

Stand Alone Solar PV System with Battery Backup System for Gonpinaing Village, Mandalay Division

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Abstract -- This project presents the design of an off- grid or stand-alone Photovoltaic (PV tracking) system with battery backup to supply electric power for Gonpinaingvillage in Mandalay division according to its energy requirements during the electricity outage. Design calculation result is presented to validate the proposed system configuration. In this project, a 60kW stand-alone solar photovoltaic system with 100% battery backup is designed for Gonpinaing village saturated away from national grid. The results of this project show that the demand of this village requires a DC 12 V battery banks. The system requires a 60 kW three phase inverter and one hundred and eighty number of 300W SANDI modules. In this project, the long-term result of the implementation of stand-alone solar PV system is preferable than that of other power plants both economically and environmentally. This system solves the problem of failing the electricity which is sensitive to the exiting central inverter system topology by proposing a PV system which is more efficient and reliable .The electricity which obtained from stand-alone solar PV system has many kinds of advantages for Gonpinaing village such as reducing air pollutions, no releasing green-house gases, no noise, low maintenance cost, installing everywhere the energy demand and energy independence.

The main purposed of this project is to design calculation of stand- alone solar PV system with battery backup system (60kW). In this project load calculation, solar radiation or sunshine hours and main components of the proposed solar PV system are considered. Moreover, panel size selecting, battery capacity, inverter sizing and charge controller sizing are calculated and chosen. The main aim of this project is to supply the electricity without having national grid. Therefore, Design and implementation of 60kW solar PV system is installed with battery backup to supply the required load demand.

Index Terms – standalone solar PV system, solar energy, rural area, dry zone

I. INTRODUCTION

Renewable energy resources are an important part of power generation in the new millennium. In the

reduction of the emission of greenhouse gases, they add the much- needed flexibility to the energy resource mix by decreasing the dependence on fossil fuels. Among the renewable energy resources, solar energy is the most essential and prerequisite resource of sustainable energy because of its ubiquity, abundance, and sustainability. Regardless of the intermittency of sunlight, solar energy, is widely available and completely free for cost. Recently, photovoltaic (PV) system is well recognized and widely utilized to convert the solar energy for electric power applications. It can generate direct current (DC) electricity without environmental impact and emission by the way of solar radiation. The DC power is converted to AC power with an inverter, to power local loads or fed back to the utility. Being a semiconductor device, the PV systems are suitable for most operation at a lower maintenance cost.

The PV application can be grouped according to the scheme of interaction with utility grid: grid connected, stand alone, and hybrid. PV systems consist of a PV generator (cell, module, and array), energy storage devices (such as batteries), AC and DC consumers and elements for power conditioning. The most common method uses the PV cells in grid network. However, to understand the performance and to maximize the efficiency of the irradiation on the PV cells, the standalone PV cells have spurred some interest especially in the area of solar tracker system.

While many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas and developing countries, where energy is often crucial in human development. As most of renewable provide electricity, renewable energy deployment is often applied in conjunction with further electrification, which has several benefits: electricity can be converted into mechanical energy with high efficiency and is clean at the point of consumption.

In addition, to the electrification with renewable energy is much more efficient and leads to a significant reduction in primary energy requirements because most renewables don't have a steam cycle with high losses (fossil power plants usually have losses of 40 to 65%).

When the utility power is unavailable and too expensive to bring into home, solar panels allow to be the utility company. People can live in peace, with no noisy gas generator to disturb the quiet. There are several variations of off-grid solar power by depending on needs and budget. All variations of off-grid solar power depend on solar electric panels and store electricity in a bank of batteries. Off-grid solar power also stores DC electricity in batteries. The addition of an inverter allows this system to convert DC electrical current coming from the batteries into AC or alternating current. AC is the standard form of electricity for anything that "plugs in" to utility power and is the appropriate current for common household appliances.

II. SOLAR ENERGY

Solar photovoltaic system or solar power system is one of the renewable energy system which uses PV modules to convert sunlight into electricity. The electricity generated can be stored or used directly, fed back into grid line or combined with one or more other electricity generators or more renewable energy source. Solar PV system is very reliable and clean source of electricity that can suit a wide range of applications such as residence, industry, agriculture, livestock, etc.

A photovoltaic system, also PV system or solar power system is a power system designed to supply usable solar power by means of photovoltaic. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity. Solar charge controller regulates the voltage and current coming from the PV panels, battery stores energy for supplying to electrical appliances when there is demand, a solar inverter to change the electric current from DC to AC, as well as mounting, cabling, and other electrical accessories to set up a working system. It may also use a solar tracking system to improve the systems overall

performance and include an integrated battery solution, as prices for storage devices are expected to decline. Strictly speaking, a solar array only encompasses the ensemble of solar panels, the visible part of the PV system, and does not include all the other hardware, often summarized as balance of system (BOS). Moreover, PV systems convert light directly into electricity and shouldn't be confused with other technologies, such as concentrated solar power or solar thermal, used for heating and cooling.

PV systems can be very simple, consisting of just a PV module and load, as in the direct powering of a water pump motor, which only needs to operate when the sun shines. However, when for example a whole house should be powered by, the system must be operational day and night. It also may have to feed both AC and DC loads have reserve power and may even include a back-up generator. Depending on the system configuration, there are three main types of PV system: stand-alone grid-connected, and hybrid. The basic PV system principles and elements remain the same. Systems are adapted to meet particular requirements by varying the type and quantity of the basic elements. A modular system design allows easy expansion, when the demands change.

A solar cell or photovoltaic cell is a device that converts light energy into electrical energy. Sometimes the term solar cell is reserved for devices intended specifically to capture energy from sunlight by the photovoltaic effect, while the term photovoltaic cell is used when the light source is unspecified.

III. STAND-ALONE PV SYSTEM WITH BATTERY BACKUP SYSTEM

A free standing or Stand Alone PV system is made up of a number of individual photovoltaic modules (or panels) usually of 12 volts with power outputs of between 50 and 100+ watts each. These PV modules are then combined into a single array to give the desired power output. A simple stand-alone PV system is an automatic solar system that produces electrical power to charge banks of batteries during the day for use at night when the sun's energy is unavailable. A stand-alone small scale PV system

employs rechargeable batteries to store the electrical energy supplied by a PV panels or array.

Stand-alone PV system are ideal for remote rural areas and applications where other power sources are either impractical or are unavailable to provide power for lighting, appliances and other uses. In these cases, it is more cost effective to install a single stand-alone PV system than pay the costs of having the local electricity company extend their power lines and cables directly to the home.

A stand-alone photovoltaic (PV) system is an electrical system consisting of an array of one or more PV modules, conductors, electrical components, and one or more loads. But a small scale PV system does not have to be attached to a roof top or building structures for domestic applications, they can be used for camper vans, RV's boats, tents, camping and any other remote location. Many companies now offer portable solar kits that allow you to provide your own reliable and free solar electrical anywhere you go even in hard to reach locations.

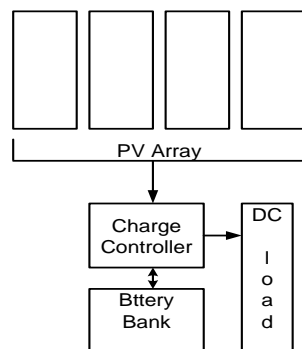


Figure 1 Stand-alone PV System with Battery Backup System with DC Load

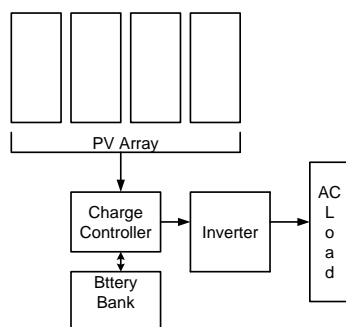


Figure 2 Stand-alone PV System with Battery Backup System with AC Load

IV. MOUNTING SYSTEM

A PV system produces the most power output when it is perpendicular to the sun. The most effective way to set this up is to use a tracking system that follows the sun as it moves across the sky. A tracking PV array can produce 20 to 30percent more electricity than a similar fixed array. The drawback of a tracking system is the energy required to follow the sun across the sky. A fixed mounting system has several benefits, such as that it is aesthetically pleasing, since you can mount the systems flush to the roof.

A. Roof Mounted Arrays

Photovoltaic array mounting can be categorized according to where the arrays are mounted, how they are supported and whether they have a fixed or changing orientation. Arrays can be either roof mounted or ground mounted. Roof mounted arrays is typically used as one of four different methods of support: rack, standoff, integrated or direct.

With the surge of interest in photovoltaic and building applications, better designs for each of these four roof mounting approaches are being pursued.

(a) Standoff mounting

Standoff arrays are mounted above and parallel to the roof surface. Standoff mounts work well for buildings with sloping roofs. When installing a standoff mounted array, the photovoltaic panels or sub arrays are often attached to the roof using point connections usually at or between the roof and the bottom of the module frame should be at least three inches.

(b) Rack mounting

Rack mounted arrays are above and tilted with respect to the roof. Rack mounts work well on flat roofs and roofs with a slope of 2 in 12 or less. They may be mechanically attached to the building structure or may employ ballast to resist wind and other mechanical loads. Rack mounts are usually subjected to higher structural loads, incur higher

costs for mounting hardware and are often less attractive than standoff mounts

(c) Integrated mounting

For integrated arrays, also referred to as building integrated photovoltaic (BIPV) or integral mounting, the array replaces conventional roofing or glazing materials. Because integrated arrays replace conventional roofing and glazing materials, they become a significant architectural feature of a building and can be aesthetically very pleasing.

B. Ground Mounted Arrays

Ground mounted arrays are supported by racks, poles or tracking stands. These arrays are secured to the ground to resist uplifting caused by wind loads. All ground mounted arrays run relatively cool because good airflow is possible over both the front and back surfaces of the modules.

(a) Rack mounting

Rack mounting is commonly used for mounting arrays on the ground. Simple structural hardware such as angles, channels and metal tubing can be used for both small and large PV arrays. Most module manufacturers and equipment suppliers offer hardware for rack mounting PV arrays on the ground.

(b) Pole Mounted

If the array consists of only a few modules, it can be mounted on a pole. Depending on the number of modules and their height above the ground, the pole may need to be set in concrete to resist being overturned during windy conditions. Among others, photovoltaic powered outdoor lighting is a good application for pole mounted arrays.

V. ADVANTAGES OF A PV SYSTEM

Like all technology, PV has both advantages and disadvantages. The industry will minimize the

advantages over time. The advantages of a PV system are described as follows:

- i PV panels provide clean – green energy. During electricity generation with PV panels there is no harmful greenhouse gas emission thus solar PV is environmentally friendly.
- ii Solar PV systems operate differently than solar thermal ones. Solar PV actually generates free electricity while solar thermal systems heat up water.
- iii Photovoltaic panels are extremely reliable and require low maintenance even in harsh conditions.
- iv Photovoltaic systems are versatile in the sense that they can be stand alone, local grid, central grid connected or even hybrid (in conjunction with other technologies like wind or hydro) systems.
- v Photovoltaic systems are modulator, where additional power generating capacity can readily be added.
- vi Photovoltaic systems have a very short lead time for installations.
- vii Photovoltaic systems last at least thirty years as typically there are no moving parts involved in electricity generation; consequently, they don't create any noise pollution.
- viii Photovoltaic has a high rate of public acceptance and an excellent safety record.
- ix Photovoltaic is a green technology and has the potential to play a major role in controlling greenhouse gases and global warming.
- x Photovoltaic industries create jobs in addition to energy and help the economic development of societies.

Thus, photovoltaic is a proven technology and a practical solution to energy crisis and security.

Table I. Monthly Average Radiation, Temperature Of Mandalay

Month	Radiation (kwh/m ³ /day)	Temperature High/Low °F
JAN	4.5	85/58
FEB	5.65	91/62
MAR	6.06	98/69

APR	6.33	102/76
MAY	5.97	99/78
JUN	5.45	95/79
JUL	4.88	95/79
AUG	4.64	93/78
SEP	4.70	93/78
OCT	4.34	92/75
NOV	4.07	88/68
DEC	3.99	84/60

VI. COMPONENTS OF STAND-ALONE PV SYSTEM

In this typical stand-alone solar PV system, the following items are included

- Photovoltaic Array
- Charge Controller
- Power conditioning for the adaptation of the photovoltaic generator to the other system components. This is a DC to AC inverter.
- Cable
- AC and DC load

The following equations are used to design for stand-alone solar PV battery backup system.

$$\text{Tilt angle, } \delta = 23.45 \sin (360/365 (n - 81)) \quad (1)$$

Total Wp of PV capacity needed

$$= \frac{\text{Total PV energy need}}{3.43} \quad (2)$$

$$\text{Number of module} = \frac{\text{Total Wp of PV capacity needed}}{\text{Rated output of module}} \quad (3)$$

$$\text{Number of series module} = \frac{\text{System nominal voltage}}{V_{\text{mpp}} \times \text{derating factor}} \quad (4)$$

Number of parallel module

$$= \frac{\text{Total number module}}{\text{Number of series module}} \quad (5)$$

$$\text{Rated array current} = \text{Number of parallel module} \times I_{\text{mpp}} \quad (6)$$

$$\text{Inverter sizing} = \text{Total Power demand kW} \times 1.25 \quad (7)$$

$$\text{Battery capacity} = \frac{\text{total energy -hr/day}}{0.85 \times 0.8 \times \text{nominal battery voltage}} \quad (8)$$

$$\text{Total no: of battery} = \frac{\text{Required battery capacity}}{\text{Rated capacity of selected battery}} \quad (9)$$

$$\text{No of series connected battery} = \frac{\text{Nominal system voltage}}{\text{Nominal battery voltage}} \quad (10)$$

$$\text{No of parallel connected battery} = \frac{\text{Total no of battery}}{\text{Series connected battery}} \quad (11)$$

$$\text{Daily electrical energy demand} = \frac{\text{Peak daily hydraulic power output}}{\eta_{\text{motor-pump}}} \quad (10)$$

Table ii. Load Calculation Of Overall Total Power Demand For Gonpinaing Village

Items	Rating	Number for one house	Total number of house
Lamp	20 W	2	100
Bulb	18 W	2	100
TV	50 W	1	50
Fan	8 W	1	25
Socket	1000 W	1	15
Other Accessories	120 W	1	5
Rice Cooker	700 W	1	50
Electronic Kettle	1000 W	1	50
Electronic Pen	1500 W	1	20

Table iii. Load Calculation For Total Energy Consumption

Items	Total Watt for items	Hours per day
Lamp	4000	6
Bulb	3600	6
TV	2500	8
Fan	200	3
Socket	15000	4
Other Accessories	600	4
Rice Cooker	35000	2
Electronic Kettle	50000	1
Electronic Pen	30000	3

Table Iv Design Data

No	Descriptions	Rating/ Amount
1	Total Power demand	68.9 kW
2	Total energy consumption	212.6 kWh/day
3	PV Watt peak	79.42kWp
4	Total Module	265 nos
5	Series connected module	18 nos
6	Parallel connected module	15 nos
7	Rated Array current	241.8 A
8	Rated Array voltage	324 V
9	Inverter size	90 kW
10	Battery capacity	130269 Ah
11	Total Batteries	130 nos
12	Series connected batteries	27 nos
13	Parallel connected batteries	5 nos
14	Charge controller	340A
15	Array short circuit current	243.6A
16	Cable size (SWG)	120 mm ²

VII. CONCLUSION

Potential of a solar PV system in Tadau Township, Madalay Division is trying to be found out. The

rough number of modules that can be accommodated on the area is determined. The solar PV plant is installed on the ground covering an area. The total power demand is 47.6 kW. So, PV system can sufficiently provide the power for the Gonpinaing village. A PV system consists of a primary energy source, power inverter to maintain the flow of energy between the AC and DC sides and the grid utility. The optimization result for peak sun hour/solar radiation in Tadau, load data, inverter sizing, battery sizing and charge controller rating are obtained. The solar PV system can provide the future energy demands. This project is focused on design photovoltaic system for the proposed village in Tadau. It also suggests load estimation, sizing of a PV system for supplying the electrical load using PV system. Although PV power system is generally more expensive than utility provided power, so that the use of PV systems is increasing in all over the world because of their optimum designs. With battery backup, batteries consume energy during charging and discharging, reducing the efficiency and output of the PV system by about ten percent for lead acid batteries.

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