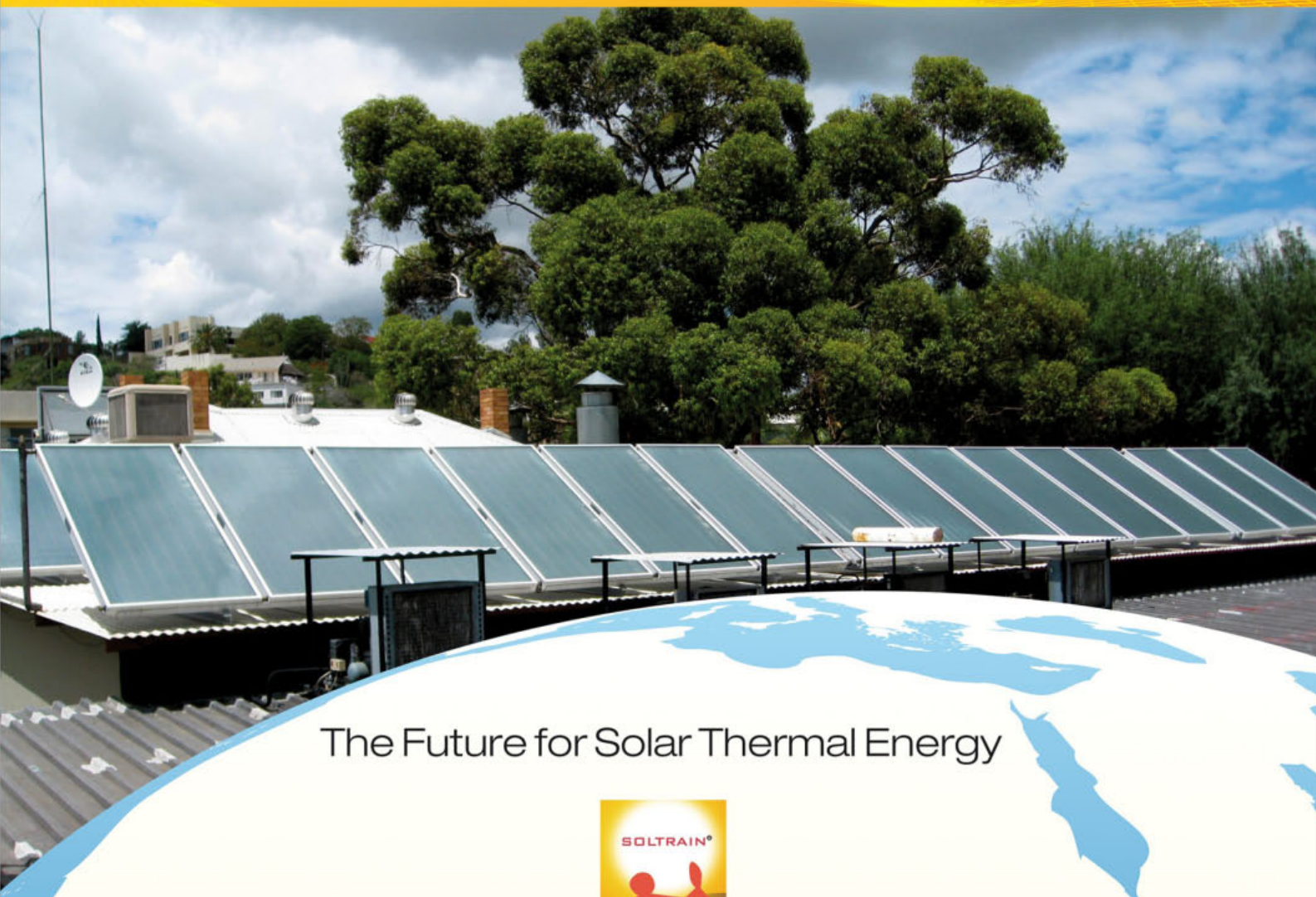
Solar Thermal Technology Roadmap



The Future for Solar Thermal Energy

SOLTRAIN®

WITH FUNDING FROM
AUSTRIAN
DEVELOPMENT
COOPERATION

Mozambique

Solar Thermal Technology Roadmap for Mozambique

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financed by Austrian Development Cooperation

Maputo, DECEMBER 2015

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Foreword

In recognizing the importance of energy in the population survival and well-being; Mozambican policy makers have traditionally assigned a high priority to the energy sector. Hence significant resources have been allocated to this sector. This allocation of resources has been mostly attributed to conventional sources of energy, namely, fossil fuels and electricity

In spite of government's effort on promoting the use of conventional sources of energy, the large majority of Mozambican population living in disperse and remote locations uses mostly non-conventional energy, biomass and fuel wood. This situation is mostly driven by the household's humble incomes. As such the Government of Mozambique has been promoting the use and development of renewable sources of energy, through research, education, training and dissemination of renewable energy technologies.
In addition, Government of Mozambique has identified in its Energy Strategy ("Resolução 10/2009" in the 4th of June) and Policy for Development of the New and Alternative Renewable Energies ("Resolução 62/2009" in the 14th of October), the importance of solar thermal energy as an alternative source to electricity, charcoal and firewood in thermal industrial and manufacture services, and an important technology to promote for the wellbeing and good living conditions of Mozambican families.

Mozambique is fortunate in its level of solar radiation, varying between 1700 to 2200 kWh/m2, which will allow for the solar resource to become a reliable and modern energy source, both for electricity supply and for thermal purposes. The Government of Mozambique has set as a target the installation of 0.1 m2 per capita of solar water heating systems by the year 2030, which will require a concerted effort of all stakeholders in the country, both public and private, as well as the development agencies that supported us since the very beginning the Mozambique's vision of a Green Future.

In line with government policy on renewable sources of energy, the Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN Project) was implemented in Mozambique through Eduardo Mondlane University (UEM) in collaboration with AEE - Institute for Sustainable Technology (Austria) and several regional partners, namely, Sustainable Energy Society & Stellenbosch University (South Africa), Polytechnic of Namibia (Namibia), and Domestic Solar Heating (Zimbabwe). The main goals of the project were to i) Create new jobs at small and medium enterprises, ii) Initiate and/or strengthen political support mechanism for solar thermal systems, iii) building up training capacities in the participating countries, iv) Improvement of quality, performance and lifetime of solar thermal systems.

This Roadmap was prepared with a view of with public to public partnerships and the engagement of the private sector in the processes of technology transfer and marketing. In this manner, we hope to promote the use of Solar Water Heating up to the point where Governmental intervention can be kept at its minimum.

We realise that there is a long way to go, including developing the regulatory framework needed to cheapen the technology and to facilitate the private sector participation in its manufacture and dissemination, as well as the establishment of financial mechanisms and packages to support private and public, individual and collective initiatives in the sector, and to nurture innovation and self-reliance of the Mozambican institutions in this particular technological area.

The Government of Mozambique will be behind the implementation of this roadmap every step of the way, and will encourage initiative, innovation and standardization of technology, processes and practices, in the view of reaching the targets for solar water heating in Mozambique and of preparing the future in which solar thermal technology is deeply ingrained in the Mozambican overall technological portfolio.

Maputo, November 2015

The Minister for Science Technology, Higher Education and Professional Training

Prof Doutor Eng. Jorge Olivio P. Nhambiu

About Soltrain

The Austrian Development Agency (ADA) and AEE INTEC (Institute for Sustainable Technologies from Austria) set up a 3-year solar thermal energy project in cooperation with Southern African educational institutions, renewable energy institutions and companies in South Africa, Mozambique, Namibia and Zimbabwe. Soltrain 2 builds on a previous project, which ran from 2009 – 2012.

The main activities of SOLTRAIN 2 are focused **awareness campaigns** on focuses on increasing awareness, capacity building, strengthening sustainable institutional structures and developing a road map for solar thermal energy use. It will inform all relevant stakeholders and the interested population about the different applications of solar thermal energy and the related impact on security of energy supply, poverty, employment and on the environment.

Another major activity is to implement a sustainable institutional structure and focal points for solar thermal information, training, support for industry and policy as well as for applied research. The **Centres of Competence** will be implemented in institutions of higher education in each country. The Centres of Competence are going to carry out a comprehensive training programme, ranging from practical hands-on training to University level courses.

Furthermore **"Solar Thermal Technology Platforms"** (STTP) will be implemented into all Centres of Competence in each partner country. These national platforms will be cross-linked to a Southern African Solar Thermal Technology Platform in order to enhance the information exchange and the cooperation between the platforms.

In order to apply the knowledge gained during the training courses, and to increase the public awareness, **40 - 50 solar thermal demonstration systems** of different sizes and applications will be installed at social institutions and small and medium enterprises.

This Roadmap was prepared by representatives of four public institutions, namely, UEM, EDM, FUNAE and ENPCT, E.P. described below. These institutions will be full involved in the implementation of this Roadmap.

About ENPCT, E.P. – Empresa Nacional de Parques de Ciência e Tecnologia E.P. STP.

ENPCT, E.P. is a public company created by the government of Mozambique in 2012, with a mandate to implement science and technology parks in Mozambique, set-up and manage infrastructure facilities and provide other services like technology assessment and professional training. It is an autonomous company under the Ministry of Science Technology Higher Education and Professional Training and Minister of Finance.

The national program for the implementation of Science and Technology Parks, was approved by the Council of the Ministers in 2008 and envisage the implementation of 4 science and technology park in country in the horizon of 10 to 15 years, namely in Nampula (north), Zambezia and Manica (Centre) and Maputo (south).

ENPCT, E.P. top management structure comprises five Board Members including the Chief Executive Officer (CEO) and a Fiscal Council. Its head quarter is located at Maluana Science and Technology Park, Maputo province.

ENPCT, E.P involvement with SOLTRAIN is recent. Given its mission, described above, ENPCT, E.P. is well suited to play major role in the local leadership of the project,

Organize and manage the program – at local level run the competitive tender/direct adjudication for the demonstration systems, Organize existing plumbing companies to be part of the program Organize marketing of the program results Own the monitoring equipment and lend it to EDM. With this view ENPCT, E.P. is also participating in the preparation of Mozambique's Road Map for SWH under SOLTRAIN's auspices.

Address:
ENPCT, E.P.
Parque de Ciência e Tecnologia de Maluana (PCTM)
Av. Moçambique km 60
Maluana, Província de Maputo

About EDM – Electricidade de Mozambique E.P.
EDM is a public power utility, of national dimension, responsible for generation, transmission distribution and commercialization of electricity in the whole Mozambican Territory. EDM is also responsible for the electrification program of Mozambique and for the Operation, Dispatch and Management of the National Transmission Network (RNT). EDM is subjected to the supervision of the Ministry of Mines and Mineral Resources (MIREME) and serves about 1.4 million families with electricity from the national grid.

EDM's involvement with SOLTRAIN is recent and results from the plan to target electricity consumers in the tourism and service sectors as potential beneficiaries of the demonstration SWH systems. With this view, EDM is also participating in the preparation of Mozambique's Road Map for SWH under SOLTRAIN's auspices. Liability avoidance and quality assurance are key to this program, to ensure that the demonstration systems are well accepted by the beneficiaries and can make the argument for a future technology roll-out program.

Address:
EDM, E.P.
Electricidade de Moçambique
Av. Agostinho Neto, 70
Cidade de Maputo

About UEM – University Eduardo Mondlane
The Eduardo Mondlane University was founded in 1964. Presently it is the largest University in Mozambique and comprises 14 Faculties and Schools. The Faculty of Engineering is one of these faculties and is responsible for training engineers in 4 different fields, namely, Mechanical, Electrical, Civil and Chemical. Its several research groups have been conducting research on several topics including the efficient use of energy and resources.

Address:
Eduardo Mondlane University (UEM)
Faculty of Engineering
Av. Moçambique, Km 1.5
Maputo
About FUNAE – Fundo Nacional de Energy

FUNAE is public agency responsible for promoting and implementing off-grid energy access and fuels distribution, with focus on Renewable Energy. It has been implementing

several projects all over the country. And based on its penetration has reached hundreds of schools and clinics with renewable energy solutions.

FUNAE had no link with SOLTRAIN before, although it has been following through the ministry the solar thermal option under SOLTRAIN program.

Following, previous experiences, after the 6 solar thermal systems installed in the clinics in Namaacha, Chimoio, Lichinga, Mueda, Ulongue and Gurue by the Ministry of Mineral Resources and Energy. In addition SOLTRIN II has installed two systems of thousent square meter each respectively in Ndlavela health center and Psychiatric hospital of Mahotas. The mass program will be directed to FUNAE, so the opportunity to match with SOLTRAIN is obvious.

Address:
Fundo de Energia (FUNAE)
R. Imprensa 256, 6º andar, Porta 610
Prédio 33 Andares
Maputo

1 Introduction

1.1 Background Note

The Solar Thermal Technology Roadmap for Mozambique was developed and discussed during three stakeholder workshops, which took place in May 2013 and March and September 2015 in Maputo.
At this stakeholder workshops experts from the Ministry of Minerals and Energy, Ministry for Education, FUNAE, UEM, Electricidade de Mozambique participated.
The Roadmap document was prepared by Fabião Cumbe, Fátima Arthur, Antonio Saíde andGeraldo Nhumaio, respectively from STP, EDM, FUNAE and UEM.

1.2 Why solar water heating systems in Mozambique?

Mozambique is a tropical country in the Southern African region with a population of about 20 million of which about 80% live in geographically dispersed rural areas. The country comprises 799 380 km² subdivided into ten provinces (CIA, 2005).

Mozambique has an high potential of energy resources. Mozambique's vast energy resources include hydropower, natural gas, coal, biomass, solar and wind. For example, the hydroelectric potential has been estimated at 12500MW with corresponding energy generation potential of 60000 GWh. The total gas potential is estimated at 25 TCF with proven gas reserves of about 3TCF, mainly located at Pande, Temane and Buzi. The total coal reserves are estimated at 3billion tones and the market potential of the solar photovoltaic in Mozambique is estimated at 60MW. However, the main sources of energy for satisfying the energy needs of Mozambique have been fuelwood and fossil fuels.

Since 1992, after the end of the civil-war, the economy of Mozambique has shown considerable improvement, recording annual growth rates of about 10% between 1994 and 1999. In 2001, the economy grew by 13%, although the inflation was at 35 % (Tonela, 2002). This economic grow has been generating considerable pressure on available local and imported energy resources. For example, the new large industrial sites such as Mozal (aluminium smelter with a peak load of 850 MW) and Moma Heavy Sands Project have contributed to increase the electricity demand from 300 MW in 1999 to about 12000 MW in 2006. Above on this, the population growth in the country is going hand in hand with urbanization, which is causing increased energy demand and environmental pressure.

In recognizing the importance of energy in the population survival and well-being, Mozambican policy makers have traditionally assigned a high priority to the energy sector. Hence significant resources have been allocated to this sector. This allocation of resources has been mostly attributed to conventional sources of energy, namely, fossil fuels and electricity. For instance, significant financial resources have been invested in the last two decades to build new electricity generation facilities, increase access generation capacity of existing facilities and increase the high voltage network from about 600 km in 1980 to about 3200 km in 2004. The government of Mozambique (GoM) is planning to raise about $800 million to increase access to electricity from 5%, in 2004, to about 15% by 2015 (SweedPower, 2004).

Furthermore, governmental policies promote the use of commercial sources of energy and the gradual reduction of biomass consumption. From an energy perspective, the

country has many strategic challenges, which include securing energy supply and secure access to modern energy services for rural population.

Due to its geographic location, Mozambique is blessed with an abundance of solar energy. The daily average solar irradiance is 5.7 kWh/m² (Boaventura Cuamba et, 2006, A solar energy resources assessment in Mozambique). Solar energy using PV is used for electricity generation in several stand-alone applications in the country. Several pilot applications especially for water pumping, telecommunications and lighting for remote sites have been successfully introduced. However, solar thermal technologies like water heaters far behind the others in terms of market penetration.

Mozambique has a great potential for renewable energy, including solar and wind, as well as hydro and geothermal in specific cases, which are still underexploited. Share of renewable energy in the primary energy supply is still very low and almost insignificant despite the effort done to overcame this situation.

In 2004, the primary energy consumption in Mozambique was about 7.9 million tons of oil equivalent (toe) - about 0.425 toe per capita. Of this, firewood and charcoal accounted for 89.94%, petroleum products and natural gas 8.03% and hydroelectricity and coal 2.03% (AfDB and OECD, 2004). However, over the last few years new renewable technologies, such as solar, are being introduced accounting for about 3% of the total renewable energy produced in 2005 (African Development Fund, 2006).

In the household sector, fuelwood and charcoal are the most used sources of energy in urban as well as in the rural areas for heating and cooking. Table 1 shows the share of charcoal and fuel wood use by the households in the main urban areas of Mozambique, for cooking. It is estimated that in Mozambique about 90% of urban households use biomass for cooking of which about 60% use fuelwood and 30% use charcoal for cooking.

Table 1: Shares of charcoal and fuelwood for cooking in Mozambique

Location	Cooking Fuel in % share		
	Charcoal	Fuelwood	Others
Lichinga	2.4	94.6	3
Chimoio	6.9	91.0	2.1
Xai-Xai	10.0	90.0	0
Tete	15.0	85.0	0
Inhambane	4.0	81.0	15
Pemba	2.4	76.0	21.6
Nampula	48.7	45.5	5.8
Matola	53.8	29.6	16.6
Beira	68.3	21.3	10.4
Quelimane	77.5	10.7	11.8
Maputo	51.2	9.9	38.9

Source: DNE (1997)

For lighting, the large majority of Mozambican population relay mostly on paraffin and biomass. According to DNE (National Directorate of Energy), in 2008 only 14% of Mozambican population had access to electricity, mostly through the electricity grid and off-grid isolated diesel systems. The installation of photovoltaic off-grid systems has been increasing in the last years. About 2500 such systems were installed in 2007 in the rural areas under the rural electrification program (through FUNAE).

In the industrial and commercial sectors, biomass, electricity and fossil fuels are the most used sources of energy for heating. In Mozambique the solar thermal market is limited to

very few solar thermal systems in operation, most of which were installed in well-off household in Maputo City, cottages and farms. Regarding social institutions, hospital and schools, so far only ninesolar thermal system were identified. The first system is installed at Mochungue Rural Hospital located in Mochungue district, in the province of Sofala – about 1000km north of Maputo, by FUNAE as a pilot project. Next, with World Bank funds under EDAP, was launched an international tender for 6 health centres and hospitals, which was comprised by 146 units solar heaters systems, each unit with 300 litres of capacity. Those systems were installed in Namaacha (8 units), Chimoio (50 units), Lichinga (30 units), Mueda (20 units), Ulongue (16 units) and Gurue (22 units).

There are no producer/manufacturer of solar thermal systems at the moment in Mozambique; the installed systems are imported. Because of the high involvement of Chinese companies in civil works and South African companies or people in tourism, most of the systems are imported from China or South Africa. The main use of the systems is hot water preparation in family houses and lodges. So far, the use of solar thermal units for industrial process was not identified.

The use and promotion of renewable technologies is inhibited basically by the low capacity for local manufacturing, financial constrains like initial cost, the financial, technological and performance risks, and the scarcity of investment capital. Like in the other countries, local production of solar thermal systems has not been, thus far, not cost effective.

Some specific reasons for the low penetration of the solar thermal technology are:

- Low level of consumer awareness leading to low market demand. This is due to a lack of Information about the technologies, their availability, and their performance. Furthermore, there is a widespread skepticism about performance and reliability of solar thermal technologies,
- Nonexistence of local assembly/manufacturing, distribution, installation and maintenance of solar thermal technologies. This causes the country to rely on more expensive imported systems, and consequently low levels of market penetration due to weak purchasing power,
- Lack of proper financing schemes and subsidies to kick-start the spread of the renewable technologies
- Late start of training programs on renewable energy at technical and professionals schools,
- Inadequate legislation and public leadership in the implementation of renewable energy technologies in the country.

1.3 Climatic Conditions

Since solar thermal is a renewable which depends on climatic conditions of the area, it is necessary to have an overview of the relevant or prevailing climatic conditions in Mozambique.

Mozambique has a tropical climate with two seasons, a wet season from October to March and a dry season from April to September. Climatic conditions vary depending on altitude. Rainfall is heavy along the coast and decreases in the north and south.
Mozambique Climate is warm and tropical with the average temperature in the country is 28° Celcius. The weather along the coast of Mozambique is sunny and warm even in

coarse midwinter which is chilling elsewhere. In summers the months ranges from October to April which is rainy, humid, and very hot. The winter months, from April to September are cooler and drier.

Mozambique has very favourable conditions for solar energy utilization. The annual global solar radiation is – depending on the region – between 1700 and 2200 kWh/m². Detailed information on global radiation in Mozambique is given in the following figure.

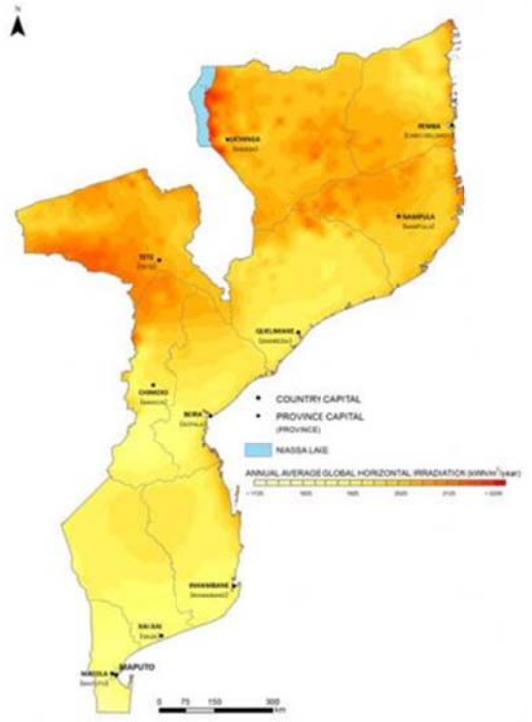


Figure 1: Annual Global Solar Radiation in Mozambique.

Source: www.atlasrenovaveis.co.mz

1.4 Existing legislation, regulations and government targets for Mozambique

The Energy Strategy ("Resolução 10/2009" in the 4th of June) and the Policy for Development of the New and Alternative Renewable Energies ("Resolução 62/2009" in the 14th of October) have both identified Solar Thermal Energy as a key area for the national development. These documents were later translated into a more detailed plan, the National Strategy for Renewable Energy 2011-2025 (EDENR 2011-25) approved by the Council of Ministers in May 2011, which sets a target of 100,000 solar thermal systems to be installed by 2025, with full technical assistance and local manufacture capabilities in place. It also identifies the need to engage the public electricity operator in the substitution of electric water heating with solar water heating, and to establish credit mechanisms and fiscal incentives, as well as appropriate tariff regimes, which will promote public and private participation in the solar markets. This plan also intended the installation of local manufacture of solar water heaters, which supports any program intending to develop local design and installation capabilities.

The Ministry's 7th Coordination Meeting of 2011 defined solar thermal as a priority of intervention. Consequently and with the support of the World Bank, through an international tender for which the selected company was chinese Golden 5 Star, there were installed 8 units in Namaacha, 50 units in Chimoio, 30 units in Lichinga, 20 in Mueda, 16 units in Ulongue and 22 units Gurue, totalling 146 units of 300 lt each, i.e. a total of 43.800 lt hot water capacity.

The Energy Strategy 2014-2023 has not yet been approved. As it stands presently, it does not specify the use of solar thermal energy in the residential or service sectors, however it sets a target of 25% of the Mozambican population with access to solar systems by 2023, i.e. access to solar energy of 7.5 million people or 1.5 million households. If all would reach the target of 0.1 m² per inhabitant, it would represent the installation of 750,000 m² of solar thermal panels, i.e. about ¼ of the target for 2030.

2 The Solar Thermal Vision for Mozambique

The solar thermal vision for Mozambique is to install 0.1 square meters (0,07 kWh) of solar collector area per inhabitant by 2030.

This relates to an overall installed collector area of 3.4 million square meters by 2030 for a population of 34 million persons countrywide.

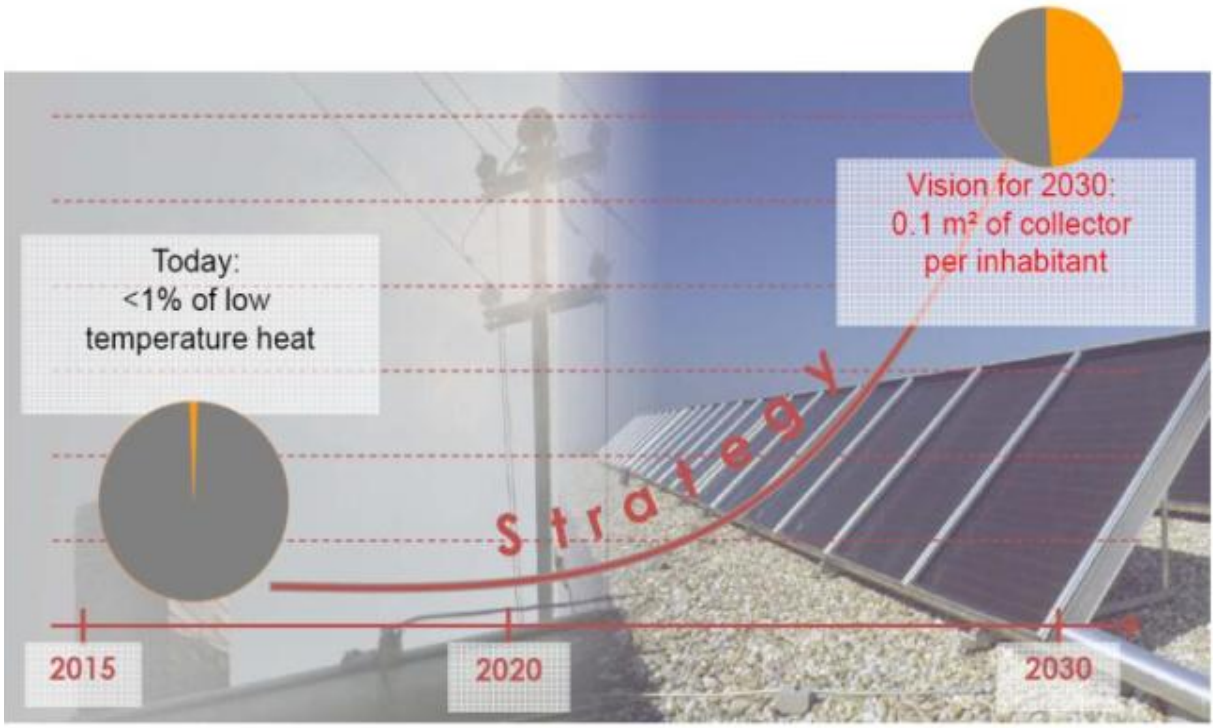


Figure 2: The Solar Thermal Vision for Mozambique for 2030

The population of Mozambique by the end of 2014 was 24.7 million people (Source: http://www.indexmundi.com) The annual population growth was between 1.8% and 2,45% between 2008 and 2014. Based on these facts the estimated population in Mozambique for 2030 is between 30 and 34 million taking an average annual population growth of 1.8 - 2% into account.

Figure 3: Population growth estimated on the population data of 2014 and the average growth rate between 2008 and 2014.

Figure 4: In order to achieve the goals of the solar thermal vision for Mozambique to install 0.1 m² collector area per inhabitant until 2030, it is necessary to install a total of 3.4 million square meters of collectors in this time period.

The estimated total solar thermal installations at the end of 2014 at about 500m² made of by the following applications:

- Small-scale, low pressure solar water heating systems (2 – 4 m²)
- Small-scale, high pressure solar water heating systems(2 – 4 m²)
- Medium-scale pumped solar water heating systems for hospitals, hotels and commercial applications

The current solar thermal market in Mozambique is characterized by:

- Very small number of installations, mainly relatively small in size
- Mainly imported thermosyphon systems from China
- Very few companies with installation and design experience

As can be seen in the following figures, the market penetration of solar water heating systems is very small compared to the neighbouring countries.

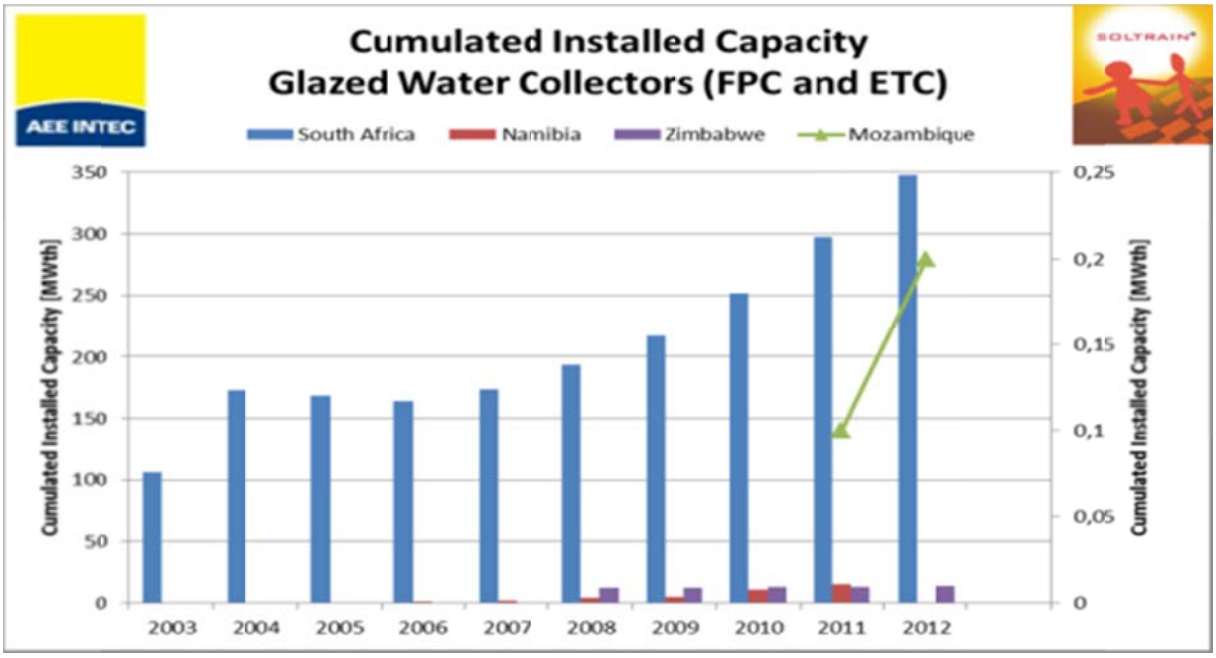


Figure 5: Cumulated installed capacity of glazed water collectors in selected southern African countries.

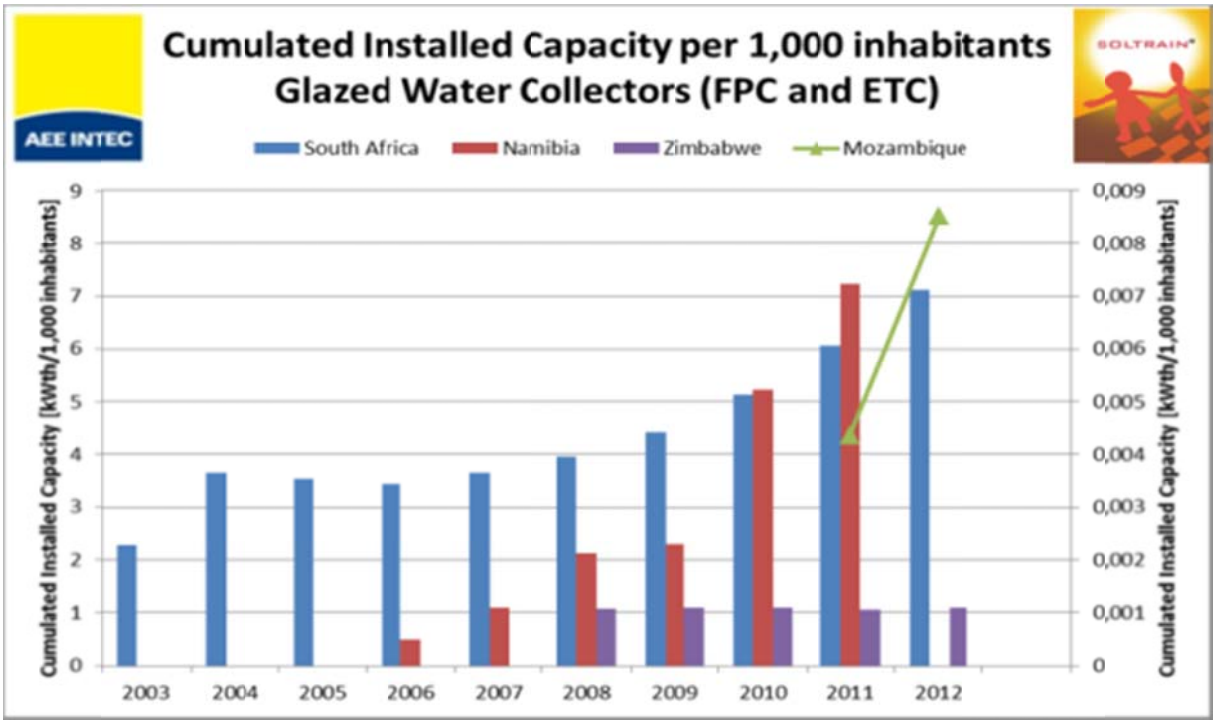


Figure 6: Cumulated installed capacity per 1000 inhabitants of glazed water collectors in selected southern African countries.

3 The Solar Thermal Technology Roadmap

The roadmap based on the vision statement aims at 3.4 million m² of solar collectors by 2030 which is translated into about 0.1 m² / inhabitant. For the purposes of this roadmap, the solar thermal market in Mozambique is divided into sub sections, based on the applications.

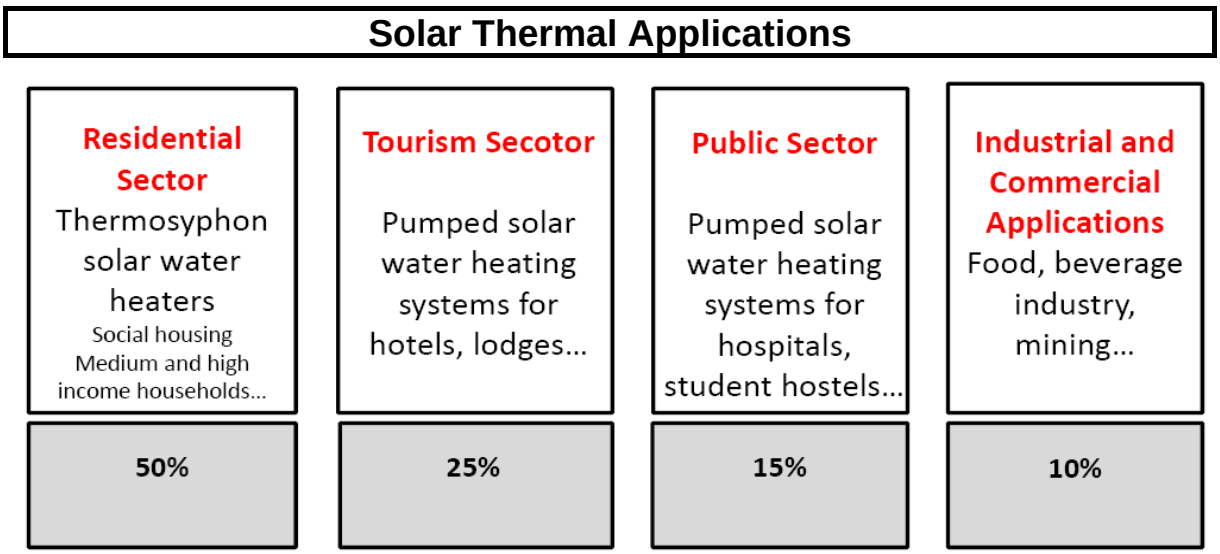


Figure 7: Most favourable solar thermal applications for Mozambique and the percentage of the overall estimated market potential

For the purposes of this roadmap, the solar thermal industry in Mozambique will focus on (though not limited) the following system types and sizes:

- Thermosyphon systems for single family houses (2 –4 m² per system)
- Thermosyphon for Lodges (2 – 4 m² per system)
- Pumped systems for hotels, hospitals etc. (20 – 100 m²)
- Cooling and air-conditioning of hotels and larger offices (20 – 500m² per system)
- Industrial applications including sea water desalination (50 - 500m² per system)

The data available for solar thermal use in Mozambique as provided by the year 2014 has been used to forecast the total anticipated or projected solar thermal installations in Mozambique as per the vision mission. The estimated solar thermal installation in Mozambique by the year 2014 was about 500 m2.

In order to achieve the vision target an ambitious annual installation growth is needed. The projected or anticipated annual growth in the installation of solar thermal technologies (in square meters per person) which should be considered to achieve the target of 0.1m2 per person is given in Figure 8.

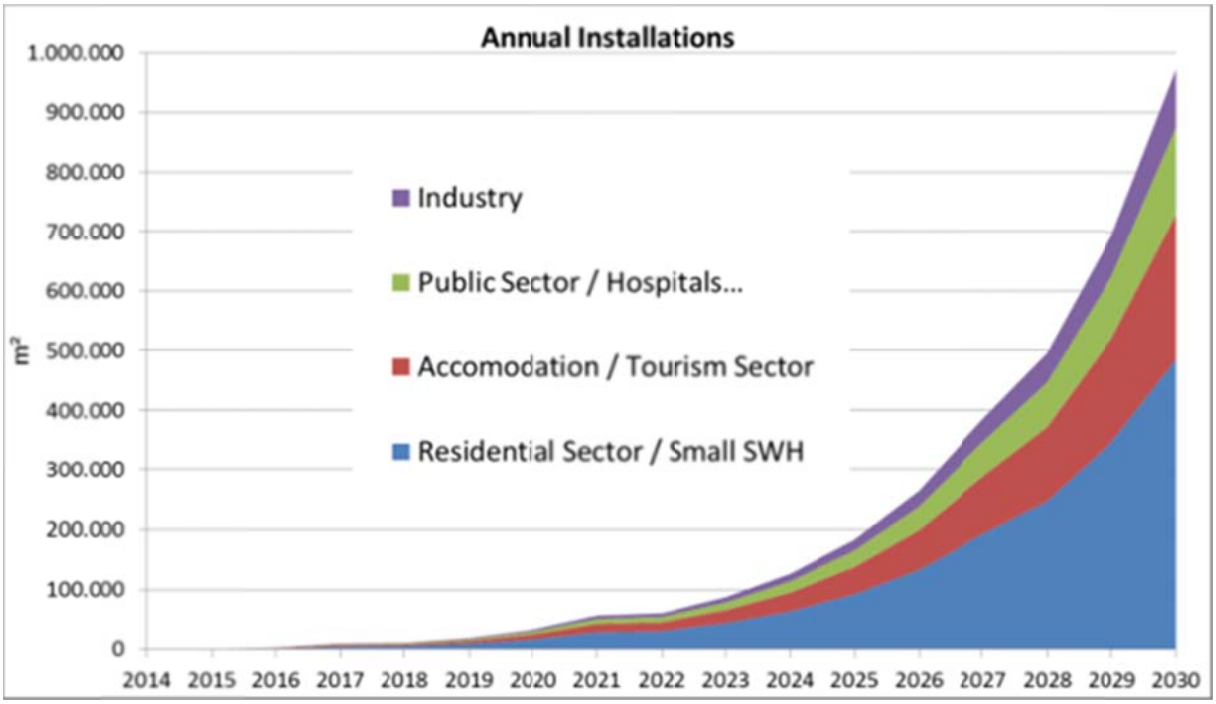


Figure 8: Annual solar thermal installations needed in the different application sectors in order to reach the goal of 3.4 million square metres in 2030

3.1 The Approach to the Roadmap

However, to achieve the envisaged target of 0.1 m2 of solar water heater collector area per individual living in Mozambique by 2030 (translating to 3.4 Million m² of collector area for a population of 34 million persons countrywide or approximately 23.8 GW thermal equivalent) the targets set in the following table are estimated as per various sectors.

Table 2: Potential of solar water heaters in Mozambique (Roadmap approach until 2030)

Sector	Number of systems	Estimation of solar thermal collector area to satisfy requirement (100 %)
Residential Sector Thermosyphon solar water heaters for social housing Medium and high income households…	1,000,000 systems New houses but also electric geyser replacement	2,350,000m²
Tourism Sector Pumped solar water heating systems for hotels, lodges…	30,000 systems	600,000 m²
Public Sector Pumped solar water heating systems for hospitals, student hostels and large service buildings	15,000 systems	450,000 m²
Industrial and Commercial Applications Food, beverage industry, mining…	3,400 systems	340,000 m²
TOTAL		3,400,000 m²

The discussion on the approach suggested towards achievement of the target 0.1m2 per inhabitant achievement of the target is outlined in the proceeding sections.

3.1.1 Thermo-syphon systems for residential sector (2 –4 m² per system)

The roadmap targets electricity consumers in the first stage, which are already using electricity for hot water use. The identification of the target population will made with the following criteria:

- Urban population
- Electricity consumption >= 250 kWh per month

Crude estimations project a share of about 25% of the electricity bill in hot water consumption. If the road map targets 600 thousand families (about 50% of existing connections), it will represent savings of the order of 450 GWh annually, by 2030, i.e. about 2% of total electricity production of Cahora Bassa Hydropower Plant.
Some very small service providers and public institutions may also fall under this range of hot-water usage/need, and will be considered at later stages of implementation.
Domestic electricity access in Mozambique is still only at 25% of the population. The second stage of the roadmap implementation will target those that have no electricity access, which corresponds, at present to about 17 million people.

Table 3: Industry and Government Roles in supporting the Thermo-syphon systems

Awareness and Marketing	
Industry Role	Production of technical brochures and other marketing material, providing information to the potential buyer/user, on procedures of O&M and installation, safety requirements of installations, on manufacturing quality standards, and on the benefits and ranges of hot water usage
Government Role	To finance and promote initiatives for dissemination of technical knowledge on SWH To develop school curricula at all levels to include the training and awareness programs on SWH To develop information platforms for public and free consultation on technological solutions, SWH potentials, technology suppliers, and other
Institutional issues	
Industry Role	To prepare itself to offer high quality services and to ensure that its after-sale services are available Suppliers must have the capability of design, installation and maintenance provision Industry must organise itself into a professional body that can represent the interests of suppliers, manufacturers and service providers with the government, in order to influence the development of appropriate policies, regulations and standards
Government Role	Develop clear regulations, policies and standards Establish a monitoring capability to enforce regulatory and standards' conformity Implement a certification system of quality for suppliers, local and imports, and support the work of consumer protection agencies on the specific technology Implement a system of fiscal benefits to cheapen the national manufacture and commercialization of SWH
Workforce development	
Industry Role	Acquire the necessary technical capabilities for design, installation maintenance service provision To follow and disseminate best work practices, including safety in work, environmental protection and business productivity, in pursuit of competitive and higher market quality ranks
Government Role	Organize and fund training courses, general and vocational, and technology dissemination programs, in order to widen the technical knowledge among specialists and the general public
Research and development	

Industry Role	Industry must engage with research and high education institutions to participate in the development of cheaper, more efficient systems, as well as contribute to the knowledge pool on the subject matter
Institutions	Research and high education institutions must work hand in hand with manufacturers, government and financiers, in the search of customised solutions for the diverse challenges that the extension of SWH entails, including the development of technical standards and regulations
Government Role	To promote and fund research and development in the subject matter, either directly and through the research and high education institutions

3.1.2 Pumped systems for tourism sector (10 – 30 m² per system)

The roadmap targets electricity consumers, which are already using electricity for hot water use. The identification of the target population will made with the following criteria:

- Hotels, guest houses, Bed and Breakfast and similar institutions, contracted to EDM on the tariff category "Large Consumers of Low Voltage – GCBT)
- Electricity consumption >= 5,000 kWh per month

There isn't enough data characterizing electricity consumption, to estimate the potential savings in this target group. For this reason, previous to the implementation of the roadmap, real measurements in selected tourist operators will be made to obtain average saving potentials based on indicators such as number of guests, weather variations, quality/star rank and other relevant .

Tourist operators have their success dependent on public perception of quality. For this reason, the roadmap will strive to implement a "Green" label for tourist operators that adopt solar water heating and will implement public awareness campaigns to engage the general public into giving preference to operators that have the Green label. Furthermore, Government evaluate the linkage of incentives and benefits with the presentation of this label.

Some small service providers and public institutions may also fall under this range of hot-water usage/need, and will be considered at later stages of implementation.

Table 4: Industry and Government Roles in supporting Pumped Systems for the tourism sector

Awareness and Marketing	
Industry Role	Production of technical brochures and other marketing material, providing information to the potential buyer/user, on procedures of O&M and installation, safety requirements of installations, on manufacturing quality standards, and on the benefits and ranges of hot water usage Coordinate with the Tourism Ministry for awareness and marketing of products and services available
Government Role	To finance and promote initiatives for dissemination of technical knowledge on SWH To develop school curricula at all levels to include the training and awareness programs on SWH To develop information platforms for public and free consultation on technological solutions, SWH potentials, technology suppliers, and other
Institutional issues	
Industry Role	To prepare itself to offer high quality services and to ensure that its after-sale services are available Suppliers must have the capability of design, installation and maintenance provision Industry must organise itself into a professional body that can represent the interests of suppliers, manufacturers and service providers with the government, in order to influence the development of appropriate policies, regulations and standards

Government Role	Develop clear regulations, policies and standards, including a Green Label for tourism operators that adopt SWH for their hot water consumption Establish a monitoring capability to enforce regulatory and standards' conformity Implement a certification system of quality for suppliers, local and imports, and support the work of consumer protection agencies on the specific technology Implement a system of fiscal benefits to cheapen the national manufacture and commercialization of SWH To establish funding schemes that will promote the substitution of electric geysers or biomass boilers with SWH technology, and are cheaper than commercial loans
Workforce development	
Industry Role	Acquire the necessary technical capabilities for design, installation maintenance service provision To follow and disseminate best work practices, including safety in work, environmental protection and business productivity, in pursuit of competitive and higher market quality ranks
Government Role	Organize and fund training courses, general and vocational, and technology dissemination programs, in order to widen the technical knowledge among specialists and the general public
Research and development	
Industry Role	Industry must engage with research and high education institutions to participate in the development of cheaper, more efficient systems, as well as contribute to the knowledge pool on the subject matter
Institutions	Research and high education institutions must work hand in hand with manufacturers, government and financiers, in the search of customised solutions for the diverse challenges that the extension of SWH entails, including the development of technical standards and regulations
Government Role	To promote and fund research and development in the subject matter, either directly and through the research and high education institutions

3.1.3 Pumped systems for the public sector (30 – 60 m² per system)

The roadmap targets at first electricity consumers, which are already using electricity for hot water use. The identification of the target population will made with the following criteria:

- Hospitals, schools, student residences and similar institutions with centralised hot water supply, contracted to EDM on the tariff category "Large Consumers of Low Voltage – GCBT or "Medium Voltage Consumers")
- Electricity consumption >= 8,000 kWh per month

There isn't enough data characterizing electricity consumption, to estimate the potential savings in this target group. For this reason, previous to the implementation of the roadmap, real measurements in selected public institutions will be made to obtain average saving potentials based on indicators such as number of people serviced, weather variations, nature of the institutions, quality/complexity level of services and other relevant.

Public institutions operate with public funds, thus from the organizational and legal points of view there is no impediment that requirements are set for the source of their hot water production. In other words, along the implementation of the roadmap regulations should be put forward to make compulsory that public institutions source at least 30% of their hot water production from solar energy. The number is tentative and will have to be validated once better data is available.

Table 5: Industry and Government Roles in supporting Pumped Systems for the public sector

Awareness and Marketing	
Industry Role	Production of technical brochures and other marketing material, providing information to the potential buyer/user, on procedures of O&M and installation, safety requirements of installations, on manufacturing quality standards, and on the benefits and ranges of hot water usage
Government Role	To finance and promote initiatives for dissemination of technical knowledge on SWH To develop school curricula at all levels to include the training and awareness programs on SWH To develop information platforms for public and free consultation on technological solutions, SWH potentials, technology suppliers, and other
Institutional issues	
Industry Role	To prepare itself to offer high quality services and to ensure that its after-sale services are available Suppliers must have the capability of design, installation and maintenance provision Industry must organise itself into a professional body that can represent the interests of suppliers, manufacturers and service providers with the government, in order to influence the development of appropriate policies, regulations and standards
Government Role	Develop clear regulations, policies and standards, including the compulsive requirement of using SWH in public institutions and spaces Establish a monitoring capability to enforce regulatory and standards' conformity Implement a certification system of quality for suppliers, local and imports, and support the work of consumer protection agencies on the specific technology Implement a system of fiscal benefits to cheapen the national manufacture and commercialization of SWH
Workforce development	
Industry Role	Acquire the necessary technical capabilities for design, installation maintenance service provision To follow and disseminate best work practices, including safety in work, environmental protection and business productivity, in pursuit of competitive and higher market quality ranks
Government Role	Organize and fund training courses, general and vocational, and technology dissemination programs, in order to widen the technical knowledge among specialists and the general public
Research and development	
Industry Role	Industry must engage with research and high education institutions to participate in the development of cheaper, more efficient systems, as well as contribute to the knowledge pool on the subject matter
Institutions	Research and high education institutions must work hand in hand with manufacturers, government and financiers, in the search of customised solutions for the diverse challenges that the extension of SWH entails, including the development of technical standards and regulations
Government Role	To promote and fund research and development in the subject matter, either directly and through the research and high education institutions

3.1.4 Pumped systems for Industrial and Commercial Applications (50 - 200m² per system)

Mozambique has a vast agricultural potential and already possesses food processing industries, cloth and beverages, most of which rely on thermal energy for their production. Examples are the tea districts of Gurué and Milange, using firewood in the tea drying processes, production of beer using marine diesel as a thermal source, and other examples.

Industrial process heat tends to be either at very high temperatures or relatively modest temperatures across a broad range of manufacturing subsectors. Despite the abundant solar energy resource in Mozambique and increased demand for final industrial energy demand mainly in form of thermal energy, there are no actual figures about the industrial use of solar energy resource in the country. Therefore the large percentage of final energy used in Mozambique, coupled with the good solar resource in the country, it is vital to consider the exploitation of solar thermal energy for industrial applications. Many industrial processes require heat on a temperature level below 250°C, as summarised in the following table. Important industrial sectors which may require solar thermal systems include the food processing and beverages industries, the textile and chemical industries and in washing processes. The solar roadmap as addressing the anticipated vision 2030, solar thermal systems can also serve the industrial market segment.

Table 6: Industrial sectors and processes with the greatest potential for solar thermal uses

Industrial sector	Process	Temperature level, °C
Food and beverages	Drying	30 — 90
	Washing	40 — 80
	Pasteurising	80 — 110
	Boiling	95 — 105
	Sterilising	140 — 150
	Heat treatment	40 — 60
Textile industry	Washing	40 — 80
	Bleaching	60 — 100
	Dyeing	100 — 160
Chemical industry	Boiling	95 — 100
	Distilling	110 — 300
	Various chemical processes	120 — 180
All sectors	Pre-heating of boiler feed water	30 — 100
	Heating of production halls	30 — 80

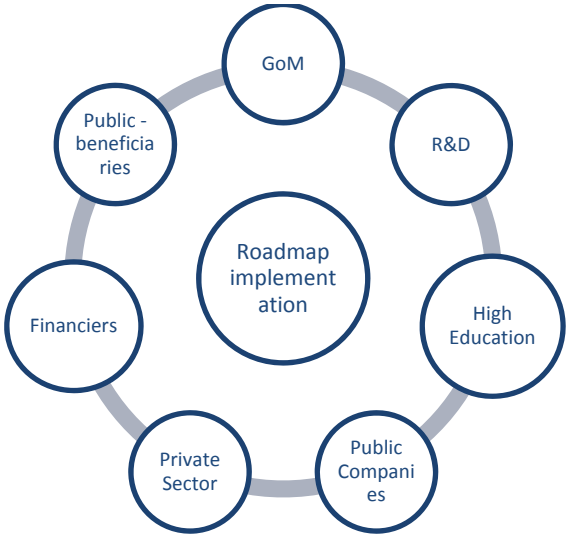
The high standard requirements of industries and large commercial enterprises cannot be met by recently created and trained plumbing companies; for this reason, work for this group will probably be targeted in midway through the roadmap implementation. Dedicated surveys will be made in order to identify potential beneficiaries and to study the feasibility of totally or partly replacing their current thermal sources (electricity, diesel, biomass) with solar.

Table 7: Industry and Government Roles in supporting Pumped Systems for the industrial and commercial sectors

Awareness and Marketing	
Industry Role	Production of technical brochures and other marketing material, providing information to the potential buyer/user, on procedures of O&M and installation, safety requirements of installations, on manufacturing quality standards, and on the benefits and ranges of hot water usage Coordinate with the Ministry for Energy (MIREME) for awareness and marketing of products and services available
Government Role	To finance and promote initiatives for dissemination of technical knowledge on SWH To develop school curricula at all levels to include the training and awareness programs on SWH To develop information platforms for public and free consultation on technological solutions, SWH potentials, technology suppliers, and other
Institutional issues	
Industry Role	To prepare itself to offer high quality services and to ensure that its after-sale services are available Suppliers must have the capability of design, installation and maintenance provision Industry must organise itself into a professional body that can represent the interests of suppliers, manufacturers and service providers with the government, in order to influence the development of appropriate policies, regulations and standards
Government Role	Develop clear regulations, policies and standards, including requirements on minimum quotas of SWH in the overall thermic consumption Establish a monitoring capability to enforce regulatory and standards' conformity Implement a certification system of quality for suppliers, local and imports, and support the work of consumer protection agencies on the specific technology Implement a system of fiscal benefits to cheapen the national manufacture and commercialization of SWH To establish funding schemes that will promote the substitution of electric geysers or biomass boilers with SWH technology, and are cheaper than commercial loans
Workforce development	
Industry Role	Acquire the necessary technical capabilities for design, installation maintenance service provision To follow and disseminate best work practices, including safety in work, environmental protection and business productivity, in pursuit of competitive and higher market quality ranks
Government Role	Organize and fund training courses, general and vocational, and technology dissemination programs, in order to widen the technical knowledge among specialists and the general public
Research and development	
Industry Role	Industry must engage with research and high education institutions to participate in the development of cheaper, more efficient systems, as well as contribute to the knowledge pool on the subject matter
Institutions	Research and high education institutions must work hand in hand with manufacturers, government and financiers, in the search of customised solutions for the diverse challenges that the extension of SWH entails, including the development of technical standards and regulations
Government Role	To promote and fund research and development in the subject matter, either directly and through the research and high education institutions

4 Roadmap Implementation

The implementation of the Roadmap will engage various stakeholders in the country, in a coordinated effort under the leadership of the Government and guided by a vision of a Green Future and efficient energy consumption for the country.



The implementation of the road Map will engage, in the first stage, the following institutions:

- The science and technology park (STP), as an incubator for entrepreneurship and knowledge dissemination
- The public electricity company (EDM), as the contractual partner of potential beneficiaries of the SWH installations
- University Eduardo Mondlane (UEM), as the training resource for all the program participants
- The Energy Fund (FUNAE), representing public promoting and financing schemes for the SWH installations

This group, headed by STP, will provide the initial thought processes and be responsible for the deliveries of initial stages of the roadmap implementation, and will also be responsible to 1) obtain the government's validation of the roadmap; 2) engage other relevant institutions into the program, as it gains speed, 3) mobilize additional funds for a technology roll-out initiatives, and 4) run the awareness and marketing campaigns for the program. In later stages of implementation of the roadmap there may be a need to review this organization and setup a coordinating body with more powers and clear mandate. The right regulatory framework and policies are critical to the success of the roadmap, and the group must soon engage the relevant ministries for the adoption of relevant regulations and standards.

To implement this SWH Roadmap, we will need to build up internal capabilities in design, installs and servicing SWH installations of various types, through the creation or resourcing of local plumbing companies, which will need to acquire quality certification before their services can be offered confidently to grand hotels and industry. The STP has the mandate to incubate and promote new technologic companies and will organize the entrepreneurship of the program.

Training of plumbers, technical staff and managers will be provided using UEM's resources, trained under the program Soltrain. Furthermore, the training programs, general and specialised must continue and reach vocational schools in the country, as a way of creating enough technical capability at the local level to support future roll-out programs.

Experience shows that public funding will be necessary to kick-off technology roll-out programs, which will provide critical mass that will sustain and ensure the feasibility of private manufacturing and commercialization of SWH in Mozambique. Thus it will be necessary to obtain a clear mandate from the Government and to engage development partners in order to establish funding schemes, whose characteristics must be based in the market characteristics and its dynamics. The FUNAE has the unique capability to organize various funding agencies into funding schemes dedicated to SWH roadmap implementation.

The installation of SWH will primarily target electricity consumers, and will intend the replacement of other thermal sources (electricity, biomass, liquid fuels) with thermal solar energy. The inclusion of the national power utility (EDM) in the program will facilitate the identification and mobilization of potential beneficiaries, and will create a vehicle and spear-head institutions for the roll-out programs that will follow the installation of the demonstration systems.

Tourism industry is booming in Mozambique, and many new hotels, restaurants and services are being built. The implementation of the Roadmap will focus on this sector first, where impacts in saving power at peak are expected and very much needed. Next, public institutions and residential consumers will be targeted, and finally the industry.

Finally, the implementation of the roadmap must be proceeded and followed with careful data gathering and impact assessments, with the view of creating a database that will allow for better design of policies and installations to be used in the roll-out programs. This role will be initially coordinated by EDM, and at later stage decisions must be made regarding a national energy database that will serve renewable energy development.

The program Soltrain was key in the preparation of this roadmap. In the next phase, the team must obtain the validation for the roadmap and must carry out its first steps of implementation, and a kick-off o fthe Road Map. Expected Outputs (deliveries) of the first 2 years of the implementation of the roadmap, are:

- Detailed recommendations on policy changes and regulatory developments
- At least 5 demonstration SWH systems, installed in medium sized tourism operators
- Data on hot water uses in tourism, correlated with other data to allow for crude modelling of hot water needs in the sector
- At least 2 Mozambican plumbing companies trained to design, install and maintain small to medium sized (pumped) SWH
- STP fully abled to certify on quality of SWH
- Draft roll-out programs for SWH in tourism, public and residential installations.

Some preliminary thought was given to the possible constraints and risks in the implementation of these first steps of the solar thermal roadmap, namely:

Potential constraints and risks	Mitigation
Unclear leadership and responsibilities of the program. Mutual roles of the various partners are not clear and no accountability is placed	STP will sign the contract with AEE-Intec on the Soltrain program, and will manage the program on the Mozambican side. Then STP will sign a contract with EDM, FUNAE and UEM detailing their roles and responsibilities in the various stages of implementation of the roadmap and the Soltrain program.
EDM will be liable to something going wrong in the installed systems, because of its "leading" involvement in the project	The installed systems must have the highest quality. EDM will develop contracts with the beneficiaries, stating roles and mutual responsibilities
Insufficient consultant resources to help set up the monitoring and quality control procedures and tools	AEE-Intec will train the plumbing companies and will train STP and EDM staff on monitoring and quality control
Inadequate or unreliable Mozambican plumbing company – the learner	STP will put together 2 new plumbing companies and will partner them with south African companies for the duration of the Soltrain program, for knowledge transfer and quality assurance. AEE Intec will help identify the south African company(s) interested in the partnership
Bad fitting between the South African installer – the contractor, and the Mozambican company – learner	STP and EDM must carefully monitor the partnerships in order to help smooth any problem that may arise
After installation maintenance and/or technical support is deficient	The partnerships between plumbing companies must include the after-sale technical support. The cost of the system must include design, installation and technical assistance for the first 2 years
Potential beneficiaries will not have funds for financing their part and no public funds are available instead	The Mozambican team must seek public funding to cover the cost-share of potential beneficiaries
The program does not have enough credibility with potential beneficiaries	The quality of the system must the ensured, and a "help desk" or technical support resource must be available to the beneficiaries
The program is not sufficiently attractive to potential beneficiaries	This situation will change with the increase of electricity tariffs and the restrictions to power supplies that are expected for the next 2-3 years
Marketing of the experience is not well made, and the experience cannot be replicated	STP and the team must engage in a wide dissemination of the vision of the program, the experiences and the results, through facebook and internet platforms, TV and newspapers as well as radio stations, workshops and other media
There is no capability to satisfy unplanned demand for more systems	Soltrain 3 is only the kick-off of the roadmap implementation. The mobilization of cheap funding to fully or partly subsidize the installation of the first 5,000 sqm of SWH (about 120 tourism and public facilities) will give time for more sustainable funding mechanisms to be put in place, and for the local plumbing companies to solidify
The chronology of the program is too slow for the market demand	The program must start as soon as possible and run in a focused result-oriented manner. The project team must be made accountable to the funding/enabling bodies
Sector's structure and policies do not adapt to include SWH in its technology portfolio	Ministries must be targeted in the dissemination campaigns, to speed up the approval of proposed policy changes. Public support to the program will also help.

These aspects of implementation must be part of the concept for Soltrain 3 program, expected to start up in March 2015.

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Maputo, 18 de Novembro 2015