Planning a Stand-Alone PV System

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Stand-alone PV Systems (also known as Off-grid PV System) are those systems that are not connected to the public electricity grid. They are generally much smaller than grid-tied systems and are commonly installed in rural areas. There are 3 main categories of Stand-alone PV Systems:

- Systems providing DC power only;
- Systems providing AC power only; and
- Systems providing both DC and AC power.

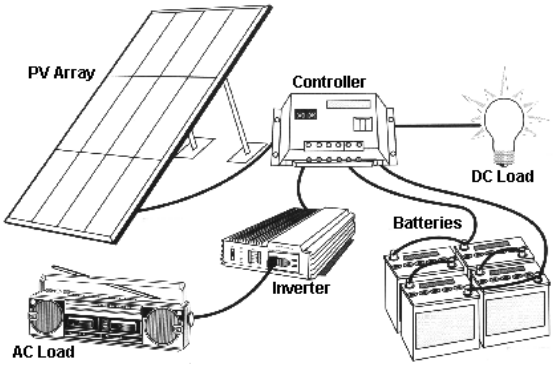
Wherever a power grid is not or not at reasonable costs available, a Stand-alone PV System can be used to generate the needed electric energy. Some examples of such applications are:

- Rural community electrification – to provide power to homes, medical centres, village halls, places of worship, schools;
- Telecom applications – to enable access and continuity to communications network for voice telephony and Internet;
- Public lightings and stations – to illuminate streets, roads, bus shelters; to provide directions and security;
- Water pumping – to facilitate water distribution for communities and agriculture support.

Overview

One of the most important tasks in planning a Stand-alone PV System is to match the prospective energy consumption with the local average solar irradiation, the resulting energy production and the required storage capacity. Since the solar modules only produce electric energy during daytime, it is necessary to store energy for the night or for cloudy days. Such storage systems mostly use rechargeable lead batteries, due to their ability to accept with high efficiency both low and high input voltages. A battery regulator prevents over-charging; a load shedding circuit prevents deep discharges. The Stand-alone PV System will provide a battery output voltage of 12 or 24 V DC in most cases. To supply devices which are only available for AC voltages a power inverter can be used.

Typical Stand-alone PV System



3 steps to size a Stand-alone PV System

Generally one should utilize only power-saving devices to be fed by a Stand-alone PV System. Additionally, by utilizing devices operating at 12 or 24 V DC, some conversion losses can be avoided. There already exist many common household appliances (eg. ceiling-mounted fans, refrigerators, lightings, cookers) that operate using DC voltages.

Step 1: Determining the electrical load

The first step involves making a list of all appliances (including lightings) and their load (as measured in watts). For every device, multiply the load with the hours of usage time. Sum up the results. Since the consumption will differ with the season, one should calculate the energy consumption independently for summer and winter season to have a better estimate.

In doing the electrical load estimation, one should exercise pragmatism and reach a balance between how much excess to have and what is actually required. At this point, it

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is important to examine your power consumption and reduce your power needs as much as possible. Identify large loads (eg. AC refrigerators and washing machines) and try to eliminate them or examine alternatives such as DC models. As mentioned earlier, using DC devices avoid losing energy in the conversion process, and typically DC appliances are more efficient and last longer. Replace incandescent fixtures with fluorescent lights wherever possible. Fluorescent lamps provide the same level of illumination at lower wattage levels. If there is a large load that cannot be eliminated, consider using it only during peak sun hours.

Step 2: Sizing the Stand-alone PV System

The daily energy yield by the Stand-alone PV System should be sufficient to cover the daily consumption. To forecast the daily energy yield we need data about the daily irradiance at the location of the PV modules. Such data is available from different sources at the web (eg. World Insolation Map). To get the energy yield provided by the Stand-alone PV System, the radiation (measured in $kWh/m^2/day$) has to be multiplied with the module capacity (nominal output, given in kWp) and the result corrected by factors including the deviation of the optimal orientation and inclination of the modules. In addition, we have to discount the transmission losses caused by the electrical resistance in the cables and during the charging/discharging process of the rechargeable battery storage. Such losses can typically sum up to about 24%.

Example: A Stand-alone PV System installed in north-eastern China (with an irradiance of $3.6kWh/m^2/day$ in July), providing 1kWp nominal output, may generate 3.6kWh of electrical power per day on average in July (a summer month). So it could meet a consumption of about 3.6 * 0.76 = 2.7kWh/day, where 0.76 is the correction factor used. However, to plan a Stand-alone PV System it will be best for one to use the month with the least irradiation of the season as base. In this case, it will be during the winter month of December whereby the irradiance is $0.65kWh/m^2/day$. Based on this, the electrical power generation is only 0.5kWh/day.

The size of a Stand-alone PV System is dependent on how much electricity must be generated to meet the load consumption. So, if only about 500Wh/day is needed, this system would suffice even for the winter season. However, if more than 500Wh/day is required then several options can be exercised. These options include:

- Increasing the nominal output of the Stand-alone PV System, or
- Re-scheduling the time usage of each device, or
- Implementing a Hybrid Stand-alone PV and Wind System.

Step 3: Dimensioning the storage capacity

Since the Stand-alone PV System generates electricity when the sun is shining, which is in many cases not the time we need the energy, we use rechargeable batteries to store electrical energy. Batteries are used to store energy for use at a later time, like night time or on cloudy days. The batteries used in a Stand-alone PV System are deep cycle batteries, similar to those that power electric golf carts. The number of batteries used in a system varies on the type of battery, and the anticipated storage needs.

The capacity of such batteries is measured in ampere-hours (Ah). It can be determined by dividing the load consumption per day (in Wh) by the output voltage (in V DC) of the storage system (mostly 12V DC or 24V DC, depending on the interconnection of the batteries). For example, if the load consumption is 500Wh and 12V DC batteries are used, then the storage capacity of the batteries to cope for a day should be 500Wh / 12V DC ≈ 42Ah.

The planned storage capacity should take into consideration the possibilities of seasonal climates. For example, considering a possibility to bridge the power gap for a 5days period during winter, one can always size the storage capacity accordingly. In this instance, it will be to multiply the daily capacity by 5, or, 42Ah/day x 5days = 210Ah.

Local regulatory considerations

After completing the 3 steps described above, the last step of the planning process will need to consider the local regulatory laws or code of practice pertaining to the safety and hazard prevention measures of electrical systems installation.

Some facility owners may wish to install the solar panels on the roof or ceiling of their building. From the perspective of security, aesthetics and space usage, such installation method does seem to be a wise choice. However, some local laws may require that such installation methods be subject to further approvals. Other code of practice may stipulate that only specific wiring colours or even type of wiring be used for electrical installation.

Besides local regulatory laws or code of practice pertaining to the safety and hazard prevention measures of electrical systems installation, there may be other legislations or statutes which may require facility owners to submit plans and blueprints of their intended installations. These documentations may require the endorsement of a certified professional engineer. There may also be a requirement for an insurance to be taken out on such installation.

Usually information pertaining to the local regulatory laws or code of practice can be found on the web. It is recommended that if one is in doubt then it is best to consult with a professional contractor or the relevant authority. Regardless of the regulatory practices that exist, it should not be a discouragement towards the implementation and use of a Solar Power System as the benefits outweighs the initial inconvenience.

Benefits of using Solar Power System

Solar power is harnessed from the sun, an infinite resource. This means energy independence (as compared to finite fossil fuel resource).

Solar power is also environmentally friendly. It does not emit greenhouse gases. It does not damage our ecosystem.

Solar power is quiet during use. It is also safe to use. Many users install their Solar Power System in their own home and still sleep soundly at night!

Solar power requires only minimal maintenance. Advances in technology have made the components of a solar power system become more reliable, durable, user-friendly and safe.

A GREEN MESSAGE

Using renewable solar energy enables us to reduce the use of fossil fuels to generate energy. Fossil fuel energy generation pollutes our environment. You are empowered to help. Do your part. Be a responsible global citizen. **SAVE GAIA.**