SOLTRAIN

Southern African Solar Thermal Training & Demonstration Initiative

SOLAR THERMAL DIMENSIONING GUIDELINES

www.soltrain.co.za

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INTRODUCTION

This brochure provides the general information for the dimensioning and design considerations of solar thermal systems. The information provided can be used for the **sizing of small residential systems** as well as for **larger systems** for the **accommodation and healthcare sectors** and includes both thermosiphon and pumped systems.

The following topics are covered:

- Types of collectors
- Types of systems
- Tilt and orientation of collectors
- Understanding hot water demand
- Sizing of hot water storage tanks
- Sizing of collector area
- Other design considerations

TYPES OF COLLECTORS

The most common solar thermal technologies used for generating hot water for residential, commercial and industrial applications are; **flat plate collectors** and **evacuated tube collectors**. These collectors are ideal for the production of heat in low temperature applications (below 100 °C) for both domestic and process heat applications.

There are advanced flat plate and evacuated tube collectors that can produce heat at temperatures above 100 °C.

TYPES OF SYSTEMS

Two types of solar thermal systems, also referred to as solar water heaters, are typically used depending on the application, namely thermosiphon and pumped systems.

THERMOSIPHON SYSTEMS

Thermosiphon systems, also referred to as **passive heating systems**, rely on the thermosiphon principle for circulating and heating water in the tank. These types of systems are most commonly used for residential applications. The location of the tank above the solar collector is important to ensure effective passive circulation in the system.

PUMPED SYSTEMS

Pumped systems, also referred to as **active heating systems**, makes use of a pump to circulate the water in the system for heating. In these systems, the location of the tank is not important, but the distance of the collector(s) from the storage tank should be minimised to reduce heat losses. These types of systems are most commonly used for large-scale installations in residential, commercial and industrial applications.

*Both thermosiphon and pumped systems can be **direct or indirect systems**. In direct systems, the water inside the tank flows **within** the collectors whereas in indirect systems, the water flowing **through** the collector does not come in contact with the water inside the collector - instead the **heat is transferred** by an internal or external heat exchanger. It is recommended to use indirect systems.*

TILT & ORIENTATION OF COLLECTORS

Solar collectors should always be installed **facing the equator**. This means that collectors installed in the southern hemisphere should be north facing. A deviation of **30°** from North is permissible in most Southern African regions, without significant reduction in the annual solar yield of the system (<5%).

The optimal tilt angle of the collector varies with season but a general rule is that the tilt angle is equivalent to the degree of latitude of the site, to ensure maximum yield throughout the year.

HOT WATER DEMAND

The hot water demand (HWD) in buildings can vary depending of the specific purpose of the building. The HWD is characterised as the litres each person uses per day. In a normal household, people use hot water for domestic purposes such as making food, washing clothes and dishes, personal hygiene, etc. This hot water use by each person will vary in larger buildings (ex. hospitals, hotels, student hostels, etc.), based on the number of beds or the number of persons the building can accommodate. In this case, the **HWD should be characterised as the litres per bed per day**. The table below provides guidelines:

Building type	Unit demand	Low demand	Medium demand	High demand
Residential	L/person /day	30	50	60
Hospitals & accommodation	L/bed /day	20	40	60

It's essential that the hot water demand be characterised as the **maximum possible demand during full occupancy** of the building. As an example, a hotel in South Africa that can cater for 120 guests with medium demand should design for a HWD of 4 800 L/day, although the hotel will not be at full capacity throughout the year.

SIZING HOT WATER STORAGE

When the daily hot water demand is calculated, the **storage tank volume** can be determined. The storage volume should be 0.8 - 1.2 times the daily hot water demand in regions with high solar radiation like southern Africa. This allows for peak hot water consumption on cloudy days to still be met. Using the previous example, a storage volume (V_{st}) is determined for the hotel in South Africa as follows:

V_{st} = HWD x 1.2 = 4 800 litres/day x 1.2 = 5 670 litres

Most manufacturers would not offer storage tanks in this specific size, therefore a capacity of 6 000 litres can be used to meet the demand. However, it is recommended that the capacity of the storage is not less than 90% or more than 120% of the calculated volume.

SIZING OF COLLECTOR AREA

The sizing of the collector area required to satisfy the daily hot water demand is essential for the **effective operation** of the solar water heating system. For small scale-residential systems, the table below provides the suitable range for the collector area required for a specific storage volume in Southern African weather conditions:

Storage volume	BP collector area	SC collector area
50 -75 liters	1.0 – 1.5 m²	0.9 – 1.3 m²
100 -150 liters	2.0 – 3.0 m²	1.5 – 2.5 m²
200 -300 liters	3.5 – 4.5 m²	3.0 – 4.0 m²
300 -450 liters	4.5 – 6.0 m²	4.0 – 5.0 m²
500 -750 liters	7.5 – 10.0 m²	6.0 – 8.5 m²

*BP - black painted absorber; SC - selective coating

A general rule of thumb is to install 1 m² of collector area with selective coating per 100 litre of storage volume for large-scale installations. For the case of the hotel, the collector area (A_c) required is calculated as follows:

A_c = 1 m² x (5 760 litres ÷ 100 litres) = 57.6 m²

This means a collector area of 57.6 m² with selective coating would be suitable for the installation. This dimensioning guideline could vary depending on the application and the heat demand, especially in the case of process heat applications.

OTHER DESIGN CONSIDERATIONS

The **installation quality** of a solar thermal system is a significant contributing factor to the effective operation, maintenance requirements and lifespan of the system. It is critical that the system be installed to the highest quality possible with adequate insulation of all hot water pipes to and from the collectors and tanks as well as all safety components and valves to ensure the installation complies with local standards. Expansion vessels have to be sized and installed correctly to ensure effective operation.

For more information on the project, events, demonstration systems visit the SOLTRAIN website at: **www.soltrain.org.za**

PARTNERS & CONTACTS

AEE-Institute for Sustainable Technologies
Country: Austria
Contact person: Werner Weiss
Tel: +43 03112 5886 117
E-mail: w.weiss@aee.at

Namibia Energy Institute
Country: Namibia
Contact person: Helvi Ileka
Tel: +26 461 207 2551
E-mail: hileka@nust.na

Botswana University
Country: Botswana
Contact person: Dr. Ditiro Setlhaolo
Tel: +267 355-4351
E-mail: setlhaolo@ub.ac.bw

National University of Science & Technology
Country: Zimbabwe
Contact person: Samson Mhlanga
Tel: +26 3 292 28242
E-mail: samson.mhlanga@nust.ac.zw

Bethel Business & Community Development Centre
Country: Lesotho
Contact person: Ivan Yaholnitsky
Tel: +266 58 742991
E-mail: ivan.yaholnitsky@gmail.com

Empresa Nacional de Parques de Ciência e Tecnologias E.P.
Country: Mozambique
Contact person: Daniel Baloi
Tel: +258 84 390 6658
E-mail: dbaloi100@gmail.com

South African National Energy Development Institute
Country: South Africa
Contact person: Dr. Karen Surridge
Tel: +21 11 038 4300
E-mail: karenst@sanedi.org.za

Centre for Renewable & Sustainable Energy Studies
Country: South Africa
Contact person: Karin Kritzinger
Tel: +27 21 808 4069
E-mail: crses@sun.ac.za

SADC Centre for Renewable Energy and Energy Efficiency
Country: Namibia
Contact person: Kudakwashe Ndhlukula
Tel: +264 61 300 051
E-mail: kuda.ndhlukula@sacreee.org