# The South African Solar Thermal Technology Road Map (SA-STTRM)



## Direction for South Africa's solar thermal energy future

**A discussion document**

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UNIVERSITEIT
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CENTRE FOR RENEWABLE &
SUSTAINABLE ENERGY STUDIES



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## 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 f**ocused awareness campaigns** on solar thermal systems to 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. These **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**" (STTPs) 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. The co-sponsored demonstration systems are placed within the Solar Thermal Flagship Districts, and shall be open to visits of Technical Tours by decision makers.

## About CRSES

The Centre for Renewable and Sustainable Energy Studies (CRSES) was established in 2006 and is currently partly funded by the Department of Science and Technology (DST) through the Postgraduate Programme in Renewable and Sustainable Energy Studies. The Hub of the Programme is in the Faculty of Engineering at Stellenbosch University in collaboration with other departments and institutes within the University structure, as well as the Sustainability Institute (SI), which is based at Lynedoch outside Stellenbosch.

***Our Vision** is that Stellenbosch University is recognised as the leading, best-known and most productive research and teaching university in the field of renewable energy in Africa facilitated by the Centre for Renewable and Sustainable Energy Studies.*

## About SESSA

The Sustainable Energy Society of Southern Africa or SESSA, is dedicated to the use of renewable energy and energy efficiency including all solar-based energies such as photovoltaics, thermal heating and cooling, wind, biomass and hydropower. These principle sources of energy can be used in passive building design and in energy efficiency projects.

The inter-disciplinary nature of SESSA attracts the membership of industry, scientists, researchers, developers and the general public – the only qualification is a keen interest in renewable energy and its utilization to ensure a sustainable energy future.

SESSA was founded in 1974 and is one of 50 National Sections of the International Solar Energy Society (ISES). ISES is regarded as the premier body in solar energy with members in over 100 countries. SESSA is the duly appointed African office of ISES.

Stellenbosch University CRSES in partnership with AEE-INTEC and SESSA hosted a very successful launch of the South African Solar Thermal Technology Platform (SA-STTP) at the Protea Hotel, Breakwater Lodge in Cape Town on Thursday, 27 November 2014. The launch was followed by an interactive workshop to formulate the South African Solar Thermal Technology Roadmap (SA-STTRM).

This workshop was attended by delegates from industry, research institutions and government.

The SA-STTRM is understood to be the implementation plan for the SETRM.

This STTRM documents the progress made in the use of solar thermal technology in South Africa and gives an analysis of the technological, legislative, regulatory and other barriers that need to be overcome to accelerate its deployment. The outcomes of the workshop as well as comments from other interested parties have been incorporated into this roadmap document.



## AGENDA

**Launch of the South African Solar Thermal Technology platform (SA-STTP) followed by an interactive workshop to formulate the South African Solar Thermal Technology Road Map (SA-STTRM)**

**27 November 2014, Protea Hotel, Breakwater Lodge, Cape Town**

09:00 – 09:30 Registration

09:30– 09:40 Welcome and Introduction: Prof Wikus van Niekerk (Stellenbosch University)

09:40– 10:00 Overview of SOLTRAIN and current status, plus launch of the SA-STTP: Werner Weiss, Managing Director AEE - Institute for Sustainable Technologies (AEE INTEC)

10:00 – 10:20 Report back from some SA-STTP workgroup convenors

- Working Group 2: SWH manufacturing: Helmut Hertzog
- Working Group 3: Solar heat for Industrial Applications: Wally Weber
- Working Group 5: Solar Thermal Systems for Buildings: Dieter Holm
- Working Group 6: Training, Education and Awareness: Ryan Dearlove

10:20 – 10:50 Background to the SA-STTRM and introduction of the European Solar Heating and Cooling Technology Roadmap: Werner Weiss

10:50 – 11:05 Coffee / Tea

11:05 – 11:20 Introduction of the SA-STTRM - Karin Kritzinger (Stellenbosch University)

11:20 – 12:50 Interactive workshop facilitated by Prof. van Niekerk to unpack and finalise the SA-STTRM:

- Residential Solar Water Heating
  - High Pressure Residential Solar Water Heating
  - Low Pressure Residential Solar Water Heating
  - Multi Family Homes Solar Water Heating
- Industrial / Commercial Installations for Solar Heating and Cooling
- Unglazed Swimming Pool Solar Water Heaters
- Solar Passive Design in Buildings
  - Solar Heat for Space Heating in Buildings
  - Passive solar heating in buildings

12:50 – 13:00 Wrap-Up and Way Forward: Prof. Wikus van Niekerk

13:00 – 13:30 Light lunch

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# Foreword

The current use of fossil fuels for the majority of South Africa's energy needs is economically, socially and environmentally unsustainable. A significant percentage of final energy used in the industrial, commercial and residential sectors is for heat and, with South Africa's unexploited higher than average solar resource, solar thermal energy can play a large part in our path to an independent, low carbon and sustainable energy future.

The South African Solar Thermal Technology Roadmap (SA-STTRM) is based on the Solar Heating and Cooling Technology Roadmap project in Europe, which was developed by the European Technology Platform on Renewable Heating and Cooling. This Roadmap is essentially market oriented to make Solar Heating and Cooling (SHC) more competitive and, thus, develops the full potential of social and environmental benefits inherent to solar thermal technologies. In this roadmap Research & Innovation (R&I) actions are identified to improve significantly the competitiveness of solar heating and cooling technology. It also describes the objectives of the roadmap, to which will be achieved in response to the societal challenges.

Furthermore, the SA-STTRM is furthermore a sector specific roadmap underpinning the Solar Energy Technology Road Maps (SETRM), an initiative of the Department of Energy (DoE) and the Department of Science and Technology (DST) supported by CSIR, SANEDI, the International Energy Agency, Solar Heating and Cooling (IEA SHC) and the GIZ, through the SAGEN programme. The sector-specific roadmaps that feed into the SETRM are coordinated by the CSIR. The process of developing the SA-STTRM is aligned with, and informs, the SETRM sector specific roadmap for solar thermal technologies.

The SA-STTRM sets out a roadmap for the development, support and promotion of solar thermal technologies in South Africa. It excludes technologies such as Concentrated Solar Power (CSP), where electricity is produced with solar thermal energy as well as Solar Photovoltaics (PV).

Finally, it attempts to document the progress made in the use of solar thermal technology in South Africa and presents an analysis of the technological, legislative, regulatory and other barriers that need to be overcome to accelerate the deployment of this technology in South Africa.

Achieving this roadmap's vision will require an effective, long-term and balanced policy effort to allow for optimal technology progress, cost reduction and ramp-up of industrial manufacturing for mass deployment. The South African Government will need to provide long-term targets and stable supporting policies to build confidence for investment in manufacturing capacity and deployment of solar thermal systems.

**The huge potential for solar thermal systems in South Africa**

South Africa faces an enormous power deficit and nearly 90% of the electricity is generated from coal. In February 2008, the Government of South Africa, their power utility, Eskom and the mines reached an agreement that the mines would cut back an immediate 10% in order to reduce the large amount of load shedding. After about 7 years of low incidence of load shedding, South Africa is yet again experiencing severe power shortages and rolling load shedding started again at the end of 2014.

Such developments of the major power supplier leaves South Africa in a very vulnerable position, hence the country must frantically explore ways of financing power projects to avert economic disruption.

Since about 40 – 50% of the electricity in the residential sector is used for heating water, solar water heaters constitute one of the major cost-effective and rapid options in order to reduce the electricity demand and thus the environmental effects like $CO_2$ emissions caused by fossil power plants.

South Africa has an excellent solar irradiation with up to 2000 kWh/m² annual radiation, and estimates from the International Energy Agency (IEA) show that solar thermal systems could meet about 70 – 80% of the region's low temperature heating and cooling demand.

This roadmap describes ways to use the huge solar potential with solar thermal systems in order to reduce significantly the electricity demand and thus also the $CO_2$ emissions of the country. By implementing the roadmap also a significant number of jobs could be created if the government supports local assembling or manufacturing.

An interactive workshop was held on 27 November 2014 at the Breakwater Lodge, Cape Town, where this roadmap was further developed through input from participants. This is a discussion document. Please feel free to distribute widely and send all comments, corrections and additions to karink@sun.ac.za.

## Key findings and actions

To be completed

A workshop aimed at stakeholders in the built environment and other interested parties, will be held in February in Gauteng to discuss the roadmaps for Solar Passive Design in Buildings.

An interactive workshop to discus and further develop the SA-STTRM will be held on 19 March 2015 at Bytes Conference Centre in Midrand. Confirmation of attendance has been received from the office of Austrian Ambassador.

# Abbreviations

| | |
|---|---|
| CRSES | Centre for Renewable and Sustainable Energy Studies |
| CSIR | Council of Scientific & Industrial Research |
| CSP | Concentrated Solar Power |
| DoE | Department: Energy |
| DST | Department: Science and Technology |
| EE | Energy Efficiency |
| GIZ | Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German technical cooperation) |
| GW | Gigawatt |
| HP | High Pressure |
| GWh | Gigawatt hour |
| IEA | International Energy Agency |
| IEA SHC | International Energy Agency Solar Heating and Cooling |
| kW | Kilowatt |
| kWh | Kilowatt hour |
| LP | Low Pressure |
| MWh | Megawatt hour |
| MW | Megawatt |
| PPPFA | Preferential Procurement Policy Framework Act |
| PSG | Project Steering Committee |
| PV | (Solar) Photovoltaic |
| R&D | Research and Development |
| RE | Renewable Energy |
| SAGEN | The South African – German Energy Programme |
| SANEDI | South African National Energy Development Institute |
| SAREC | South African Renewable Energy Council |
| SA-STTP | South African Solar Thermal Technology Platform |
| SA-STTRM | South African Solar Thermal Technology Roadmap |
| SETRM | Solar Energy Technology Road Maps |
| SESSA | Sustainable Energy Society of South Africa |
| SU | Stellenbosch University |
| SWH | Solar Water Heater/Heating |
| WG | Working Group |

# 1. Background

The SA-STTRM is a sector-specific roadmap underpinning and informing the Solar Energy Technology Road Maps (SETRM), an initiative of the Department of Energy (DoE) and the Department of Science and Technology (DST) supported by CSIR and SANEDI. The process to develop the SETRM was started in 2010. In 2012, the International Energy Agency as well as the GIZ, through the SAGEN programme came on board to support the revised SETRM process.[1] On 27 November 2014, the SA-STTRM draft document was discussed at an open stakeholder meeting in Cape Town. The mood of the meeting was constructive and participative.

All comments received have been integrated into this document by CRSES.

## The Solar Energy Technology Road Maps (SETRMs)

The Solar Energy Technology Roadmap (SETRM) is a joint initiative of the Department of Energy (DoE) and the Department of Science and Technology (DST) supported by the CSIR and SANEDI. This initiative will be supported by both local and international organisations such as the GIZ and the International Energy Agency (IEA) that the PSC deems relevant.

The purpose of the SETRM is to prepare a guide to the local development of solar energy technologies and their deployment taking into consideration relevant policies and initiatives. The DST has developed a SETRM in 2010 but the scope covered on the DST study was limited to Research and Development of solar technologies.

The IEA describes a roadmap as a strategic plan that outlines the steps a country needs to take to achieve stated outcomes and goals. It clearly outlines links among tasks and priorities for action in the near, medium and long term. Technology-specific roadmaps are intended to support the development of a specific type of technology, e.g. solar PV, CSP, etc. South Africa however, has opted to develop a consolidated roadmap for both solar PV and CSP technologies, which will be based on the IEA methodology.

Various national departments and industry players have specific interests in respect of the development of solar energy technology in South Africa and it has become critical to develop a single document that consolidates these disparate efforts, and that maps out a pathway that all stakeholders can follow. As such, the SETRM also aims to improve coordination in the sector.



[1] http://www.eskom.co.za/AboutElectricity/RenewableEnergy/Documents/H2SA_SETRM_Pogramme.ppt

The SETRM is the investigation of a solar energy technology road map for South Africa, which takes into consideration the draft "Energy, Research, Development and innovation (ERD&I)" strategy drivers that include universal access economic growth, and environmental protection as a framework. The roadmap also highlights key strategic focus areas required, interventions by various role-players and how best South Africa might use its competitive advantage of solar radiation.

The SETRM covers the following (1) Analysis of the status of solar energy technologies (globally); (2) South African strengths in solar energy technologies; (3) Analysis of linkages with South African energy and climate change policies/strategies, and the current energy crisis; (4) Direction for energy research capability; (5) An assessment of the country's competitiveness in solar energy technologies; (6) A clearly articulated and peer reviewed prioritization process, core technologies to be developed over the next 10 years (split into a short, medium and longer term ) with clearly measurable objectives for each, should then be selected, and the associated roadmaps developed. The attendant resource requirements to be estimated, and (7) a SWOT analysis and associated mitigation measures.

**Statement of Purpose**

The South African Solar Energy Technology Road Map (SETRM) is being developed to provide a comprehensive, aligned, achievable and time-bound strategic plan that will help guide: policy and regulatory development, industrial strategy and related investment, education and skills programme development, innovation, research and development; and the overall diffusion of solar technologies in the country, as well as, given the country's significant regional impact, in the broader Southern Africa region.

**The objectives of the SETRM are:**

To develop a clear, comprehensive, and prioritized implementation plan (i.e. roadmap) for the development and diffusion of concentrated solar power; solar photovoltaic technology (ies); solar heating and cooling technologies; related R & D in South Africa toward reduced energy use, carbon emissions reduction; distributed electricity generation, expanded independent power production and electricity supply to the national grid, and the reduction of reliance on carbon fuels.

**Process**

The development process of the South African SETRM involves four key phases: Planning and Preparation; Visioning; Roadmap Development; and Roadmap Review and Validation. The Planning and Preparation phase of the SETRM process involves the undertaking of researching and aggregating available reports on the sector, attending stakeholder fora, engaging with sector stakeholders, and undertaking research on relevant policies, industry incentives, public and private stakeholders and sector earmarked finance.

The Visioning phase of SETRM process involves bringing key stakeholders together, along with the researchers, consultants and development partners that have been developing various independent solar sector related strategic plans and/or programmes that focus on South and Southern Africa.

The intent in convening the gathering is to enlighten everyone to the collective work being undertaken, illicit support for the various projects, and to explore points of mutual interest toward alignment and mutually beneficial exploitation of the various platforms that have been or are under development in the country.

The Roadmap Development phase of the SETRM process involves compiling and drafting a document that reflects the work that has been done in the country to date in the relevant solar fields and through a consultative process developing an aggregate set of goals, timelines, responsible actors, requisite inputs and catalysts and agreed on metrics to review progress and measure and evaluate the rate and degree of success achieved through the implementation of the SETRM process - within each of the three sub-sectors.

The Roadmap Review phase of the SETRM process is the final stage of the process and involves stakeholder review and assessment of the written plan of action and affords stakeholders the opportunity to point out any inconsistencies, changes, and/or corrections to be made to the SETRM report - toward the improvement of the document and toward increasing the likelihood that a maximum number of stakeholders will find the document relevant, useful in their planning, and worthy of being their default strategy to develop within their respective spheres of influence.

http://www.energy.gov.za/files/SETRM/setrm_overview.html

The South African Solar Thermal Technology Roadmap (SA-STTRM) is a project within the South African Solar Thermal Technology Platform (SA-STTP), which forms part of the SOLTRAIN 2 project. The other SOLTRAIN partners in Southern Africa, Namibia, Zimbabwe and Mozambique, are developing similar STTRMs and all four roadmaps will be incorporated into one document by the end of the project.

The SA-STTP supports the switch from fossil fuels to sustainable solar energy sources for applications such as water heating, (solar) cooling, process heat and low temperature steam.

The SA-STTP brings together all interested parties from academia, government, financial institutions, end-users and industry to;

- Share information on technical, practical and financial aspects of solar thermal energy
- Identify knowledge gaps and opportunities
- Mobilise institutions or individuals to do the required research
- Disseminate the results and keep record of the roll-out of solar thermal energy systems in the country

Furthermore, the SA-STTP links with a Southern African STTP as well as the STTP in Europe.

The SA STRM outlines the path to arrive at the ***Vision of the SA-STTP***, namely;

***To have ½ $m^2$ of net solar thermal collector area for every member of the population by 2030 in South Africa. (Circa 30 $10^6$ $m^2$ by 2030)[2].***

***This relates to an installed capacity of 21 $GW_{th}$ and annual electricity savings of 34 000 GWh, avoiding 23 Million tons of $CO_2$ every year.***

The estimated population in South Africa for 2030 is between 54 and 68 million[3] [4] [5]

From this, the target for solar thermal installations by 2030, according to the vision of the SA-STTP, is 30 million $m^2$ (if the population is taken at 60 million for 2030)

The estimated solar thermal installations at the end of 2014 is at least 2 277 835 $m^2$, made of by the following[6];

- Low Pressure Residential Solar Water Heating (1 $m^2$ per unit): 200 000 $m^2$
- High Pressure Residential Solar Water Heating (4 $m^2$ per unit): 1 200 000 $m^2$
- Multi Family Homes Solar Water Heating (10$m^2$ per unit): 10 635 $m^2$
- Industrial / Commercial installations for Solar Heating and Cooling (180 $m^2$ per installation): 3 444m
- Unglazed Swimming Pool Solar Water Heaters: (200 $m^2$ per unit): 867 000 $m^2$
- Solar Heat for Space Heating/Cooling in Buildings: (323 $m^2$ per unit): 1 292 $m^2$



[2] In comparison: Countries like Cyprus and Israel had already about 0.6 m² *of solar thermal collector area for every member of the population installed* in the year 2012 . *Source: IEA – Solar Heat Worldwide report, Edition 2014.*

[3] http://www.timeslive.co.za/local/2011/01/25/south-africa-s-population-to-shrink-after-2030

[4] http://www.issafrica.org/uploads/AF7_15Oct2013V2.pdf

[5] http://www.ifs.du.edu/ifs/frm_CountryProfile.aspx?Country=ZA

[6] http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2014.pdf

- Solar Passive Design in Buildings: No available statistics

## Existing legislation, regulations and government targets for South Africa

### Targets

Department of Energy: 1 Million Solar Water Heaters by 2014[7]

The White Paper on Renewable Energy (2003): 10 000GWh of energy to be produced from renewable energy sources by 2013[8]

The South African Government's National Development Plan 2030 has a target of 3 000 000 solar water heaters by 2030[9]

The 2011 Green Economy Accord signed by Government and business reiterates the 2014 target of 1 000 000 solar water heaters, secures the support of the insurance industry for replaced units, and commits to promote the marketing of solar water heaters[10].

### Regulation and legislation

SANS 10400-XA Energy Efficiency in New Buildings: A minimum of 50% of the annual average heating requirement for hot water must be provided by means other than electric resistance heating or fossil fuels[11]

The Preferential Procurement Policy Framework Act (PPPFA) regulations, which came into effect on the 7 December 2011, empower the Department of Trade and Industry to designate industries, sectors and sub-sectors for local production at a specified level of local content. Solar Water Heater Components have a 70% minimum threshold for local content[12].

### Rebates

Eskom: Residential solar water heater programme for high pressure solar water heaters[13]

Department of Energy contract programme for low-pressure solar water heaters (not in place as yet)

### Programmes

City of Cape Town Solar Water Heater Programme[14]

eThekwini: Shisa Solar[15]

Johannesburg: City Power Solar Water Heating Programme[16]

Nelson Mandela Bay and Ekhurhuleni Solar Water Heater Pilot Programmes (currently on hold)



[7] http://www.energy.gov.za/files/swh_frame.html
[8] http://www.energy.gov.za/files/renewables_frame.html
[9] http://www.gov.za/issues/national-development-plan/
[10] http://www.gov.za/documents/download.php?f=159756
[11] https://www.sabs.co.za/Sectors-and-Services/Services/Energy/index.asp
[12] http://www.dti.gov.za/industrial_development/ip.jsp
[13] http://www.eskom.co.za/IDM/EskomSolarWaterHeatingProgramme/Pages/Solar_Water_Heating_Programme.aspx
[14] http://savingelectricity.org.za/pages/water_heaters.php
[15] http://www.shisasolar.org.za
[16] http://www.joburg.org.za/index.php?option=com_content&view=article&id=8304:08102012-launch-of-solar-water-heating-programme-by-city-power&catid=217:press-releases-2013&Itemid=114

# 2. The technology roadmap

For the purposes of this roadmap, the solar thermal applications in South Africa are divided into sub divisions, namely;

- Residential Solar Water Heating
  - High Pressure Residential Solar Water Heating
  - Low Pressure Residential Solar Water Heating
- Industrial / Commercial / Multi-Family Housing Installations for Solar Heating and Cooling
- Unglazed Swimming Pool Solar Water Heaters
- Solar Passive Design in Buildings
  - Solar Heat for Space Heating in Buildings
  - Passive solar heating in buildings

A roadmap for each of these sections is developed below and these roadmaps are then combined in Section 3.

The following priority research themes as identified in a SOLTRAIN stakeholders workshop held on 7 October 2014 at the SESSA/SAREC offices in Parkwood, Johannesburg and for which SANEDI gave major input, are included in the SA-STTRM. This priority list is understood to be open-ended.[17]

**High Priority**

1. Research national policies of 10 international ST champions (Cyprus, Austria, Israel ..) & their applicability to SA
2. Update C van Horen *Externality Cost Study of Electricity Generation in RSA* which was written in the previous century
3. Independent research on peak demand impact of Eskom SWH Rebate Scheme
4. Independent study on lessons learned from Eskom SWH rebate scheme, including energy saved
5. Optimisation study on enlarged SWH energy storage cost vs peak demand cost saving
6. Development of a transparent, interactive model to create long-term stable government Solar Thermal policies
7. Government and SESSA awareness campaigns to focus on EE rather than rebates. Research end user perceptions, preferences
8. Research Solar Thermal Market potential in South and Sothern Africa (see EU study)
9. Quantify historical cost of policy uncertainty in RSA
10. Research efficacy import duties vs local content legislation in RSA

**Medium Priority**

11. Study on nameplate standing losses vs reality standing losses of all storage HW systems
12. Social uplitment cost/benefits of SWH
13. Job creation through maintenance on Eskom rebate installations

[17] http://www.blackdotenergy.co.za/events-seminars/

14. Finding a cost-effective test procedure reflecting realistic frost risk in South Africa, including climate change
15. Research perceived stigma/status attached to LP/HP SWH
16. Research Solar Cooling technologies suitable for RSA

**Low Priority**

17. Find a low-cost SWH that is suitable for both the high and low-income market, which can be completely manufactured in SA with materials and components from SA.

## Roadmap 1: High Pressure Residential Solar Water Heating

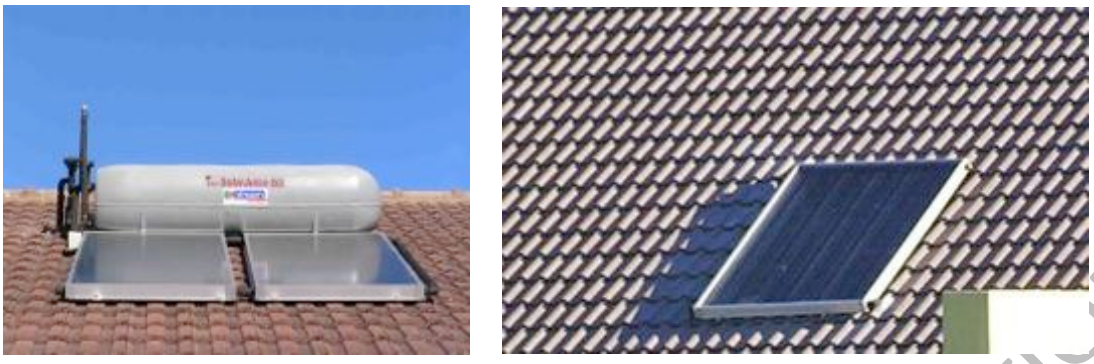

**Figure 1: Typical high pressure solar water heaters with flat plate collectors**

High-pressure (HP) solar water heaters are the typical technology used by middle to upper income families in residential homes. They consist of a high-pressure water tank, or geyser, and a solar collector. Units included under this definition are the typical HP systems as were defined by the Eskom SWH programme as well other as HP tank and collector combinations for household use.

The solar collector can be flat plate or evacuated tubes, and the transfer of heat to the geyser can be direct or indirect, and circulated by thermosyphon or pumped. The geyser can be installed above the collector outside, or split and installed inside the roof space.

Water is traditionally heated by electric resistance elements in South Africa and the energy to heat hot water typically requires up to 50% of monthly residential electricity spend. South Africa is blessed with abundant sunshine, and switching to a solar water heater can typically save more than 70% of the electricity spend for hot water over a year[18].

A rebate, based on the potential electricity saving that generally amounts to about one third of the capital cost of the installation, has been available through Eskom since 2008 to the end of 2014.

An amendment to the National Building Regulations and Building Standards (SANS10400 Part XA: Energy usage in Buildings) to introduce requirements for energy usage in buildings came into effect on 9 November 2011. This includes the requirement to install a SWH or heat pump in all new buildings for 50% of the water heated[19].

The City of Cape Town as well as eThekwini Municipality have programmes in place to promote the installations of high-pressure solar water heaters. Nelson Mandela Bay Metropole and Ekhuruleni Municipalities had pilot programmes in place where high-pressure solar water heaters could be paid off via the municipal bill. Both these programmes are on hold at present.

The cost for solar water heaters can be added to a home loan and short-term loans are supported by all the large commercial banks[20] [21] [22] [23]. The insurance industry (the largest procurer of standard geysers in South Africa) supports the switch to solar and actively supports the SWH industry[24] [25] [26] [27] [28].



[18] http://solarthermalworld.org/sites/gstec/files/Solar%20Market%20-%20South%20Africa.pdf
[19] http://www.buildingregulations.co.za/free-downloads/
[20] http://www.absa.co.za/Absacoza/Offers/Promotions/Solar?cmpid=PSC_BT13101
[21] http://www.nedbank.co.za/website/content/homeloans_microsite/greening.asp
[22] http://sustainability.standardbank.com/solar-water-heaters/

The strong government support, coupled with the financial benefits from installation of a solar water heater, has convinced many entrepreneurs on entering the market, significantly growing the supply side[29]. However, all these measures have not been able to convince households in South Africa to install solar water heaters, and the demand remains low.

The total residential geyser market in South Africa is estimated at 450 000 units per year. In the light of this, it should be clear from Figure 2 and Figure 3 that the high-pressure solar heater market is performing well below its potential. The average solar collector area per residential solar water heater installation is estimated at 4 $m^2$ [30].

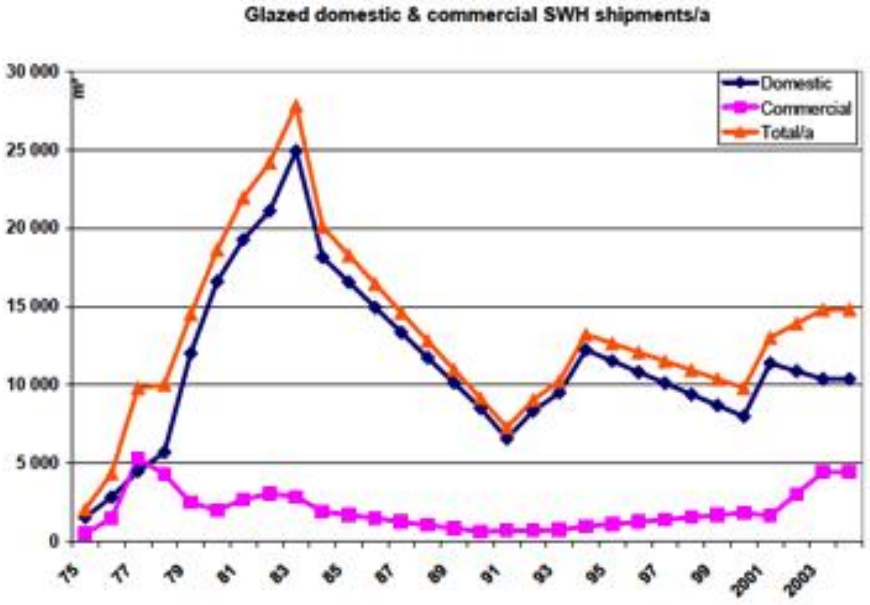


**Figure 2: Solar water heater collectors installations in $m^2$ per year 1975 - 2005[31]**



[23] https://www.fnb.co.za/home-loans/building-loan.html
[24] http://sustainability.standardbank.com/solar-water-heaters/
[25] http://www.nedbankgroup.co.za/sustainEnvironmentFacilitation.asp
[26] http://www.santam.co.za/about-us/media-centre/sustainability/hot-water-is-going-green-with-santam/
[27] http://www.absa.co.za/Absacoza/Offers/Promotions/Solar?cmpid=PSC_BT13101
[28] http://www.thefulcrumgroup.co.za/uploads/files/SAIA_Bulletin_-_May_2014_+114835.pdf
[29] http://green-cape.co.za/assets/Uploads/GreenCape-MIR-Energy-Efficiency.pdf
[30] HOLM, D. 2005. **Market Survey of Solar Water Heating in South Africa.** Energy Development Corporation (EDC) of the Central Energy Fund (CEF). Johannesburg, quoted by http://solarthermalworld.org/sites/gstec/files/Solar%20Market%20-%20South%20Africa.pdf
[31] http://solarthermalworld.org/sites/gstec/files/Solar%20Market%20-%20South%20Africa.pdf

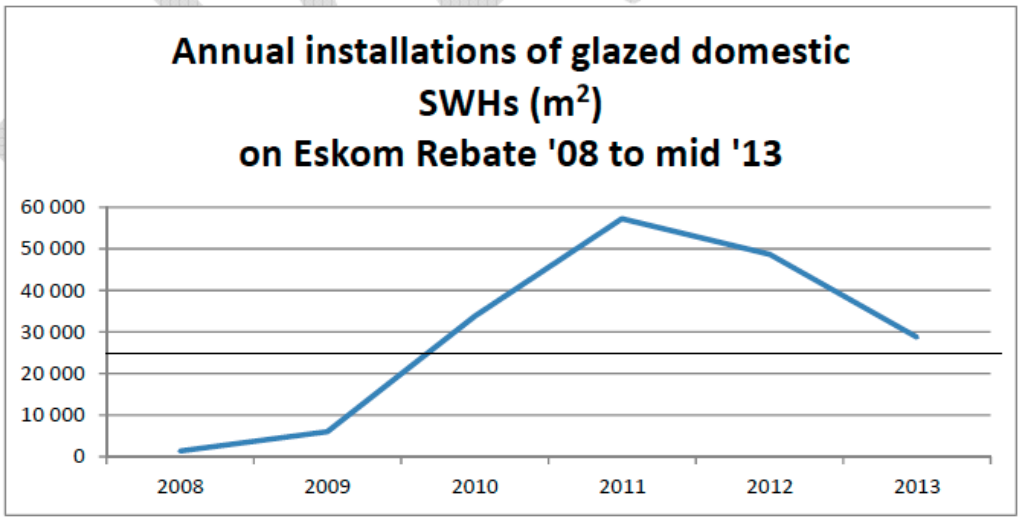


**Figure 3: Solar water heater collector installations in $m^2$ per year on the Eskom rebate 2008 - 2013[32]**

Estimated units installed 2014: ~150 000[24]

Estimated installation area at 4 $m^2$ per installation: ~600 000 $m^2$

Estimated total houses with existing geysers in South Africa for 2009 (potential for solar water heaters at 1 geyser per house at 100% penetration) ~4 200 000[33]

Target for 2030: ~12 000 000 $m^2$ (3 000 000 units)

To grow the installed area to ~12 000 000 $m^2$ by 2030, requires a growth rate of 21% per annum on annual installations.



[32] http://green-cape.co.za/assets/Uploads/GreenCape-MIR-Energy-Efficiency.pdf

[33] http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCMQFjAB&url=http%3A%2F%2Fsessa.org.za.resources.s3.amazonaws.com%2FSWH_DoE_High_Level_%2520Framework_Workshop_5Nov.pdf&ei=2BIrVOz5PMqM7Abtn4GQCQ&usg=AFQjCNHIHc6BnDhtYv4aAfyIMKLZSJ4HUg&bvm=bv.76477589,d.ZGU&cad=rja

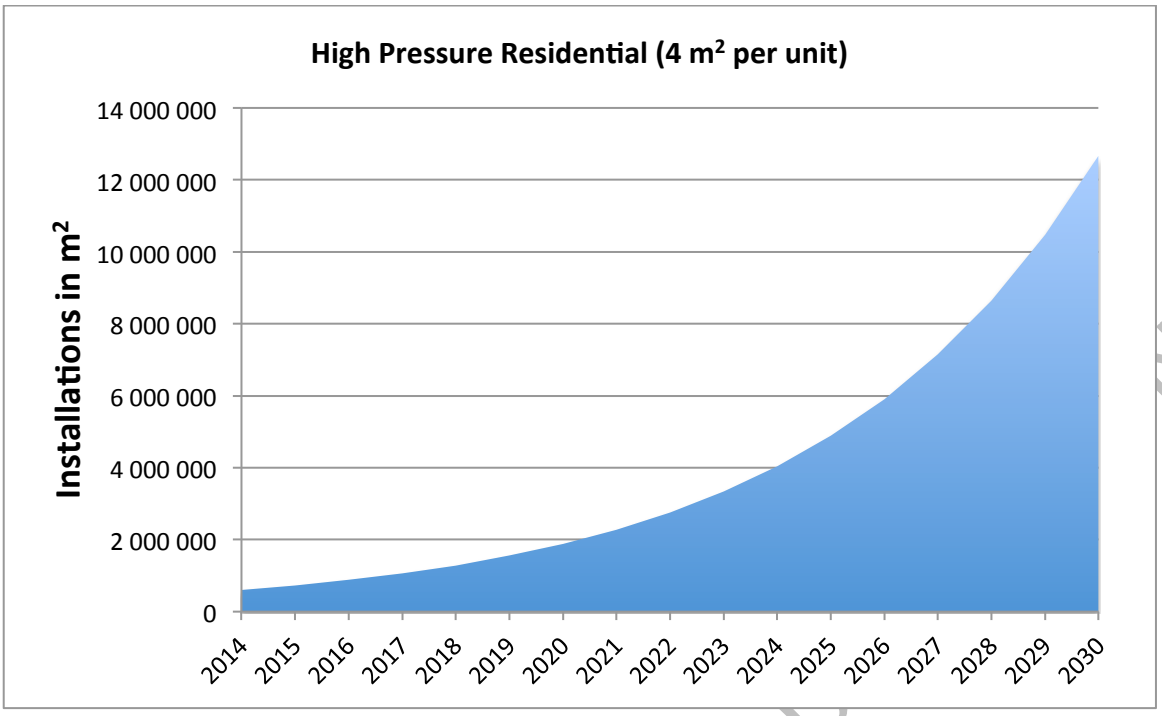


**Figure 4**: Projected installations for the high pressure system sector based towards the goal to reach 0.5 m² installed collector area per inhabitant by 2030.To reach this, an annual 21% growth rate in installations is necessary



**Table 1: Industry and Government roles in support of High Pressure Residential Solar Water Heaters**

| **Awareness and Marketing** | |
|---|---|
| **Industry Role** | Collect and share consumer satisfaction surveys<br>Develop the needs for marketing campaigns<br>Improve the awareness of cost saving of solar<br>Support Government and SESSA awareness campaigns to focus on EE rather than rebates. Research end user perceptions, preferences |
| **Government Role** | Support industry in awareness and marketing activities<br>Assist and support (financially and through leadership by example) marketing campaigns – Awareness of rebate schemes and other support structures<br>Support and develop installations for demonstration purposes<br>(Compare CSIR campaign of 1970 / 1080 for awareness)<br>Create an awareness of available support for start-up cost (including testing cost) for new entries in the market<br>Develop Government and SESSA awareness campaigns to focus on EE rather than rebates. Research end user perceptions, preferences<br>Demonstration Projects |
| **Research and Development** | Raise the awareness of research capacity / not just technology, also markets<br>Create awareness of the role of research to assist industry in pricing and improving |

| | |
|---|---|
| | the technology<br>Monitor and feed-back of existing installations<br>Disseminate research results |
| **Institutional Issues** | |
| **Industry Role** | Insurance sector could take a leading role[34]<br>Banks need to actively promote loans for SWHs<br>Industry needs to clean up its own act – perception of charlatans. Strong ombudsman function lead by industry (end user does not trust the industry)<br>Create shared back-up pool to cover poor installations<br>Share information on a merged platform |
| **Government Role** | Create a clear, transparent, stable and consistent policy environment that is communicated in time with good lead times<br>Continue with the SWH rebate scheme until a sustainable market is established<br>Support the inclusion of component testing [35] [36] Announce changes well in advance<br>Promulgate and enforce regulations for a switch to green hot water at point of geyser failure (to support the insurance industry)<br>Promulgate and enforce regulations for energy efficient water heating at sale of property<br>Support local manufacturing concerns (mainly concerns of the manufacturing industry on the sustainability of the market supported by subsidies)<br>Apply SANS10400 and other relevant legislation consistently at Local Government level<br>Create a link between performance test on components and where the product is installed geographically in an easy to understand outline<br>Share information on a merged platform<br>Support SWH Testing Facilities |
| **Research and Development** | Collaborate on a national basis to ensure productive use of resources<br>Define research priorities in consultation with Industry and Government stakeholders<br>Lobby for additional funding to support SWH R&D |
| **Education and Training** | |
| **Industry Role** | Ensure all installers well trained and certified<br>Ensure proper maintenance<br>Ensure well trained salesperson<br>Industry organisations to develop and enforce accreditation for members (SESSA/PIRB/Builders) and use ombudsman to bring renegades to account<br>Make use of skills development programmes |
| **Government Role** | Develop, support and expedite training certification (qcto / saqwa) – hot water installation qualification<br>Develop hands on public education<br>Regulate installer and COC certification<br>Support start-up cost (including testing cost) for new entries in the market |



[34] http://www.thefulcrumgroup.co.za/uploads/files/SAIA_Bulletin_-_May_2014_+114835.pdf
[35] http://green-cape.co.za/assets/Uploads/energy-efficiency/The-case-for-component-testing-du-plessis-mulcahy.doc
[36] http://green-cape.co.za/assets/Uploads/energy-efficiency/Component-testing-for-SWH-120912-1.pdf

| | |
|---|---|
| **Research and Development** | Support education and training activities by making expertise and facilities available |
| **Research and Development** | |
| **Industry Role** | Support initiatives to collect and share installation statistics<br>Develop more efficient and lower cost collectors<br>Reduce manufacturing cost of collectors, tanks and components |
| **Government Role** | Take the lead with collection and sharing of installation statistics in IEA SHC format, and incorporate in annual Stats SA reports<br>Fund R&D in this area<br>Enhance regional alignment of manufacturing and installation standards |
| **Research and Development** | Conduct appropriate SWH R&D based on the requirements of the STTP |

## Roadmap 2: Low Pressure Residential Solar Water Heating

**Figure 5: Typical gravity fed / low-pressure solar water heater with evacuated tube collector**

Gravity fed solar water heaters, also known as low-pressure solar water heaters, represent the typical technology used for water from solar thermal energy in low cost housing developments in South Africa. The hot water tank is fed via a separate feeder-tank with a ball valve to reduce the high pressure of the water from the municipality, and the hot water flows to the house with the pressure from gravity alone, minus pressure losses of the pipework. These geysers are always installed on the rooftop and most make use of evacuated tubes to collect the solar heat.

The South African government supported the installation of gravity fed solar water heaters with the Division of Revenue Act Allocations (DoRA) from 2009 – 2011, and a rebate from 2011 to December 2012. About 400 000 units (mostly Chinese imports) were installed with these schemes. A Revised Contracting Model has been designed and would have been rolled out in 2014. Due to the sectoral determination from the Department: Trade and Industry, only units deemed to be locally manufactured will be able to qualify for this programme.

Over and above these national initiatives, some local governments also have installed, and are in the process of installing gravity fed solar water units for low-income households. Some examples are Kuyasa, Joe Slovo[37] and Lwandle[38] in Cape Town, The City of Johannesburg solar water Heating Programme by City Power[39], Nelson Mandela Bay Metropole's Zanembula Solar Water heater Pilot Project[40] and eThekwini's Low Cost Solar Water Heater Programme[41]

Low-pressure, gravity-fed solar water heaters can in addition play a role in off grid rural areas, for large and small scale applications, such as residential, game lodges, clinics, mining, staff ablution blocks etc.

Estimated installations 2014: 400 000



[37] http://www.westerncape.gov.za/news/solar-water-heaters-and-partnership-pays-joe-slovo-housing-langa

[38] http://lcs-rnet.org/pdf/lcs_rnet_meetings/2010/ppt_p5_2_3_Thorne_prst.pdf

[39] http://www.joburg.org.za/index.php?option=com_content&view=article&id=8304:08102012-launch-of-solar-water-heating-programme-by-city-power&catid=217:press-releases-2013&Itemid=114

[40] http://www.nelsonmandelabay.gov.za/Content.aspx?objID=425

[41] http://www.kznenergy.org.za/download/projects/8_eThekwini_Energy_Office_Project_Briefing_Document_Low_Cost_Solar_Water_Heaters.pdf

Estimated $m^2$ of installation area at 1 $m^2$ per installation: 400 000 $m^2$

Estimated total houses without geysers in 2009 (potential units at 100% penetration at 1 geyser per house) ~5 300 000[42]

The South African government has committed to install 600 000 units in the next two years. For the purposes of this roadmap, it is presumed that this commitment of 300 000 units per year will be sustained up to 2030, to produce a total installation number of 5 200 000.

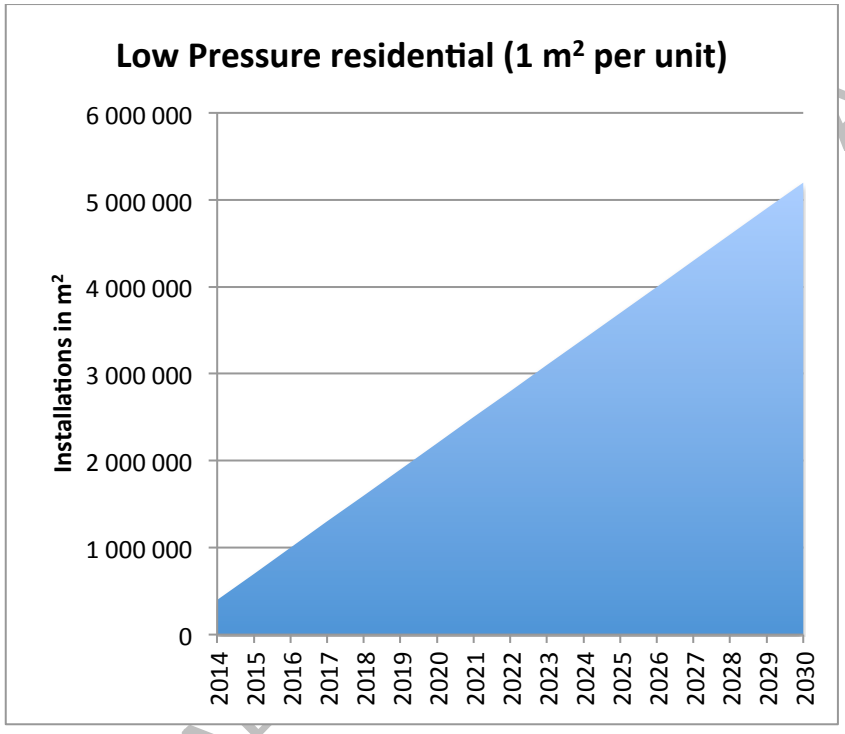


**Figure 6:** Projected installations for the low pressure system sector based on the goal to reach 0.5 m² installed collector area by inhabitant by 2030.



[42]http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCMQFjAB&url=http%3A%2F%2Fsessa.org.za.resources.s3.amazonaws.com%2FSWH_DoE_High_Level_%2520Framework_Workshop_5Nov.pdf&ei=2BIrVOz5PMqM7Abtn4GQCQ&usg=AFQjCNHIHc6BnDhtYv4aAfyIMKLZSJ4HUg&bvm=bv.76477589,d.ZGU&cad=rja

**Table 2: Industry and Government roles in support of Gravity Fed Residential Solar Water heaters**

| | |
|---|---|
| **Awareness and Marketing** | |
| **Industry Role** | Promote low pressure SWHs in low income communities, urban and rural areas<br>Raise the awareness in agricultural and other areas that fall outside of the DoE roll-out programme<br>Raise awareness of life cycle cost of higher quality, more expensive units vs lower cost, lower quality units<br>Create awareness of the positive stories to counteract bad experience/press |
| **Government Role** | Promote and subsidise low pressure SWHs in low-income communities<br>Include other communities outside formal settlements in the DoE roll-out programmes<br>Raise awareness of other rebate / subsidy schemes (ie local government schemes) available for low-pressure SWHs |
| **Research and Development** | Increase the awareness of the available expertise available to test and develop low-pressure SHW components and systems |
| **Institutional Issues** | |
| **Industry Role** | Develop manufacturing facilities for low pressure systems, especially collectors<br>Industry needs to clean up its own act – perception of charlatans. Strong ombudsman function lead by industry<br>Ensure good quality systems with strong warranties – ombudsman can play a role<br>Strong industry body to work with financial institutions to come up with a warranty fund (fidelity fund) where % of revenue goes into fund to maintain the installed systems |
| **Government Role** | Develop and implement a stable, clear, transparent, stable and consistent policy environment that is communicated in time with good lead times<br>Put measures in place for the roll out of 300 000 units per year on an on-going, sustainable basis<br>Enforce local manufacturing requirements<br>Enforce SA National Building Regulations on all buildings, with penalties for non-compliance<br>Develop clear legal direction on ownership of installed systems, especially concerning maintenance and/or replacement of hail damage etc.<br>Investigate possibility of alternative support schemes (soft loans)<br>**Enforce** minimum product and installation standards, including warranty<br>Address the current problems with failing, low quality systems installed to date<br>Support the testing of components |
| **Research and Development** | Collaborate on a national basis to ensure productive use of resources<br>Define research priorities in consultation with Industry and Government stakeholders<br>Lobby for additional funding to support SWH R&D |
| **Workforce Development (Training and Education)** | |
| **Industry Role** | Ensure oversight from qualified installers<br>Employ formally trained staff and support the formal training of existing staff |
| **Government Role** | Support training and certification of installers |
| **Research and Development** | Support training programmes with expertise and facilities |
| **Research and Development** | |

| | |
|---|---|
| **Industry Role** | Develop low cost, low pressure SWHs<br>Research into life cycle cost of higher quality, more expensive units vs lower cost, lower quality units |
| **Government Role** | Support the development of low cost, low pressure SWHs that can be locally manufactured<br>Support research into the cost of and impact of past and new subsidy schemes |
| **Research and Development** | Conduct appropriate SWH R&D based on the requirements of the STTP |

## Roadmap 3: Industrial / Commercial / Multi-Family Residential installations for Solar Heating and Cooling

**Figure 7: The world's largest solar thermal installation for industrial application at a copper mine in Chile[43]**

**Figure 8: Typical multi family building solar water heater installation, Stellenbosch**



[43] http://solarthermalworld.org/content/275-mw-provide-heat-copper-mine-chile

**Figure 9: Installation at student residences, University of Pretoria**

In this section of the road map, all solar water heater installations that are of a larger size than for a typical household are combined. These can include installations for multi family homes, flats and dormitories, shopping centres and office blocks as well as industrial installations where solar thermal energy is used for process heat and or cooling.

The large percentage of final energy used in South Africa, coupled with the good solar resource, results in a yet to be exploited potential for larger solar thermal energy systems for industrial and commercial applications. Large SWH installations are also frequently used in multi-family residential units such as apartment blocks, hostels and student residences.

For case studies of large systems installed in South Africa, see http://www.blackdotenergy.co.za

Installations for this sector are estimated at 213 installations of ~50 $m^2$, giving a total installed area of 10 635 $m^2$ for 2014.

If this market is grown at 60% per year on total installed area from this very low base, a total area of 368 935 $m^2$ will be installed by 2030.

Estimated installations 2014: 213[44]

Estimated $m^2$ of installation area at 50 $m^2$ per installation: 10 635 $m^2$

Estimated number of hotels and multi family homes in South Africa ???

Potential for industrial process heat might be determined from boiler statistics, which are at present not available.

If this market is grown with 40% per year on total installations, there will be 48 848 m2 of solar collectors installed by 2030.

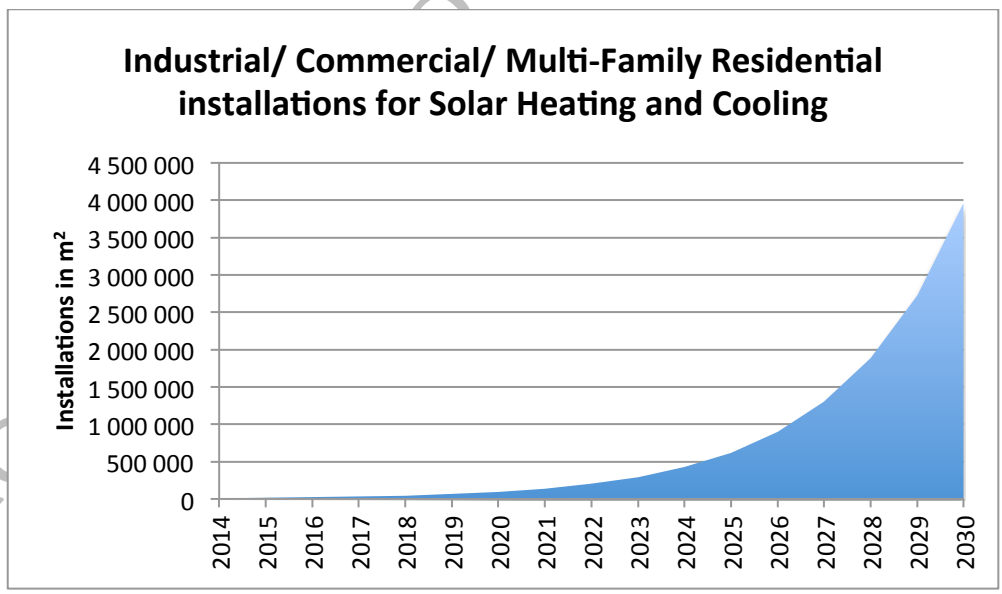


**Figure 10:** : Projected installations for Industrial / Commercial / Multi-Family Residential installations based on the goal to reach 0.5 m² installed collector area by inhabitant by 2030.

[44] http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2014.pdf

**Table 3: Industry and Government roles in support of large-scale Industrial/Commercial Solar Collectors**

| | |
|---|---|
| **Awareness and Marketing** | |
| **Industry Role** | Develop expertise and products for larger scale SWH applications<br>Promote larger systems to industrial clients |
| **Government Role** | Implement rebates or other incentives for large customers as part of a demand side management programme<br>Lead by example<br>Promote the use of SWHs in the industrial and commercial sectors<br>Establish a dedicated subsidy programme for large-scale solar thermal systems. This should include mandatory consulting of experts in the planning phase and also mandatory third party monitoring of the installed systems e.g. by Universities. This way negative examples can be avoided and attractive showcases proving the reliability and financial effectiveness of large SWH systems can be communicated effectively. |
| **Research and Development** | Develop and distribute material to promote the application of larger SWH installations<br>Carry out the independent consulting and monitoring programme for the subsidy programme described above. |
| **Institutional Issues** | |
| **Industry Role** | Insure standard maintenance contracts, and maintenance training<br>Clarify the necessary steps needed to be able to offer solar heat contracting (to overcome amortisation time dilemma).<br>Establish international cooperation with other solar thermal industry associations. |
| **Government Role** | Introduce SWH legislation for preheating and industrial/agricultural process heat<br>Certification of components / efficiency curves of collectors / certified collectors<br>Design phase<br>Design to be signed off by a competent person (this is in the EE building regulation) in place<br>Enforcement of EE building regulation |
| **Research and Development** | Monitor and publish results of large SWH installations<br>Collaborate on a national basis to promote large-scale SWH R&D<br>Define research priorities in consultation with Industry and Government stakeholders<br>Lobby for additional funding to support large-scale ST R&D<br>Establish international cooperation with research institutions working on large-scale ST systems |
| **Education and Training** | |
| **Industry Role** | Employ or consult trained engineers and technicians to design, install and maintain larger systems |
| **Government Role** | Support training programmes at the tertiary level of engineers and technicians qualified to design and install large SWH systems<br>Support the training of building control officers to evaluate the current and future specificantions<br>NHBRC building contractors |
| **Research and Development** | Develop training programmes for engineers and technicians that can design and install large SWH systems |

| | |
|---|---|
| | Support training and education of engineers and technicians with expertise and facilities |
| **Research and Development** | |
| **Industry Role** | Develop products and components for local manufacture<br>Support the development of in-house and external expertise to design and implement large SWH systems |
| **Government Role** | Support the R&D of local components for the industry |
| **Research and Development** | Conduct appropriate SWH R&D based on the requirements of the STTP for large-scale SWH systems<br>Develop low-cost monitoring systems to effectively assess the performance of installed large-scale ST systems |

## Roadmap 4: Unglazed Swimming Pool Solar Water Heaters

**Figure 11: Typical rooftop installation of an unglazed swimming pool heater in South Africa**

The market for unglazed swimming pool heaters is showing strong growth in South Africa, without any government support or interventions. These heaters consist of an array of thin plastic tubes, usually installed on a roof or any other suitable flat surface. When the pool pump circulates the water through the filtration systems, the water is also circulated through the collector and heats up at high efficiencies because of the small temperature rise required.

Estimated installations 2014: 4 335[45]

Estimated $m^2$ of installation area at 20 $m^2$ per installation: 86 700 $m^2$

The number of swimming pools in South Africa is estimated at 800 000[46]

If this market is grown with 35% per year on total installations, there will be 527 630 installations, or 10 522 598 $m^2$ of solar collectors installed by 2030, which represents 65% of the current number of swimming pools in South Africa.



[45] http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2014.pdf
[46] http://active.cput.ac.za/energy/past_papers/DUE/2008/PPT/DUE%20Conference%20-%20Workshops/Swimming%20Pools/R%20Hill.pdf

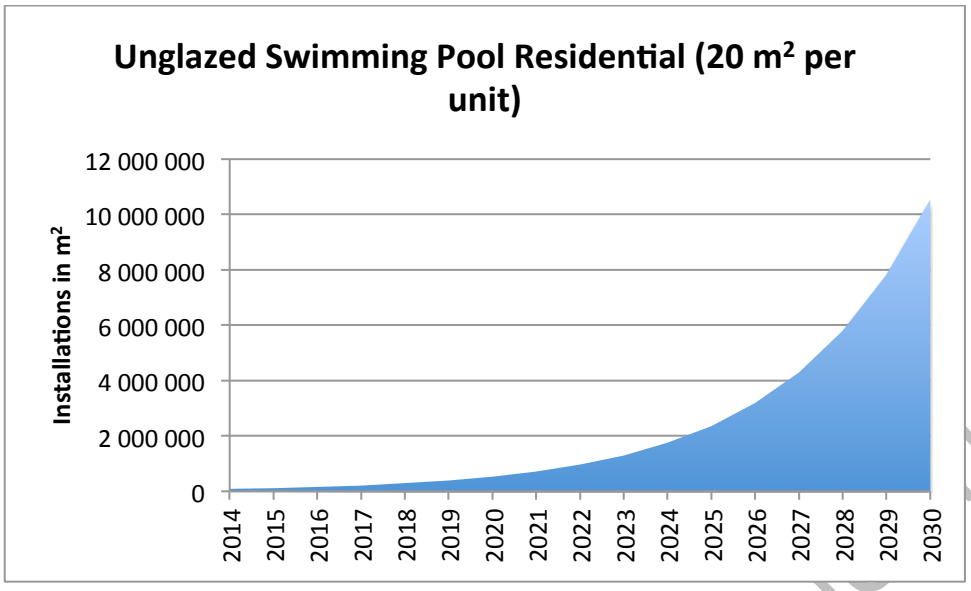


**Figure 12:** Projected installations for unglazed solar collectors for swimming pool applications based on the goal to reach 0.5 m² installed collector area by inhabitant by 2030.

**Table 4: Industry and Government roles in support of Unglazed Swimming Pool Solar Water Heaters**

| | |
|---|---|
| **Awareness and Marketing** | |
| **Industry Role** | Promote unglazed collectors for swimming pools |
| **Government Role** | Promote unglazed collectors for swimming pools |
| **Research and Development** | Conduct measurements and publish the results to quantify the benefit of unglazed SWHs |
| **Institutional Issues** | |
| **Industry Role** | Develop suitable unglazed SWH systems for SA conditions |
| **Government Role** | Replace non-solar water heaters with solar on all government installations, public swimming pools |
| **Research and Development** | Participate in collaborative research and measurement projects, specifically with industry |
| **Workforce Development** | |
| **Industry Role** | Train installers of unglazed systems |
| **Government Role** | Support development of formal training programmes of installers |
| **Research and Development** | Support training activities with expertise and facilities |
| **Research and Development** | |
| **Industry Role** | Support the development of lower cost collectors |
| **Government Role** | Support the development of lower cost, locally manufactured collectors |
| **Research and Development** | Conduct appropriate SWH R&D based on the requirements of the STTP |

## Roadmap 5: Passive Solar Thermal (PST) heating /cooling of buildings

Solar passive design is the art and science of using the natural forces of a given climate and a building's orientation, size, disposition and management of its elements in order to achieve indoor comfort, while using a minimum of imported energies. Energies flow naturally while the building is in a passive mode – hence passive design.

Solar thermal buildings outlast the life cycle of power stations, and can be built faster and more cost-effectively. These buildings constitute solar collectors with built-in energy storage facilities.

Solar passive or solar thermal (PST) design pertains to *inter alia* orientation, window placement, operable windows, thermal mass, insulation and solar chimneys. While ST design can be quite demanding and sophisticated, the building systems are typically simple, demanding minimal maintenance. Solar thermal design also reduces the energy demand of HVAC buildings.

Buildings in the Developing and Developed World consume 40% of the primary energy, while emitting 36% of GHGs (UN University for Advanced Study of Sustainability, 2015. **Sustainable Urban Futures**). The main driver for energy use in buildings is the lack of indoor comfort. Efforts to address this lack of comfort include artificial lighting, artificial heating/cooling, (de)humidification, and fresh air supply. Artificial lighting tends to increase the amount of excess indoor heat generation, as does the increasing use of electric appliances that eject their waste heat into the indoor environment.

In South Africa, heating and cooling accounts for 38.5% of the total final energy consumed in buildings (DAH 2007). In all new buildings, this percentage has to be reduced gradually to near zero by the year 2030: ..."Progressively strengthen the energy efficiency criteria set out in the South African National Standard 204 to achieve a zero carbon building standard by 2030..." (NDP, p. 288, Ch. 8 - Transforming Human Settlements). The assumption is that the existing building stock will be upgraded at a rate of 9% per year (R Milford 2009. **Greenhouse Gas Emission Baseline and Reduction Potential from Buildings in South Africa.** UNEP SBCI, Paris).

The combined annual savings of *new* PST buildings plus upgrading of the *existing* stock has been illustrated in **Figure 13**.

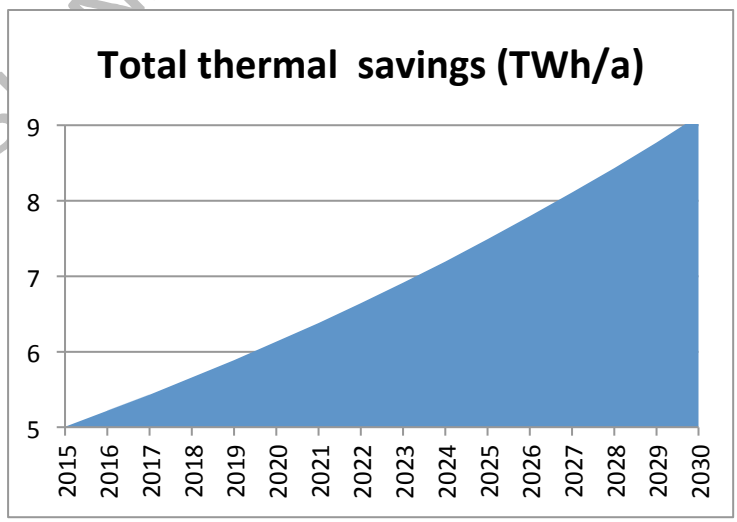


**Figure 13: Annual savings through solar thermal heating/cooling of new and retrofit buildings in South Africa in TWh/annum**

The above savings can be translated into equivalent SWH collector areas as follows:

Assuming an average global radiation of 1900kWh/$m^2$.a in South Africa, this translates to an average energy harvest of 1900kWh/$m^2$.a x 0, 44 = ±800kWh/$m^2$a. Hence, one TWh is equivalent to 1 250 000$m^2$ of SWH. The resultant SWH equivalent area of the annual savings through solar thermal buildings is shown in **Figure 14**.

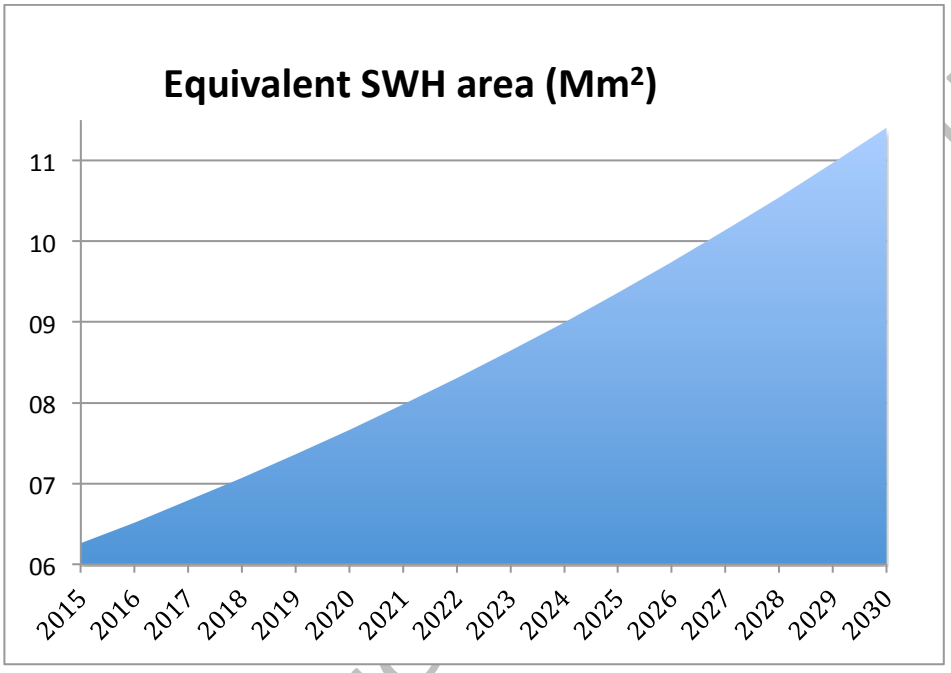


**Figure 14: Equivalent SWH area of solar thermal heating/cooling of new and retrofit buildings in South Africa in Million $m^2$**

It should be noted that solar thermal buildings include at least one day's integral thermal storage as a result of the prescribed interior thermal mass (SANS10400XA).

The above calculation does not include the energy content of manufacturing, transporting and demolishing building materials and components.

**Table 5: Industry, Research and Government roles in support of Passive Solar Thermal (PST) Design in Buildings**

| **Awareness and Marketing** | |
|---|---|
| **Industry Role** | Lack of awareness and information is a key barrier: overcome by programs promoting passive solar thermal (PST) efficiency in buildings.<br>Champion the NDP target of Near Zero Energy Buildings incorporating PST by 2030.<br>Demand leadership by example in solar thermal government buildings from all tiers of government<br>Advertise the fact that higher levels of energy efficiency in buildings result in increased economic production for the same amount of energy.<br>Make architects, contractors and vendors aware of possible (potential) funding opportunities for PST design (informed customer)<br>Include orientation, local site environment (model local climatic data, impacts of |

| | |
|---|---|
| | overshadowing and physical obstruction to predict solar gain annually) and natural lighting (climate-based daylight modelling) in all new house/building plan design prior to building. |
| **Government Role** | Lead by example in implementing/upgrading passive solar thermal improvements to government buildings from all tiers of government. Implement program for all government buildings to be near zero energy at least two years ahead of the private sector.<br>Prioritise PST buildings as part of the NDP.<br>Monitor and publish ST buildings progress in Stats SA.<br>Provide solar access rights by providing restrictions on vegetation, structures and objects that could impair passage of light or air flow.<br>Feed in tariffs to guarantee prices for developers when implementing PST designs in new building based on future health and environmental benefits. |
| **Research and Development** | Develop and implement passive PST building design curricula at tertiary institutions.<br>Develop and support regional and sub-regional centres of excellence of passive PST building design and implementation.<br>Monitor and publish existing buildings' energy performance.<br>Update SANS10400XA annually. |
| **Institutional Issues** | |
| **Industry Role** | Create multidisciplinary PST building forum.<br>Provide consumers with a home (current and building plan) energy rating using certified energy raters.<br>Report energy rating, estimate of annual energy use and cost, recommended improvements, their costs, potential savings and expected payback time for building improvements (consumer pays for service but cost included in loan) |
| **Government Role** | Invoke SANS10400XA rigorously at municipality level and prosecute non-compliance.<br>Implement appliance and building energy rating as a priority.<br>Package of interventions in standard 30m$^2$ RDP house: ceiling, roof insulation, window size and partitions (short payback); residential and commercial building codes can require higher efficiency standards in middle – and upper income houses and commercial buildings (regulation rather than subsidy);<br>Local government finance efficiency measures and recoup the outlay by structuring tariffs to include the saved energy costs as repayments.<br>Financial incentives rather than regulation (tax credits) for passive design upgrades<br>Provide consumer loans at lower interest PST improvements. |
| **Research and Development** | Study applicability of international ST building success stories and feed back to national building regulations. |
| **Workforce Development** | |
| **Industry Role** | Obtain feedback from developers and other stakeholders.<br>Promote Green Building Council work.<br>Participate in Eskom Eta Award Competitions.<br>Potential for job creation in passive design and construction.<br>Train more energy raters. |
| **Government Role** | Train building inspectors and designers in PST aspects in the national building regulations.<br>Develop courses in ST building design. |

| | |
|---|---|
| | Provide loans in the range of 10 to 20 per cent of incremental capital required for PST improvements or upgrades would likely be enough to tip balance in favour of energy efficiency investments and job creation opportunities in PST. |
| **Research and Development** | Develop and promote methodologies to upgrade the existing building stock in South Africa, including finance models. |
| **Research and Development** | |
| **Industry Role** | Financial institutions and government to create a low-interest fund for PST buildings in South Africa.<br>Move beyond pilot project research, scale up demonstration projects |
| **Government Role** | Target new and existing energy intensive government buildings for priority ST interventions.<br>Develop and implement solar access legislation to protect investment in ST facilities.<br>Cooperate regionally on PST developments.<br>Provide standards, incentives and recovery of PST program costs.<br>Use all PST technologies without selecting a winner.<br>Build/create long term foundation for passive solar research in RSA |
| **Research and Development** | Increase PST research budget to 4% of total investment of buildings in South Africa. |

*Authors of Roadmap 5: Dieter Holm and Contributors: Frank Raymondo (green home owner) Keith (Energy expert), Malcolm Worby (green architect), Jean Simonis (Hydrologist) and energy experts from Specialised Solar Systems

# 3. Combined roadmap and way forward

**Table 6: Total installations of solar collectors in $m^2$, 2014 – 2030**

| | High Pressure Residential systems (4 $m^2$ per unit) [$m^2$] | Gravity Fed residential systems (1 $m^2$ per unit) [$m^2$] | Industrial/ Commercial/ Multi-Family Residential installations for Solar Heating and Cooling [$m^2$] | Unglazed Swimming Pool Collectors (20 $m^2$ per unit) [$m^2$] | Passive Solar Thermal (PST) heating /cooling of buildings [$m^2$ equivalent] | TOTAL (excluding PST) [$m^2$] |
|---|---|---|---|---|---|---|
| 2014 | 600 000 | 400 000 | 10365 | 86 700 | - | 1 099 079 |
| 2015 | 726 000 | 700 000 | 15029 | 117 045 | 6 300 000 | 1 560 089 |
| 2016 | 878 460 | 1 000 000 | 21792 | 158 011 | 6 552 000 | 2 060 279 |
| 2017 | 1 062 937 | 1 300 000 | 31599 | 213 315 | 6 814 080 | 2 609 867 |
| 2018 | 1 286 153 | 1 600 000 | 45819 | 287 975 | 7 086 643 | 3 221 964 |
| 2019 | 1 556 245 | 1 900 000 | 66437 | 388 766 | 7 370 109 | 3 913 467 |
| 2020 | 1 883 057 | 2 200 000 | 96333 | 524 834 | 7 664 913 | 4 706 244 |
| 2021 | 2 278 499 | 2 500 000 | 139684 | 708 525 | 7 971 510 | 5 628 729 |
| 2022 | 2 756 984 | 2 800 000 | 202541 | 956 509 | 8 290 370 | 6 718 056 |
| 2023 | 3 335 950 | 3 100 000 | 293685 | 1 291 288 | 8 621 985 | 8 022 946 |
| 2024 | 4 036 500 | 3 400 000 | 425843 | 1 743 238 | 8 966 864 | 9 607 605 |
| 2025 | 4 884 165 | 3 700 000 | 617472 | 2 353 372 | 9 325 539 | 11 557 034 |
| 2026 | 5 909 840 | 4 000 000 | 895335 | 3 177 052 | 9 698 561 | 13 984 252 |
| 2027 | 7 150 906 | 4 300 000 | 1298235 | 4 289 020 | 10 086 503 | 17 040 188 |
| 2028 | 8 652 596 | 4 600 000 | 1882441 | 5 790 177 | 10 489 963 | 20 927 242 |
| 2029 | 10 469 641 | 4 900 000 | 2729539 | 7 816 739 | 10 909 562 | 25 917 949 |
| 2030 | 12 668 266 | 5 200 000 | 3957832 | 10 552 598 | 11 345 944 | 32 380 726 |

The total installed collector area of ~30 million $m^2$ is related to an installed capacity of 21 $GW_{th}$.

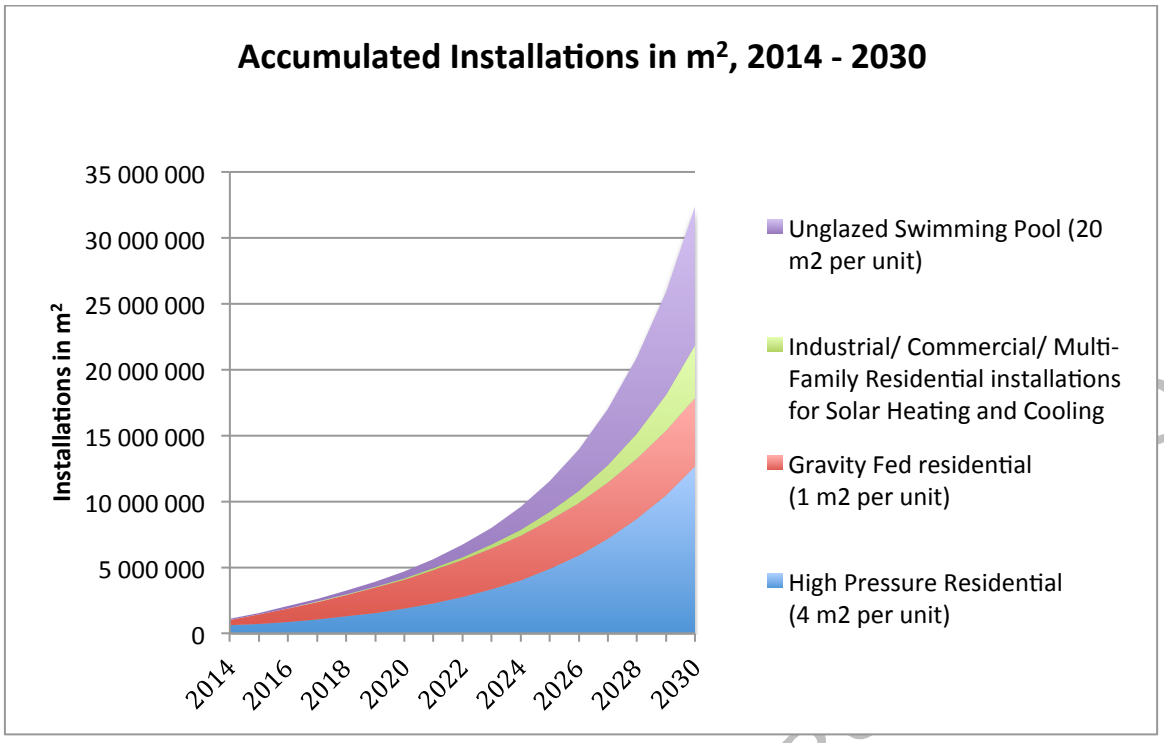


**Figure 15:** Projected total solar thermal collector installations based on the goal to reach 0.5 m² installed collector area by inhabitant by 2030 Development 2014 – 2030

If the Roadmap goal of installing ½ m² collector area (30 million m²) in the different applications is reached by 2030, South Africa would save annually 34,000 GWh electricity and would avoid 23 million tons of CO2. The following figure shows how the different applications would contribute to this overall savings.

If the saving from Passive Solar Thermal is included, the saving in electricity as well as the carbon saving is even higher.

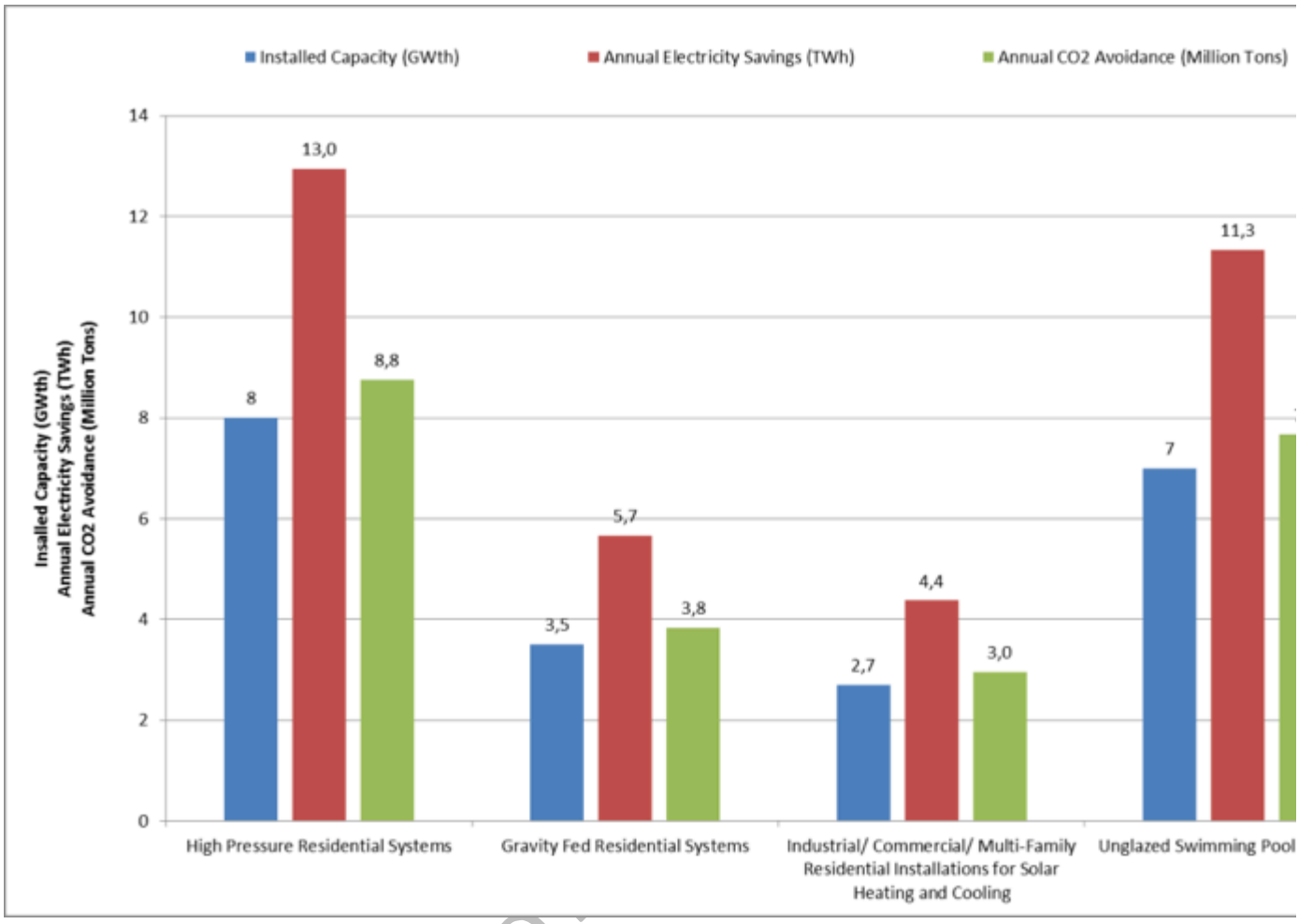


**Figure 16:** Installed capacity, annual electricity savings as well as avoided CO2 emissions based on the assumption that the Roadmap goals ar reached by 2030.

**Figure 17: Participants at the STRM workshop on 27 November in Cape Town**

## Appendix 1: Interested Parties

ABSA
Advocate Neville Melville, Consumers Ombudsman
AEE-Intec
AGS Solar
Blackdot Energy
Cape Chamber of Commerce
Central Energy Fund Group of Companies (CEF)
City of Cape Town
City Power
Cape Peninsula University of Technology
City of Cape Town
Crest Africa
Centre for Renewable and Sustainable Energy Studies (CRSES)
CSIR
Department: Energy (DE)
Department: Science and Technology
Duratherm
Department: Trade and Industry (DTI)
E3
Enervision
Energy Research Centre (ERC)
Eskom
eThekwini Energy Office
Euroheat
First National Bank (FNB)
FOGI
Franke
Frost And Sullivan
Geyserwise
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
GreenCape
Hisun Solar
Hollard
Holms and Friends
ICLEI Africa
iLanga Heat
Ikhwezi Solar
Innovation Group
Investec
Institute of Plumbing South Africa (IOPSA)
Kayema
Kwikot
Lion of Africa
Masters Artisans Academy
Master Builders Association
MTech
National Solar
National Business Initiative (NBI)
Nedbank
Nelson Mandela Metropolitan University (NMMU)
National Regulator for Compulsory Specifications (NRCS)
North-West University (NWU)
Outsurance
PowerzOn
Plumbing Industry Regulation Board (PIRB)
Renaissance Solar
South African Consumer Union (SANCU) Clif Johnston
South African Property Owners Association (SAPOA)
South African Bureau of Standards (SABS)
South African Insurance Association (SAIA)
South African Institute of Architects (SAIA)
South African Local Government Association (SALGA)
SANEA
Sanedi
Santam
SESSA
Solac
Solahart
Solar Heat Exchangers
Solarbeam
Solardome
Solar Juice
Solar IQ
Solarmax
Solar Primeg
SOLTRAIN
Standard Bank
Stellenbosch University
Suntank
SWH-Mancosa
Tasol
Tecron
The Copper Alliance
Tshwane University of Technology (TUT)
University of Cape Town (UCT)
University of Johannesburg (UJ)
University of Pretoria (UP)
Urban Earth
Watersmith
Western Cape Government (WCG)
WWF
Xstream Geysers

# Appendix 2: Data from IEA SHC reports "Solar Heat Worldwide 2005 – 2014"

To convert from $MW_{th}$ to $m^2$, divide th $MW_{th}$ by 0.7

**Table 7: Total capacity in operation by the end of 2012 [$MW_{th}$]**

| Country | Water Collectors | | | Air Collectors | | TOTAL [$MW_{th}$] |
|---|---|---|---|---|---|---|
| | unglazed | FPC | ETC | unglazed | glazed | |
| Albania | | 77,8 | 0,6 | | | 78,3 |
| Australia | 3.045,0 | 2.035,6 | 47,6 | 196,0 | 5,0 | 5.329,2 |
| Austria | 391,0 | 3.002,7 | 55,7 | | 1,3 | 3.450,8 |
| Barbados* | | 92,2 | | | | 92,2 |
| Belgium | 31,5 | 230,6 | 38,5 | | | 300,7 |
| Brazil | 1.620,3 | 4.163,1 | | | | 5.783,4 |
| Bulgaria | | 84,0 | 1,4 | | | 85,5 |
| Canada | 544,7 | 43,0 | 25,0 | 244,8 | 16,9 | 874,4 |
| Chile*** | | 56,0 | | | | 56,0 |
| China | | 12.177,7 | 168.212,3 | | | 180.390,0 |
| Croatia# | | 84,0 | | | | 84,0 |
| Cyprus | 1,5 | 605,7 | 16,2 | | | 623,4 |
| Czech Republic | 327,6 | 235,1 | 61,5 | | | 624,2 |
| Denmark | 14,4 | 444,0 | 6,0 | 2,3 | 12,6 | 479,3 |
| Estonia | | 2,8 | 1,8 | | | 4,6 |
| Finland | 8,2 | 21,2 | 4,5 | | | 34,0 |
| France (mainland) + | 74,0 | 1.623,3 | 29,5 | 3,5 | 0,8 | 1.731,1 |
| Germany | 409,9 | 10.095,4 | 1.282,4 | | 21,5 | 11.809,2 |
| Greece | | 2.872,9 | 12,5 | | | 2.885,4 |
| Hungary | 9,5 | 118,1 | 35,8 | 1,3 | 1,0 | 165,6 |
| India | | 3.521,7 | 994,0 | | 14,1 | 4.529,8 |
| Ireland | | 129,2 | 61,2 | | | 190,4 |
| Israel | 22,3 | 2.901,5 | | 0,4 | | 2.924,2 |
| Italy | 30,6 | 2.048,6 | 333,5 | | | 2.412,7 |
| Japan | | 3.064,8 | 58,3 | | 352,1 | 3.475,2 |
| Jordan*** | 4,2 | 611,4 | 171,3 | | | 786,8 |
| Korea, South | | 1.179,4 | | | | 1.179,4 |
| Latvia | | 2,0 | 0,8 | | | 2,8 |
| Lebanon*** | | 163,8 | 204,4 | | | 368,2 |
| Lithuania | | 2,3 | 1,9 | | | 4,2 |
| Luxembourg | | 24,5 | 3,3 | | | 27,9 |
| Macedonia* | | 17,5 | 0,5 | | | 18,0 |
| Malta | | 25,2 | 8,6 | | | 33,8 |
| Mexico | 582,1 | 610,6 | 228,2 | 0,2 | 5,6 | 1.426,7 |
| Morocco*** | | 343,9 | | | | 343,9 |
| Mozambique | | 0,2 | | | | 0,2 |
| Namibia** | | 14,5 | 0,9 | | | 15,4 |
| Netherlands | 293,1 | 300,2 | 11,9 | | | 605,2 |
| New Zealand* | 4,9 | 100,1 | 6,8 | | | 111,8 |
| Norway | 1,4 | 22,0 | 1,9 | | 2,1 | 27,4 |
| Poland | | 641,6 | 206,5 | | | 848,1 |
| Portugal | 1,5 | 661,9 | 15,5 | | | 678,9 |
| Romania | | 56,5 | 21,0 | | | 77,5 |
| Russia# | | 12,3 | 0,9 | | | 13,2 |
| Slovakia | | 88,1 | 14,8 | | | 102,9 |
| Slovenia | | 117,3 | 13,5 | | | 130,8 |
| South Africa | 606,8 | 266,7 | 80,9 | | | 954,5 |
| Spain | 93,9 | 1.862,9 | 117,2 | | | 2.074,0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sweden | 91,0 | 182,0 | 42,0 | | | 315,0 |
| Switzerland | 148,1 | 686,7 | 51,1 | 613,3 | | 1.499,2 |
| Taiwan | 1,6 | 927,1 | 75,3 | | | 1.003,9 |
| Thailand | | 84,3 | | | | 84,3 |
| Tunisia | | 415,1 | 32,3 | | | 447,5 |
| Turkey | | 9.580,2 | 1.268,4 | | | 10.848,5 |
| United Kingdom | | 376,6 | 120,2 | 13,3 | | 510,1 |
| United States | 14.311,4 | 1.853,3 | 82,1 | 66,7 | 14,0 | 16.327,4 |
| Uruguay** | | 8,8 | | | | 8,8 |
| Zimbabwe | | 13,1 | 0,6 | | | 13,7 |
| **TOTAL** | **22.670** | **70.983** | **174.061** | **1.142** | **447** | **269.303** |

Note: If no data is given: no reliable database for this collector type is available.

**Table 8: New installed capacity in 2012 [$MW_{th}$/a]**

| Country | Water Collectors | | | Air Collectors | | TOTAL [$MW_{th}$] |
|---|---|---|---|---|---|---|
| | unglazed | FPC | ETC | unglazed | glazed | |
| Albania | | 14,7 | 0,1 | | | 14,8 |
| Australia | 455,0 | 167,6 | 21,3 | 24,5 | 0,7 | 669,1 |
| Austria | 1,7 | 140,6 | 3,9 | | 0,6 | 146,7 |
| Belgium | | 35,4 | 8,1 | | | 43,4 |
| Brazil | 367,9 | 438,1 | | | | 806,0 |
| Bulgaria | | 5,2 | 0,4 | | | 5,6 |
| Canada | 50,1 | 4,6 | 5,5 | 11,1 | 8,7 | 79,8 |
| Chile* | | 15,3 | | | | 15,3 |
| China | | 3.500,0 | 41.230,0 | | | 44.730,0 |
| Croatia # | | 9,6 | | | | 9,6 |
| Cyprus | 0,0 | 14,5 | 1,0 | | | 15,5 |
| Czech Republic | 35,0 | 25,9 | 9,1 | | | 70,0 |
| Denmark | | 78,8 | 0,4 | | | 79,1 |
| Estonia | | 0,6 | 0,6 | | | 1,3 |
| Finland | | 2,1 | 0,7 | | | 2,8 |
| France mainland + | | 168,5 | 6,1 | 3,2 | 0,7 | 178,5 |
| Germany | | 725,2 | 79,8 | | | 805,0 |
| Greece | | 169,1 | 1,1 | | | 170,1 |
| Hungary | 1,1 | 24,5 | 10,5 | 0,2 | 0,2 | 36,4 |
| India | | 374,5 | 640,5 | | 5,6 | 1.020,6 |
| Ireland | | 13,0 | 5,7 | | | 18,7 |
| Israel | 0,8 | 217,4 | | | | 218,2 |
| Italy | | 198,7 | 32,3 | | | 231,0 |
| Japan | | 111,1 | 2,2 | | 5,6 | 118,9 |
| Jordan* | | 38,2 | 9,6 | | | 47,8 |
| Korea, South | | 44,6 | | | | 44,6 |
| Latvia | | 0,1 | 0,1 | | | 0,2 |
| Lebanon* | | 30,8 | 15,4 | | | 46,2 |
| Lithuania | | 0,4 | 0,8 | | | 1,3 |
| Luxembourg | | 2,3 | 0,6 | | | 2,9 |
| Malta | | 1,0 | 0,4 | | | 1,4 |
| Mexico | 76,7 | 66,7 | 66,7 | | | 210,0 |
| Morocco* | | 55,0 | | | | 55,0 |
| Mozambique | | | 0,1 | | | 0,1 |
| Netherlands | 19,2 | 19,6 | 5,6 | | | 44,4 |
| Norway | | 10,7 | 0,6 | | 1,4 | 12,6 |
| Poland | | 151,2 | 60,2 | | | 211,4 |
| Portugal | 0,1 | 58,5 | 5,0 | | | 63,6 |
| Romania | | 6,0 | 4,9 | | | 10,9 |
| Russia # | | 4,3 | 0,2 | | | 4,5 |
| Slovakia | | 4,6 | 0,7 | | | 5,3 |
| Slovenia | | 9,5 | 2,1 | | | 11,6 |
| South Africa | 34,3 | 15,5 | 35,2 | | | 85,1 |
| Spain | 2,5 | 147,7 | 8,8 | | | 159,1 |
| Sweden | 0,6 | 5,8 | 2,1 | | | 8,5 |
| Switzerland | 8,3 | 87,9 | 12,1 | | | 108,3 |
| Taiwan | 0,0 | 74,0 | 8,3 | | | 82,3 |
| Thailand | | 15,9 | | | | 15,9 |
| Tunisia | | 52,0 | 1,5 | | | 53,5 |
| Turkey | | 802,4 | 334,6 | | | 1.137,0 |
| United Kingdom | | 33,5 | 8,0 | 3,5 | | 45,0 |
| United States | 530,2 | 160,8 | 8,4 | 10,5 | 9,8 | 719,7 |
| Zimbabwe | | 0,6 | 0,4 | | | 1,0 |
| **TOTAL** | **1.583,4** | **8.354,1** | **42.651,7** | **52,9** | **33,2** | **52.675,3** |

Note: If no data is given: no reliable database for this collector type is available.

**Table 9: Newly installed capacity in 2011 [$MW_{th}$/a]**

| Country | Water Collectors | | | Air Collectors | | TOTAL [$MW_{th}$] |
|---|---|---|---|---|---|---|
| | unglazed | FPC | ETC | unglazed | glazed | |
| Albania | | 9.0 | 0.1 | | | 9.1 |
| Australia | 420.0 | 240.8 | 15.6 | 25.2 | 0.6 | 702.2 |
| Austria | 4.0 | 155.1 | 6.1 | | 0.2 | 165.4 |
| Belgium | | 24.9 | 7.0 | | | 31.9 |
| Brazil | 358.5 | 362.3 | | | | 720.7 |
| Bulgaria | | 7.0 | 0.6 | | | 7.6 |
| Canada | 52.1 | 5.5 | 6.7 | 19.9 | 5.0 | 89.2 |
| Chile | | 7.6 | | | | 7.6 |
| China | | 2,016.0 | 38,304.0 | | | 40,320.0 |
| Cyprus | 0.1 | 18.8 | 1.2 | | | 20.0 |
| Czech Republic | 45.5 | 34.4 | 11.7 | | | 91.6 |
| Denmark | | 43.3 | 0.4 | | | 43.7 |
| Estonia | | 0.6 | 0.6 | | | 1.3 |
| Finland | | 2.1 | 0.7 | | | 2.8 |
| France (mainland) | | 169.5 | 6.2 | 0.4 | 0.1 | 176.2 |
| Germany | | 806.4 | 82.6 | 0.3 | | 889.3 |
| Greece | | 161.0 | | | | 161.0 |
| Hungary | 1.1 | 9.8 | 4.2 | 0.2 | 0.2 | 15.4 |
| India | | 707.0 | | | | 707.0 |
| Ireland | | 8.8 | 5.8 | | | 14.5 |
| Israel | 1.8 | 259.7 | | | | 261.4 |
| Italy | | 237.5 | 35.5 | | | 273.0 |
| Japan | | 108.7 | 1.3 | | 7.5 | 117.5 |
| Jordan | | 38.2 | 9.6 | | | 47.8 |
| Korea, South | | 38.3 | | | | 38.3 |
| Latvia | | 0.7 | 0.6 | | | 1.3 |
| Lebanon | | 28.0 | 14.0 | | | 42.0 |
| Lithuania | | 0.4 | 0.8 | | | 1.3 |
| Luxembourg | | 2.5 | 0.7 | | | 3.2 |
| Malta | | 1.6 | 0.3 | | | 2.0 |
| Mexico | | 66.5 | 59.5 | 0.2 | | 126.2 |
| Mozambique | | | 0.1 | | | 0.1 |
| Netherlands | 19.2 | 22.0 | 3.5 | | | 44.7 |
| Poland | | 131.2 | 46.4 | | | 177.6 |
| Portugal | 0.2 | 88.4 | 0.5 | 0.1 | | 89.2 |
| Romania | | 6.0 | 4.9 | | | 10.9 |
| Slovakia | | 13.5 | 2.6 | | | 16.1 |
| Slovenia | | 6.3 | 2.1 | | | 8.4 |
| South Africa | 33.7 | 30.0 | 27.5 | | | 91.2 |
| Spain | 6.0 | 174.8 | 12.1 | 1.1 | | 193.9 |
| Sweden | 15.8 | 11.0 | 3.6 | | | 30.4 |
| Switzerland | 6.3 | 90.4 | 6.1 | 6.3 | | 109.1 |
| Taiwan | | 70.3 | 7.7 | | | 78.0 |
| Tunisia | | 45.0 | 5.6 | | | 50.6 |
| Turkey | | 910.8 | 353.2 | 1.1 | | 1,265.1 |
| United Kingdom | | 51.1 | 13.2 | 3.9 | | 68.2 |
| United States | 523.5 | 125.9 | 8.0 | 10.9 | 4.2 | 672.5 |
| Zimbabwe | | 0.2 | 0.2 | | | 0.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **TOTAL** | **1,487.8** | **7,348.6** | **39,072.7** | **69.5** | **17.9** | **47,996.5** |

**Table 10: Newly installed capacity in 2010 [$MW_{th}$/a]**

| Country | Water Collectors** | | | Air Collectors** | | TOTAL [$MW_{th}$] |
|---|---|---|---|---|---|---|
| | unglazed | FPC | ETC | unglazed | glazed | |
| Albania | | 5.2 | 0.1 | | | 5.3 |
| Australia | 476.0 | 253.6 | 25.1 | | | 754.7 |
| Austria | 3.9 | 187.7 | 8.3 | 0.2 | | 200.1 |
| Belgium | | 21.9 | 4.9 | | | 26.8 |
| Brazil | 345.6 | 331.1 | | | | 676.7 |
| Bulgaria | | 5.4 | 0.5 | | | 5.9 |
| Canada | 59.3 | 8.0 | 8.0 | 62.7 | 1.6 | 139.6 |
| Chile | | 5.6 | | | | 5.6 |
| China | | 2,100.0 | 32,200.0 | | | 34,300.0 |
| Cyprus | 0.1 | 23.1 | 1.2 | | | 24.4 |
| Czech Republic | 37.1 | 51.7 | 12.4 | | | 101.2 |
| Denmark | | 43.4 | 0.3 | | | 43.6 |
| Estonia | | 0.1 | 0.3 | | | 0.4 |
| Finland | | 2.8 | 1.4 | | | 4.2 |
| France | | 221.9 | 6.3 | | | 228.2 |
| Germany | | 724.5 | 80.5 | | | 805.0 |
| Greece | | 148.8 | 1.1 | | | 149.8 |
| Hungary | 1.7 | 10.3 | 4.4 | 0.2 | 0.1 | 16.7 |
| India | | 425.9 | 196.3 | | | 622.2 |
| Ireland | | 12.2 | 9.2 | | | 21.4 |
| Israel | | 221.2 | | | | 221.2 |
| Italy | | 299.3 | 43.8 | | | 343.0 |
| Japan | | 102.8 | 3.4 | | 8.3 | 114.5 |
| Jordan | 4.2 | 55.7 | 8.9 | | | 68.8 |
| Korea, South | | 48.9 | | | | 48.9 |
| Latvia | | 0.1 | 0.1 | | | 0.1 |
| Lithuania | | 0.0 | 0.1 | | | 0.1 |
| Luxembourg | | 2.5 | 0.7 | | | 3.2 |
| Malta | | 1.2 | 0.8 | | | 2.0 |
| Mexico | 63.0 | 66.5 | 59.5 | | 1.8 | 190.8 |
| Morocco* | | 48.5 | | | | 48.5 |
| Namibia | | 3.8 | 0.6 | | | 4.4 |
| Netherlands | 18.6 | 32.1 | 2.8 | | | 53.5 |
| Norway | 0.1 | 1.5 | 0.6 | | | 2.2 |
| Poland | | 77.7 | 24.5 | | | 102.2 |
| Portugal | 0.2 | 130.9 | 0.2 | | | 131.4 |
| Romania | | 6.0 | 4.9 | | | 10.9 |
| Slovakia | | 9.0 | 1.5 | | | 10.5 |
| Slovenia | | 10.5 | 2.8 | | | 13.3 |
| South Africa | 35.0 | 29.6 | 5.4 | | | 70.0 |
| Spain | 7.7 | 220.9 | 15.1 | | | 243.6 |
| Sweden | 12.0 | 9.5 | 5.0 | | | 26.5 |
| Switzerland | 8.4 | 90.3 | 11.0 | 5.6 | | 115.3 |
| Taiwan | 0.0 | 81.2 | 8.3 | | | 89.4 |
| Tunisia | | 50.5 | 8.8 | | | 59.3 |
| Turkey | | 1,160.6 | | | | 1,160.6 |
| United Kingdom | | 52.9 | 20.7 | | | 73.6 |
| United States | 656.5 | 157.8 | | | | 814.3 |
| Zimbabwe | | 0.3 | 0.1 | | | 0.4 |
| TOTAL | 1,729.3 | 7,554.7 | 32,789.4 | 68.7 | 11.8 | 42,154.0 |

**Table 11: Newly installed capacity in 2009 [$MW_{th}$/a]**

| Country | Water Collectors* | | | Air Collectors* | | TOTAL [$MW_{th}$/a] |
|---|---|---|---|---|---|---|
| | unglazed | glazed | evacuated tube | unglazed | glazed | |
| **Albania** | | 7.0 | 0.1 | | | **7.1** |
| **Australia** | 434.0 | 338.1 | 25.4 | | | **797.6** |
| **Austria** | 5.8 | 243.9 | 5.4 | 0.3 | | **255.4** |
| **Barbados** | | 4.9 | | | | **4.9** |
| **Belgium** | | 31.9 | 3.6 | | | **35.5** |
| **Brazil** | 284.9 | 273.8 | | | | **558.7** |
| **Bulgaria** | | 5.6 | | | | **5.6** |
| **Canada** | 51.1 | 6.4 | 0.8 | 31.7 | 0.6 | **90.6** |
| **Chile** | | 6.3 | | | | **6.3** |
| **China** | | 1,400.0 | 28,000.0 | | | **29,400.0** |
| **Cyprus** | | 37.1 | 1.4 | | | **38.5** |
| **Czech Republic** | | 21.0 | 7.0 | | | **28.0** |
| **Denmark** | | 36.4 | 1.8 | | | **38.2** |
| **Estonia** | | 0.04 | 0.3 | | | **0.3** |
| **Finland** | | 2.0 | 0.8 | | | **2.8** |
| **France** | | 185.5 | | | | **185.5** |
| **Germany** | | 1,001.0 | 129.5 | | | **1,130.5** |
| **Greece** | | 143.2 | 1.1 | | | **144.2** |
| **Hungary** | 2.1 | 9.8 | 5.6 | 0.4 | 0.14 | **18.0** |
| **India** | | 365.8 | 19.3 | | | **385.0** |
| **Ireland** | | 18.5 | 11.3 | | | **29.8** |
| **Israel**** | 2.0 | 186.5 | | | | **188.5** |
| **Italy** | 4.9 | 283.8 | 47.3 | | | **336.0** |
| **Japan** | | 97.9 | 1.2 | | 8.5 | **107.5** |
| **Jordan** | | 21.3 | 6.4 | | | **27.7** |
| **Korea, South**** | | 48.1 | | | | **48.1** |
| **Latvia** | | 0.03 | 0.10 | | | **0.1** |
| **Lithuania** | | 0.04 | 0.11 | | | **0.1** |
| **Luxembourg** | | 2.6 | 0.7 | | | **3.3** |
| **Macedonia** | | 2.1 | | | 0.0 | **2.1** |
| **Malta** | | 3.1 | 2.9 | | | **6.0** |
| **Mexico** | 52.9 | 57.4 | 49.3 | | 3.8 | **163.3** |
| **Namibia** | | 2.8 | 0.2 | | | **3.0** |
| **Netherlands** | 20.2 | 31.7 | | | | **51.9** |
| **New Zealand**** | 0.3 | 17.2 | | | | **17.6** |
| **Norway** | 0.2 | 1.2 | 0.15 | | | **1.5** |
| **Poland** | | 74.5 | 26.5 | | | **101.0** |
| **Portugal** | 1.1 | 91.0 | 9.5 | | | **101.5** |
| **Romania** | | 7.7 | 6.3 | | | **14.0** |
| **Slovak Republic** | | 8.1 | 1.3 | | | **9.5** |
| **Slovenia** | | 11.9 | 3.5 | | | **15.4** |
| **South Africa** | 37.8 | 21.3 | 2.5 | | | **61.6** |
| **Spain** | 7.7 | 262.5 | 11.2 | | | **281.4** |
| **Sweden** | 17.5 | 9.2 | 5.7 | | | **32.4** |
| **Switzerland***** | 8.4 | 94.7 | 7.2 | 7.7 | | **118.1** |
| **Taiwan** | | 72.9 | 8.6 | | | **81.6** |
| **Thailand**** | | 10.3 | | | | **10.3** |
| **Tunisia** | | 49.1 | 10.4 | | | **59.5** |
| **Turkey** | | 668.5 | | | | **668.5** |
| **United Kingdom** | | 36.4 | 26.0 | | | **62.4** |
| **United States** | 599.6 | 111.6 | 18.7 | | 1.3 | **731.2** |
| **Uruguay**** | | 5.1 | | | | **5.1** |
| **Zimbabwe** | | 0.2 | 0.10 | | | **0.2** |
| **TOTAL** | **1,530.5** | **6,428.7** | **28,459.1** | **40.0** | **14.2** | **36,472.5** |

**Table 12: Newly installed capacity in 2008 [$MW_{th}$/a]**

| Country | Water Collectors | | | Air Collectors | | TOTAL [$MW_{th}$/a] |
|---|---|---|---|---|---|---|
| | Unglazed* | Glazed* | evacuated tube* | Unglazed* | Glazed* | |
| Albania | | 6.8 | 0.1 | | | 6.9 |
| Australia | 420.0 | 193.9 | 9.8 | | | 623.7 |
| Austria | 10.7 | 240.5 | 2.9 | | | 254.0 |
| Barbados | | 1.9 | | | | 1.9 |
| Belgium | | 57.4 | 6.3 | | | 63.7 |
| Brazil | 195.2 | 274.6 | | | | 469.8 |
| Bulgaria | | 2.8 | | | | 2.8 |
| Canada | 62.7 | 9.2 | 0.8 | 23.9 | 0.8 | 97.4 |
| Chile | | 6.3 | | | | 6.3 |
| China | | 1,085.0 | 20,615.0 | | | 21,700.0 |
| Cyprus | | 28.2 | 0.7 | | | 28.9 |
| Czech Republic | | 18.6 | 6.0 | | | 24.5 |
| Denmark | | 21.7 | 1.4 | | | 23.1 |
| Estonia | | 0.4 | | | | 0.4 |
| Finland | 0.2 | 2.7 | 0.5 | | | 3.4 |
| France | | 273.0 | | | | 273.0 |
| Germany | | 1,330.0 | 140.0 | | 4.8 | 1,474.8 |
| Greece | | 205.5 | 3.2 | | | 208.6 |
| Hungary | | 6.0 | 1.8 | | | 7.7 |
| India | | 324.4 | 16.2 | | | 340.7 |
| Ireland | | 22.2 | 8.3 | | | 30.5 |
| Israel | 1.8 | 194.6 | | | | 196.4 |
| Italy | | 252.0 | 42.0 | | | 294.0 |
| Japan | | 143.9 | 1.4 | | 9.4 | 154.7 |
| Jordan | | 14.0 | 21.0 | | | 35.1 |
| Korea | | 36.1 | | | | 36.1 |
| Latvia | | 1.3 | | | | 1.3 |
| Lithuania | | 0.6 | | | | 0.6 |
| Luxembourg | | 2.0 | 0.6 | | | 2.5 |
| Macedonia | | 2.7 | 0.4 | | | 3.1 |
| Malta | | 4.2 | | | | 4.2 |
| Mexico | 34.8 | 81.2 | | | | 115.9 |
| Namibia | | 2.8 | 0.1 | | | 2.9 |
| Netherlands | 19.8 | 16.4 | | | | 36.1 |
| New Zealand | 0.4 | 14.3 | | | | 14.7 |
| Norway | 0.1 | 0.7 | 0.1 | | | 1.0 |
| Poland | | 62.9 | 27.9 | | | 90.7 |
| Portugal | 0.6 | 55.2 | 5.0 | | | 60.8 |
| Romania | | 5.6 | | | | 5.6 |
| Slovak Republic | | 8.4 | 1.1 | | | 9.5 |
| Slovenia | | 9.8 | 1.8 | | | 11.6 |
| South Africa | 70.2 | 15.0 | 12.7 | | | 97.8 |
| Spain | 22.4 | 286.3 | 17.5 | | | 326.2 |
| Sweden | 20.1 | 10.2 | 8.6 | | | 38.8 |
| Switzerland* | 6.6 | 72.8 | 6.2 | 4.9 | | 90.4 |
| Taiwan | 0.2 | 74.0 | 8.2 | | | 82.4 |
| Thailand | | 7.0 | | | | 7.0 |
| Tunisia | | 52.5 | 3.5 | | | 56.0 |
| Turkey | | 651.0 | | | | 651.0 |
| United Kingdom | | 33.1 | 23.6 | | | 56.7 |
| United States | 773.9 | 134.1 | 23.7 | | 1.8 | 933.5 |
| Uruguay | | 2.9 | | | | 2.9 |
| Zimbabwe | | 0.2 | 0.02 | | | 0.3 |
| TOTAL | 1,639.5 | 6,358.6 | 21,018.0 | 28.8 | 16.9 | 29,061.77 |



Table 2: Installed capacity in 2007, $MW_{th}$/a

| Country | Water Collectors | | | Air Collectors | | TOTAL [MWth] |
|---|---|---|---|---|---|---|
| | unglazed*** | glazed | evacuated tube | unglazed*** | glazed*** | |
| **Albania** | | 6,50 | 0,06 | | | **6,56** |
| **Australia** | 403,20 | 142,10 | 2,10 | | | **547,40** |
| **Austria** | 6,06 | 194,33 | 2,38 | | | **202,78** |
| **Barbados** | | 1,91 | | | | **1,91** |
| **Belgium** | 6,18 | 25,90 | 3,50 | | | **35,58** |
| **Brazil** | 68,21 | 332,78 | 0,25 | | | **401,23** |
| **Bulgaria** | | 1,75 | | | | **1,75** |
| **Canada** | 27,92 | 1,02 | 1,67 | 11,94 | 0,09 | **42,64** |
| **China** | | 770,00 | 14.028,00 | | | **14.798,00** |
| **Cyprus** | | 10,50 | 0,70 | | | **11,20** |
| **Czech Republic** | 4,20 | 13,23 | 4,27 | | | **21,70** |
| **Denmark** | 0,42 | 16,10 | 0,28 | 2,38 | 2,45 | **21,63** |
| **Estonia** | | 0,25 | | | | **0,25** |
| **Finland** | | 1,47 | 0,44 | | | **1,91** |
| **France *** | 3,71 | 213,50 | 8,89 | | | **226,10** |
| **Germany** | 21,00 | 588,00 | 70,00 | | | **679,00** |
| **Greece** | | 195,30 | 2,80 | | | **198,10** |
| **Hungary** | | 4,20 | 1,40 | | | **5,60** |
| **India** | | 175,00 | | | 4,90 | **179,90** |
| **Ireland** | | 10,41 | 3,36 | | | **13,77** |
| **Israel** | 0,49 | 49,70 | | | | **50,19** |
| **Italy** | 2,56 | 147,00 | 24,50 | | | **174,06** |
| **Japan** | | 116,36 | 2,84 | | 8,76 | **127,95** |
| **Jordan** | | 5,37 | 2,52 | | | **7,89** |
| **Latvia** | | 1,05 | | | | **1,05** |
| **Lithuania** | | 0,49 | | | | **0,49** |
| **Luxembourg** | | 2,10 | | | | **2,10** |
| **Macedonia** | | 1,37 | 0,14 | | | **1,51** |
| **Malta** | | 3,85 | | | | **3,85** |
| **Mexico** | 32,40 | 75,59 | | | | **107,99** |
| **Namibia** | | 1,97 | 0,13 | | | **2,10** |
| **Netherlands** | 19,41 | 13,94 | | | | **33,35** |
| **New Zealand** | 0,42 | 8,26 | 3,61 | | | **12,29** |
| **Norway** | 0,14 | 0,50 | 0,04 | | | **0,68** |
| **Poland** | | 32,92 | 14,78 | | | **47,70** |
| **Portugal** | 0,43 | 31,14 | 3,99 | | | **35,56** |
| **Romania** | | 0,35 | | | | **0,35** |
| **Slovak Republic** | | 10,89 | 6,94 | | | **17,83** |
| **Slovenia** | | 4,56 | 0,81 | | | **5,37** |
| **South Africa** | 47,11 | 9,80 | | | | **56,91** |
| **Spain** | 2,10 | 175,70 | 7,70 | | | **185,50** |
| **Sweden** | 14,30 | 10,89 | 6,94 | | | **32,13** |
| **Switzerland **** | 7,22 | 44,12 | 1,79 | 1,40 | | **54,53** |
| **Taiwan** | | 87,50 | 6,93 | | | **94,43** |
| **Thailand** | | 5,60 | | | | **5,60** |
| **Tunisia** | | 27,30 | 0,70 | | | **28,00** |
| **Turkey** | | 490,00 | | | | **490,00** |
| **United Kingdom** | | 18,90 | 18,90 | | | **37,80** |
| **United States** | 787,53 | 90,73 | 14,36 | | 0,89 | **893,51** |
| **TOTAL** | **1.455,00** | **4.172,20** | **14.247,69** | **15,72** | **17,08** | **19.907,69** |

**Table 13: Installed capacity in 2006, $MW_{th}/a$**

| Country | Water Collectors | | | Air Collectors | | TOTAL [MWth] |
|---|---|---|---|---|---|---|
| | unglazed*** | glazed | evacuated | unglazed*** | glazed*** | |
| Albania | | 5,57 | 0,05 | | | 5,63 |
| Australia | 385,00 | 109,20 | 10,50 | | | 504,70 |
| Austria | 4,85 | 202,82 | 2,05 | | | 209,72 |
| Barbados | | 1,91 | | | | 1,91 |
| Belgium | 6,18 | 21,89 | 3,06 | | | 31,12 |
| Brazil | | 304,03 | | | | 304,03 |
| Bulgaria | | 1,54 | | | | 1,54 |
| Canada | 25,40 | 0,92 | 0,50 | 16,41 | 0,03 | 43,26 |
| China | | 1.260,00 | 11.340,00 | | | 12.600,00 |
| Cyprus | | 42,00 | | | | 42,00 |
| Czech Republic | 4,20 | 12,94 | 2,48 | | | 19,62 |
| Denmark | 1,12 | 19,95 | 0,70 | | 4,90 | 26,67 |
| Estonia | | 0,21 | | | | 0,21 |
| Finland | | 2,38 | | | | 2,38 |
| France * | 4,20 | 198,80 | 7,70 | | | 210,70 |
| Germany | 21,00 | 945,00 | 105,00 | | | 1.071,00 |
| Greece | | 174,30 | | | | 174,30 |
| Hungary | | 0,70 | | | | 0,70 |
| India | | 350,00 | | | | 350,00 |
| Ireland | | 2,87 | 0,63 | | | 3,50 |
| Israel | 2,66 | 155,40 | | | | 158,06 |
| Italy | 2,56 | 109,06 | 18,59 | | | 130,20 |
| Japan | | 183,87 | 0,97 | 12,21 | | 197,04 |
| Jordan | | 5,37 | 2,52 | | | 7,89 |
| Lativa | | 0,84 | | | | 0,84 |
| Lithuania | | 0,42 | | | | 0,42 |
| Luxembourg | | 1,75 | | | | 1,75 |
| Macedonia | | 1,48 | 0,03 | | | 1,51 |
| Malta | | 3,15 | | | | 3,15 |
| Mexico | 20,32 | 47,41 | | | | 67,73 |
| Namibia | | 1,20 | | | | 1,20 |
| Netherlands | 17,09 | 10,46 | | | | 27,55 |
| New Zealand | 0,42 | 6,72 | 2,35 | | | 9,49 |
| Norway | | 0,49 | 0,07 | | | 0,56 |
| Poland | 0,11 | 24,61 | 4,38 | | | 29,09 |
| Portugal | | 19,81 | | | | 19,81 |
| Romania | | 0,28 | | | | 0,28 |
| Slovak Republic | | 5,39 | 0,56 | | | 5,95 |
| Slovenia | | 4,41 | 0,42 | | | 4,83 |
| South Africa | 45,57 | 9,66 | | | | 55,23 |
| Spain | | 113,31 | 9,19 | | | 122,50 |
| Sweden | 9,39 | 13,88 | 6,10 | | | 29,37 |
| Switzerland ** | 6,27 | 35,25 | 1,06 | 0,70 | | 43,27 |
| Taiwan | | 79,55 | 5,99 | | | 85,54 |
| Tunisia | | 24,17 | 0,33 | | | 24,50 |
| Turkey | | 490,00 | | | | 490,00 |
| United Kingdom | | 18,90 | 18,90 | | | 37,80 |
| United States | 1.010,99 | 83,57 | 3,58 | | 0,39 | 1.098,52 |
| **Total** | **1.567,33** | **5.107,43** | **11.547,67** | **29,31** | **5,32** | **18.257,07** |

Installed Capacity 2006, MWth

**Table 14: Installed capacity in 2004, $MW_{th}/a$**

| Installed Capacity in 2004 MWth/yr | | | | | | | |
|---|---|---|---|---|---|---|---|
| Country | Water collectors | | | Air Collectors | | TOTAL | Water coll |
| | unglazed | glazed | evacuated tube | unglazed | glazed | | glazed+ev.tube |
| Albania | 0,00 | 6,18 | 0,00 | 0,00 | 0,00 | **6,18** | 6,18 |
| Australia | 270,90 | 105,00 | 0,70 | 0,00 | 0,00 | **376,60** | 105,70 |
| Austria | 6,23 | 126,00 | 1,82 | 0,00 | 0,00 | **134,05** | 127,82 |
| Barbados | 0,00 | 1,91 | 0,00 | 0,00 | 0,00 | **1,91** | 1,91 |
| Belgium | 0,00 | 10,29 | 0,00 | 0,00 | 0,00 | **10,29** | 10,29 |
| Brazil | 0,00 | 270,12 | 0,00 | 0,00 | 0,00 | **270,12** | 270,12 |
| Canada | 25,24 | 0,82 | 0,14 | 11,34 | 0,00 | **37,53** | 0,96 |
| China | 0,00 | 1.050,00 | 8.400,00 | 0,00 | 0,00 | **9.450,00** | 9.450,00 |
| Cyprus | 0,00 | 21,00 | 0,00 | 0,00 | 0,00 | **21,00** | 21,00 |
| Czech Republic | 0,00 | 5,67 | 0,28 | 0,00 | 0,00 | **5,95** | 5,95 |
| Denmark | 0,00 | 8,40 | 0,00 | 0,00 | 3,50 | **11,90** | 8,40 |
| Estonia | 0,00 | 0,18 | 0,00 | 0,00 | 0,00 | **0,18** | 0,18 |
| Finland | 0,00 | 0,98 | 0,16 | 0,00 | 0,00 | **1,14** | 1,14 |
| France (incl. Oversea Departments) | 4,34 | 77,50 | 0,00 | 0,00 | 0,00 | **81,84** | 77,50 |
| Germany | 21,00 | 472,50 | 52,50 | 0,00 | 0,00 | **546,00** | 525,00 |
| Greece | 0,00 | 150,50 | 0,00 | 0,00 | 0,00 | **150,50** | 150,50 |
| Hungary | 0,21 | 1,75 | 0,14 | 0,00 | 0,00 | **2,10** | 1,89 |
| India | 0,00 | 140,00 | 0,00 | 0,00 | 0,00 | **140,00** | 140,00 |
| Ireland | 0,00 | 0,84 | 0,56 | 0,00 | 0,07 | **1,47** | 1,40 |
| Israel | 0,00 | 49,00 | 0,00 | 0,00 | 0,00 | **49,00** | 49,00 |
| Italy | 0,00 | 40,60 | 0,00 | 0,00 | 0,00 | **40,60** | 40,60 |
| Japan | 0,00 | 172,40 | 3,24 | 0,00 | 0,00 | **175,64** | 175,64 |
| Lativa | 0,00 | 0,35 | 0,00 | 0,00 | 0,00 | **0,35** | 0,35 |
| Lithuania | 0,00 | 0,35 | 0,00 | 0,00 | 0,00 | **0,35** | 0,35 |
| Luxembourg | 0,00 | 1,19 | 0,00 | 0,00 | 0,00 | **1,19** | 1,19 |
| Macedonia | 0,00 | 1,05 | 0,00 | 0,00 | 0,00 | **1,05** | 1,05 |
| Malta | 0,00 | 2,86 | 0,09 | 0,00 | 0,00 | **2,95** | 2,95 |
| Mexico | 28,86 | 19,24 | 0,00 | 0,00 | 0,00 | **48,11** | 19,24 |
| Namibia | 0,00 | 0,03 | 0,00 | 0,00 | 0,00 | **0,00** | 0,03 |
| Netherlands | 22,40 | 18,20 | 0,00 | 0,00 | 0,00 | **40,60** | 18,20 |
| New Zealand | 0,00 | 5,57 | 0,43 | 0,00 | 0,00 | **6,00** | 6,00 |
| Norway | 0,14 | 1,05 | 0,00 | 0,00 | 0,18 | **1,37** | 1,05 |
| Poland | 0,46 | 15,79 | 1,89 | 0,00 | 0,00 | **18,13** | 17,68 |
| Portugal | 0,00 | 11,26 | 0,00 | 0,00 | 0,00 | **11,26** | 11,26 |
| Slovak Republic | 0,00 | 3,85 | 0,00 | 0,00 | 0,00 | **3,85** | 3,85 |
| Slovenia | 0,00 | 1,26 | 0,21 | 0,00 | 0,00 | **1,47** | 1,47 |
| South Africa | 42,70 | 9,80 | 0,01 | 0,00 | 0,00 | **52,51** | 9,81 |
| Spain | 3,15 | 55,44 | 4,41 | 0,00 | 0,00 | **63,00** | 59,85 |
| Sweden | 6,07 | 12,25 | 1,79 | 0,00 | 0,00 | **20,11** | 14,04 |
| Switzerland | 7,82 | 20,93 | 0,88 | 1,40 | 0,00 | **31,03** | 21,81 |
| Taiwan | 0,00 | 72,26 | 5,86 | 0,00 | 0,00 | **78,12** | 78,12 |
| Tunisia | 0,00 | 4,90 | 0,00 | 0,00 | 0,00 | **4,90** | 4,90 |
| Turkey | 0,00 | 336,00 | 0,00 | 0,00 | 0,00 | **336,00** | 336,00 |
| United Kingdom | 0,70 | 8,40 | 7,00 | 0,00 | 0,00 | **16,10** | 15,40 |
| United States | 884,96 | 32,58 | 0,13 | 0,00 | 0,26 | **917,93** | 32,71 |
| **Total** | **1.325,18** | **3.340,06** | **8.482,24** | **12,74** | **4,01** | **13.164,19** | **11.822,30** |