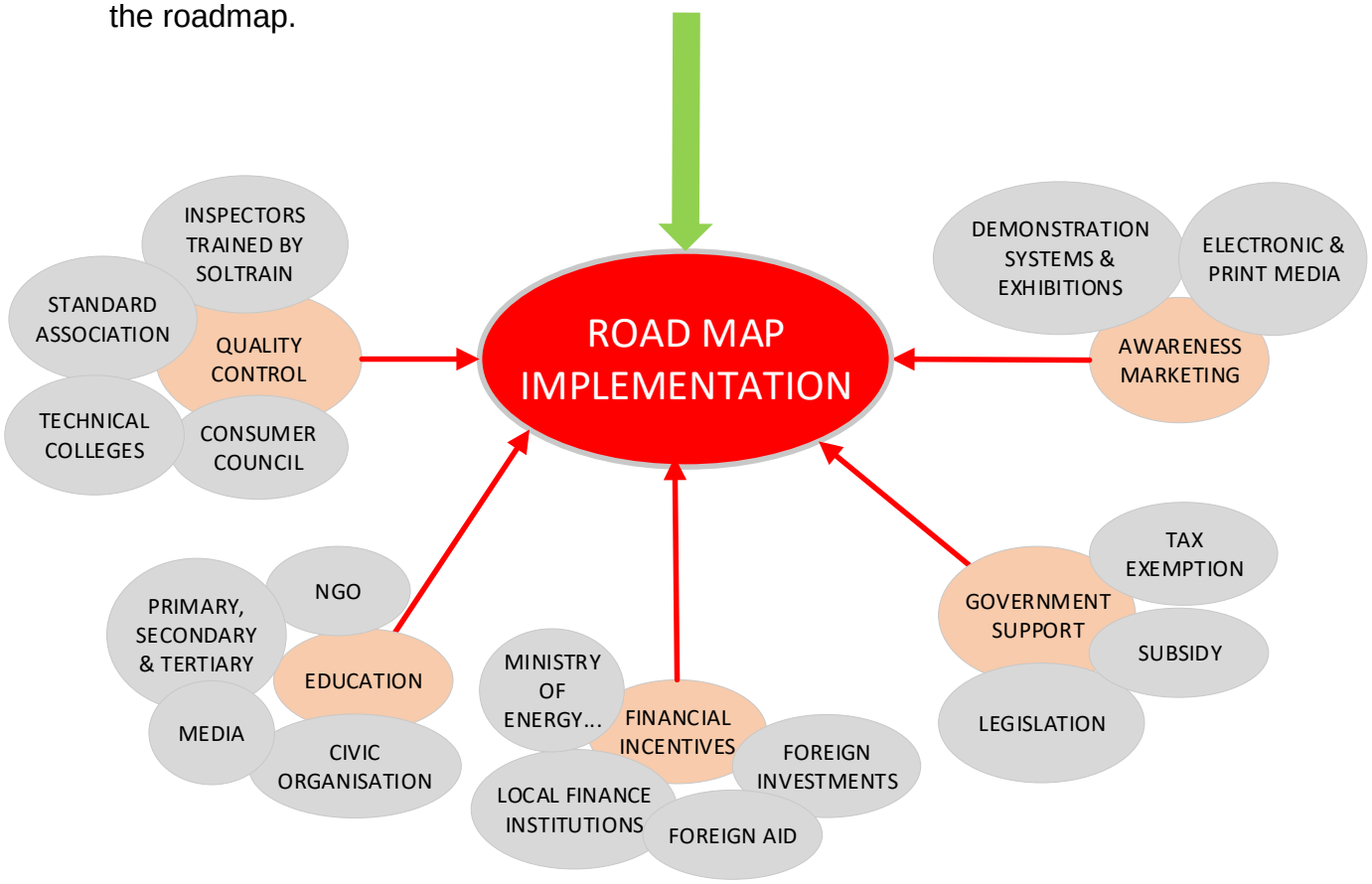


Figure 6: Roadmap Implementation Plan

4.1 Annual Implementation targets

According to assumptions derived from regional experience, the lion's share of future installations will come from the residential sector, In Zimbabwe the domestic sector will contribute about 90%, whilst the public commercial and industry will share the remaining 10%. Table 7 shows the annual installation targets that are expected to grow exponentially up to 2030.

Table 7: Annual installation targets

	Residential Sector (Retrofitting)	Residential (non-electrified and rural)	Residential (new urban households)	Public and Commercial Installations (Hostels, Hospitals and Hotels)	Industrial Installations (Food & Beverages, Textile, Chemical, Mining, Agriculture etc.)	Annual Installations	Cummulative
Year	**[m²]**	**[m²]**	**[m²]**	**[m²]**	**[m²]**	**[m²]**	**[m²]**
Carry over from previous installations							**39,000**
2019	5,065	3,124	7,176	1,224	295	16,884	**55,884**
2020	6,960	4,292	9,860	1,682	406	23,201	**79,085**
2021	9,564	5,898	13,549	2,311	558	31,880	**110,966**
2022	13,142	8,104	18,618	3,176	767	43,807	**154,772**
2023	18,059	11,136	25,583	4,364	1,053	60,195	**214,967**
2024	24,814	15,302	35,153	5,997	1,447	82,714	**297,682**
2025	34,097	21,027	48,304	8,240	1,989	113,658	**411,339**
2026	46,853	28,893	66,375	11,323	2,733	156,177	**567,516**
2027	64,381	39,702	91,206	15,559	3,756	214,603	**782,119**
2028	88,466	54,554	125,327	21,379	5,161	294,886	**1,077,005**
2029	121,561	74,963	172,212	29,377	7,091	405,204	**1,482,209**
2030	167,037	103,006	236,636	40,367	9,744	556,791	**2,039,000**
Total	**600,000**	**370,000**	**850,000**	**145,000**	**35,000**	**2,000,000**	

The Roadmap targets to install an additional 2,000,000 m^2 of collector area by 2030 to the already installed capacity of 39,000 m^2. With the population of Zimbabwe expected to grow to 20 million by 2030, the target will be to install about **0.1 m^2 / inhabitant**. Figure 6 shows the annual exponential growth of the installations for each sector.

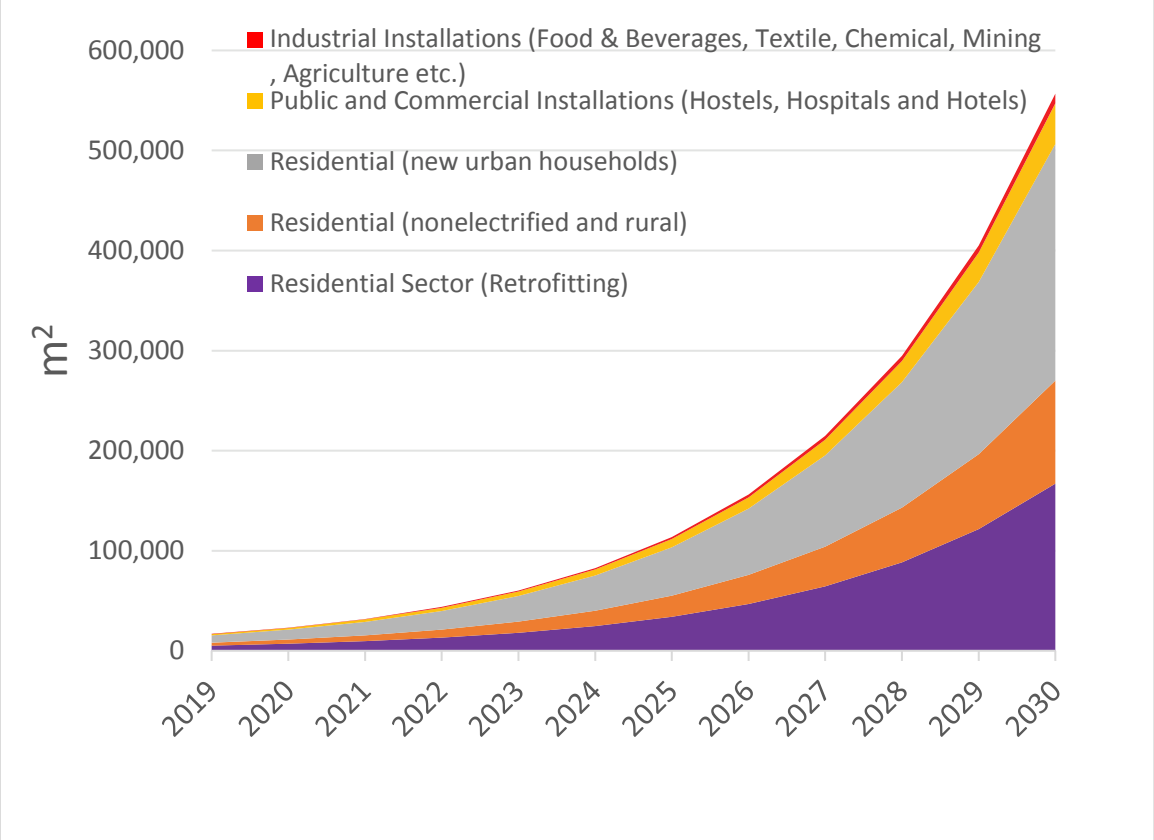


Figure 7: Annual targets for implementation

4.2 Key Stakeholders in implementation

The implementation process starts with the identification of key stakeholders. The key stakeholders comprise of institutions drawn from the support pillars. Some of the partners include;

i. Ministry of Energy and Power Development (MoEPD) - who are responsible for policy and regulations.

ii. The Zimbabwe Electricity Supply Authority Holdings – the companies are the custodians of the energy supply in the country and will benefit from offsetting planned new fossil generation and reduced pressure on the grid.

iii. Research institutions- University of Zimbabwe, National University of Science and Technology, Midlands State University, Harare Institute of Technology, Chinhoyi University of Technology, Lupane State University, Bindura University of Science Education, Great Zimbabwe University, Gwanda State University, Manicaland University of Science and Technology, Scientific and Industrial Research and Development Centre who are responsible for innovation,

development of solar thermal systems applied to Zimbabwe 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, and manufacturing with local content.

vii. Standards Association of Zimbabwe (SAZ) are responsible for standards formulation and quality control of solar thermal products and installations.

4.3 Implementation Plan: Short Term (2019-2024)

4.3.1 Formation of a National Task Force operating under MoEPD to draw out a strategy and plan of action for rolling out the ZSTTP

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.

4.3.2 Adoption of Roadmap as an Addendum to Renewable Energy Policy

The synergizing of the Roadmap with the Renewable Energy Policy which current await Parliament approval.

4.4 Implementation Plan: Long Term (2025-2030)

The implementation by stakeholders supported by different Ministries as highlighted in section 3.1 with a monitoring and evaluation system managed by the MoEPD to fulfil vision 2030.

5 CONCLUSION

The Vision for the ZSTTP is to enable Zimbabwe achieve 0.1 m^2 collector area per citizen by the year 2030 based on the National Water Heating Programme. The immediate benefits of the Vision are: decrease in the fossil generation of electricity and reduction in carbon emissions and contribution to the energy mix of the country. The implementation of the roadmap will depend on the stakeholders led by the Government on the one hand through policy and strategy and implementation taskforce on the other hand through coordinating structures.

6 REFERENCES

AFBD, (2011) *Zimbabwe Report Rehabilitation and Recovery in the Power Sector,* [ONLINE] Available At: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/10.%20Zimbabwe%20Report_Chapter%208.pdf ACCESSED 01 January 2017

Batidzirai, B.; Lysen, E. H.; Van Egmond, S.; and Van Sark, W., G., J., H., M; (2009), *Potential for solar water heating in Zimbabwe,* Renewable and Sustainable Energy Reviews 13 (2009) 567–582

Draft National Renewable Energy Policy, *First Draft Realised November 2016 National Renewable Energy Policy* Ministry of Energy and Power Development, Republic of Zimbabwe:

Herald, (2015), Geyser ban to save 300 MW [ONLINE] Available At: http://www.herald.co.zw/geyser-ban-to-save-300mw/ ACCESSED 20 Nov 2016

Housing Conference and Expo (2016) *National Housing Delivery Programme* - Housing Conference & Expo: 12-15 July 2016 ICC Rainbow Towers Hotel, Harare

Hove, T., Mubvakure, B., and Schwarzlmuller, A., (2007). *Final report on the survey on demand of solar water heaters in the institutional sector*. ZimSun Market Survey (2006 - 2007)

NEP, (2012) National Energy Policy. Ministry of Energy and Power Development, Republic of Zimbabwe,

SE4ALL (2012). *Sustainable Energy for All - Zimbabwe Rapid Assessment and Gap Analysis* Draft final – 14 June 2012

Transitional Stabilisation Programme Reforms Agenda (TSP), (2018), Republic of Zimbabwe Economic Blueprint for October 2018-December 2020, Harare: Published 5 October 2018

UNESCO (1997), *World Solar Programme (1996-2005)*, [ONLINE] Available At: http://unesdoc.unesco.org/images/0011/001134/113453Eo.pdf ACCESSED 01 January 2017

World Bank (2013), Fact Sheet: The World Bank and Energy in Africa. [ONLINE] Available At: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/0,,contentMDK:21935594~pagePK:146736~piPK:146830~theSitePK:258644,00.html ACCESSED 31 December 2016

ZERA, (2016). *Recommended solar companies in Zimbabwe*. [ONLINE] Available At: http://www.zera.co.zw/index.php/rsc ACCESSED 31 December 2016

ZimAsset, (2013), Republic of Zimbabwe, Zimbabwe Agenda for Sustainable Socio-Economic Transformation

ZimStat, (2012), Zimbabwe Population Census National Report 2012, Zimbabwe National Statistics Agency, Harare

ZimStat, (2017). Inter-Censal Demographic Survey Report 2017, Zimbabwe National Statistics Agency, Harare

APPENDIX 1: POLICY DOCUMENTS/RESOURCES

- National Energy Policy (NEP) of 2012 promotes the increased uptake of renewable energy resources in the country among others.
- The National Electricity Act of 2002 makes provision for Independent Power Producers (IPPs) to participate in electricity generation.
- Rural Electrification Act of 2002 to spearhead rapid and equitable electrification of rural areas in Zimbabwe.
- The Energy Regulatory Authority Act of 2011 (Established ZERA) The Act provides requirements, processes and regulations related to energy resource licensing.
- Transitional Stabilisation Programme Reforms Agenda (2018) Promotes increased uptake of renewable energy (2018 -2020)
- The Biofuels Policy 2015 Draft has been completed
- The Rural Energy Master Plan (REMP) - REF 2015 Under development.
- The UNSE4ALL Rapid Assessment and Gap Analysis (2012, then updated 2015)

Work in progress

- The Renewable Energy Readiness Assessment (RRA) - IRENA 2015 Draft completed.
- 1st and 2nd communications to the UNFCCC and INDCs – MEWC
- Zimbabwe's Nationally Determined Contributions (NDCs) and Zimbabwe's Climate Change Response
- Sustainable Energy for Children in Zimbabwe – UNICEF 2015
- National Renewable Energy Policy (in process – draft completed)
- National Integrated Energy Resource Plan (NIERP) - Tender Stage
- Independent Power Producer (IPP) Policy -Tender Stage
- Renewable Energy Feed-in Tariff (REFiT) - Draft Completed
- SE4ALL Action Plan - Draft Completed
- Solar PV Grid Code - Draft Completed
- Net Metering Regulations - Draft Completed
- ZETDC Electricity Tariff Schedule - Effective September 2014
- Zimbabwe Electricity Demand Profile
- Solar PV "Bell Curve"

NOTES

SOLTRAIN Local Partner Organization

National University of Science and Technology

Contact Person:

Eng Samson Mhlanga

Industrial & Manufacturing Engineering Department,
National University of Science and Technology
P O Box 939 Ascot, Bulawayo, Zimbabwe
Tel: 263-9-282842 Fax: 263-9-286803 cell: 263-772-250918
email: Samson.mhlanga@nust.ac.zw; smhlanga126@gmail.com

Visit www.soltrain.org for more information on other partner organisations and contributions by SOLTRAIN Project.

Printed by: DP printmedia