STUDY OF PV SYSTEM

by

ABDIRAHMAN AHMED OSMAN (190033205)

ABDULHAKIM NUURA (190033202)

ABASS MUNTARI (190033204)

ABDULHAFIZ ALIYU JANI (190033203)

A Thesis Submitted to the Academic Faculty in Partial Fulfilment of the Requirements for the Diploma of Electrical and Electronic Engineering

BACHELOR OF SCIENCE IN TECHNICAL EDUCATION WITH SPECIALIZATION IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical and Electronic Engineering

Islamic University of Technology (IUT)

Gazipur, Bangladesh

FEBRUARY 2021

STUDY OF PV SYSTEM

Approved by:

Mr. Fahim Faisal

Supervisor and Assistant Professor,

Department of Electrical and Electronic Engineering,
Islamic University of Technology (IUT),
Board bazar, Gazipur-1704.

Date: ……

Table of Contents

List of Figures

Acknowledgements

We thank Almighty for His generous gifts which enabled us to complete this thesis. We first and foremost want to express our heartfelt gratitude and acknowledgment to *Mr. Fahim Faisal, Assistant Professor* of the *Department of Electrical and Electronic Engineering*. He is patient, full of knowledge, critically think worthy, and extremely helpful as well, allowing him to finish this thesis work thoroughly and nicely. We'd like to extend our gratitude to those who assisted in the process. We praise our parents for their generosity. We strive to find a reason for any possible inaccuracies in this article.

Abstract

Renewable energy is thought of as a way to get rid of fossil fuels'. From an economic and environmental standpoint, solar power may be very appealing with its bottom-up data-intensive research. Our intuition estimates that the amount of electricity is going to be produced by a 96.8W stand-alone photovoltaic panel in the South residential hall at IUT. The solar radiation unit expense was found to be $0.456/Wh, whilst the PV system components were found to be the most costly.

Chapter 1

Introduction

Having concerned over using the world's natural resources and potential energy supplies, it has generated an increased demand for solar power, Photovoltaics was developed, a new photovoltaic technology that directly converts solar radiation into electricity Wafers are commonly made of silicon while susceptible to daylight may yield a trifling amount of photovoltaic current With these photovoltaic cells and/modules, large quantities of electrical power can be produced with no moving parts, no pollution, or noise to power, consumers will be arranged and sized depending on the number and configuration of your photovoltaic (PV) system, as well as the components.

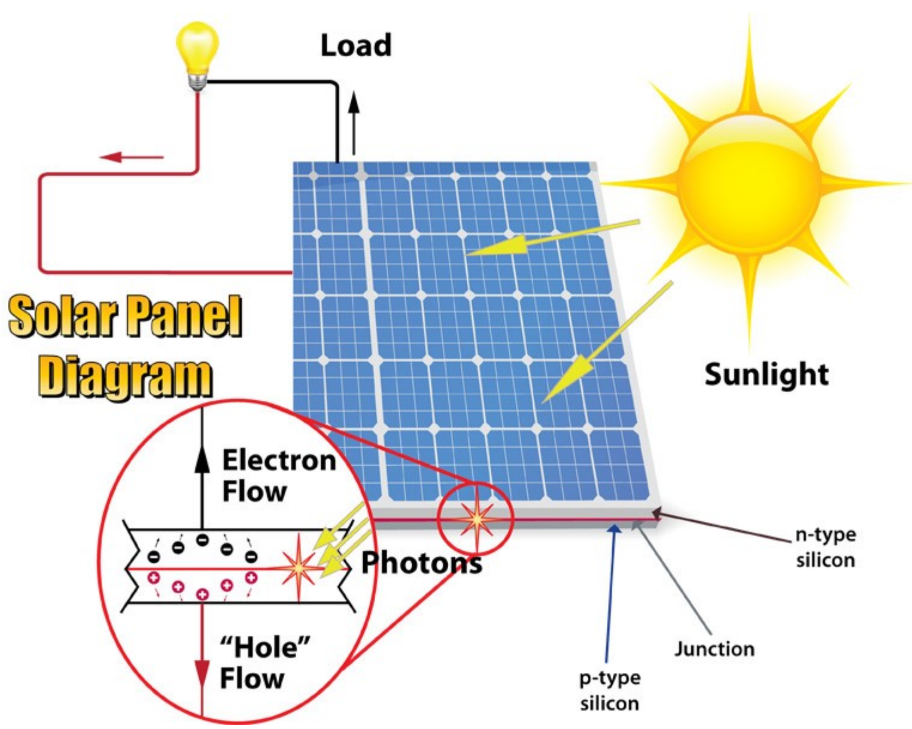


Figure: 1.1: Solar Panel Diagram

Most of the energy is generated and/distributed by electrical utilities. The electricity is delivered through the grid, which, from the substation to the customers, and via the equipment in the center. The grid will run for miles from the power plants to thousands of miles. If the grid system goes down, you don't have to count on the utility. Incidents such as overloaded networks or significant weather occurrences will cause outages. But if you have a PV system, you can power your entire home and life without concern for grid problems. The utility is only needed to get the system operational, but not to use the grid when your energy production is required all year long. This can be used in the summer when the sun is not as intense even when it's not.

1.1 Antiquity of Photovoltaic

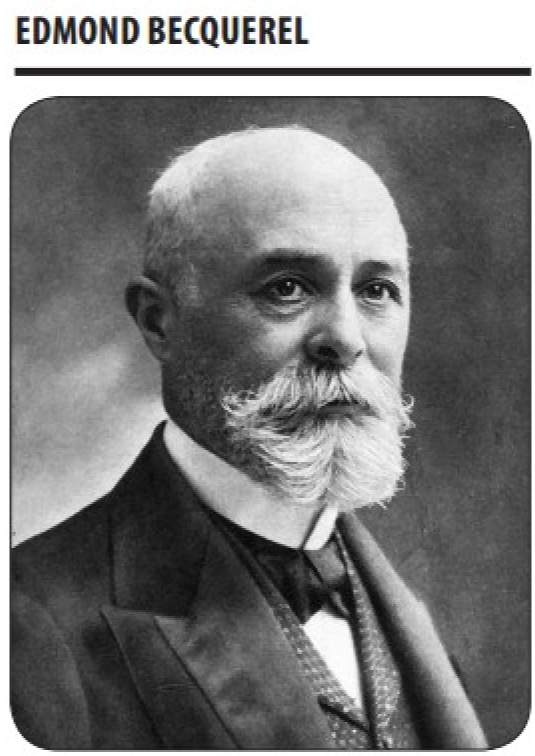


Figure: 1.2 Physicist Edmond Becquerel.

French physicist Edmond Becquerel first pronounced the photovoltaic effect in 1839, but it has always been a curiosity of science for the next half of the century and onwards and onwards. Around the age of 19, Becquerel discovered some light-sensitive materials that generated only weak currents.

Light to be created by selenium was discovered in the 1870s. Charles Frit produced the first selenium cell, which achieved electricity-to-to-light conversion at about 18% efficiency in 1883. To put it another way, a PV cell's electrical-to-to-radiant conversion efficiency is the ratio. Improving this PV efficiency is critical in this debate since it is required to make conventional energy competitive. Between the two World Wars, research became more advanced and the method more refined. Highly-crystalline commercialization of photovoltaic began in the 1940s and 1950s Scientists at Bell Laboratories used the Czczochrals method to create the first crystalline silicon photovoltaic cell in the year 1954 As a result of technological advancements, the cost has decreased over the last quarter-century and the performance has improved. Today's PV devices transform 30% of the radiant energy into electricity This method has resulted in PV cells with conversion rates of 46% the current cost of these innovations

It is only used in lower cost areas, such as in aerospace and industrial Photovoltaics enjoyed a brief stint in the 1980s in mass-market products, including calculators, radios, flashlights, and batteries. Following the decade-long energy shortages, industrial and residential projects took an interest in photovoltaic systems as well. Simultaneously the present period sees a rise in people using PV systems for off-grid health facilities, water pumping, and telecommunications for rural/subsistence purposes. Today, the PV module output is increasing at 25% per year, and U.S., Japan, and Europe's utility-scale PV programs are all moving at an increasing pace.

1.2 Current PV Technology

A photovoltaic (PV) is a semiconductor component that can be called a solar cell. Groups of PV cells are connected to form modules and arrays and are capable of powering something electrical. With the proper power conversion equipment, PV systems can generate alternating current (AC) and can be connected to the grid for operation in parallel or series. Solar cells power this traffic light. Attached to the support structure are two boxes, one for Operation and one for control.

Figure: 1.3 Solar Traffic Signal.

Solar cells provide power to this traffic signal. Attached to the support Pole are two boxes: one that stores batteries for Operation while it’s dark, and one that houses a Control panel.

1.2.1 The solar resource

First, the researchers concentrated on energy—solar radiation. To everyone's dismay, the evaluation discovered that solar energy is plentiful and nearly covers the globe. It differs greatly in population density, but not in income. In comparison to fossil fuels, uranium, and sites ideal for hydropower, are typically widely distributed. Solar is a more equal resource notes Jean.and others are taking advantage of it More than 1% of the world's electricity is produced by solar. Solar power growth is outstripping expectations by a large amount in the United States. In 2014, solar-generated a third of the new generation capacity; and particularly for commercial and utility-scale installations have seen incredible growth in recent years Systems to add-ons in the United States annually Annual PV capacity additions in the United States by system type.

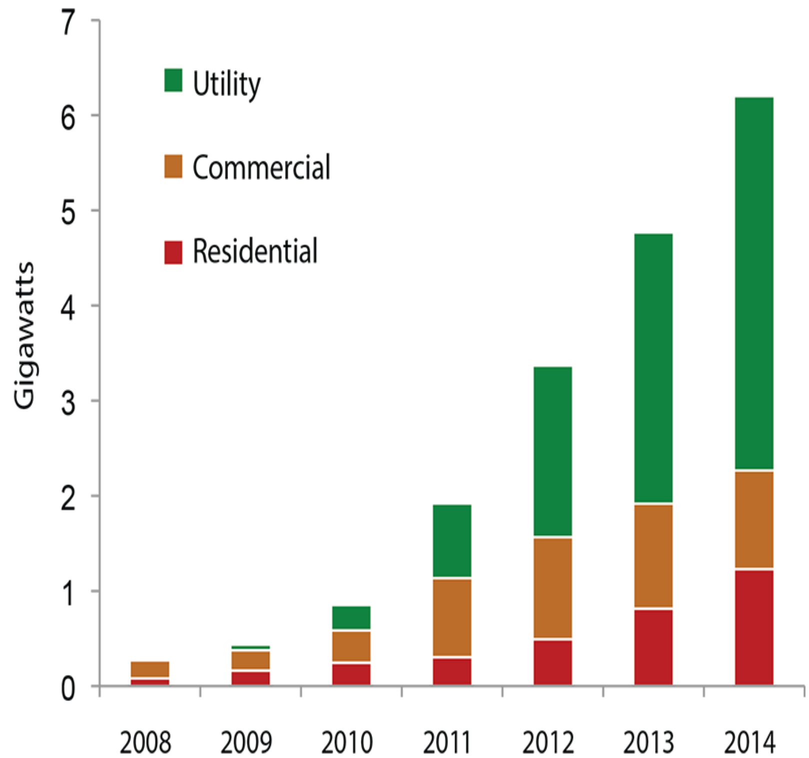


Figure: 1.4

Installed PV capacity represents more than 1% of global electricity generation This chart shows total annual additions to PV capability from 2008 to 2014. arena, industrial, and residential capacity increased last year, the largest increase occurring in the arena. over these four years, U.S. PV capability expanded from 0.8 GW to 18.3 GW. With those figures, 2014's solar production equates to the combined capacity of many major power plants. Crystalline silicon is the majority of current solar panel deployment—that has been commercially available for decades and is improving the deployment is within reach with these advances, according to Bulović.

But doing so is hard. in the solar PV market, there are two types of costs: the solar module expense, which consists of solar cells, glass, casing, and frame, and installation, plus the balance of system (BOS), which may include licensing, interconnection, and wiring hardware and related labor. The module price has fallen by 85% since 2008, but the BOS costs have remained stagnant. Today, the solar panel costs less than one-fifth of the overall installation cost and a third of the utility-scale in the U.S. That's the cost of the rest.

Saving money is hard with silicon The silicon is not good at absorbing sunlight, and therefore, a dense, brittle layer is needed to prevent cracking. The BOS increases the weight and rigidity of a silicon module. We need a cell that performs just as well as the others, but is easier to transport and installs by the dozen. Researchers around the world are trying to develop new PV cells. It is going to start with a more complex type of nanomaterial, not silicon, which is structurally simple

1.2.2 Comparing and contrasting the technologies

PV systems now have several, albeit differing implementation issues that are difficult to assess. They are using light-absorbing materials at the most basic level. In general, there are three types. Wafer-based cells include conventional crystalline silicon and traditional crystalline silicon and others, including amorphous (non-crystalline) and copper indium gallium (di) arsenide, plus newer thin-film options such as perovite, and QDS comparing the choices in an organized fashion a classification created in 2001 groups the traditional systems by their efficiencies and costs Bulč explains, however, that this scheme doesn't quite explain the current PV technology environment. Additionally, it is belittling and pejoratively. "3rd gen" still sounds better than "1st gen" Silicon still accounts for much of the market; it is the most popular first-generation technology.

For current use, the MIT team came up with a new architecture It is determined by the number of molecules or crystals that form the building block. Modern PV components range from cadmium telluride by organic or inorganic compounds up to nanomaterials (see the diagram below). all technology exists on a single scale; it does not rise and fall; one place does not excel Moreover, she says, "We find that there is a connection between uncertainty and the success measures.

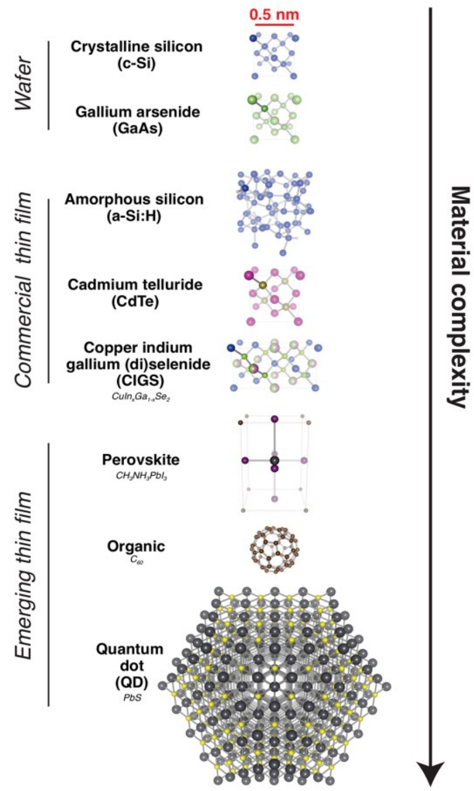


Figure: 1.5 Material Complexity

This depicts the proposed classification system of PV technologies based on the number of atoms in a molecule or crystal unit. These elements are to demonstrate their complexity single- or few-atom layer block wafer-based Thin-film technologies are organized in order of increasing complexity, from basic atomic materials such as silicon telluride to nanomaterials such as quantum dots that have several thousand leads and sulfur atoms.

Reduce production costs while silicon is basic, producing wafers and solar cells, which call for higher purity and a higher temperature, is costly due to their highly regulated environments to process is harder, but results in less expense and lower energy consumption In general, preliminary reactions can be used to convert materials to molecules that contain QDs. The complex building blocks can be deposited at low temperatures, or during manufacturing, in which case of solution extrusion they can be compatible with several substrates as well as high-speed processes.

Power conversion efficiency, defined as the fraction of the solar energy that exits as electrical. Crystalline silicon also has the lowest lifetime record efficiency of 26 percent Emerging new technologies are at 10%–20%– and possibly below It is possible to engineer nanoparticles that absorb light with orders of magnitude less material than silicon for optimum light absorption. so as the silicon-based solar cell is 100 microns thick, the perovite-based cell can be even thinner, as reported by Bulova And there is no need for mechanical support on lightweight glass in these processes.

To date, such novel thin-film PV technologies have provided short-the-emissions but long-term performance reliability remains a problem. But the range of useful attributes could be expanded with more work and research. Lightweight, compact, and durable solar modules can be used in grid-connected BOS installations to decrease costs. They may be used to power cell phones, small water treatment systems, and remote areas. Finally, their properties would enable novel applications. For example, sunscreen molecules can be built to absorb ultraviolet and infrared light while letting through visible light.

1.2.3 Materials availability

Another problem is whether the solar will scale up a hundredfold—perhaps a factor. Is the large-scale deployment of solar power going to be compromised by the lack of critical materials? Which one is faster: software or hardware?

Determined the required materials for each PV system and then, by 2050, the percentage was estimated to be 5%, 50%, or 100% of global electricity demand This ranges from 1,250 GW in 2050 to 25,000 GW of installed PV in 2050, all which dwarfs today's 200 GW. Finally, they calculated how many extra, or how many future global manufacturing days, or years, it will take to reach the chosen implementation goals.

It summarizes their results. using six years' of existing silicon to produce energy to meet the total demand Such a prediction of silicon scale-up by 2050 is feasible, as a result

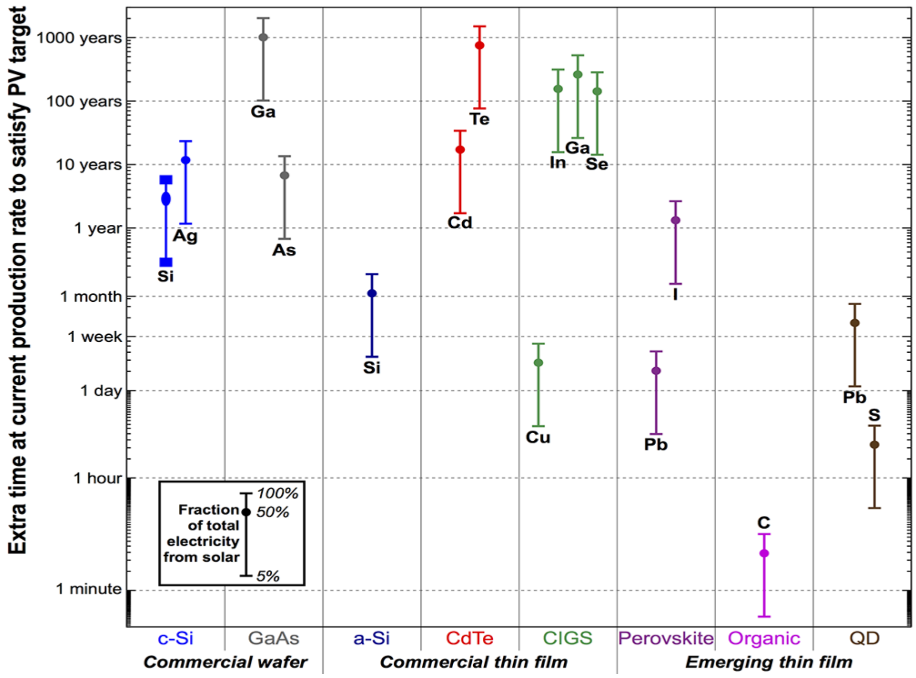


Figure: 1.6 Material Requirements.

The availability of key materials could prevent a significant increase in solar power. This chart illustrates how much more time it will take to supply three stages of 2050 electricity demand—a minimum of 5%, 10%, and a target of 100%—expanding on PV technologies. Today's silicon-based cells and PV technologies don't have a silicone cap to need more than a few hundred years to be made at the current costs using commercial technology, such as cadmium telluride thin-film technologies No amount of growth will be enough to satisfy the expected demand for those materials between now and 2050. Thin technologies can also be implemented consider telluride Tellurium is present in gold at a quarter the amount of gold. 1,400 years of extractive telluride production is expected to meet the current telluride demand well over 100 years of indium, gallium, selenium, and gold production will be required to meet all CIGS cell's electricity needs in the year 2050. But these technologies have a future — they will still produce hundreds of giga watts of power It seems doubtful that this will dominant solar be the pre technology thin-film emerging contrast [industries use] meeting 100% of demand will need 22 days of lead and six hours of sulfur output. Their various elements will have to be produced over 3 years.

1.3 Developing PV Technologies

There are several emerging or experimental new PV technologies on the market today. This new technology will significantly affect how much of our solar power is used. Look for new applications of technology that can save costs or improve on different functions. Thin silicon sheets are manufactured by drawing rather than sawing. This technique is quicker and less inefficient However, the final product could be of poorer quality. In certain instances, their conversion performance would be better. Embedded thin-film technologies. This new PV cell production method is better for small and versatile PV panels. This is not a crystal, but amorphous in structure. This PV material can be used in making any number of materials

Chapter 2

Statistics of Photovoltaic

It took until 2010, to install the first 40 GW of photovoltaic (PV) modules

Figure: 2.1

By the end of 2012, more than 100 GW had been installed.

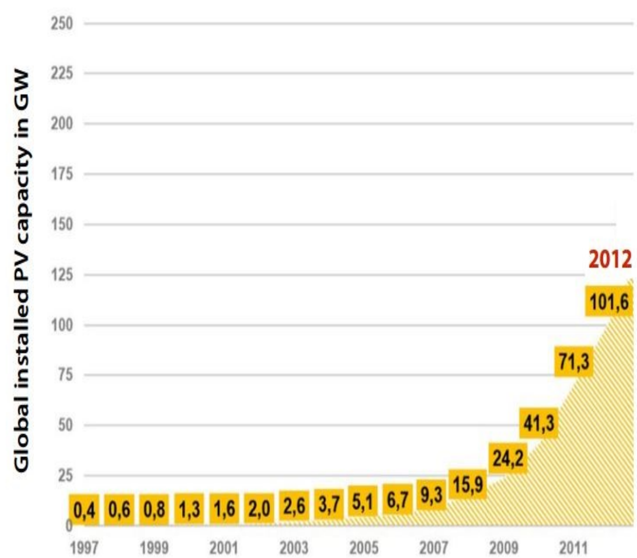


Figure: 2.2

Now, more than 40 GW are installed every year!

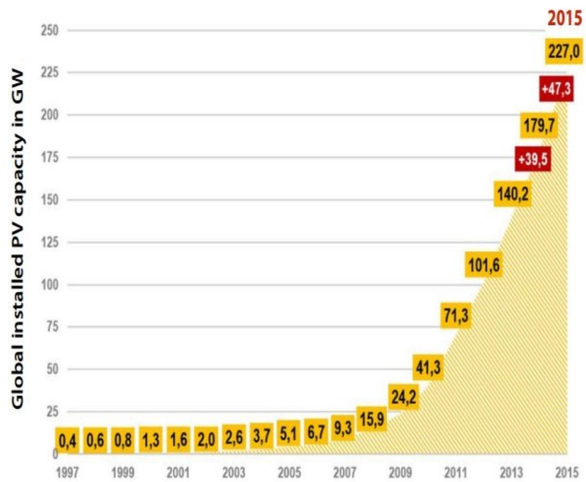


Figure 2.3

Between 1997 and 2015 the average annual growth was 43%! Photovoltaic has the largest growth rate of no fossil electricity generation technologies!

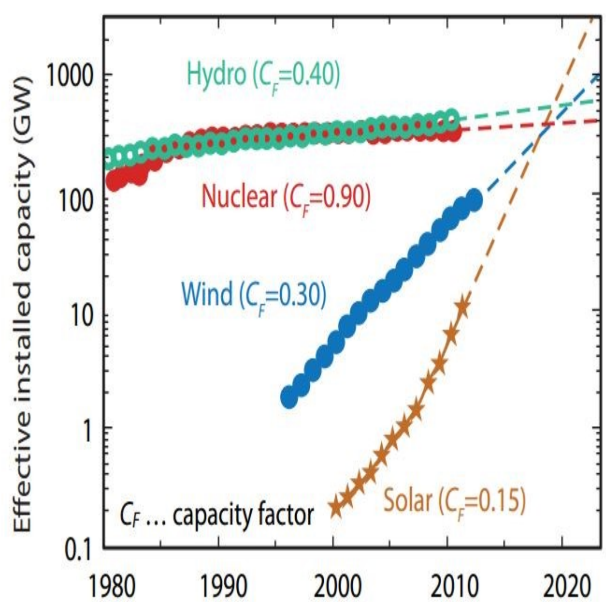


FIGURE: 2.4 Effective Installed Capacity (GW) A. Smets, K. Jäger, et al., "Solar Energy" (UIT Cambridge, 2016)

In 2015, more than 7%of electricity was generated by PV in Germany, Greece, and Italy.

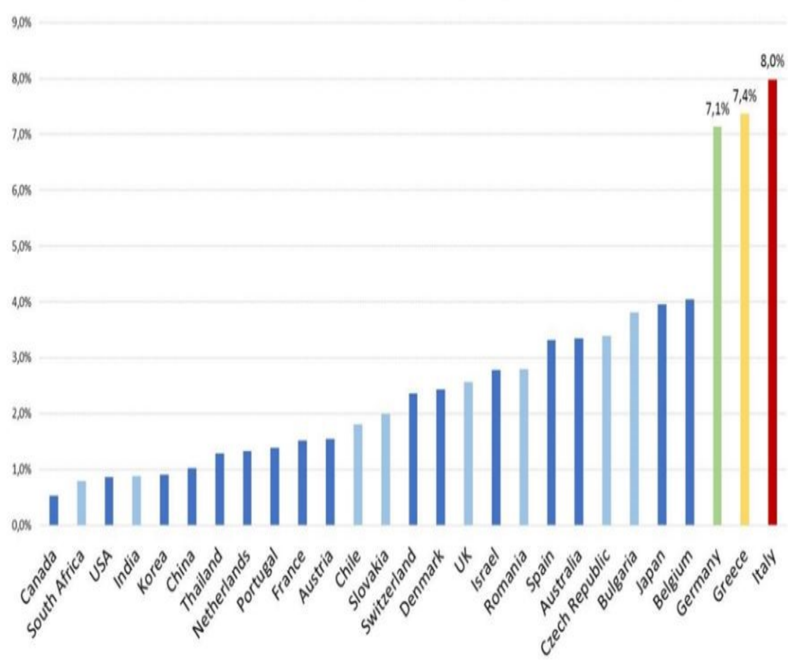


Figure: 2.5

Chapter 3

PV Systems

3.1 PV System Components

This machine counts on PV modules to generate

1. Power Inverter

The PV modules provide direct current rather than alternating current the DC flows in one direction most energy-efficient devices, including toys, operate on batteries. Otherwise, AC is a time-current that reverses its direction regularly (120 times per second). Appliances and mobile equipment use the sort of power supplied by utilities. Within the most basic systems, DC is provided by PV modules Inverters are also implemented in applications where DC is required.

2. Battery System

The PV is illuminating the battery bank Power is provided as required. The charge controller protects the battery from being shorted and extends its life. Often PV devices use batteries to fuel DC or AC equipment. Systems that use only DC devices don't require an inverter. Whenever a measurement is done in a system, losses are produced as well. And, for example, the Inverter efficiency defines how often control is wasted while an inverter is used Even, as batteries are used to store electricity, the extra charge is taken out of the batteries and related devices.

3.2 How a PV System Works

The word "photon" means "light" The word "volt" may be named after Alessandro, who discovered the first-ever voltameter (cavity) Photovoltaic means "light-volt. We're also familiar with solar cells as the new talk of the town. any calculators, wristwatches, and outdoor lighting is provided by solar power. However, the aspects of operation and interfacing with other electrical systems remain consistent with existing codes and guidelines.

Depending on the functional and operational specifications, major and minor components, functional and operational minor components kind of include DC-AC power inverter, battery bank, and battery controller, as well as an additional balance of system (BOS) requirements will be required. Figure 3 illustrates a photovoltaic system's components

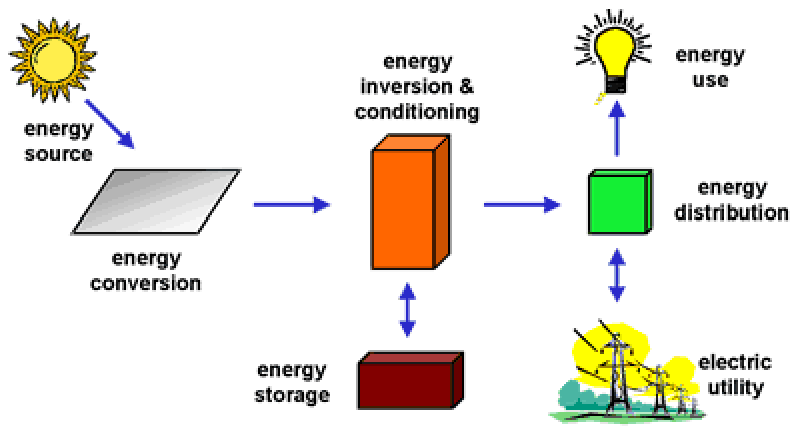


Figure: 3.1 Major photovoltaic system components.

3.3 Types of PV Systems

The technical and operating specifications for photovoltaic systems typically define how attached the components are to other loads. For certain applications, photovoltaic systems are designed to provide both DC and AC/DC electricity and can also be integrated with the energy grid.

A grid-connected or utility-active PV system is intended to operate in tandem with the electrical grid The most critical element is the battery (PCU). The PCU transforms the DC power generated by the PV system into AC power according to voltage and power quality specifications of the grid and disconnects the grid if the utility turns off. A bi-directional interface links the PV system circuits to the electric utility network. It can either back-feed the site's electrical loads or provide AC power to the site itself from the photovoltaic power source. At night and during other occasions when energy needs are greater than the system performance, the balance is supplied by the utility All grid-connected PV systems must have this function, and keep feeding the utility in the event of outages.

PV-systems stand-based on their own and are configured and sized to supply either DC or AC. these kinds of systems may also be powered by a PV or may be combined with a wind turbine or grid generator into PV-hybrid systems the only standalone PV system could also be a DC-coupled one, which would link the PV module or array to a DC load (Figure 3). Since direct-coupled devices have no batteries, they are ideal for water pumps, cooling fans, solar thermal pumps, and similar-sized circulation systems. Accurately matching the system impedance to the array's full power generation is an essential factor in overall system efficiency. They use a special kind of electronic DC-DC converter, called a maximum power point tracker (MPPT), to help exploit the available power output.

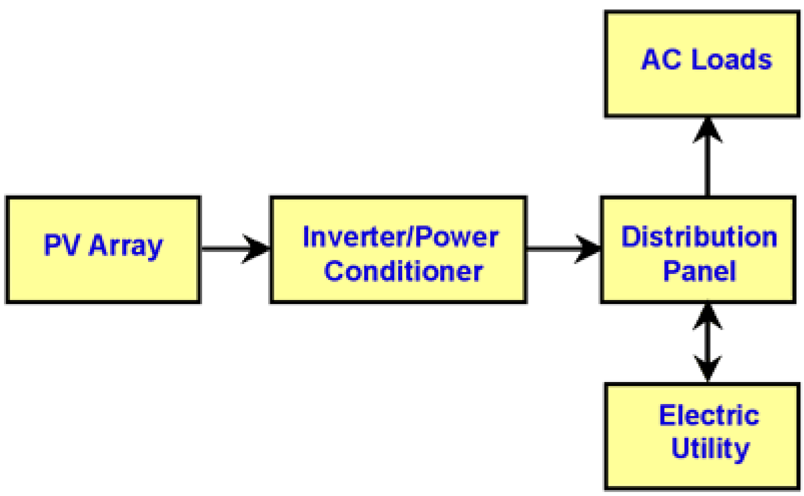


Figure: 3.2 Diagram of grid-connected photovoltaic system.

1. Stand-Alone Photovoltaic Systems

2. Many stand-alone PV systems use batteries for storage. shows a normal solar system powering DC and AC shows how a standard PV array is planned

3. Typical chart for a stand-alone photovoltaic (PV) system:

Figure: 3.3, Direct-coupled PV system.

In many stand-alone PV systems, batteries are used for energy storage. Figure 3.4 shows a diagram of a typical stand-alone PV system powering DC and AC loads. Figure 3.5 shows how a typical PV hybrid system might be configured.

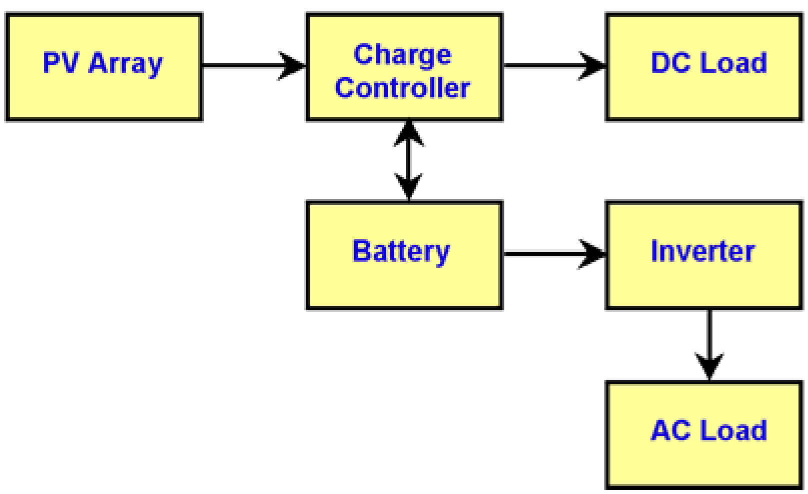


Figure: 3.4 Diagram of stand-alone PV system with battery storage powering DC and AC loads.

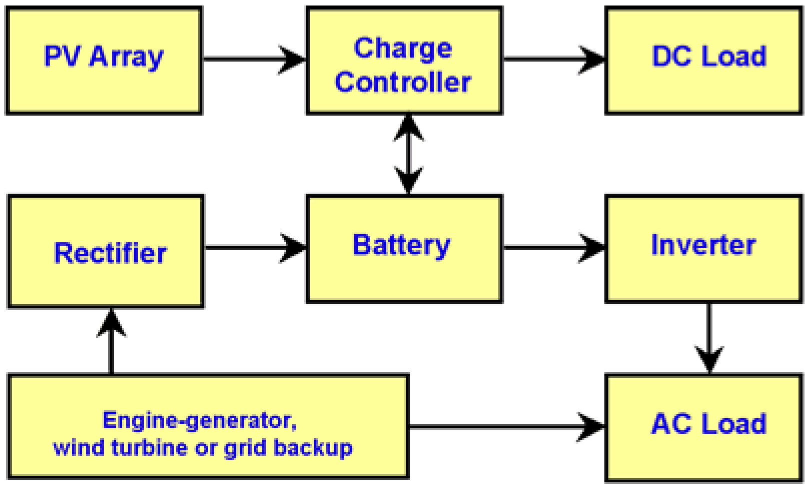


Figure: 3.5 Diagram of photovoltaic hybrid system.

3.4 Scale of PV Systems

The commercial method is used at a commercial or manufacturing location. Residential systems normally have a large area on top of the house to create them and thus generate more electricity. For example, a supermarket may usually opt to install a solar battery on their roof while still deciding to buy its electricity from a provider for several years. This form of a device may be able to power the whole or a portion of an enterprise. Often used by energy providers to provide base load or peaking electricity to purchasable clients large portions of land are usually necessary an outsized PV collection that's being used to meet peak electrical needs in the summer when AC is much larger The array generates the greatest power when the sun is at its height and additional power is required by consumers. Some solar technologies and solar power can be generated by using solar thermal systems concentrated solar power (CSP) provides concentrated electricity to high temperatures although the energy that enters the earth is so diffused, it must be condensed to generate electricity.

Mojave Station is located in the California desert. The SEGS power plant has a total capacity of 354 megawatts. A giant heliotropic mirror array concentrates sunlight on a tall tower. s for over 140,000 households The entire world's energy can be generated at the CSP plant. There is a dish on the dish that absorbs sunlight to direct the signal, with a generator at the focal point. Concentrated solar technologies require heavy sunshine, including deserts. The first to tap CSP for growing electricity demand would possibly be developing countries.

Chapter 4

Cells, Modules, & Arrays

Photovoltaic cells are usually coupled electrically in series or in parallel to deliver higher voltage and current levels. PV cells are contained in environmentally-protective laminates, which are the primary components of PV systems. A photovoltaic array is any mixture of power-generating PV modules and photovoltaic panels.

Photovoltaic cells, modules, panels, and arrays are evaluated under Standard Test Conditions (STC). Overall light conditions with test temperature of 25o C (77o F) and incident solar irradiance of 1000 W/m2 with an optical density of 1.5 scattering index every product is marketed based on both a warranty and accuracy information found within the manufacturer's specifications.

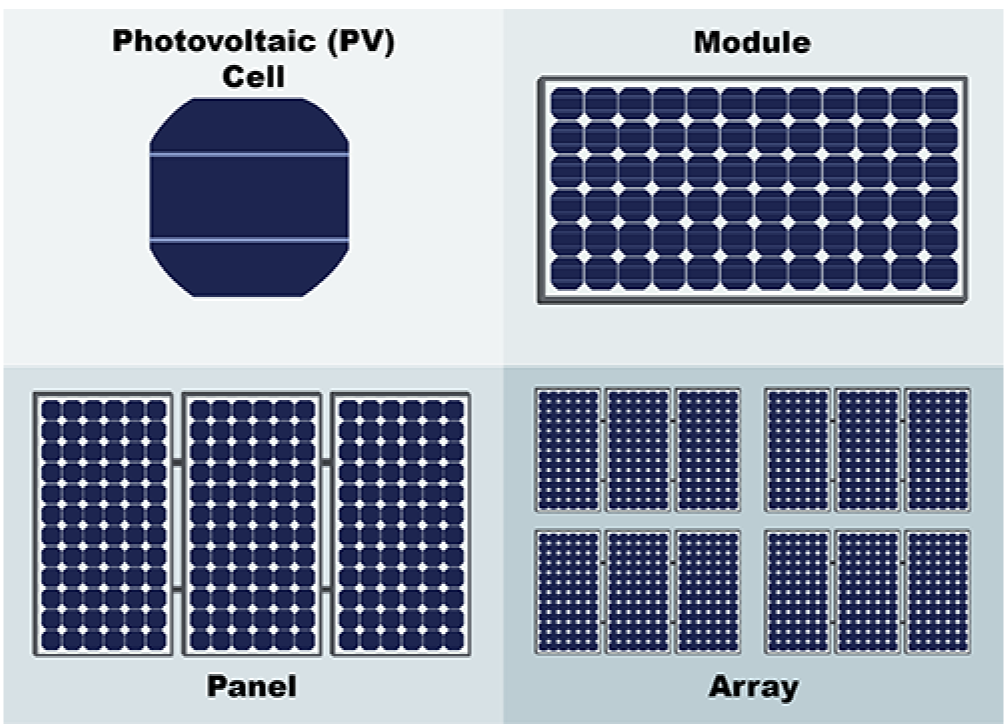


Figure: 4.1 Photovoltaic Cells, Modules, Panels and Arrays.

4.1 How a Traditional PV Cell is made

Traditional photovoltaic cell manufacturing

Let us focus on how PV cells are created and how they generate electricity. The first stage of cooking is roasting the chicken in the oven, or on the grill. The pure silicon PV cell is constructed from a slab (or wafer). The top of the slab is very evenly distributed for an "n" dopant, such as phosphorus. There is a small volume of "P" dopant, usually boron, which is diffused on the bottom of the slab. Atom composition of dopants is the same as that of the first substance Silicon has one fewer electron in its outer shell than the bor. The silicon wafer has a large (more than generous) negative charge due to the phosphorous applied to it. This is called p-type silicon the silicon has similar numbers of protons and electrons, however, the electrons are not physically bound to the atoms. If they are in various locations within the layer, they are likely to seek out new locations for acceptance. This silicon does not feature a negative character but has a negative charge. The silicon substrate is called p-type (p = positive). P-type silicon has the same number of protons and electrons but has a net negative charge.

As soon as the n-type silicon comes into contact with the p-type silicon, electrons are freed from the n layer and create a shield to keep others from coming in. The point of touch and border is known as the point of contact. There is now a negative charge within the p-type section and a positive charge within the n-type section due to the motion of the 2 sets of electrons. This electrical mismatch at the point of charging leads to an E-field.

Third step: eliminating their atoms these electrons are repelled by the n-type silicon and attracted to the p-type silicon. At worst, photon-electron collisions occur in the silicon nucleus.

As the free electrons are drawn out of the silicon, they repel one another due to being of their charge. The wire channels the electrons away from the other devices. This current flows through the circuit from the p-type to the n-side to the n-side.

Further, a semi-conducting load path gathers electrons from the semiconductor and transfers them to the external load, and a back circuit uses these electrons.

Functioning of the photovoltaic modules is based on the voltage differences between two points.

Photovoltaic systems use solar cells to generate electricity is using photovoltaic technologies

The light's properties can be ascertained using observation and scientific calculations. Light can be a photon, or it can be a wave. The light rays are called photons. The massless particles called photons move at the speed of light. It's proven that the energy of the photon depends on the wavelength and hence the frequency, according to Einstein's formula.

4.2 PV Modules and Arrays

For more power, PV cells are connected together to form larger units Called modules. Photovoltaic cells are connected in series and/or parallel circuits to produce higher voltages, currents, and power Levels. A PV module is the smallest V component sold commercially, and can range in power output from about 10 watts to 300 watts. Fig: Photovoltaic Arrays Are Made of Individual Cells

A typical PV module consists of PV cells sandwiched between a clear Front sheet, usually glass, and a backing sheet, usually glass or a type of tough plastic. This protects them from breakage and from the Weather. An aluminum frame can be fitted around the PV module to enable easy affixing to a support structure. Photovoltaic arrays include two or more PV modules assembled as a pre-wired, field installable unit. A PV array is the complete power-generating unit, consisting of any number of modules and panels. System might be configured to operate normally in grid-connected mode and also power critical loads from a battery bank when the grid is de-energized.

4.3 Flowchart for PV Array Mode

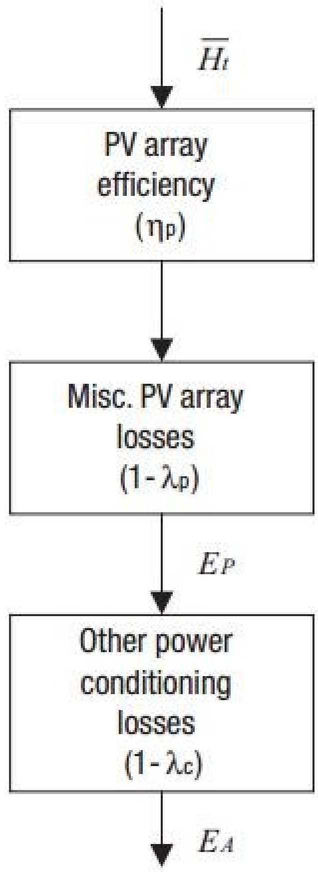


Figure: 4.2 Flowchart For Pv Array Mode

4.4 Types of loads

The relationship between load and solar resource is carefully considered by RET Screen. In certain situations, the photovoltaic device will directly meet a portion of the energy demand, with no current passing through the tank (this has some important consequences in terms of energy delivered by the system because inefficiencies within the battery storage can then be ignored). The solar-load correlation defined by the consumer determines what proportion of the energy demand is frequently met: -

i) It is positive. For example, consider a fan attached to a PV module; the fan only operates when solar power is available (water pumping still falls under this category, but a different type is used).

ii) As this is a case of an ongoing load, i.e. a load that has an equal value during the day, it is often treated in RET Screen. This does, in effect, necessitate the use of a battery. Cathodic security and surveillance mechanisms are two examples.

iii) It's a no. In this scenario, all of the energy is supplied to the load after going through the battery. This applies to any instances that do not fall under the Good or 0 groups. It's worth noting that daytime sporadic loads (such as the refrigerator) fall into this category as well. The final consequence of this equation may be a three-part division of the DC equivalent electrical demand:

When and where:

: Is this a portion of the market that is specifically fulfilled by PV modules?

Whenever there is a sufficient amount of energy produced;

: is it a constant part of the market during the day; and

: Refers to the portion of demand that will be served solely by the battery.

Note which will be reached either directly by the PV modules (during the day) or indirectly by the PV modules (at night).

When there is enough sunlight) or by the battery (at night or when there isn't enough sunlight).

There's not enough sunlight). The method for calculating this is often defined in the following paragraphs.

It employs the critical PV absorption stage, which is defined as the load's constant energy demand:

Where is written in WH and is written in W

4.5 Benefits and Limitations

4.5.1 Benefits

Photovoltaic devices have several benefits:

1. They work in a secure, clean, and quiet manner;
2. They are extremely dependable;
3. They are almost maintenance-free;
4. They are cost-effective in rural areas and with a few residential and commercial applications.

Applications in the commercial sector

5. They're adaptable and can be extended to meet rising electrical demands.

Home and company requirements;

6. They go to provide grid independence or back-up during a power outage. a failure of service;

4.5.2 Limitations

PV systems also have some realistic limitations:

- PV systems cannot run continuously;
- PV devices are incompatible with energy-intensive applications such as heating;
- Grid-connected networks are becoming more affordable, but they can be costly to shop for and deploy.
- The process used to build PV technology has the potential to be detrimental to the ecosystem.

Chapter 5

Increasing Efficiency of Photovoltaic

5.1 Making Solar Panels More Efficiency

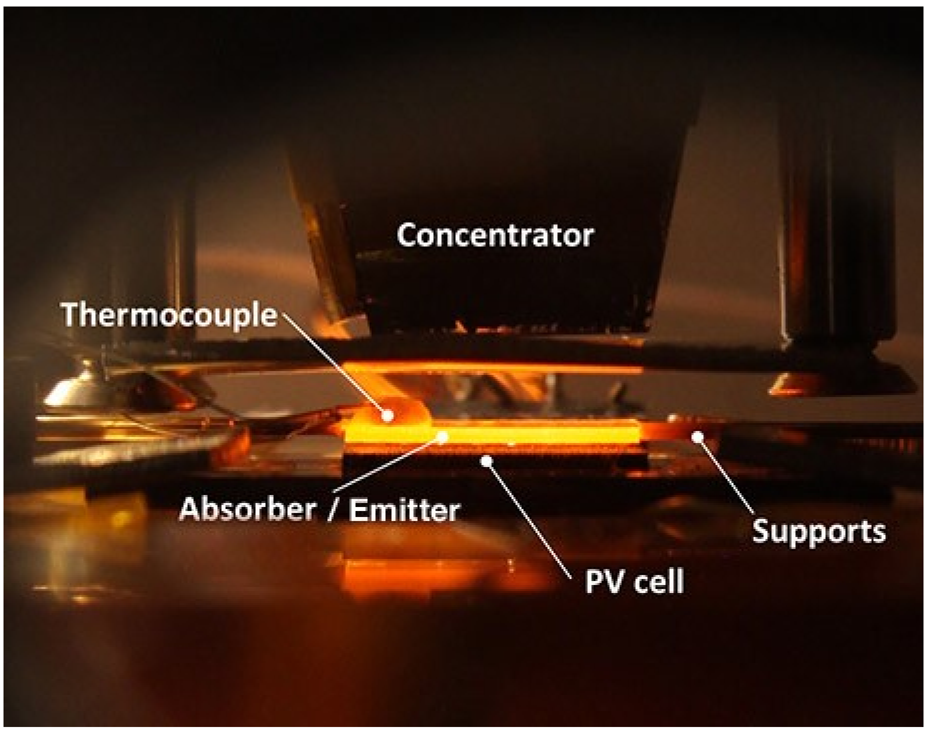


Figure: 5.1 Cross-Sectional View Of An Operating Solar Thermo Photovoltaic

Researchers are developing a new method of capturing solar energy that will make it easy to store and use on-demand in the future. A group of Massachusetts Institute of Technology researchers has built a substitute for solar power capture that makes it easy to store and use on-demand later.

The team developed a tool that increases the performance of solar panels by capturing wavelengths of sunlight that are typically lost by traditional photovoltaic cells. The emitter is a bonded film of silicon/silicon dioxide photonic crystals that converts heat into light, which is then absorbed by the PV cells. This causes even more of the sunlight's energy to be converted into electricity. According to the squad, the basic idea has been discussed for many years.

Previous Research

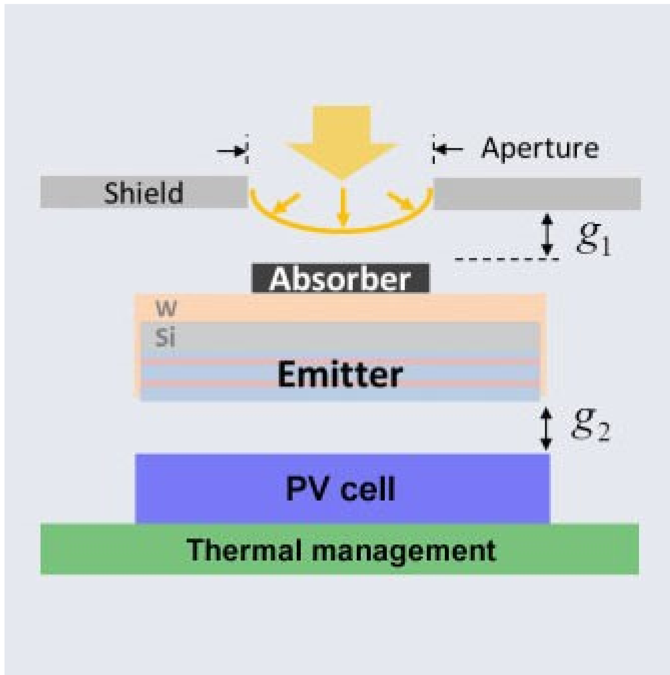


Figure**: 5.2**

However, the MIT researchers believe that with more optimization, an equal quiet improvement could be feasible at even lower illumination concentrations, making the systems simpler to run. This, according to Lenert, is due to the research facility's ongoing efforts to improve thermally-driven spectral conversion process regulation using wavelength and angular selective surfaces. Reducing the amount of solar energy input used to achieve an equal operating temperature."

If the team succeeds in producing electricity from sunlight effectively and on-demand using an STPV system, it will have a significant effect on how society uses solar energy, or at the very least have another green alternative for applications where solar thermal plants or photovoltaics are insufficient, according to Lenert.

5.2 Ways to Improve Solar Cell Efficiency

What is the meaning of solar cell efficiency? The amount of radiation radiated from the sun onto the Earth's atmosphere over a year. Solar cells aid in the conversion of available sunlight into electrical energy. Some moving parts or reactions are used to prevent this. As a result, increasing the efficiency of solar cells becomes important.

The most important thing you'll do when buying a solar array makes an educated decision. You'll be able to decide which system delivers the best value for your money as well as ensuring that you get the best production from your system by doing so. These versions contain at least two layers of materials that aren't equivalent and have different wavelength sensitivities.

Use a Solar Concentrator if possible. With the use of a solar concentrator, the solar light is also absorbed. Those concentrators aim to funnel sunlight falling on a large area into smaller areas. The task is facilitated by the use of large mirrors or other equipment. As a result, the overall performance of solar cells, which are often very costly, is often improved. Not only can you get more muscle, but you also save money.

Installing Photovoltaic Panels Correctly Photovoltaic panels must be properly mounted. This will ensure that the panels get the maximum amount of sunshine during the day, as well as throughout the year. If you live in the hemisphere, the tilt of your solar panels should be more against the true south. Similarly, if you're in the hemisphere, they should be faced north. From 9 a.m. to 3 p.m., the panels can be tilted so that they receive direct sunlight with no obstruction. Whenever possible, stay away from the shaded areas.

When you add your solar cells in a sequence, this is especially true. This is how it acts as a resistor and aids in the calculation of the total current. Ensure that the solar panels are kept clean. The effectiveness of your solar array is reduced as dust accumulates on the glass surface. As a consequence, the sunlight that will otherwise penetrate the photovoltaic cells is lost. As a result, it is critical that you simply ensure that no dust or debris collects on the surface of your cell.

Preventing a Temperature Increase is a must. As the temperature rises, efficiency decreases. Care must be taken to ensure there is enough space between the panels and thus the roof to keep air circulation.

Calculation of the average efficiency is characterized by its average module temperature TC for normal (25°C) temperature, and βp is the coefficient for PV module efficiency T ais used to measure the monthly atmospheric temperature of Tc.

What are Nominal Operating Cell and Kt of a NOCT? Huh, how about PN modules? For normal user inputs, values will be entered by the user or will be defaulted to when the array's tilt is precise (i.e. adequate to the latitude minus the declination). if the angle deviates from the perfect equation (17), it should be multiplied by a value equal to C acceleration of Earth (sM -s) Sm is the optimum and is particular as long as

On-grid Model is the on-grid model (see Figure below). Other than that means nothing is mentioned. The recommended level of usable energy is sufficient Alternatively, the latter is usually advised It is adequate only for the nominal array power

5.3 Calculation of average efficiency

The array is characterised by its average efficiency, ηp, which is a function of average module temperature Tc where ηr is the PV module efficiency at reference temperature Tr (= 25°C), and βp is the temperature coefficient for module efficiency. Tc is related to the mean monthly ambient temperature Ta through Evans' formula (Evans, 1981):

$$T_C - T_a = (219 + 832k_t)\frac{NOCT - 20}{800}$$

Where NOCT is the Nominal Operating Cell Temperature and Kt the monthly clearness index. Hr, NOCT and βp depend on the type of PV module considered. They can be entered by the user or, for "standard" technologies, are assumed to take the values given in Table below.

Table: PV Module Characteristics for Standard Technologies

PV module type	η_r (%)	NOCT (°C)	β_p (%/°C)
Mono-Si	13.0	45	0.40
Poly-Si	11.0	45	0.40
a-Si	5.0	50	0.11
CdTe	7.0	46	0.24
CIS	7.5	47	0.46

The equation above is valid when the array's tilt is optimal (i.e. equal to the latitude minus the declination). If the angle differs from the optimum the right side of equation (17) has to be multiplied by a correction factor Cf defined by:

$$C_f = 1 - 1.17 x 10^{-4} (s_M - s)^2$$

where Sm is the optimum tilt angle and sis the actual tilt angle, both expressed in degrees (in the case of tracking surfaces, RET Screen uses the tilt angle at noon although Evans does not provide any indication about what the correction should be in such configurations).

5.3.1 On-Grid Model

The on-grid model is the simplest system model (see Figure below). In particular no load is specified and no array size is suggested. Instead, the latter is suggested by the user. The suggested inverter is simply equal to the nominal array power.

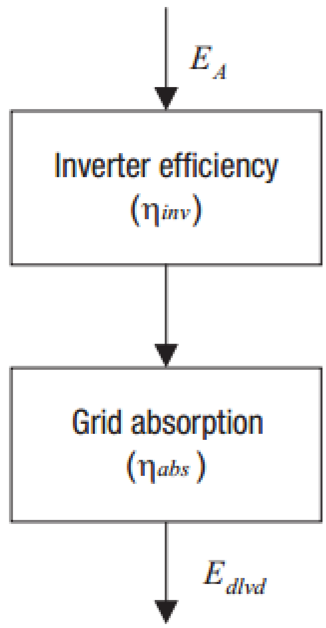


Figure: 5.3 On-Grid Model

To be directly connected to the electrical grid replaced by the model. Employee is triumphal. Where is the inverter efficiency? counting on the grid setup not being able to cnosume any of this electricit otrue energythe Edsel , where is the total energy absorption rate. To deliver low-price, self-sustaining homes for a wide range of customers, this construction is off-the-the-grid, ensuring the houses do not need mains power and are supplied by renewable power provided resources like solar panels, propane, water, or wind turbines

5.3.2 Off-Grid Model

5.3.2.1 Overview

The off-grid model represents stand-alone systems with a battery backup, with or without an additional genset. The conceptual framework of the model is shown in Figure 12. Energy from the PV array is either used directly by the load, or goes through the battery before being delivered to the load. The remainder of the load is provided by the genset if there is one, that is, stand-alone and hybrid systems differ only by the presence of a genset that supplies the part of the load not met directly or indirectly by photovoltaics.

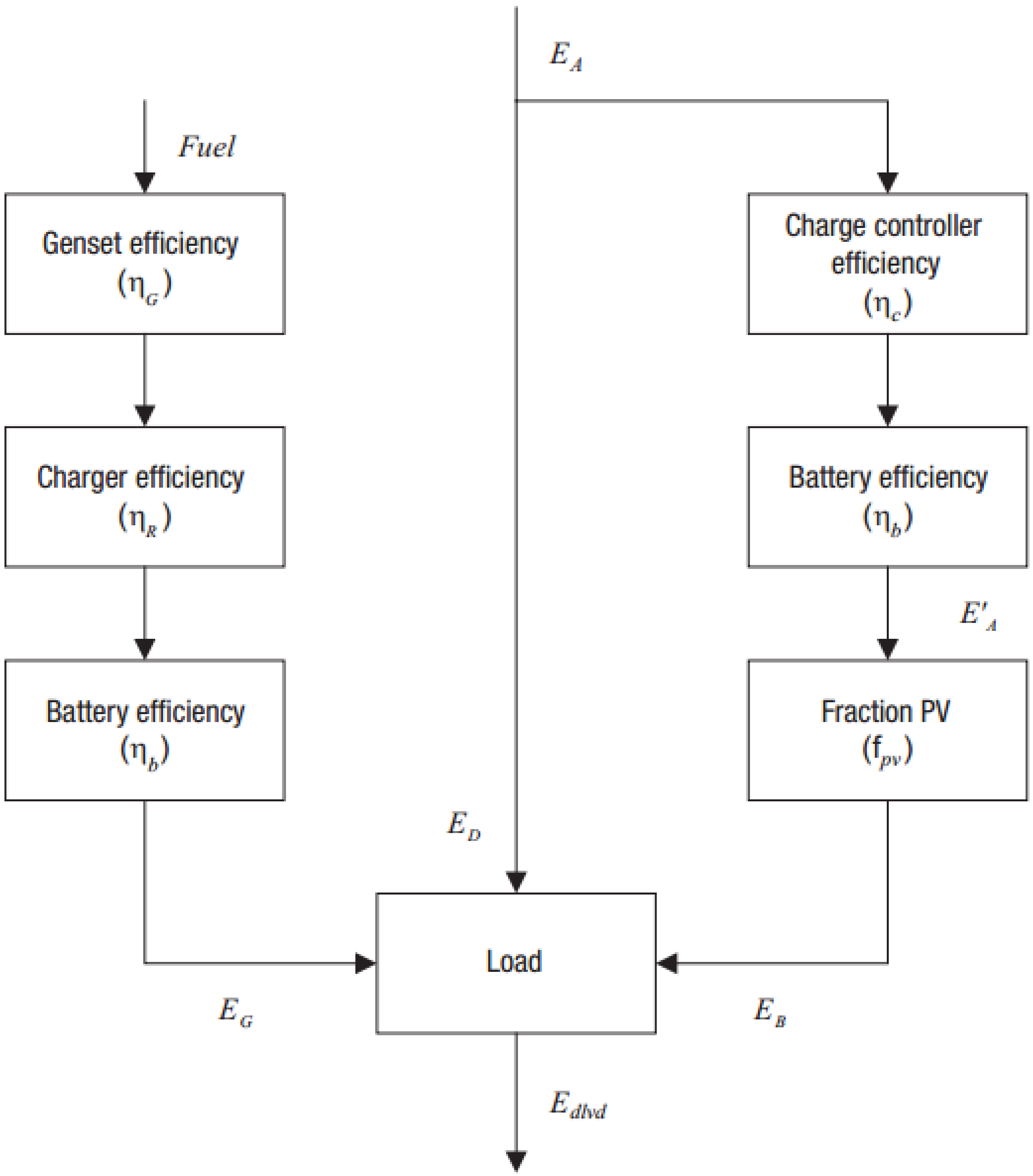


Figure: 5.4 Off-Grid Model's Flow Chart

5.3.2.2 Load calculation

Equivalent DC demand:

The off-grid model either uses battery backups or runs completely without generators. The primary distinction between a stand-alone and a hybrid system is the inclusion of a Genset that complements or supplements the remainder of the load, which is not covered by any other system and light as well as photovoltaic power: one thing led to another

Referring to the processes on-grid with a flowchart (FIGURE 5.4) makes it possible to follow how ideas flow from suggestions to plans to invoices and workload estimation. The market for DC electricity and AC voltage is equivalent to the customer defines both AC and DC usage (both are expressed in kilowatt-hours a day). Inverter efficiency is applied to transform AC energy to DC energy. Therefore, the corresponding value DC total is $3.0 x 1.5.0 = $3.5

Chapter 6

Conclusion

6.1 Fossil Fuels vs. Solar Energy

6.1.1 Energy Density

You will be able to remove more or less energy from each square meter They can't be compared because different energy sources have different densities; however, fossil fuels have a higher energy quality. It does, in reality, however, not power many solar cars.

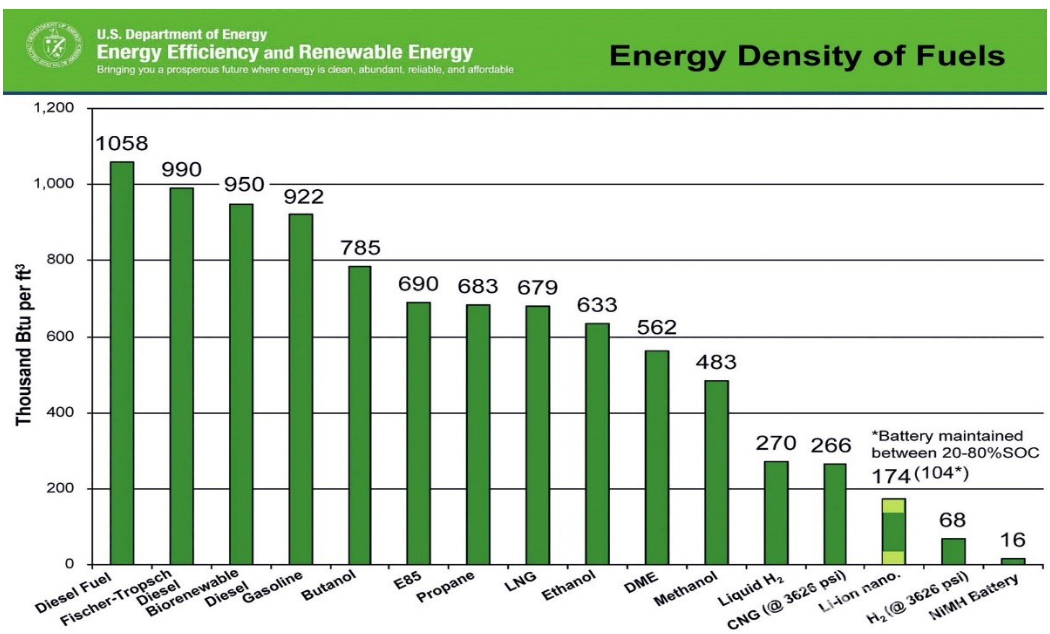
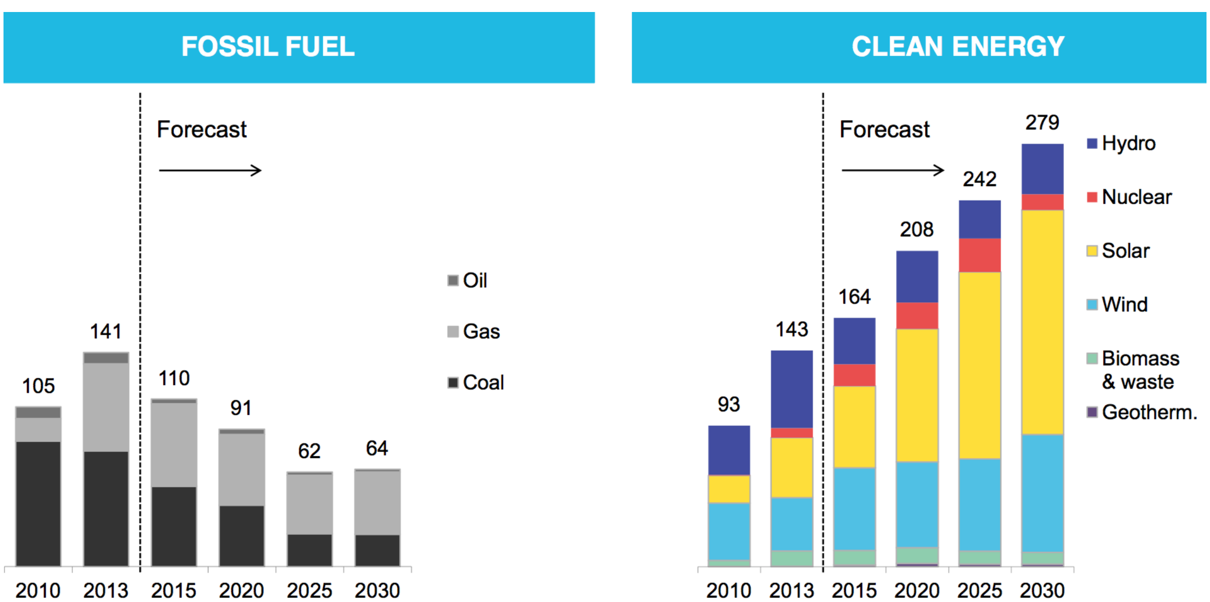


Figure: 6.1 Energy density of fuel

6.1.2 Availability

Fossil resources are running out Grandma's gallon of gas usually takes a long time to shape, but only uses a short period. When you use a gallon of petrol, one less gets used. alternative fuels will be there for the next 4-5 billion years Reducing the amount of solar power per day has little effect on Wednesday. Regardless of your views on these different fossil fuels, they will all be used up even before the sun dies.

An internet power source requires some electricity to create, uses harmful materials during its construction, but does so little harm to the environment due to its widespread use. The aggregation and transport of fossil fuels may cause pollution, but even more so, fuel combustion emits toxins add to that, they are also a significant producer of CO2, which can affect the world's climate basically since solar power is produced in different ways, it has different values Fossil plants are less costly per megawatt when you purchase the electricity. The upfront costs are higher, but the gasoline is free and upkeep is a lot less for fuel plants. The necessary cost of fuel-plant electricity is around 2-3 times that of solar energy. When you throw in distribution costs and site-specific factors, the total costs of solar power will still be lower.



(a) (b)

Figure: 6.2: (a) Fossil Fuels Availability. (b) Availability Of Clear Energy.

6.1.2.1 Long-Term Availability

Fossil fuels are a limited resource. The gallon of gasoline you burned to get to grandma's took millions of years to make, but you used it in just a few minutes. So when you burn a gallon of gas, there's one less gallon to go around. Solar energy is -- at least for the next 4 or 5 billion years -- a renewable resource. If you collect 1,200 watt-hours on Tuesday, you will not reduce the amount of solar energy you can collect on Wednesday. No matter what you believe about how much coal, natural gas and petroleum remains buried in the Earth, those fossil fuels will run out far earlier than the life of the sun.

6.1.3 Emissions

Some energy is expended in the manufacture of solar energy systems, some toxic compounds are used in their fabrication and large solar farms can disrupt the habitat of their locales, but the net environmental impact of solar energy generation is extremely small. Fossil fuels can damage the environment during their collection and transport, but even more importantly, fossil fuel combustion produces environmental toxins. On top of that, they also produce huge volumes of carbon dioxide, which is a gas that influences the global climate.

6.1.4 Cost

Because solar power is generated in a completely different way from fossil fuel-based power, it's a little complicated to compare the price. Fossil-fuel plants are not as expensive per megawatt as solar power systems, but you'll need to pay for the fuel as long as you use the plant. Solar power costs more up front, but the fuel is free, and the maintenance costs are much lower than for fossil fuel plants. Putting the factors together, the basic costs of solar power generation are about two to three times the cost of fossil fuel plants. When you add in distribution costs and specific local variables, there are some places where solar energy is already as cheap as fossil-fuel energy -- and solar costs are likely to fall more than fossil-fuel costs.

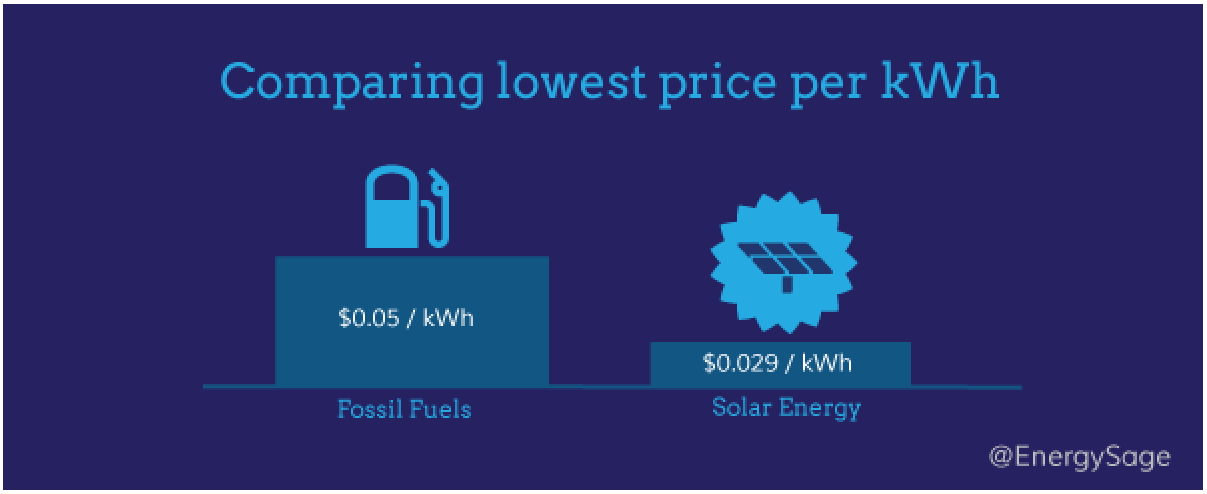


Figure: 6.3 comparison of cost pricing

6.2 Wind energy vs. solar energy

more prevalent in the US Just 19% of all renewable electricity was generated in the United States in 2015, and 6% came from solar. Mass consumers use wind power, but households in rural communities favor solar power

The most notable benefit of wind turbine advantage is that they don't rely on the sun on. To put it another way, this means that they only have electricity 24 hours a day, not every day. However, to be successful, wind turbines had to be located over any barriers that could obstruct the wind.

A conventional wind turbine for residential use must be at least 80 feet tall. Installation sites where wind speeds of at least 12 MPH were recommended If you live in an environment with plenty of open lands, many hills, and little trees, then wind turbines are also an ideal way to produce green energy. If you are looking to find an alternative power source, wind turbines that are smaller but still produce slight additional electricity 'boost' are available.

Additionally, solar panels are mostly used on roofs to have adequate energy for the majority of your needs. Inside the solar shopping cart, 84% of the annual electricity requirements were covered by solar energy in 2015 as moving parts for generators, turbines have also wear and tear otherwise, the solar PV system would need ground-mounted panels with a monitoring system (only for utility systems).

In the end, though, solar energy is a more feasible and affordable solution for home energy generation than wind. As suburban solar is factored in, a finding by Inland Power & Light becomes apparent. They noticed that, in Spokane, people keep hearing about the benefits of solar and wind power so they installed them. After 14 months, they were able to generate about five times as much power as anticipated.

In suburban and rural settings; solar is always the most economical option next.

- Solar power grid
- No rotating pieces
- Low cleaning
- Costs little to no money
- Consistent and NASA data is provided
- Places with normal wind speeds but five meters per second
- is less noticeable than a steam operational"
- prioritizes cables and wiring
- Less conducive to lightning damage
- May not get damaged by wind
- Typically mounted on the roof

6.2.1 Comparing Costs

With all of the factors to consider, all of the advantages and disadvantages to solar, wind and other alternative energy resources to take into account, there's one fundamental question everyone has about renewable energy systems: "What's it going to cost?"

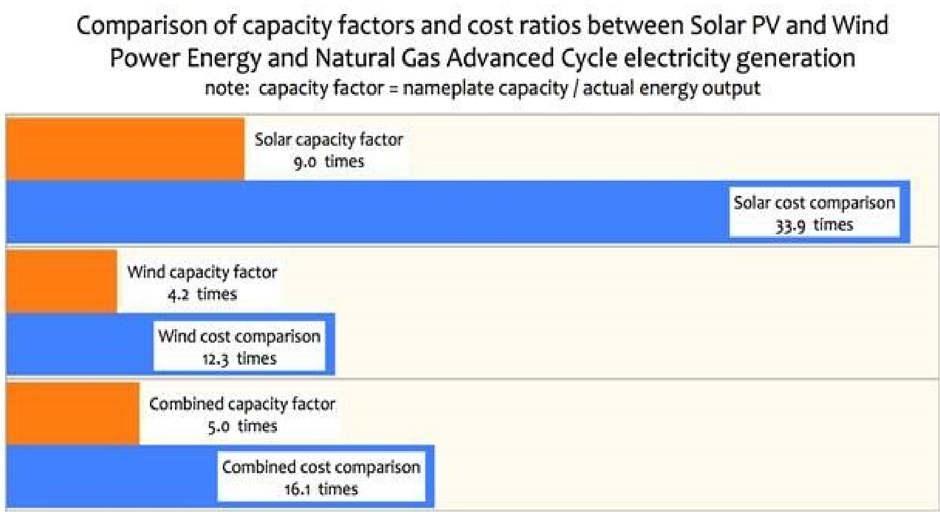


Figure: 6.4 cost comparison of Solar vs. Wind

- **Solar**

The total cost of a residential solar energy system varies substantially depending on several factors, including size of household, location, panel and accessory manufacturers, etc. Nevertheless, you should expect some steep upfront costs for the purchase and installation of any home solar system. However, those steep upfront costs are substantially mitigated by a federal government tax credit, through which the homeowner can claim a 30 percent credit for qualifying expenditures on his or her purchase of a home solar system. State and/or local incentives may also be available

- **Wind**

Like solar, residential wind energy systems come with steep upfront costs. Economies of scale play a big role in the cost of wind turbines. Residential or small farm-scale turbine systems, for example, come with lower costs overall, but a higher cost per kilowatt of energy production capacity. According to U.S Department of Energy's 2014 Distributed Wind Market Report, the average cost for turbines 2.5 to 10 kW in size (a 10 kW turbine, for example, is a reasonably sized unit for powering a large home) was $7,200 per kW, with small wind turbine installed costs trending downward.

Figure: 6.5 Wind Energy

6.3 Hydro Power vs. Solar Power

Figure: 6.6 Hydro vs. Solar

Time-tested sources of clean energy Although all fossil fuels and those substitutes have advantages over the use of coal or gas, each raises a separate collection of concerns for environmental policy and energy production.

On a cost basis, hydropower has a clear benefit over renewable energy In contrast, the U.S.S. Department of Energy considers hydropower the least green energy among us Of the 6% of the capacity that hydroelectricity represents, almost half of it comes from the United States. Solar panels tend to cost higher. Electricity costs: USD 90 per megawatt-hour to produce using hydropower, or USD 144 per Megaw of solar power.

6.3.1 Cost Considerations

In terms of production costs, hydropower holds a strong advantage over solar power. The U.S. Department of Energy calls hydropower the most common and least expensive form of renewable energy in the United States. Hydroelectricity represents 6 percent of all U.S. energy production, and accounts for 70 percent of all renewable energy generated in the United States. Solar installations tend to cost much more. For example, 1 megawatt-hour of electricity costs $90.3 in 2011 dollars to generate using hydropower, or $144.30 to generate using solar collectors, according to the U.S. Energy Information Administration.

6.3.2 Environmental Impact

Solar electricity is harmless, according to the National Atlas of the US. Many of the environmental costs of solar power result from the collector plates. Conversely, hydroelectric production also has a detrimental effect on the climate. Fish migration and biodiversity would be adversely affected by the building of dams on rivers.

6.3.3 Supply Stability

Hydropower represents a more stable and reliable means of generating electricity than solar power. Solar power generation works best when the sun is at its peak, which generally happens during the middle of the day. After the sun sets, solar power systems have no more energy to draw from. Storms and clouds can also impact solar power production. The U.S. Department of the Interior calls hydropower more responsive than other systems for meeting peak energy demands. Hydro plants have the ability to switch systems on and off with ease to respond to changes in demand, which can help to eliminate blackouts and brownouts.

6.3.4 Availability and Access

Solar energy can be used almost anywhere to power a home, generate electricity or run small appliances like roadside signs or even calculators. The U.S. Department of Energy's Solar Energy Potential Map shows that every location in the continental United States offers enough sunlight to generate at least 250 watts of electricity per square foot of collector space per day, with many locations capable of generating much more than that. Hydropower production, on the other hand, is limited to locations with access to a sufficient supply of running water to power turbines and other generating equipment. Many areas in the United States are considered exclusion areas, where federal or other statutes prohibit the use of hydropower production.

6.4 Solar energy vs. nuclear energy

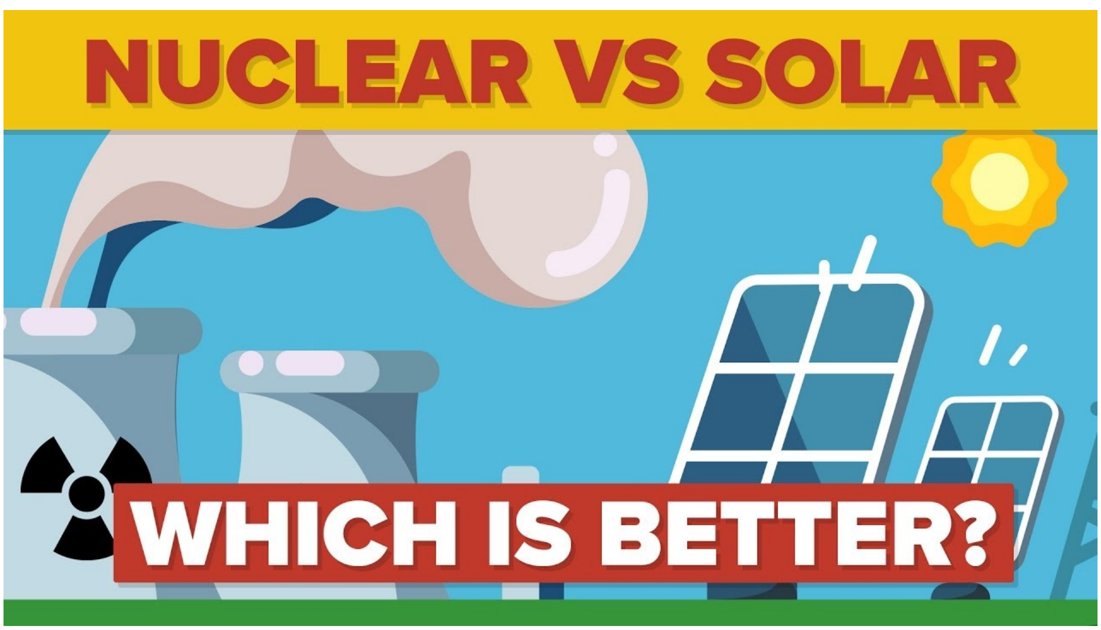


Figure: 6.7 Solar vs. Nuclear

Molarity (Speed of Light, squared). Here, the problems come up. Solar energy prevents humans from having the effects of an out of harm as far away as 93 million miles away from the reactor (the sun). However, for radiation safety, make sure to use the other shielding (i.e., sunscreen). Additionally, stop doing anything that would weaken our main radiation shield (the ozone layer in the upper atmosphere).

The reactor is here on Earth, behind the lead, and behind concrete protection. Fission releases hazardous materials which must be withdrawn from the reactor and deposited elsewhere (behind other lead, steel, and concrete shielding). All and everything is vulnerable to lose, human error, and natural disaster. if your health is endangered by radiation leakage, the only alternative is to limit your proximity to the source (is if you can't get far away) is to swallow iodine pills. Finally, go for the same companies who run those ventures as well. Neither is their record overall, but still decent (they are, after all, mere mortals)

6.5 Geothermal and Solar

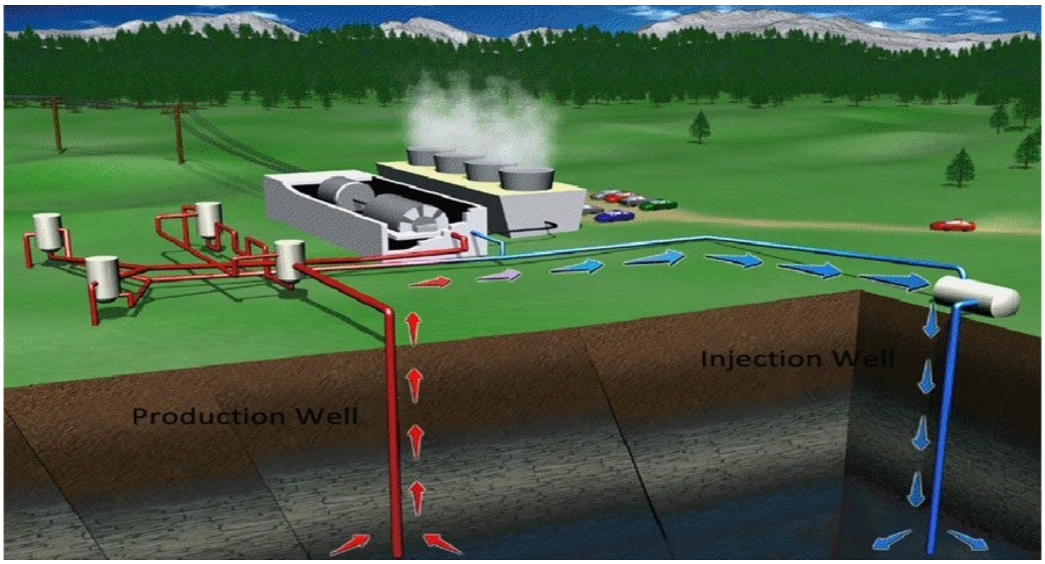


Figure: 6.8 Solar vs. Geothermal

Regardless of where you are on the earth, the temperature is still 50°F 6 feet below the surface. This effect can be seen in caves and mines all year round. Daniel's home water heat pump has been reversed and re-circulated. Over the winter, the solution reaches your home at 50° and is then heated to your optimum temperature. When it's humid, this happens. The air pump uses a little energy to pump up the ground.

Every geothermal heat pump requires as much power as if you had purchased a second, energy-efficient refrigerator. Geothermal heat pumps consume 75% less power than an HVAC rig and are more eco-friendly than using oil or propane. Nowadays, here's where solar fits in. With solar geothermal, you will remove your entire carbon footprint using a residential solar system, allows them to help keep the lights on and run their geothermal system If you own your solar and geothermal, you should expect free energy.

References

[1] U.S. Energy Information Administration: What are the Major Sources and Users of Energy in the United States?, 2016, Accessed: November, 2017.

[2] Solar Energy Industry Association: U.S. Market Installs 832 Megawatts in Q2 2013; Grows 15% Over Last Quarter, Accessed: November, 2017.

[3] California Energy Commission: Renewable Energy vs. Fossil Fuels

[4] Stanford University: Economic Analysis of Solar Power: Achieving Grid Parity

[5] Columbia University: Solar Energy Production Much Cleaner than Fossil Fuel, But Industry Can Still Improve, New Report Says

[6] International Journal of Green Energy: A Comparison of Energy Densities Prevalent Energy Sources in Units of Joules per Cubic Meter

[7] Keith Hughes Founder, Owner and Chief Project Designer West Seattle Natural Energy, Solar Power vs. Wind Power Cost, Types, Pros & Cons of Home Wind & Sola, Accessed November 2017

[8] Emily Beach; Updated April 25, 2017, Hydro Power Vs. Solar Power Advantages, Accessed November 2017

[9] available:https://dandelionenergy.com/geothermal://-vs-solar/ [Accessed 2016]

[10] Jake Kornack, Energy Consultant, “What’s the Difference Between Geothermal and Solar”, September 4, 2017, Accessed November 2017.