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SOLTRAIN
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Index

SOLTRAIN welcomes new Project Partner from Botswana

By Dr E Matlotse

The Clean Energy Research Centre (CERC) is one of six strategic research centres at the University of Botswana. It was established to advance research, education, and advocacy for clean energy and energy efficiency. To fulfil its mandate, CERC relies on strategic collaborations with the faculties at the University, with Government ministries and departments, the local industry, and most importantly with regional and international partners/researchers. The work and commitment of staff at the CERC is project-driven. When a project like SOLTRAIN unfolds, the CERC coordinates the mobilisation of staff participants to the project, from the diverse expertise existing in the University faculties.

Botswana electricity needs stand out at around 600 MW and was importing about 70-80% from Eskom in South Africa while the remaining was produced locally from Morupule A Power Station. Due to internal pressure, Eskom curtailed its supply to Botswana substantially and that coupled to the failed Morupule B Power project, a shortfall in supply for Botswana was experienced. The Morupule B Power project was meant to supply a total of extra 600 MW of electrical power which was going to allow the country to be able to export some of its power to neighbouring countries, but it suffered a number of technical problems. Due to that, a number of load shedding incidents became the order of the day. In mitigation, the locally 90 MW Orapa and 70 MW Matshelagabedi diesel generation sets were introduced but these proved to be very expensive. In addition, Botswana Power Corporation (BPC) (the country's sole electricity supply company), embarked on demand side management measures in which they remotely switched off electric geysers during the times of peak (morning between 6:00am and 10:00am and, evening 18:00pm and 22:00pm). This by BPC, was a bid to ensure that the electricity power is used effectively and efficiently. Further, a presidential directive was passed which advocated for the uptake of solar water geysers to be installed so that the problem is dealt with on permanent basis.

In the past, many solar water geysers were installed in most government buildings and some in homes around the country. It is estimated that more than 90% of these are not functioning and most are being replaced by electric ones. This malfunctioning is attributed to lack of knowledge in solar heating technology such that the designs, installations and maintenances of these were wrongly done. As a consequent, generally, this led to lack of trust in solar water heating technology nationally such that the businesses associated with this business had to close as business for them dropped drastically.

Recently, the national electricity situation has improved, in that, better Eskom deal has been negotiated, the Morupule B Power Station is improving in terms of its power that it can now supply and other deals have been negotiated with Mozambique national power producers. It should be noted that most of the electrical power produced (Morupule A & B Power Station) locally is from coal. There is only grid-connected 1.3 MW solar PV plant in Phakalane which supplies to the national grid. Also, most electric power from Eskom is generated from coal. Coal being a fossil fuel, it contributes a lot when it comes to greenhouse gas emissions which in turn contribute a lot to climate change.

Since Botswana is a signatory to many of the international agreements relating to issues of tackling climate change, the use of fossil fuels should be curtailed in place of renewable energy sources as these are environmentally friendly. Also, the Botswana National Energy Policy is about to be finalised and it advocates for the migration from fossil fuel to renewable energy technologies in dealing with energy nationally. Coupled with this initiative, the government of Botswana is embarking on developing the renewable energy and energy efficiency strategies in which two independent international consultants are engaged to pursue these undertakings, respectively. The first step in dealing with reduction of greenhouse gas emissions can be gradually executed by introducing projects as small as replacing electric geysers with solar water thermal systems. When this is done, the power supply from fossil fuels can be curtailed. In this regard SOLTRAIN 3 serves as an advocate for the training in the design, installation and maintenance of solar thermal system technologies. Also, very fundamental, this SOLTRAIN project facilitates for the setting up of the National Solar Thermal Technology Platform (STTP) which converges stakeholders to advocate and spread the word about the good that can be offered by solar thermal technologies. This is coupled by the use of demonstration projects which are practically on the ground to finally seal the message regarding these technologies.

BBCDC
BETHEL BUSINESS AND COMMUNITY DEVELOPMENT CENTRE

2016 SOLTRAIN LESOTHO HIGHLIGHTS

By Ivan Yaholnitsky

Solar energy technology and utilisation course

In January BBCDC conducted a one week course on solar energy technology and utilisation for a group of eight individuals sponsored by the Malealea Development Trust in Lesotho. It was a general introduction to solar energy and included physics, current economics, solar geometry and applications. The group installed a small PV system during the week, built a solar oven, fabricated and installed a solar chimney for ventilation, and built a flat plate water heating collector. The course was hands on and included many workshop activities.

Fig. 1: Participants enjoying the solar energy technology and utilisation course.

Fig. 2: Clear sunny conditions were perfect for the practical implementation of projects.

Fig. 3: The participants completed a number of practical projects during the week's course.

Solar water heating system

In February BBCDC completed installation of another demonstration solar water heating system at Edma Guest House in Mohales Hoek under the auspices of SOLTRAIN 2. Three 150 litre high pressure indirect systems with flat plate collectors were installed.

Fig. 4: Stephen Lelimo with the 150 litre demo unit installed in Mohales Hoek.

Success with solar fruit and vegetable driers

From January to March, the BBCDC students and workshop were busy with an order placed by World Vision Lesotho for 366 solar fruit and vegetable driers. BBCDC students carried out all the fabrication and assembly and the project has been such a success that in June 2016, World Vision requested delivery of a further 96 driers.

Fig. 5: Solar driers being assembled in the BBCDC workshop.

Fig. 6: Painting of the newly constructed solar fruit and vegetable driers.

Fig. 7: Completed driers with protective polycarbonate film still in place, ready for delivery.

Azimuth tracking array built on a rotating rondavel roof

In March BBCDC began construction of a small rondavel that would be fitted with a rotating roof. It is a research project, and follows on work completed in 2015 to build an azimuth tracking array. Azimuth tracking augments solar gain considerably, especially in summer. When complete, the rotating turret roof will be fitted with a solar water heater and large PV array and monitored for performance.

Fig. 8: Fixed track and movable structure of the rotating roof, as seen from the inside of the rondavel.

Fig. 9: Roof sheeting and testing proof of concept to build an azimuth tracking array on a rotating roof.

BBCDC wins Energy Globe Award

In late May BBCDC was proud to learn that the organisation had received the Energy Globe Award for Lesotho for 2016.

Fig. 10: Energy Globe Award banner for Lesotho.

Solar Cooking configurations

BBCDC has a long history of developing and utilising various configurations for solar cooking. A promising technology for bread baking using a parabolic trough continues to be tested and refined. In June BBCDC cut a new parabolic template and fabricated a jig table to enable scaling up of this technology with improved workshop procedures.

Fig. 11: Nthabiseng Leteketa and Raymond Onuoha with the parabolic template for a solar trough used for baking purposes.

Fig. 12: Bread rolls baked in 30 minutes... a delicious use of solar energy!

Fig. 13: Parabolas at work on a clear day, used for testing solar cooking technologies.

CAPE BREWING COMPANY'S SOLAR PROCESS HEAT SYSTEM

By Dr Eugene Joubert

Background

The Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University, supported by the SOLTRAIN 2 project, approached Cape Brewing Company (CBC) with the proposal to investigate the possibility of using solar thermal (ST) technology to produce hot water for the brewery and thereby reducing their paraffin fuel consumption and boiler load. A pre-feasibility study was conducted by CRSES indicating that a ST system of about 120 m^2 collector area and 10 000 litre storage would provide 60 % of the existing hot water needs and be a good investment, especially considering the EUR 11 000 subsidy from SOLTRAIN 2. With favourable pre-feasibility results CBC decided to proceed with the tender process. After an on-site walkthrough and opportunities for questions and answers, ten proposals were received, all from South African companies. From these candidates a shortlist was prepared which were then interviewed until a final decision was made on the best candidate to install the solar thermal system.

The System

In Figure 1a, the installed collector array at CBC can be seen. The collector array consists of 12 GREENoneTEC GK3102 collectors, each with a gross area of approximately 10 m^2. The collectors are arranged in three rows of four collectors each, providing a gross collector area of approximately 120 m^2. The system has a 10 000 litre solar buffer storage including three-way stratification as shown in Figure 1b.

Figure 1: CBC solar thermal system: a) collector array and b) stratified buffer storage.

The solar thermal system consists of a solar loop, charging loop and discharge loop as shown in Figure 2. The solar loop working fluid is a water-glycol mixture driven by a variable-speed pump. The system is protected against overheating by an active safety cooler, but also has standard good practice measures implemented (or available) such as hydraulic design for favourable draining behaviour, night cooling through the collectors and pressure safety valves. Water from the solar buffer storage is heated by the solar loop through a custom built heat exchanger which separates the glycol from the brew water. All components on the charging and discharge loops, including the heat exchanger, are made of stainless steel.

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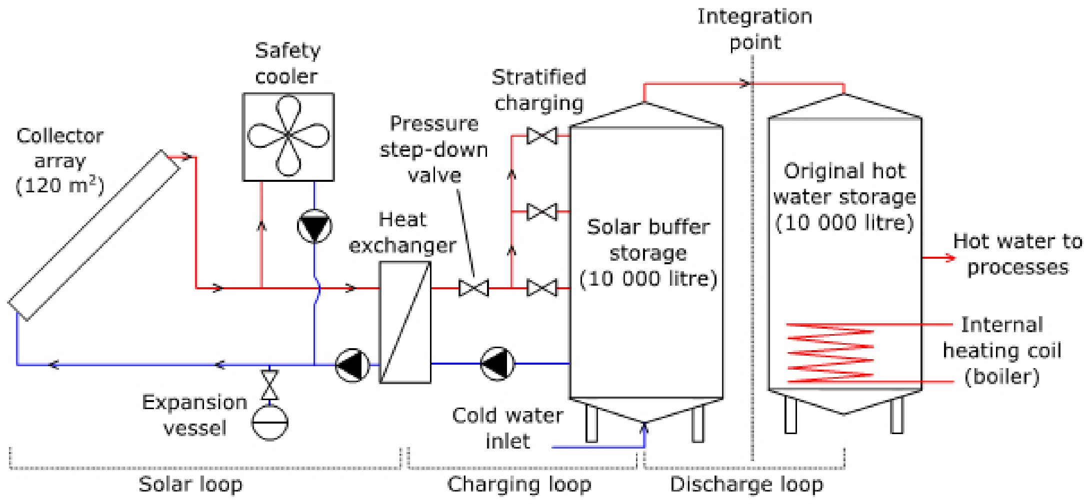

Figure 2: Simplified hydraulic scheme of the CBC solar thermal system with integration into the brewery.

The solar buffer storage tank is charged using three-way external stratification (see also Figure 1b). Integration of the new system occurs at the original hot water storage. From the original hot water storage, all hot water needs are drawn and then replenished by the water from the solar buffer storage. The original hot water storage and solar buffer storage operate at atmospheric pressure which is lower than the solar loop pressure. To reduce the risk of leaks through the heat exchanger (due to higher pressure on the solar loop side of the heat exchanger) a pressure step-down valve is used to raise the pressure on the charging loop side of the heat exchanger to higher than the solar loop side. After the step-down valve, the pressure is reduced to atmospheric at which the storage tanks operate.

Performance Calculations

To calculate the system performance, simulations were conducted using the Polysun software. The CBC hot water demand profile, at the time of the tender, was estimated to be 7 000 litres/day at 85 °C (the demand has increased significantly since). For simulation purposes the demand was distributed equally over the day starting at 01h00 and ending at 19h00, according to the operation schedule. The brewery typically operates for 245 days per year, excluding on weekends, public holidays and a two week summer holiday period in December. The available roof area was approximately 190 m², orientated north-east and has a 15° tilt.

In Figure 3, the simulated solar contribution to the final heat demand is shown for one year. The variability in the demand is influenced by the varying absences due to number of weekends and holidays during each month. The solar gains (Q_{sol}) follow the seasonal trend with very high solar fractions (SF) in summer (almost 90 % in January) and significantly lower contributions in the winter (42 % in July), which is also the local rainy season. The data show that there is always a need for the auxiliary heat source (boiler), due to the heat demand in early morning, but also because special care was taken not to oversize the system at any period of operation.

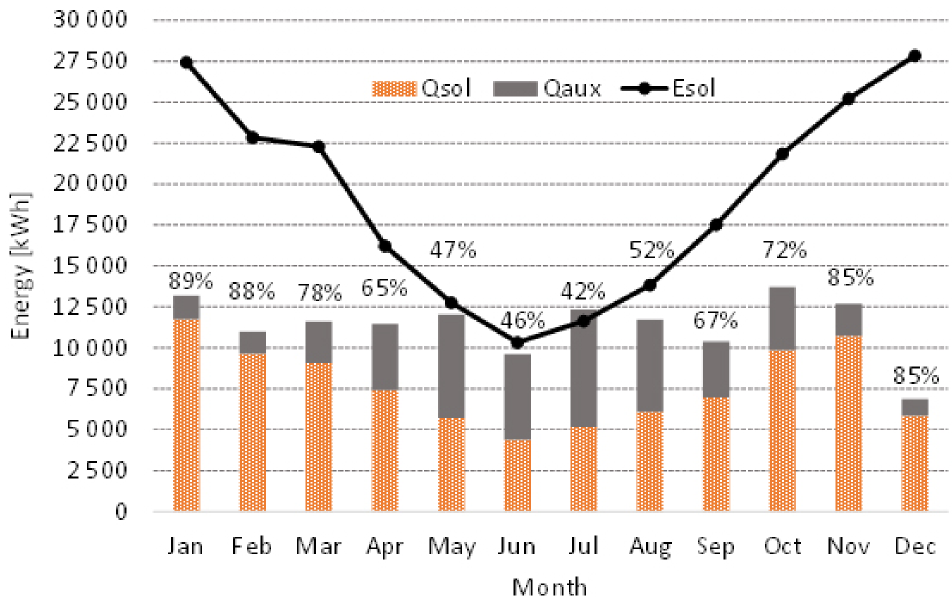

Figure 3: Polysun simulation results showing the solar energy onto the collectors (E_{sol}), the auxiliary heat demand (Q_{aux}) and the solar heat transferred to the process (Q_{sol}). The solar fractions ($SF = Q_{sol}/Q_{use}$) are provided as percentages above the bars, with $Q_{use} = Q_{sol} + Q_{aux}$, i.e. the total energy consumed by the process.

The overall simulation results and economic performance figures are provided in Table 1. The internal rate of return (IRR) is approximately 17 % indicating that the system is a good investment. The CBC solar system is one of only a handful of process heat applications in South Africa that are pioneering this market segment; it uses state-of-the-art large 10 m² collectors and has a custom-built stainless steel heat exchanger and tank that includes stratification.

Table 1: Summary of annual results for the simulated system

Parameter	Value
Collector gross area	120.7 m²
Storage volume	10 000 litre
Average ambient temperature	16.4 °C
Solar irradiation onto collectors *(E_{sol})*	229 730 kWh
Total energy to process *(Q_{use})*	136 617 kWh
Solar energy to process *(Q_{sol})*	92 635 kWh
System efficiency *(Q_{sol}/E_{sol})*	40.3 %
Solar fraction *($SF = Q_{sol}/Q_{use}$)*	67.8 %
IRR	16.7 %
Fuel (paraffin) savings	11 769 litre
CO_2 emission reduction	32 302 kg

SOLAR THERMAL TECHNOLOGY INITIATIVE YIELDS POSITIVE RESULTS AT MASS HOUSING PROJECT IN NAMIBIA

By Ms Helvi Ileka

The Solar Thermal Training and Demonstration Initiative (SOLTRAIN) project's objectives include the strengthening of the relationship between the Ministry of Mines and Energy (MME) and the National Housing Enterprise (NHE) in the implementation of the 2007 cabinet directive instructing that solar hot water heaters be installed in government buildings, and supporting NamPower's electricity demand side management efforts. In an effort to develop a flagship site for the SOLTRAIN project in Windhoek that can be used as a showcase for promotion of solar hot water among policymakers and project financers, the project has facilitated the installation of 62 solar water heaters at low cost houses in Windhoek's Otjomuise. This has been a collaborative effort led by the Namibia Energy Institute at the Namibia University of Science and Technology (NUST), together with the MME and the NHE.

A collaboration agreement was signed in May 2015 between the MME, NHE and Trinity Business Solution who will supply and install the solar water heaters). The installations commenced in December 2015 and were completed in March 2016. Trinity Business Solutions' technicians, many of whom were interns from different Vocational Training Centres, who installed the systems received training from an expert from AEE INTEC in Austria, Mr Rudi Moschik, at a workshop before starting with installation.

The Namibia Energy Institute, under the guidance of the AEE INTEC of Austria, has installed system performance monitoring systems at 6 houses (4 with solar water heaters and 2 with electric geysers) so as to provide practical data on typical household energy consumption, to verify and demonstrate the efficiency and cost-effectiveness of solar water heaters versus electrical geysers in Namibia. This flagship district serves to provide proof of concept that a house with solar water heating is a lower cost option when compared to an electric geyser. Once policymakers are convinced, they will be encouraged to extend the cabinet directive on implementing solar hot water systems to all public development companies that use public funds to construct houses, such as the NHE.

For example, based on data from the first three months of monitoring (Jan – March), the solar yield in Otjomuise is between 140 and 145 kWh/month. A family of three using a solar water heater (160L) had no need for any electrical back-up during this three-month period. In the six houses monitored, the hot water consumption ranged from 17 to 34 litres for one person per day.

While the amount of data currently available is limited, it appears that electricity demand in the homes using electric geysers is significantly higher than in homes using solar water heaters. The electricity demand for electric geysers (100L) ranges from 45 to 90 kWh per month. In addition, the data show clearly that both systems, solar and electric, suffer from significant thermal losses from storage tanks. This is an area where significant additional energy savings can be achieved through the development of standards. Further research into monitoring the different types of solar and electric water heating systems will soon become required.

SOLTRAIN Project was pitched as one of the regional prospective projects of Southern African Centre for Renewable Energy and Energy Efficiency (SACREEE).

The Namibia Energy Institute (NEI) at Namibia's University of Science and Technology (NUST) was requested by the SACREEE team to pitch the SOLTRAIN Project as one of prospective flagship projects of SACREEE at the third knowledge management component of the Energy and Environmental Partnership (EEP) programme "Knowledge Exchange Forum" (KEF). This forum took place in collaboration with the Southern African Centre for Renewable Energy and Energy Efficiency (SACREEE) in Namibia on June 2nd 2016 at the Avani Hotel.

Presentations, information sessions and round table discussions on topics of relevance to EEP project developers were presented and discussed. The event was attended by more than 80 participants, consisting of Energy and Environment Partnership coordinators from Swaziland, South Africa, Botswana and Namibia. Representative from EEP-lead donor funding countries such as Finland, UK and Austria also attended the event. Ms Helvi Ileka, the Projects Officer at NEI at NUST, pitched a 5 minute video presentation for the SOLTRAIN Project.

She highlighted the main objective and scope of the project, current costs, time frames of the programmes and progress to date of the projects, especially the development of the Solar Thermal Road Map and the joint research projects and scientific publications that have a direct linkage to the Knowledge Management System of SACREEE. Additionally, she informed the participants on the value proposition of the projects for SACREEE.

SOLTRAIN
Phase 2 successfully completed

By Werner Weiss

The comprehensive work program of phase 2 of SOLTRAIN was implemented from November 2012 until February 2016. All goals were met, and several were surpassed. This is the result of the excellent co-operation of all involved project partners and the solar thermal industry of southern Africa.
In total, more than 1200 people were trained in solar thermal technology and 127 solar thermal demonstration systems were installed. With these systems, 522 tons of CO_2 emissions are avoided annually and the avoided electricity cost is ZAR 3.5 million.

The overall goal of SOLTRAIN – Phase 2 was to contribute to the switch from a fossil fuel-based energy supply to a sustainable energy supply system based on renewable energies in general, but solar thermal energy in particular. The project was carried out in five southern African countries: Lesotho, Mozambique, Namibia, South Africa and Zimbabwe. The activities were funded by the Austrian Development Agency (ADA) via the ERP-Fund, and co-funded by the OPEC Fund for International Development (OFID).

SOLTRAIN Phase 2 consisted of the following initiatives:

As lack of awareness was seen as one of the main obstacles to the broad implementation of renewable energy technologies in general, and of solar thermal technologies in particular, ***comprehensive awareness activities were carried out.***

In order to inform stakeholders from industry, education, policy, administration, social institutions, and the financing sector, a total of ***25 stakeholder workshops with 812 participants*** took place in the partner countries.

Other project activities to inform the general public about SOLTRAIN and the possibilities of using solar thermal energy included participation in trade fairs, articles in newspapers and journals, and a number of radio and TV contributions.

In 2014 and 2015 BBCDC, the project partner from Lesotho received the prestigious *Energy Globe Award* for Lesotho. This raised not only the profile of BBCDC but also of SOLTRAIN activities on an international scale.

Further recognition came from the ***Eskom Eta Energy Efficiency Award,*** awarded on 4 December 2013 to Prof Dieter Holm from the South African project partner SESSA for the SOLTRAIN activities in the category for energy efficiency awareness. To raise awareness of the project, a number of international conferences were attended. Representatives from all SOLTRAIN partner organizations participated in the ***International Conference on Solar Technology in Development Cooperation*** in Frankfurt, Germany on 6 and 7 November 2014, and at the ***South African International Renewable Energy Conference*** (SAIREC 2015) from 4 – 7 October 2015 in Cape Town.

Another main objective of SOLTRAIN Phase 2 was the *establishment and implementation of Solar Thermal Technology Platforms (STTPs) in Centres of Competence* in Namibia, Mozambique and South Africa. The STTPs were founded by the main stakeholder groups in each country and were implemented in Centres of Competence (CoC) hosted by institutions of higher education in each country. The formal integration of the CoCs into the host institutions - The Centre for Renewable and Sustainable Energy Studies (CRSES), University Eduardo Mondlane (UEM), Namibia Energy Institute (NEI) and The Sustainable Energy Society of Southern Africa (SESSA) - is proven by official confirmation letters of the host institutions.

During several stakeholder workshops, the STTPs formulated solar thermal visions for 2030, discussed and passed Solar Thermal Technology Roadmaps and also elaborated by-laws for the Solar Thermal Technology Platforms. The ***Solar Thermal Technology Roadmaps (STTRMs) are now available as a guideline***

for policy to support and disseminate solar thermal technologies in the project partner countries.

In Mozambique, the Solar Thermal Technology Roadmap is recognised by the Ministry for Science, Technology, Higher Education and Professional Training. In the other countries, the process of endorsement is in progress.
One of the core activities of SOLTRAIN Phase 2 was offering training courses. ***In total, 24 Train the Trainer courses and training courses for vocational training centres were carried out, as well as 39 dissemination courses with a total of 1212 participants.***

A training course for quality inspectors, as well as two workshops for determining policy and administration, were carried out in Lesotho.

In South Africa and Namibia, two workshops for financial institutions were presented.

At the educational institutions' CoCs, a number of university level courses on renewable energy in general were held, with a special focus on solar thermal energy for students.

In order to support the project partners with training equipment for future training courses, the institutions were equipped with eight pumped solar thermal systems and seven thermosyphon systems. Ten of these systems have been installed on solar trailers, and monitoring devices complete all of the systems.
At Stellenbosch University, the upgrade of the collector test facility to European Standards was supported by SOLTRAIN enabling commercial tests to be successfully performed at the beginning of 2016.

In order to apply the knowledge gained during the training courses, demonstration systems were installed in so-called Solar Thermal Flagship Districts to showcase different solar thermal applications.
According to the defined project documentation,[1] it was the goal of SOLTRAIN 2 to install about 75 solar thermal demonstration systems of different sizes and applications at both social institutions and small to medium-sized enterprises.
Due to the fact that the contributions of the beneficiaries and other donors to the demonstration systems were significantly higher than initially expected, ***it was possible to install 127 demonstration systems*** instead of the 75 systems.
The number of direct beneficiaries from these 127 solar thermal demonstration systems is estimated at 1 800. Taking into account the multiple uses in hospitals, schools, homes for elderly people and other social institutions, this amounts to about 5 000 people annually.

[1] All three project documents (SOLTRAIN II, OFID and Lesotho)

The beneficiaries of a significant number of the installed systems are women (e.g. a girls' school in Zimbabwe, and maternity clinics in Lesotho and Mozambique) *and marginalized groups* like a residents of a sheltered employment centre, a residential facility for adults with cerebral palsy, orphans, patients of a psychiatric hospital in Mozambique, two hospitals, and two retirement villages.
The annual solar yield of all solar thermal systems funded by ADA and OFID sources, and installed in phase 1 and 2 of the SOLTRAIN project, was 1 500 MWh. This corresponds to electricity savings of 1 650 MWh/a and ***522 tons of avoided CO_2 emissions. The avoided electricity cost corresponds to ZAR 3.5 million.***

The total cost of all 127 demonstration systems (including installation) was € 903 641. The contribution of the SOLTRAIN project was € 281 468 (31%) and the contribution of the beneficiaries and funds from other donors was € 622 173 (69%).

In order to increase solar thermal energy technology awareness, to show different solar thermal applications, and to motivate decision makers to support a broad market implementation, eight technical tours with 152 decision makers to the Flagship Districts were carried out. These tours were highly successful and showed proven successes in the demonstration projects.

SOLTRAIN 3
First Workshop

By Dr Karen Surridge-Talbot

Implementation Strategies for Solar Thermal Technologies in South Africa

On the 17th May 2016, SANEDI hosted the first workshop of SOLTRAIN 3 at the Innovation Hub in Pretoria, South Africa. The aim of the workshop was to stimulate a brainstorming session to discuss collaborative coordination, and constructive contributions for the solar thermal sector in South Africa. It included a review of the progress to date and future plans of the SOLTRAIN programme, a look at the solar thermal sector requirements in terms of technology, regulatory framework/ policy and standards (current and future), and an overview of the Solar Thermal Technology Platform (STTP) activities and coordination thus far.

The creation of an enabling environment in the solar thermal sector will require support, reliable and motivated involvement and commitment of stakeholders from a technology, skills/training, policy, administration and finance knowledge base. This workshop focused on providing a discussion platform for stakeholders with a background in technology, skills/training, administration, policy and finance to gather and develop tailor-made solutions in order to stimulate the installations of solar thermal systems and thus contribute to job creation, security of energy supply and reduction of CO_2-emissions.

The discussions that ensued from the various presentations were lively and captured the interest of stakeholders from all sectors. Some of the salient points that were focal throughout the workshop included:

1. Quality control and regulation training with evaluation, with regards to accreditation issues and CPD points around qualifications, as well as the possibility of industry association accreditation.
2. Intellectual property issues for technologies and how technology ownership should be addressed.
3. Policy and regulations were singled out as being paramount.
4. Policy support for ensuring product and workmanship quality; this to be supported by an industry message about the technology. This lead to further discussions around the potential for localisation.
5. Lobbying at various levels through dissemination of information, creating awareness of and promoting the sector, training and skills development, successful implementation of projects, data management and engaging government department such as the Department of Trade and Industry (DTI) regarding the building regulation act revision.
6. A definite need for a focus on what government wants and needs to know in current Solar Water Heating Programmes was identified. This is required to address the areas of regulations, standards and testing. This is important in identifying *who is doing what* in the government-funded work, and what these results are yielding in terms of research and development as well as localisation.
7. It was also identified specifically for the projects being implemented through SOLTRAIN, but also in other commercial spaces, that there is a need for maintenance contracts to be put in place that cover the warranty period on systems. This would aid in system confidence and reputation through maintaining correctly functioning systems over these warranty time periods.

It was identified that there is a definite need for specialised courses focusing on combination solar thermal and heat pump technologies as well as their industrial applications. The overall outcomes of this workshop identified that SOLTRAIN 3 will focus on the monitoring and quality of systems to support the technology reputation and thus stimulate more extensive market creation. The next two workshops will take place in Johannesburg on 18 August and Stellenbosch in South Africa in late October or early November 2016. (Watch this space for exciting updates!) Finally, it was strongly expressed that system maintenance is paramount as this impacts technology reputation... news travels, let's show everyone how great solar thermal energy is!

SOLTRAIN
Phase 3

By Werner Weiss

According to the World Bank, today some 25 countries in sub-Saharan Africa are facing a power supply 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.

Using Solar Water Heating Systems for domestic uses, as well as for heating and cooling of hospitals, hotels, student hostels and providing heat for industrial processes, could play a major role in reducing the stress on the security of electricity supply in the six partner countries Botswana, Lesotho, Mozambique, Namibia, South Africa, and Zimbabwe.

Due to these reasons, all partner countries of SOLTRAIN Phase 3 are pursuing policies that enhance security of supply, energy conservation and increase energy access, to augment the existing national plans and policies to increase the use of solar thermal systems. Within the Southern African Development Community (SADC), the increased use of renewable energies is seen as an essential topic[1] and solar water heating systems are identified as one of the major technologies for demand side energy management[2].

Phase 3 of the SOLTRAIN project is therefore focused on the national and regional governmental renewable energy targets, as well as on the results and lessons learnt from the two previous phases of SOLTRAIN, which were carried out from 2008 to 2016.

It is the overall aim of the SOLTRAIN project to ensure that the results achieved in the previous phases of the project are successfully implemented in the partner institutions and governmental bodies of the partner countries, and to initiate or strengthen sustainable national solar thermal roll-out programs that continue far beyond the duration of the project.

The specific project outcome required from SOLTRAIN Phase 3 is to facilitate and support the partner institutions and governmental bodies of the partner countries in the implementation of their sustainable national solar thermal roll-out programs.

[1] REN21: SADC Renewable Energy and Energy Efficiency Status Report, Paris 2015

[2] SADC: Regional Infrastructure Development Master Plan, Energy Sector Plan, August 2012

The project focuses on three main target groups:

- <u>Local implementation partners:</u> Educational and research institutions like universities, vocational schools and other training centres
- <u>Target groups:</u> Installers of solar thermal systems as well as policy, administrative and financial sectors. This target group consists of about 750 participants from the different training courses. It is the aim to have gender balanced participation in the training courses.
- <u>Beneficiaries:</u> 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.
- In the call for applications for demonstration systems, a special focus is going to be on institutions which support women (e.g. girls' schools, maternity clinics, shelters for battered women) and marginalized groups.
- It is estimated that about 7,000 persons will directly benefit from these demonstration systems by reducing their energy bills and by improving the standard of hygiene in the establishment.

Targeted indicators of the expected outputs

- 12 Policy workshops offered, with a total of 250 participants
- 500 Persons trained in 22 training courses on design, installation and maintenance of solar thermal systems
- 3 National Solar Thermal Roadmaps developed in stakeholder processes for Botswana, Lesotho and Zimbabwe
- 6 National Solar Thermal Roadmaps implemented in Botswana, Lesotho, Mozambique, Namibia, South Africa and Zimbabwe
- 6 Solar thermal statistics analyses (one per partner country) on the development of the solar thermal markets available
- 70 Solar thermal demonstration systems installed, in operation and quality checked

Background and context

Around 2.4 billion people in developing and transition countries are currently deprived of access to modern energy services. Energy poverty negatively affects large numbers of people and the economy in sub-Saharan Africa.

There are close links between energy supply and practically all aspects of sustainable development, such as access to water, agricultural and industrial productivity, health care, education, job creation, environmental pollution and climate change.

According to the World Bank[3] today some 25 countries in sub-Saharan Africa are facing an energy crisis, evidenced by rolling electricity blackouts.

Key issues in Africa's power sector:

- Low access and insufficient capacity - Some 24% of the population of sub-Saharan Africa has access to electricity compared to 40% in other low income countries. Excluding South Africa, the entire installed generation capacity of sub-Saharan Africa is only 28 GW, equivalent to that of only Argentina.
- Poor reliability - African manufacturing enterprises experience power outages on average 56 days per year. As a result, companies lose 6% of sales revenue in the informal sector. Where back-up generation is limited, losses can be as high as 20%.
- High costs - Power tariffs in most parts of the developing world fall in the range of US$0.04 to US$0.08 per kilowatt-hour. However, in sub-Saharan Africa, the average tariff is US$0.13 per kilowatt-hour. In countries dependent on diesel-based systems, tariffs are higher still. Given poor reliability, many companies operate their own diesel generators at two to three times that cost, with associated environmental costs.

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.

In South Africa for instance, the pressure on energy efficiency measures to contribute to mitigating the supply challenge has steadily mounted. After the extended period of excess generation capacity, South Africa ran into electricity supply constraints (Figure 1) when the growing need for electricity outpaced the rate at which power stations were being built. As a result the country experienced repeat power outages from late 2007, continuing to 2015, where it reached a negative reserve margin of almost 15%. The ability to supply in South Africa's electricity needs is a major challenge and electricity supply is likely to remain vulnerable into the foreseeable future.

[3] Fact Sheet: The World Bank and Energy in Africa, http://web.worldbank.org

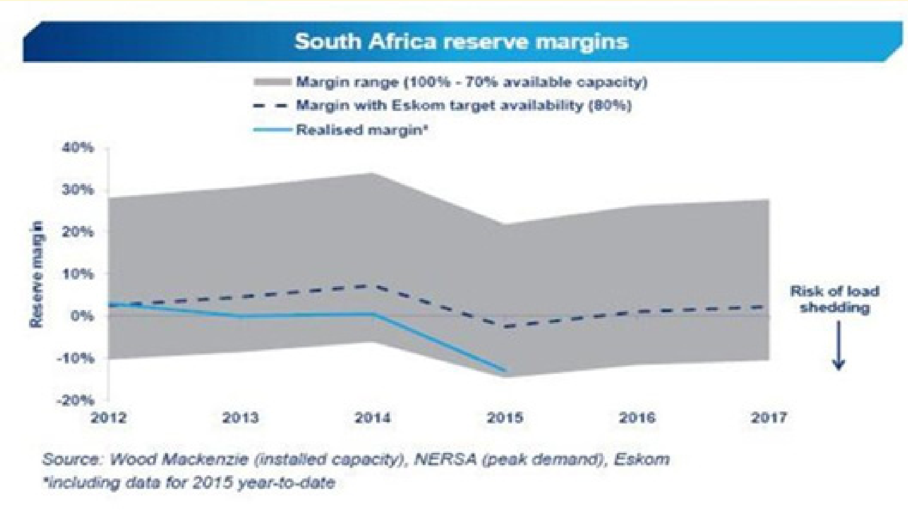

Figure 1: Percentage reserve margin (% buffer between the available supply and projected demand of electricity)

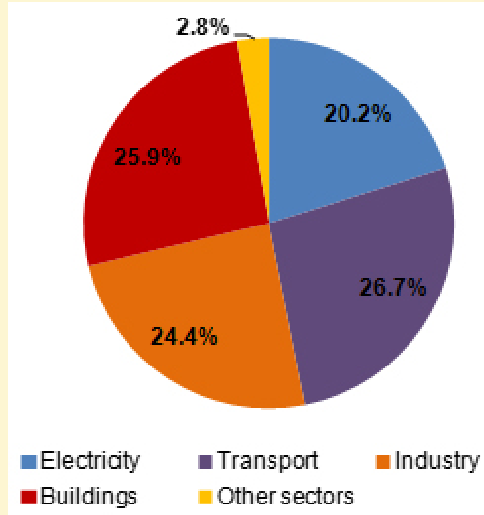

Figure 2: World total final energy consumption, 2011 (322 EJ) Source: Paolo Frankl, IEA, Paris

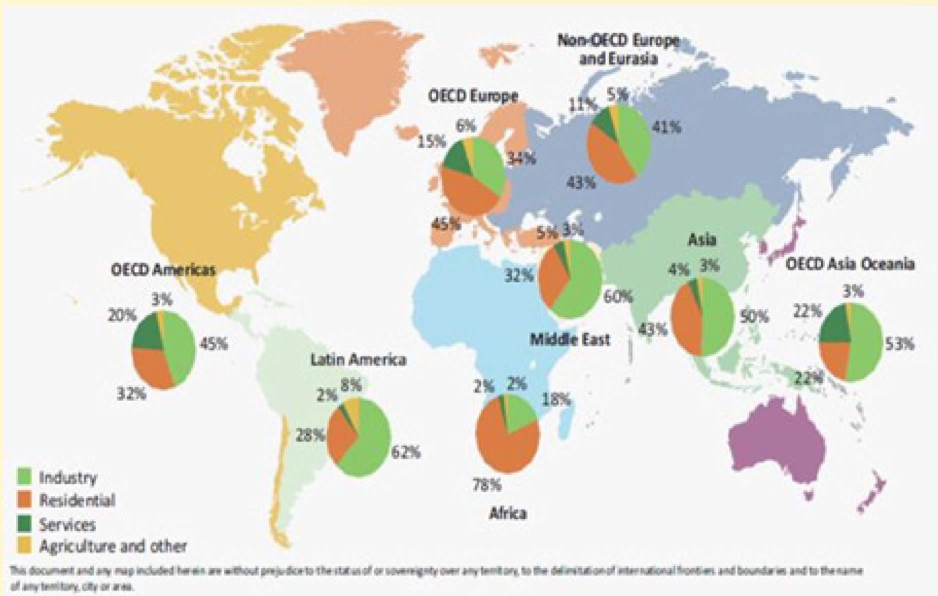

Figure 3: Use of heat in different regions and sectors worldwide. Source: IEA Energy Technology Perspectives 2012

The role of heat in Africa

It needs to be stated here that policies usually only focus on electricity when talking about energy and energy policy measures.

With this approach, more than 50% of the final energy consumption in sub-Saharan African counties is neglected, which happens to be for heat generation. As such, high value energy like electricity is being used for low temperature heat applications. This is a waste of resources and is very inefficient, from an energetic and sustainable development point of view.

In southern Africa, 40 - 50% of the electricity in the residential sector is used for hot water preparation as soon as people have access to electricity. Solar water heaters would be one of the significant alternative options to reduce the electricity demand for this, and thus the environmental effects like CO_2 emissions from fossil-power energy generating plants.

According to the Integrated Demand Side Management (IDM) Program of the South African power utility Eskom, solar water heating systems for domestic uses, as well as for heating and cooling of hospitals, hotels, student hostels and providing heat for industrial processes, could play a major role in reducing the stress on the security of the electricity supply (see figure 4).

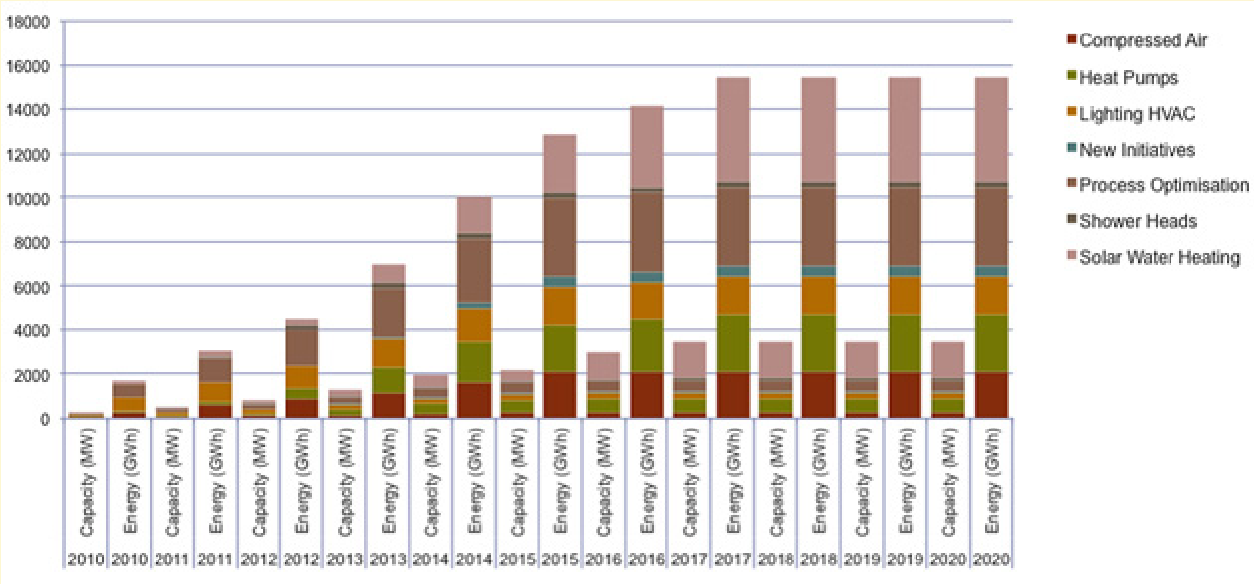

Figure 4: IDM component as included in the Integrated Resource Plan 2010. The anticipated contribution from IDM interventions to the national electricity plan in South Africa. Solar water heating could play a significant role. Source: ISGAN IDM Case Study South Africa

Problem analysis and analysis of local potential solutions

As mentioned above, the SADC region has seen significant levels of growth in electricity consumption in recent years. Subsequently, major disruption of the power supply in Botswana, Lesotho, Namibia, Mozambique, South Africa and Zimbabwe is the main threat to the economic growth being experienced.

In addition, the average cost of electricity is increasing more than 10% per annum, which adds to the financial burden for households, social institutions, and small and medium enterprises (SMEs). Since a considerable proportion of electricity is used for converting electricity into low temperature heat, for domestic hot water or low temperature heat in the food and beverage industry, solar water heaters would be one of the major potential solutions to significantly reduce the electricity demand and the running costs for households, social institutions, tourism facilities and SMEs.

In order to inform the population and key stakeholders of the six partner countries about the possibilities to switch from biomass-based hot water preparation in rural areas and electricity-based hot water preparation in areas with access to the electrical grid, broad awareness activities are going to be carried out. By switching to solar water heating systems the work load of women in rural areas can be significantly reduced, since the demand on firewood would decrease.

Current status of solar thermal utilization in sub-Sahara Africa

African countries have an excellent solar irradiation of between 1800 kWh and 2400 kWh annual radiation and estimates from the International Energy Agency (IEA) suggest that solar thermal systems could meet about 70 – 80% of the region's low temperature heating and cooling demand.

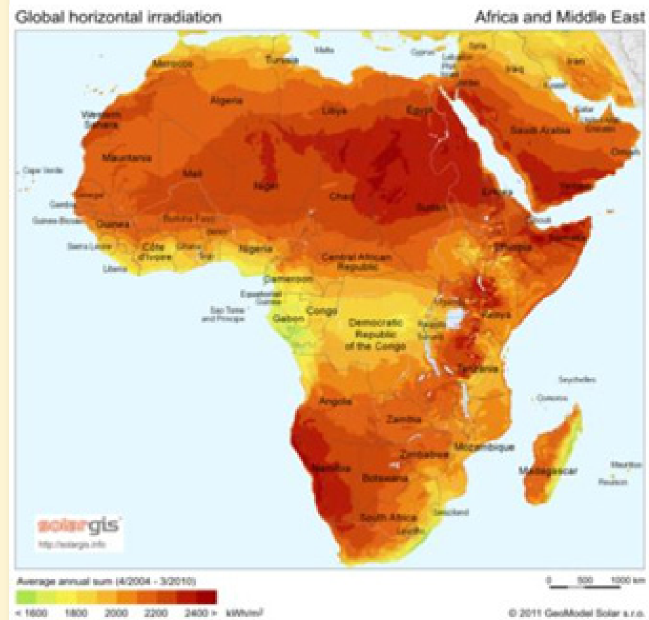

Figure 6: Global solar radiation in Africa (Source: Solargis)

In comparison with other regions of the world, the use of solar thermal energy in African countries is still on very low, even though the availability of solar radiation is one of the highest worldwide and available in all African countries. In 2013 the share of the solar energy generating capacity installed in sub-Saharan Africa was 0.3% of the total capacity worldwide. Nearly 82% of the world-wide capacity of 406 GWth was installed in China and Europe, with comparably low solar radiation.

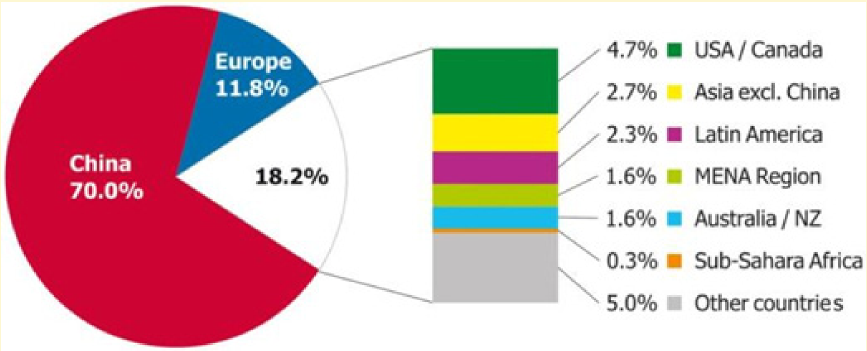

Figure 7: Share of total installed solar energy generating capacity in operation by economic regions at the end of 2013. Source: Mauthner, F., Weiss, W. (2015) Solar Heat Worldwide

Even if the total installed capacity in sub-Saharan Africa is on a low level, a positive market trend has been observed in recent years. Sub-Sahara Africa showed the second biggest market growth in 2012 and 2013, following the MENA[4] region.

[4] Middle East and North Africa

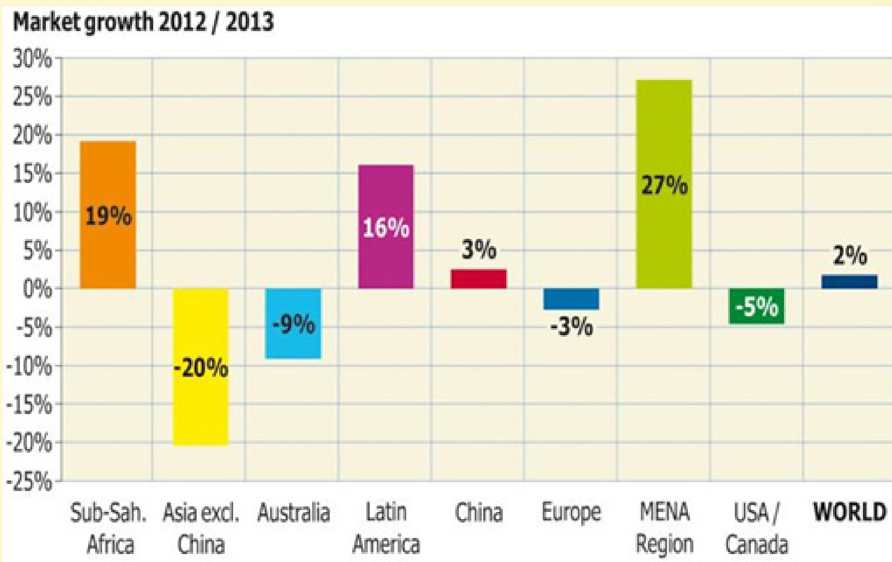

Figure 8: Market growth of newly installed capacity in 2012/2013 by economic region and world-wide. Source: Mauthner, F., Weiss, W. (2015) Solar Heat Worldwide

The main reasons for the low utilization of solar thermal systems in the partner countries were analysed in the course of the mid-term review of SOLTRAIN Phase 2. The findings according to the mid-term review were:

- Lack of promotion
- High initial capital cost of solar thermal systems compared to electric water heaters of comparative capacity
- The absence of low interest finance to assist with the installation costs of solar thermal systems
- Poor installation, freezing problems and low maintenance
- Lack of a coordinated coherent, development policy

The main problems for not using solar thermal systems detected in social institutions were lack of funds and lack of confidence. Therefore social institutions often opt for the safer but more expensive monthly electricity bill.

Also political problems were detected in the course of the mid-term review. Here the main obstacles identified for manufacturers of solar heating systems were:

- the lack of coordinated coherent development policy, which allows the local industry to grow instead of importing cheap, low quality Chinese products
- the absence or unstable financial subsidy schemes, and
- the high cost for SABS system testing are seen as.

Another problem is that an institutional structure, which supports public awareness, training, R&D and implementation of solar thermal energy, was not available in all SADC member states. The SOLTRAIN project aims at initiating Centres of Competence on solar thermal energy technologies in the partner countries.

Local market potential

By increasing the standard of living and access to electricity, hot water consumption will rise as a result in the residential sector, hotels, hospitals, and in industry.

Assuming that the SOLTRAIN partner countries would have the same hot water consumption per capita as the countries with the worldwide highest solar thermal market penetration (Cyprus and Israel), an annual electricity demand of about 73.842 GWh would be needed in the six project partner countries annually to prepare the hot water.[5]

If we also assume that the SOLTRAIN partner countries would have the same solar thermal market penetration as the two leading countries had already reached in 2012 (466 kWth/1000 inhabitants), it can be calculated that the electricity saved annually with solar thermal systems would be 73.842 GWh. This avoided electricity consumption equals the amount of basic electricity required for 38% of the population of the SOLTRAIN partner countries. In other words: By investing in solar thermal systems, the partner countries could avoid significant investment in, and running costs of, power plants as well as reducing fuel imports.

[5] The daily hot water consumption in Cyprus and Israel is about 35 litre/person

Table 1: Annual electricity savings and avoided CO_2 emissions due to the installation of solar thermal systems

Country	Population	Installed capacity kWth	Annual Electricity savings GWh	Basic electricity for number of households	Annual CO2 avoidance Million Tons
Botswana	2.155.784	1.005.673	1.628	814.116	1
Lesotho	1.942.008	905.947	1.467	733.385	1
Namibia	2.198.406	1.025.556	1.660	830.212	1
Mozambique	24.692.144	1.025.556	1.660	830.212	1
South Africa	53.006.857	24.727.699	40.035	20.017.661	27
Zimbabwe	13.771.721	6.424.508	10.402	5.200.792	7
SOLTRAIN Countries	97.766.920	45.608.268	73.842	36.920.979	50

The following figures from the International Energy Agency (IEA) show the long term potential for solar heating and cooling in different economic regions worldwide. As can be seen in these figures, there is significant potential in Africa for solar water and space heating, as well as solar heating for low temperature industrial processes.

Potentials based on the results of the Solar Thermal Roadmap processes

The solar thermal potentials shown in the Solar Thermal Roadmaps, which were developed in stakeholder processes in Namibia, South Africa and Mozambique in phase 2 of SOLTRAIN, are quite significant.
According to the Namibian Solar Thermal Roadmap, it is the aim to achieve installation of 1.5 million m² of solar thermal collector area by 2030, which translates to about 0.5 m² per inhabitant.

A similar goal has been defined in the South African Solar Thermal Roadmap - 0.5 m² of solar thermal collector area for every member of the population is to be installed. This relates to an installed capacity of 21 GWth.
A little less ambitious are the potentials seen in Mozambique, where 0.1 m² of solar collectors shall be installed by 2030. In total, a significant market of 3.4 million m² is seen as the potential for installing solar thermal collectors until 2030.

Potentials according to the IEA Solar Thermal Roadmap

The SOLTRAIN Roadmap potentials are in accordance with the international solar thermal potentials, which were published by the International Energy Agency (IEA) in the Solar Thermal Roadmap. The following figures show the solar water and space heating potential and the potential for industrial process heat by economic region.

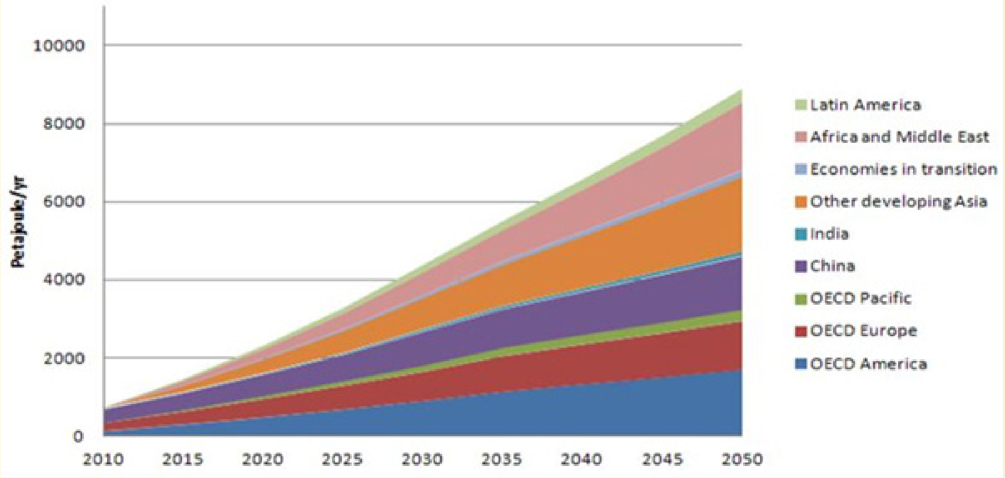

Figure 9: IEA Roadmap vision for solar water and space heating by economic region (PJ/yr)
Source: IEA SHC Technology Roadmap Solar Heating and Cooling, 2012

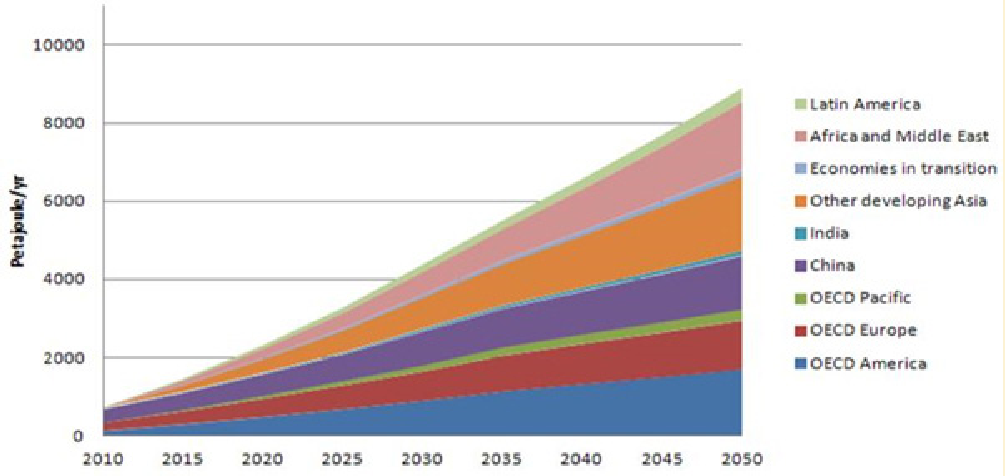

Figure 10: IEA Roadmap vision of solar process heat for low temperature industrial heat (EJ/yr)
Source: IEA SHC Technology Roadmap Solar heating and Cooling, 2012

Barriers to implementation

Extensive implementation of Solar Thermal Programs can play an important role in providing the energy needs of a country and can do so at a comparatively low cost. It furthermore presents an opportunity to create and protect employment and contribute to the environmental aspirations of the country.

Barriers to implementation include

- required upfront capital investment
- long payback periods
- low levels of awareness and
- low confidence in projected energy and cost savings that will be achieved

The most critical mitigation of barriers is a policy, regulatory and funding framework that promotes and supports solar thermal implementation and creates an appropriate and stable enabling environment.

A range of funding models is needed, adjusted to the needs of the different user groups. Further, effective pricing structures and levels, channels to market and technology options assist in making incentives accessible to more consumers.

Effective communication is another critical aspect of successful implementation.

Strategic approach and methodology

Phase 3 of the SOLTRAIN project is focused on achieving the national and regional governmental targets, as well as on implementing the results and lessons learnt in the two previous phases of the project.

One focus of SOLTRAIN is to contribute to the reduction of energy poverty by improving access to solar water heating systems and where required, space heating, thus reducing the expenses for fuels. Due to support of local production, and training in assembling and maintenance, jobs and income can be created as an indirect result of SOLTRAIN.

In comparison to electrical water heating systems or fire wood, there are no running costs or labour needed over the life time of a solar thermal system. The household expenses or labour saved for preparing hot water can be used for education or other important things to improve the daily life of citizens.

By creating income in different sectors (training, manufacturing, assembling, installation, and maintenance) and reducing the running costs of households, poverty in general can be reduced; SOLTRAIN will contribute to this poverty alleviation.

As improving access to modern energy is a factor in reducing energy poverty, it is SOLTRAIN aims to increase the affordability of solar thermal systems. Therefore workshops with financial institutions will be carried out to assess the possibilities of providing finance for solar thermal systems, such as creating micro financing schemes.

The overall work program was developed in several meetings with all implementing partners from all partner countries between October 2014 and October 2015.

It was agreed that in order to be successful with the broad deployment of solar thermal systems in southern Africa, it is necessary to have a coherent strategy to promote this technology. The overall approach and the elements of the project are illustrated in the figure below.

The figure illustrates the elements needed for a broad, successful and sustainable implementation of solar thermal systems. Ambitious targets have to be set in well-defined solar thermal roadmaps. Based on the required project targets, a comprehensive training program on all educational levels can be defined. The recently trained persons will have to prove their understood the content by having to apply their knowledge first in demonstration systems.

In order to be successful in a broad implementation, financial incentives are necessary in most countries. This has to be provided by banks or by the state. Regulations are essential when it comes to quality control and warranties. Last but not least, awareness campaigns are necessary in order to inform the public about the benefits of the technology and national research and development capacities (R&D) have to be built up if support of local production is to be established.

The planned impact of phase 3 is a contribution to improved energy access and security, in particular solar thermal, while mitigating global climate change and poverty reduction.
The focus of the training on medium-scale solar thermal applications shall significantly broaden the application area, from small-scale solar water heating systems in the residential sector to medium-scale systems for hotels, student hostels, hospitals and other social institutions, to large–scale systems for the commercial and industrial sectors.

This will be done on the basis of the Solar Thermal Roadmaps, which were developed in stakeholder processes for some countries in phase 2. Therefore phase 3 is a logical next step concerning the implementation of the road map and to support roll-out programs based on training and quality measures provided in SOLTRAIN so far.

The planned demonstration systems will prove the performance of solar thermal systems and the related energy and CO2 savings in new applications as well as small-scale applications for social housing programs in the partner countries.

To strengthen ownership responsibility for the solar thermal demonstration projects, it is foreseen that the beneficiaries will have to contribute 50% to the system costs. This measure is intended to increase the probability that the solar thermal systems (including running costs) are maintained after the end of the project.

In order to support **gender mainstreaming,** a special sensitivity will be on invitation of female participants to the training courses and student projects. In addition, in the calls for applications for solar thermal demonstration systems, a special focus is going to be on institutions which support women and marginalized groups.

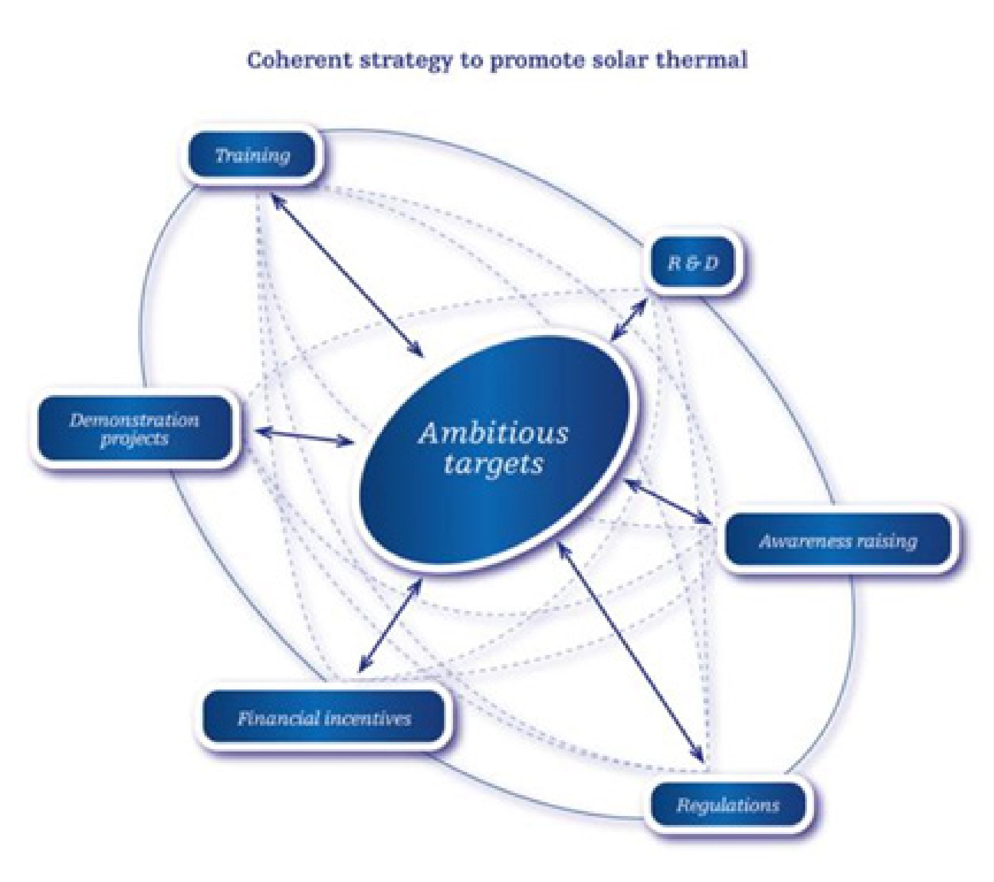

Figure 11: Elements of the project