



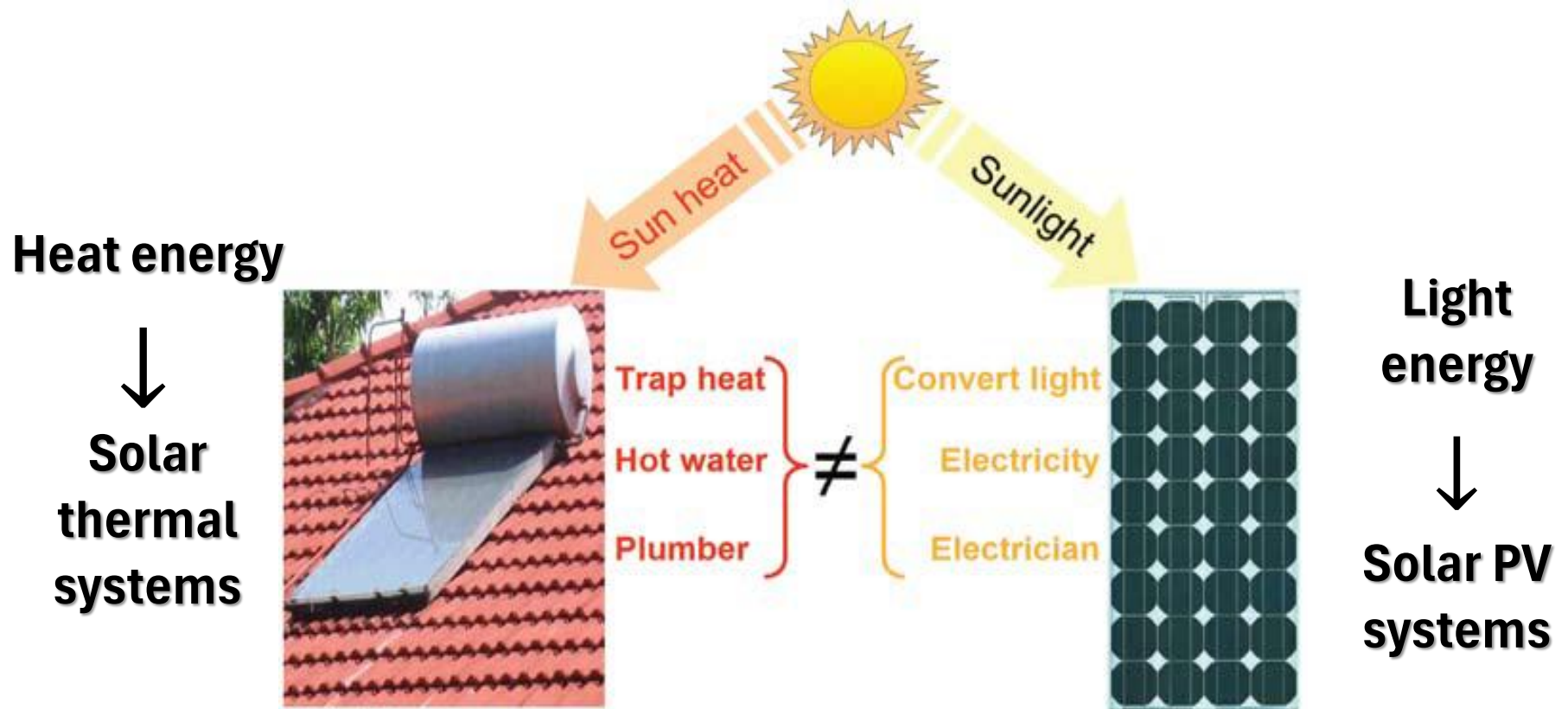
Overview of Solar Energy Conversion Systems and Applications

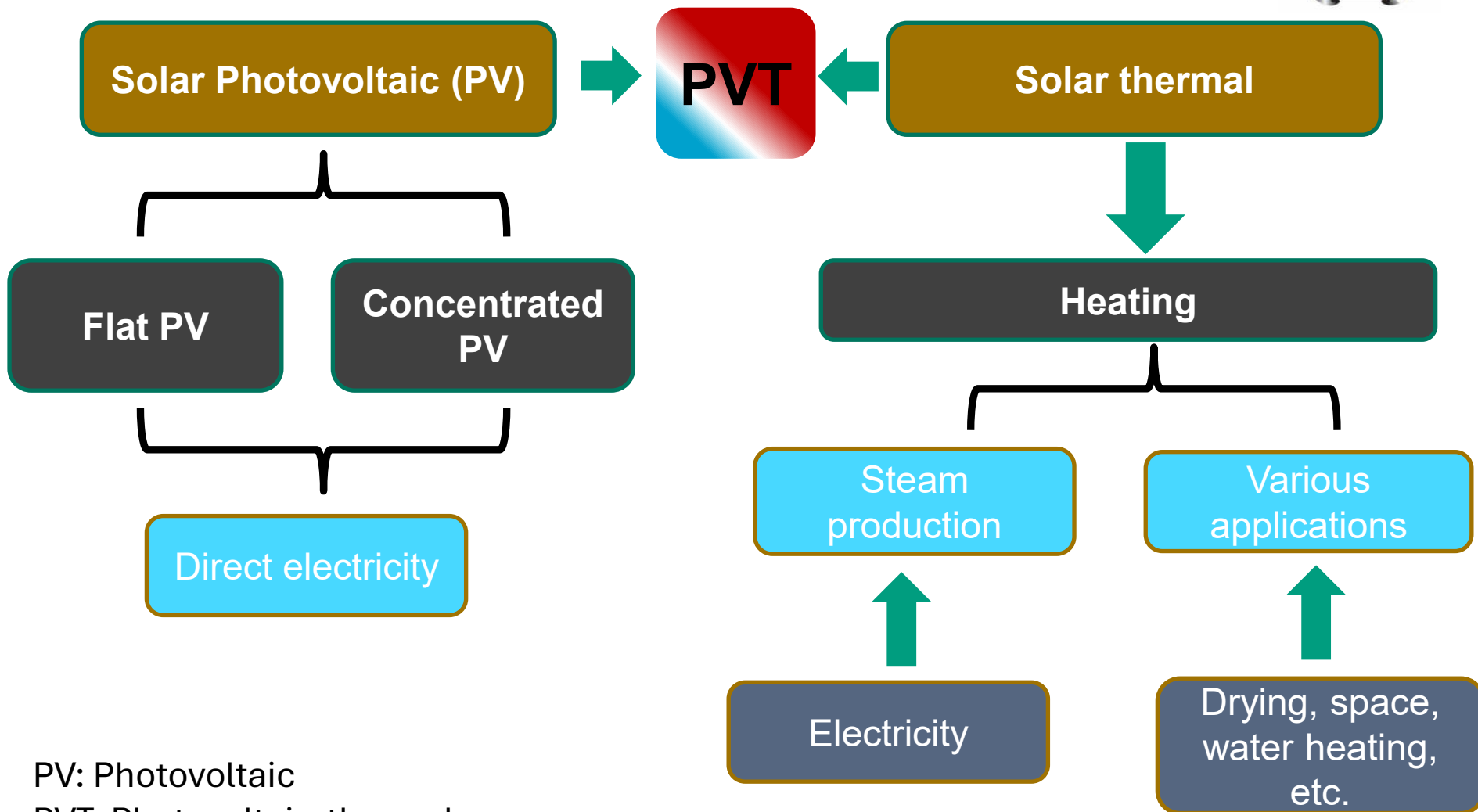
Sam Adaramola

Faculty of Economics, Energy and Management Sciences (FEEMS)

Contact

sadaramola@mubs.ac.ug





PV: Photovoltaic
PVT: Photovoltaic-thermal

Solar Energy Conversion Systems



SOLAR PV APPLICATIONS



Soroti Solar Power Plant, Uganda – 10 MW



<https://observer.ug/news/e-a-largest-solar-power-plant-commissioned-in-soroti/>

Land area covered:

- 33 acres $\approx$ 287.5 plots (50 ft by 100 ft)

- Generated electricity is sold directly to the national grid (UTECL, in Uganda) at an agreed cost
- *Global Energy Transfer Feed-in-Tariff (GET-FiT)*

Land area covered:

- 14 hectares $\approx$ 301 plots (50ft by 100 ft)

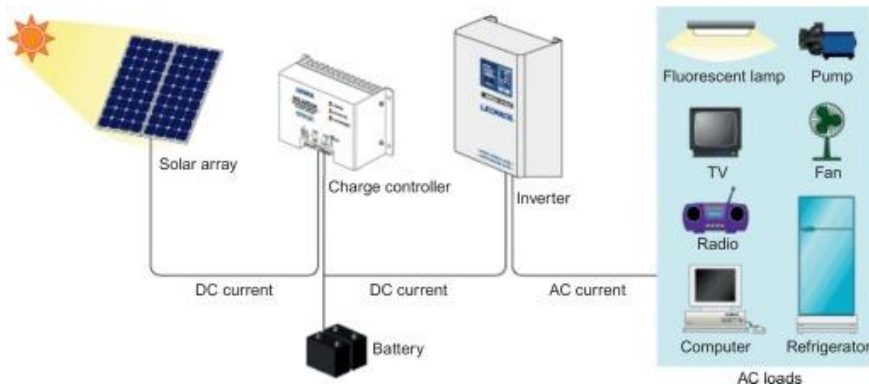
Tororo Solar North Plant, Uganda – 10 MW



<https://tororosolarnorth.energy/>



<https://stock.adobe.com/no/search?k=solar+panel+house>



<https://www.sciencedirect.com/topics/engineering/solar-home-systems>

- ❑ For residential use – direct current (DC) and alternating current (AC) appliances
- ❑ Grid-connected or standalone systems.
- ❑ Residential electrical loads can be divided into two:
 - i. Low energy-intensive appliances powered by an independent Solar PV system (DC/AC),
 - ii. High energy-intensive appliances powered by the national grid

Electricity Generation-Solar Home Systems

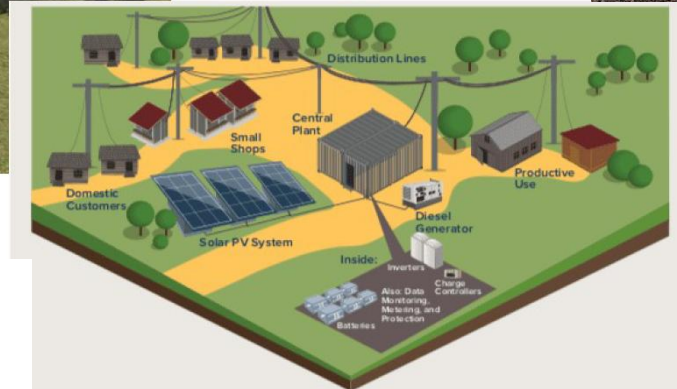


Photos by Sam in Kenya, Ghana, and Uganda

- ❑ Small-scale for different applications, such as streetlights, security lights, and potable lights.
- ❑ Can be ready-to-use appliances with a solar module and battery incorporated



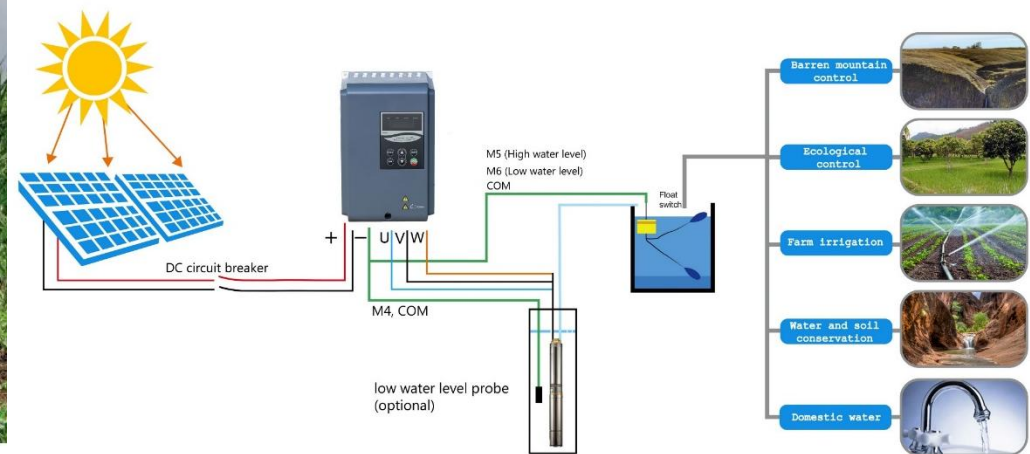
Electricity Generation – Small-scale uses



Source: <https://rmi.org/minigrids-money-reduce-costs/>

- ❑ Combination of solar PV and other electricity-generating technologies such as diesel/gasoline generators.
- ❑ Mostly used in microgrid/minigrid installations
- ❑ Battery systems can be included for energy storage and reduce fuel consumption by the diesel/gasoline generators.

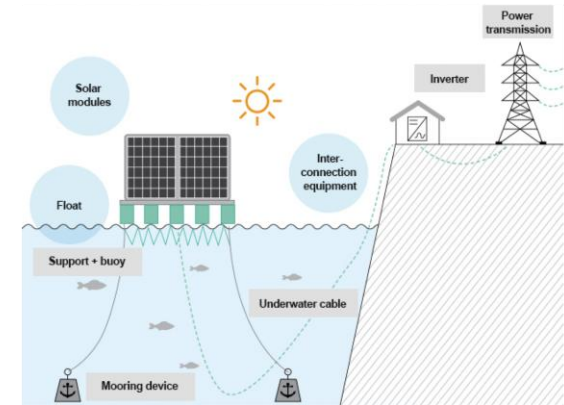
Electricity Generation – Hybrid Systems



<https://barraksolarnrg.com/pumpingsystem.html>

- ❑ Water pumping systems for different applications, such as irrigation and domestic.

Solar PV –Water Pumping Systems



<https://www.theagilityeffect.com/en/article/floating-solar-a-solution-to-land-scarcity/>

<https://www.offshore-energy.biz/germany-launches-worlds-first-vertical-floating-solar-power-plant/>



Electricity Generation – Floating solar PV



<https://www.ise.fraunhofer.de/en/business-areas/solar-power-plants-and-integrated-photovoltaics/integrated-photovoltaics/agrivoltaics.html>



<https://uslightenergy.com/agrivoltaic-farming-in-pa-what-crop-is-best-for-agrivoltaics/>

Electricity Generation – Agrivoltaic



<https://www.renewableenergymagazine.com/emily-newton/four-amazing-benefits-of-adding-parking-lot-20221215>



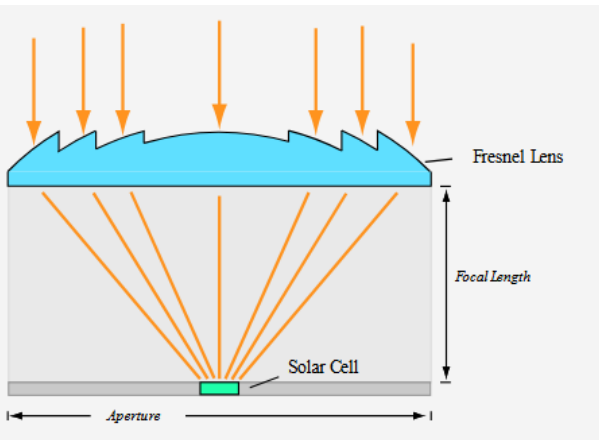
<https://pv-plus.co.uk/commercial-solar-pv-partners/>

Electricity Generation – Parking Lot and Flat Roof

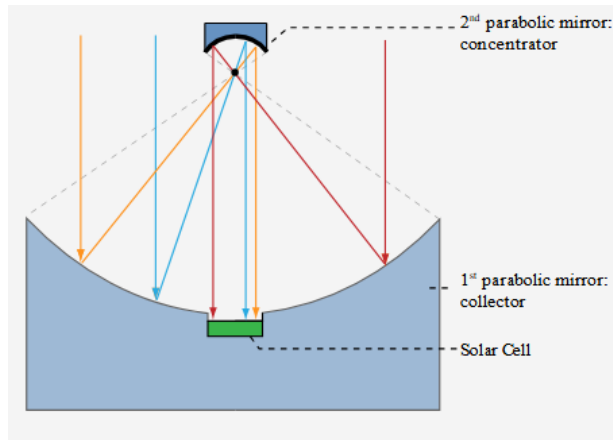


Waste Desalination Applications

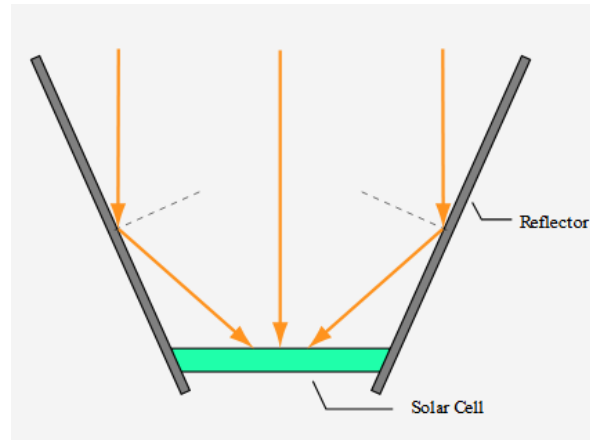
Fresnel Lens



Parabolic Mirrors



Reflectors

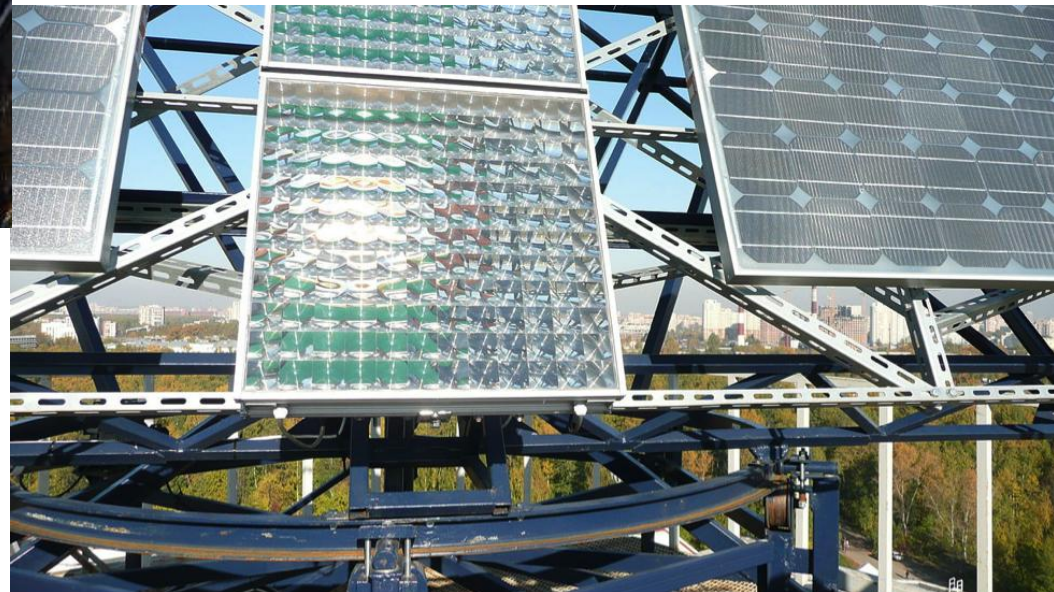


	Low concentration	Medium concentration	High concentration
Degree of concentration	2 - 10	10 - 100	> 100
Tracking?	No tracking necessary	1-axis tracking sufficient	Dual axis tracking required
Cooling	No cooling required	Passive cooling sufficient	Active cooling required in most instances.
Photovoltaic Material	High- quality silicon		Multi-junction cells

https://www.greenrhinoenergy.com/solar/technologies/pv_concentration.php

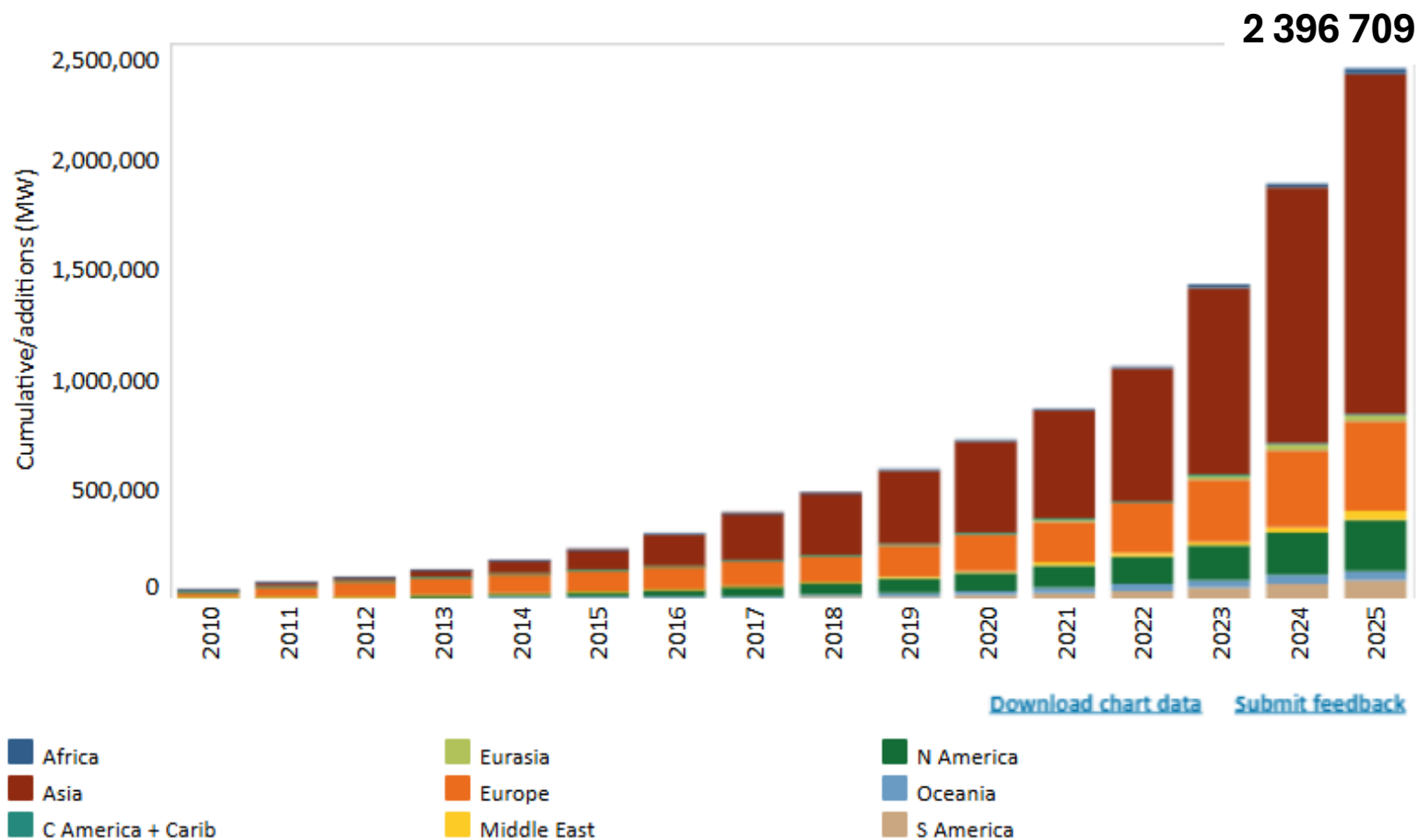


<https://solar-energy.uq.edu.au/facilities/st-lucia/concentrating-photovoltaic-array> in Australia



<https://courses.ems.psu.edu/eme812/node/537> in St. Petersburg Academic University - Russia

Electricity Generation – Concentrating Solar PV



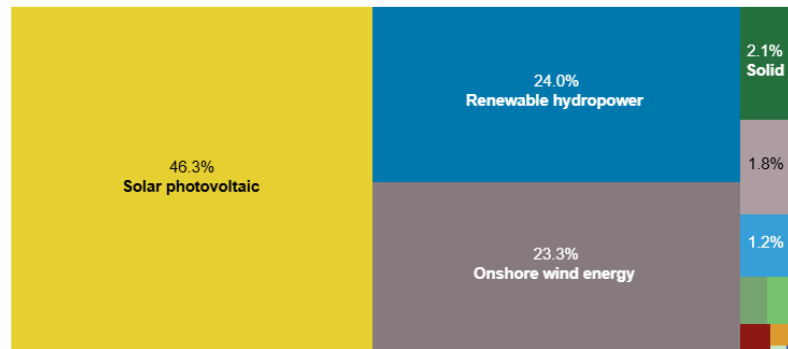
©IRENA

Last update: 17 July, 2026

Source: <https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Regional-Trends>

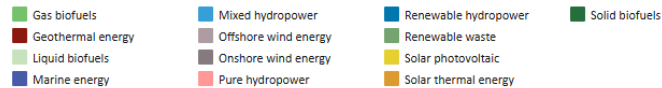
Solar Energy Installation (MW) - by region

Cumulative installed power capacity in 2025



[Download chart data](#)

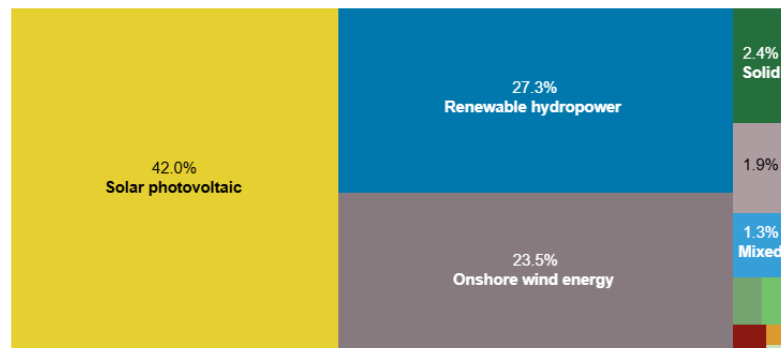
[Submit feedback](#)



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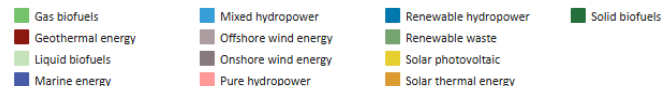
Last update: 17 July, 2026

Cumulative installed power capacity in 2024



[Download chart data](#)

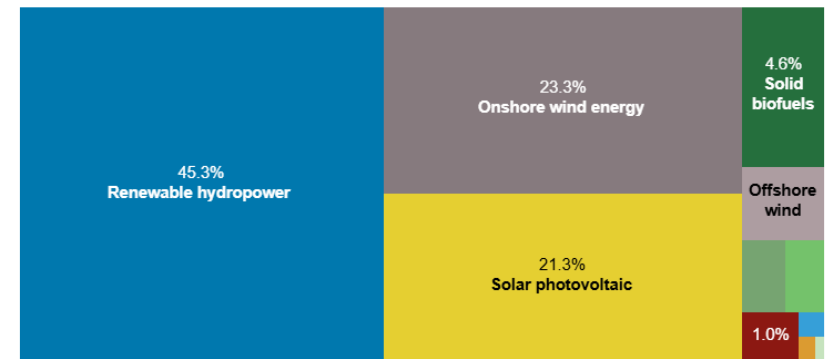
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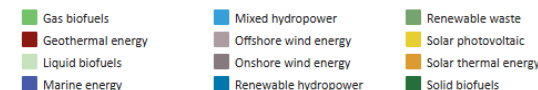
Last update: 17 July, 2026

For electricity generation in 2024



[Download chart data](#)

[Submit feedback](#)



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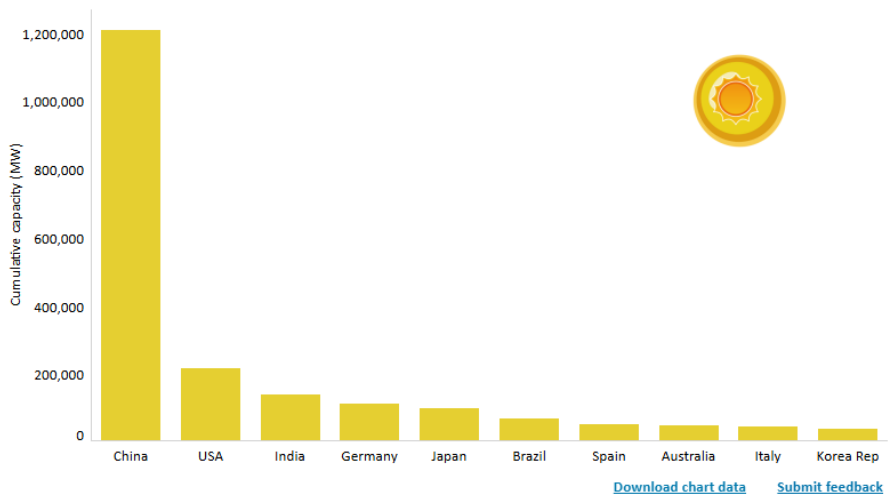
Last update: 17 July, 2026

Source: <https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Technologies>

Solar PV Contribution to RE-Based Electricity Generation¹⁷



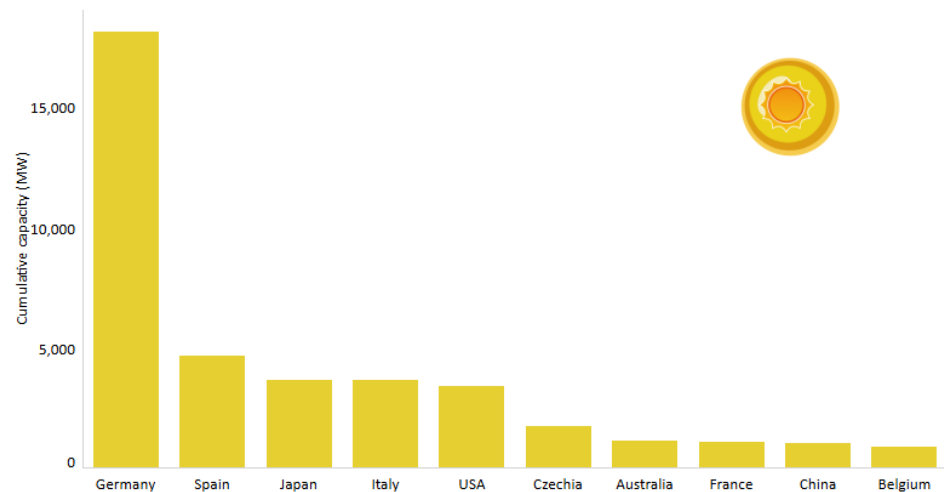
2025



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Last update: 17 July, 2026

2010

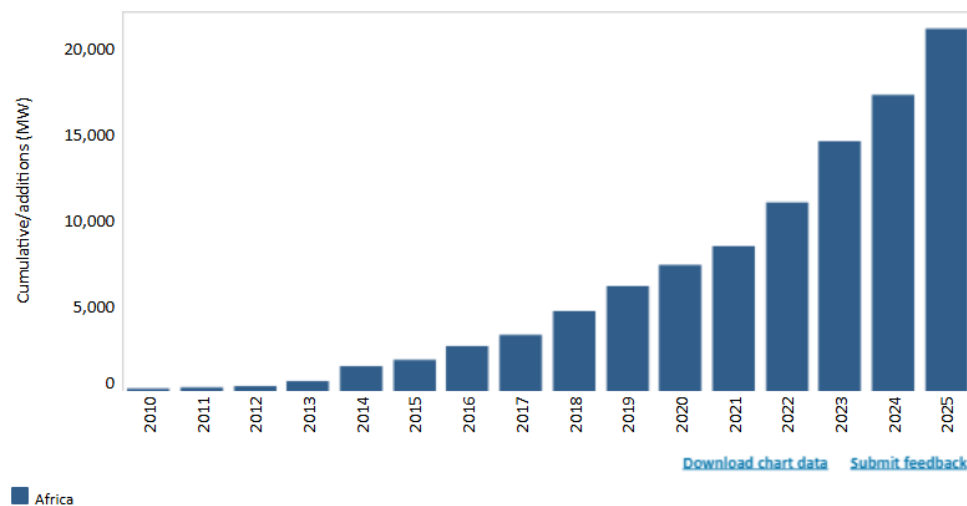
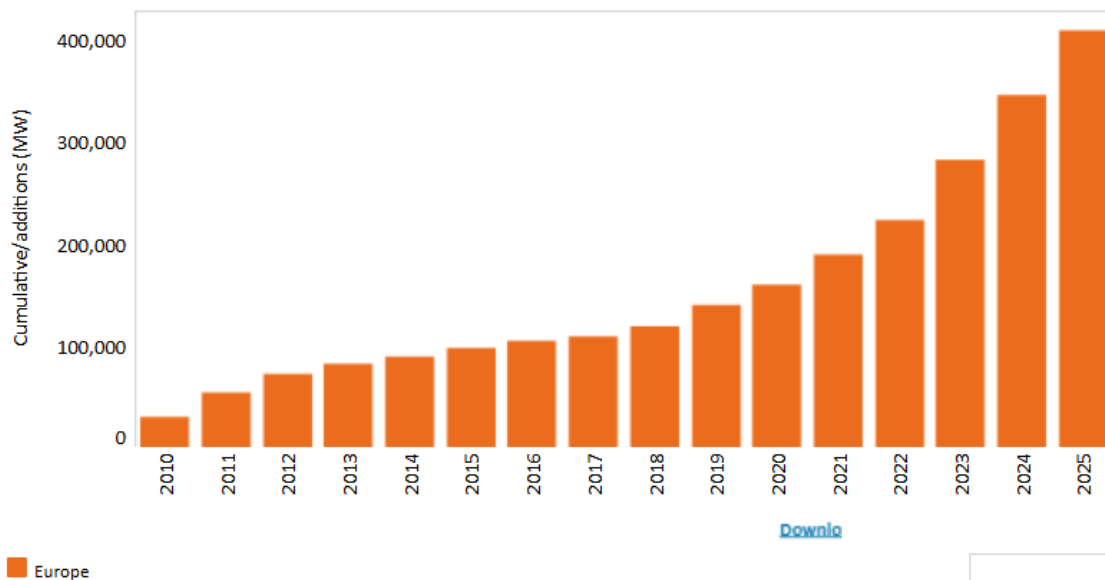


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Last update: 17 July, 2026

<https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Country-Rankings> (21 August 2026)

Solar Energy Installation (MW) – Top 10 Countries



©IRENA

Last update: 17 July, 2026

Source: <https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Regional-Trends>

Solar Energy Installation (MW) - by region



Name	Installed capacity (MW)
Access Solar (Soroti)	10.0
Tororo solar north	10.0
Kabusasoke solar power station	20.0
Emerging Power U Ltd (Mayuge/Bufulubi)	10.0
Xsabo Nkonge Solar	20.0
Tororo PV Power Project (Tororo PV Power Co. Ltd)	10.0
Kalangala Infrastructure Services	1.6
Busitema Solar PV	4.0

Source: Data extracted from <https://www.era.go.ug/index.php/stats/generation-statistics/installed-capacity>

Total installed capacity = 85.6 MW (in 2025)

Note:

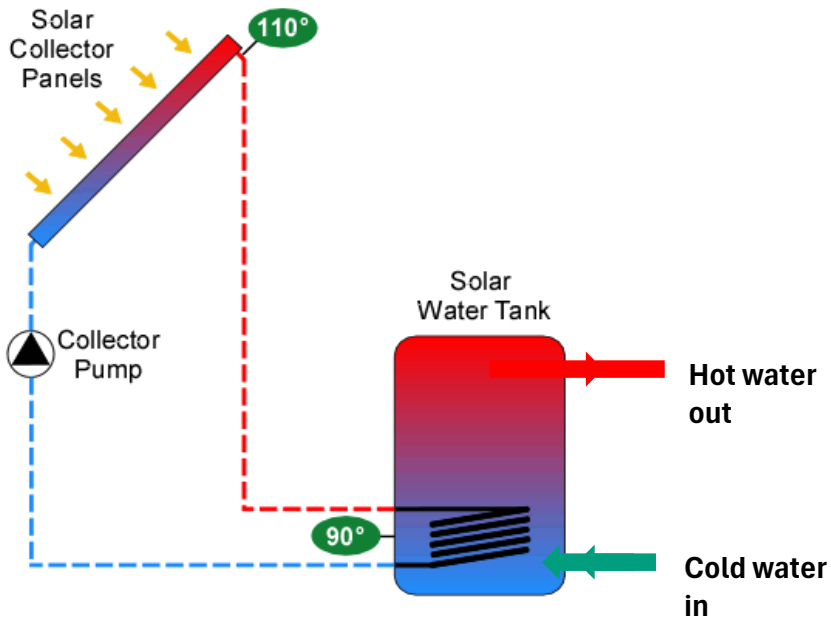
- This installed capacity excludes some decentralized installations on private and public premises.

Solar PV Power Plants in Uganda

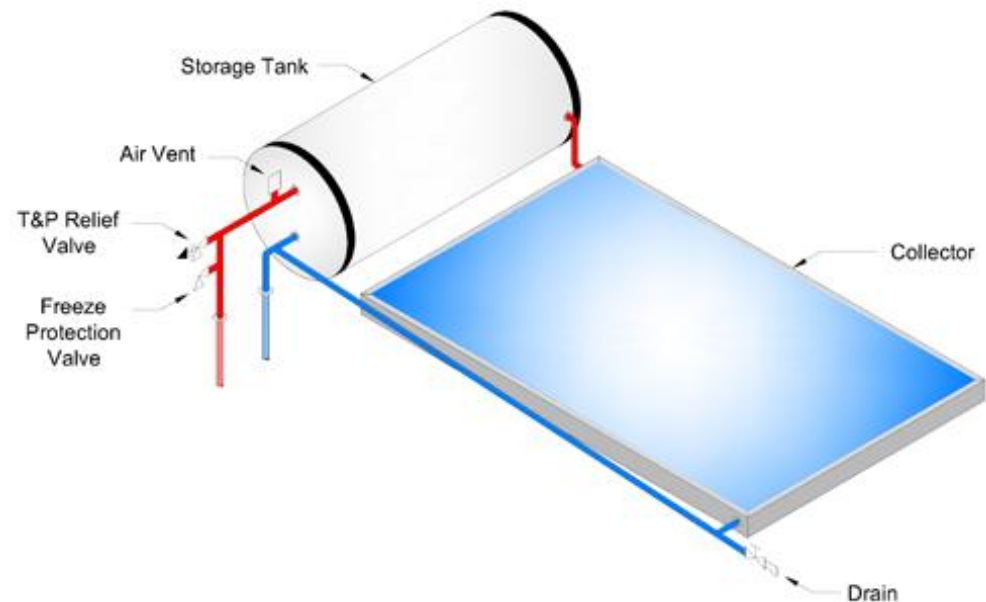


SOLAR THERMAL APPLICATIONS

<https://www.iea-shc.org/solar-heat-worldwide>



Active solar water heaters)



Working principle: Temperature difference

Passive solar water heaters)

Source: E Ramde (Mechanical Engineering, KNUST), Lecture material

Solar Water Heating Systems – Flat Plate



Solar water heater (Photo Sam in Uganda)



Around 400,000 thermosiphon systems were built in Brazil as part of the Minha Casa, Minha Vida social housing program.

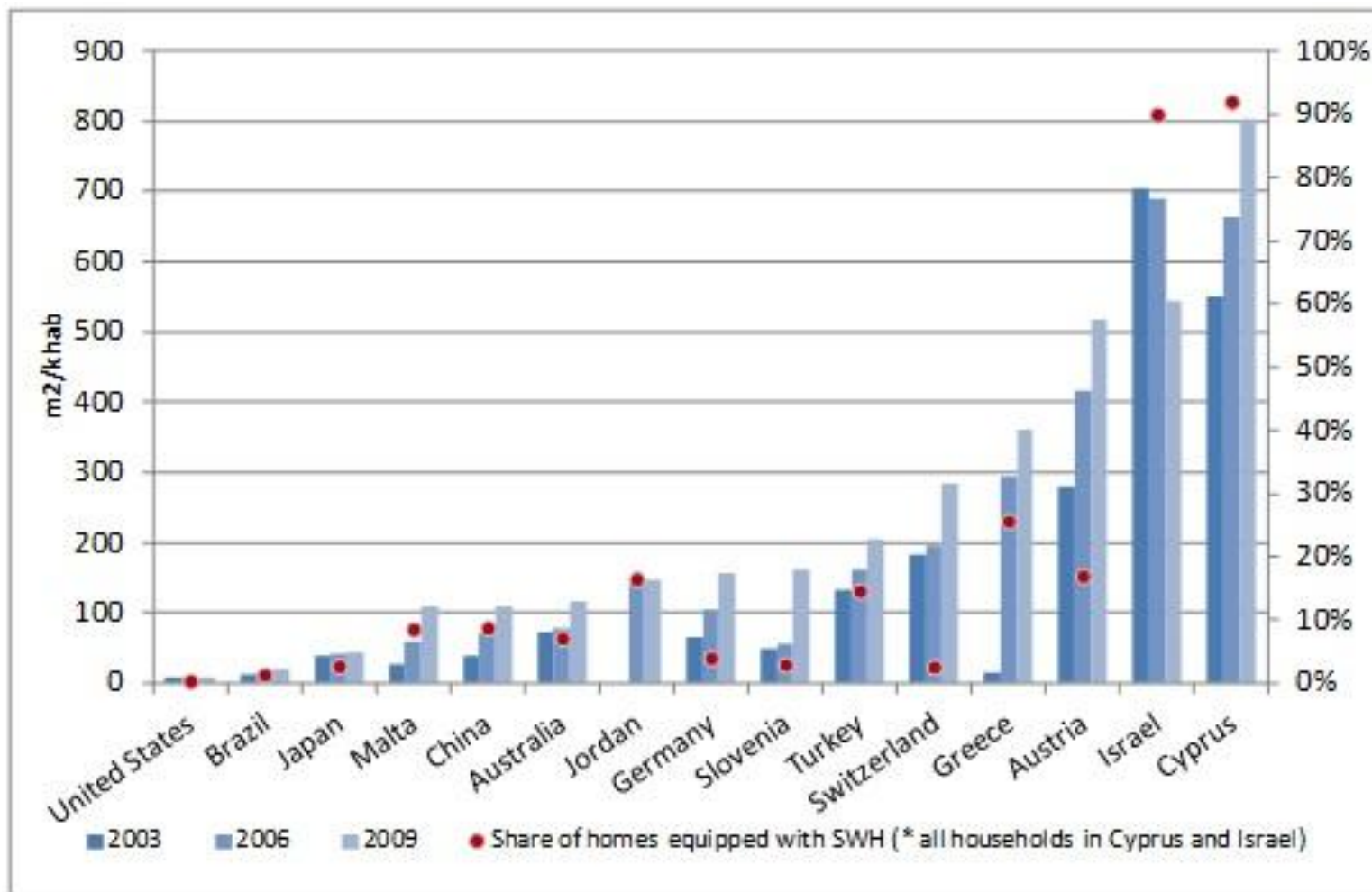
Photo: TUMA



<https://www.indiamart.com/proddetail/industrial-solar-water-heater-11438154133.html>

<https://www.iea-shc.org/Data/Sites/1/publications/2020-06-01--Solar-Heat-Worldwide-2020-Press-Release.pdf> (20 August 2026)

Solar Water Heating Systems – Flat Plate



Source: <https://www.enerdata.net/publications/executive-briefing/solar-water-heating-world.html>



Country	Type of measures	Target	Expected CO ₂ emission reduction (ktCO ₂) ²
Austria	Rebates Subsidies	169 ktoe by 2020	1,000
Cyprus	Subsidies	90 ktoe by 2020	1,000
France	Tax credit Investment grants	927 ktoe by 2020 4 million homes equipped with SWH by 2020	3,100
Germany	Preferential loans Subsidies	1,245 ktoe by 2020	4,400
Greece	Tax reductions Minimum solar contribution to the hot water supply	355 ktoe by 2020 60% of hot water needs from solar	1,100
Italy	Tax credit Subsidies	1,586 ktoe by 2020	5,000
Portugal	Subsidies Tax reductions Preferential Loans Mandatory SWH system on new buildings	160 ktoe by 2020 + 100,000 m ² /year until 2020 1 m ² /occupant in new buildings	510
Spain	Minimum solar contribution to the hot water supply	644 ktoe by 2020 10 million m ² by 2020	2,300

Source ENERDATA, from National Renewable Energy Action Plans, International Energy Agency and REN21

Country	Type of measures	Target	Expected CO ₂ emission reduction (ktCO ₂) ³
Morocco	Subsidies	1.7 million m ² by 2020	450
Tunisia	Subsidies Preferential loans	2.5 million m ² by 2020	670
South Africa	Tax reductions Rebates	4 million homes equipped by 2020	
Lebanon		1.05 million m ² by 2020	290
Israel	Mandatory SWH system on new buildings		
United States	Tax credit		
Brazil	Subsidies	15 million m ² by 2015	3,700
Mexico		1.8 million m ² by 2012	500
India	Subsidies Investment grant	15 million m ² by 2017 20 million m ² by 2022	4,100 5500
China	Subsidies	300 million m ² by 2020	54,500
Taiwan	Subsidies	6 million m ² by 2020	1,100
South Korea	Subsidies	342 ktoe by 2020 1,882 ktoe by 2030	1,100 6,000
Australia	Renewable energy certificates Tax credits Rebates, Subsidies	12% of homes equipped with SWH by 2020	

Source ENERDATA, from REN21 and the International Energy Agency

Source: <https://www.enerdata.net/publications/executive-briefing/solar-water-heating-world.html>

Policies for solar water heating systems



Akershus Energy Park (Norway): <https://www.greenvisits.no/product/akershus-energy-park/>



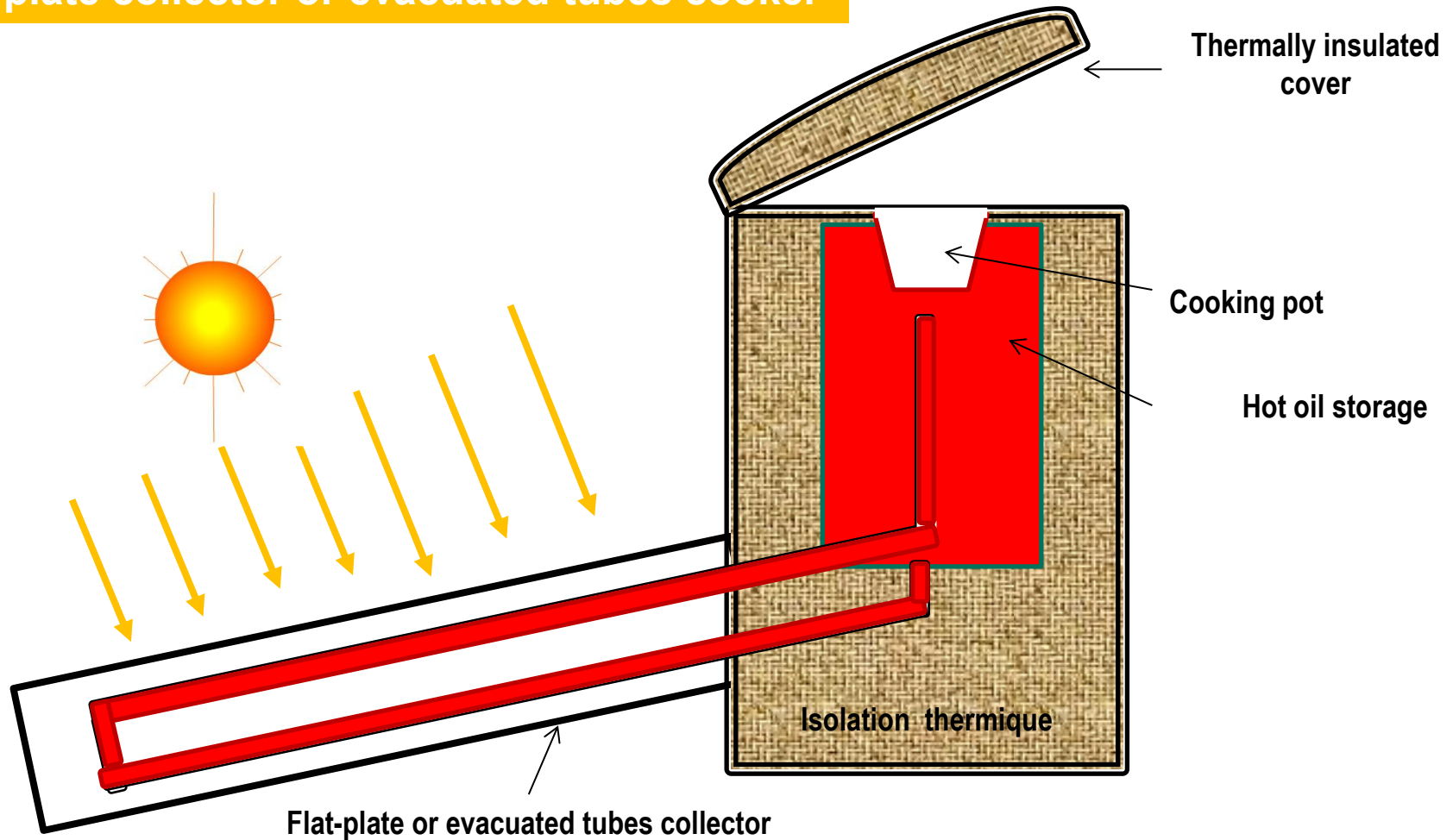
Solar district heating plant, Nordby, Samsoe, Denmark

<https://www.alamy.com/stock-photo-solar-district-heating-plant-nordby-samsoe-denmark-europe-34472041.html>

Solar water heating systems



Flat-plate collector or evacuated tubes cooker



Source: E Ramde (Mechanical Engineering, KNUST), Lecture material

Solar Cooking Stoves

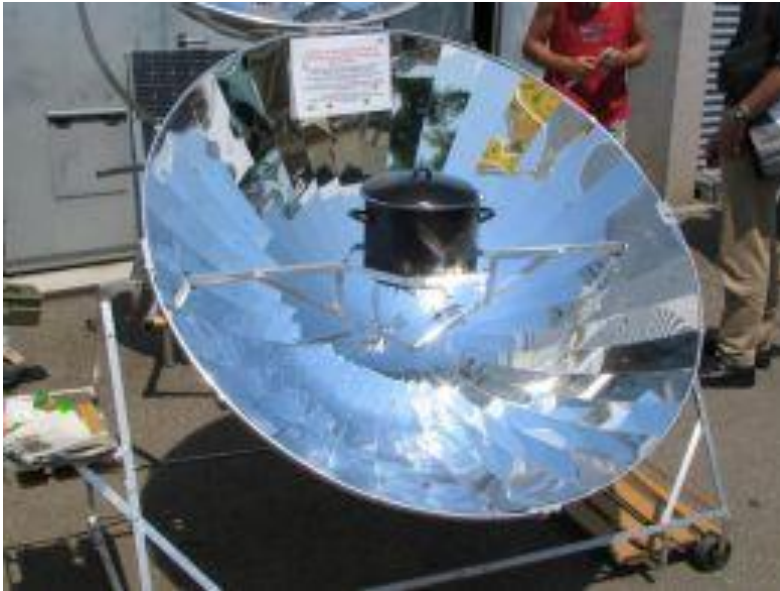


<http://www.your-solar-energy-home.com/solar-ovens.html>



<http://solarcooking.org/newsletters/scrapr10.htm>

Solar Cooking Stoves



<https://www.loc.gov/rr/scitech/SciRefGuides/solarovens.html>



<http://greenbusinesswatch.org/blog/solar-cooking-offers-new-ways-to-eat>

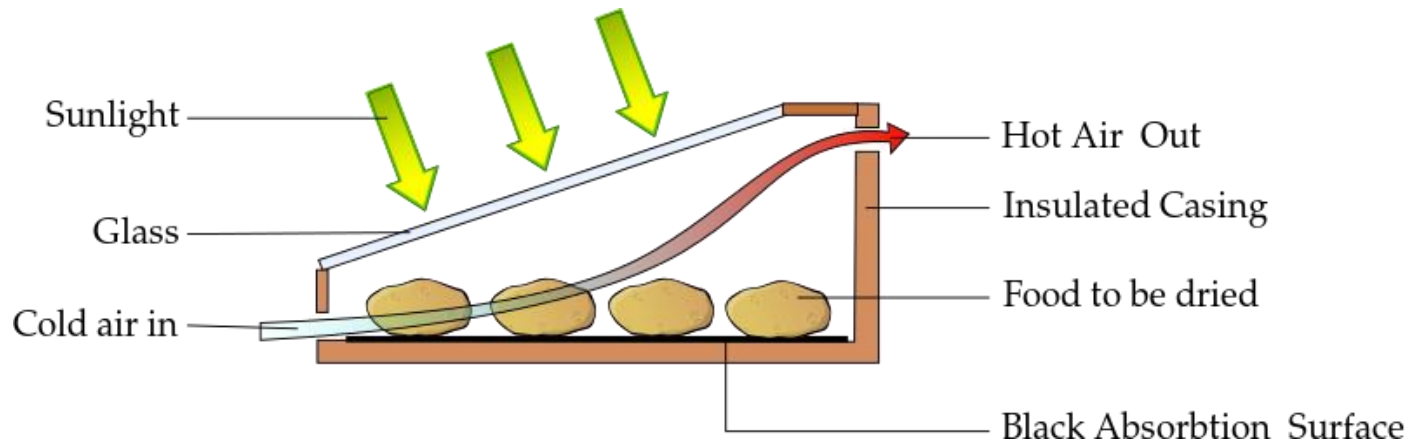
Solar Cooking Stoves



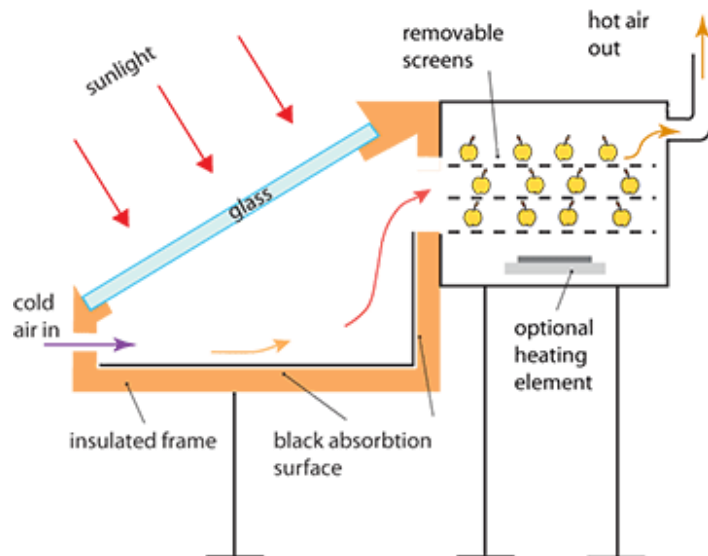
Compound Parabolic Evacuated tube cooker

Source: E Ramde (Mechanical Engineering, KNUST), Lecture material

Solar Cooking Stoves

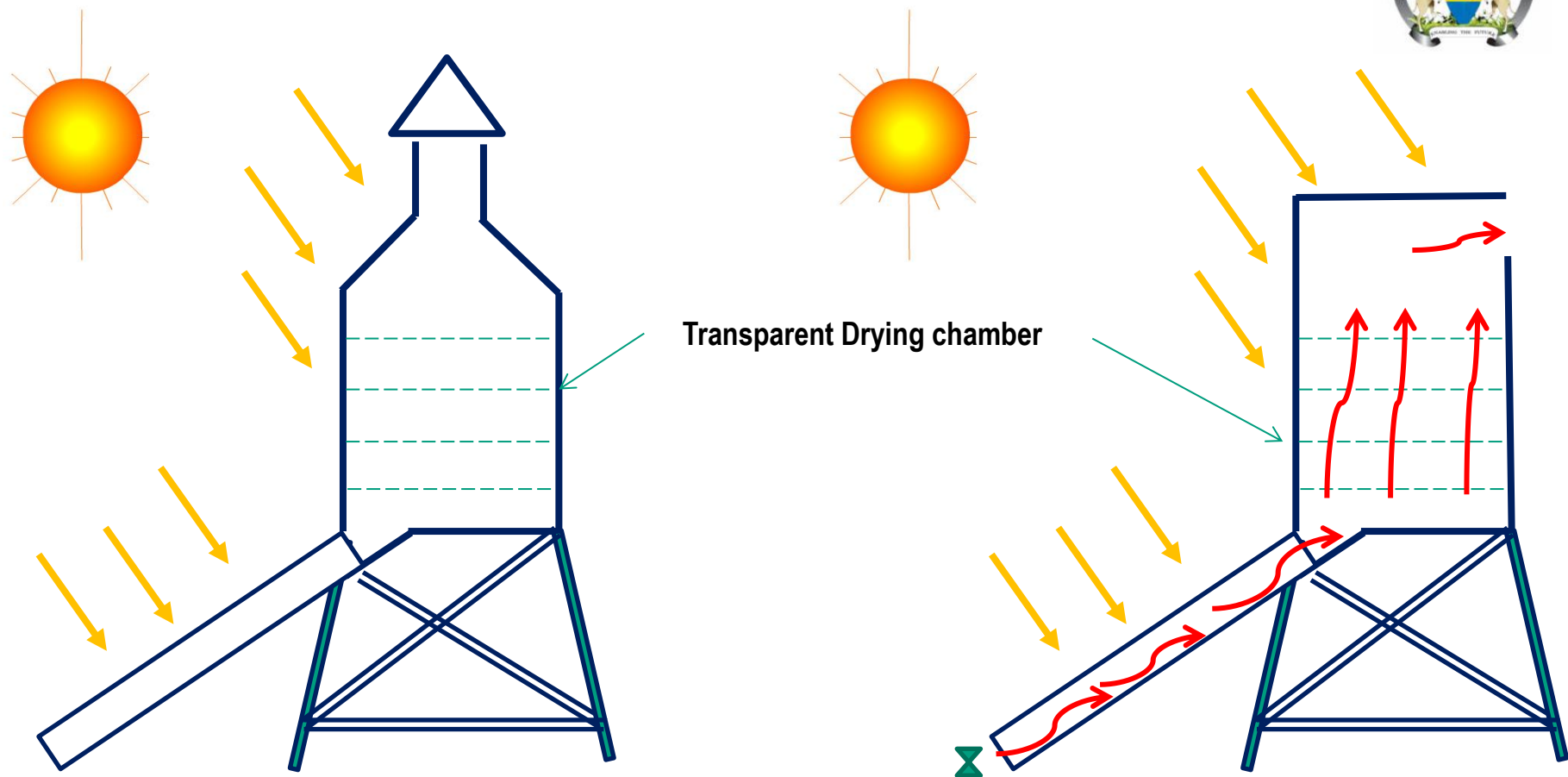


<https://www.e-education.psu.edu/eme811/node/692>



<https://www.meatsandsausages.com/drying-preservation/drying-food/solar-drying>

Solar Drying systems



Source: E Ramde (Mechanical Engineering, KNUST), Lecture material

Solar Drying systems

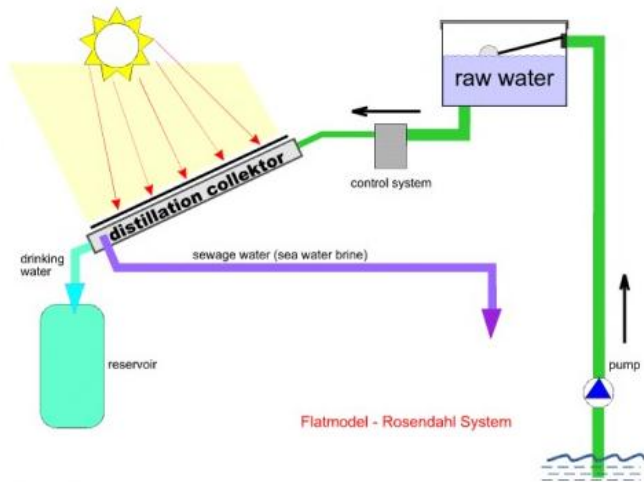


<https://attrsolarindia.com/solar-green-house-dryer/>

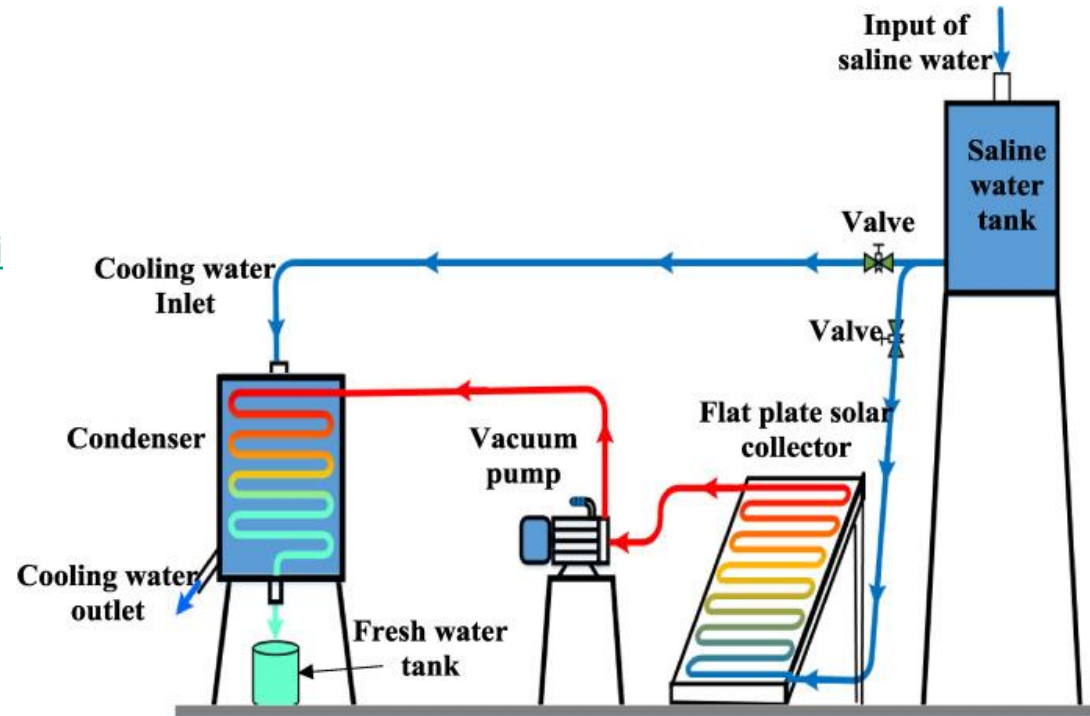


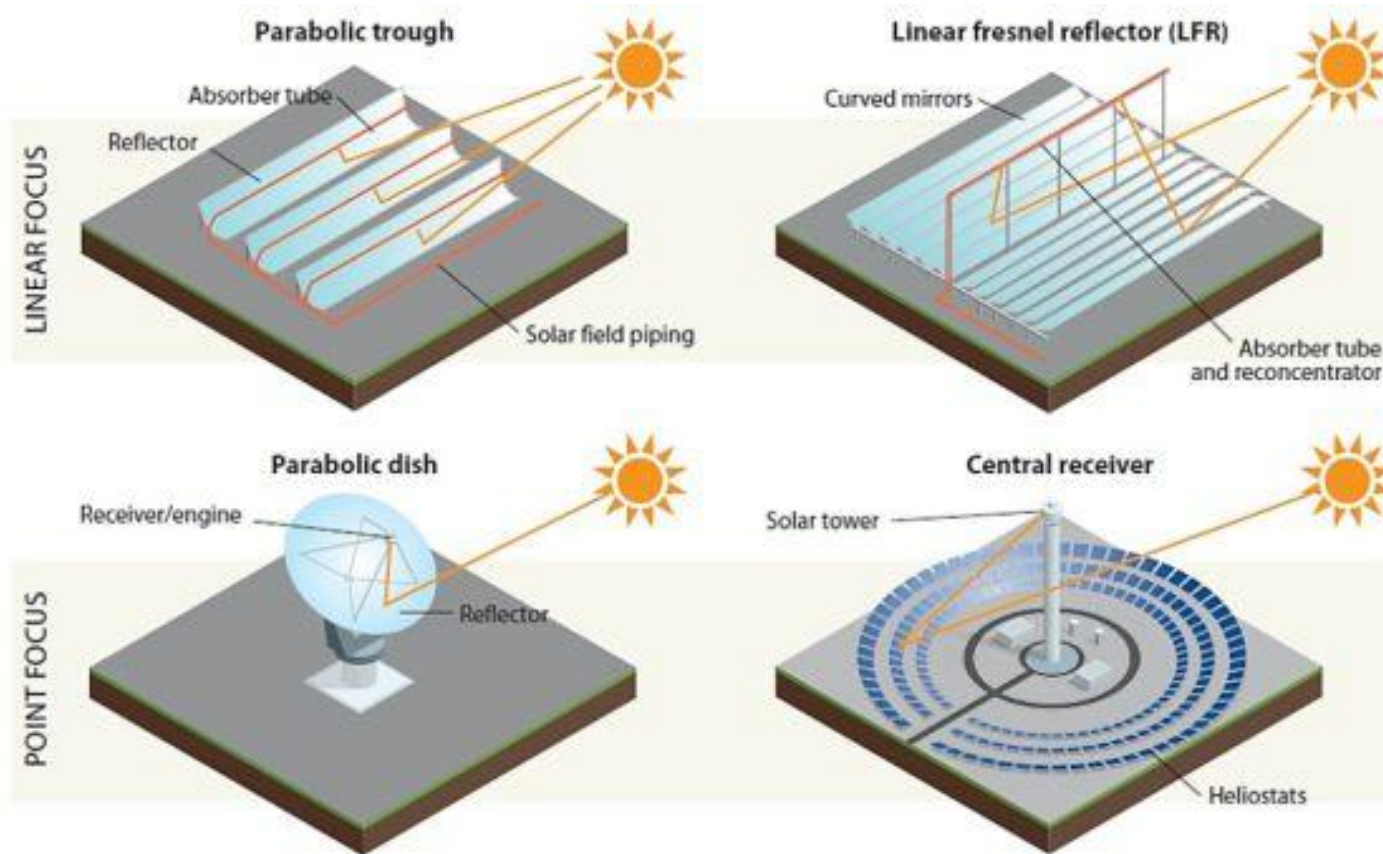
<https://www.covestro.com/press/solar-dryers-support-coffee-production-in-ethiopia/>

Solar Drying systems – Greenhouse Systems



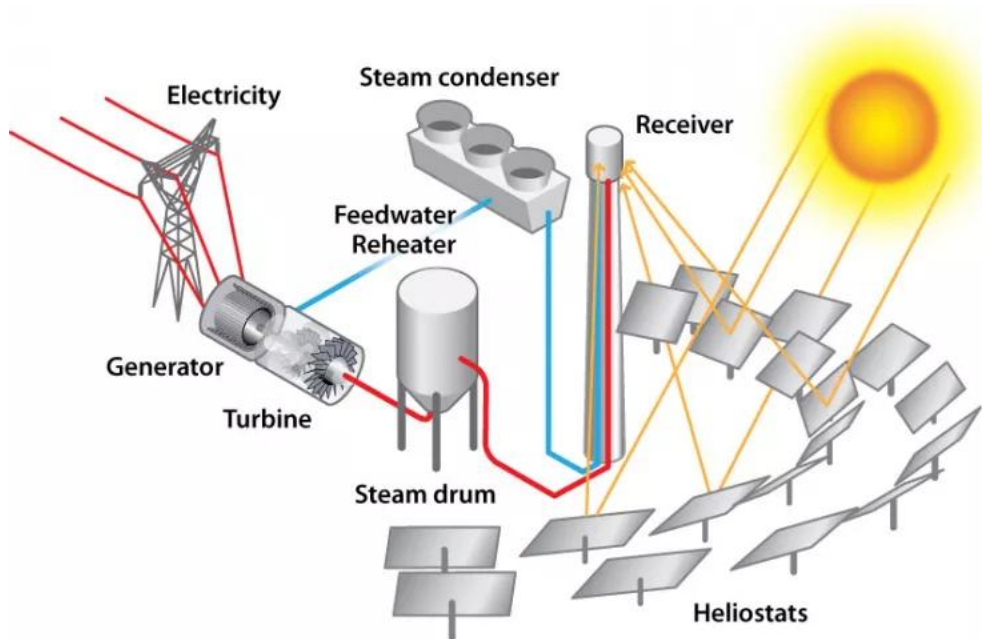
<https://www.iwapublishing.com/news/distillation-treatment-and-removal-contaminants-drinking-water>





Concentrated solar power (CSP) technologies

Source: <https://www.bbvaopenmind.com/en/technology/innovation/concentrating-solar-power-renewable-energy-source/>



Ashalim Solar Thermal Power Station 121 MW - Be'er Sheva Israel

Concentrated solar power station

Source: <https://www.treehugger.com/what-solar-tower-and-how-does-it-work-4865294>



Source: <https://meconstructionnews.com/57497/al-maktoum-solar-park-fifth-phase-launched>

Mohammed bin Rashid Al Maktoum Solar Park, Dubai

Read more:

<https://www.mbrsic.ae/en/about/mohammed-bin-rashid-al-maktoum-solar-park/>

Read more about operational solar thermal stations:

https://en.wikipedia.org/wiki/List_of_solar_thermal_power_stations

Ivanpah Solar Electric Generating System California, USA



Source: <https://dreambigfilm.com/stories/image-29-ivanpah/>

Number of collectors: 173 500

Capacity: 392 MW

Cost: US\$2.2 billion



<http://loriskedelsky.info/small-passive-solar-house/>

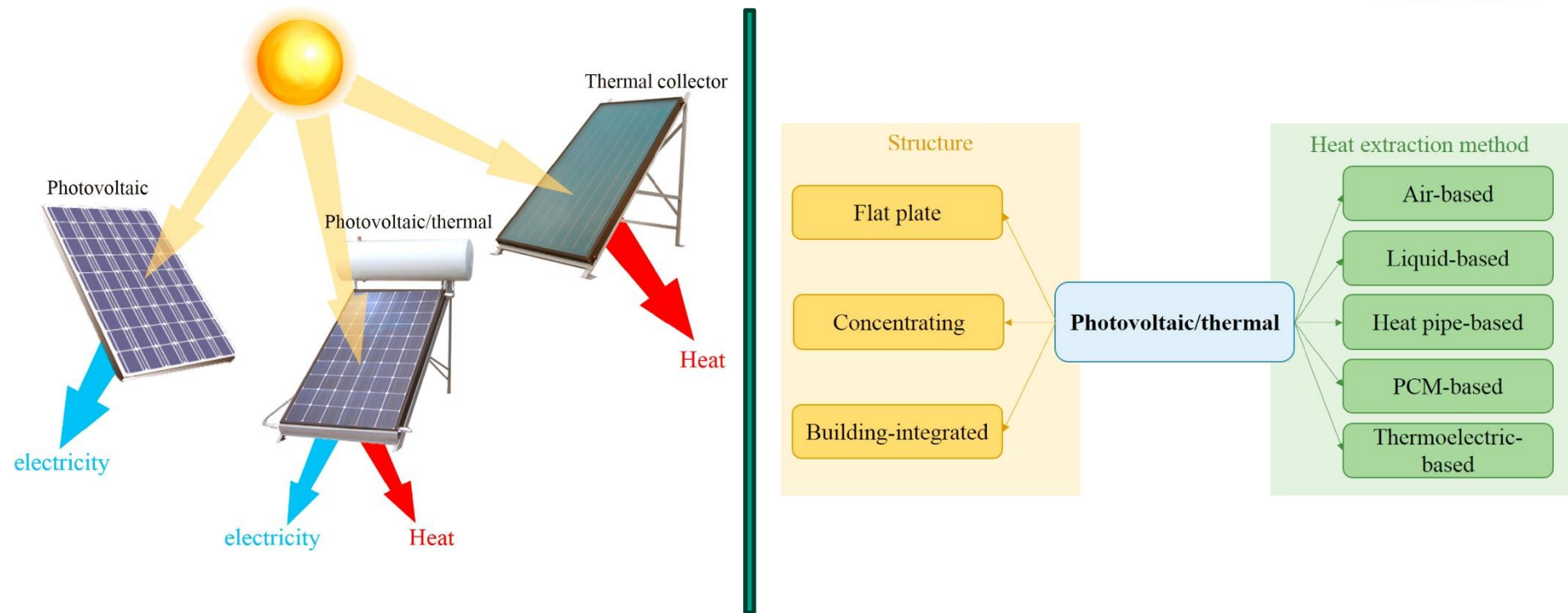


<https://www.pinterest.at/pin/463941199084467624/>

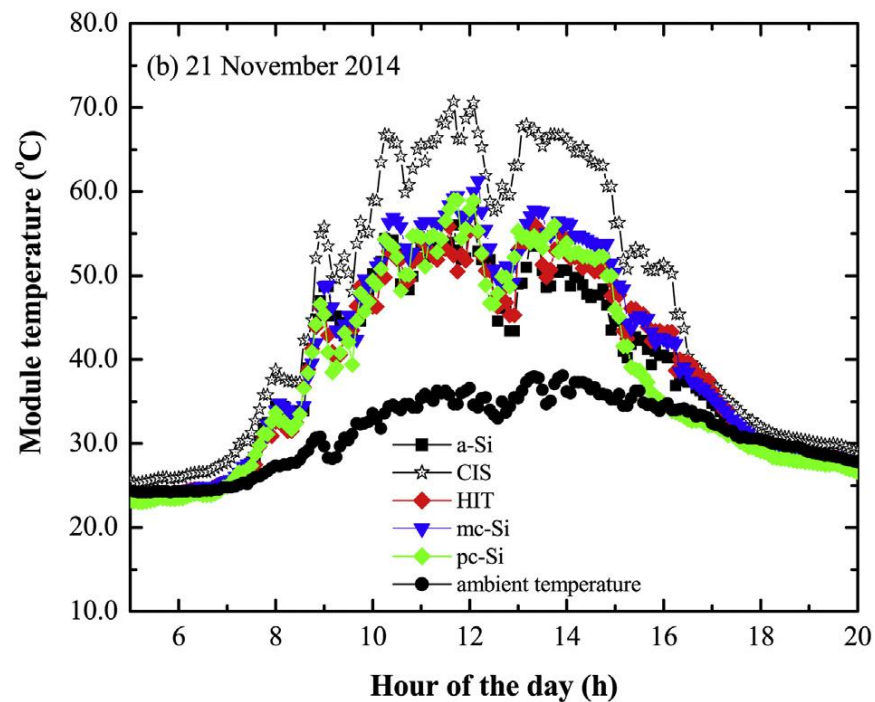
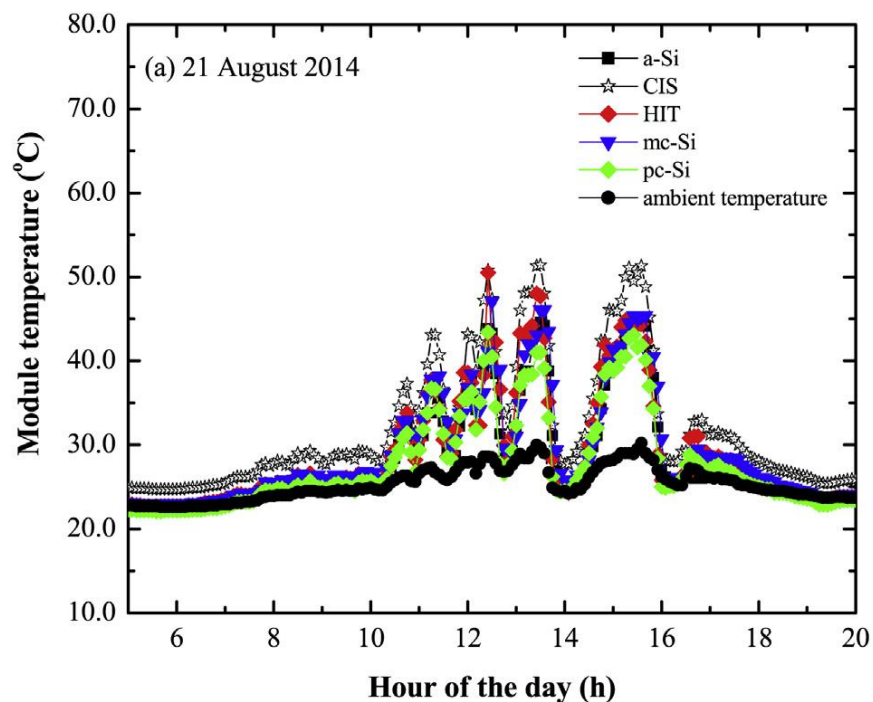
Space: Warming and Lighting



SOLAR PV-THERMAL APPLICATIONS

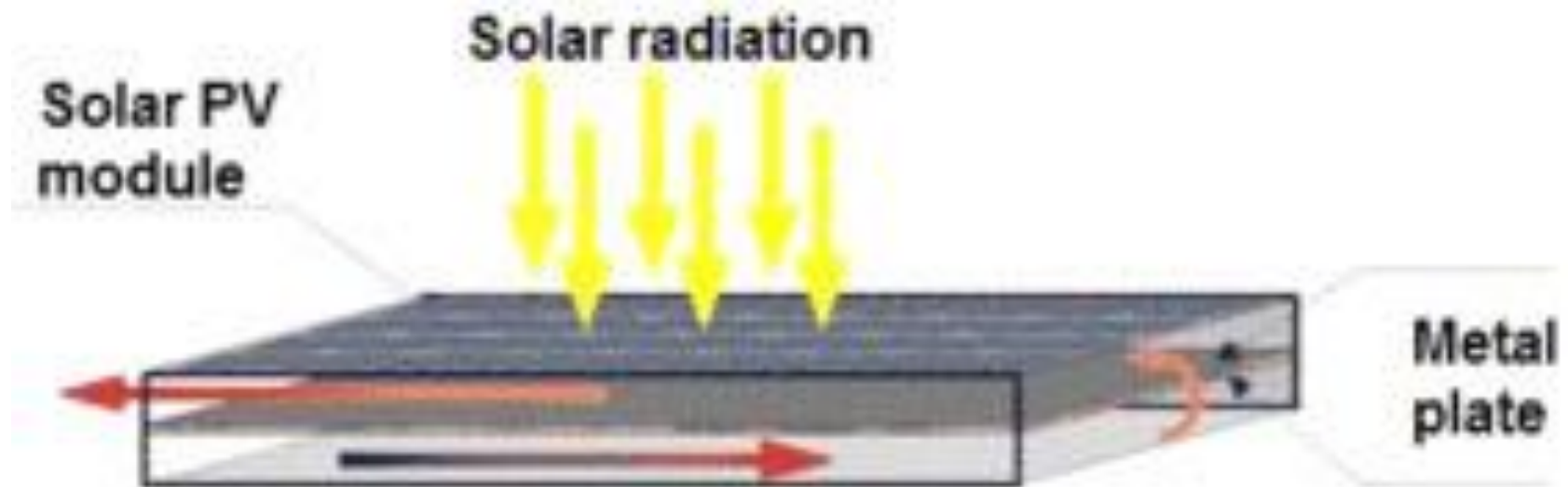


Yazdanifard F and Ameri M. Exergetic advancement of photovoltaic/thermal systems (PV/T): A review. Renewable and Sustainable Energy Reviews 97 (2018) 529-553; <https://doi.org/10.1016/j.rser.2018.08.053>



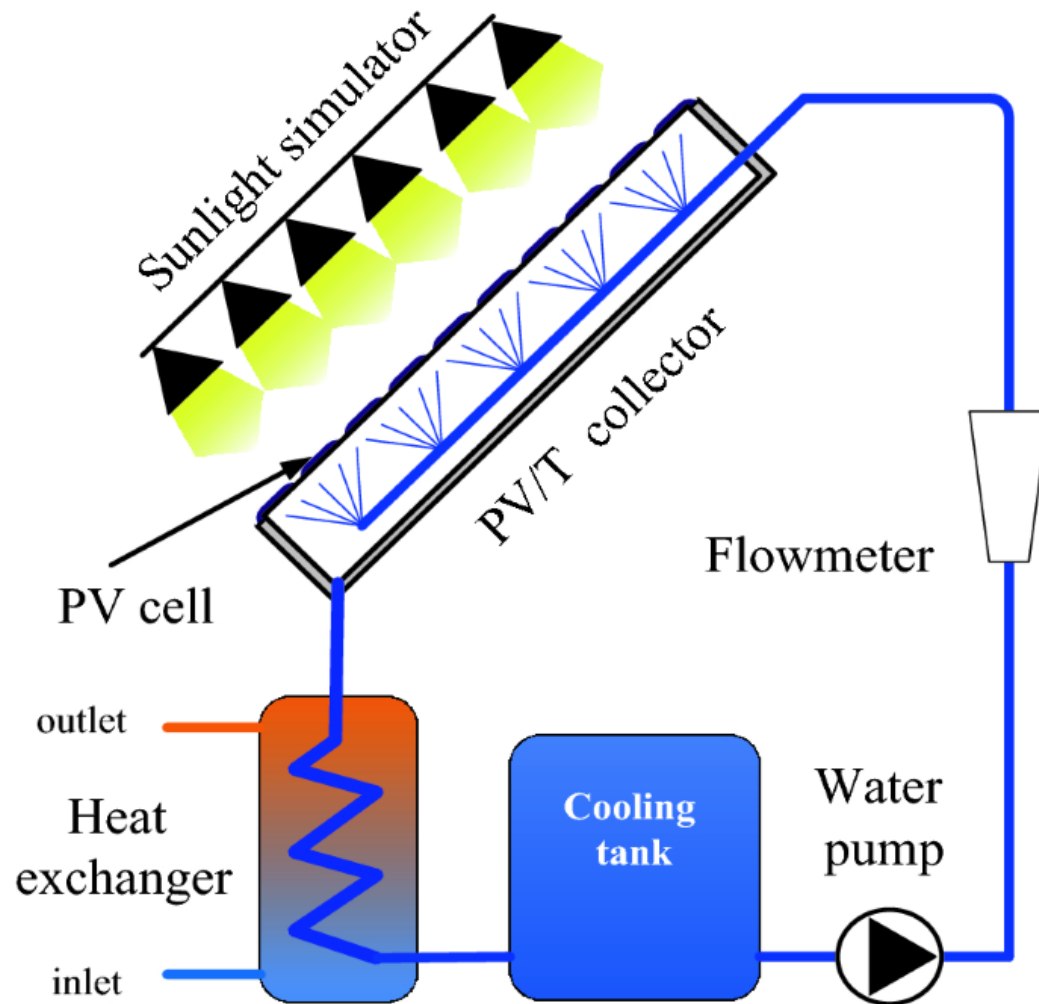
Daily module temperature for different solar PV modules in Kumasi Ghana

David A. Quansah, Muiyiwa S. Adaramola, George K. Appiah, Isaac A. Edwin. Performance analysis of different grid-connected solar photovoltaic (PV) system technologies with combined capacity of 20 kW located in humid tropical climate. International Journal of Hydrogen Energy 42 (7), 2017, 4626-4635; <https://doi.org/10.1016/j.ijhydene.2016.10.119>



<http://www.grammer-solar.com/cms/en/solar-air/products/pv-hybrid-collector.html>

Michael et al. Renewable and Sustainable Energy Reviews 51 (2015) 62-88



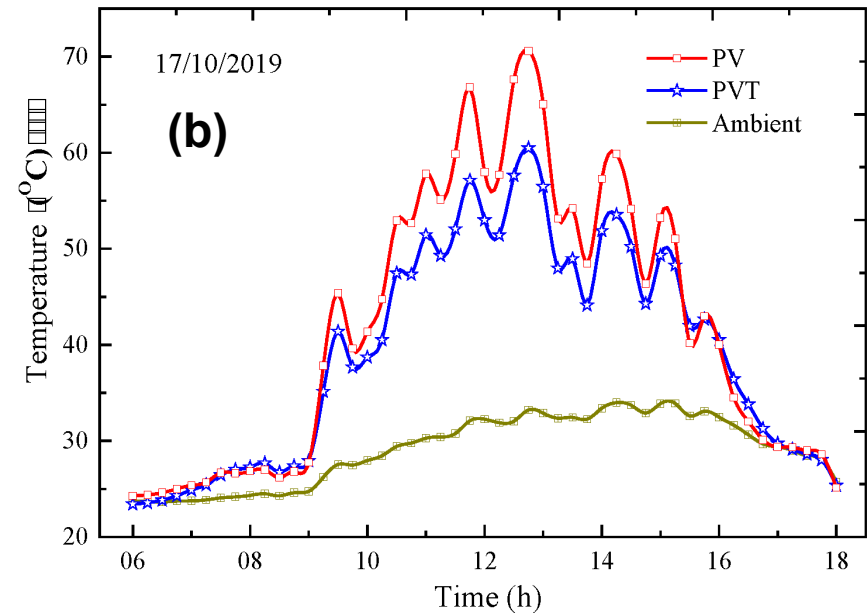
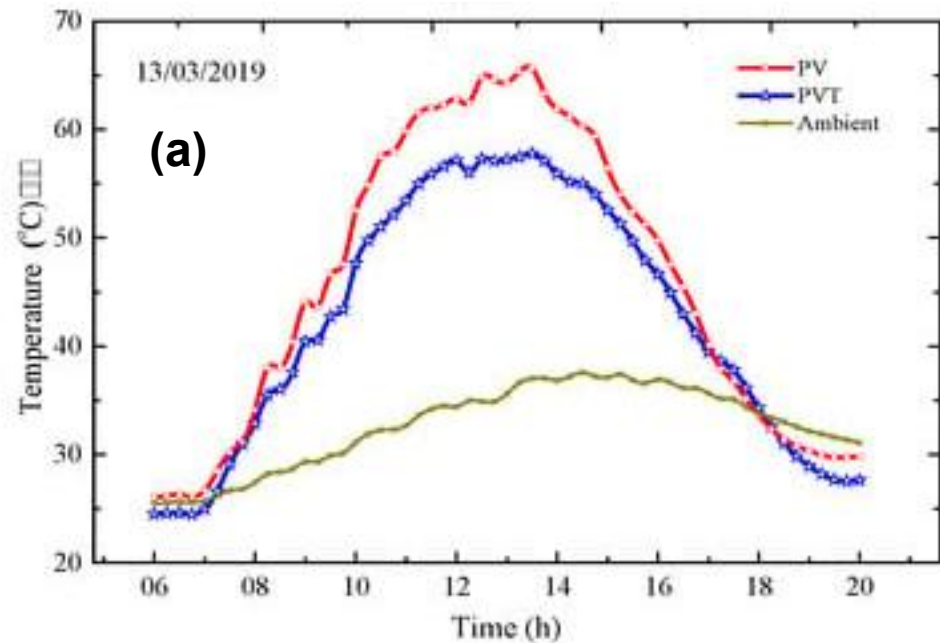
Ghazy, M., Ibrahim, E.M.M., Mohamed, A.S.A. et al. Cooling technologies for enhancing photovoltaic–thermal (PVT) performance: a state of the art. *Int J Energy Environ Eng* **13**, 1205–1235 (2022). <https://doi.org/10.1007/s40095-022-00491-8>

PVT Application – Water Heating Systems



PVT Experimental-setup at Kwame Nkrumah University of Science and Technology Ghana

Abdul-Ganiyu, S.; Quansah, D.A.; Ramde, E.W.; Seidu, R.; Adaramola, M.S. Investigation of Solar Photovoltaic-Thermal (PVT) and Solar Photovoltaic (PV) Performance: A Case Study in Ghana. *Energies* **2020**, *13*, 2701. <https://doi.org/10.3390/en13112701>



PVT and PV modules temperature profiles at daytime showing variations in: (a) daily temperature variation on a stable sunny day and (b) daily temperature variations on an unstable sunny day

Abdul-Ganiyu, S.; Quansah, D.A.; Ramde, E.W.; Seidu, R.; Adaramola, M.S. Investigation of Solar Photovoltaic-Thermal (PVT) and Solar Photovoltaic (PV) Performance: A Case Study in Ghana. *Energies* **2020**, *13*, 2701. <https://doi.org/10.3390/en13112701>

PVT and PV modules temperature profiles



Hybrid solar PV and water heating system installation at KNUST Kumasi Ghana



Questions?