Designing a Solar Pumping System

There are many aspects of designing a solar pumping system. This guide provides the information to correctly select a pump, controller, sensors, solar array, wiring, and pipe. The process is broken down into the following steps:

STEP 1 - *Determining your basic amount of water required per day.*

STEP 2 - *Calculating the TOTAL DYNAMIC HEAD.*

STEP 3 - *Determining the solar insolation for your location.*

STEP 4 - *Selecting the pump, controller, and solar array.*

STEP 5 - *Selecting the correct solar array mounting method.*

STEP 6 - *Selecting the right size pump cable and pipe.*

STEP 7 - *Using water level sensors and pump controls.*

IMPORTANT NOTE: SDS series pumps and SCS series pumps use a different process for some steps in the design, especially pump selection. Look for "SDS ONLY" or "SCS ONLY" in the text.

STEP 1 - *Daily Water Requirement and Storage*

The size and cost of your system will depend on the amount of water required per day. AC pumping systems connected to a utility power grid are generally designed to run on demand with a specified flow rate. Unlike grid-tied systems, solar pumping systems are designed to provide a certain quantity of water per day. Water is pumped during sunlight hours and stored in a tank. The daily requirement is simply a total of all water required during a 24 hour period. This quantity is expressed in GALLONS PER DAY.

Tanks are used to store water for use during the night or periods of cloudy weather. Tanks are usually large enough to hold 3 to 5 days of daily water output. If your application requires large amounts of water on a periodic basis, like watering a crop once a week, divide the weekly requirement by 7 to arrive at an average daily requirement. A system such as this should have a tank large enough to hold at least 1.5 times the weekly requirement.

Information about water needs is available from many sources. Government agencies can provide information for household and agricultural applications. Some guidelines for water uses and daily quantities are shown below. These are general guidelines only, actual values depend on many factors.

TABLE 1 – *Typical Water Requirements (Gallons Per Day)*

Each Person for all purposes: 50 - 75
Each Milking Cow 35
Each Cow/Calf Pair 35 – 40
Each Horse or Dry Cow 10 – 20
Each Sheep 2
Each Hog 4
100 Chickens 4

STEP 2 - *Calculating TOTAL DYNAMIC HEAD*

Total Dynamic Head, or TDH, is a very important factor in system design. TDH is the effective pressure the pump must operate against. TDH is expressed in FEET. TDH is the sum of 4 factors:

1. PUMPING LEVEL

PUMPING LEVEL is the level of the water in the well while pumping at the required flow.

(see **FIGURE 1** on page 12). The STANDING WATER LEVEL water is also called the "static" (at rest) water level.The

DRAWDOWN,measured in feet, is the difference between the Static Water Level and the Pumping Level.

2. VERTICAL RISE
VERTICAL RISE is the amount of rise between the pump discharge pipe and the point of use.
It could be a small rise to the top of a holding tank or a large rise to the top of a hill.

3. FRICTION LOSS
The FRICTION LOSS, measured in equivalent feet, is the pressure required to overcome friction in the pipes from the pump to the point of use. The friction is based on: rate of flow, the length, diameter, and type of pipe, and also the number and type of pipe fittings used. The higher the flow rate the more the Friction Loss. Tables are used to determine the friction loss. (See Chart or the Engineering Section on our Web Site)

4. TANK PRESSURE
TANK PRESSURE, expressed in equivalent feet of head, is the operating pressure of the storage tank. Each pound of pressure (PSI) is equal to 2.31 feet.

Total Dynamic Head = *Pumping Level + Vertical Rise + Friction Loss + Tank Pressure*

TOTAL VERTICAL LIFT
To calculate TOTAL DYNAMIC HEAD it is best to make a sketch like

FRICTION LOSS
In most cases, calculating FRICTION LOSS can be simplified. If the system storage tank is located close to the well, 30 feet or less, and the recommended pipe size is used, a simple rule can be used.

Friction loss, in equivalent head, can be estimated at 5% of the TOTAL VERTICAL LIFT. This will allow for a few straight runs of pipe and a few fittings.
In cases where the tank is located far from the well, more than 10 meters (30 feet),more accurate calculations must be used for

FRICTION LOSS. FRICTION LOSS is based on the size and length of the pipe, the number and type of fittings, and the FLOW RATE.
Solar pumping systems, unless connected to a battery, pump only when the sun is shining on the solar array. Cloudy weather will
also affect the flow rate. The flow rate varies over the course of the day with the peak flow occurring at midday. Because our system
design is not complete (a pump and array have not been selected yet), the TOTAL DAILY OUTPUT can only be estimated. To estimate
the flow rate,make a guess for the TOTAL DAILY OUTPUT and use the following equations:

US:
GPM (gallons per minute) = GPD (gallons per day) / 360
Metric:
LPM (liters per minute) = LPD (liters per day) / 360
Example:
DAILY REQUIREMENT = 3600 liters per day
FLOW RATE = 3600 / 360 = 10 liters per minute

Calculate the friction loss by adding the length of all piping in the system. Use TABLE 2 or 3 to express the friction loss from fittings in equivalent length of pipe. Add the total of fitting losses to pipe losses. Using the total equivalent length of pipe, and the flow rate, find the head loss in meters per meter of pipe,or feet per foot of pipe, from TABLE 4 or 5. Multiply this number by the total equivalent length of pipe. This number is the FRICTION LOSS in meters or feet of head.

When the system design is complete, use the actual DAILY OUTPUT of the chosen pump and array, recalculate the FLOW RATE, and review the FRICTION LOSS calculations. If necessary, recalculate the FRICTION LOSS and the TOTAL DYNAMIC HEAD and double-check your pump and array choice.

TANK PRESSURE

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 the water is allowed to flow free into an open or vented tank, the TANK PRESSURE is zero, use a value of zero when calculating TOTAL DYNAMIC HEAD. To convert pressure to equivalent head, use the following formulas:

US:
HEAD (in feet) = PRESSURE (psi) x 2.31
Metric:
HEAD (in meters) = PRESSURE (kPa) x 0.102
Example:
FIGURE 1 is a good example of how a system should be sketched to calculate TOTAL DYNAMIC HEAD.The worksheet on the following page can be used for the calculation.Practice the calculation using FIGURE 1). The TOTAL DYNAMIC HEAD for this system equals 92.852 feet.