

PROFESSIONAL TRAINING REPORT

AT SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY



(Deemed to be University)

“SOLAR PHOTOVOLTAIC SYSTEM”

Submitted By:

MAHANTHI MADHUSUDHANA RAO (39140028)

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SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY

JEPPIAAR NAGAR, RAJIV GANDHI SALAI,

CHENNAI – 600119. TAMILNADU.

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VATIO ENERGY INDIA PRIVATE LIMITED

VATIO Energy is an efficiency-driven entrepreneurship inspired by a vision of creating a greener tomorrow by harnessing the power of solar energy. In doing so, we seek to improve our customers' daily lives by significantly reducing your electricity bills.

VATIO has provided solar panels and inverters to large corporations and government agencies, and has also helped thousands of individual homeowners with tailor-made solar and energy systems.

DECLARATION



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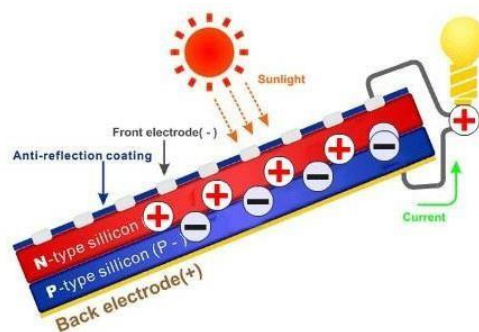
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SOLAR ENERGY

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar radiation, along with secondary solar-powered resources such as wind and wave power, hydroelectricity and biomass, account for most of the available renewable energy on earth. Only a minuscule fraction of the available solar energy is used.

Solar powered electrical generation relies on heat engines and photovoltaic. Solar energy's uses are limited only by human ingenuity. A partial list of solar applications includes space heating and cooling through solar architecture, potable water via distillation and disinfection, day lighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes. To harvest the solar energy, the most common way is to use solar panels.

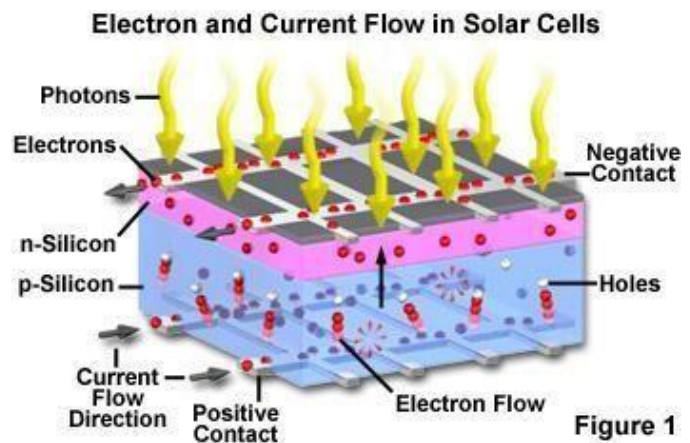
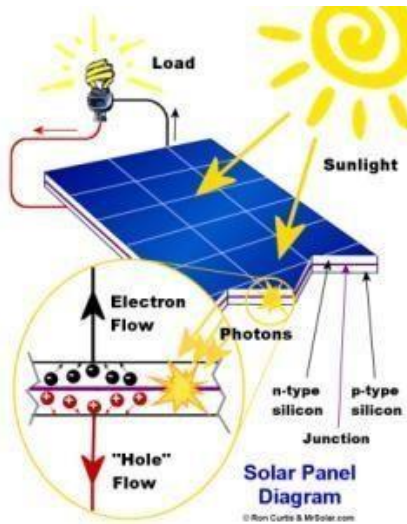
Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.



Photovoltaic Effect

photovoltaic effect, process in which two dissimilar materials in close contact produce an electrical voltage when struck by light or other radiant energy. Light striking crystals such as silicon or germanium, in which electrons are usually not free to move from atom to atom within the crystal, provides the energy needed to free some electrons from their bound condition. Free electrons cross the junction between two dissimilar crystals more easily in one direction than in the other, giving one side of the junction a negative charge and, therefore, a negative voltage with respect to the other side, just as one electrode of a battery has a negative

voltage with respect to the other. The photovoltaic effect can continue to provide voltage and current as long as light continues to fall on the two materials. This current can be used to measure the brightness of the incident light or as a source of power in an electrical circuit, as in a solar power system (see fig 1).

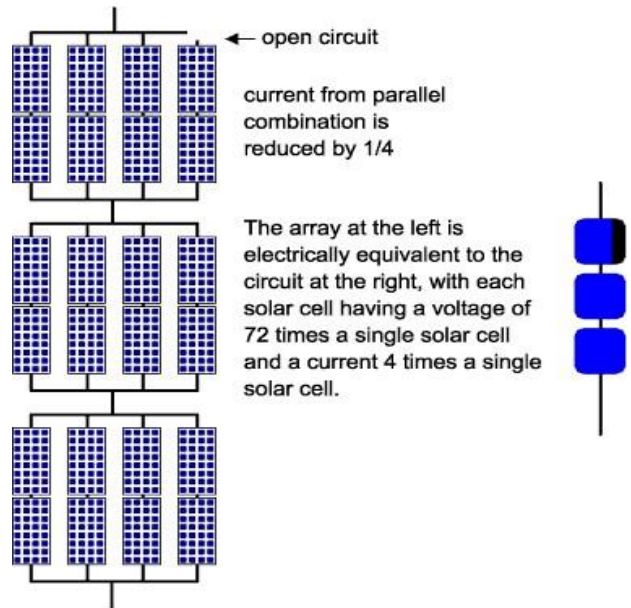


PV MODULE

Cell



Array



Available cell technologies

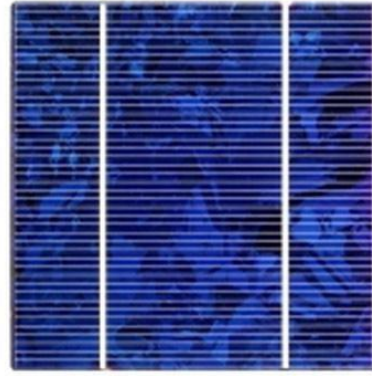
- Monocrystalline Si
- Multicrystalline Si
- Thin film ◦ Amorphous Si ◦ Cadmium Telluride ◦ CIGS ◦ Organic
- CSP

1. Mono Crystalline

- Most efficient commonly available module 15-20%
- Expensive to produce
- Circular cell creates wasted space on module



Mono crystalline



Multi crystalline

2. Multi Crystalline

- Less expensive to make than single crystalline module
- Cells slightly less efficient than a single crystalline 14-16%
- Square shape cells fit into module efficiently using entire space

3. Thin Film

A **thin-film solar cell** (TFSC), also called a thin-film photovoltaic cell (TFPV), is a solar cell that is made by depositing one or more thin layers (thin film) of photovoltaic material on a substrate. The thickness range of such a layer is wide and varies from a few nanometres to tens of micrometers.

Many different photovoltaic materials are deposited with various deposition methods on a variety of substrates. Thin-film solar cells are usually categorized according to the photovoltaic material used:

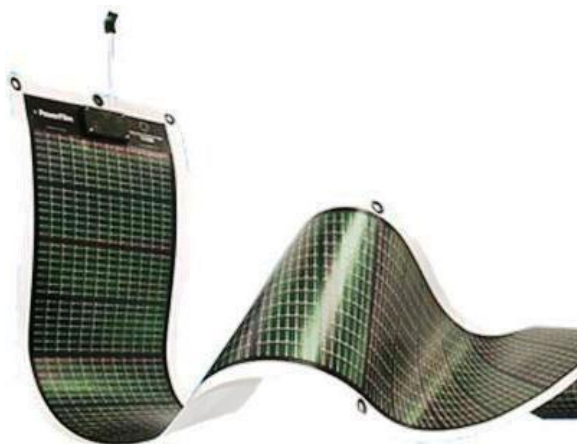


FIG. thin film solar cell

3(a) Amorphous Silicon

- Most inexpensive technology to produce
- Metal grid replaced with transparent oxides
- Efficiency 6-9%
- Can be deposited on flexible substrates
- Less susceptible to shading problem
- Better performance in low light condition than with crystalline modules



FIG. Amorphous Silicon solar cell

3(b) Cadmium Telluride Solar Cell

Cadmium telluride (CdTe) photovoltaics describes a photovoltaic (PV) technology that is based on the use of cadmium telluride thin film, a semiconductor layer designed to absorb and convert sunlight into electricity. Cadmium telluride PV is the first and only thin film photovoltaic technology to surpass crystalline silicon PV in cheapness for a significant portion of the PV market, namely in multi-kilowatt systems. Best cell efficiency has plateaued at 16.5% since 2001.



FIG. Cadmium Telluride Solar Cell

3(c) CIGS

Copper indium gallium selenide (CIGS) is a direct-bandgap material. It has the highest efficiency (~20%) among thin film materials. Traditional methods of fabrication involve vacuum processes including co-evaporation and sputtering. Recent developments at IBM and Nanosolar attempt to lower the cost by using non-vacuum solution processes.

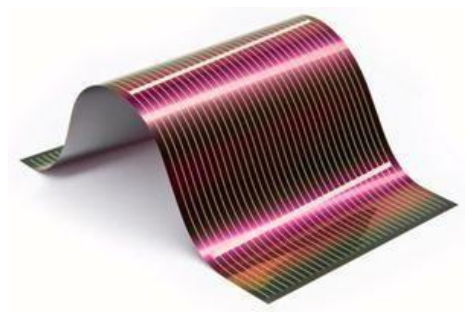
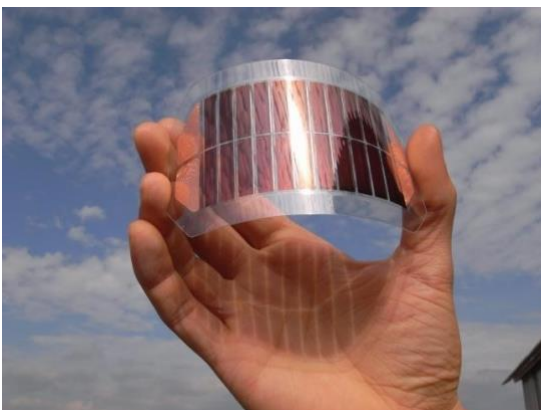


FIG. showing CIGS solar cell

3(d) Organic solar cell

An organic photovoltaic cell (OPVC) is a photovoltaic cell that uses organic electronics--a branch of electronics that deals with conductive organic polymers or small organic molecules for light absorption and charge transport.

The plastic itself has low production costs in high volumes. Combined with the flexibility of organic molecules, this makes it potentially lucrative for photovoltaic applications. Molecular engineering (e.g. changing the length and functional group of polymers) can change the energy gap, which allows chemical change in these materials. The optical absorption coefficient of organic molecules is high, so a large amount of light can be absorbed with a small amount of materials. The main disadvantages associated with organic photovoltaic cells are low efficiency, low stability and low strength compared to inorganic photovoltaic cells.



4. CSP

Concentrated solar power (CSP) systems, also known as **concentrated solar thermal (CST)** systems, are systems that use mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Electrical power is produced when the concentrated light is converted to heat which drives a heat engine (usually a steam turbine) connected to an electrical power generator.



Types of concentrated solar power

CSP is used to produce electricity (sometimes called solar thermoelectricity, usually generated through steam). Concentrated solar technology systems use mirrors or lenses with tracking systems to focus a large area of sunlight onto a small area. The concentrated light is then used as heat or as a heat source for a conventional power plant (solar thermoelectricity). The solar concentrators used in CSP systems can often also be used to provide industrial process heating or cooling, such as in solar air-conditioning.

Concentrating technologies exist in four common forms, namely parabolic trough, dish stirlings, concentrating linear fresnel reflector, and solar power tower. Although simple, these solar concentrators are quite far from the theoretical maximum concentration. For example, the parabolic trough concentration is about 1/3 of the theoretical maximum for the same acceptance angle, that is, for the same overall tolerances for the system. Approaching the theoretical maximum may be achieved by using more elaborate concentrators based on nonimaging optics.

Different types of concentrators produce different peak temperatures and correspondingly varying thermodynamic efficiencies, due to the differences in the way that they track the Sun and focus light. New innovations in CSP technology are leading systems to become more and more cost-effective.

Parabolic trough



A parabolic trough is the most widely deployed and proven type of solar thermal power technology.

A parabolic trough consists of a linear parabolic reflector that concentrates light onto a receiver positioned along the reflector's focal line. The receiver is a tube positioned directly above the middle of the parabolic mirror and is filled with a working fluid. The reflector follows the Sun during the daylight hours by tracking along a single axis. A working fluid (e.g. molten salt) is heated to 150–350 °C (423–623 K (302–662 °F)) as it flows through the receiver and is then used as a heat source for a power generation system. Trough systems are the most developed CSP technology

Fresnel reflectors



Fresnel reflectors are made of many thin, flat mirror strips to concentrate sunlight onto tubes through which working fluid is pumped. Flat mirrors allow more reflective surface in the same amount of space as a parabolic reflector, thus capturing more of the available sunlight, and they are much cheaper than parabolic reflectors. Fresnel reflectors can be used in various size CSPs.

Dish stirling



Dish engine systems eliminate the need to transfer heat to a boiler by placing a Stirling engine at the focal point.

A dish stirling or dish engine system consists of a stand-alone parabolic reflector that concentrates light onto a receiver positioned at the reflector's focal point. The reflector tracks

the Sun along two axes. The working fluid in the receiver is heated to 250–700 °C (523–973 K (482–1292 °F)) and then used by a Stirling engine to generate power. Parabolic dish systems provide the highest solar-to-electric efficiency among CSP technologies, and their modular nature provides scalability

Solar power tower

A solar power tower consists of an array of dual-axis tracking reflectors (heliostats) that concentrate light on a central receiver atop a tower; the receiver contains a fluid deposit, which can consist of sea water. The working fluid in the receiver is heated to 500–1000 °C (773–1273 K (932–1832 °F)) and then used as a heat source for a power generation or energy storage system. Power tower development is less advanced than trough systems, but they offer higher efficiency and better energy storage capability.

Advantages & Disadvantages of Photovoltaics

Advantages

- Electricity produced by solar cells is clean and silent. Because they do not use fuel other than sunshine, PV systems do not release any harmful air or water pollution into the environment, deplete natural resources, or endanger animal or human health.
- Photovoltaic systems are quiet and visually unobtrusive.
- Small-scale solar plants can take advantage of unused space on rooftops of existing buildings.
- PV cells were originally developed for use in space, where repair is extremely expensive, if not impossible. PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance.
- Solar energy is a locally available renewable resource. It does not need to be imported from other regions of the country or across the world. This reduces environmental impacts associated with transportation and also reduces our dependence on imported oil. And, unlike fuels that are mined and harvested, when we use solar energy to produce electricity we do not deplete or alter the resource.

A PV system can be constructed to any size based on energy requirements. Furthermore, the owner of a PV system can enlarge or move it if his or her energy needs change. Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. These environmental impacts are minor and can be easily controlled through recycling and proper disposal.

Disadvantages

- Solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV devices and in part to the conversion

efficiencies of the equipment. As the conversion efficiencies continue to increase and the manufacturing costs continue to come down, PV will become increasingly cost competitive with conventional fuels.

- Solar power is a variable energy source, with energy production dependent on the sun. Solar facilities may produce no power at all some of the time, which could lead to an energy shortage if too much of a region's power comes from solar power.

EFFECTS ON PV MODULES

Shading and dirt

Photovoltaic cell electrical output is extremely sensitive to shading. When even a small portion of a cell, module, or array is shaded, while the remainder is in sunlight, the output falls dramatically due to internal 'short-circuiting' (the electrons reversing course through the shaded portion of the p-n junction).

If the current drawn from the series string of cells is no greater than the current that can be produced by the shaded cell, the current (and so power) developed by the string is limited. If enough voltage is available from the rest of the cells in a string, current will be forced through the cell by breaking down the junction in the shaded portion. This breakdown voltage in common cells is between 10 and 30 volts. Instead of adding to the power produced by the panel, the shaded cell absorbs power, turning it into heat. Since the reverse voltage of a shaded cell is much greater than the forward voltage of an illuminated cell, one shaded cell can absorb the power of many other cells in the string, disproportionately affecting panel output. For example, a shaded cell may drop 8 volts, instead of adding 0.5 volts, at a particular current level, thereby absorbing the power produced by 16 other cells. Therefore it is extremely important that a PV installation is not shaded at all by trees, architectural features, flag poles, or other obstructions.

Most modules have bypass diodes between each cell or string of cells that minimize the effects of shading and only lose the power of the shaded portion of the array (The main job of the bypass diode is to eliminate hot spots that form on cells that can cause further damage to the array, and cause fires.).

Sunlight can be absorbed by dust, snow, or other impurities at the surface of the module. This can cut down the amount of light that actually strikes the cells by as much as half. Maintaining a clean module surface will increase output performance over the life of the module.

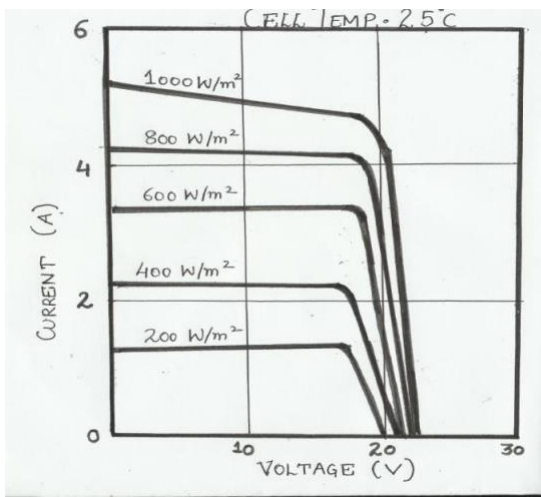
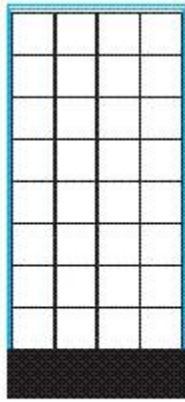
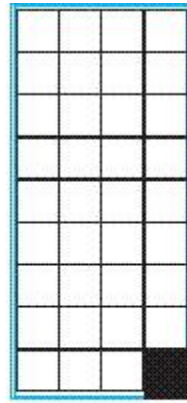


FIG. VI Characteristics showing effect of dirt on solar cell

- Depends on orientation of internal module circuitry relative to orientation of the shading
- Shading can half or even completely eliminates the output of a solar array



Example of full-cell shading that can reduce PV module power to zero



Example of full-cell shading that can reduce PV module power by 1/2

☀ Temperature

Module output and life are also degraded by increased temperature. Allowing ambient air to flow over, and if possible behind, PV modules reduces this problem.

In 2010, solar panels available for consumers can have a yield of up to 19%, while commercially available panels can go as far as 27%. Thus, a photovoltaic installation in the southern latitudes of Europe or the United States may expect to produce 1 kWh/m²/day. A typical "150 watt" solar panel is about a square meter in size. Such a panel may be expected to produce 1 kWh every day, on average, after taking into account the weather and the latitude.

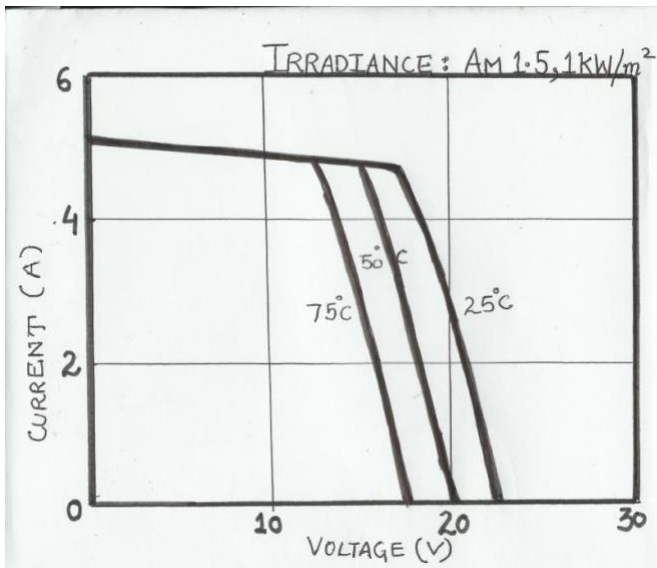


FIG. VI Characteristics showing effect of Temperature

OTHER PARTS OF SOLAR PLANT

1. BATTERY

Battery basics

Battery = device stores electrical energy (chemical to electrical and vice versa)

Capacity = amount of electrical energy battery will contain

STATE OF CHARGE = available battery capacity

Depth of discharge = energy taken out of battery

Efficiency = (energy o/p) / (energy i/p)

Battery Details

TYPES

- Primary (Single Use)
- Secondary (Rechargeable)
- Shallow 20% DOD
- Deep Cycle 80% DOD

Unless lead acid batteries are charged upto 100%, they will lose capacity over time

Serial Connection

Portable equipment needing higher voltages use battery packs with two or more cells connected in series. Figure 1 shows a battery pack with four 1.2V nickel-based cells in series to produce 4.8V. In comparison, a four-cell lead acid string with 2V/cell will generate 8V, and four Li-ion with 3.6V/cell will give 14.40V. A 12V supply should work; most battery-operated devices can tolerate some over-voltage.

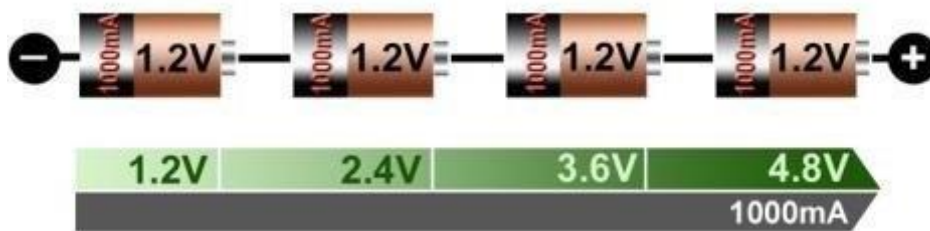


Figure 1: Serial connection of four NiCd or NiMH cells

Adding cells in a string increases the voltage; the current remains the same.

Figure 2 illustrates a battery pack in which “cell 3” produces only 0.6V instead of the full 1.2V. With depressed operating voltage, this battery reaches the end-of-discharge point sooner than a normal pack and the runtime will be severely shortened. The remaining three cells are unable to deliver their stored energy when the equipment cuts off due to low voltage. The cause of cell failure can be a partial short cell that consumes its own charge from within through elevated self-discharge, or a dry-out in which the cell has lost electrolyte by a leak or through inappropriate usage.

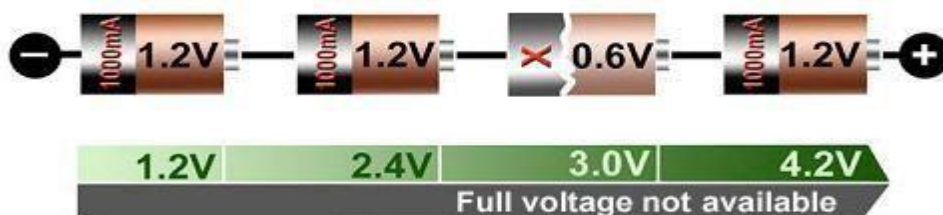


Figure 2: Serial connection with one faulty cell

Faulty “cell 3” lowers the overall voltage from 4.8V to 4.2V, causing the equipment to cut off prematurely. The remaining good cells can no longer deliver the energy.

Parallel Connection

If higher currents are needed and larger cells with increased ampere-hour (Ah) ratings are not available or the design has constraints, one or more cells are connected in parallel. Most

chemistries allow parallel configurations with little side effect. Figure 3 illustrates four cells connected in parallel. The voltage of the illustrated pack remains at 1.2V, but the current handling and runtime are increased fourfold.

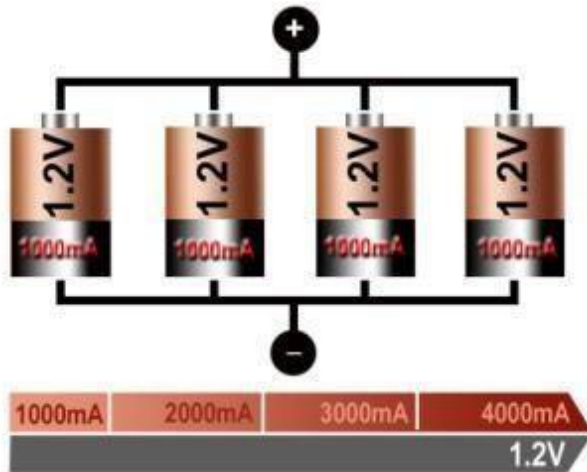


Figure 3: Parallel connection of four cells

With parallel cells, the current handling and runtime increases while voltage stays the same.

A high-resistance cell, or one that is open, is less critical in a parallel circuit than in serial configuration, however, a weak cell reduces the total load capability. It's like an engine that fires on only three cylinders instead of all four. An electrical short, on the other hand, could be devastating because the faulty cell would drain energy from the other cells, causing a fire hazard. Most so-called shorts are of mild nature and manifest themselves in elevated self-discharge. Figure 4 illustrates a parallel configuration with one faulty cell.

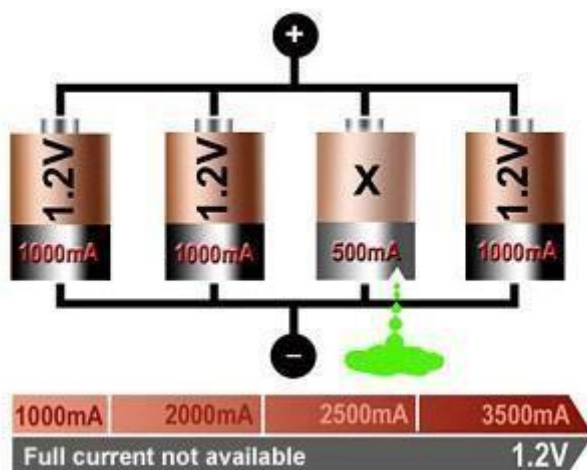


Figure 4: Parallel/connection with one faulty cell

A weak cell will not affect the voltage but will provide a low runtime due to reduced current handling. A shorted cell could cause excessive heat and

Serial/Parallel Connection

The serial/parallel configuration shown in Figure 5 allows superior design flexibility and achieves the wanted voltage and current ratings with a standard cell size. The total power is

the product of voltage times current, and the four 1.2V/1000mAh cells produce 4.8Wh. Serial/parallel connections are common with lithium-ion, especially for laptop batteries, and the built-in protection circuit must monitor each cell individually.

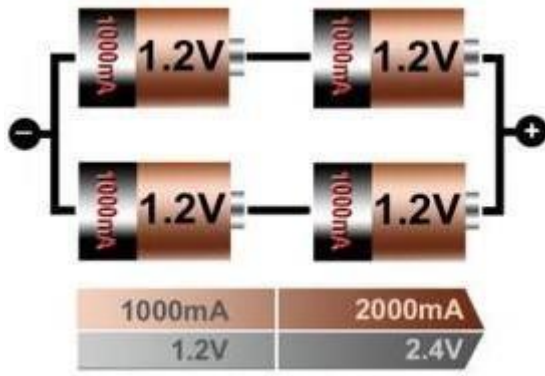


Figure 5: Serial/parallel connection of four cells

This configuration provides maximum design flexibility.

Series connection.

Loads/sources wired in series

- Voltages are additive
- Current is equal
- One interconnection wire is used between two components (- to +)
- Combined module makes series string
- Leave the series string from a terminal not used in series connection

Parallel connection

Load/source wired in parallel

- Voltage remain constant
- Currents are additive
- Two interconnection wires are used between two component (+ to + & - to -)
- Leave off either terminl
- Modules exiting to next component can happen at any parallel terminal

Dissimilar modules in series

- voltage remains additive

If A is 30V/6A and B is 15V/3A, resulting voltage will be 45V

- current taken on lowest value

For modules A and B wired in series, what be the current level of array 3A

Dissimilar modules in parallel

- Amperage remains additive

For same modules A and B, current will be 9A

- voltage taken on lower value.

For same modules A and B, Voltage will be 15V

Battery capacity

Capacity

Ampere X Hours= Amp*Hrs

$$100\text{AH} = 100\text{A} * 1\text{hrs}$$

$$= 1\text{A} * 100\text{hrs}$$

$$= 20\text{A} * 5\text{hrs}$$

- Capacity changes with discharge rate
- Higher the discharge rate, lower the capacity and vice versa
- Higher the temperature higher the percent of rated capacity

Rate of charge or/ discharge

Rate=C/T

C=battery rated capacity

T= cycle time period

Maximum recommended charge or discharge rate=C/3 to C/5

Functions of Battery

- storage for the night
- storage during cloudy weather
- portable power
- surge for starting motors

“due to the expense and inherent inefficiencies of batteries it is recommended that they only be used when absolutely necessary ”

2. CHARGE CONTROLLER

Charge Controller is necessary since the brighter the sunlight, the more voltage the solar cells produce, the excessive voltage could damage the batteries. A charge controller is used to maintain the proper charging voltage on the batteries. As the input voltage from the solar array rises, the charge controller regulates the charge to the batteries preventing any overcharging. Most quality charge controller units have what is known as a 3 stage charge cycle that goes like this:

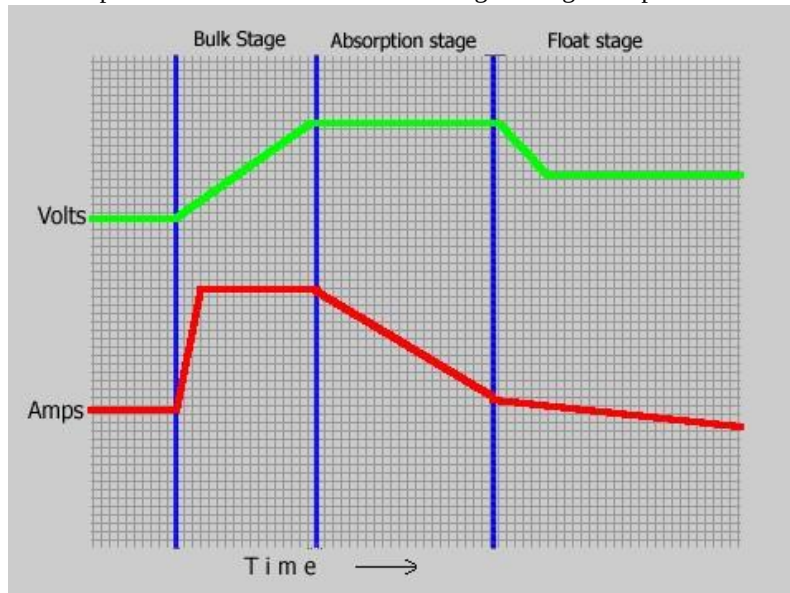


FIG. showing Charge Controller

- 1) **BULK:** During the Bulk phase of the charge cycle, the voltage gradually rises to the Bulk level (usually 14.4 to 14.6 volts) while the batteries draw maximum current. When Bulk level voltage is reached the absorption stage begins.
- 2) **ABSORPTION:** During this phase the voltage is maintained at Bulk voltage level for a specified time (usually an hour) while the current gradually tapers off as the batteries charge up.

3) **FLOAT:** After the absorption time passes the voltage is lowered to float level (usually 13.4 to 13.7 volts) and the batteries draw a small maintenance current until the next cycle.

FIG. showing the relationship between the current and the voltage during the 3 phases of the charge cycle can be shown visually



by the graph below.

3.CHARGE INVERTER



FIG. showing Charge Inverters

Square Wave power inverters: This is the least expensive and least desirable type. The square wave it produces is inefficient and is hard on many types of equipment. These inverters are usually fairly inexpensive.

Modified Sine Wave power inverters: This is probably the most popular and economical type of power inverter. It produces an AC waveform somewhere between a square wave and a pure sine wave.

True Sine Wave power inverters: A True Sine Wave power inverter produces the closest to a pure sine wave of all power inverters and in many cases produces cleaner power than the utility company itself. It will run practically any type of AC equipment and is also the

most expensive. Many True Sine Wave power inverters are computer controlled and will automatically turn on and off as AC loads ask for service.

Grid Tie Power Inverters: Solar grid-tie inverters are designed to quickly disconnect from the grid if the utility grid goes down. This is an NEC requirement that ensures that in the event of a blackout, the grid tie inverter will shut down to prevent the energy it produces from harming any line workers who are sent to fix the power grid. Grid-tie inverters that are available on the market today use a number of different technologies. The inverters may use the newer high-frequency transformers, conventional low-frequency transformers, or no transformer. Many solar inverters are designed to be connected to a utility grid, and will not operate when they do not detect the presence of the grid. They contain special circuitry to precisely match the voltage and frequency of the grid.



FIG. showing inverter

Inverter features

An electronic device used to convert dc into ac

Disadvantages

- Efficiency penalty
- Complexity
- Cost

4. SAFETY EQUIPMENT

Over-Current Protection of PV Systems

According to the National Electric Code, every wire that carries current needs to be protected from exceeding its rated capacity. In fact, each ungrounded electrical conductor within a PV system needs to be protected by overcurrent devices such as fuses or circuit breakers. If the

current through a given circuit exceeds the rated amperage, the fuse or breaker will engage and stop any potential problems down the line such as wires melting, fire, etc. The maximum overcurrent protection is nothing more than the maximum amperage each wire within your system can carry.

Fuses

• Why Use a Fuse

With the positive and negative cables securely fastened to the battery terminals, and the solar panel outside and exposed to the elements, any cable **connection** failure is most likely to happen near the solar panel rather than at the battery. If the end of the negative cable touch any exposed metal of the positive cable (or vice versa), a short **circuit** will occur. Huge amounts of electric current will flow potentially causing sparks, melting the cable, and/or even causing the battery to explode.

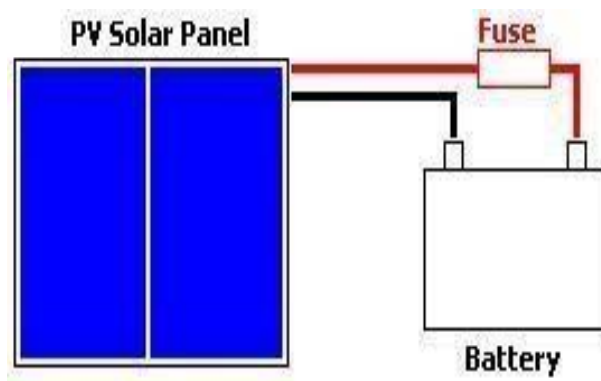


FIG. showing a typical battery and solar panel connection

With an appropriately rated fuse fitted in the positive cable as near to the battery as possible any short circuit will be over within a split second before any serious damage can be done.



FIG. Showing Fuses

DC circuit-breakers

In addition to fuses, protection of photovoltaic modules is provided by string circuit-breakers. They protect photovoltaic modules from fault currents. For example, in large systems they prevent regeneration from intact modules to modules with a short-circuit. Their advantage over fuses is that they are immediately ready for use after a trip and when the cause of the trip has been remedied.



FIG, showing Circuit Breakers

5. Grounding

A ground system provides four primary functions:

- To help disperse or divert energy from lightning strikes
- To provide safety in case some problem or fault energizes the cabinet or chassis of equipment with dangerous voltages
- To provide a controlled RF return path for end-fed (single wire feed) or poorly configured or improperly designed transmission-line fed antennas
- To provide a highly conductive path for induced or directly coupled radio-frequency currents, rather than having them flow in lossy soil

A ground will **NOT**.....

A ground normally will not help reception. The exception is an antenna system design problem or installation problem causing the antenna system to be sensitive to common mode feedline currents. If adding a station ground helps reception or transmission, there is an antenna system flaw.

A ground will not reduce the chances or number of lightning strikes. A properly installed and bonded entrance ground can only reduce or eliminate lightning **damage** from hits.

GRID TIE SOLAR SYSTEM

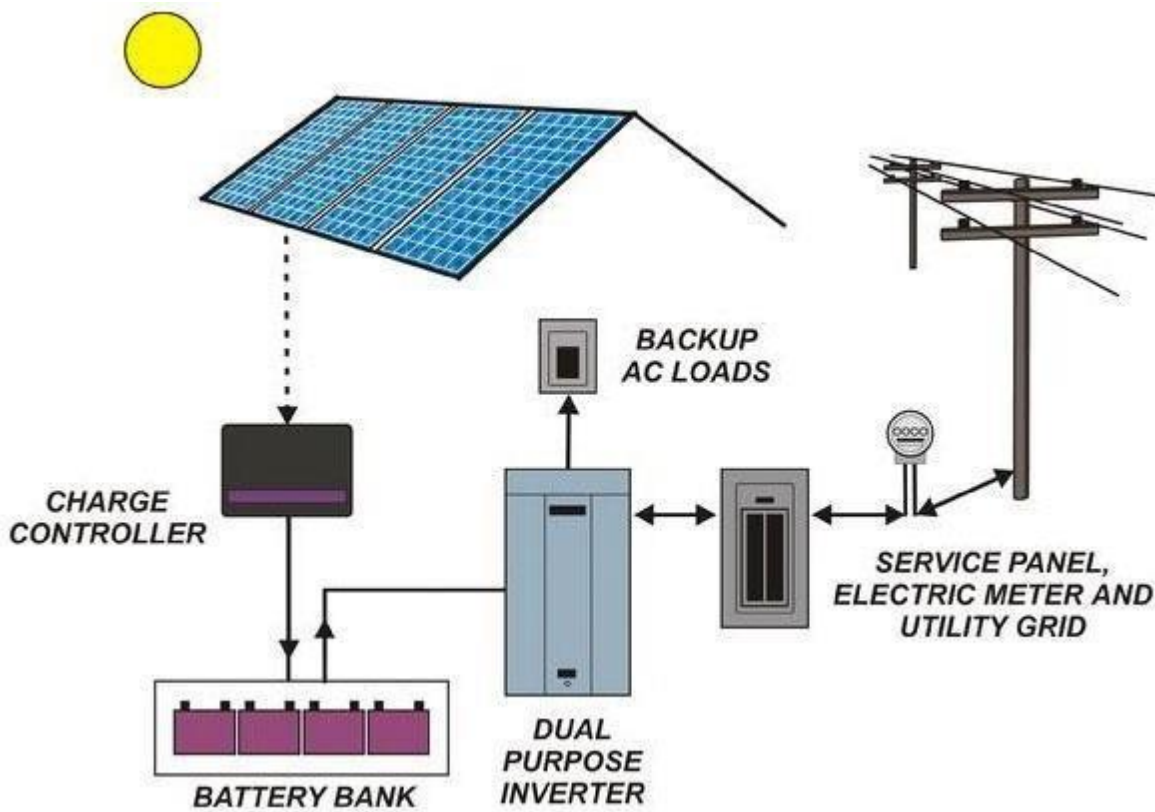


FIG. A typical Grid Tie Solar System

It is a **photovoltaic (PV) system interacting with the utility, and can be with or without batteries**, that utilizes relatively new breed of inverters that can actually sell any excess power produced by your solar array back to the utility grid. These systems are easy to install and since some do not have batteries for back-up, the lack of batteries in these systems means no messy maintenance or replacements to worry about. The solar modules can be mounted on roof or out in the yard.

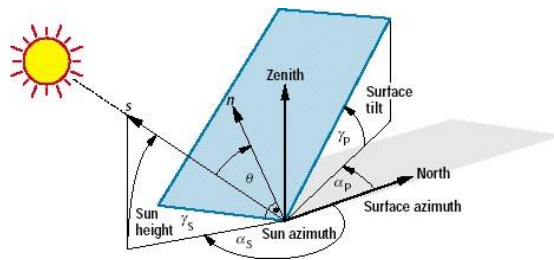
In this system, excess electricity produced is sell back at same retail rate in which one buy electricity from utility company. This is called "**net metering**" and is the simplest way to setup a grid-tie PV system. In such a system you only have one utility kWh meter and it is allowed to spin in either direction depending on buying or selling energy

SOLAR PLANT SITE SELECTION

Solar plant site selection depends upon following factors

- Azimuth & altitude
- Magnetic declination
- Proper orientation & tilt angle for solar collector
- Concept of solar window

Site selection-panel direction



- Face south
- Correct for magnetic declination

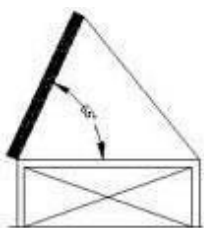
Site selection-tilt angle

Maximum performance is achieved when panels are perpendicular to sun rays

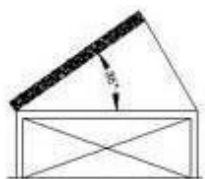
Year round tilt= latitude

Winter = +15 latitude

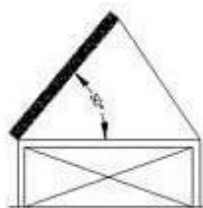
Summer = -15 latitude



Winter



Summer



Year-Round

Solar access

- Optimum solar window 9am-3pm
- Array should have no shading in the window

Solar Pathfinder

Solar Pathfinder is non-electronic. Simple and straight-forward in its engineering, it requires no special skills or technical know-how. One simple tracing does the job and becomes the permanent record for the solar data. When properly cared for, the unit will give the user years of accurate site analysis.



FIG. Showing Solar Path Finder

The Solar Pathfinder uses a highly polished, transparent, convex plastic dome to give a panoramic view of the entire site. All the trees, buildings or other obstacles to the sun are plainly visible as reflections on the surface of the dome. The sunpath diagram can be seen through the transparent dome at the same time.

Because the Solar Pathfinder works on a reflective principle rather than actually showing shadows, it can be used anytime of the day, anytime of the year, in either cloudy or clear weather. The actual position of the sun at the time of the solar site analysis is irrelevant. In fact, the unit is easier to use in the absence of direct sunlight. It could even be used on a moonlit night.

SOLAR TRACKING SYSTEM

Why Solar Tracking Systems

Global warming has increased the demand and request for green energy produced by renewable sources such as solar power. Consequently, solar tracking is increasingly being applied as a sustainable power generating solution.

Solar Tracking System is a device for orienting a solar panel or concentrating a solar reflector or lens towards the sun. Concentrators, especially in solar cell applications, require a high degree of accuracy to ensure that the concentrated sunlight is directed precisely to the powered device. Precise tracking of the sun is achieved through systems with single or dual axis tracking.

Single axis tracking systems

In single axis tracking systems, the panels can turn around the centre axis. LINAk can provide the actuators that tilt the panels.

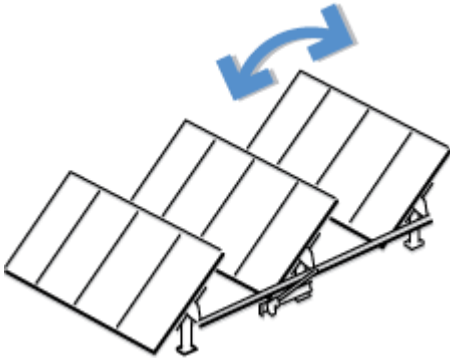


FIG. showing single axis tracking system.

Dual axis tracking systems

Dual axis tracking is typically used to orient a mirror and redirect sunlight along a fixed axis towards a stationary receiver. But the system can also gain additional yield on the PV cells.

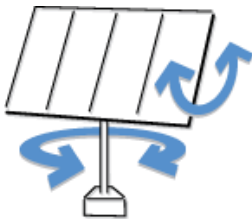


FIG. showing Dual axis tracking system

OFF GRID



Overview of the offgrid Solar Power System

The generator of the solar power system (or the engine) has no moving parts and it is silent. The generator is an array of solar panels. Solar panels are converting sun light radiation directly to DC electrical power, taking advantage of the photoelectric effect.

Since electricity is needed around the clock and the sun (what delivers power to the panels) is available only during daylight, some way to store electricity during the day to be used overnight is a necessity. The third element is the off-grid inverter. The inverter inverts the DC electricity from the battery into more useful AC electricity (220V, 50 Hz). One more necessary element is the *charge controller* that protects the array of batteries from overcharge.

Off-the-grid homes are autonomous; they do not rely on municipal water supply, sewer, natural gas, electrical power grid, or similar utility services. A true off-grid house is able to operate completely independently of all traditional public utility services like

- Lights
- Stereo receiver, tape deck, CD/DVD player
- TV
- Computer, printer/scanner, and satellite modem
- Coffee pot and coffee bean grinder
- Microwave oven
- Vacuum cleaner

SOLAR THERMAL

Solar thermal energy (STE) is a technology for harnessing solar energy for thermal energy (heat). Solar thermal collectors are classified by the USA Energy Information Administration as low-, medium-, or high-temperature collectors. Low temperature collectors are flat plates generally used to heat swimming pools. Medium-temperature collectors are also usually flat plates but are used for heating water or air for residential and commercial use. High

temperature collectors concentrate sunlight using mirrors or lenses and are generally used for electric power production.

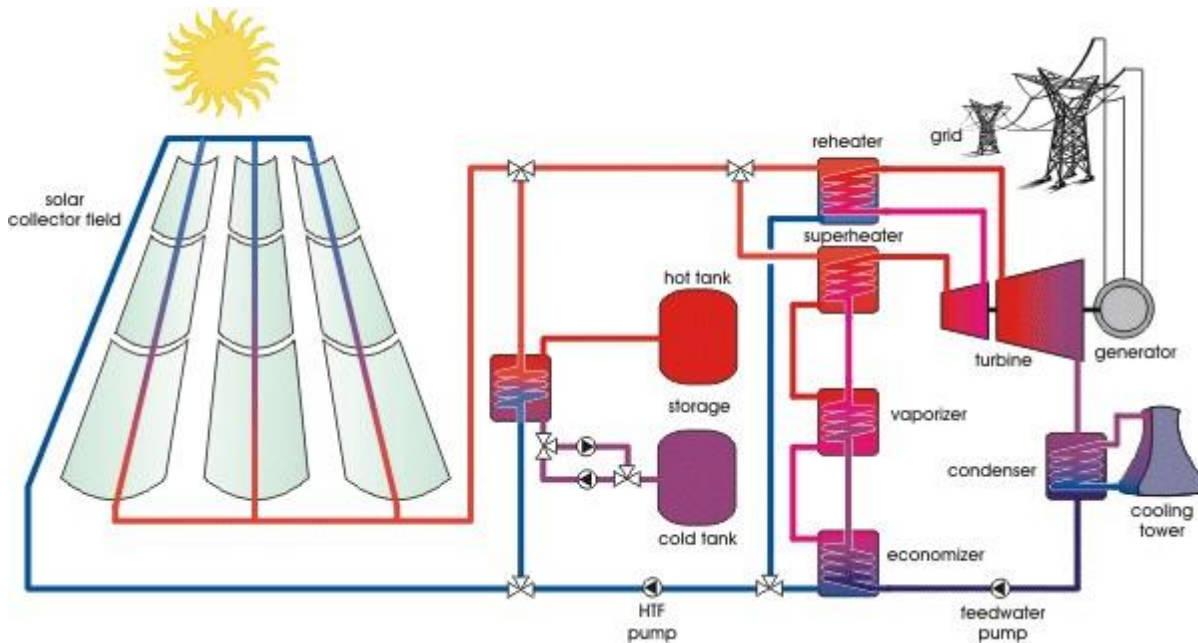


FIG. Showing A Typical Solar Thermal System

In solar thermal, fluid is heated in solar collectors. This highly vaporised fluid produces steam which is used to rotate turbine and this will produce electricity. The steam, after returning from turbine, is condensed and cooled in cooling towers. Cooled steam is feed backed and reused. Electricity generated is supplied to grid.

BIPV



FIG. Showing Building Integrated Photo Voltaic

Building-integrated photovoltaics (BIPV) are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades. They are increasingly being incorporated into the construction of new buildings as a principal or ancillary source of electrical power, although existing buildings may be retrofitted with BIPV modules as well. The advantage of integrated photovoltaics over more common non-integrated systems is that the initial cost can be offset by reducing the amount spent on building materials and labour that would normally be used to construct the part of the building that the BIPV modules replace. These advantages make BIPV one of the fastest growing segments of the photovoltaic industry. Solar panels use a tin oxide coating on the inner surface of the glass panes to conduct current out of the cell. The cell contains titanium oxide that is coated with a photoelectric dye.

Most conventional solar cells use visible and infrared light to generate electricity. In contrast, the innovative new solar cell also uses ultraviolet radiation. Used to replace conventional window glass, or placed over the glass, the installation surface area could be large, leading to potential uses that take advantage of the combined functions of power generation, lighting and temperature control.

SMART GRID

Smart grid is a type of electrical grid which attempts to predict and intelligently respond to the behaviour and actions of all electric power users connected to it - suppliers, consumers and those that do both – in order to efficiently deliver reliable, economic, and sustainable electricity services.

In Europe, the smart grid is conceived of as employing innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

- Better facilitate the connection and operation of generators of all sizes and technologies;
- Allow consumers to play a part in optimising the operation of the system;
- Provide consumers with greater information and options for choice of supply;
- Significantly reduce the environmental impact of the whole electricity supply system;
- Maintain or even improve the existing high levels of system reliability, quality and security of supply;
- Maintain and improve the existing services efficiently;

Goals of the Smart Grid

Broadly stated, a smart grid could respond to events which occur anywhere in the power generation, distribution and demand chain. Events may occur generally in the environment, e.g., clouds blocking the sun and reducing the amount of solar power or a very hot day requiring increased use of air conditioning. They could occur commercially in the power supply market, e.g., customers change their use of energy as prices are set to reduce energy use during high peak demand. Each event motivates a change to power flow.

Smart energy demand describes the energy user component of the smart grid. It goes beyond and means much more than even energy efficiency and demand response combined. Smart energy demand is what delivers the majority of smart meter and smart grid benefits.

Smart energy demand is a broad concept. It includes any energy-user actions to:

- Enhancement of reliability
- Reduce peak demand,
- Shift usage to off-peak hours,
- Lower total energy consumption,
- Actively manage electric vehicle charging,
- Actively manage other usage to respond to solar, wind, and other renewable resources, and
- Buy more efficient appliances and equipment over time based on a better understanding of how energy is used by each appliance or item of equipment.

All of these actions minimize adverse impacts on electricity grids and maximize consumer savings.

Smart Energy Demand mechanisms and tactics include:

- Smart meters,
- Dynamic pricing,

- Smart thermostats and smart appliances,
- Automated control of equipment,
- Real-time and next day energy information feedback to electricity users,
- Usage by appliance data, and
- Scheduling and control of loads such as electric vehicle chargers, home area networks (HANs), and others

Smart grid functions

According to the United States Department of Energy's Modern Grid Initiative report, a modern smart grid must:

1. Be able to heal itself
2. Motivate consumers to actively participate in operations of the grid
3. Resist attack
4. Provide higher quality power that will save money wasted from outages
5. Accommodate all generation and storage options
6. Enable electricity markets to flourish
7. Run more efficiently
8. Enable higher penetration of intermittent power generation sources

SOFTWARE SOLAR PRO

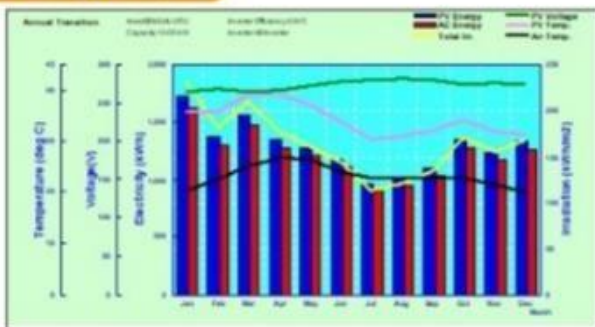
- Solar pro is used to create 3D models of residentials, commercial flat-roof, ground-mounted, and single & dual-axis tracker PV system. The shading effects of each object created in solar pro, including trees, buildings and adjacent PV arrays, can be easily visualized on a minute-by-minute basis, 365 days of the year.
- Solar pro predicts hourly electricity generation using scientific, industry-standard mathematical models. IV curve calculations are performed at the module level and take into account irradiation & temperature data, shading, and other detailed loss factors.



PV GENERATION SYSTEM SIMULATION

- ▶ This is a example report for Bangalore.
- ▶ This report has a energy graph, each month detailed report, economy simulation and PV data for complete 365 days.

Energy Graph



Location and PV data

*Location

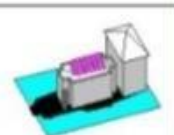
BENGALURU
INDIA
[Address]

*Title

[Words]

*PV System Information

Capacity: 10.05kW
System Setting: 1 Inverter, 3 Parallel, 10 Series
Manufacturer: WINACO
Model: WSP-335MX

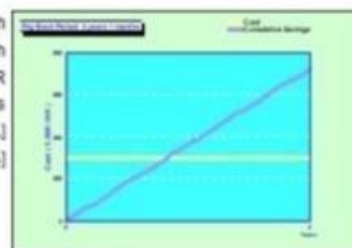


12-Month Detailed Report

Month	AC Energy	Electricity AC Energy	Electricity AC Energy	Electricity AC Energy	Electricity AC Energy	Electricity AC Energy
Jan	1,251.30	1,251.30	0.00	12,315	12,315	0
Feb	1,305.34	1,305.34	0.00	13,095	13,095	0
Mar	1,485.02	1,485.02	0.00	14,890	14,890	0
Apr	1,285.36	1,285.36	0.00	12,864	12,864	0
May	1,212.77	1,212.77	0.00	12,129	12,129	0
Jun	1,121.43	1,121.43	0.00	11,214	11,214	0
Jul	912.23	912.23	0.00	9,122	9,122	0
Aug	962.27	962.27	0.00	9,625	9,625	0
Sep	1,046.67	1,046.67	0.00	10,467	10,467	0
Oct	1,284.27	1,284.27	0.00	12,843	12,843	0
Nov	1,177.40	1,177.40	0.00	11,774	11,774	0
Dec	1,270.34	1,270.34	0.00	12,709	12,709	0
Max Value	1,485.02	1,485.02	0.00	14,890	14,890	0
Min Value	912.23	912.23	0.00	9,122	9,122	0
Avg Value	1,251.30	1,251.30	0.00	12,315	12,315	0

Economy Simulation

Annual AC Energy: 14,700 kWh
Annual Load Energy: 0 kWh
Electric Bill Reduction: 147,004 INR
Pay Back Period: 2 years 1 months
Crude Oil Reduction: 3,778 [L]
CO2 Reduction: 7,527 [kg-CO₂]



*User Text

www.sauryaenertech.com

www.apollosolar.com

www.batteryuniversity.com

www.greenworldinvestor.com

www.hvvn.com www.sesi.com

www.reeep.com

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www.solarsouthwest.org

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www.timesofindia.com

