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Introduction

For decades, solar power is only identified as the conversion of energy from the sun's light to electricity. While this is an accurate definition, most people do not know that the energy harvested must first be converted to electrical energy to be able to produce generally functional electricity. The conversion is made possible through the photovoltaic or PV, a method that uses semiconductors to convert the sun's radiation to electrical energy.

Components of a Simple Solar Power System

Solar or photovoltaic cells

The assembly of semiconductors and electronics or solar cells is enclosed in a photovoltaic module, more commonly known as a solar panel. Several solar panels are called solar panel array.

Battery

A solar panel collects and generates energy from the sun's radiation. PV panels convert this energy to direct current electricity, a current that is produced by batteries. Although connecting a DC load directly to the solar panel is possible, batteries play an important role to a properly working photovoltaic system.

- The battery stores energy generated by the PV panels
- It stores excess energy that exceeds that of what the load requires
- The battery serves as a back-up energy source when there is no supply from the PV system

During the whole process, the battery experiences a cyclical process of charging and discharging. When it stores harvested and excess energy, the battery is charged. When the load consumes electricity, the battery is discharged. During the day, the cycle is continuous especially if the solar panels are not generating sufficient electricity for the load. As the day ends, the battery experiences continuous discharge, depending on the load and the availability of stored energy.

Regulator

A regulator is optional yet a vital equipment in a photovoltaic system. During the cyclic process, the battery is likely to become overcharged or over-discharge, a situation that shortens the batteries' lifespan. A regulator prevents such situations from happening by regulating the batteries' condition. It maintains a stage of charge where it monitors when the battery will be overly charge or discharge. In general, a regulator keeps the batteries in the most appropriate working conditions.

Converter/ Inverter

A converter allows the DC electricity stored into the batteries to be converted to AC or alternating current electricity, the type of energy that is used by the mains power supply. The DC/AC or direct/alternating converter is also called an inverter and is used to match the required current and voltage by the load. It is typical to experience some energy loss during electricity conversion.

Load

Any appliances that consumes electricity is considered a load. When choosing a load for the solar power system, it is necessary to start with a low power component before installing additional solar panels to avoid wasting of resources. PV systems are ideal for illumination as lights only consume several watts compared to bigger appliances like television, components, or computers. There are also lightings that operates on direct current electricity, allowing the use of solar power system in a low budget scale.

Solar panels, battery, regulator, converter, and load make up the solar panel system. When all of these components are installed properly, a solar power system can sustain itself for years.

Benefits of Solar Power

For most residential users, power grid is the most convenient source of electricity. It seems like a huge power shortage or outage is still in the distant future. However, the increasing worry about the exhaustion of fossil fuels is drawing authorities all over the world to exploit renewable energy sources. As solar energy is the most commercialized among other renewable energy, it is necessary to know how you, as a residential end-user, can benefit from solar power.

Low-cost production

Solar power is a proven commercial energy source. Among other renewable resources such as wind, hydro, biomass, biofuel, and geothermal power, solar power the only clean energy that is able to generate a large market scale including residential users. Due to the advancement in solar energy technology and the consistent improvement of financing approaches, solar energy project implementation is steadily reducing.

China’s emergence as one of the biggest manufacturer of solar panels largely affects the cost of end-user materials. The country also produces wind turbines although exports are limited unlike the global production and export of PV panels.

Infinite energy source

Depletion of fossil fuels is an unvarying threat to energy security. Fossil fuels are non-renewable energy sources and its exhaustion is inevitable, which means power supply shortages all over the world. On the other hand, renewable energy like solar, wind, and geothermal power are able to generate electricity without depleting natural resources. These natural energies are infinite sources of energy. If installed and utilized properly and strategically, renewable energy can supply the whole world with clean electricity.

Earth friendly

Solar energy, like all green energy, produces relatively small amounts of greenhouse gases or GHG, one of the major factors to the thinning of the ozone layer. It reduces the carbon footprint in all sectors. The utilization of alternative energy also promotes the production of low carbon technology products such as LED-powered lights, low-carbon appliances, and hybrid cars. More energy efficient storage and solar panels are being developed to improve the viability of alternative energy.

Modification of electricity usage

Solar power systems are not only able to generate and supply power to residential users, it also allows end-users to modify their electricity usage. This is

made possible by a two-way smart grid system between the main power supplier and the consumer. When your solar power system generates excess energy, the power meter turns backwards. A synchronous inverter is necessary, as it will be the one to match the incoming main supply. When such favourable conditions occur, your electricity supplier pays you back for the excess energy generated by the solar power system.

Alternative energy is by nature unpredictable as the amount of generated energy greatly depends on weather conditions.

Incessant government support

The fact that the recession hardly had an impact to alternative sources demands proves that renewable energy is a stable and continuously strengthening industry. The unrelenting government support, including incentive packages from various countries, helped boost the industry especially solar, wind, and biofuel generation. Energy smart technologies are gaining increased support from capital and private equity investors, giving way to digital and power saving applications in the market.

Governments all over the world are offering stimulus packages of tax credits and incentives to residential, commercial, and industrial users. Aside from tax deductions for individuals and companies that install solar power systems, the federal government also offers cash back reward programs, property tax

investors partner with solar companies to sponsor recycling programs and allow conscious consumers to dispose old products properly.

Low maintenance and operating cost

The ideal set-up requires it to have optimum sunlight exposure during the day, and if this is achieved, then expect consistent energy generation on ideal weather conditions. However, proper operating and maintenance must be done periodically to ensure optimum collection of sunlight.
PV panels, if installed properly and strategically, are virtually maintenance free. Basic maintenance of solar panels includes keeping the solar panel array clean and free of debris. Washing the PV panels is also recommended especially if you live in a particularly dusty region. Use non-abrasive cleaners and wash cloth to avoid scratching the panels. A garden hose can be use to rinse the panels.

Life expectancy

Aside from its self-sufficiency, solar panels have an average of 20 or more years of operational life. With recent developments of materials used in building PV panels, the life expectancy and viability of solar panels is expected to improve in the coming years. During these years, approximately $2,000 is needed as maintenance and operating cost of PV panels.

Eliminate the cost and difficulties of transporting conventional fuel

The federal government allots billions of dollars to transport fuel and other natural gas to the country for electricity generation. Solar power systems reduce such cost, as photovoltaic panels do not require fuel or natural gas to convert sunlight to electricity. Building of large solar power plants also allows local generation of environmentally friendly electricity where it can be delivered to residential, commercial, and industrial users.

Electric cars can charge their batteries using green energy, reducing the use of fuel, gas, and oil as well as preventing carbon dioxide emission. Solar power system also helps stabilize the economy of countries that lack natural resources of natural gas.

Solar Power Technology

Steady funds from the government and the pouring support of investors have lead to innovations in solar energy's infinite potentials. There are three solar energy active conversions: solar photovoltaic, concentrated solar power, and solar heating and cooling.

Photovoltaic panels

Photovoltaic panels use silicon solar panels to convert the sun's radiation to electrical energy. PV cells can be installed according to electricity needs and can power small devices like calculators and watches to a whole residential power requirement.

There are also two kinds of photovoltaic panels: crystalline silicon (c-Si) modules and thin film modules.

C-Si modules

Majority of PV modules are based in crystalline silicon due to abundant resources. There are two main forms of c-Si: single-c-Si module and mc-Si or multi-crystalline silicon module. Commercial sc-Si converts electricity better than mc-Si while the latter is less expensive than single crystalline silicon modules.

Thin film modules

Thin film PV modules are made by depositing extremely thin layers of photosensitive materials in glass, plastic, or stainless steel backing. The first thin film produce is a-Si or amorphous silicon. It offers several advantages including low consumption of raw materials, high production and automation efficiency, better performance in high ambient temperature, simple assembly and manufacturing integration, and more resistant to overheating. On the other hand, thin film modules have lower efficiency than crystalline silicon modules and the industry is yet to develop modules with long-term reliability.

Underway research is the integration of single-crystalline and amorphous PV cells. The study aims to better the efficiency of thin film modules in the following years.

Photovoltaic technology is a reliable source of electricity to residential and commercial users due to the effective supporting policies and remarkable cost reduction. Emerging technology include concentrating photovoltaic and organic solar cells. Concentrating PV utilizes an optical concentrator system that focuses sunlight into a small efficiency cell. It is currently ongoing test stages on pilot applications.

Concentrated solar power

CSP concentrates energy from the sun's rays to heat a thermal receiver suitable to hold high temperatures. Unlike a photovoltaic system where sunlight is converted to electricity, the thermal receiver converts sunlight to heat where it will be transported to a steam generator to convert it to electricity.

Concentrated solar power has been in operation for almost two decades and is a proven solar energy technology. It is not as marketable and simple as PV modules but the government of United States and Spain supported the technology to respond to the global crisis. CSP are mostly used by large power grid companies as it can collect and generate more electricity than PV panels. There are four current CSP technologies categorized in their ability to focus the sun' rays and receive the sun's energy: parabolic troughs, parabolic dishes, linear Fresnel collectors, and Towers or CRS.

Parabolic troughs

Parabolic troughs consist of two parallel lines of mirror or reflector curved in a single direction to focus the sun's energy to a fluid carrying receiver placed in the heart of the curved trough mirror. The sun's energy heat the fluid inside the tube and the generated heat energy is used to generate electricity using a steam engine or generator. The tubes or absorber collectors are generally made of stainless steel and coated with a selective coating. Both the reflector and

absorber collector moves with the sun as it crosses the sky. This ensures that the sun is continually focused on the receiver pipes. Parallel lines of parabolic troughs are called collector fields.

Parabolic trough plants are hybrid. When there is insufficient sunlight, the plants burn natural gas such as coal and fuel to meet load requirements.

Parabolic dish

Parabolic dish plants use dish mirrors to concentrate sunlight and focus it to a thermal receiver. Unlike parabolic troughs, parabolic dish is a standalone unit, which is composed of a collector, thermal receiver, and an engine. The entire unit tracks the sun all throughout the day. The engine eliminates the need for heat transfer fluid and cooling water. Instead, the engine or generator is air-cooled. Parabolic dish uses dual axis collectors, allowing it to capture maximum amount of sunlight during the day. Compared to other CSP technologies, parabolic dishes offer the highest solar energy to electricity conversion as it can achieve extremely high temperatures and high efficiencies.

One of the drawbacks of small parabolic dishes is it does not work well with thermal storage. The converted electricity must be fed immediately to solar grids. However, very large parabolic dishes are found to be more compatible with thermal storage and natural gas back-up. Manufacturers as well as promoters

see huge parabolic dishes to compete with larger solar thermal plants in the future.

Linear Fresnel Reflectors

This CSP technology is much like parabolic troughs as it uses a single axis collector and a fluid-carrying receiver. However, linear Fresnel collectors are made of long rows of ground mounted mirrors or reflectors to concentrate the sun's rays. The thermal receiver is elevated and fixed atop the reflectors. Although the design has lower efficiency than parabolic troughs, it requires less land and is also more inexpensive than troughs. The current design of LFRs made possible direct steam generation by allowing water to be fed directly on the thermal receiver and be boiled at about 50 bars of atmospheric pressure. The saturated steam produced is use to power a steam cycle. LFRs produce lower optical efficiency compared to troughs and are low in compatibility with thermal storage.

Power Towers

Also known as central receiver systems, power towers employ thousands of field tracking reflectors, heliostats, to collect sun's radiation. The reflectors are mounted atop a fixed tower. Sunlight is absorb molten salt or pressurized water, working the fluid flowing through the receiver and serving as thermal storage as well. Power towers surpassed the operating temperature of parabolic troughs

and linear Fresnel reflectors but not parabolic dishes. Power tower design offers more flexibility as designers can choose a wide array of heliostats, thermal storage, power blocks, and transfer fluids. This CSP technology has more potential for lower operating costs than line-focus technologies like parabolic troughs and LFRs.

PV panels or CSP

PV panels are more marketable and available to end-users. However, CSP is considered more cost-effective than photovoltaic panels. CSP can convert 60 – 80% of the sun's rays to electricity while PV panels can only convert 10 – 15% of sunlight to grid compatible electricity. PV panels' energy generation can be scarce as it is limited to the amount of sunlight whereas CSP reigns supreme especially in desert locations. On the other hand, the simplicity and availability of PV panels make it a more viable solution than CSP that is yet to make its mark on the market. With the progression of solar energy technology, there is a great possibility of combining PV panels with CSP technology as demand for green energy increases steadily in different parts of the world.

Solar thermal energy (STE)

Solar thermal energy is the harnessing of sunlight and utilized it in specific purposes such as heating/cooling water or building spaces. Unlike PV panels, solar thermal collectors convert heat to thermal energy so it can be used as a

heating and cooling facility. Solar thermal collectors are categorized in low, medium, and high collectors. Low thermal collectors can heat swimming pools using flat plates that are similar to PV panels. Medium thermal collectors are used for both residential and commercial use and also utilize flat plates. High thermal collectors use CSP technology as it can convert heat better than flat plates. It is use in general power production. Concentrated solar power is a technique employed by solar thermal plants.

Uses of Solar Thermal Energy in Solar Heating and Cooling

Water heating

Residential and commercial users generally install low solar thermal collectors as a heating facility for swimming pools. A simple solar thermal heater can be composed of a series of black painted pipes layered in an insulated box and framed with glass, plastic, or metal panels. Potable water runs through these collectors and into the storage tank. Potable water can be cycled several times into the collectors and back to the tank again to increase water temperature.

Thermosyphon system uses this configuration. The tank is placed above the collectors and takes advantage of the hot water's natural tendency to rise above cold water. As hot water is drawn out for use, untreated potable water is fed through the collector.

Water tanks under the collector need an electric pump to drive the water inside the collector. Such a system needs an anti-freeze or anti-corrosive chemical to treat the circulating fluid. A heat transfer fluid is also required to heat the end-users water supply.

Space heating and cooling

Low temperature collectors are also use for space heating. This is necessary in colder parts of the world, especially during winter season. Huge quantity of electricity is needed and if the building is well designed for solar insolation, a building can be cost and fuel-efficient and can provide a comfortable habitat.

A simple solar space heating configuration is the installation of a Trombe wall. This is an enormous black painted wall and has a double glazed skin to prevent the sun's heat from escaping. UTC or unglazed transpired collectors are perforated sun-facing walls used for pre-heating ventilation. Transpired collectors' short payback period of 3 to 12 years makes it a cost-effective alternative to Trombe wall and other glazed collector systems.

Space cooling is not as technical as space heating and can be done through natural methods like planting deciduous trees. The leaves serve as shade during summer and its branches and limbs let the warmth of light pass through during winter. Other cooling solutions include installation of dome roofs and thermally massive structures, shaded windows, and bamboo structures. For mechanical

space cooling methods, use of absorption refrigeration cycles and desiccant cycles are proven methods to promote a cooler space.

Solar cooking

This technology has been used for years in developing countries. A solar cooker is composed of wooden box lined with insulation and covered with a reflector. The reflector concentrates the heat of the sun to the pots, which are painted black to maximize heat absorption. The cooking time is relatively slower but is compensated by the lack of fuel cost. This cooking method is normally used in regions with strong and sufficient sunlight.

The Scheffler solar cooker configuration is much like concentrated solar power (CSP) as it uses a parabolic dish with a single axis tracking the course of the sun throughout the day. Since the reflector system has a focal point, it can reach high temperatures, allowing faster cooking time. Larger Scheffler solar cookers have been in production since 2008.

Solar drying

Solar thermal energy can be used to dry crops, woods, and food products like grains, fruits, and fish. Solar drying is a low cost solar thermal technology that uses transpired plate air collectors that are based on black materials or fabric. It

is also environmentally friendly and improves the quality of the crops with minimal cost.

Solar water distillation

This is useful in regions where clean water is not always available. Solar thermal collectors heat the potable water where it evaporates and condenses at the bottom of the covering glass.

Wind and Solar Energy: Compatible Hybrids of Two Alternative Energy Sources

Solar power is a renewable energy resource but its intermittent nature makes it difficult to provide stable and reliable power that meets the required electricity demand. The inevitable change of seasons and weather conditions limit the amount of sunlight in various regions. Due to this, most residential and commercial solar power users use substantial backup in the form of fuel and coal powered electric grids, as solar power system cannot generate sufficient energy for the whole year. Combination of two alternative energy systems in a strategic location also reinforces the autonomy of the system.

Low cost production of wind energy positively reduces the overall cost of solar and wind power system combination. Wind energy is also one of the major sources of alternative energy and investor’s support for wind power generation

exceeded other alternative energy sources. It also comes second for overall renewable energy generation in the world with hydropower placing as the number one renewable energy resource.

The federal government is pushing the use of combined solar and wind energy to answer the limitations of solar energy. The plan is concentrated on regions where there are strong winds at night and ample sunlight during the day. This includes locations near mountains and the ocean or sea like rural and wider geographic areas. The combination of solar and wind energy is a proven alternative energy tandem as most of the time, there are strong gusts of wind at night when solar panels cannot collect and generate energy from the sun. Instead of using grid-tied electricity, wind energy serves as the backup energy generator as well as another electricity contributor to independent electric systems. There may still be a need for baseload power but it would only be minimal.

Solar and wind energy installation

Installing of a dual alternative energy system require separate regulators for both PV panels and wind turbine to ensure that both systems run on optimum conditions. A stationary battery that can hold deep discharge cycles is widely used due to availability and affordability. What makes wind and solar energy compatible is their ability to generate direct current electricity. As mentioned in the introduction, an inverter must be employed to convert DC to AC power. A DC source center serves as a connection point for other DC sources, batteries, and

loads. For hybrid wind and solar energy, both systems must be connected to a DC source through separate regulators with no additional controls required.

1. Installation of wind turbine and solar energy is done separately and must be mounted/installed in strategic locations. Many wind turbines have built-in direct drive generators. Connect the output wires to the regulator. The rule of the thumb for small wind turbines is that the amp-hour capacity of the battery bank must be at least six times of the renewable charging current. Although the demand for the battery will be low because of the incorporated PV system, ascertaining your electricity demand is necessary to avoid over-discharging and overcharging the battery.

2. Once the wind turbine is installed, connect the wiring of the turbine transformer or regulator to the DC source center breaker. Follow the wiring diagram provided by the DC source center.

3. Mount the PV panel in a location where it can collect sunlight all day long. Panels are simple to connect as they can be plugged together but for safer installation, read the manufacturer's manual. Connect the PV panels to its corresponding regulator and then connect the controller to the DC source center's breaker.

4. The battery bank must be configured to optimize the generated power and the loads' power requirements. This can be done by wiring the batteries in parallel,

series, or series-parallel. For higher voltage, wire the battery in series and in parallel for higher ampere rating and longer battery usage. Battery voltages of renewable energy systems come in 12v, 24v, 48v, 60v, and 72v.

5. Once the batteries are wired accordingly, connect it to the DC source center relay. This is to ensure that the collected energy is input by the regulator and the output comes from the battery bank to the inverter. Again, follow the DC source center's wiring diagram.

6. Connect the output of the DC source center to the converter/inverter to convert direct alternating current to 110V AC or (220V AC in other parts of the world). The inverter can also be fed to the backup generator like grid-tied or off-grid systems. The inverter must be connected directly to the house main electrical panel.

Solar Energy Products

With recent innovations in solar power technology, more electrically powered products are aiming to utilize solar power to keep up with the solar energy revolution.

Solar panels

Solar photovoltaic panels or simply PV panels are the most popular solar power product both in residential, commercial, and industrial applications. Its popularity is due to the programs and stimulus packages financed by government agencies throughout the world. It is a proven source of electricity both to rural and urban regions. PV panels can power billboards, bus stop, highway traffic and sign lights, emergency telephones, navigational buoys, as well as residential home appliances like television, fans, pumps, computers, etc.

Solar powered pumps

In rural areas, solar powered pumps are use to supply water to residential areas, livestock, farms, etc. In the metropolitan, it is a convenient way to supply water to gardens and fountains. Typically, a DC solar powered pump is used in smaller applications like fountains while AC solar powered pumps are suitable for any type of application, be it landscaping or irrigation.

Solar boats and vehicles

Solar boats are ideal to use in still waters like lakes. It can be easily powered in a nice, sunny day without using batteries and is easy to be rowed if there is insufficient solar energy. Hybrid vehicles are automobiles powered by two or more power sources. In the case of solar hybrid cars, the car typically is powered by fuel or other energy source while the electronics are powered by solar energy. There are solar-charged vehicles as well, which mainly used solar energy to charge the car's battery. Electric bicycles, which use electric motors, also have solar electric bicycles where solar energy is used to charge the bike's motor. Solar hybrid boats are also available

.

Solar pool heaters

This uses solar thermal power and not the usual PV panels. A flat plate, normally called solar thermal collectors are used to collect heat which then converts it to electricity by heating water to produce steam and drive a turbine connected to an electrical generator. The process is more complex than PV panels but is more cost-effective and job-efficient.

Solar pool heaters can be mounted on the rooftop where the solar thermal collectors can collect sufficient sunlight. Swimming pools can be heated in two ways: direct or open loop system and indirect or close loop system. In the open loop system, the water is circulated on a hot water storage tank where the

collectors heat the potable water. In close loop system, a heat exchanger is use to separate the potable water from the fluid that circulates through the collector. When the fluid is heated, it is then combined with the potable water. The close loop system is ideal for cold weather while the open loop system is only applicable to tropical or moderate weather conditions.

Solar pool covers

Automatic pool covers use an electric motor to mechanically cover the pool after use. The motor is powered by solar energy while the pool cover is made from standard materials. However, pool covers can replace solar pool heaters as a pool cover is able to increase and decrease the pool's temperature. During hot weather, a pool cover reduces the heat from the sun by absorbing 75% of solar energy that may strike the pool surface. During cold weather, pool covers keep the pool's water in moderate temperature as it does not only absorb heat, it also absorb freezing temperature.

Solar lighting

Indoor solar lighting is possible through a daylighting system that collects and distributes sunlight for indoor illumination. Outdoor solar lighting is composed of simple solar power system where the lights are continuously being charged through the day and discharge at night by illuminating walkways.

World's Top Solar Companies

Numerous PV panel manufacturers are entering the mainstream market today. In a month's time, there are several announcements of cheaper solar panel costs and an even more exhilarating newfound technology. To help you deal with the confusion, here is a list of some of the top PV panel producers all over the world.

1. First Solar (FSLR) - is a US based solar panel known for its Cadmium Tellerium technology, which allows the production of the lowest priced thin film photovoltaic panels in the world. The Cd-Te technology, however, is highly criticized for its low efficiency. Nevertheless, First Solar still retains the use of the more reliable crystalline silicon and is popular as one of major PV panel makers in 2009, as well as the largest producer of thin film PV modules.

2. Sharp – the number one electronics company in Japan, Sharp is the third largest producer of PV panels as well as the world's top earning solar company in 2009. However, due to China's solar energy development plans, it only ranked fifth in 2011. Sharp has also switched its focus from c-Si to a-Si because of the high production cost of crystalline silicon. Nevertheless, this Japanese electronics giant is still one of the biggest and most reliable solar companies in the world.

3. SunPower – SunPower Corporation is based in Silicon Valley and enjoys the reputation of the best producer of highly efficient c-Si PV panels in the world.

SunPower produces c-Si solar panels that are 50% more efficient than standard crystalline silicon PV modules. It's solar ranch project is considered to be the largest photovoltaic installation the world. The corporation faced hard times due to the higher cost of their PV panels but is slowly undergoing a recovery phase. Just like other Western counterparts, SunPower I also challenged by the Asian's solar panel production. In 2010, SunPower acquired SunRay Renewable Energy.

4. Trina Solar – one of the most solid solar companies in the world, Trina Solar is known as one of the lowest cost maker of PV panels. This may be because they sell their solar panels at very low prices as well. It is slowly gaining popularity in Europe. Trina Solar sell PV panels at about $340 per 200 watt PV panel.

5. Yingli Green Energy – one of the oldest companies in China, Yingli has been growing consistently for the last five years. However, as new solar companies are expanding, Yingli finds it hard to expand and improve at the same rate as FSLR and TSL, which are both of the same size as Yingli Green Energy.

6. Suntech – Suntech takes advantage of the low overhead expenses in China and reaps the sweet price of taking risk in a foreign land. In 2010, Suntech became the world's number 1 producer of PV panels and paved the way for China's solar power market growth. Suntech is one of the quality producers of solar panels in China. The company also provides environmentally-friendly electricity to residential, commercial, and industrial sectors and public utility applications.

7. JA Solar – Unlike other big names in the solar power industry, JA Solar first began to produce PV panels instead of going big and create PV modules. JA Solar is considered by some experts as the most undervalued solar company in its early years. However, its fast growth and expansion to PV module production makes it more possible to become a world leader in solar cell and solar panel production in the coming years.

8. Motech – a Taiwan based solar panel producer, Motech ranked first in 2007 but has suffered intensely in the following years due to the rapid growth of other Asian solar companies and the resulting low cost competition. Nevertheless, it is currently expanding in the US and is stating polysilicon production at AES Polysilicon.

9. Gintech – Gintech is one of the fiercer competitors of Motech in Taiwan. It is currently the largest producer of solar cell in the country. Like JA Solar, Gintech focuses on producing solar cells instead of modules.

10. Canadian Solar – headquartered in Ontario, Canada, the company produces and sells a wide-array of solar panels for a very low price. Canadian Solar also have factories in China to enter the Asian market.

11. Solarworld – the biggest German manufacturer of PV panels, Solarworld is strongly expanding in the US and still holds operations in Europe. The company has suffered due to low cost competition. It is also the only Western company

that is still not expanding in Asia. Solarworld is best known for using raw and recycled materials in PV production, which accounts for the its low price modules competing in the industry.

12. Renewable Energy Corporation – the company is based in Norway and mainly produces polysilicon and solar wafers. Just like other Western solar companies, REC has been hit terribly by the decline of PV panel prices. REC owns other direct and indirect subsidiaries as well as a 33% stake in Sovello AG.

13. Panasonic/Sanyo – Sanyo is a producer of highly efficient solar panels. The company produce and sells PV panels in Japan and United States. With the buyout by Panasonic, another leader in electronics technology, products expanded into energy storage and efficient solar energy home solutions.

14. LDK Solar - the company is the largest manufacturer of solar wafers that are used by c-Si PV panels. LDK Solar is highly limited by competitors but is seen to grow in the next couple of years. The company produce multicrystalline silicon (mc-Si) PV wafers and sell these to PV manufacturers across the globe.

15. GCL Poly – GCL is one of the largest suppliers of polysilicon and solar wafers in 2010. This is an impressive bout considering that it is virtually unknown in 2008. GCL is growing rapidly but are not yet into manufacturing of PV cells and modules.

Why Invest in Solar Energy Companies

In the beginning of 2009, huge companies and corporations saw the fast decline of the world's economy. Many renowned names in the business even filed for bankruptcy. 2009 was a dark year for global economics. It's only in the last quarter of the year that investors and corporations saw the silver lining. 2010 was the year of rebuilding confidence and taking opportunities.

The world energy demand suffered during the recession but amazingly, the alternative energy sector is hardly touched. Amidst the economic slowdown in 2009, the alternative energy industry is having a blast. Garnered revenues for the top three alternative energy i.e. solar photovoltaic, wind, and biofuel, increased by 15.8% with solar PV acquiring more than 40% of the share.

The resilience of solar energy to the ever changing world of stocks makes it a fine attraction. This stimulating package is even made more lucrative by new solar energy technologies, efficiency regulations, building codes, commercialization of energy storage, and global funds for renewable energy. To begin your solar energy venture, here is a list of 10 of the biggest solar companies that dominates the stock exchange.

First Solar – the US based solar company has been hit by competitive solar panel prices in 2010 but in terms of company management, financial stability and growth, and profitability, First Solar remains to be competitive and well-run. It

would be nice to invest and have a nice look at dividends as the stocks rise in the ASE.

JA Solar – JASO's commitment to turn revenues into profits even with low cost of production is paying back the company well. JA Solar ranks number 2 in terms of global profits due to increasing margins. Although there is a huge debt that still needs to be paid, the tremendous ROE is greatly turning equity into income. JA Solar is expected to become a world leader, not only as a solar company but as one of the best solar stocks to buy.

GT Solar – still an emerging solar company, GT Solar is the strongest financial health in the solar industry. The company has increased its revenue by an outstanding 1000% in just five years and only acquired debts in 2010. However, the number of shares is quite numerous for the size of the company but it is compensated by its ROE, which is highest in the industry. its high profitability score can surely increased its growth margin. GT Solar is a key investment and holds a remarkable record of secure and healthy financial growth. This in effect can influence the share price.

Trina Solar – Overall, Trina Solar is one of the most solid solar companies in the industry. During First Solar's difficulty in 2010, Trina Solar was the one of the companies to take on the lead. Their market expands to major parts of the world including Europe, Asia, and the United States. For investors, Trina Solar proves

to be a handsome buy as its ROE and ROIC are taking a growth leap each year. It has strong financial health and the trends are all leaning to higher valuations.

Jinko Solar – this young company may not have entered the list of the biggest solar energy producers in the world because of its relatively young age in the industry but its potential for growth is very impressive. With expected increase of shares, strong margins, and high P/E ratio, JKS offers a lot of rewards but also some inevitable risks. It may have relative debts to handle but if it can keep its debts from increasing and continue its growth phase Jinko Solar can surely compete with other larger companies.

ReneSola – Like JKS, ReneSola is still small but definitely armed with strong growth capabilities. The company develops quality solar wafers, which proves to be a profitable. Its expansion in China opens many possibilities and are not yet affected by price competitions as its main competitor, GCL-Poly is still in the expansion state.

The future of photovoltaic

The production of thin-film PV cells is partially replacing crystalline silicon PV panels. Cadmium Telluride (Cd-Te): a relatively low-cost thin-film solar cell produced by First Solar, amorphous silicon (a-Si): produced by Sharp, and Copper-Indium-Gallium-Selenide (CIGS): first manufactured by Global Solar

panels in the near future.

The increase in production and demand is due to its potential to be more efficient than traditional silicon-based PV panels. Although CIGS shows potential to increase its efficiency by 19.9%, it has not reached the efficiency of c-Si, which is 40%. However, the promise of development and better technology is driving more solar companies to invest in thin-film solar production.

Moreover, the mark of share of c-Si, in a span of 10 years, has drastically fallen from 90% while thin-film solar cells show growth from less than 10% to more than 40%. Although the difference is vast, these figures show that thin-film solar cell production and marketability holds more promises for the future.