Kurdistan Engineers Union
Iraqi Kurdistan Region

Design and Installation of Solar Electric System

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Abstract

The main objective of this article is to Design of Solar Electric System, Installation and Operation For the purpose of decreasing Load , on network, also the electric networks performance is increased via installing grid-connected PV systems. However, power and voltage fluctuation issues, malfunctioning of protective devices, under loading and overloading of feeders and harmonic distortions are probably undesirable consequences. Thus, the dynamic voltage instability is highly affected by the parameters of PV system, like cloud shedding effects, temperature, and rapid alteration in solar radiation, and PV power drop is shortly affected by voltage cloud sweep, leading to fluctuation of voltage and voltage drop in situation of having huge load boost.

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1. Introduction

As the demand for solar electric systems grows, progressive builders are adding solar photovoltaic (PV) as an option for their customers. This overview of solar photovoltaic systems will give the builder a basic understanding of:

- Evaluating a building site for its solar potential
- Common grid-connected PV system configurations and components
- Considerations in selecting components
- Considerations in design and installation of a PV system
- Typical costs and the labor required to install a PV system
- Building and electric code requirements

Where to find more information Emphasis will be placed on information that will be useful in including a grid-connected PV system in a bid for a residential or small commercial building. We will also cover those details of the technology and installation that may be helpful in selecting subcontractors to perform the work, working with a designer, and directing work as it proceeds. A summary of system types and components is given so the builder will know what to expect to see in a design submitted by a subcontractor or PV designer.

2. EVALUATING A SITE FOR SOLAR PV POTENTIAL.

Does the Iraqi Kurdistan Have Good Solar Potential? This is a very common question and the answer is, yes, it gets enough sun for grid-connected photovoltaic systems to operate well and receives as much solar energy annually as the other countries average.

Evaluating a Building Site

While the Iraqi Kurdistan may have well to excellent solar potential, not every building site will be suitable for a solar installation. The first step in the design of a photovoltaic system is determining if the site you are considering has good solar potential. Some questions you should ask are:

- Is the installation site free from shading by nearby trees, buildings or other obstructions?
- Can the PV system be oriented for good performance?
- Does the roof or property have enough area to accommodate the solar array?
- If the array will be roof-mounted, what kind of roof is it and what is its condition?

2.1. Mounting Location –

Solar modules are usually mounted on roofs. If roof area is not available, PV modules can be pole-mounted, ground-mounted, wall-mounted or installed as part of a shade structure (refer to the section "System Components/Array Mounting Racks" below).

2.2. Shading

Photovoltaic arrays are adversely affected by shading. A well-designed PV system needs clear and unobstructed access to the sun's rays from about 9 a.m. to 3 p.m., throughout the year. Even small shadows, such as the shadow of a single branch of a leafless tree can significantly reduce the power output of a solar module.

1 Shading from the building itself – due to vents, attic fans, skylights, gables or overhangs – must also be avoided. Keep in mind that an area may be unshaded during one part of the day, but shaded at another part of the day. Also, a site that is unshaded in the summer may be shaded in the winter due to longer winter shadows.

2.3. Orientation

This is because when manufacturers assemble solar modules from cells, they wire groups of cells in series with each other. Shading one cell will essentially turn off all the cells in its group. Shading can be evaluated using tools such as the "Solar Path Finder" (www.solarpathfinder.com).

2.4. Tilt

To achieve yearly maximum output of power in the winter and in the summer generally the optimum tilt of a PV array must be calculated

3. PHOTOVOLTAIC SYSTEM TYPES

There are three main **types** of **solar PV** and storage **systems**: **grid**-tied, **grid**/hybrid and off-**grid**. They all have their advantages and disadvantages and it really comes down to the customer's current **energy** supply and what they want to get out of the **system**

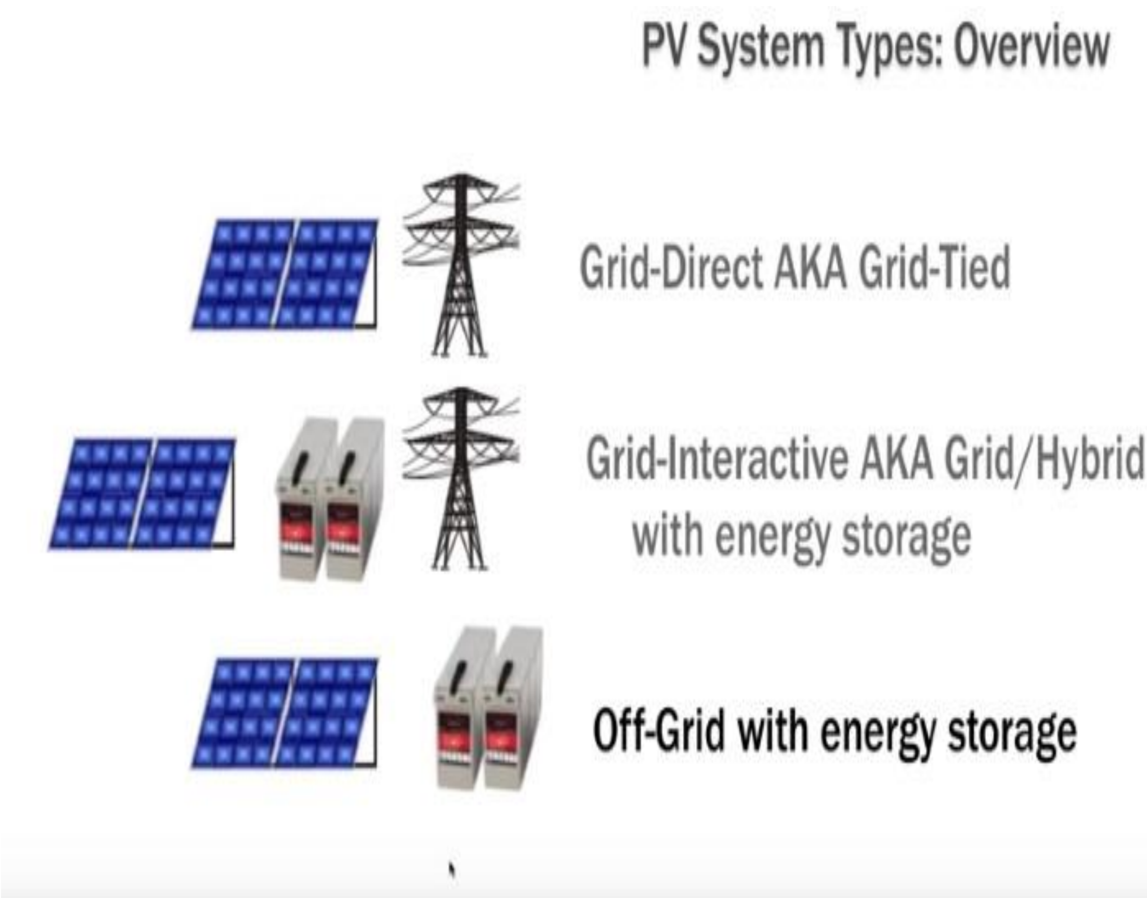


Figure 1 Photovoltaic System Types

3.1. Grid-tied system

A grid-tied system is a basic solar installation that uses a standard grid-tied inverter and does not have any battery storage. This is perfect for customers who are already on the grid and want to add solar to their house. These systems can qualify for state and federal incentives which help to pay for the system. Grid-tied systems are simple to design and are very cost effective because they have relatively few components. The main objective of a grid-tied system is to lower your energy bill and benefit from solar incentives.

One disadvantage of this type of system is that when the power goes out, so does your system. This is for safety reasons because linemen working on the power lines need to know there is no source feeding the grid. Grid-tied inverters have to automatically disconnect when they don't sense the grid. This means that you cannot provide power during an outage or an emergency and you can't store energy for later use. You also can't control when you use the power from your system, such as during peak demand time.

But if a customer has a basic grid-tied system, they are not out of luck if they want to add storage later. The solution is doing an AC-coupled system where the original grid tied inverter is coupled with a battery back-up inverter. This is a great solution for customers who want to install solar now to take advantage of incentives, but aren't ready to invest in the batteries just yet.

A customer can benefit from net-metering because when the solar is producing more than they are using, they can send power back to the grid. But in times when the loads are higher than what the solar is producing they can buy power from the utility. The customer is not reliant on the solar to power all of his or her load. The main take away is that when the grid goes down, the solar is down as well and there's no battery back-up in the system.

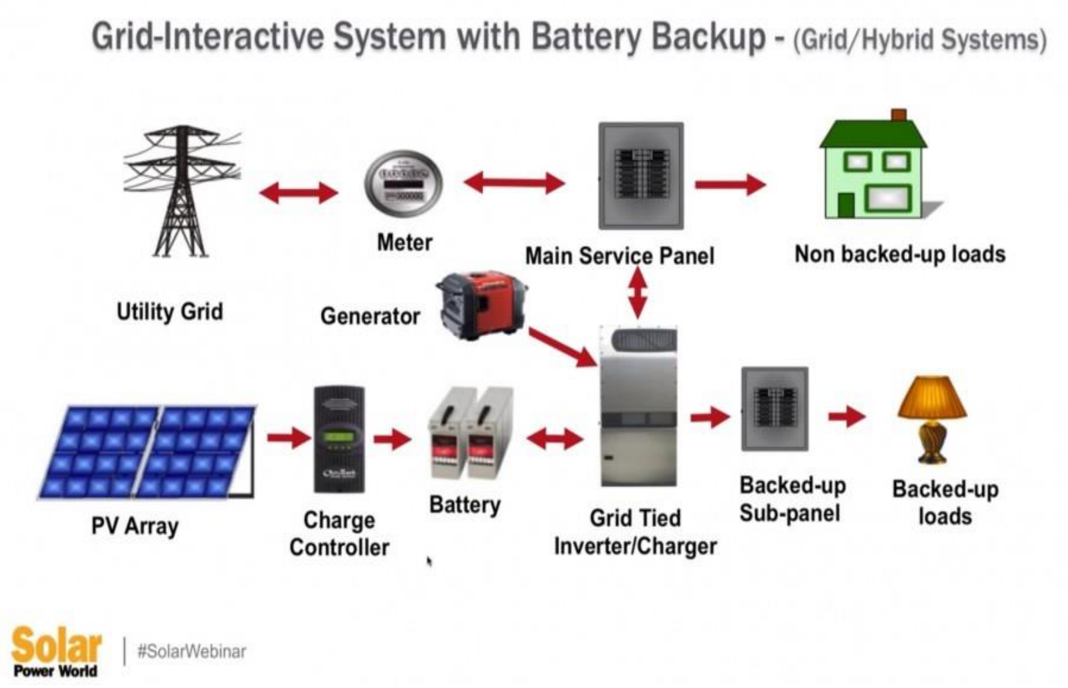


Figure 2 Grid Interactive System with Battery Back Up (Grid\Hybrid System)

3.2. Grid-tied system with battery back-up

The next type of system is a grid tied system with battery back-up, otherwise known as a grid-hybrid system. This type of system is ideal for customers who are already on the grid who know that they want to have battery back-up. Good candidates for this type of system are customers who are prone to power outages in their area, or generally just want to be prepared for outages.

With this type of system, you get the best of both worlds because you're still connected to the grid and can qualify for state and federal incentives, while also lowering your utility bill. At the same time, if there's a power outage you have back up. Battery based grid-tied systems provide power during an outage and you can store energy for use in an emergency. You are able to back up essential loads such as lighting and appliances when the power is out. You can also use energy during peak demand times because you can store the energy in your battery bank for later use.

Cons of this system are that they cost more than basic grid-tied systems and are less efficient. There are also more components. The addition of the batteries also requires a charge controller to protect them. There must also be a sub panel that contains the important loads that you want to be backed up.

Not all the loads that the house uses on the grid are backed up with the system. Important loads that are needed when the grid power is down are isolated into a back-up sub panel.

3.3. Off-grid system

Off-grid systems are great for customers who can't easily connect to the grid. This may be because of geographical location or high cost of bringing in the power supply. In most cases, it doesn't make much sense for a person connected to the grid to completely disconnect and do an off-grid system.

The benefits of an off grid system is that a person can become energy self-sufficient and can power remote places away from the grid. You also have fixed energy costs and won't be getting a bill from your energy use. Another neat aspect of off grid systems is that they are modular and you can increase the capacity as your energy needs grow. You can start out with a small, budget-conscious system and add on over time.

Because the system is your only source of power, many off-grid systems contain multiple charging sources such as solar, wind and generator. You have to consider weather and year round conditions when designing the system. If your solar panels are covered in snow, you need to have another way to keep your batteries charged up. You also will most likely want to have a back-up generator just in case your renewable sources are not enough at times to keep the batteries charged.

One disadvantage is that off-grid systems may not qualify for some incentive programs. You have to also design your system to cover 100% of your energy loads, and hopefully even a little bit more. Off-grid systems have more components and are more expensive than a standard grid-tied system as well.

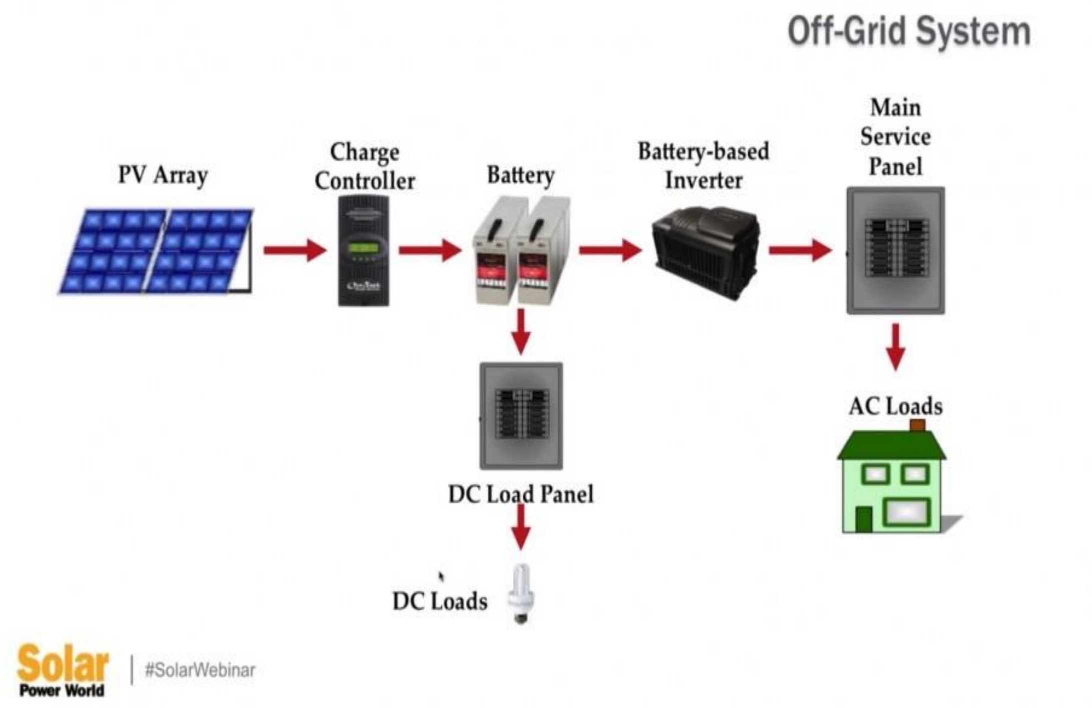


Figure 3 off Grid System

4. System Components

Basic components of grid-connected PV systems with and without batteries are:

1. Solar photovoltaic modules
2. Array mounting racks
3. Grounding equipment
4. Combiner box
5. Surge protection (often part of the combiner box)
6. Inverter
7. Meters – system meter and kilowatt-hour meter
8. disconnects:

   - Array DC disconnect

   - Inverter DC disconnect

- Inverter AC disconnect
- Exterior AC disconnect

If the system includes batteries, it will also require:

1. Battery bank with cabling and housing structure
2. Charge controller
3. Battery disconnect

5.Solar photovoltaic modules

The heart of a photovoltaic system is the solar module. Many photovoltaic cells are wired together by the manufacturer to produce a solar module. When installed at a site, solar modules are wired together in series to form strings. Strings of modules are connected in parallel to form an array.

5.1. Module Types

Rigid flat framed modules are currently most common and most of these are composed of silicon. Silicon cells have atomic structures that are single-crystalline (a.k.a. mono-crystalline), poly-crystalline (a.k.a. multi-crystalline) or amorphous (a.k.a. thin film silicon). Other cell materials used in solar modules are cadmium telluride (CdTe, commonly pronounced “CadTel”) and copper indium diselenide (CIS). Some modules are manufactured using combinations of these materials. An example is a thin film of amorphous silicon deposited onto a substrate of single-crystalline silicon.

5.2. Building Integrated Photovoltaic Products

PV technology has been integrated into roofing tiles, flexible roofing shingles, roofing membranes, adhesive laminates for metal standing-seam roofs, windows, and other building integrated photovoltaic (BIPV) products

5.3. Rated power

Is the maximum power the panel can produce with 1,000 watts of sunlight per square meter at a module temperature of 25o C or 77o F in still air. Actual conditions will rarely match rated conditions and so actual power output will almost always be less.

5.4. PV System Voltage

Modern systems without batteries are typically wired to provide from 235V to 600V. In battery-based systems, the trend is also toward use of higher array voltages, although many charge controllers still require lower voltages of 12V, 24V or 48V to match the voltage of the battery string.

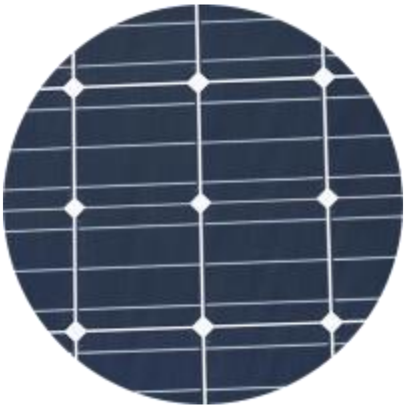
5.5. Warranty

It is important to verify warranty periods of all components of the system, including solar modules. Most modules are very durable, long lasting and can withstand.

Different types of solar panels serve different needs and purposes.

1st Generation Solar Panels

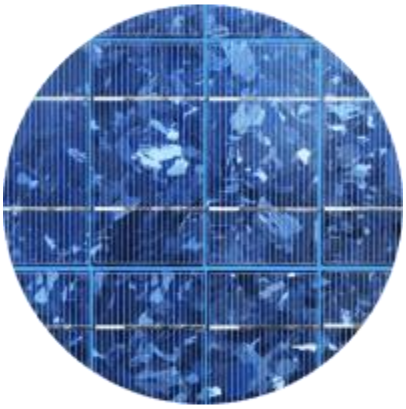
These are the traditional types of solar panels made of monocrystalline silicon or polysilicon and are most commonly used in conventional surroundings. Mon crystalline Solar Panels (Mono-SI)



This type of solar panels (made of monocrystalline silicon) is the purest one. You can easily recognise them from the uniform dark look and the rounded edges. The silicon's high purity causes this type of solar panel has one of the highest efficiency rates, with the newest ones reaching above 20%.

Monocrystalline panels have a high power output, occupy less space, and last the longest. Of course, that also means they are the most expensive of the bunch. Another advantage to consider is that they tend to be slightly less affected by high temperatures compared to polycrystalline panels.

Polycrystalline Solar Panels (Poly-SI)



You can quickly distinguish these panels because this type of solar panels has squares, its angles are not cut, and it has a blue, speckled look. They are made by melting raw silicon, which is a faster and cheaper process than that used for monocrystalline panels.

This leads to a lower final price but also lower efficiency (around 15%), lower space efficiency, and a shorter lifespan since they are affected by hot temperatures to a greater degree. However, the differences between mono- and polycrystalline types of solar panels are not so significant and the choice will strongly depend on your specific situation. The first option offers a slightly higher space efficiency at a slightly higher price but power outputs are basically the same.

2nd Generation Solar Panels

These cells are different types of thin film solar cells and are mainly used for photovoltaic power stations, integrated in buildings or smaller solar systems.

Thin-Film Solar Cells (TFSC)

If you are looking for a less expensive option, you might want to look into thin-film. Thin-film solar panels are manufactured by placing one or more films of photovoltaic material (such as silicon, cadmium or copper) onto a substrate. These types of solar panels are the easiest to produce and economies of scale make them cheaper than the alternatives due to less material being needed for its production.

They are also flexible—which opens a lot of opportunities for alternative applications—and is less affected by high temperatures. The main issue is that they take up a lot of space, generally making them unsuitable for residential installations. Moreover, they carry the shortest warranties because their lifespan is shorter than the mono- and polycrystalline types of solar panels. However, they can be a good option to choose among the different types of solar panels where a lot of space is available.

Amorphous Silicon Solar Cell (A-Si)

Have you ever used a solar powered pocket calculator? Yes? Then you have definitely seen these types of solar panels before. The amorphous silicon solar cell is among the different types of solar panels, the one that is used mainly in such pocket calculators. This type of solar panel uses a triple layered technology, which is the best of the thin film variety.

Just to give a brief impression of what “thin” means, in this case, we’re talking about a thickness of 1 micrometre (one millionth of a metre). With only 7% efficiency rate, these cells are less effective than crystalline silicon ones—that have an efficiency rate of circa 18%—but the advantage is the fact that the A-Si-Cells are relatively low in cost.

3rd Generation Solar Panels

3rd generation solar panels include a variety of thin film technologies but most of them are still in the research or development phase. Some of them generate electricity by using organic materials, others use inorganic substances (CdTe for instance).

Bio hybrid Solar Cell

The Biohybrid solar cell is one of the types of solar panels, that is still in the research phase. It has been discovered by an expert team at Vanderbilt University. The idea behind the new technology is to take advantage of the photosystem 1 and thus emulate the natural process of photosynthesis. In case you want to learn more about how the biohybrid solar cell works in detail, read more about it in the American Journal of Optics and Photonics. It explains more detailed how these cells work. Many of the materials being used in this cell are similar to the traditional methods, but only by combining the multiple layers of photosystem 1, the conversion from chemical to electrical energy becomes much more effective (up to 1000 times more efficient than 1st generation types of solar panels).

Cadmium Telluride Solar Cell (CdTe)

Among the collection of different types of solar panels, this photovoltaic technique uses Cadmium Telluride, which enables the production of solar cells at relatively low cost and thus a shorter payback time (less than a year). Of all solar energy technologies, this is the one requiring the least amount of water for production. Keeping the short energy payback time in mind, CdTe solar cells will keep your carbon footprint as low as possible. The only disadvantage of using Cadmium Telluride is its characteristic of being toxic, if ingested or inhaled. In Europe especially, this is one of the greatest barriers to overcome, as many people are very concerned about using the technology behind this type of solar panel.

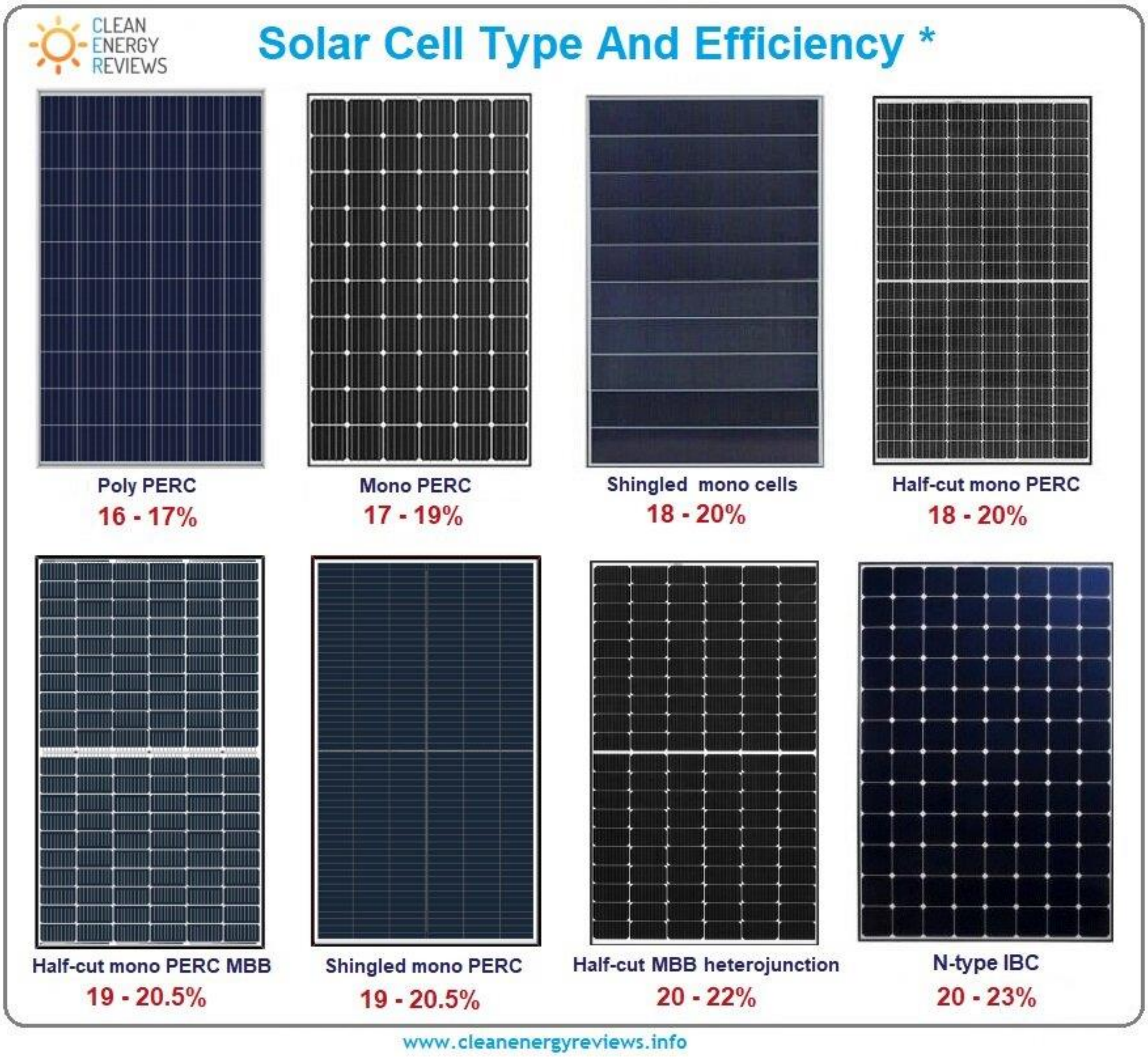


Figure 4 Solar Cell Type And Efficiency

6. Array Mounting Racks

Arrays are most commonly mounted on roofs or on steel poles set in concrete. In certain applications, they may be mounted at ground level or on building walls. Solar modules can also be mounted to serve as part or all of a shade structure such as a patio cover. On roof-mounted systems, the PV array is typically mounted on fixed racks, parallel to the roof for aesthetic reasons and stood off several inches above the roof surface to allow airflow that will keep them as cool as practical.

7. Grounding Equipment

Grounding equipment provides a well-defined, low-resistance path from your system to the ground to protect your system from current surges from lightning strikes or equipment malfunctions. Grounding also stabilizes voltages and provides a common reference point. concerning local code requirements. Equipment Grounding – Equipment grounding provides protection from shock caused by a ground fault. A ground fault occurs when a current-carrying conductor comes into contact with the frame or chassis of an appliance or electrical box. All system components and any exposed metal, including equipment boxes, receptacles, appliance frames and PV mounting equipment, should be grounded.

System Grounding

System grounding requires taking one conductor from a two-wire system and connecting it to ground. In a DC system, this means bonding the negative conductor to ground at one single point in the system. This must be accomplished inside the inverter, not at the PV array.

8. Combiner Box

Wires from individual PV modules or strings are run to the combiner box, typically located on the roof. These wires may be single conductor pigtails with connectors that are pre-wired onto the PV modules. The output of the combiner box is one larger two wire conductor in conduit. A combiner box typically includes a safety fuse or breaker for each string and may include a surge protector.

9.Surge Protection

Surge protectors help to protect your system from power surges that may occur if the PV system or nearby power lines are struck by lightning. A power surge is an increase in voltage significantly above the design voltage.

10. Meters and Instrumentation

Essentially two types of meters are used in PV systems:

- Utility Kilowatt-hour Meter
- System Meter Utility Kilowatt-Hour Meter –

The utility kilowatt-hour meter measures energy delivered to or from the grid. On homes with solar electric systems, utilities typically install bidirectional meters with a digital display that keeps separate track of energy in both directions. Some utilities will allow you to use a conventional meter that can spin in reverse. In this case, the utility meter spins forward when you are drawing electricity from the grid and backwards when your system is feeding or "pushing" electricity onto the grid.

System Meter

The system meter measures and displays system performance and status. Monitored points may include power production by modules, electricity used, and battery charge. It is possible to operate a system without a system meter, though meters are strongly recommended. Modern charge controllers incorporate system monitoring functions and so a separate system meter may not be necessary.

11. Inverter

Inverters take care of four basic tasks of power conditioning:

- Converting the DC power coming from the PV modules or battery bank to AC power
- Ensuring that the frequency of the AC cycles is 60 cycles per second
- Reducing voltage fluctuations
- Ensuring that the shape of the AC wave is appropriate for the application, i.e. a pure sine wave for grid-connected systems

Criteria for Selecting a Grid-Connected Inverter

The following factors should be considered for a grid-connected inverter:

- listing of the inverter for use in a grid-interactive application
- The voltage of the incoming DC current from the solar array or battery bank.
- The DC power window of the PV array

• Characteristics indicating the quality of the inverter, such as high efficiency and good frequency and voltage regulation

• Additional inverter features such as meters, indicator lights, and integral safety disconnects

• Manufacturer warranty, which is typically 5-10 years

• Maximum Power Point Tracking (MPPT) capability, which maximizes power output

Most grid-connected inverters can be installed outdoors, while most off-grid inverters are not weatherproof. There are essentially two types of grid-interactive inverters: those designed for use with batteries and those designed for a system without batteries.

Power Quality

Inverters for grid-connected systems produce better than utility-quality power. For grid-connection, the inverter must have the words “Utility-Interactive” printed directly on the listing label

Voltage Input

The inverter’s DC voltage input window must match the nominal voltage of the solar array, usually 235V to 1000V for systems without batteries and 12, 24 or 48 volts for battery-based systems.

AC Power Output

Grid-connected systems are sized according to the power output of the PV array, rather than the load requirements of the building. This is because any power requirements above what a grid-connected PV system can provide is automatically drawn from the grid.

Surge Capacity

The starting surge of equipment such as motors is not a consideration in sizing grid-connected inverters. When starting, a motor may draw as much as seven times its rated wattage. For grid-connected systems, this start-up surge is automatically drawn from the grid.

Frequency and Voltage Regulation

Better quality inverters will produce near constant output voltage and frequency.

Efficiency

Modern inverters commonly used in residential and small commercial systems have peak efficiencies of 92 percent to 94 percent, as rated by their manufacturers. Actual field conditions usually result in overall efficiencies of about 88 percent to 92 percent. Inverters for battery-based systems have slightly lower efficiencies

Integral Safety Disconnects

The AC disconnect in most inverter models may not meet requirements of the electric utility (see section "Disconnects"). Therefore, a separate exterior AC disconnect may be required even if one is included in the inverter. All inverters that are UL listed for grid-connection include both DC disconnects (PV input) and AC disconnects (inverter output). In better inverters, the inverter section can be removed separately from the DC and AC disconnects, facilitating repair.

Maximum Power Point Tracking (MPPT)

Modern non-battery based inverters include maximum power point tracking. MPPT automatically adjusts system voltage such that the PV array operates at its maximum power point. For battery-based systems, this feature has recently been incorporated into better charge controllers.

Inverter-Chargers

For battery-based systems, inverters are available with a factoryintegrated charge controller, referred to as inverter-chargers. Be sure to select an inverter-charger that is rated for grid-connection, however. In the event of a grid power outage, use of an inverter-charger that is not set up for grid-connection would result in overcharging and damaging the batteries, known as "cooking the batteries."

Automatic Load Shedding

For battery-based systems, the inverter can automatically shed any unnecessary loads in the event of a utility power outage. Solar loads, i.e. the loads that will be kept powered up during the outage, are connected to a separate electrical sub-panel. A battery-based system must be designed to power these critical loads.

Warranty

Inverters typically carry warranties of 5 years, although the industry is moving toward a 10-year warranty. The transformer and solid state components of an inverter are both susceptible to overheating and damage from power spikes, reducing its life.

12. Disconnects

Automatic and manual safety disconnects protect the wiring and components from power surges and other equipment malfunctions. They also ensure the system can be safely shut down and system components can be removed for maintenance and repair. For grid connected systems, safety disconnects ensure that the generating equipment is isolated from the grid, which is important for the safety of utility personnel. In general, a disconnect is needed for each source of power or energy storage device in the system. For each of the functions listed below, it is not always necessary to provide a separate disconnect. For example, if an inverter is located outdoors, a single DC disconnect can serve the function of both the array DC disconnect and the inverter DC disconnect. Before omitting a separate disconnect, however, consider if this will ever result in an unsafe condition when performing maintenance on any component. Also consider the convenience of the disconnects location. An inconveniently located disconnect may lead to the tendency to leave the power on during maintenance, resulting in a safety hazard.

Array DC Disconnect

The array DC disconnect, also called the PV disconnect, is used to safely interrupt the flow of electricity from the PV array for maintenance or troubleshooting. The array DC disconnect may also have integrated circuit breakers or fuses to protect against power surges.

Inverter AC Disconnect

The inverter AC disconnect disconnects the PV system from both the building's electrical wiring and the grid. Frequently, the AC disconnect is installed inside the building's main electrical panel. However, if the inverter is not located near the electrical panel, an additional AC disconnect should be installed near the inverter

Exterior AC Disconnect

Utilities commonly require an exterior AC disconnect that is lockable, has visible blades and is mounted next to the utility meter so that it is accessible to utility personnel. An AC disconnect located inside the electrical panel or integral to the inverter would not satisfy these requirements. One alternative that is as acceptable to some utilities as an accessible AC disconnect is the removal of the meter itself, but this is not the norm. Prior to purchasing equipment, consult the electric utility to determine their requirements for interconnection.

Battery DC Disconnect

In a battery-based system, the battery DC disconnect is used to safely disconnect the battery bank from the rest of the system.

13.Battery Bank

Batteries store direct current electrical energy for later use. This energy storage comes at a cost, however, since batteries reduce the efficiency and output of the PV system, typically by about 10 percent for lead-acid batteries. Batteries also increase the complexity and cost of the system.

Types of batteries commonly used in PV systems are:

Batteries used in home energy storage typically are made with one of three chemical compositions: lead acid, lithium ion, and saltwater. In most cases, **lithium ion batteries** are the best option for a solar panel system, though other battery types can be more affordable.

Lead acid

Lead acid batteries are a tested technology that has been used in off-grid energy systems for decades. While they have a relatively short life and lower DoD than other battery types, they are also one of the least expensive options currently on the market in the home energy storage sector. For homeowners who want to go off the grid and need to install lots of energy storage, lead acid can be a good option.

Lithium ion

The majority of new home energy storage technologies, such as the , use some form of lithium ion chemical composition. Lithium ion batteries are lighter and more compact than lead acid batteries. They also have a higher DoD and longer lifespan when compared to lead acid batteries. However, lithium ion batteries are more expensive than their lead acid co**unterparts.**

Saltwater

A newcomer in the home energy storage industry is the saltwater battery. Unlike other home energy storage options, saltwater batteries don't contain heavy metals, relying instead on saltwater electrolytes. While batteries that use heavy metals, including lead acid and lithium ion batteries, need to be disposed of with special processes, a saltwater battery can be easily recycled. However, as a new technology, saltwater batteries are relatively untested, and the one company that makes solar batteries for home use (Aquion) filed for bankruptcy in 2017.

14.Charge Controller

A charge controller, sometimes referred to as a photovoltaic controller or battery charger, is only necessary in systems with battery back-up. The primary function of a charge controller is to prevent overcharging of the batteries. Most also include a low voltage disconnect that prevents over-discharging batteries. In addition, charge controllers prevent charge from draining back to solar modules at night. Some modern charge controllers incorporate maximum power point tracking, which optimizes the PV array's output, increasing the energy it produces.

Types of Charge Controllers

There are essentially two types of controllers:

Shunt and series. A shunt controller bypasses current around fully charged batteries and through a power transistor or resistance heater where excess power is converted into heat. Shunt controllers are simple and inexpensive, but are only designed for very small systems. Series controllers stop the flow of current by opening the circuit between the battery and the PV array. Series controllers may be single-stage or pulse type. Single-stage controllers are small and inexpensive and have a greater load-handling capacity than shunt-type controllers. Pulse controllers and a type of shunt controller referred to as a multi-stage controller (e.g., three-stage controller) have routines that optimize battery charging rates to extend battery life.

Most charge controllers are now three-stage controllers. These chargers have dramatically improved battery life.

Selection – Charge controllers are selected based on:

• PV array voltage – The controller's DC voltage input must match the nominal voltage of the solar array.

• PV array current – The controller must be sized to handle the maximum current produced by the PV array.

14. Safety During the Installation

Roof-mounted PV systems require that subcontractors, including electricians, work on the roof. It is the builder's legal responsibility to ensure that the installer follows safe practices during the installation. Lack of proper safety equipment can result in significant fines to the builder. For details of safety requirements refer to the federal Occupational Safety and Health Administration's (OSHA) 2001 Code of Federal Regulations, Chapter 29 Part 1926, "Safety and Health Regulations for Construction" at www.osha.gov.

A danger specific to PV systems is that solar modules generate DC electricity when exposed to light. As well, PV systems may have multiple electrical sources – modules, the utility grid, and perhaps batteries. Manufacturers of modules and other electrical components will provide safety precautions that should be carefully followed.

In addition to the electrical hazards, hefting modules onto a sloped roof poses a hazard. When installing modules on the roof, at least one safety eye must be installed for tying off. Work is facilitated by installing two safety eyes and a line between them for attaching the lanyard, thus allowing the installer to move back and forth more free.

15. Special Considerations in Wiring PV Systems

In wiring solar PV systems, there are at least two concerns that an electrical contractor or electrician may not have previous experience with. First, the system on the array side of the inverter must be designed for DC power, which requires larger wire sizes than for AC power at the same voltage. Second, array wiring must be sized and selected to withstand elevated temperatures.

16. System Design Considerations

System Considerations In designing a PV system, it is important to consider the system as a whole: how the components work together and how the PV system fits in with the building.

Pre-engineered PV Systems It is important to properly size and match each component such that the overall system operates optimally. To address this concern, many distributors offer pre-engineered systems in which components are selected to work together as a unit. Pre-engineering may not guarantee a flawless system, but the concerns over product compatibility and specification of individual components will have been addressed up front.

PV Modules and the Building Design – The builder or PV designer must also consider the PV system and the building as a system. The PV array should be located considering the aesthetics of the building. As well, the modules must be located so that building features such as gables and overhangs do not shade the modules. This usually means locating the array on the roof as close as possible to the ridge.

The builder should consider designing a south facing roof for the array for optimum power production. As noted previously, the orientation of the array is very forgiving, however, and the roof does not need to face directly south, if not possible given other design constraints.

17.Conclusions

The role of PV in the generation of electricity will overtake other forms of renewable energy and that 50 % of all new buildings will incorporate PV in their design while the debate over the use of nuclear fuel continues despite doubts as to its long-term economic and environmental viability.

It can be seen that the overriding vision is for PV to become a major global supplier of electricity in the twenty-first century at affordable cost cheaper than fossil fuels within the context of potentially catastrophic climate change, which was largely triggered by the industrial revolution and the use of fossil fuels, emphasizing the ease of use and installation and its almost pollution-free generation

In 1977 the cost of one Watt of electricity produced by PV was US$76.67 which has fallen to US$0.25 per Watt today. While in 1960 the efficiency of a crystalline silicon cell was 6 % and today is more than 25 %. Because one of the major applications for PV panels is on roofs and facades.

Finally in this paper we reached that Design and Type of installation of solar system play a great role and represents the fit-to-purpose that the project must achieve to be a Success.

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Acronyms and Abbreviations

Absorbent glass mat (AGM)

Building integrated PV (BIPV)

Cadmium telluride (CdTe)

Direct current (DC)

International Association of Electrical Inspectors (IAEI)

Kilowatt-hours (kWh)

Maximum power point (Vmpp)

Maximum Power Point Tracking (MPPT)

National Electrical Code (NEC)

Photovoltaics (PV) Efficiency and Renewable Energy (EERE