Solar Water Pumping Basics and Terminology

Everything You Need to Know about Solar Water Pumping

Where do solar pumping systems work?

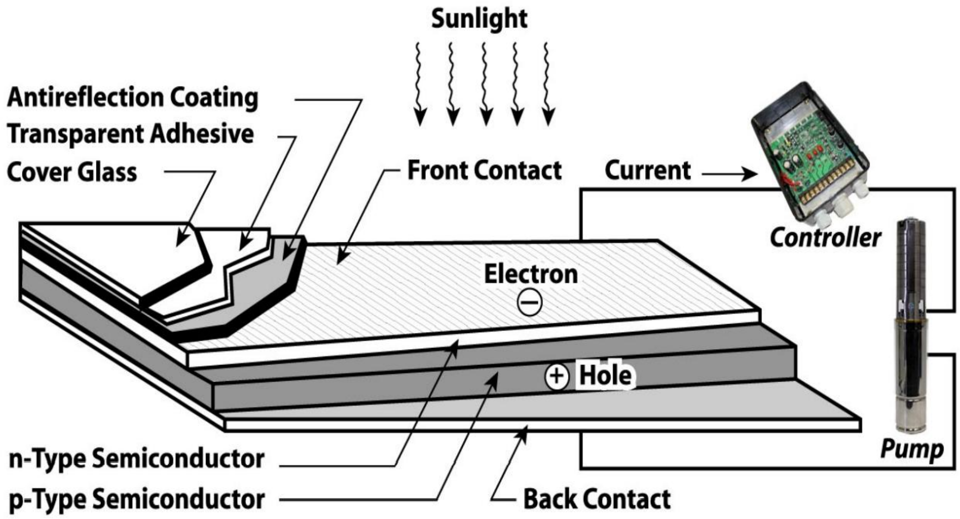
Solar pumping systems work anywhere the sun shines. The majority of the continental U.S. enjoys plenty of sun to operate a pumping system economically. The intensity of light varies greatly throughout the day. Morning and afternoon sunlight is less intense because it is entering the earth's atmosphere at a high angle and passing through a greater cross section of atmosphere, which reflects and absorbs a portion of the light.

We measure sun intensity in equivalent full sun hours. One hour of full sun is roughly equivalent to the sunlight on a clear summer day at noon. The sunlight or insolation levels also vary seasonally. Fortunately, most needs for water correspond with the sunniest seasons of the year – spring, summer and fall. Small to medium solar electric pumping systems are easily portable. By mounting the solar system on an axle or trailer, a system can be moved from well to well. This increases the economic return of a system by increasing the seasons of use. It may also correspond with the rotation of grazing areas.

Solar power and water pumping are a natural fit. Generally, water is needed most when the sun is shining at its brightest. Solar modules generate maximum power in full sun conditions when we typically need larger quantities of water. Because of this "sun synchronous" matching, solar is an economic choice over windmills and engine driven generators for most locations where utility power is non-existent. Owners of solar water pumping systems enjoy a reliable power system that requires no fuel and very little attention

How does the sun power a pump?

The photovoltaic effect produces a flow of electrons. Electrons are excited by particles of light and find the attached electrical circuit the easiest path to travel from one side of the solar cell to the other. Envision a piece of metal such as the side panel of a car. As it sits in the sun, the metal warms. This warming is caused by the exciting of electrons, bouncing back and forth, creating friction, and therefore, heat. The solar cell merely takes a percentage of these electrons and directs them to flow in a path. This flow of electrons is, by definition, electricity. Photovoltaics or solar electric cells convert sunlight directly into electricity. This electricity is collected by the wiring in the module, then supplied to the DC pump controller and motor, which, in turn pumps water whenever the sun shines. At night, or in heavy cloud conditions, electrical production and pumping ceases.



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The Economics of Solar Water Pumping

The economy and reliability of solar electric power make it an excellent choice for remote water pumping. Cattle ranchers in the Western U.S., Canada, Mexico, and Australia are enthusiastic solar pump users. Their water sources are spread over many miles of rangeland where power lines are few and refueling and maintenance costs are substantial.

Dankoff Solar Booster Pump

If your water source is 1/3 mile or more from the powerline, solar is a favorable economic choice. This fact is reinforced by a number of Rural Electric Co-Operatives across the U.S. These Co-Ops actively advocate the use of solar pumps, as the cost to extend new lines is subsidized by other rate payers. A solar pump minimizes future costs and uncertainties. The fuel is free. Moving parts are reduced to as few as one. A few spare parts can assure you many years of reliable water supply at near-zero operating costs.

Fixed vs Tracking Mount Structure:

Fixed Mount structures are less expensive and tolerate higher wind loading. By fixing the modules due south, less water is pumped than a tracking system which orients the modules towards the sun as it arcs across the southern sky.

Tracking mount structures keep the modules at a 90 degree angle to the sun all day long. This provides more power to the pump over a longer period of the day, which produces 20 to 40 percent more water daily in the summertime.

Are Solar Trackers and Water Pumping a good match?

Not necessarily. While utilizing a tracker will increase your total energy output by 20%- 40% (depending on season, location, and sun conditions), the cost of a tracker can be high. As most solar pumping systems feature one to four solar panels, buying extra panels can have a bigger effect on your output than adding a tracker, and additionally, may be a more economical solution. Dankoff Solar believes adding trackers to a simple water pumping system simply adds more moving parts, which will only complicate both the installation, and could affect the performance of your system. Generally, we use a fixed mount structure and can add additional solar panels as needed.

Solar Array Placement and Mounting

Solar modules should be located in a sunny spot where no shading occurs. Even shadows from a tree limb, tall grass, or fence rails can substantially reduce power output. For these reasons we typically mount the solar modules on a pole or ground mount above any obstacles. Remember the solar array can be placed some distance from the water source if shading is a problem. Wire size can be increased to compensate for longer cable runs and the associated voltage drop.

Water Storage is Efficient and Effective:

Storing water in a good sized cistern or stock tank has many advantages. It is less expensive and more efficient than storing energy in batteries, giving your system a flywheel effect over cloudy days and letting the pump work at a slower continuous pace over the day. As a rule of thumb, the tank should be able to store 3 to 5 days of water. Generally speaking, animals, plants and humans use less water on cloudy days. Conversely, the sunniest days are when we consume the most water and when the solar modules are providing the pump with the most power.

Windmills: Yesterday's Answer to Remote Water Delivery:

There are still thousands of windmill water pumping units standing in the western U.S. Regrettably, many are inoperable. These pumpers were very valuable for remote (off grid) sites, with the proper minimum wind conditions, when manpower was plentiful and cheap. Windmills, though potentially long lasting, need dedicated maintenance.
The downhole leathers require inspection and high winds can cause mechanical damage to the blades. Parts for these mills are expensive and sometimes difficult to locate.

Solar water pumping systems have many advantages over windmill water pumps. Though the initial cost of solar powered systems can be similar to that of a windmill (however, in many cases far less) the lifetime costs are much lower. Windmills must be used where there is a steady, constant wind for maximum results while solar pumps operate anywhere the sun shines. Solar pumping systems can be installed in less than a day by an individual or small crew and can be portable, while windmills (because of the need to erect a tower) can take a larger crew a much longer time to install.

Solar powered water pumping systems are the modern day upgraded version of the windmill which uses natural resources to deliver water in off-the-grid locations.

Why doesn't Dankoff Solar recommend battery systems?
While batteries may seem like a good idea, they have a number of disadvantages in pumping systems. They reduce the efficiency of the overall system. The solar modules operating voltage is dictated by the battery bank and is reduced substantially from levels which are achieved by operating the pump directly. Batteries also require additional maintenance and under and overcharge protection circuitry which adds to the cost and complexity of a given system. For these reasons, only about five percent of solar pumping systems employ a battery bank.

Long Term Cost-Benefit Analysis: Solar or Generator Powered Pumping Systems?
Generators are commonly used to provide power in areas where there is no power grid. There are numerous studies regarding the economics of solar power versus gas/diesel generators as a power choice. These studies consider all costs involved: the modules, mounting racks, pumps, various components, installation, fuel, maintenance, yearly inspections, component replacements, and even salvage value. The purpose of these studies is to determine a life cycle cost as well as a present value of the pumping system.

One such comparison was done by the Bureau of Land Management at Battle Mountain, Nevada specifically regarding solar water pumping systems. For a 3.8 gallon per minute system with a 275 ft design head, the solar system cost only 64% as much over a 20 year period as the generator system did over a 10 year period. The remote solar system also used only 14% as many labor hours as did the generator powered system. In 1989, Sandia National Laboratories noted that solar pumping systems in remote locations would often be cost effective compared to generators, even with the upfront costs being as much as 500% higher than a generator powered system. Low end generators, which are initially inexpensive, require consistent maintenance and only have a design life of around 1,500 hours.

Small to medium sized solar pumping systems will often cost less initially than a durable slow speed engine driven generator. Most larger scale solar pumping systems initially bear a higher cost than generator systems, but the solar systems are far more economical in the end.

How does solar powered pumping compare to AC generators and windmills?

System Type	Advantages	Disadvantages
Solar Electric Powered System	• Low maintenance • Clean • No fuel needed • Easy to install • Relatively high initial cost • Reliable long life • Lower output in cloudy weather • Unattended operation • Low recurrent costs • System is modular and can be matched closely to need	• Relatively high initial cost • Lower output in cloudy weather
Diesel (or petrol) powered systems	• Moderate capital costs • Portability • Extensive experience available • Easy to install	• Needs maintenance and eventual • Maintenance often inadequate, reducing its life • Fuel costs are on the rise • Noise, dirt and fumes problem • Site visits necessary
Windmill	• Potentially long lasting • Works well in a windy state	• High maintenance • Costly repairs needed • Difficulty in locating parts • Seasonal disadvantages • Requires special tools to work on • Labor intensive • No wind = No power = No water

Common Rancher Concerns:
With cattle prices fluctuating frequently and being difficult to forecast, the cost of getting water to the cattle has become one of a rancher's main monetary concerns. Every dollar wasted on an inefficient watering system is a dollar of profit out of the rancher's pocket. When faced with a need for a new watering system, or simply to repair an old system, the natural thought is to look at the option with lowest initial cost, but this does not always translate to being the most cost effective option in the long run. A wise rancher will not only look at the initial cost, but will also consider the long term costs along with the reliability of the pumping system. Efficient watering systems can help boost the rancher's profits in subsequent years, and often times a solar pumping system will pay for itself in the first 2-3 years of use.

What is Total Dynamic Head and how can I calculate it?

Total Dynamic Head (TDH) is a very important factor in system design. TDH is essentially the effective pressure against which the pumping system must operate. TDH is generally measured in meters or feet, and is the sum of three factors, total vertical lift, friction loss and tank pressure.

1) Total Vertical Lift

Total vertical lift is the sum of the static water level, drawdown and elevation. The static water level (SWL), again measured in meters or feet, is the distance from the top of the well to the surface of the water level within the well while no water is being pumped (See Figure on next page). The static water level is also commonly referred to as the "static water level". Drawdown is essentially the drop in water level, measured in meters or feet, which results from pumping water from the well. Depending on the well, the drawdown may be 3 to 50 feet (1 to 15 meters) or greater. Slower producing wells will have a greater drawdown than a faster producing well. Drawdown is also directly related to the flow rate of the pumping system, meaning the faster the water is pumped, the more feet (or meters) of drawdown you will experience. Typically, the standing water level and drawdown can be measured by the well drilling company or by testing your existing well. Elevation simply is the number of feet of vertical rise from the well to the ultimate delivery point (i.e. storage tank).

2) Friction Loss

The friction loss, measured in meters or feet, is the pressure required to overcome friction in the pipes from the pump to point of use. The friction is dependent on several factors such as the length diameter and type of piping used, as well as the number of pipe fittings used. The greater the rate of flow, the greater the amount of friction loss. See Tables 2-5 for more in depth information regarding friction loss calculations.

3) Tank Pressure

Tank pressure, again measured in meters or feet, is the operating pressure of the storage tank. Solar pumping systems typically utilize large storage tanks, as the entire day's water is being pumped over a 5 to 6 hour period of peak sun. Rarely will these storage tanks be pressurized, however, systems running with battery power can be used to pump into a pressurized storage tank. For most typical storage systems with no pressurized tank, the tank pressure will be zero.

Therefore,

TOTAL DYNAMIC HEAD = TOTAL VERTICAL LIFT + FRICTION LOSS + TANK PRESSURE TOTAL VERTICAL LIFT

To calculate the TDH for your system, we recommend utilizing the sketch and worksheet on the following pages. The worksheet will assist you in calculating total vertical lift, drawdown and tank pressure.

What is Friction Loss and how can I calculate it?

In most cases, calculation of friction loss can be simplified. Assuming your storage tank is located fairly close to your well head, 10 meters (30 feet) or less, and assuming the recommended pipe sizes are used, a very simple rule can be followed. In these instances, friction loss will be very close to 5% of the total vertical lift. This will allow for a few straight runs of pipe and use of minimal pipe fittings.

In cases where the storage tank will be located further from the well, more accurate calculations must be used. Friction loss is affected by the length of the piping, the number of fittings used, the number of turns in your piping, the diameter of the piping as well as the rate of flow through the piping. Unless a battery backup system is used (which we do not recommend), your solar pumping system will only pump during the 5-6 peak sun hours. Logic follows that cloudy, hazy, or otherwise overcast days can diminish the performance of the pumping system. With the flow rate varying from one day to the next, or even throughout the day during varying levels of sunlight, the flow rate has to estimated.

Use the following formulas for reference in estimating a flow rate:

U.S. flow rate - GPM (Gallons Per Minute) = GPD / 300
Metric flow rate - LPM (Liters Per Minute) = LPD / 300

Example: Assume you calculated your daily watering requirement to be 3,000 GPD. By dividing your daily water requirement of 3,000 gallons by 300, you get an average flow rate of 10 GPM.

3,000 / 300 = 10 Gallons Per Minute

After estimating your average flow rate, calculate the friction loss by adding the length of all piping used in the system. Next you will count all of the fittings used in your piping design and refer to tables 2 and 3 on the following pages to calculate the total length of the fittings used. After adding the length of pipe to the length of fittings, you now effectively have the total length water will travel through your piping. The last step is to find the appropriate decimal in figure 4 or 5 (depending on whether you use the English or metric system of measurement). Take this ratio from the figure and multiply it by your total length of pipes and fittings to get the total frictions loss.

Example: You have a system with 400 feet total of pipe lengths and fittings and an average flow rate calculated of 5 GPM. Assuming you are using 1” pipe, table 5 gives you a ratio of 0.018.

400’ of total pipe and fittings x 0.018 = 7.2’ of total friction loss

What is tank pressure and how can I calculate it?
Tank pressure is specified from other system needs. When a pressurized tank is used, convert the cutoff pressure to meters or feet of head. If water is allowed to flow freely into the storage tank, then the pressure tank value will be zero. To convert pressure to its equivalent head in meters or feet, use the following formulas:

US: HEAD (in feet) = PRESSURE (psi) x 2.31
METRIC: HEAD (in meters) = PRESSURE (kPa) x 0.102

Worksheet #1 – Total Dynamic Head

CALCULATING TOTAL VERTICAL LIFT:

Standing Water Level	Line 1	____________
Drawdown	Line 2	____________
Elevation	Line 3	____________
TOTAL VERTICAL LIFT (add lines 1 - 3)	Line 4	____________

CALCULATING FRICTION LOSS:

Simplified method (see previous page):		
TOTAL FRICTION LOSS (multiply line 4 by 0.05)	Line 5	____________
Calculated Method, tank is far from well (see previous page):		
Total length of pipes	Line 6	____________
Total length of all fittings (use Figure 2 or 3)	Line 7	____________
Total length of pipes and fittings (add lines 6 & 7)	Line 8	____________
Total Daily Output	Line 9	____________
Rate of flow (divide Line 9 by 300)	Line 10	____________
Friction loss factor (from Table 4 or 5)	Line 11	____________
TOTAL FRICTION LOSS (multiply Lines 8 & 11)	Line 12	____________

CALCULATING TOTAL DYNAMIC HEAD:

TOTAL VERTICAL LIFT (enter Line 4)	Line 13	____________
TOTAL FRICTION LOSS (enter Line 5 or Line 12)	Line 14	____________
TANK PRESSURE (in meters or feet of head)	Line 15	____________
TOTAL DYNAMIC HEAD (add Lines 13-15)	Line 16	____________

Figure 1 is a detailed diagram of a hypothetical pumping application. If you use the numbers from Figure 1 in Worksheet 1 to the left, you should calculate a Total Dynamic Head of approximately 92.75'.

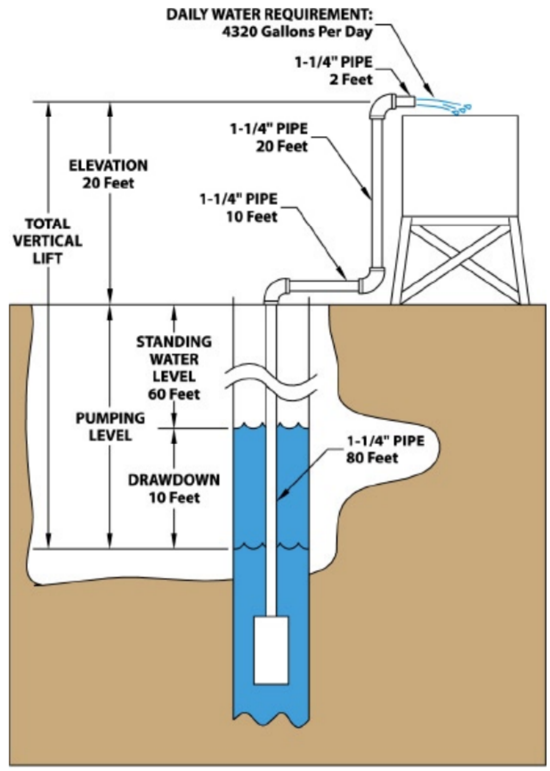


FIGURE 1

Table 2 – Friction Loss for fittings in equivalent meters

Type of fitting and application	Diameter of Pipe fitting					
	1/2"	3/4"	1"	1.25"	1.5"	2"
	Equivalent pipe length (in meters)					
Insert Coupling	0.9	0.9	0.9	0.9	0.9	0.9
Threaded Adapter (plastic to thread)	0.9	0.9	0.9	0.9	0.9	0.9
90° Standard Elbow	0.6	0.6	0.9	1.2	1.2	1.5
Standard Tee (Straight)	0.3	0.6	0.6	0.9	0.9	1.2
Standard Tee (90° Flow)	1.2	1.5	1.8	2.1	2.4	3.3
Gate Valve	0.3	0.3	0.3	0.3	0.6	0.6
Swing Check Valve	1.5	2.1	2.7	3.7	4.0	5.2

Table 3 – Friction Loss for fittings in equivalent meters

Type of fitting and application	Diameter of Pipe fitting					
	1/2"	3/4"	1"	1.25"	1.5"	2"
	Equivalent pipe length (in feet)					
Insert Coupling	3	3	3	3	3	3
Threaded Adapter (plastic to thread)	3	3	3	3	3	3
90° Standard Elbow	2	2	3	4	4	5
Standard Tee (Straight)	1	2	2	3	3	4
Standard Tee (90° Flow)	4	5	6	7	8	11
Gate Valve	1	1	1	1	2	2
Swing Check Valve	5	7	9	12	13	17

Table 4 – Friction Loss for Schedule 40 PVC Pipe – Meters

Flow in Liters per Minute	Diameter of the Pipe in millimeters					
	Loss in meters of head per one meter of pipe					
	15.8mm	20.9 mm	26.6 mm	35.1 mm	40.9 mm	52.5 mm
5	0.0058					
10	0.021	0.0053				
15	0.0044	0.011				
20	0.076	0.019	0.0057			
25	0.11	0.041	0.0086			
30	0.16	0.054	0.012			
35	0.21	0.069	0.016			
40		0.086	0.021	0.0055		
45		0.1	0.026	0.0069		
50		0.14	0.031	0.0084		
60		0.19	0.043	0.012		
70			0.058	0.016	0.0073	
80			0.74	0.02	0.0093	
90			0.092	0.025	0.012	
100			0.11	0.03	0.014	0.0047
125			0.17	0.046	0.021	0.0071
150				0.064	0.03	0.01
175				0.085	0.04	0.013
200				0.11	0.051	0.017
225				0.14	0.064	0.021
250				0.17	0.077	0.026

Table 5 - Friction Loss for Schedule 40 PVC Pipe – Feet

Flow in Liters per Minute	Diameter of the Pipe in millimeters					
	Loss in meters of head per one meter of pipe					
	1/2"	3/4"	1"	1.25"	1.5"	2"
5	0.041					
10	0.087	0.022				
15	0.148	0.037				
20	0.222	0.057	0.018			
25	0.312	0.08	0.025			
30	0.415	0.106	0.033			
35	0.53	0.135	0.042			
40	0.66	0.168	0.052			
45	0.805	0.204	0.063	0.017		
50		0.286	0.089	0.023		
60		0.38	0.118	0.031	0.014	
70		0.486	0.151	0.04	0.019	
80		0.605	0.228	0.06	0.028	
90			0.387	0.091	0.043	0.013
100				0.127	0.06	0.018
125				0.169	0.08	0.024
150				0.216	0.12	0.03
175				0.28	0.125	0.038
200					0.154	0.046
225					0.216	0.064
250					0.287	0.085

Estimating Your Daily Solar Insolation:
The daily output of a solar pumping system will vary dependent on the amount of direct sunlight striking the surface of the solar modules in your solar array. The more sunlight, the more power that is generate, which corresponds with increased water flow. The amount of sunlight a given geographic location will receive varies, due to weather conditions and seasonal climate changes. Additionally, your water usage patterns will vary throughout the year. The next several pages will contain “solar maps” (solar insolation charts,) which will aid you in estimating your solar insolation. These maps will provide you with a number S.H.O.T. (Sun Hours on Tilt) which is a measure of how many peak sun hours one can expect on average, for a given geographic location.

The first step is to determine the pattern of water usage. If your pumping application calls for a minimum amount of water each day (which most do), the system needs to be designed to provide adequate water in the months with the least solar insolation, which is generally the winter months. The solar maps reflected on the next several pages are provided for both June and December. Users requiring relatively stable amounts of water throughout the year should refer to the December maps if in the Northern Hemisphere, or the June map if in the Southern Hemisphere. Systems designed using these maps will provide the required volume of water in months where the least sunlight is available, while having the ability to produce more water than needed in the months with greater solar insolation.

If the application requires more water in the summer months than winter, then your system should be designed using the June map for those in the Northern Hemisphere, or the December map for those in the Southern Hemisphere. Systems designed with these maps will produce adequate water in both the summer and winter months. The assumption when using these maps is your solar array is positioned such that full exposure to the sun throughout the day is facilitated without obstruction (such as shade from trees or hills).

The angle at which your solar array is tilted towards the sun will also affect the energy produced. In order to produce the most energy, the solar array must be pointed directly at the sun with the rays of sunlight falling at a perpendicular angle from the surface of the solar array. The S.H.O.T. maps provide the optimal angle at which the array should be tilted for maximum energy production throughout the year. In fact, these maps are only accurate when the array is mounted at the angle specified on the map(s). If the angle of tilt is incorrect, the water production can be greatly reduced. Users in tropical areas, between +23° and -23° of latitude, should examine the maps from both June and December in estimating their solar insolation.

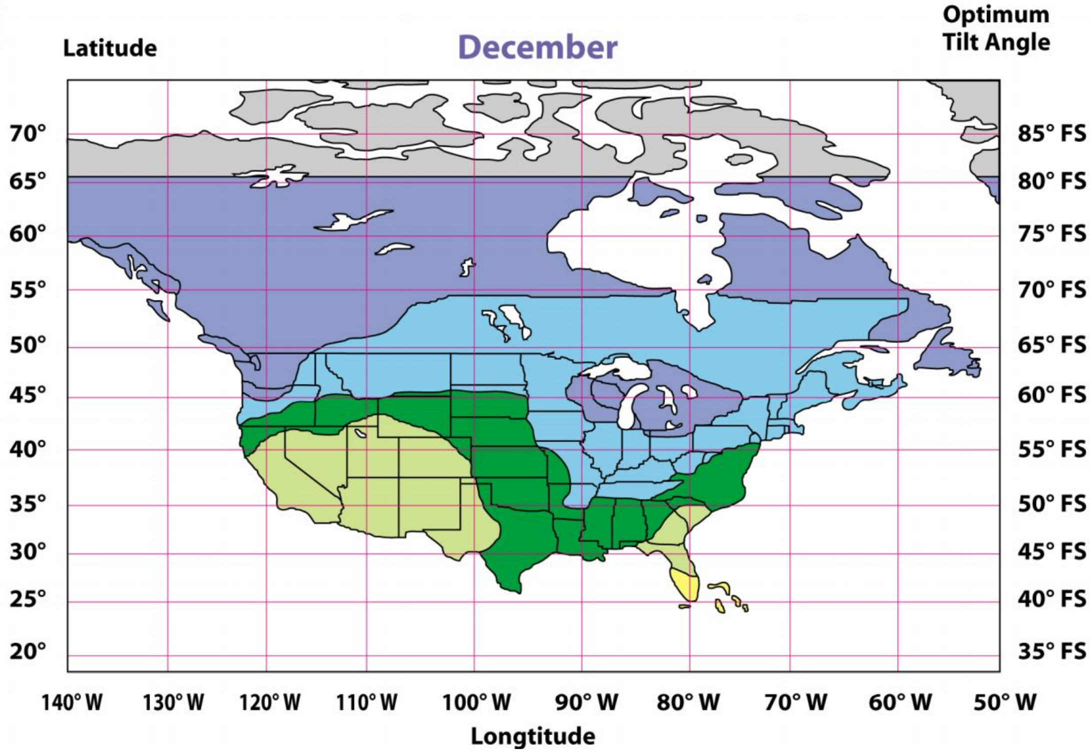
Additionally, the degree of tilt for users in tropical latitudes is of special concern, as the correlation between mounting angle and latitude are not exact. Solar arrays should not be mounted at angles of less than 15°, despite the fact the sun may be directly overhead. Arrays mounted at angles less than 15° from the horizon will over time become covered with dirt and debris, which will greatly affect the performance of your solar pumping system. Mounting your solar array at angles of 15° or greater ensures that rain and gravity will help keep the modules clean.

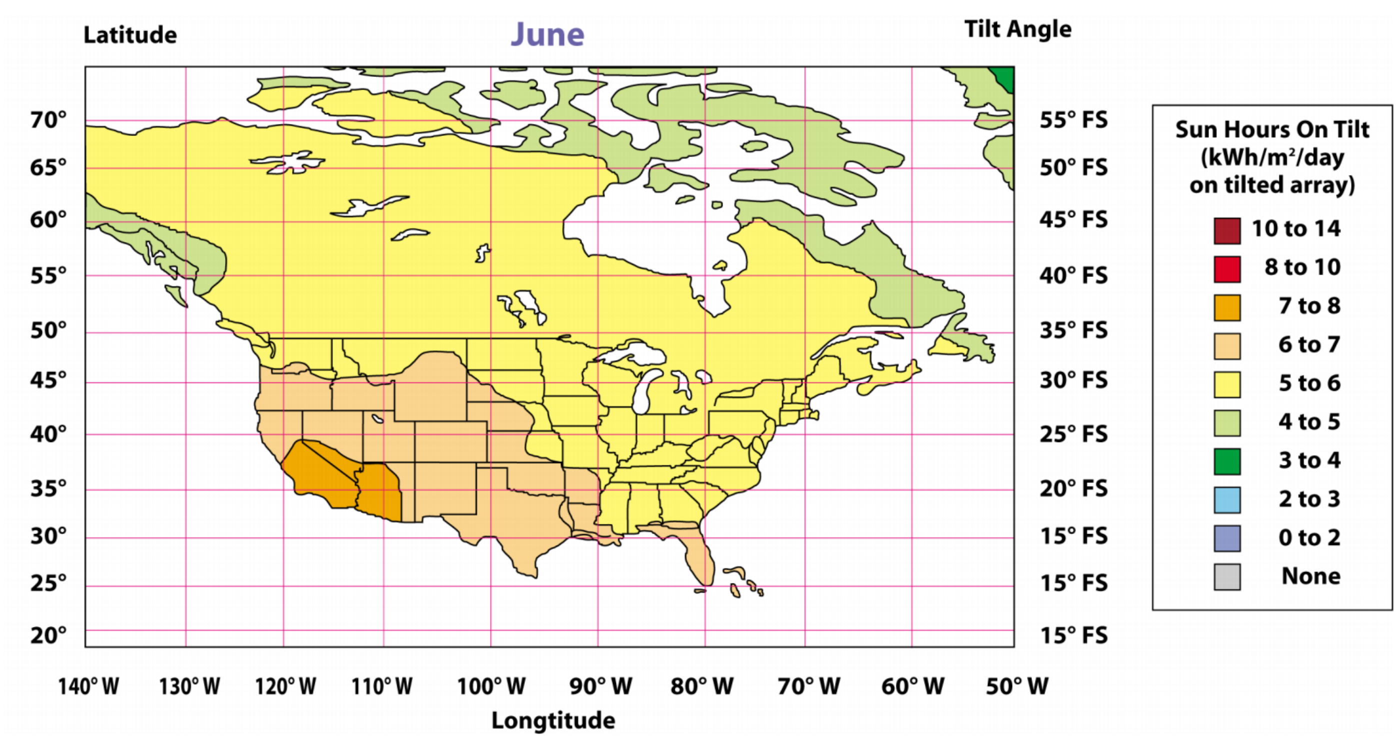
Lastly, make certain for customer in the Northern Hemisphere your solar array is tilted to the south, and vice versa for customers in the Southern Hemisphere.

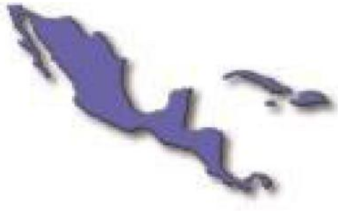
S.H.O.T. and Tilt Angle
To determine your solar resource, follow these steps:

1) Decide whether to design the system for winter or summer.
2) Find your location on the maps, be certain to use the appropriate map for winter in summer.
3) Locate your installation site on the correct map, which will give you the solar insolation figure (measured in sun hours)
4) Locate the latitude for your installation site and use this angle (minimum of 15°) to mount your solar array.

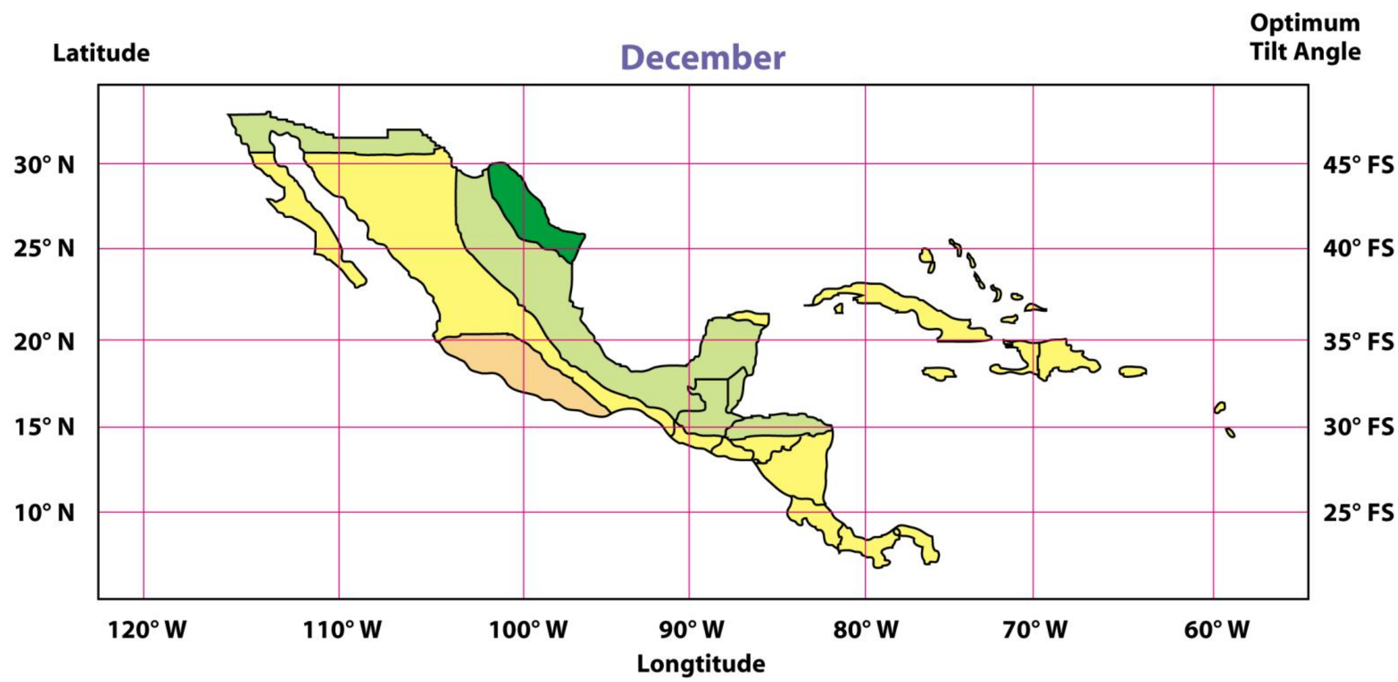
Canada and USA
Sun Hours On Tilt (S.H.O.T.)
Maps

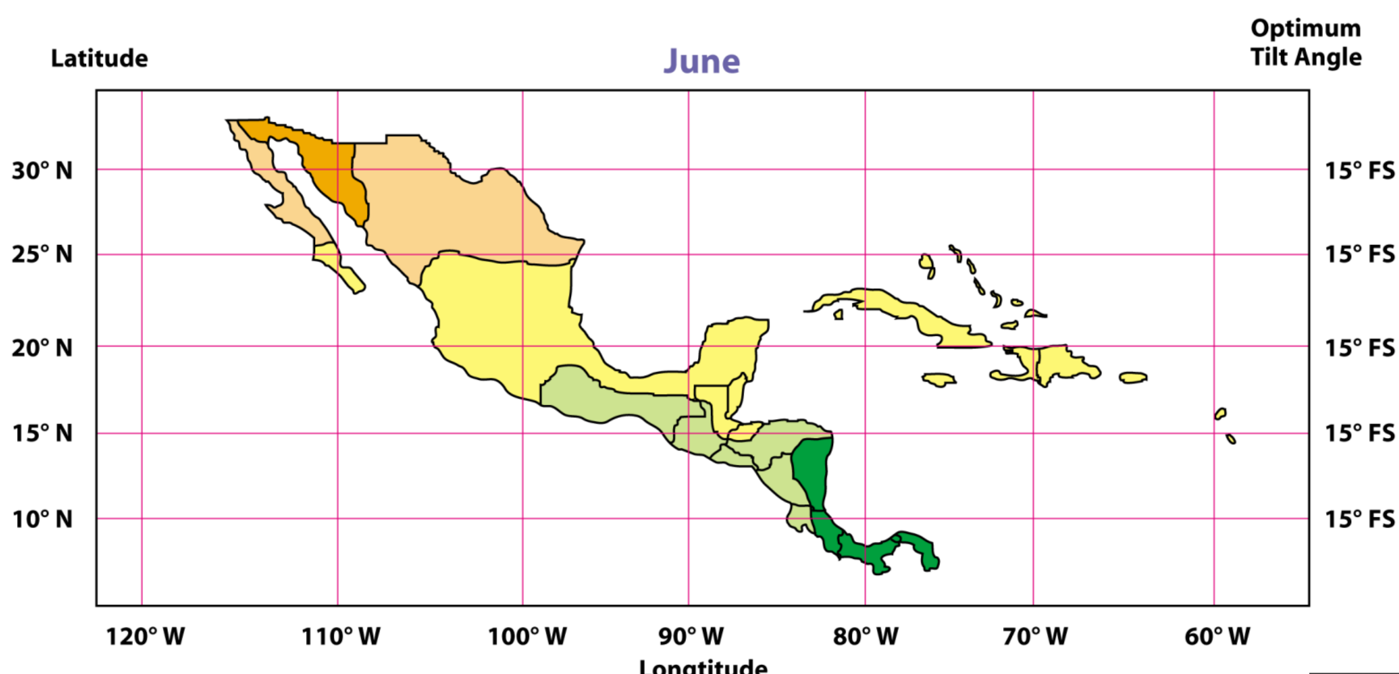






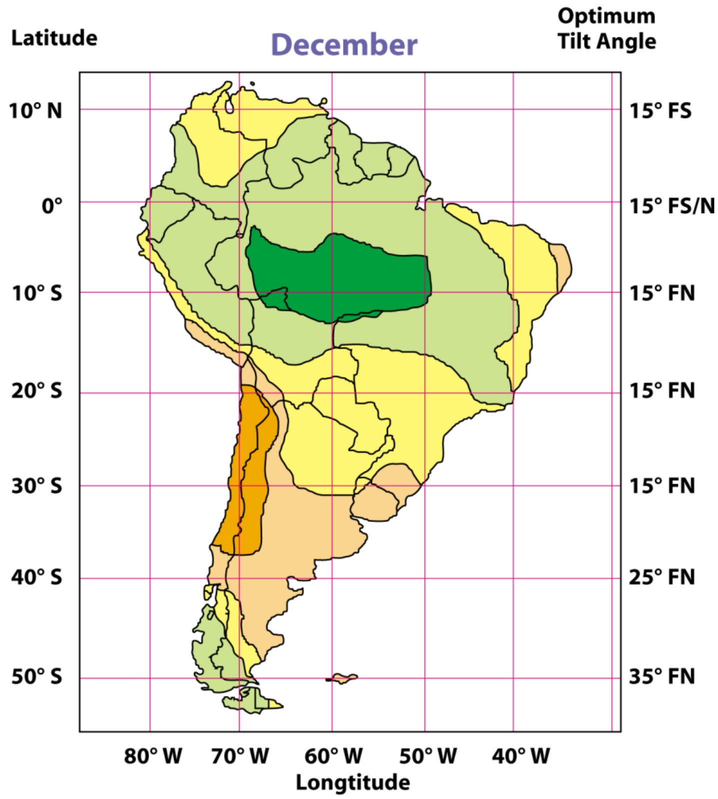
Mexico, Central America and Caribbean Nations Sun Hours On Tilt (S.H.O.T.) Maps

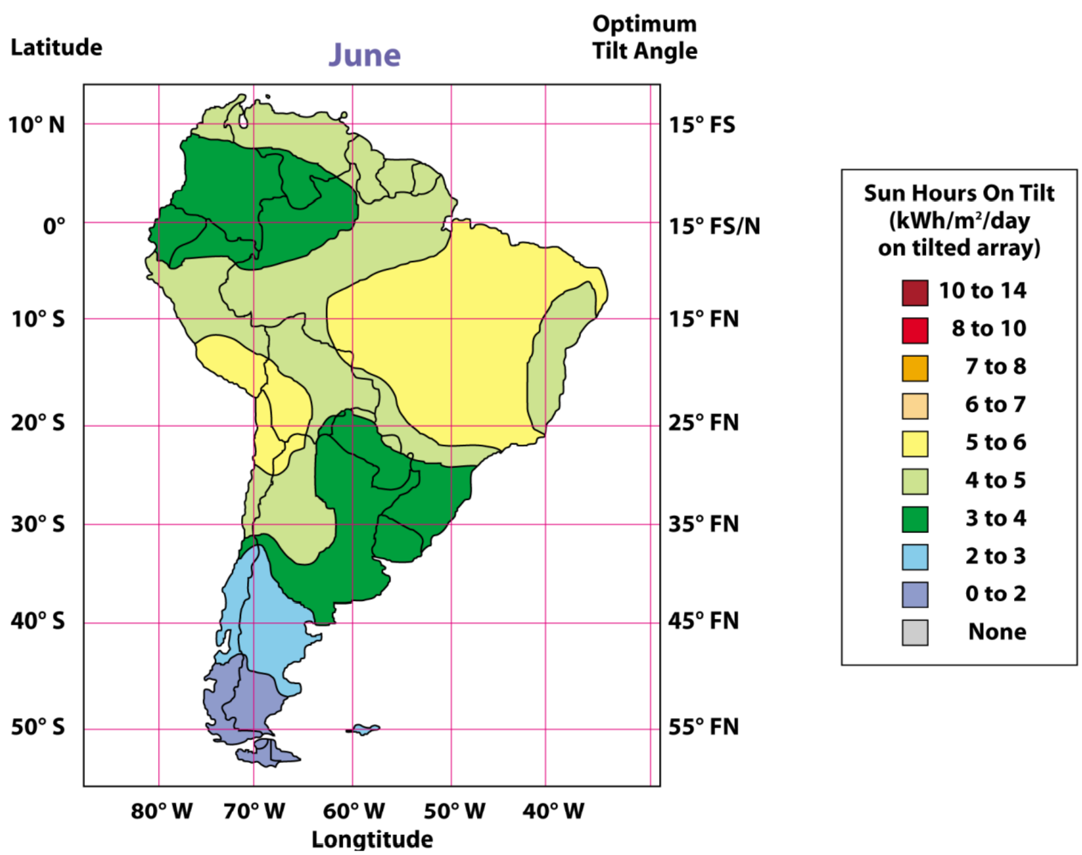




Latitude

South America Sun Hours On Tilt (S.H.O.T.) Maps





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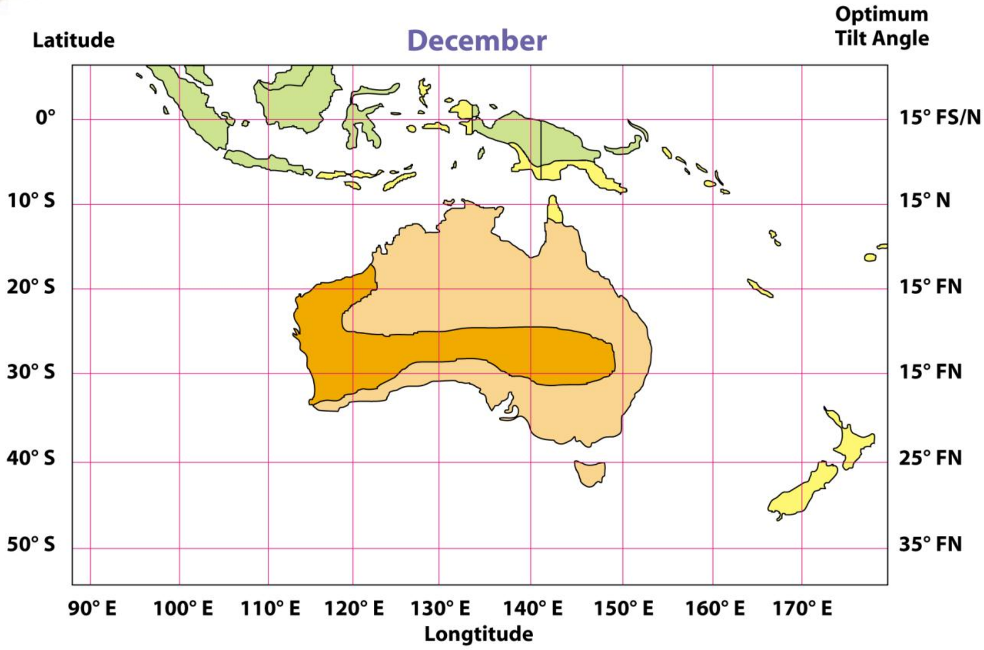
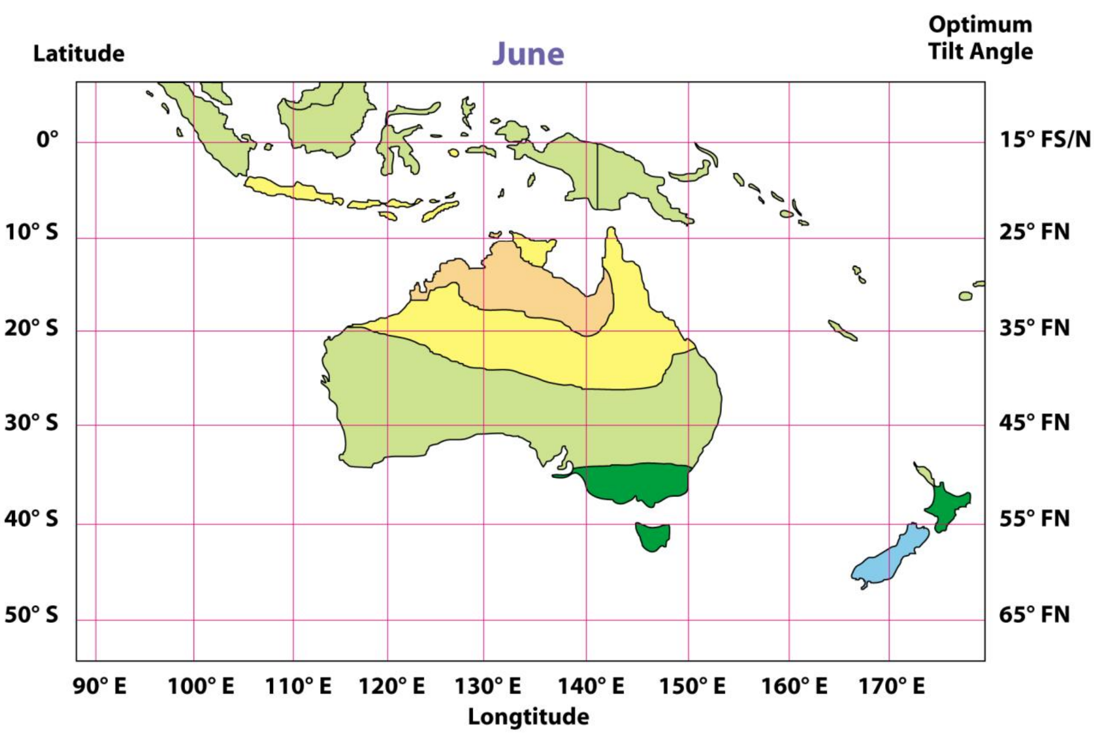
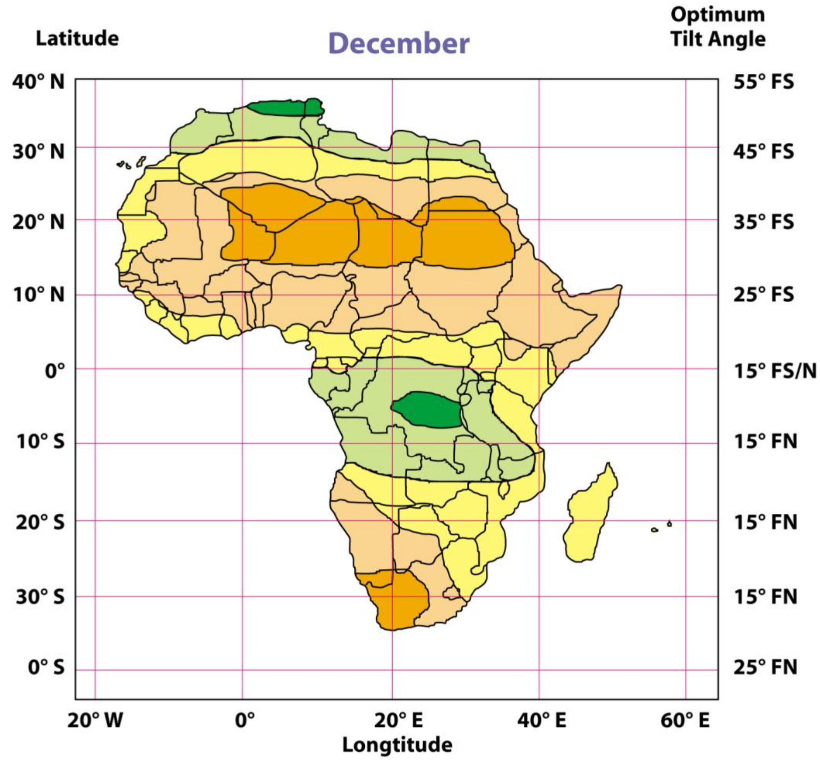
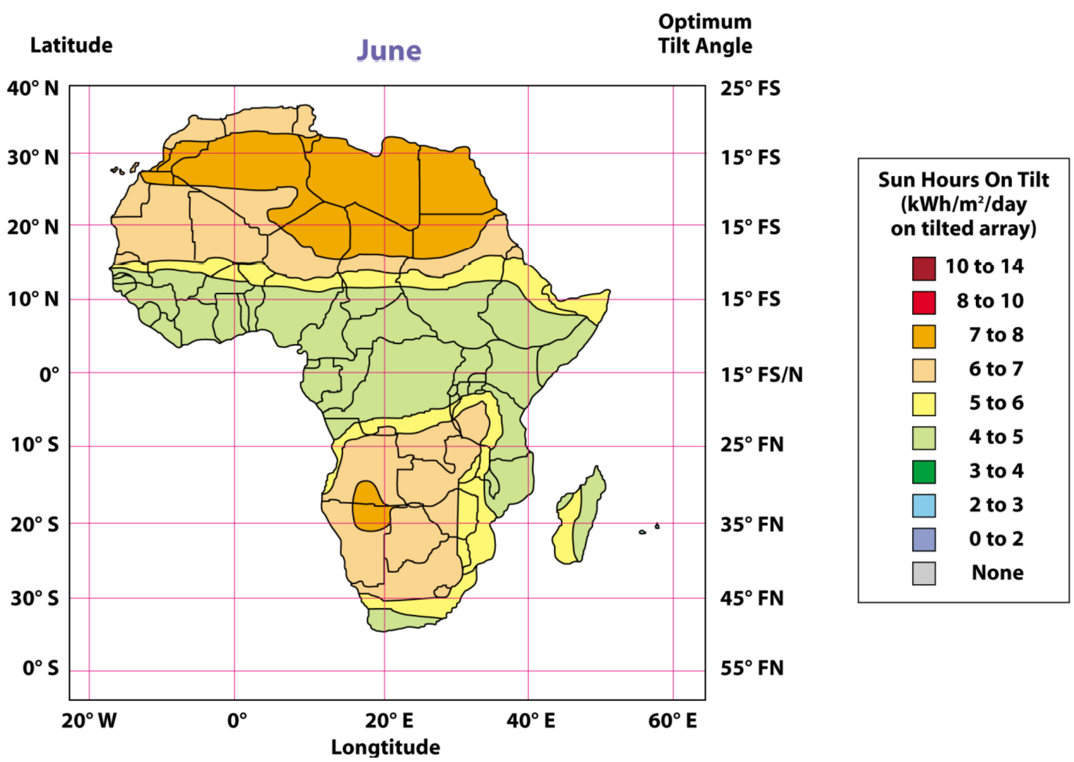
Australasia Sun Hours On Tilt (S.H.O.T.) Maps



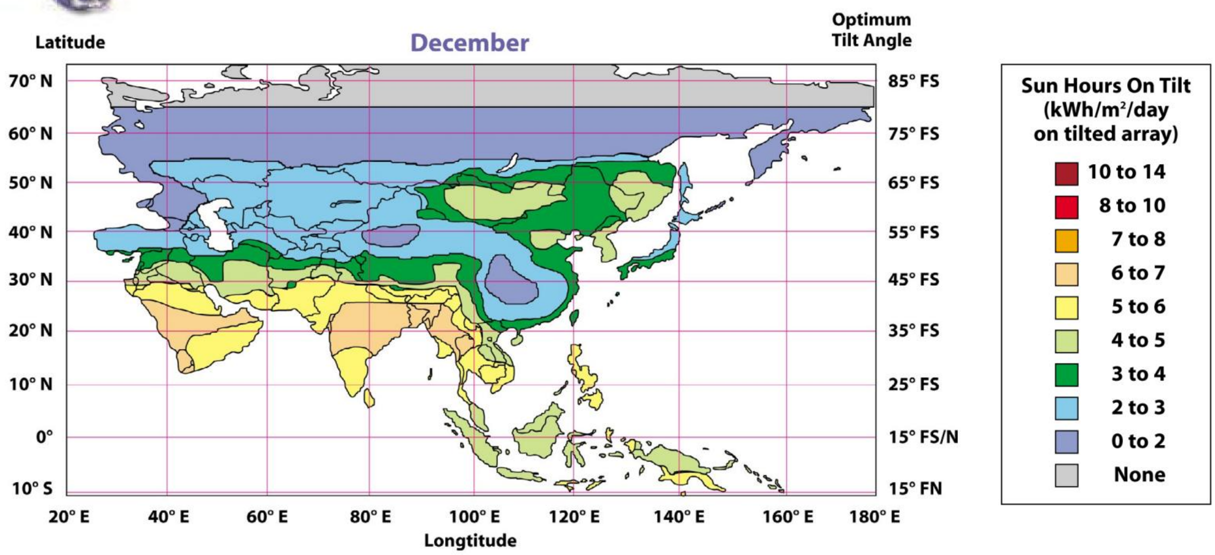


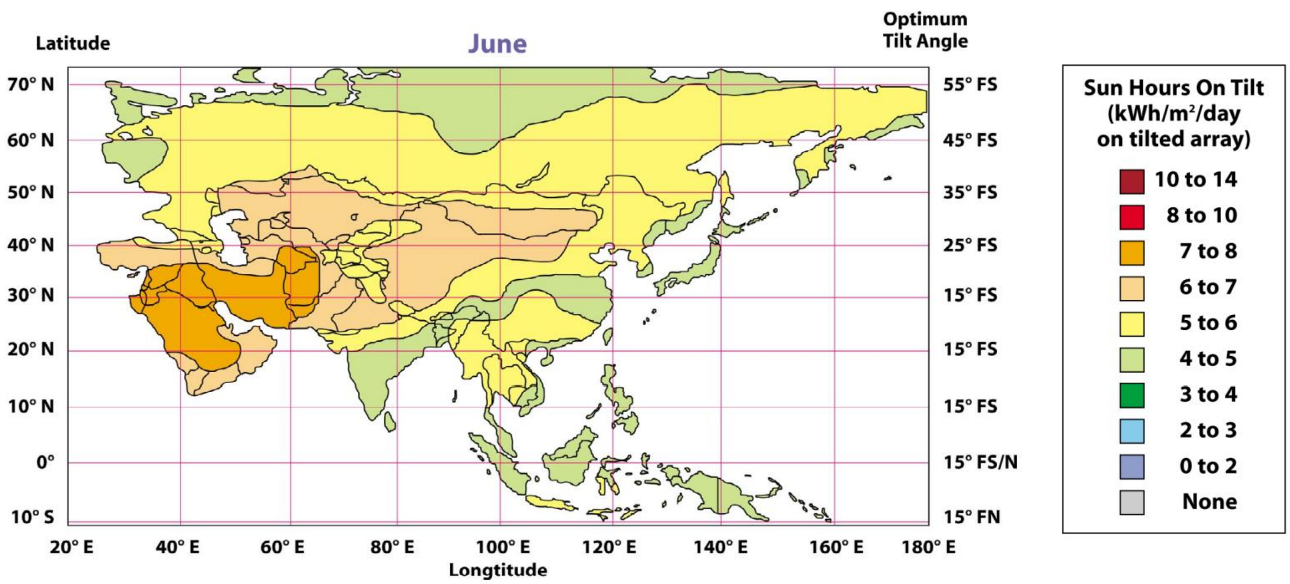
Africa Sun Hours On Tilt (S.H.O.T.) Maps



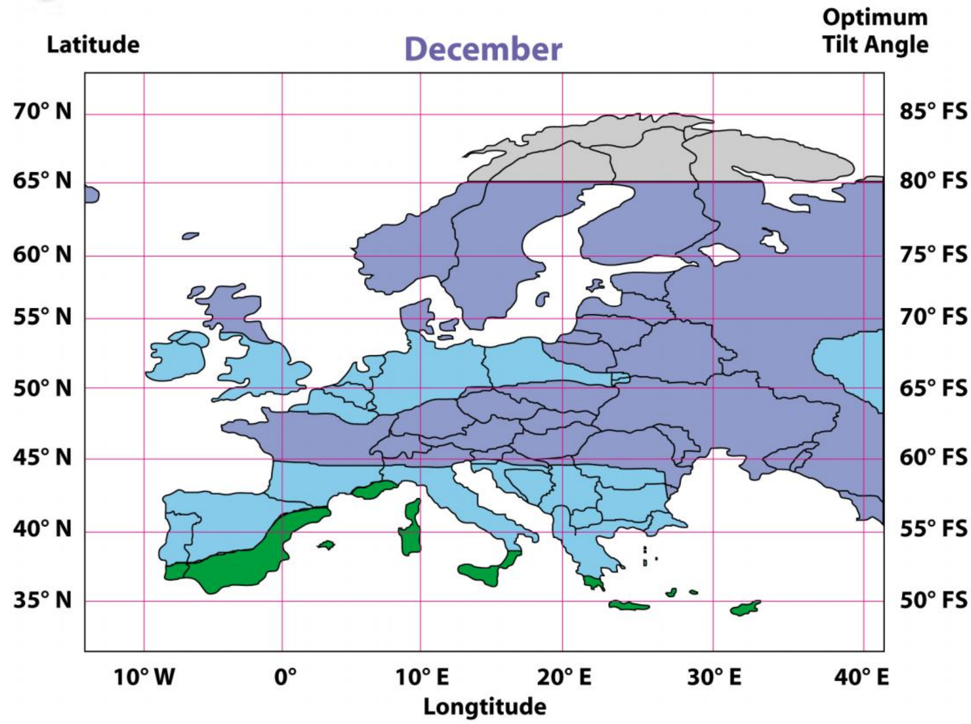


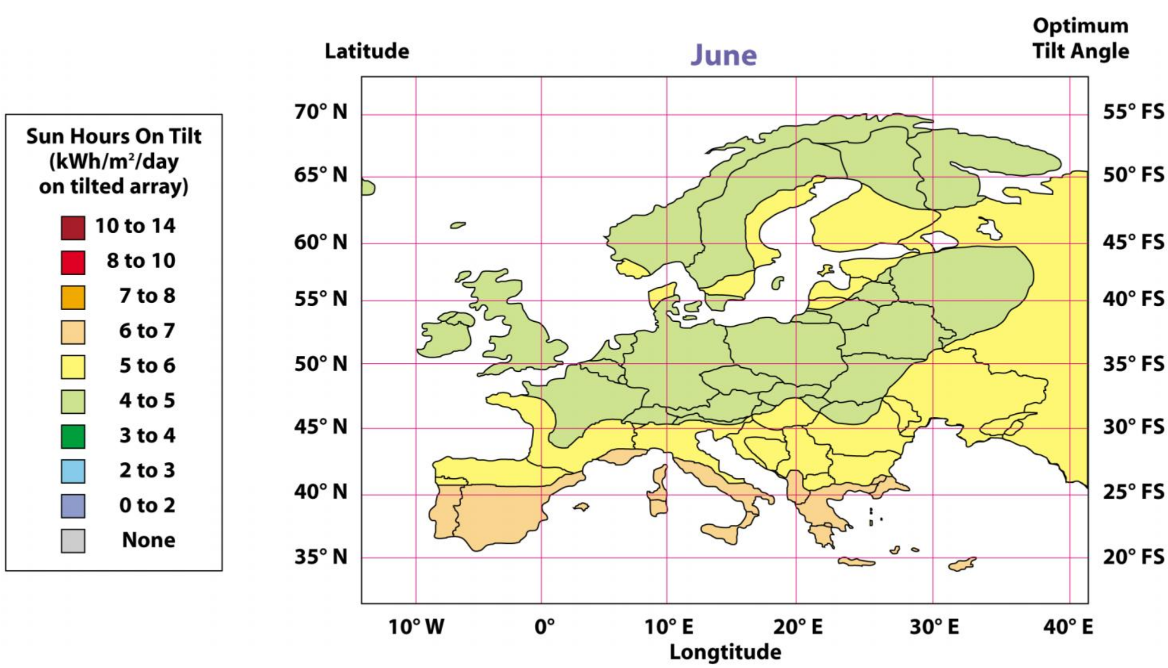
Asia
Sun Hours On Tilt (S.H.O.T.) Maps





Europe
Sun Hours On Tilt (S.H.O.T.)
Maps





Glossary

AC - Alternating current. Electrical energy which reverses its direction at regular intervals, typically 60 Hertz.

Ampere or Amp - Electric current is measured in amperes or amps

Array (Solar Array) - A group of solar electric modules connected together

Battery Bank - A group of batteries wired together to store power in a solar electric system. Allows power to be stored at night, on cloudy days, or to use more power than the array can produce at one time.

Centrifugal Pump - A pump which utilizes rotating impellers to accelerate water upward.

Controller - This converts the power from the solar array in a certain voltage/current configuration to a voltage/current configuration more efficiently utilized by the pump.

Current - The rate of flow of an electric charge. Current is measured in amperes or amps.

Current Booster - A function of a controller which converts a given voltage & current output from the array to a more useful configuration to the pump, typically providing more current but nearly equal power.

Diaphragm Pump - A positive displacement pump which utilizes a cam shaft causing piston displacement. A flexible elastometer (diaphragm) acts as a sealing mechanism in the cam and piston assembly.

DC - Direct current. Electrical energy flowing in one direction and of substantially constant value.

Drawdown - The distance or depth the standing water level lowers when water is pumped from the well at a given rate.

Elevation - Vertical distance from the ground to the input level of a tank or other means of storage.

Flow Rate - Volume of water provided per second, minute, hour or day.

Friction Loss - Pressure loss due to the resistance to water flow in a pipe.

GPM - Acronym for Gallons per Minute, used to measure the rate of water flow.

Ground Mount - A fixed array mounting method for solar modules which have multiple connections to earth.

Inverter - An appliance used to convert independent DC power into AC power.

Kilowatt or kW - Unit of measurement reflecting 1,000 Watts (See Watts).

Line Loss - Power loss across a length of wire. Copper wire, depending on its size, has a specified resistance per foot. Wire is then adequately sized to meet a specified line loss (typically of 3% - 5%).

LPM - Acronym for Liters per Minute, used to measure the rate of water flow.

Module - Modular solar electric charger; the term is used interchangeably with solar electric panel.

Mounting Angle - Angle of array, as measured from horizontal.

Parallel Wiring - A system of wiring for solar electric panels or batteries which increases the amperage of a given array. Parallel wiring is “+” to “+” (positive to positive) and “-” to “-” (negative to negative).

Photovoltaic (PV) - Photovoltaic essentially means to convert light into electricity. This is often referred to as PV for short, but is more commonly referred to as a “solar panel”

Pole Mount - A stationary pole top solar array mounting method, where the panels are affixed atop a pole, as opposed to a ground mounted array.

PSI - Pounds per Square Inch, a unit of measurement for pressure.

Sand Shroud - An apparatus which “shrouds” the pump (using a collar and section of large diameter pipe) to ensure input water enters the pump from below, so that sand and sediment are no longer entrained in the input water.

Series Wiring – A system of wiring, for solar electric modules or batteries, which increases voltage. Series wiring is “+” to “-” (positive to negative).

Solar Cell - The smallest basic solar electric device, which generates electricity when exposed to light. Typical solar modules are comprised of 36-72 solar cells wired in series.

Solar Electric - The preferred term used to describe something which uses sunlight to produce electricity.

Standing Water Level - The distance from the top of the well to the surface of the water in the well when no water is being pumped.

Sun Hours on Tilt (S.H.O.T.) - The number of sun hours at a given angle from the horizon (on average).

System Grounding - A means of electrically connecting a photovoltaic system to ground.

Tank Pressure - For pressurized systems, pressure of a tank in psi or kpa.

Total Dynamic Head - A means of expressing the load of a pumping system at given rate of flow in terms of its equivalent vertical column of water (i.e. vertical lift and friction converted to vertical lift).

True Maximum Power Point Tracking (MPPT) - A feature of the pump controller which ensures the solar array operates at its maximum power point.

Voltage or Volts - Voltage is the amount of electrical pressure, which causes electricity to flow in the power line. If electricity were water, voltage would be the measure of pressure at the faucet.

Watts - A watt is a measurement of total electrical power. volts x amps = watts

Watt Hour - The quantity of electrical energy used or produced when one Watt is used for one hour.

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