SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Best Practice Examples

Demo Applications and Success Stories of Thermosyphon and PV Hot Water Systems

IEA SHC TASK 69 | Solar Hot Water for 2030

Technology Collaboration Programme
by iea

Best practice examples

Demo Applications and Success Stories of Thermosyphon and PV Hot Water Systems

This is a report from SHC Task 69: Solar Hot Water for 2030 and work performed in Subtask A: State-of-the-art and operating environments in different regions and Subtask B: Thermosyphon hot water systems

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Solar Heating & Cooling Technology Collaboration Programme (IEA SHC)

The Solar Heating and Cooling Technology Collaboration Programme was founded in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency.

Our mission is: "Through multi-disciplinary international collaborative research and knowledge exchange, as well as market and policy recommendations, the IEA SHC will work to increase the deployment rate of solar heating and cooling systems by breaking down the technical and non-technical barriers."

IEA SHC members carry out cooperative research, development, demonstrations, and exchanges of information through Tasks (projects) on solar heating and cooling components and systems and their application to advance the deployment and research and development activities in the field of solar heating and cooling.

***Our focus areas**, with the associated Tasks in parenthesis, include:*

- *Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44, 54, 69)*
- *Solar Cooling (Tasks 25, 38, 48, 53, 65)*
- *Solar Heat for Industrial and Agricultural Processes (Tasks 29, 33, 49, 62, 64)*
- *Solar District Heating (Tasks 7, 45, 55, 68)*
- *Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56, 59, 63, 66)*
- *Solar Thermal & PV (Tasks 16, 35, 60)*
- *Daylighting/Lighting (Tasks 21, 31, 50, 61)*
- *Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)*
- *Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43, 57)*
- *Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46)*
- *Storage of Solar Heat (Tasks 7, 32, 42, 58, 67)*

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- *SHC Solar Academy*
- *Solar Heat Worldwide, annual statistics report*
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Contents

1 Executive Summary

In the frame of Subtask A of the SHC Task 69: Solar Hot Water for 2030 best practice examples as well as common systems in different regions worldwide have been collected to provide an overview of the status quo of solar thermosyphon systems as well as PV hot water systems. The regions considered were chosen according to the classification used in the IEA SHC Solar Heat Worldwide report [1], namely Asia excluding China[1], China, Europe, Latin America, Middle East and North Africa, North America, Oceania and Sub-Saharan Africa.

A template was developed to collect information about system location, system type, application, beneficiary, installer, maintainer, year of installation, as well as technical details about collector brands and models, collector and tank size, insulation, operating conditions, performance indicators, investment cost and operational cost as well as any funding received. Further the contributors were asked to add information about challenges that occurred and innovative solutions that were used to overcome these challenges. However, it was quite difficult to receive detailed information from all the different regions, therefore some of the systems are presented in a more general way. Others are not best practices in the strict sense of the word, but commonly used systems. Nevertheless, these systems were integrated into this report to catch a glimpse of what kind of thermosyphon solar systems are used in the different regions worldwide. The information provided was gathered from experts active in the field of Solar Thermosyphon and PV Hot Water in the different regions, supported by desktop research especially with regards to regions where no input from experts could be received.

Further, a classification of commonly used systems is given for the two technologies in chapter 3. Solar thermosyphon systems are mainly characterized by the type of heat exchange (direct and indirect) as well as the collector type, evacuated tubes and flat plate collectors respectively, and tank used. PV Hot Water systems roughly are classified into grid-connected and stand-alone systems. A further classification is given whether the systems use inverters or not.

In total eleven best practice examples with detailed information are available regarding thermosiphon systems, two each in India and China, two in Latin America (Brazil and Mexico), one in the MENA region (Egypt) and four in the SADC region (Namibia, Zimbabwe, Lesotho, South Africa). With regards to PV Hot Water there are examples available from China and South Africa. Europe and Argentina contribute solar thermosyphon examples without detailed information. Unfortunately, for North America and Oceania no best practices are available. Instead, a few companies active in the field of SWH and PV Hot water are listed for interested parties to get in contact. With regards to Australia, a study done by Harry Suehrcke for Subtask D of the IEA SHC Task 69 explains the development of renewables in Australia over the last 15 years [2].

Acknowledgement: We would like to thank all the contributors who provided detailed information for best practice examples in their countries to make this report possible.

[1] The People's Republic of China is referred to as "China" in this report

2 Introduction

Thermosiphon systems account for more than half of the total installed solar thermal capacity worldwide (status at the end of 2023 [1]), and their potential to cover an important share of domestic hot water worldwide is even larger, but country strategies to include the technology into the country energy mix are scarce and mainly focused on small countries like Barbados, Cyprus, Greece, Hawaii or Israel.

According to a survey done within IEA SHC Task 69 [2a], direct thermosiphon systems are common in warmer climates in China, India, Latin America, Sub-Saharan Africa and the MENA region, where there is no risk of freezing. In colder climates such as in Europe, especially in the Mediterranean region, Japan or Northern China, indirect systems are prevalent. In China, most systems use evacuated tube collectors, whereas in Europe flat plate collectors are dominant. There is also potential for local manufacturing with small and medium-sized enterprises that can be highly supported by governments through tax incentives and other supporting regulations like building codes. Current developments focus on making systems easier to use through smart control, remote access via cell phone, temperature visualization or monitoring apps.

For a standard thermosyphon system with a 150 Litre tank and 2 m^2 of collector area in countries such as China and India, typical system prices are in the range of USD 250 to 500 and USD 500 to 1000. In European markets, prices are in the range of USD 1,000 to 1,500. In Australia prices are ranging from USD 1,000 to more than USD 2,500 per system. In North America, solar thermosiphon systems only take a share of 1% according to the Solar Heat Worldwide Report Ed. 2025 [1] despite of the high potential in several southern states like Florida or California. Reasons are seen in the high prices for the systems compared to other technologies especially natural gas as well as aesthetic reasons [3].

The survey also asked for the market growth potential. Most Chinese manufacturers expected little or no growth, while companies in countries of Sub-Saharan Africa, Latin America and Europe's Mediterranean area, are more optimistic. About two third (60%) of the companies expected a growth rate between 0 and 10% in the coming years.

The work done for this deliverable can also be seen as a starting point and probably it can motivate planners, producers and installers of solar hot water systems worldwide to work together across regions, exchange knowledge and success stories and work on identified challenges regarding quality issues, capacity building and training demand. Solar thermosyphon is a well proven technology and learning from best practice examples may help to overcome challenges that may occur in the different regions. The second technology, PV Hot Water is currently on the rise in countries with high PV penetration rates on the one hand, to prevent curtailment of renewable power capacities, and a need for off-grid solutions on the other hand. South Africa and China provided examples in this field: In South Africa solutions to overcome load shedding are essential to increase comfort and reduce dependence on the grid. In China, balcony solutions become more and more common for high rise buildings. Finally, the identified best practices are essential to inform policy and decision makers as well as the broader public about the potential of solar hot water solutions to contribute to clean and affordable hot water supply to increase the people’s well-being and living standard in the respective countries.

Additional to this report and the market survey done within Subtask A, valuable insights with regards to technical questions, standards, training necessities and policy regulations regarding solar thermosyphon systems and PV Hot Water are given in the Deliverables of Subtask B, Subtask C and Subtask D of IEA SHC Task 69: Solar Hot Water for 2030. Please refer to the website for more information https://task69.iea-shc.org/ .

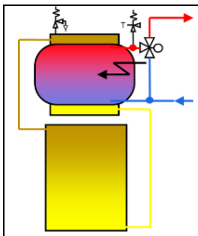
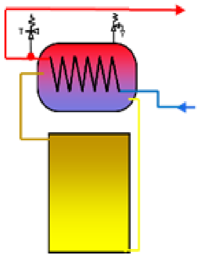
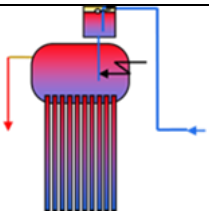
3 System Classifications

3.1 Classification of thermosyphon systems

The working principle of thermosyphon systems is natural convection to circulate water. No pumps and electricity are needed; therefore, the systems are quite simple and reliable with low need for maintenance. Usually, they are cost-effective with the initial investment paying back within a few years. Thermosyphon systems can be classified with regards to the collector, flat plate collector or evacuated tubes respectively, and the heat exchange. Direct systems circulate the potable water directly without using a heat exchanger, with regards to indirect systems a heat exchanger is used, for example double jacket tank or spiral tube heat exchanger (see Table 1).

Regarding the full spectrum of solar thermal collectors and systems including applications, an overview can be found in several publications, e. g. [4][5][6][7].

Table 1. Exemplary types of solar thermosyphon systems: Indirect solar thermosyphon system with electrical backup heating and double jacket tank, indirect solar thermosyphon system with hot water storage and internal heat exchanger, direct solar thermosyphon system with hot water storage tank and evacuated tubes. (Source schematics: AEE INTEC / Rudi Moschik, Photos: AEE INTEC / SOLTRAIN)

 	Indirect solar thermosyphon system with electrical backup heating. The collector can be flat plate or evacuated tubes respectively. The heat exchange in this case is done via double jacket tank.
 	Indirect solar thermosyphon system with hot water storage and internal heat exchanger. The collector can be flat plate or evacuated tubes respectively.
 	Direct solar thermosyphon system with hot water storage tank and evacuated tubes.

3.2 Classification of PV hot water systems

PV based hot water systems gained interest recently because using surplus PV electricity for hot water production can increase the self-consumption of locally produced electricity when there are low feed-in tariffs or when the grids are unreliable. Further it is used to prevent curtailment of locally produced PV electricity because of grid constraints. The systems do not need rooftop tanks and freezing or stagnation are not an issue with regards to PV hot water systems, compared to solar thermosiphon systems.

Directly coupled systems do not use inverters to keep the setup simple and to reduce installation cost. These systems are used in regions with unreliable electricity grids like in South Africa, as off-grid solutions or when grid connection costs are high.

Partially coupled systems are used in countries with high PV penetration, using electric hot water tanks, diverters and smart grid solutions to prevent the curtailment of locally produced electricity.

4 Examples: Thermosyphon Systems

4.1 Asia excl. China (Region #1)

4.1.1 Raichur Hostel for Girl Students (India)

Raichur Hostel for Girl Students (India)

Figure 1. Thermosyphon System "Raichur Hostel for Girl Students". Source: Nuetech Solar Pvt. Ltd.

Hydraulics

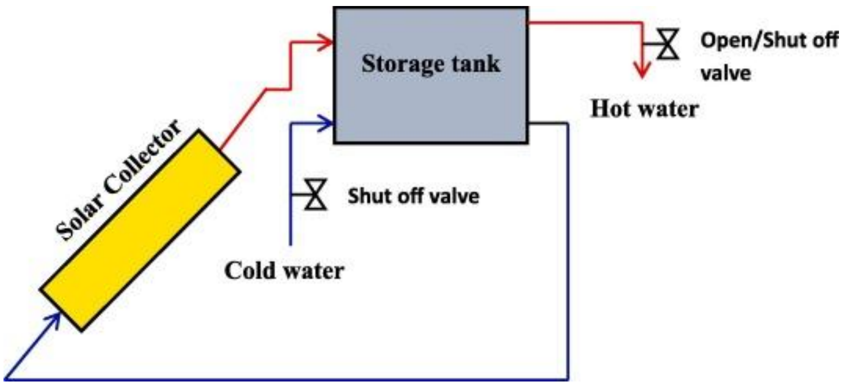


Figure 2. Hydraulic scheme of the thermosyphon system "Raichur Hostel for Girl Students". Source: Nuetech Solar Pvt. Ltd.

About

The thermosyphon system caters to hot water needs for bathing for 35 girls students residing in the hostel built by the State government of Karnataka. Over 50 such systems were built by the State government. The supplier of the thermosyphon system has trained and contracted a local technician for upkeeping and maintenance for a period of 5 years, to be extended with additional annual maintenance contracts.

Application, motivation

The State government has a target to promote low carbon heating technologies and furthermore to create education amongst the future generation on benefits of solar energy. During cloudy days back-up electrical heating is provided.

Challenges, best practice solutions, innovations

The system showcases in practice how solar energy can be used for meeting hot water requirements without burning of fossil fuels and to save energy. Students residing can later install similar systems in their families when they move to their respective homes after completion of their higher level education. No significant problems occurred during planning and installation. The upkeep and maintenance contract with a local technician assures a reliable operation.

System	
Location	Raichur, District Karnataka, India
Latitude, longitude	16.2160° N, 77.3566° E
Altitude	407 m asl
System type	Direct thermosyphon with flat plate collectors
Application	Domestic Hot Water
Customer / Beneficiary	Hostel for girl students
Installer	Nuetech Solar Private Limited
Maintainer / Operator	Social Welfare Department, State Government of Karnataka
Commissioning year	2024
System brand and model	Nuetech Sun Pot - FPC
Total gross collector area / power	8 m^2 (5.6 kW_{th})
Total tank volume	500L
Maximum operating temperature	60 °C
Maximum operating pressure	N/A
Total capital cost (CAPEX)	€ 1,600 (final customer price including shipping, installation and taxes)
Total O&M costs per year (OPEX)	5% of CAPEX
Funding / subsidy	100% State government owned
Funding agency	State government
Public data set	N/A
Project website	https://raichur.nic.in/en/social-welfare/

Collector	
Collector type	Flat Plate Collector
Absorber type (for flat plate collectors)	Copper absorber selectively coated
Collector brand and model	Nuetech Sun Pot - FPC
Gross collector area / power	2 m^2 (1.4 kW_{th})
Number of collectors	4
Mounting	Roof
Orientation (azimuth)	0° (south)
Tilt	25°
Heat transfer fluid	Water
Product certification	Bureau of Indian Standards
Data sheet	N/A

Storage	
Storage type	Insulated mild steel tank
Number and size of storages	4 x 125L
Storage brand and model	Nuetech Sun Pot
Insulation type	Polyurethane foam
Insulation thickness	40 mm
Product certification	Bureau of Indian Standards
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	None
Piping	Chlorinated poly vinyl chloride (CPVC)
Piping insulation	None
Heat exchanger type	N/A
Back-up system type	Electric hot water boiler
Back-up system nominal power	N/A
Solar fraction	60%

Performance indicators	
Guaranteed lifetime	3 a
Expected lifetime	20 a
Daily heat gain	18 kWh/a average (whole system)
Annual solar yield	4500 kWh/a (whole system)
Annual performance ratio	N/A
Avoided CO_2:	Approximately 4 tons CO_2 annually (whole system)

Resources

https://www.nuetechsolar.com

https://raichur.nic.in/en/social-welfare/

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4.1.2 Government School Ballari (India)

Government School Ballari (Karnataka)

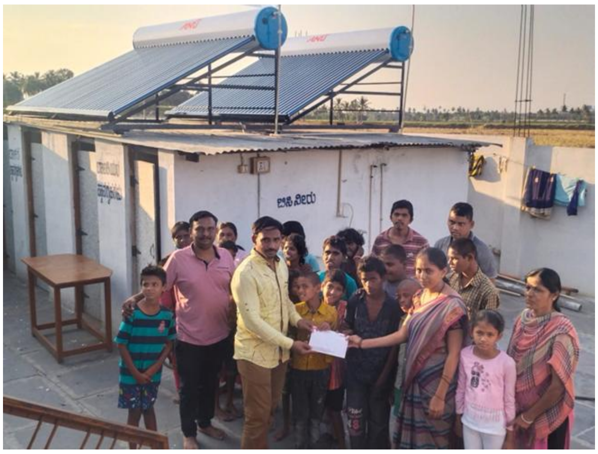

Figure 3. Installed Collectors at Government School Ballari (Karnataka State). Source: Jaideep Malaviya, Malaviya Solar Energy Consultancy

Hydraulics

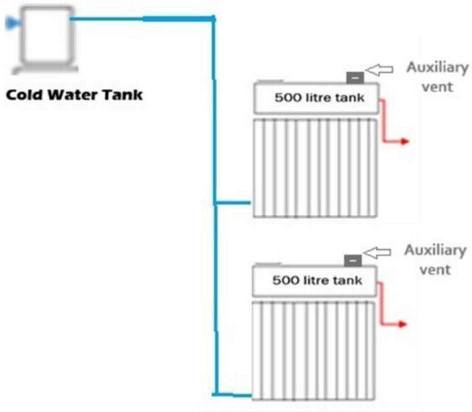

Figure 4. Hydraulic scheme of the thermosyphon system "Ballari Government School". Source: Jaideep Malaviya, Malviya Energy Consultancy

About

Fifty children boarded in residential schools were using electrical heated hot water system. Owing to unreliable supply they were subject to flu-like symptoms especially from legionella bacteria.

Application, motivation

On a pilot basis the State government decided to explore solar water heating systems as sunlight is amply available for nearly 300 days and can provide with reliable hot water for bathing. Besides it will reduce the cost of electricity bill.

Challenges, best practice solutions, innovations
The roof structure was a galvanized sheet and was challenging to install the structure that could bear the weight. A strong fabricated base structure had to be made. It was also a challenge to get the storage tanks on to the roof owing to limited space for workmanship. Using special skilled workers it was finally achieved.

System	
Location	Ballari, District Karnataka, India
Latitude, longitude	15° 30' and 15°50' north latitude and 75° 40' and 77° 11' east longitude
Altitude	455 m asl
System type	Direct thermosyphon with evacuated tube collectors
Application	Domestic Hot Water
Customer / Beneficiary	Governmental school
Installer	Anu Solar Private Limited
Maintainer / Operator	
Commissioning year	2023
System brand and model	Anu Solar ETC Solar Water Heater
Total gross collector area / power	15 m^2 (10.5 kW_{th}) (2 systems)
Total tank volume	2x500L
Maximum operating temperature	
Maximum operating pressure	N/A
Total capital cost (CAPEX)	€ 1,250 (final customer price including transport, installation and taxes)
Total O&M costs per year (OPEX)	
Funding / subsidy	100% State government owned
Funding agency	State government
Public data set	N/A
Project website	https://dom.karnataka.gov.in/ballari/public/new-page/MURARJI%20DESAI%20RESIDENTIAL%20SCHOOLS/en

Collector	
Collector type	Evacuated tube collector
Absorber type (for flat plate collectors)	
Collector brand and model	Anu Solar ETC Solar water heater
Gross collector area / power	7.5 m^2 (5.25 kW_{th})
Number of collectors	2
Mounting	Roof
Orientation (azimuth)	0° (south)
Tilt	45°
Heat transfer fluid	
Product certification	Bureau of Indian Standards
Data sheet	N/A

Storage	
Storage type	Stainless steel
Number and size of storages	2 x 500L
Storage brand and model	Anu Solar
Insulation type	
Insulation thickness	
Product certification	Bureau of Indian Standards
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	None
Piping	
Piping insulation	None
Heat exchanger type	N/A
Back-up system type	No back-up
Back-up system nominal power	N/A
Solar fraction	100%

Performance indicators	
Guaranteed lifetime	
Expected lifetime	20 a
Daily heat gain	
Annual solar yield	12,500 kWh/a (two systems)
Annual performance ratio	N/A
Avoided CO_2:	Approximately 200 tons CO_2 of 20 years lifetime

Resources

https://anusolar.com/index.php/service/solar-water-heaters/

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4.2 China (Region #2)

4.2.1 Puda health and wellness resort – Panzhihua, Sichuan Province (China)

Puda health and wellness resort – Panzhihua, Sichuan Province

Figure 5. Puda Health and Wellness Resort, Panzhihua, Sichuan Province, China. Source: Shandong Linuo Ritter New Energy Co., Ltd

Hydraulics

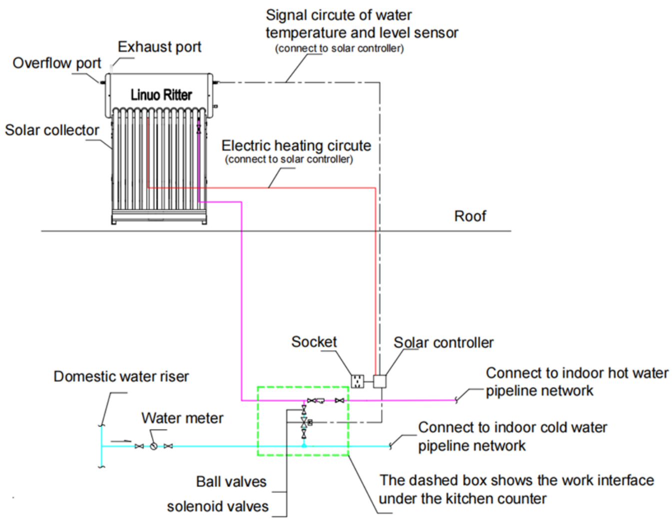

Figure 6. Hydraulic scheme of Puda Health and Wellness Base, Panzhihua, Sichuan Province. Source: Shandong Linuo Ritter New Energy Co., Ltd

About

Sichuan Puda Health and Wellness resort, also known as Puda Sunshine International Health and Wellness Resort, is located in the Ecotourism Demonstration Zone of Renhe District, Panzhihua City, 8 kilometers away from the urban area of Panzhihua. It is a benchmark demonstration project for the health and wellness industry deployed by Sichuan Development (Holdings) Co., Ltd. in Panzhihua, with a planned area of approximately 13,000 mu (about 866.67 hectares) and a construction land area of about 2,800 mu (about 186.67 hectares).

The project adopts 1,650 sets of 164-liter vacuum tube solar water heaters as the heat source for domestic hot water. It has won the Gold Award for Design in the "China Human Settlement Model Planning and Design Competition and has been designated as a Panzhihua Health and Wellness Demonstration Base, a Sichuan Provincial Key Project, and a Sichuan Provincial Investment Promotion Project. Additionally, it has received honors such as a Sichuan Provincial Key Tourism Project, one of the Top Ten Excellent Tourism Investment Projects in Sichuan, and the Best Health and Wellness Destination in Sichuan.

Application, motivation

China's solar energy resources are relatively abundant, and making full use of solar energy helps reduce the consumption of traditional energy sources and mitigate environmental pollution. Among these efforts, solar water heaters, as exemplary products utilizing renewable energy, are designed with a core philosophy centered on "maximizing solar energy utilization, minimizing additional energy consumption, and reducing carbon emissions throughout the entire lifecycle." Through technological innovation and system optimization, they achieve end-to-end energy savings from energy capture to hot water supply, serving as a critical technological pathway for realizing the "dual carbon" goals (peaking CO_2 emissions before 2030 and achieving carbon neutrality before 2060) in the building and household sectors.

Challenges, best practice solutions, innovations

Challenge: The building orientations are relatively irregular, and there are high requirements for the product's appearance.

Solution: Adopt customized product appearances and reasonably arrange the solar water heaters according to different building orientations to ensure the water heaters face due south.

System

Location	Panzhihua, Sichuan province
Latitude, longitude	26°35′ N, 101°28′ E
Altitude	1198
System type	Compact vacuum tube system with water tank
Application	Resident
Customer / Beneficiary	Resident
Installer	Shandong Linuo Ritter New Energy Co., Ltd
Maintainer / Operator	Shandong Linuo Rittert New Energy Co., Ltd
Commissioning year	2020
System brand and model	Linuo Ritter
Total gross collector area / power	2.52
Total tank volume	152
Maximum operating temperature	85
Maximum operating pressure	0.05MPa
Total capital cost (CAPEX)	3,869,250 Yuan RMB (approx. 490,500 €[2])
Total O&M costs per year (OPEX)	12,575 Yuan RMB (approx. 1590 €)
Funding / subsidy	Company investment
Funding agency	Panzhihua Polonda Real Estate Development Co., Ltd. / Panzhihua Puyida Real Estate Development Co., Ltd
Public data set	N/A
Project website	N/A

[2] According to OANDA exchange rate 0.12679 (avg.) on 25/05/2026

Collector	
Collector type	Full glass vacuum tube
Absorber type (for flat plate collectors)	Selective coating
Collector brand and model	Linuo Ritter/vacuum tube type
Gross collector area / power	2.52㎡
Number of collectors	1650
Mounting	Roof
Orientation (azimuth)	0
Tilt	50
Heat transfer fluid	Water
Product certification	N/A
Data sheet	N/A

Storage	
Storage type	Stainless steel insulated water tank
Number and size of storages	152L/set
Storage brand and model	Linuo Ritter
Insulation type	Polyurethane foam
Insulation thickness	55mm
Product certification	GB/T 19141
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	1.5kW
Piping	PPR
Piping insulation	N/A
Heat exchanger type	N/A
Back-up system type	Electric hot water boiler
Back-up system nominal power	1.5kW/set
Solar fraction	70%

Performance indicators	
Guaranteed lifetime	15years
Expected lifetime	15 years
Daily heat gain	5.88 kWh/a average (The whole project)
Annual solar yield	3,542,550 kWh/a (The whole project)
Annual performance ratio	/
Avoided CO_2:	Approximately 3531 tons CO_2 annually (The whole project)

Resources

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4.2.2 Huludao City Ecological Environment Bureau Longgang Sub-bureau Clean Heating Project (China)

Huludao City Ecological Environment Bureau Longgang Sub-bureau Clean Heating Project

Figure 7. Huludao City Ecological Environment Bureau Longgang Sub-bureau Clean Heating Project, Liaoning Province, China. Source: Shandong Linuo Ritter New Energy Co., Ltd

Hydraulics

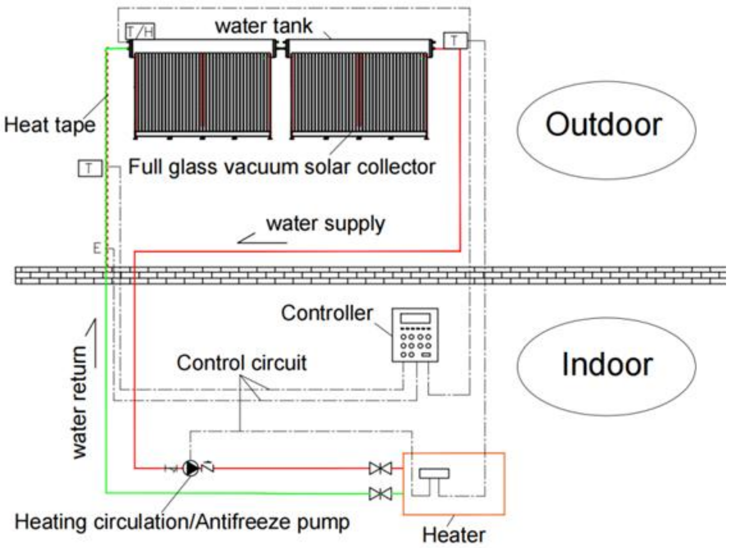

Figure 8. Hydraulic scheme of Huludao City Ecological Environment Bureau Longgang Sub-bureau Clean Heating Project. Source: Shandong Linuo Ritter New Energy Co., Ltd

About

The clean heating project of Liaoning Huludao City Ecological Environment Bureau Longgang Branch is mainly to solve the demand for rural residents' winter, using clean energy to replace traditional coal or wood stoves, and reduce pollutant emissions. The project is equipped with 2 sets of 40-tube full-glass tube heating machines for each household, totaling 1900 households.

Application, motivation

Traditional rural heating methods exhibit low combustion efficiency and cause severe pollution. China's solar energy resources are relatively abundant, and making full use of solar energy can help reduce the consumption of traditional energy sources and mitigate environmental pollution. Adopting solar heating products can partially meet winter heating demands while also providing households with domestic hot water.

Challenges, best practice solutions, innovations

Challenge one: Wind-resistant. The solar water heating project is located in Huludao, Liaoning Province, where it is close to the sea, with strong winds blowing all year round.

Solution: The solar heating main unit is fixed with steel rope around the building.

Challenge two: Antifreeze.

The project site experiences 145 days per year with a daily average temperature ≤ 5°C, and the average temperature during these periods is -3.2°C, necessitating anti-freeze measures. From energy-saving and economic perspectives, a combination of heat tape and a circulating/anti-freeze heating pump is adopted for freeze protection. The heating circulation/antifreeze pump is controlled by the controller on the heater, enabling both heating circulation and antifreeze cycles.

Control Principles:

(1) When the heater is turned on, it activates the circulation pump for 5 minutes. If the solar water temperature reaches the set temperature during this period, the circulation pump continues running, and the indoor heating is supplied by solar energy.

(2) When the solar water temperature falls below the set temperature, the electric heating is activated. At this point, the system operates in a combined mode of solar energy and electric heating.

(3) When the solar water temperature drops below 25°C, the circulation pump stops, and the system operates solely on electric heating.

(4) After the circulation pump stops, it runs for 5 minutes every hour to check whether the solar water temperature meets the heating requirements. This also helps prevent pipe freezing.

(5) The antifreeze pump takes priority as the primary frost protection measure, while heat tape serves as a supplementary solution.

System

Location	Huludao, Liaoning province
Latitude, longitude	40°56′ N, 120°38′ E
Altitude	17
System type	Compact vacuum tube system with water tank
Application	Resident
Customer / Beneficiary	Resident
Installer	Shandong Linuo Ritter New Energy Co., Ltd
Maintainer / Operator	Shandong Linuo Ritter New Energy Co., Ltd
Commissioning year	2019
System brand and model	Linuo Ritter
Total gross collector area / power	5.0 ㎡
Total tank volume	180 L
Maximum operating temperature	85
Maximum operating pressure	0.05 MPa

Total capital cost (CAPEX)	14,252,700 Yuan RMB (approx. 1,807,000 €[3])
Total O&M costs per year (OPEX)	67,000 Yuan RMB (approx. 8490 €)
Funding / subsidy	Fiscal budget
Funding agency	Huludao City
Public data set	N/A
Project website	N/A

Collector	
Collector type	Full glass vacuum tube
Absorber type (for flat plate collectors)	Selective coating
Collector brand and model	Linuo Ritter/vacuum tube type
Gross collector area / power	5.0m^2/180L
Number of collectors	1900
Mounting	Roof
Orientation (azimuth)	0
Tilt	50
Heat transfer fluid	Water
Product certification	N/A
Data sheet	N/A

Storage	
Storage type	Stainless steel insulated water tank
Number and size of storages	180L/set
Storage brand and model	Linuo Ritter
Insulation type	Polyurethane foam
Insulation thickness	55mm
Product certification	GB/T 19141
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	2kW
Piping	PPR
Piping insulation	N/A
Heat exchanger type	N/A
Back-up system type	Electric hot water boiler
Back-up system nominal power	2kW
Solar fraction	70%

Performance indicators	
Guaranteed lifetime	15years
Expected lifetime	15 years
Daily heat gain	26.3 kWh/a average (The whole project)
Annual solar yield	59,964,000 kWh/year (The whole project)
Annual performance ratio	/
Avoided CO_2:	Approximately 5978.4 tons CO_2 annually (The whole project)

Resources

3 According to OANDA exchange rate 0.12679 (avg.) on 25/05/2026

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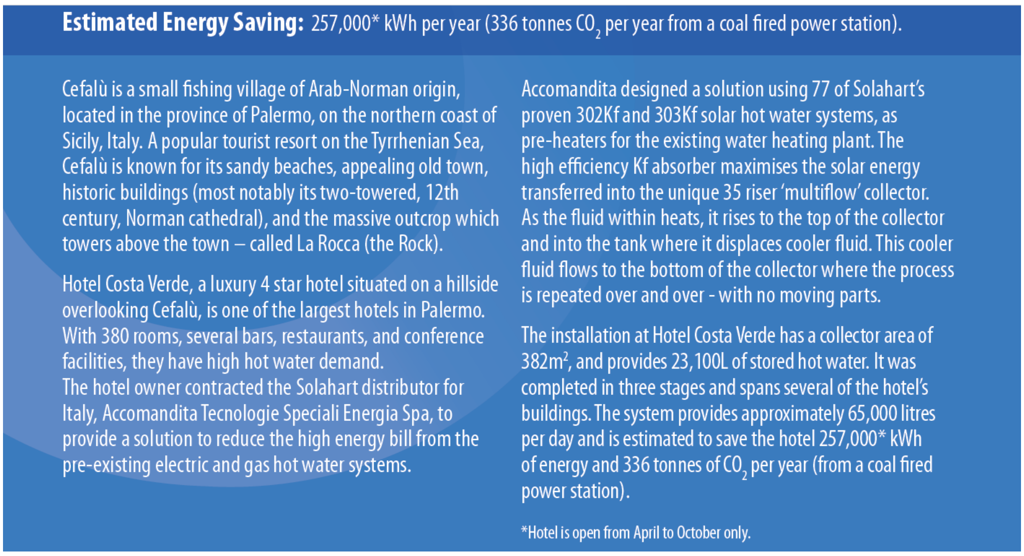
4.3 Europe (Region #3)

In Europe, especially the Mediterranean countries are suitable for solar thermosyphon systems. Two examples are presented here, one from Italy (provided by Dean Clift, Solarhart Australia) and one from Greek (IEA SHC Solar Heat Worldwide Report Ed.

4.3.1 Hotel Costa Verde (Italy)



Estimated Energy Saving: 257,000* kWh per year (336 tonnes CO_2 per year from a coal fired power station).

Cefalù is a small fishing village of Arab-Norman origin, located in the province of Palermo, on the northern coast of Sicily, Italy. A popular tourist resort on the Tyrrhenian Sea, Cefalù is known for its sandy beaches, appealing old town, historic buildings (most notably its two-towered, 12th century, Norman cathedral), and the massive outcrop which towers above the town – called La Rocca (the Rock).

Hotel Costa Verde, a luxury 4 star hotel situated on a hillside overlooking Cefalù, is one of the largest hotels in Palermo. With 380 rooms, several bars, restaurants, and conference facilities, they have high hot water demand.
The hotel owner contracted the Solahart distributor for Italy, Accomandita Tecnologie Speciali Energia Spa, to provide a solution to reduce the high energy bill from the pre-existing electric and gas hot water systems.

Accomandita designed a solution using 77 of Solahart's proven 302Kf and 303Kf solar hot water systems, as pre-heaters for the existing water heating plant. The high efficiency Kf absorber maximises the solar energy transferred into the unique 35 riser 'multiflow' collector. As the fluid within heats, it rises to the top of the collector and into the tank where it displaces cooler fluid. This cooler fluid flows to the bottom of the collector where the process is repeated over and over - with no moving parts.

The installation at Hotel Costa Verde has a collector area of 382m², and provides 23,100L of stored hot water. It was completed in three stages and spans several of the hotel's buildings. The system provides approximately 65,000 litres per day and is estimated to save the hotel 257,000* kWh of energy and 336 tonnes of CO_2 per year (from a coal fired power station).

*Hotel is open from April to October only.

4.3.2 The Bay Hotel Zakynthos (Greece)

In 2014, the company Sole SA based in Athens installed thermosyphon collectors with a total collector area of 280 m² and 21,000 lt. at the Bay Hotel in Zakynthos.

Figure 9. 280 m² and 21,000 lt solar thermosyphon system at the Bay Hotel, Zakynthos (Greece). Source: Sole SA
https://www.sole.gr/erga#&gid=1&pid=22

4.4 Latin America (Region #4)

4.4.1 Habitações de Interesse Social (Trindade, Brazil)

Habitações de Interesse Social (Trindade)

Figure 10. Thermosiphon systems at Social Housing in Trindade, Brazil. Source: Abrasol / Danielle Johann

About

This project features a solar thermosiphon water heating system developed for low-income housing, within the scope of Brazil's federal housing program “My House My Life”, which has delivered millions of homes nationwide. In this specific case, located in Trindade, Goiás, 3,000 solar collectors (totaling 6,000 m² of collector area) and 3,000 thermal storage tanks of 200 liters each were installed — providing a total of 600,000 liters of solar-heated water, with no electric backup on storage tank.

Application, motivation

The system was implemented in single-family homes with a focus on energy efficiency, sustainability, and social inclusion. The main goal was to provide access to hot water for bathing with low operating costs and significant energy savings. The system achieves a solar fraction of approximately 70% and contributes to a reduction of 160 tons of CO_2 emissions per year.
One of the key motivations was to reduce the demand for extensive electrical infrastructure normally required for conventional water heating systems. By relying on solar energy and eliminating the need for electric heating within the thermal reservoir, the project significantly reduced peak electricity consumption and minimized the costs of grid installation — especially important in housing developments located far from major cities.
As a simple and cost-effective solution, the electric backup is not integrated into the tank but provided through standard electric showers, used only during rare cold periods. This ensures that electrical energy is consumed only in exceptional situations, maintaining low operational costs and high overall solar contribution.

Challenges, best practice solutions, innovations

Key challenges addressed in this project included:

- **Scale and standardization:** ensuring efficient and uniform installation across 3,000 homes.

- **Structural limitations:** the lack of masonry roof structures required the development of an external metal support system in a plug-and-play format.
- **Cost-effectiveness:** maintaining low system costs was critical to ensure project viability.
- **Water pressure management:** municipal water pressure can reach up to 60 mH_2O, which would require expensive high-pressure tanks. To solve this, pressure-breaking header tanks were installed above each thermal reservoir, reducing pressure to just 1.5 mH_2O and enabling the use of cost-effective tanks.

This combination of technical solutions made the system scalable, replicable, and effective for large-scale social housing programs.

System	
Location	Trindade, Goias, Brazil
Latitude, longitude	16° 38′ 56″ (S), 49° 29′ 20″ (W)
Altitude	758 m
System type	Solar thermosiphon system
Application	Domestic hot water
Customer / Beneficiary	Affordable Housing Program
Installer	Pro-Sol Solar Energy
Maintainer / Operator	Pro-Sol Solar Energy
Commissioning year	2018
System brand and model	Pro-Sol / Flat Plate Solar Collector Blue 2.0 (84.8 kWh/month/m²)
Total gross collector area	3.000 systems / 6.000 m²
Annual solar yield	6.1 MWhth
Total tank volume	3.000 systems X 200L = 600,000L
Maximum operating pressure	1.5 mH_2O
Total capital cost (CAPEX)	1,400,000 USD
Funding / subsidy	1,400,000 USD
Funding agency	Brazilian Ministry of Cities

Collector	
Collector type	Flat plate collector
Absorber type (for flat plate collectors)	Aluminium with Selective Coating
Collector brand and model	Pro-Sol / Flat Plate Solar Collector Blue 2.0
Gross collector area / power	6.000 m² (84.8 kWh/month/m²)
Number of collectors	3.000
Mounting	Roof
Orientation (azimuth)	18° (north-east)
Tilt	32°
Heat transfer fluid	Water
Product certification	INMETRO

Storage	
Storage type	Water tank, horizontal
Number and size of storages	3.000 x 200L
Storage brand and model	Pro-Sol 200l 1.5 mca
Insulation type	Polyurethane
Insulation thickness	20 mm
Product certification	INMETRO

System connection / integration, back-up system	
Electric heat element (nominal power)	N/A
Piping	EPDM
Piping insulation	10 mm
Heat exchanger type	N/A
Back-up system type	Electricity
Back-up system nominal power	N/A
Solar fraction	70%

Performance indicators	
Guaranteed lifetime	5 years
Expected lifetime	20 years
Annual solar yield	6.1 MWhth
Avoided CO2:	160ton CO2

Resources

https://publications.iadb.org/publications/portuguese/document/Habitacao-de-interesse-social-no-Brasil-propostas-sobre-locacao-social.pdf

Author(s)

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4.4.2 Solar thermosiphon systems for vertical houses (Mexico)

Solar thermosiphon systems for vertical houses in Mexico City

Figure 11. Vertical Houses in Mexico City Photo: Módulo Solar

Layout of the systems

Figure 12. Layout of the thermosyphon systems. Source: Módulo Solar.

About

The thermosyphon systems were installed for individual vertical houses in Mexico City. A total of 50 systems installed. Módulo Solar as a supplier, designer and installer of the systems, designed the project to comply with the environmental normativity of Mexico City.

Application, motivation

Mexico City has a mandatory environmental normativity for the installation of solar water heaters on new housing buildings. The construction developer contracted Módulo Solar for the design and implementation of the solution.

Challenges, best practice solutions, innovations

The design and layout of the installation of solar water heaters in vertical buildings need to be optimized to avoid shadows and optimal technical conditions.

Every system has an intelligent gas backup boiler, with cero gas consumption in stand-by modus and only operates when there is not enough hot water provided by the solar water heater.

System

Location	Mexico City
Latitude, longitude	19.42 ° N, -99.12 ° E
Altitude	2,510 asl
System type	Direct thermosyphon with flat plate collectors
Application	Domestic Hot Water
Customer / Beneficiary	Procsa
Installer	Módulo Solar
Maintainer / Operator	Procsa
Commissioning year	2024
System brand and model	Axol 150 by Módulo Solar
Gross collector area / power	2 m^2 (1.4 kW_{th})
Total tank volume	150L
Maximum operating temperature	60 °C
Maximum operating pressure	N/A
Total capital cost (CAPEX)	€ 400 (final customer price for each thermosyphon system)
Total O&M costs per year (OPEX)	1% of CAPEX
Funding / subsidy	Privat investment
Funding agency	
Public data set	
Project website	

Collector

Collector type	Flat Plate Collector
Absorber type (for flat plate collectors)	Copper absorber selectively coated
Collector brand and model	AXOL HVA by Módulo Solar
Gross collector area / power	2 m^2 (1.4 kW_{th})
Number of collectors	50
Mounting	Roof
Orientation (azimuth)	0° (south)

Tilt	20°
Heat transfer fluid	Water
Product certification	NOM 027 ENER/SCFI By SENER/CONUEE MEXICO. IDEREE
Data sheet	N/A

Storage	
Storage type	Insulated enamelled steel tank
Number and size of storages	50 x 150L
Storage brand and model	AXOL by Módulo Solar
Insulation type	Polyurethane foam
Insulation thickness	45 mm
Product certification	NOM 027 ENER/SCFI
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	None
Piping	Polypropylene (PPR)
Piping insulation	None
Heat exchanger type	N/A
Back-up system type	Gas boiler
Back-up system nominal power	N/A
Solar fraction	75%

Performance indicators	
Guaranteed lifetime	10 a
Expected lifetime	25 a

Resources

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4.4.3 Common practice thermosyphon systems (Argentina)

Following a couple of common practice examples from Argentina are presented. In 2023, 84% of the newly installed solar thermal systems have been solar thermosyphon systems, in total 49,179 m² [1].

Figure 13. Pictures of common practice thermosiphon systems in Argentina. Photos: Christian Navntoft / Solarmate SA

4.5 Middle East and North Africa (Region #5)

4.5.1 Military Academy in Cairo (Egypt)

SUNPAD (integrated storage collector) installation at New Military Academy in Cairo, Egypt

Figure 14. SUNPAD Integrated storage collectors at New Military Academy in Cairo, Egypt Phot: Summit powered by GREENoneTEC

Figure 15. Collectors mounted on concrete skeleton to avoid shadowing Photo: Summit powered by GREENoneTEC

Hydraulics

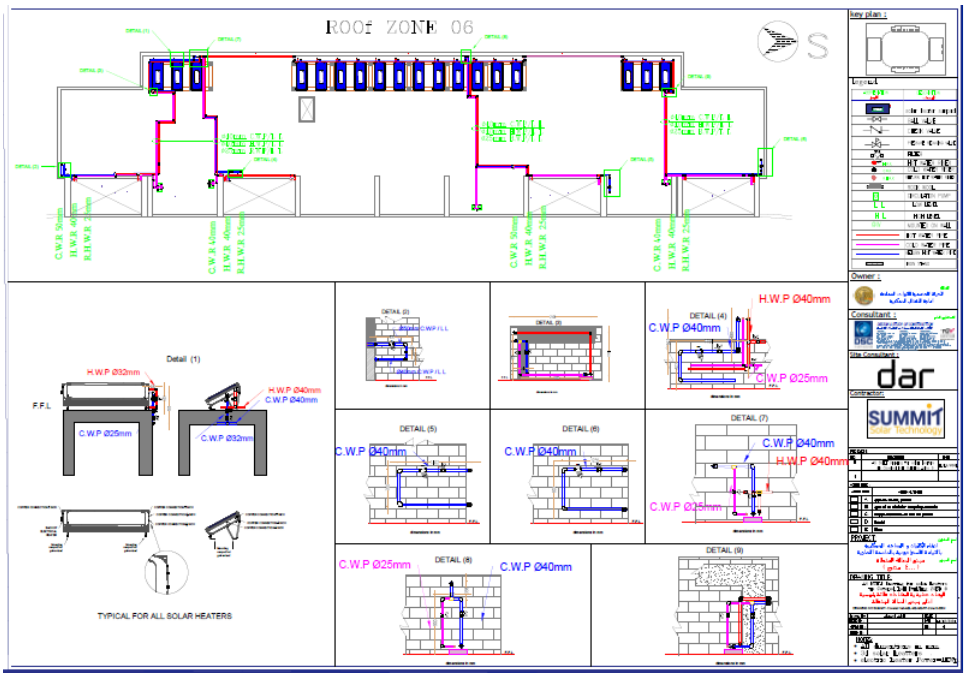

Figure 16. Hydraulic Scheme of Roof Zone 6 Source: Summit

About

Hot water for the cadets of the New Military Academy of the new capital city of Egypt.

1 – The main sports hall : 34 units of SUNPAD

2 – The main changing room: 60 units of SUNPAD

Application, motivation

Egypt is the heaven for SUNPAD due to the high temperature rates all over the year and the clear sky with bright sun even in the winter which means very efficient solar water heating system with more than 400l/day.

Also, due to the PLUG & PLAY concept of SUNPAD, which means that engineers and technicians understand the system fast and easy.

Simple to install, simple to use, simple to maintain.

Challenges, best practice solutions, innovations

One problem that had to be solved was how to maintain the same pressure for all units working together. The solution was using regulating pressure valves for every unit.

Although there is a high wall balustrade beside the SUNPADs as much sun should be catched as possible. To solve this problem a concrete skeleton with tailored dimensions was designed and casted to raise the SUNPAD from the finish floor level to the balustrade level.

The system is a best practice example as it is easy to connect, easy to install, easy to understand, easy to have good results and almost maintenance free.

System	
Location	Cairo, Egypt
Latitude, longitude	N/A
Altitude	N/A
System type	SUNPAD
Application	Public and Sports
Customer / Beneficiary	Egyptian Ministry of Defence
Installer	SUMMiT SOLAR TECHNOLOGY CO.
Maintainer / Operator	N/A
Commissioning year	2023 - 2024
System brand and model	GREENoneTEC SUNPAD)
Total gross collector area / power	206.8m^2
Total tank volume	14100L
Maximum operating temperature	77°C
Maximum operating pressure	5 bar
Total capital cost (CAPEX)	USD 280,000$ [final customer price including shipping, installation and taxes]
Total O&M costs per year (OPEX)	-----
Funding / subsidy	No funding received
Funding agency	N/A
Public data set	N/A
Project website	N/A

Collector	
Collector type	SUNPAD
Absorber type (for flat plate collectors)	SUNPAD
Collector brand and model	SUNPAD
Gross collector area / power	2.05 m² (1.4 kW)
Number of collectors	94
Mounting	ROOF
Orientation (azimuth)	SOUTH
Tilt	30°
Heat transfer fluid	---
Product certification	TÜV Rheinland, SUNPAD (Registration Number 011-7S2956 A)
Data sheet	https://www.dincertco.de/logos/011-7S2956%20A.pdf

Storage	
Storage type	SUNPAD
Number and size of storages	Integrated storage
Storage brand and model	SUNPAD
Insulation type	Extended Polypropylene (EPP)
Insulation thickness	50 mm
Product certification	TÜV Rheinland, SUNPAD (Registration Number 011-7S2956 A)
Data sheet	https://www.dincertco.de/logos/011-7S2956%20A.pdf

System connection / integration, back-up system	
Electric heat element (nominal power)	1 or 2kW
Piping	PP
Piping insulation	Rockwool 25mm
Heat exchanger type	N/A
Back-up system type	Electrical
Back-up system nominal power	1 or 2 kW
Solar fraction	100% of hot water demand covered by the system

Performance indicators	
Guaranteed lifetime	5 years warranty
Expected lifetime	15 years
Daily heat gain	N/A
Annual solar yield	N/A
Annual performance ratio	N/A
Avoided CO_2:	N/A

Resources

https://www.sunpad.solar/

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4.6 North America (Region #6)

In North America currently only one percent of solar thermal systems are thermosyphon systems [1], although there is high potential in Southern States like Florida or California. Hawaii has a higher penetration because of a solar water heater mandate.

American Solar Energy Society https://ases.org/

Companies active in the field are for example

SunEarth https://sunearthinc.com/

Alternate Energy Technologies https://www.aetsolar.com/thermosiphon-systems

4.7 Oceania (Region #7)

With regards to Australia, a study done by Harry Suehrcke for Subtask D of the IEA SHC Task 69 (Success Stories) explains the development of renewables in Australia over the last 15 years. Please refer to the respective Deliverable on the website https://task69.iea-shc.org/ .

Important companies in Australia working in the field of solar water heating are for example

Solahart Industries Pty Ltd https://solahart.com/

Rheem Australia Pty Ltd https://www.rheem.com.au/rheem/products/Residential/Residential-Solar-Water-Heater-%7C-Solar-Heating/c/solar

4.8 Sub-Sahara Africa (Region #8)

4.8.1 Aussenkehr (Namibia)

Aussenkehr Orange River Vineyards Solar Water Heaters

Figure 17. Thermosiphon systems at Aussenkehr Orange River Vineyards, view from north. Source: SOLTRAIN

Figure 18. Each house for the vineyard workers is equipped with a solar thermosiphon system. Source: SOLTRAIN

Hydraulics

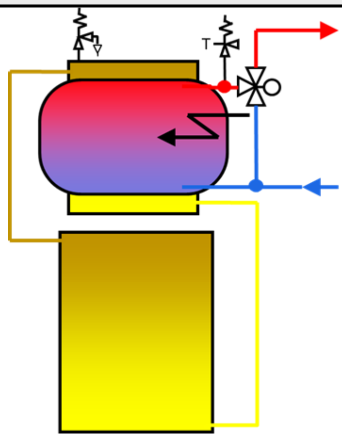

Figure 19. Indirect solar thermosiphon system for the workers' houses at Aussenkehr Orange River Vineyards, Namibia. Source: AEE INTEC

About

There were 58 systems with 2.13 m² flat plate collector area and 160 L hot water storage tank installed, that provide domestic hot water for the vineyard workers.

Application, motivation

Orange River Vineyard Investment (Pty) Ltd (ORVI) operates and irrigation system for the cultivation of table grapes along the Orange River in Aussenkehr, Karas Region, in the south of Namibia. Through the irrigation it is possible to grow grapes in the desert to provide local jobs, housing and working towards the betterment of the community. ORVI has built 58 low-cost houses for their staff. The grape farm is focusing on sustainability initiatives to improve its efficiency and lower the environmental impact. Each house has been equipped with a 160L solar thermosiphon system. There is also a photovoltaic system installed providing electricity.

Challenges, best practice solutions, innovations

The weather conditions in the region are characterised by the desert climate posing high stress with regards to temperatures and sand on the systems. The collectors are designed to withstand these extreme weather conditions. The tempered glass protects the system from hail damage. Overheating of the collectors is an issue if the water consumption is low.

System

Location	Aussenkehr,
Latitude, longitude	28.365278 ° (S), 17.410056 ° (E)
Altitude	95 m
System type	Indirect solar thermosiphon system
Application	Domestic hot water
Customer / Beneficiary	Workers at vineyard
Installer	Solsquare Energy (Pty) Ltd
Maintainer / Operator	Solsquare Energy (Pty) Ltd
Commissioning year	2021
System brand and model	Calpak / Flat Plate Solar Collector M4-210

Total gross collector area / power	58 systems / 123.4 m² / 86.48 kW_{th}
Total tank volume	9280 litres
Maximum operating temperature	N/A
Maximum operating pressure	N/A
Total capital cost (CAPEX)	67,700,00 EUR
Total O&M costs per year (OPEX)	N/A
Funding / subsidy	30,470,00 EUR
Funding agency	Austrian Development Cooperation
Public data set	N/A
Project website	https://www.soltrain.org/systems/aussenkehr-low-cost-housing/detail

Collector	
Collector type	Flat plate collector
Absorber type (for flat plate collectors)	Aluminium
Collector brand and model	Calpak / Flat Plate Solar Collector M4-210
Gross collector area / power	123.4 m² (86.48 kWth) (58 systems)
Number of collectors	58
Mounting	Roof
Orientation (azimuth)	45° (north-east)
Tilt	20°
Heat transfer fluid	Water
Product certification	NCSR DEMOKRITOS -SOLAR AND ENERGY SYSTEM LAB NO: SKM 9975, DIN CERTRO
Data sheet	N/A

Storage	
Storage type	Water tank, horizontal
Number and size of storages	58 x 160L
Storage brand and model	Cicero Hellas S.A.
Insulation type	
Insulation thickness	20 mm
Product certification	N/A
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	nominal power N/A
Piping	Copper
Piping insulation	20 mm
Heat exchanger type	N/A
Back-up system type	Electricity
Back-up system nominal power	N/A
Solar fraction	

Performance indicators	
Guaranteed lifetime	7 a
Expected lifetime	10 a
Daily heat gain	N/A
Annual solar yield	MWh (simulated)
Annual performance ratio	N/A
Avoided CO_2:	kg CO_2

Resources

https://www.soltrain.org

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4.8.2 CPS Sisters Convent of Lady Kingsdale (Zimbabwe)

CPS Sisters Convent of Lady Kingsdale

Figure 20. Thermosyphon system "CPS Sisters Convent of Lady Kingsdale", view from south. Source: National University of Science and Technology (NUST), Zimbabwe.

Figure 21. Thermosyphon system "CPS Sisters Convent of Lady Kingsdale", view from north. Source: National University of Science and Technology (NUST), Zimbabwe.

Hydraulics

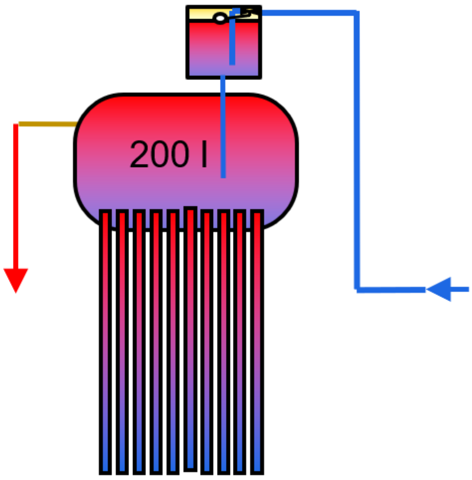

Figure 22. Hydraulic scheme of one thermosyphon system of "CPS Sisters Convent of Lady Kingsdale". The hot water supply of the five units is done independently of each other. Source: AEE INTEC.

About

The system is made up a 5x 200L storages with evacuated tube collectors installed by Sunex P/L under the SOLTRAIN IV programme. The system is a direct system with a booster pump to assist the water to reach the second floor.

Application, motivation

The CPS Sisters Convent consists of Sisters who visit the site as well as retired Sisters. The facility is very essential to women in helping them accessing hot water for different domestic purposes such as bathing and washing of cloth. The aim is to make the premise as self-sustainable as possible. The provision of hot water through a thermosyphon system was chosen to be the best option, replacing a 150L electric geyser. The solar hot water system lessens the cost of running the facility on electricity bills and builds a role model for self-sustained Convents.

The institution solely uses the thermosyphon system for water heating. The site has also a 5kVA and an 8kVA Photovoltaic system installed to completely doing away with electricity.

Challenges, best practice solutions, innovations

A major challenge was getting the tanks and equipment onto the roof. Roof mounting was the best practice in this case as the clients were elderly women and their bathroom facilities were on the second floor. Installing the systems directly over the bathroom areas reduced the cost of installation as well as the heat losses for the transport of the hot water to the bathrooms. Roof mounted systems allow the use of gravity to transport the hot water to the showers. To get the cold water to the roof, the municipal water pressure is used in combination with a booster pump. A back-up system was not installed, due to the need to have an automated control system, as a manual operation would have led to failures.

System	
Location	Bulawayo, Zimbabwe
Latitude, longitude	20.101944 °S, 28.610556 °E
Altitude	1314 m asl
System type	Direct thermosyphon system with flat plate collectors
Application	Domestic Hot Water
Customer / Beneficiary	CPS Sisters Convent of Lady Kingsdale
Installer	Sunex Pvt Ltd
Maintainer / Operator	Local SME
Commissioning year	2022
System brand and model	Jiangsu Sunpower Solar Technology - SPR
Total gross collector area / power	13.76 m^2 (5 x 2.752 m^2) (9.60 kW_{th})
Total tank volume	1000L (5 x 200 l)
Maximum operating temperature	95 °C
Maximum operating pressure	N/A
Total capital cost (CAPEX)	€ 5,682 (final customer price including shipping, installation and taxes)
Total O&M costs per year (OPEX)	~100 USD/a (mainly due to water softener)
Funding / subsidy	€ 2,840
Funding agency	Austrian Development Agency (ADA) - SOLTRAIN project
Public data set	N/A
Project website	https://www.soltrain.org/systems/cps-sisters-convent/detail

Collector	
Collector type	Evacuated tube collector
Absorber type (for flat plate collectors)	N/A
Collector brand and model	Jiangsu Sunpower Solar Technology, SP-58/1800-24R
Gross collector area / power	2.752 m^2 (1.93 kW)
Number of collectors	5
Mounting	Roof
Orientation (azimuth)	0° (north)
Tilt	30°
Heat transfer fluid	Water
Product certification	Solar Keymark
Data sheet	SK Certificate: https://www.fm-solar.de/tpl/download/SC1075-12solar-certificat.pdf

Storage	
Storage type	Water tank, horizontal
Number and size of storages	5 x 200L
Storage brand and model	Jiangsu Sunpower
Insulation type	Polyurethane
Insulation thickness	50 mm
Product certification	N/A
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	N/A (no back-up system)
Piping	Copper
Piping insulation	None
Heat exchanger type	N/A
Back-up system type	N/A
Back-up system nominal power	N/A
Solar fraction	100% of hot water demand covered by the system

Performance indicators	
Guaranteed lifetime	7 a
Expected lifetime	10 a
Daily heat gain	N/A
Annual solar yield	11.80 MWh (simulated)
Annual performance ratio	N/A
Avoided CO_2:	4100.00 kg CO_2

Resources

https://www.soltrain.org

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4.8.3 Solarsoft low pressure solar water heaters (Lesotho)

Solarsoft low pressure solar water heaters

(a)

(b)

(c)

(d)

Figure 23. Thermosyphon systems "Solarsoft low pressure solar water heaters", showing installations at the Solarsoft sales and service office (figures (a) & (b)) and Solarsoft Fresh Fast Foods (figures (c) & (d)). Source: Solarsoft.

Hydraulics

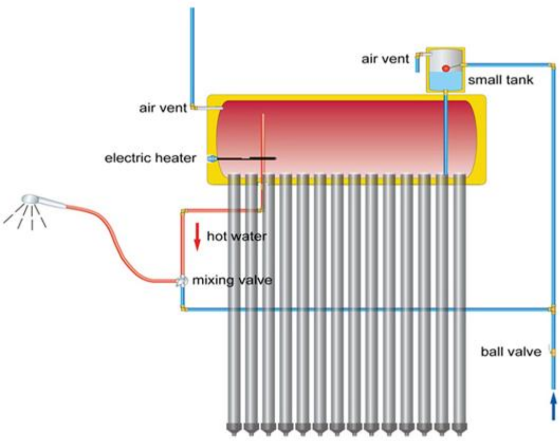

Figure 24. Hydraulic scheme of one thermosyphon system of "Solarsoft low pressure solar water heaters". Source: Solarsoft.

About

Solarsoft is an energy services, sales and consultancy business headquartered in Mohales Hoek (Lesotho). Among other activities, the company installs, maintains and operates low pressure solar water heaters. These systemsinclude an insulated storage tank, evacuated glass (Rand) tubes, a small nurse tank on top with a float valve for filling, and a light metal mounting stand for either flat or tilted roofs. They require no vacuum breakers or pressure relief valves, and installation is fast and easy. They work well in Lesotho's sunny climate.

Application, motivation

What is salient in the region is the demographic and economic context, which means high rates of poverty, unemployment and poor living conditions. Even availability of fresh clean water in many situations is not guaranteed. Therefore, warm or hot water for bathing and cleaning is an extraordinary accomplishment, even if the technology is not advanced or complicated. Hence low pressure solar water heaters with evacuated glass tubes are highly appropriate. This is an excellent product for consumers because of the good performance/cost ratio, and for installers, that must survive with slim margins. Simplicity, easy and speed of installation is important when profits are tight. Commodification characterizes the manufacturing space, with numerous global suppliers offering a similar product with competitive pricing.

Challenges, best practice solutions, innovations

The greatest benefit is the simplicity and standardization of components. As well, stands corresponding to different roof profiles can easily be adapted or modified. In some regions of Southern Africa, and Lesotho is special in this regard, winter frost is a significant problem. The evacuated tube SWHs are robust and unaffected by frost, thus avoiding all the complexity, cost and efficiency losses of heat exchangers and polypropylene glycol.

If unused, these SWHs turn into steam generators and boil after two days. Other problems include contaminated and unreliable municipal water supply.

System

Location	Mohales Hoek, Lesotho
Latitude, longitude	30.14145°S, 27.46718°E
Altitude	1554 m asl
System type	Direct thermosyphon with Rand tubes
Application	Domestic hot water and fast food outlet
Customer / Beneficiary	Solarsoft / Operator of fresh fast food stall
Installer	Solarsoft
Maintainer / Operator	Solarsoft
Commissioning year	2021, 2022, 2023
System brand and model	Zentek
Total gross collector area / power	1.8m^2 (1.67 kW)
Total tank volume	100L
Maximum operating temperature	100 °C
Maximum operating pressure	N/A
Total capital cost (CAPEX)	USD 350
Total O&M costs per year (OPEX)	N/A
Funding / subsidy	N/A
Funding agency	N/A
Public data set	N/A
Project website	https://soltrain.org/news/solarsoft-fresh-fast-food-in-mohales-hoek

Collector	
Collector type	Evacuated glass (Rand) tubes
Absorber type (for flat plate collectors)	N/A
Collector brand and model	Shandong Zentek Energy & Power Co
Gross collector area / power	1.8m^2 (1.677kW)
Number of collectors	1
Mounting	Flat Roof
Orientation (azimuth)	0° (north)
Tilt	30°
Heat transfer fluid	N/A
Product certification	N/A
Data sheet	https://www.zentekenergy.com/product-item/non-pressurized-solar-collector/#specification

Storage	
Storage type	Stainless Steel Tank
Number and size of storages	1 x 100L
Storage brand and model	Zentek
Insulation type	Polyurethane foam
Insulation thickness	50-55mm
Product certification	N/A
Data sheet	https://www.zentekenergy.com/product-item/non-pressurized-solar-collector/#specification

System connection / integration, back-up system	
Electric heat element (nominal power)	N/A
Piping	Pex (Cross-linked Polyethylene): Supply and Distribution
Piping insulation	Yes
Heat exchanger type	N/A
Back-up system type	N/A
Back-up system nominal power	N/A
Solar fraction	100% of hot water demand covered by the system

Performance indicators	
Guaranteed lifetime	7 a (warranty)
Expected lifetime	15 a
Daily heat gain	15 kWh
Annual solar yield	3.750MWh (simulated)
Annual performance ratio	N/A
Avoided CO_2:	1.303 kg CO_2

Resources

https://www.zentekenergy.com

https://www.soltrain.org/

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4.8.4 Tholo Heights Student Accommodation (South Africa)

Tholo Heights Student Accommodation

Figure 25. Thermosyphon Systems at Tholo Heights Student Accommodation (University of North West). Source: SOLTRAIN / Alt Ener Pro Pty Ltd, South Africa.

Hydraulics

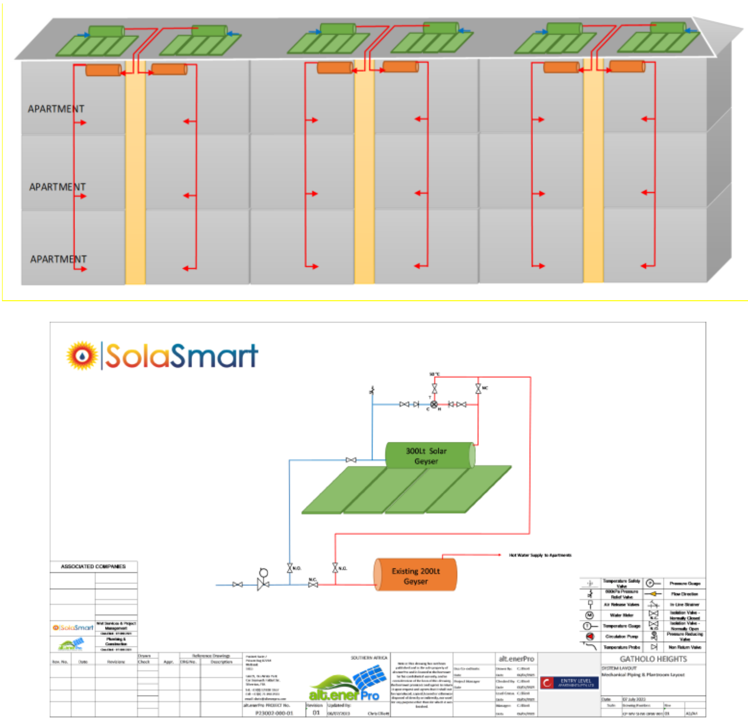

Figure 26. Hydraulic scheme of the thermosyphon system at Tholo Heights Student Accommodation. Source: SOLTRAIN / Alt Ener Pro Pty Ltd, South Africa

About

The Site comprises of 315 Apartments which house 1041 Black Students, 40% Male and 60% Female. Occupancy is at 100% the entire year. All Students attend the North West University – Maheking Campus – North West Province of South Africa.

91 X 300L systems with 6.12m² of collector area have been installed equipped with thermostatic blending valves.

The total installed hot tank capacity is 46650 L. Hot Water consumption is at 52050 L per day according to 50L per day per student.

Application, motivation

The core purpose of the project is to offer Consumption (kWh) and Demand (kW) savings by adding storage and prefeeding into existing hot water storage tanks. Additional interventions such as timer control on the elements, replacing the 4kW elements with 3kW in the 200L standard geysers and blending hot water to 45 Deg has been added. The element reduction reduced the damand by 0.1 MW.

Challenges, best practice solutions, innovations

The Solar Tank & Collectors are locally manufactured by Sun Tank SA. It consists of Stainless Steel High Pressure Jacket Tank & Collectors in an Indirect Thermosyphon setup.

System

Location	Mmabatho Unit 7, Mahikeng, 2790, South Africa
Latitude, longitude	-25.83771, 25.59982
Altitude	1281 m asl
System type	Indirect thermosyphon with flat plate collectors
Application	Domestic Hot Water
Customer / Beneficiary	Hostel for students of University of North West
Installer	Alt Ener Pro Pty Ltd
Maintainer / Operator	Entry Level Apartments (Pty) Ltd, South Africa
Commissioning year	2024
System brand and model	SunTank South Africa
Total gross collector area / power	6.12m^2 (4.3 kW$_{th}$)
Total tank volume	300L/200L
Maximum operating temperature	55 °C
Maximum operating pressure	N/A
Total capital cost (CAPEX)	€ 3,367 (final customer price including transport, installation and taxes)
Total O&M costs per year (OPEX)	N/A
Funding / subsidy	20%
Funding agency	International Partnerships Austria via SOLTRAIN
Public data set	N/A
Project website	N/A

Collector

Collector type	Flat Plate Collector
Absorber type (for flat plate collectors)	Copper absorber solar black paint
Collector brand and model	SunTank SUN1.5P
Aperture collector area / power	1.53 m^2 (1.1 kW$_{th}$)
Number of collectors	364
Mounting	Roof
Orientation (azimuth)	North/North-west/North-east
Tilt	25°
Heat transfer fluid	glycol
Product certification	SABS SANS 1307
Data sheet	N/A

Storage	
Storage type	SunTank Double Jacket Stainless steel for high pressure
Number and size of storages	91 x 300L
Storage brand and model	SunTank South Africa
Insulation type	N/A
Insulation thickness	50 mm
Product certification	SANS 151
Data sheet	N/A

System connection / integration, back-up system	
Electric heat element (nominal power)	yes
Piping	copper
Piping insulation	19 mm
Heat exchanger type	Double jacket tank
Back-up system type	Electric
Back-up system nominal power	N/A
Solar fraction	60%

Performance indicators	
Guaranteed lifetime	10 a
Expected lifetime	N/A
Daily heat gain	2126 kWh/a average (whole system)
Annual solar yield	776 193 kWh/a (whole system)
Annual performance ratio	N/A
Avoided CO_2:	N/A

Resources

SOLTRAIN project / Blueline Aqua (Pty) Ltd
https://soltrain.org/

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5 Examples: PV Hot Water Systems

5.1 China (Region #2)

5.1.1 PV Hot Water for High-Rise Buildings

PV Heating Hot Water system - low-cost, simple design, high energy utilization solution

Photovoltaic hot water systems offer diverse system configurations tailored to various building types, demonstrating significant advantages in terms of installation flexibility, operational efficiency, and maintenance sustainability, as follow (see also Figure 27):

1. **Separate Wall-Mounted PV Water Heater System**: This configuration is optimally designed for traditional wall-mounted solar energy communities, providing a reliable and space-efficient solution for residential applications.
2. **Separate Wall-Mounted System Combined With PV Integrated Subystem**: To accommodate varying lighting conditions across building heights, this hybrid approach integrates split wall-mounted photovoltaic hot water systems for high-rise users with photovoltaic distribution systems for low-floor residents, ensuring efficient energy utilization across different elevations.
3. **PV Integrated Subsystem Water Heater System**: This system is particularly suitable for residential areas with ample rooftop lighting space, featuring water tanks installed in bathrooms or integrated with traditional centralized hot water systems for enhanced thermal storage and distribution.

The photovoltaic hot water system operates via electrical transmission, eliminating the need for complex hydraulic components such as circulation pipelines, pumps, and valves, while offering multiple advantages including simplified infrastructure with no requirement for buffer tanks, water filtration, or antifreeze systems; reduced maintenance due to the absence of circulating fluids that minimizes pipeline corrosion and media degradation; long-term reliability supported by photovoltaic modules with service lives exceeding 20 years and low failure rates in electrical wiring; intelligent control enabling precise temperature regulation in water storage tanks for enhanced operational stability; and cost efficiency through lower long-term maintenance expenses and improved safety performance compared to conventional systems—attributes that collectively underscore the system's robustness, sustainability, and adaptability to modern residential energy demands.

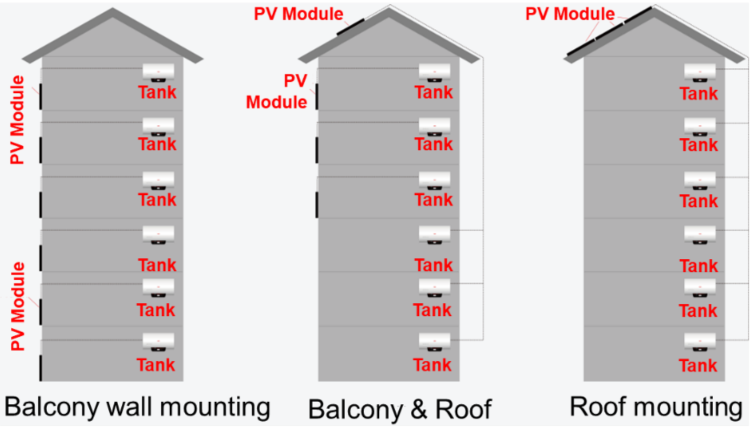

Figure 27. Distributed PV water heater solutions for different floors Source: China Academy of Building Research/Mengmeng Bian

Figure 28. PV hot water system solutions for high-rise buildings in practical application projects. Source: Jiangsu Sunrain Solar Energy Co., Ltd.

The photovoltaic hot water system operates on the principle of the photovoltaic effect, wherein photovoltaic modules convert solar energy into direct current (DC) electricity. This DC electricity is subsequently channeled through a combiner box and connected to the household water tank via a photovoltaic connector, thereby directly heating the water body. The integrated photovoltaic hot water system is designed to function independently of the grid, eliminating the need for metering. It bypasses the necessity for batteries and inverters, which contributes to its cost-effectiveness. When compared to conventional solar thermal systems, photovoltaic systems exhibit several distinct advantages. They are generally smaller in size and lighter in weight, making them particularly suitable for deployment in cold regions. The installation of these systems is highly flexible, which translates into lower costs for auxiliary materials and installation. Additionally, they are associated with reduced operating costs and simpler system operation and maintenance requirements. This innovative system has already been successfully implemented in various photovoltaic and solar engineering projects, including those in Tianjin, Jinan, Taiyuan, and other locations in China as shown in Figure 29.

Figure 29. Practical application cases of PV heating hot water systems. Source: Micoe Technology Group Co., Ltd

5.2 Sub-Sahara Africa (Region #8)

5.2.1 Solar PV water heating, lighting and device charging for affordable housing (South Africa)

Tanganani - Solar PV water heating, lighting and device charging solution for affordable housing

Figure 30. First phase of Tanganani affordable housing development under construction. Solar PV panels are visible on the roofs.

Figure 31. Example 2-bedroom house with solar PV panels (left), distribution board inside the 2-bedroom house with solar PV water heating control dial and USB device charging ports visible (right)

Hydraulics – basic wiring

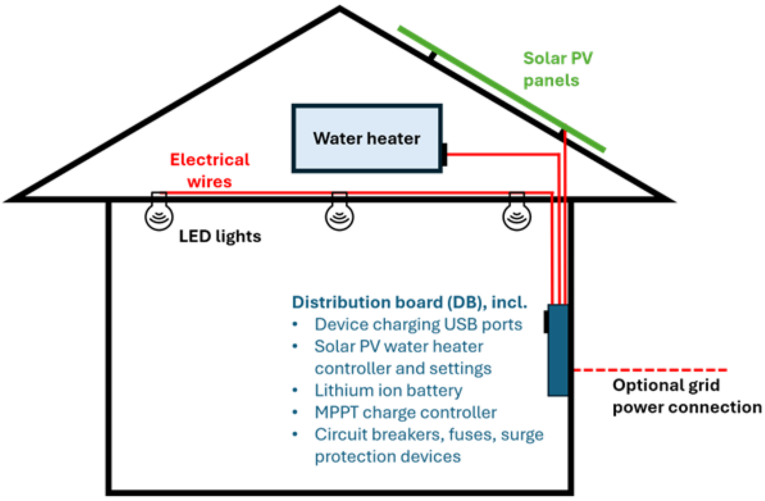

Figure 32. Schematic of basic wiring PV hot water system Tanganani

About

MXTech, PowerOptimal (solar photovoltaic or PV water heater controller) and Kwikot (water heater) have developed a unique solution for affordable housing that utilises solar PV power to heat water as well has provide lighting and device charging with a backup lithium-ion battery in one compact box (called a "Ready DB (distribution board") and all powered by the same 2 or 3 x 550W solar PV panels. The system can run fully off-grid or with optional grid power connection. This solution is being rolled out across an affordable housing development of over 9000 housing units. Phase 1 of the development (680 units) has commenced, with about 250 houses already built and the first houses already occupied.

Application, motivation

The South African government subsidises affordable housing and has decided to mandate the provision of minimal solar PV power (at least 1 x 500W panel) to each affordable housing unit. With the innovative, cost-effective solution from MXTech, PowerOptimal and Kwikot, residents have access to hot water, lighting and device charging at zero cost, even if there is no grid electricity connection or in case of grid power failures.

Challenges, best practice solutions, innovations

To our knowledge, this is the first time globally that hot water, lighting and device charging with battery backup have been combined in a single off-grid offering powered by solar PV.

The most challenging aspect was to get to a specification that was both very cost-effective (affordable) and delivered sufficient hot water and power for the households' needs. This was resolved through careful engineering and all suppliers providing the best possible pricing, based on potential project scale. Integration into the affordable housing designs and construction process was also a challenge and was resolved through collaboration between the parties involved.

This project illustrates a key benefit of solar PV compared to solar thermal – the same electricity used to heat water can be used for other household purposes as well.

System	
Location	Johannesburg, Gauteng, South Africa
Latitude, longitude	25.931957 °S, 28.027731 °E
Altitude	1400 m
System type	Solar PV water heating
Application	Domestic hot water
Customer / Beneficiary	Affordable housing residents
Installer	MXTech
Maintainer / Operator	MXTech
Commissioning year	2025
System brand and model	Solar PV water heater: Elon 100 (PowerOptimal) Charge controller, all other components: Insele i1000 HomeGrow (MXTech) Electric water heater: Superline Dual 150L 600 kPa (Kwikot)
Total gross collector area / power	2-bedroom units: 1.1 kW per unit (1.1 MW per 1000 units) 3-bedroom units: 1.65 kW per unit (1.65 MW per 1000 units)
Total tank volume	150L per unit (150 kL per 1000 units)
Maximum operating temperature	65 °C
Maximum operating pressure	6 bar
Total capital cost (CAPEX)	Approx. ZAR20 000 per unit
Total O&M costs per year (OPEX)	None
Funding / subsidy	Public-private partnership (privately funded with government subsidy)
Funding agency	National government
Public data set	N/A
Project website	https://tanganani.com/

Collector	
Collector type	550W solar PV panels
Absorber type (for flat plate collectors)	N/A
Collector brand and model	Jinko Tiger Pro Mono 550W
Gross collector area / power	2.1 m² (550 W_p)
Number of collectors	2 (2-bedroom units) or 3 (3-bedroom units)
Mounting	Roof
Orientation (azimuth)	Varied – NW to NE
Tilt	26°
Heat transfer fluid	DC electricity
Product certification	IEC61215, 61730
Data sheet	https://www.jinkosolar.com/uploads/5ff587a0/JKM530-550M-72HL4-(V)-F1-EN.pdf

Storage	
Storage type	Electric hot water storage cylinder
Number and size of storages	150L per tank (9000 tanks for overall development)
Storage brand and model	Kwikot Superline Dual 150L 600kPA
Insulation type	Polyurethane foam
Insulation thickness	57 mm
Product certification	SANS 151
Data sheet	https://www.kwikot.com/superline-600-dual-150-litres

System connection / integration, back-up system	
Electric heat element (nominal power)	3 kW
Piping	Electrical wiring, plastic piping
Piping insulation	No
Heat exchanger type	N/A
Back-up system type	Grid electricity (electrical element)
Back-up system nominal power	3 kW
Solar fraction	55%+

Performance indicators	
Guaranteed lifetime	5 years
Expected lifetime	10 years (25 years for solar PV modules)
Daily heat gain	4 – 6.5 kWh (for 2- or 3-panel systems)
Annual solar yield	1 500 – 2 400 kWh/a (simulated)
Annual performance ratio	21.33% (as per solar PV panel specifications)
Avoided CO_2:	1.3 – 2.1 ton CO_2e/housing unit/year (based on SA's carbon emissions intensity of 0.8665 kg CO_2e/kWh as of latest available data) For the full 9000+ unit development, it will be 11.7 – 18.9 kton CO_2e/yr

Resources

https://mxtech.co.za/

https://poweroptimal.com

https://kwikot.com

https://tanganani.com/

https://valumax.co.za/megacity-project/tanganani-mega-project/

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6 Appendix

6.1 Abbreviations

SOLTRAIN	Solar Thermal Training and Demonstration Initiative funded by the Austrian Development Cooperation since 2009; currently the project SOLTRAIN+ is implemented in the SADC countries Botswana, Lesotho, Namibia, South Africa and Zimbabwe with a focus on renewable heating and cooling as well as energy efficiency, technical trainings and demonstration systems https://soltrain.org/

6.2 List of Figures

6.3 List of Tables

6.4 References

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