Design and Renewable Energy

Solar Energy – PV and Solar thermal

Why solar energy?

- Environmental concerns/reduce carbon emissions
- Save money on electric bills
- General interest in new technologies
- Increase in building value

How can you use solar in your home or business?

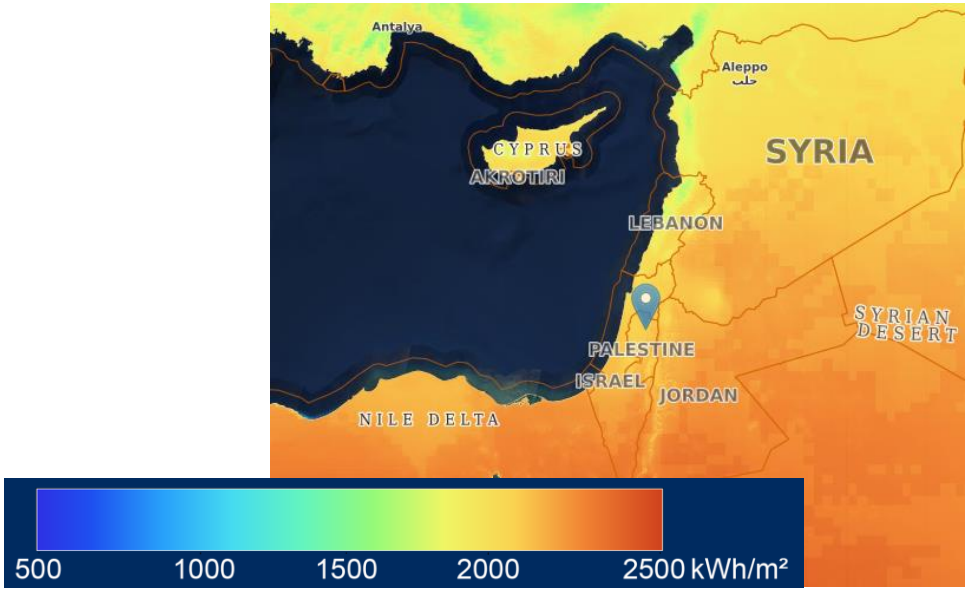
- Electricity from Solar
  - Solar photovoltaics (PV)
- Heat from Solar
  - Passive solar
  - Solar thermal/hot water
  - Solar air heater

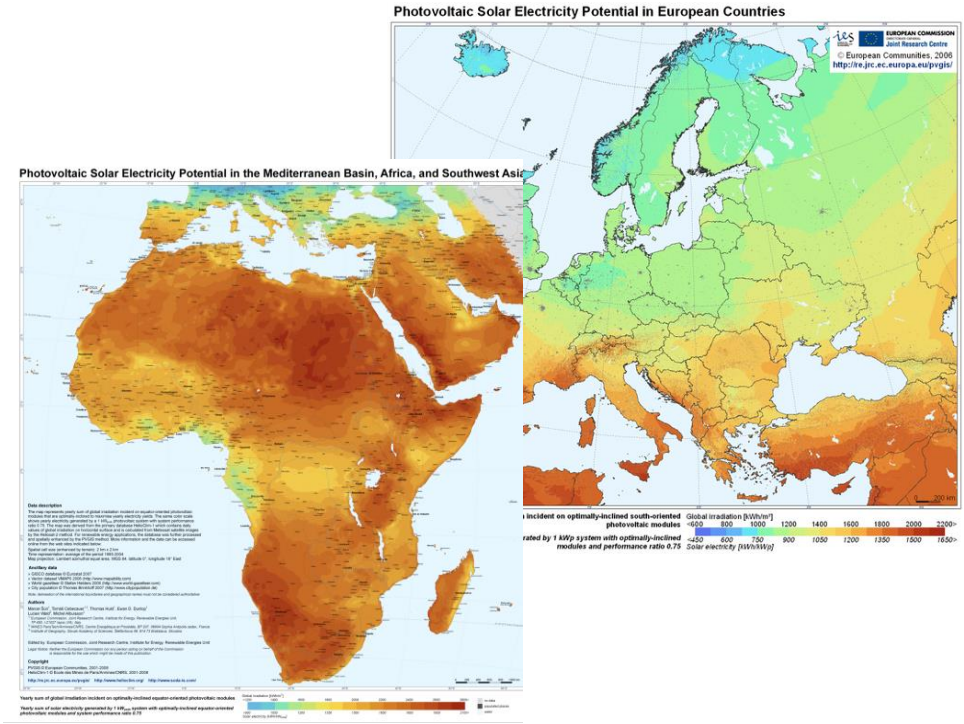
Solar Photovoltaic (PV)

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect

Does solar work in Palestine?

Long summer days = more hours to capture sun's energy




Photovoltaic Solar Electricity Potential in European Countries
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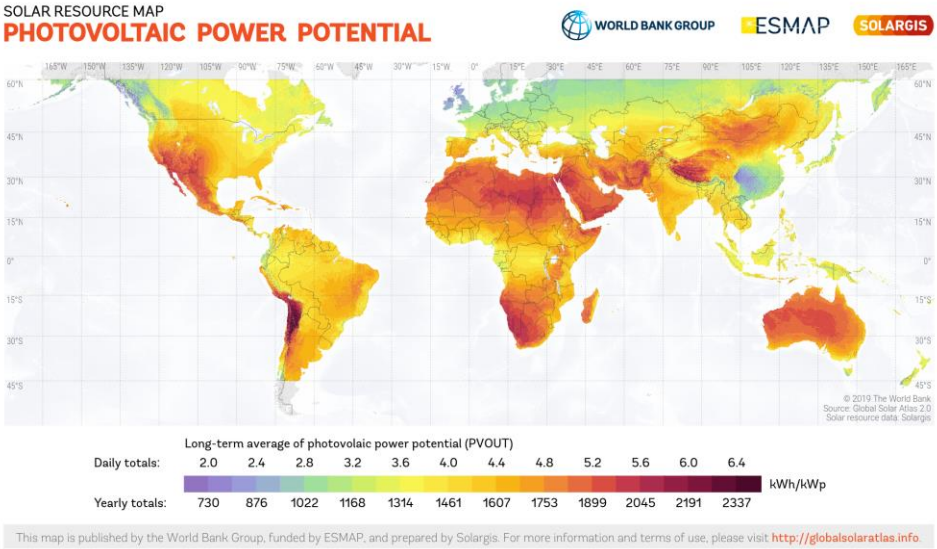
http://re.jrc.ec.europa.eu/pvgis/
Photovoltaic Solar Electricity Potential in the Mediterranean Basin, Africa, and Southwest Asia


SOLAR RESOURCE MAP
PHOTOVOLTAIC POWER POTENTIAL
WORLD BANK GROUP
ESMAP
SOLARGIS
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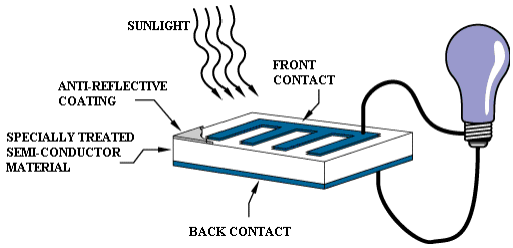
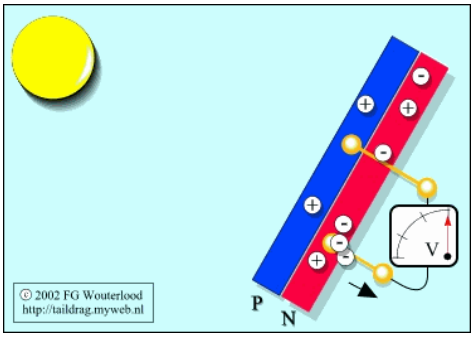
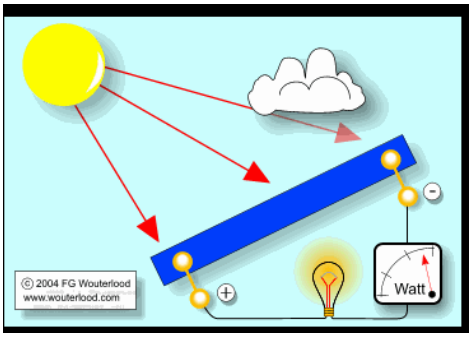
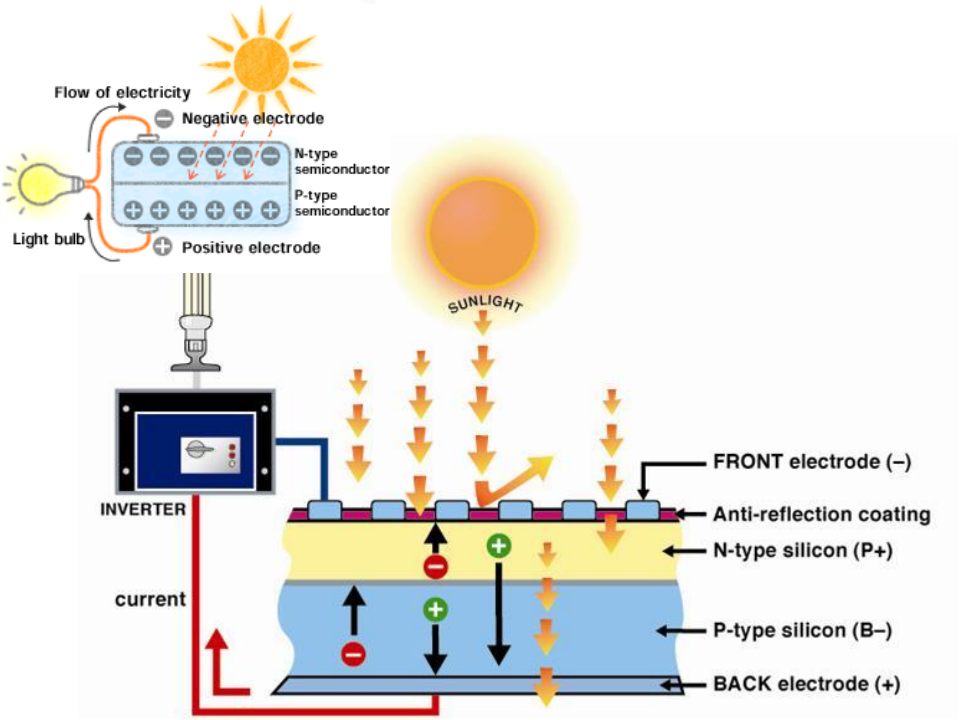
Source: Global Solar Atlas 2.0
Solar resource data: Solargis
Long-term average of photovolaic power potential (PVOUT)
Daily totals: 2.0 2.4 2.8 3.2 3.6 4.0 4.4 4.8 5.2 5.6 6.0 6.4 kWh/kWp
Yearly totals: 730 876 1022 1168 1314 1461 1607 1753 1899 2045 2191 2337
This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit http://globalsolaratlas.info.



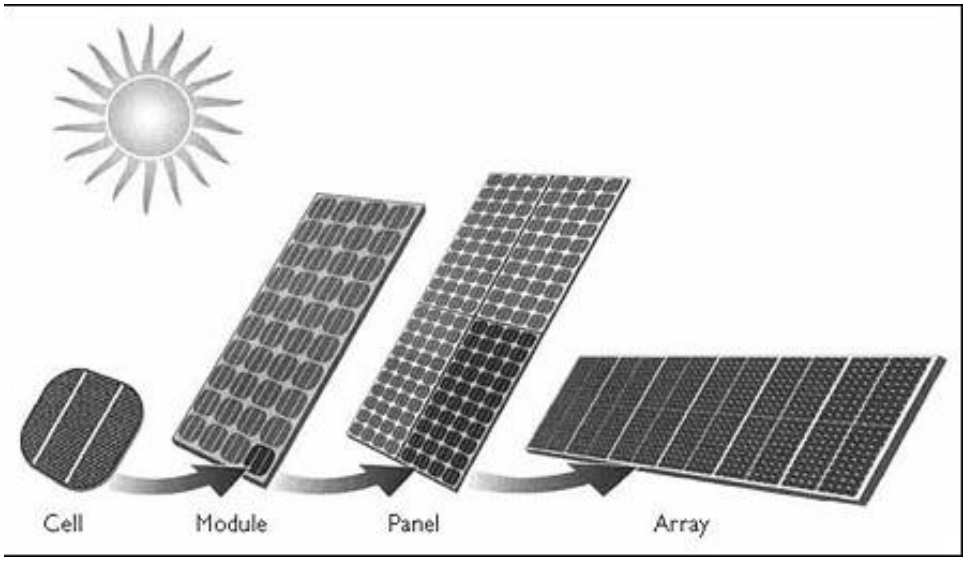
Photovoltaic (PV) or solar electric modules are solid state devices that convert solar radiation directly into electricity



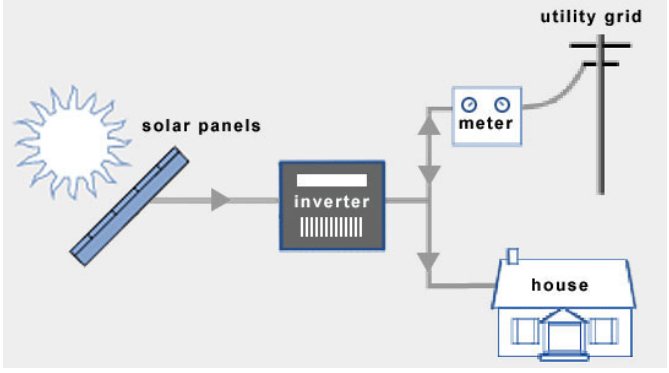


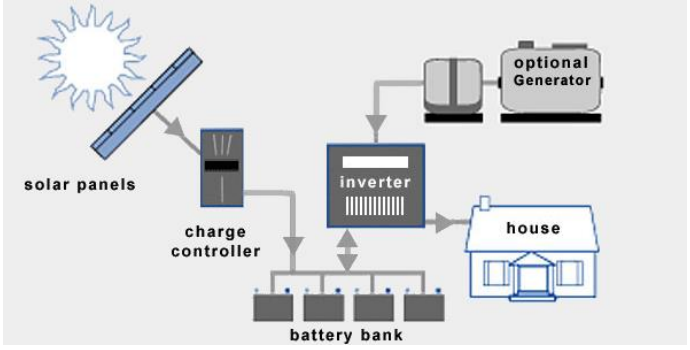


PV from cell to array

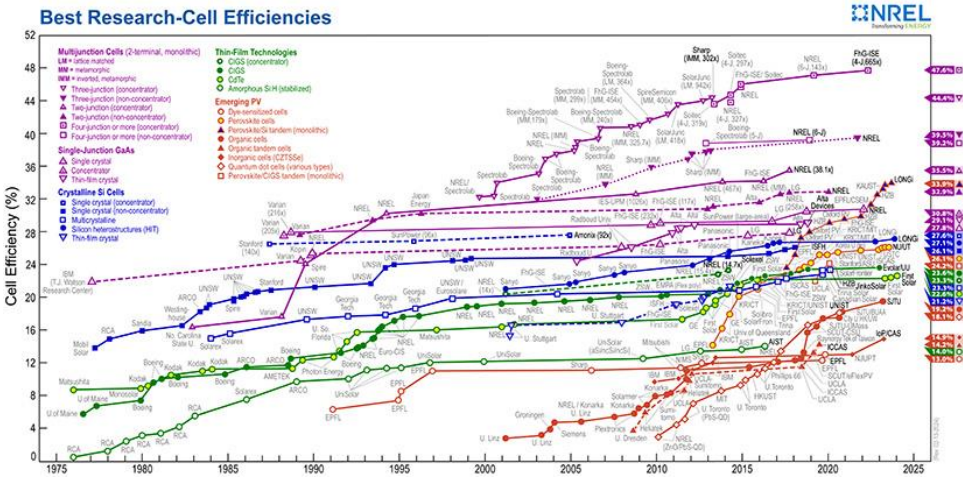


Types





PV efficiency



Solar vocabulary

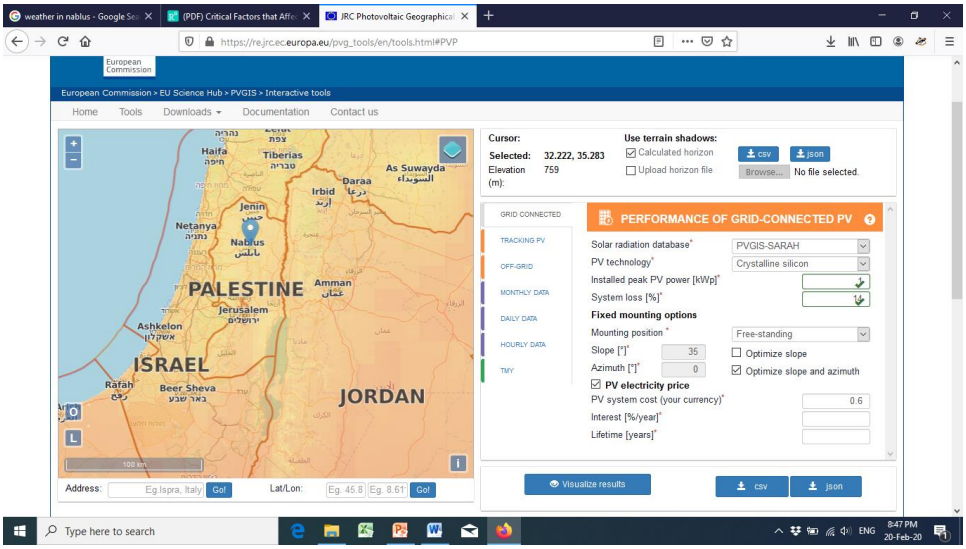
- **A kilowatt (kW) is an instantaneous measure of power. (1000 watts = 1kw)**
- **A kilowatt-hour (kWh) is a unit of energy**
  - Equivalent to one kilowatt (1 kW) of power expended for one hour (e.g. Ten 100 watt light bulbs burning for 1 hour)
- **1 kW of PV produces about 1,600 kWh/yr in Palestine**
  - Average home uses about 9,000 kWh/yr

Determining system size

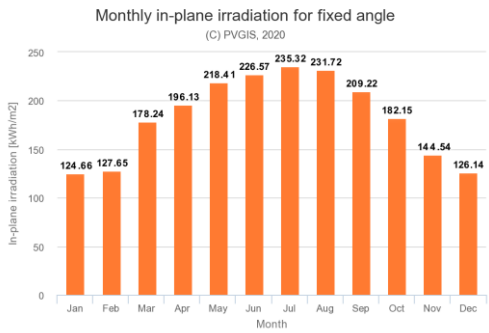
- **Your goals for electric bill offset**
- **Roof space available for PV (**10 Sq meter area is **required for 1 Kw** capacity)
- **How Many solar panels (250- or 320 watt)**
- **Roof shading / orientation / pitch**
- **Depends on your budget or your investment goals**
- **Complexity of installation will impact budget**

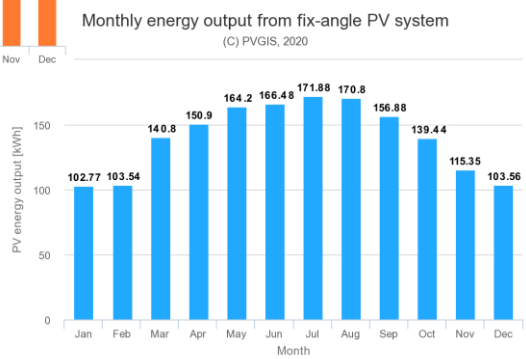
Watts are related to the output of each panel; meaning a 100 Watt panel under ideal conditions will generate 100 watt-hours of electricity each hour and a 200 Watt panel will generate 200 watt-hours each hour.

https://ec.europa.eu/jrc/en/pvgis



PVGIS output report





Sample PV Costs:

Based on a 5 KW system ($1.2/watt): $6,000

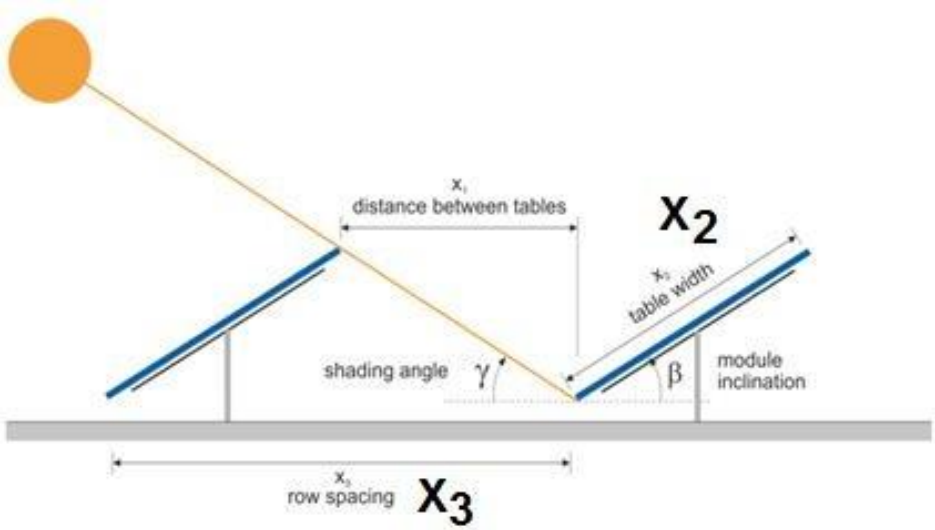
Start-up Cost: NIS 21,000

Production per year = 8190 kWh/year

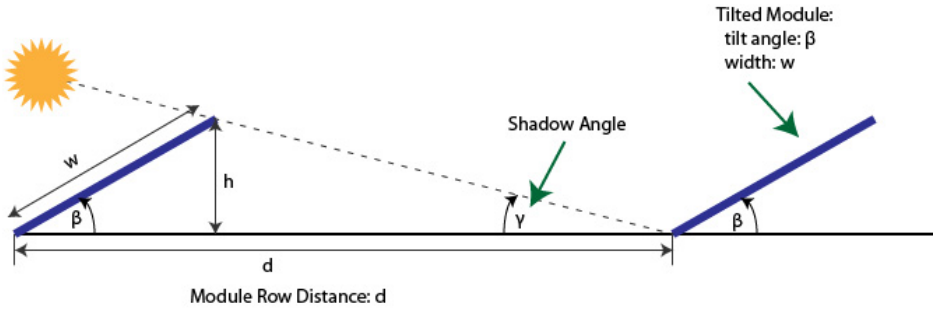
Net Metering Credit value over 25 years: NIS 122,850.00

Payback period = 4.27 years

PV installation



The optimal tilt angle of the modules will depend on the latitude. In countries of medium latitude like Germany or the UK, a simple formula of d = 3w (where d is the distance between rows and w is the width of a module) at an optimal tilt angle of 30° can be applied.



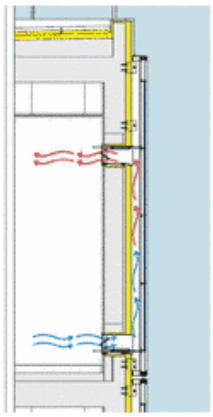
Building integrated PV

- A Building Integrated Photovoltaic (BIPV) system consists of integrating photovoltaic modules into the building envelope, such as the roof or the façade.
- It is simultaneously serving as building envelope material and power generator, BIPV systems can provide savings in materials and electricity costs,
- reduce use of fossil fuels and emission of ozone depleting gases, and add architectural interest to the building

Building Integrated PV (BIPV)

Shading

Envelope



Roof

Solar thermal / hot water

DOE/NREL, Alan Ford

Used to heat residential, commercial or industrial water supplies as well as space heating and pools.

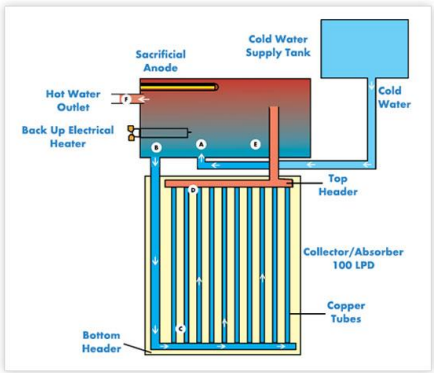
A collector - typically fastened to a roof or a wall facing the sun – is used to heat an anti-freeze solution that is either pumped (active system) or driven by natural convection (passive system) through it.

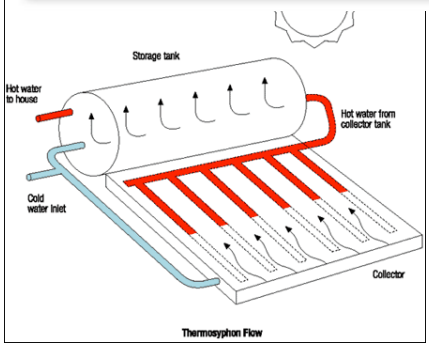
Solar thermal: Solar air heater

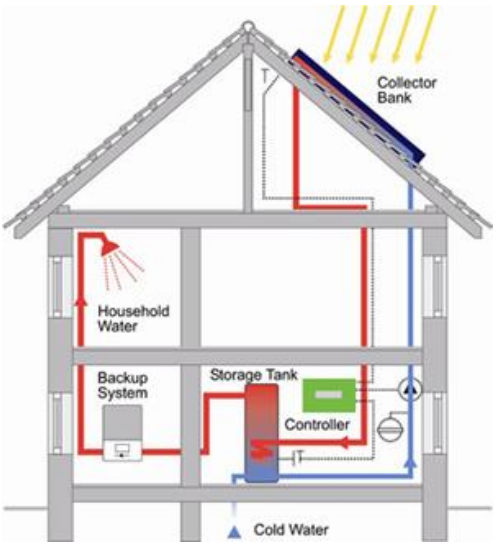
Energy from the sun is captured by an absorbing medium and used to heat air.

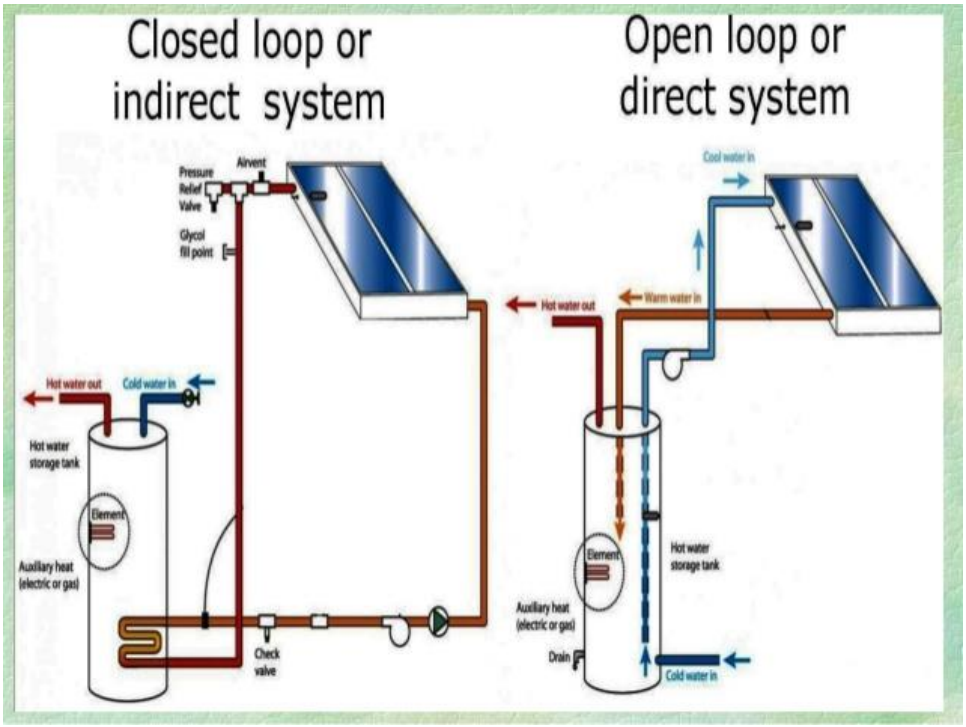
Works like a greenhouse by circulating air from inside a home through the system mounted on the exterior wall.

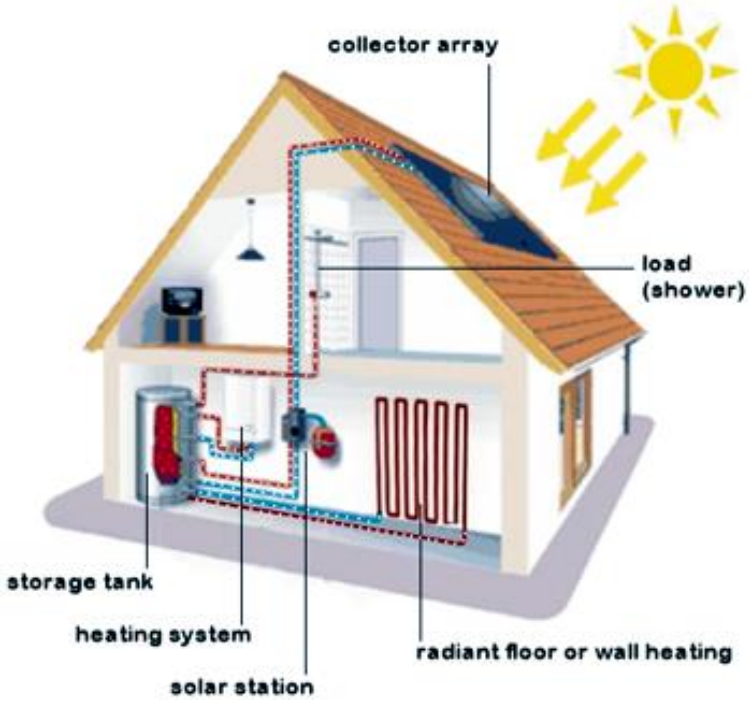

Toughened Glass
Glass layerage
Alumimum Alloy Frame
Galvanization sheet iron
Absorptire material
Frame heat preservation
Bottom heat preservation
Collect and Divide water pipe
www.sunline.com.cn


Sacrificial Anode
Cold Water Supply Tank
Hot Water Outlet
Cold Water
Back Up Electrical Heater
Top Header
Collector/Absorber 100 LPD
Copper Tubes
Bottom Header


Storage tank
Hot water to house
Hot water from collector tank
Cold water inlet
Collector
Thermosyphon Flow


Collector Bank
Household Water
Backup System
Storage Tank
Controller
Cold Water


Closed loop or indirect system
Open loop or direct system
Pressure Relief Valve
Airvent
Glycol fill point
Hot water out
Cold water in
Hot water storage tank
Element
Auxiliary heat (electric or gas)
Check valve
Cool water in
Hot water out
Warm water in
Element
Hot water storage tank
Auxiliary heat (electric or gas)
Drain
Cold water in

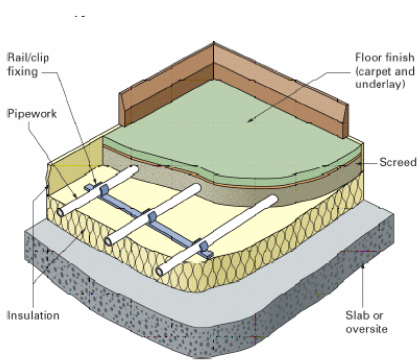

collector array
load (shower)
storage tank
heating system
solar station
radiant floor or wall heating

System components

The major components of an underfloor heating system are:

- The heat source – A boiler or heat pump.
- Circulating pump – Standard domestic units.
- Flow and return manifolds – installed above the floor for access.

- Underfloor heating circuit pipework – typically 15mm to 22mm diameter 'plastic' **polybutylene** pipe with oxygen diffusion barrier.
- Insulation – below pipes in floor.



Typical Floor Construction

Under floor heating calculation

q = U value * (θF- θi)

θF = Floor temperature °C

θi = Room temperature °C

U value for air= 11.1 W/m2K

- ***Example:***

At a room temperature of 20° C and a floor temperature of 27° C a heat output of

q = 11.1 W/m² K * 7°K (27° C - 20° C) = 77.7 W/m² would be achieved.

Heat Output (W/m² floor area)	Spacing between pipes (mm)	Water temperature (°C) Flow						Floor surface temperature (°C)
140	250	54						32
	230	51						
	150	49						
125	250	51						31
	230	48	54					
	150	46	51					
110	250	48	52					29
	230	45	50	54				
	150	43	48	51				
95	250	45	49	53				28
	230	42	46	50	55			
	150	40	44	48	52			
80	250	41	45	48	52			27
	230	39	42	45	49			
	150	37	41	43	47			
65	250	39	42	43	47	55		26
	230	36	39	41	45	52		
	150	35	38	39	43	50		
50	250	36	38	40	43	48	54	24
	230	34	36	37	40	46	51	
	150	32	34	36	38	44	49	

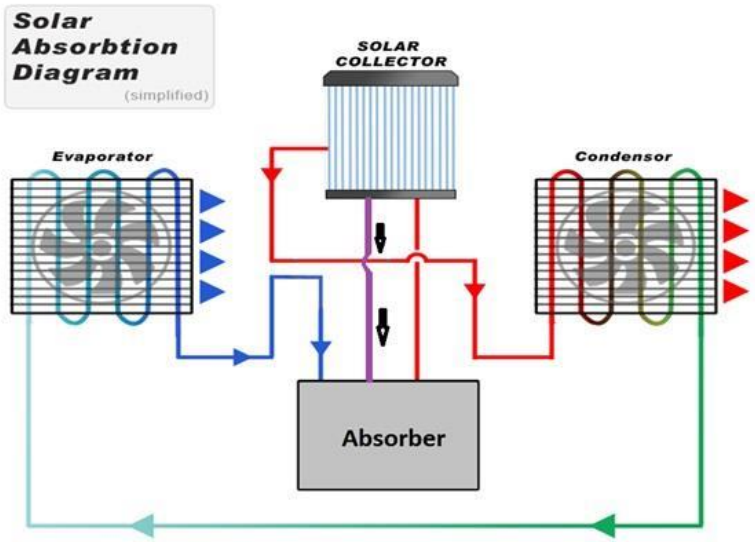
Advantages

- **Hidden** from view.
- **Even heat** distribution over the whole room area.
- Useful in rooms where there is **little wall space** available for radiators e.g. Schools.
- Useful for rooms that are periodically **wet** since they dry out quickly e.g. Changing rooms, shower rooms.
- Useful for rooms where a **warm floor** is an advantage e.g. Primary schools, Kindergarten schools.
- Hygienic since there is no place for dust and dirt to be trapped.

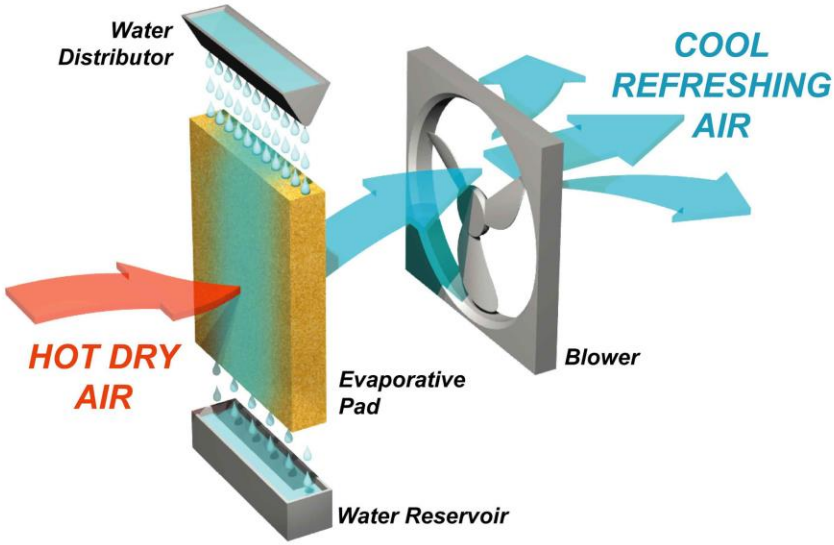
Disadvantages

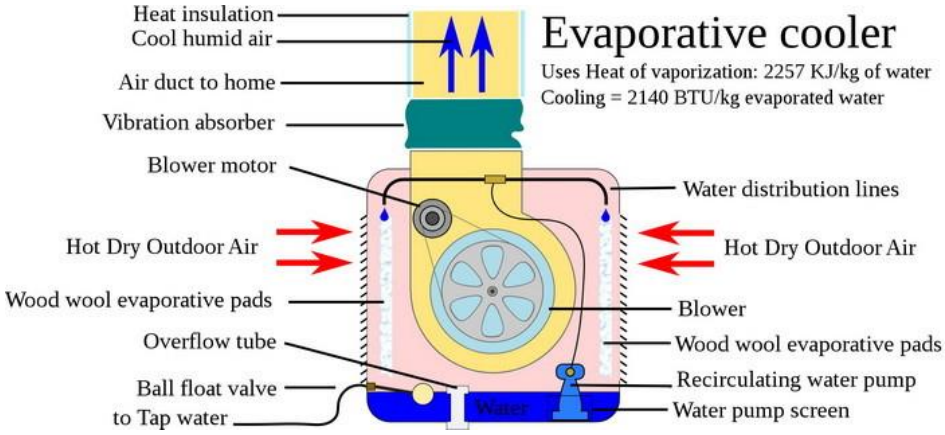
- **Slow heat** up and **Slow response** to changes in controls.
- **Leaks** are difficult to find.
- Can be **slightly more expensive** to install compared to radiators.
- Can be **more expensive** to run if not controlled adequately.
- During construction the pipes may need to be protected if heavy traffic could damage pipes.

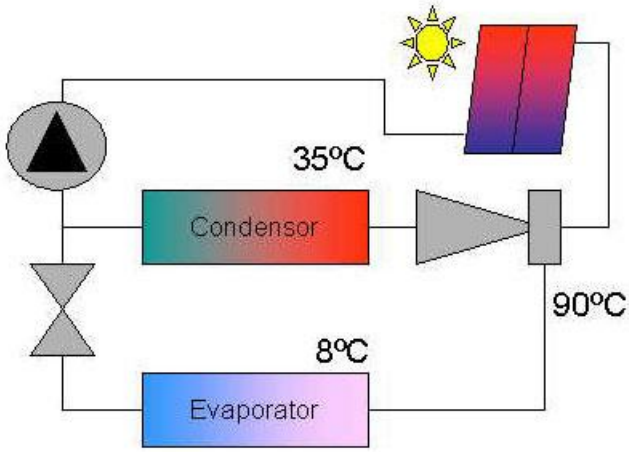
Solar cooling



How **EVAPORATIVE COOLING** works






35°C
Condensor
90°C
8°C
Evaporator