

Report

On-grid Solar Roof System@TD

Mr.Suthipong Thanasansakorn (TRSDH)

Mr.Thaweesak Thimkrap (MESH)

Acting Sub Lt. Anusorn Chanyim (FPHE)

Training and Research Supporting Division

28 January 2022

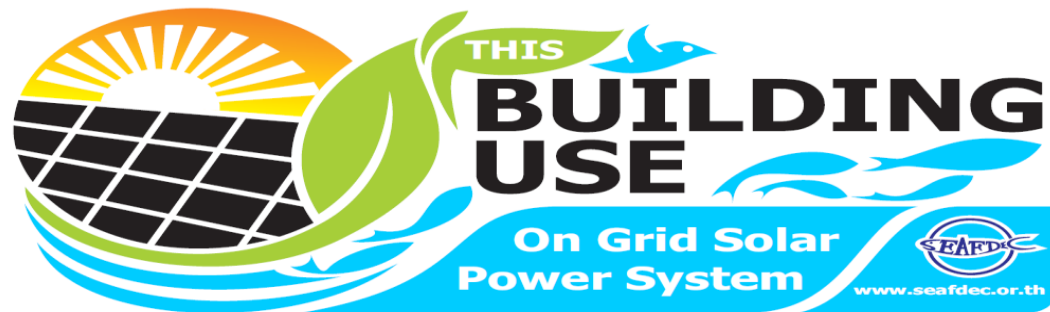


Table of contents

(1) Background _____	3
(2) Introduction _____	3
(3) Rational _____	4
(4) More Sustainable and Resilient _____	4
(5) Objective _____	5
(6) Output _____	5
(7) Advantages and disadvantages of the on-grid system _____	5
(8) Solar Panels _____	7
(9) Exclusive discussion _____	8
(10) Categorize the different types of solar panels _____	9
(11) Solar inverter _____	12
(12) The different types of solar inverters _____	13
(13) DC/AC Circuit breaker _____	16
(14) Solar energy monitoring system _____	16
(15) Smart power sensor _____	17
(16) Proceeding _____	17
(17) Maintain the solar panel system _____	18
(18) Benefits of predictive maintenance _____	18
(19) Power cable for solar cells _____	18
(20) Implementation and results _____	19
(21) The way forward _____	22
(22) Acknowledge _____	22
(23) Recommendation _____	23
(24) References _____	23

Table of illustration

Illustrate 1. The principle On-grid solar roof system _____	6
Illustrate 2. On-grid solar roof system for Training Department _____	7
Illustrate 3. The global total solar PV market scenario 2021-2025 _____	8
Illustrate 4. Monocrystalline Solar Panels (Mono-SI) _____	10
Illustrate 5. Polycrystalline Solar Panels (Poly-SI) _____	10
Illustrate 6. Thin-Film Solar Cells (TFSC) _____	11
Illustrate 7. Solar Inverter _____	12
Illustrate 8. The Central (or string) inverter _____	13
Illustrate 9. Power optimizer inverter _____	14
Illustrate 10. Microinverter _____	15
Illustrate 11. DC/AC circuit breaker _____	16
Illustrate 12. Solar energy monitoring system _____	16
Illustrate 13. The Huawei Smart Power Sensor _____	17
Illustrate 14. Example 1 _____	20
Illustrate 15. Example 2 _____	20
Illustrate 16. Example 3 _____	21

1. Background

Solar energy is an essential source of renewable energy. Unlike some of the other sources of energy, solar energy lasts longer and will be accessible as long as we have the sun. It has now been proved to be extremely beneficial not only for the environment but also for the private economy. This advantage is well recognized at global and regional levels.

SEAFDEC, as an international organization that promotes sustainability of fisheries which also includes its concerns on the development of affordable, inexhaustible, and clean energy for fisheries, therefore, solar energy technologies will be one of SEAFDEC's interests which have huge longer-term benefits. It will also enhance TD's energy security through reliance on an indigenous, inexhaustible, and mostly import-independent resource, reduce pollution, lower the costs of mitigating global warming. The Marine Engineering Section of TD proposes this sub-activity under the project implementation of Responsible Fishing Technology and Practice for the year 2021 to initially apply and utilize solar energy as an alternative clean power source for TD other than regular electric supply.

However, since this would be piloted at the TD, the additional costs of the incentives for early deployment should be considered learning investments as the initial requirements must be wisely spent and need to be widely shared. The Marine Engineering Section expects to attain well achievements of this activity and would greatly encourage TD staff or those who are interested to apply this alternative power source to their households in the future when it is proven worth investment and environmentally friendly appearance.

2. Introduction

Solar systems are made up of solar panels (modules), a mounting system, and a solar inverter with a computerized controller. Solar panels produce DC electricity from sunlight. Then the inverter converts the generated electricity into AC so that it can be used in the household. The computerized controller manages the solar system and ensures optimal performance. The 2 common systems are called off-grid solar systems, off-grid PV system refers to an installation that is not connected to the electricity grid. This means that the energy produced is stored and used on site. Essentially, off-grid photovoltaic systems operate from the energy stored in a resource battery.

An on-grid system is a solar cell system connected to the grid from the electricity (municipal power) power generation system. This system uses solar panels for generating electricity. After that, it will supply power to the Grid Tie Inverter or in other words, the transformer itself. This converts direct current (DC) to alternating current (AC) and is connected to the home power system. for further sharing. This system is suitable for daytime use only, such as a house that is used during the day. Office buildings that work during the day, temples, schools, universities or offices, etc.

3. Rational

Application and utilization of solar power for the SEAFDEC training department is a major challenge on knowledge and experience on various technologies and materials. Yet, it is an excellent opportunity for SEAFDEC engineers to enhance their knowledge and experience in the utilization and maintenance skills of solar energy systems. Before applying this technology on the fishing vessels, a pilot and demonstration activity will be initiated at the TD's facility. It is expected that the meeting room and/or research and training vessel will be designated as a pilot for applying this solar energy system.

A solar system with a grid connected to powering the building with renewable energy during office hours when sunlight hits on the solar surfaces. The electricity produced by the solar panels is converted to AC power to the power distributing system of the designated building's electrical equipment to utilize solar energy. In many cases, an optimal solution will be installed simultaneously both the solar system and an emergency generator called 'diesel-solar hybrid systems' to supply electric power.

In addition, the utilization of solar power at the office of TD will enhance the organization's image as an environmentally friendly office. It would also enable awareness and education to SEAFDEC staff, guests, and people around the TD office.

4. More Sustainable and Resilient

Comes to fishing operations it is known that oil prices have become the major cost a profound direct impact on incomes and good livelihood of fishers. Consequences of reserves and the limited availability of fossil fuels inhuman timescale. Solar radiation is a renewable resource of extraordinary scale. As the IEA notes in a 2011 report, "Solar energy is the largest energy resource on Earth and is inexhaustible." The amount of solar energy received by Earth in a year exceeds the energy that has been garnered from oil, LPG gas, natural gas, coal, and nuclear sources in the history of humankind.

The amount received by the planet in an hour is greater than the globe's entire yearly energy consumption. Because solar facilities can be so broadly spread out, and because they're made up of many separate devices, they're better protected against disruptive events like storms, which can knock out power to large populations by damaging just one generator or transformer station in a centralized electricity grid. And because many solar technologies use less water than other sources of fuel e.g., fossil fuel or nuclear power plants, they may also be more resilient in the face of drought.

5. Objective

- Reduction of greenhouse gases emits by the office of SEAFDEC/TD by applying and utilizing solar energy as an environmentally friendly alternative power source.
- Study on cost and effectiveness of the utilization of solar power in the office building as baseline information for SEAFDEC staff apply in their residence and relevant agencies e.g., Department of Fisheries-Thailand, ¹DMCR, ²FMO, etc.
- Enhancing skill and experience on the system installation and utilization of renewable energy to possibly apply to the TD training and research vessels in the future.
- Improvement and promotion of the organization's image on sustainable energy utilization and reduction of greenhouse gases emission.

6. Output

- The production of green electricity supplied to the designated loads e.g., meeting room and/or research and training vessel and which can promote to relevant agencies.
- Monitoring, evaluation, and report on the fossil fuels saving from the installation of solar energy and the SOP or handbook to support promotion environmental impact on the reducing on greenhouse gases. Because Solar energy is a clean, renewable resource more environmentally friendly, power powered by sunlight, as well as the power to the office by greatly is not generally associated with pollution, so you will lessen your carbon footprint.
- SEAFDEC/TD promotional and training materials to present marine engineering training courses on optimizing energy is account as one option for reduced dependence on foreign oil and fossil fuels
- In the long term, there can be a high return on investment due to the amount of free energy a solar panel can produce, it is estimated that the average household will see 50% of their energy coming in from solar panels.
- Sustainable improvement in the utilization of solar energy will last forever whereas it is estimated that the world's oil reserves will last for 30 to 40 years.

7. Advantages and disadvantages of the on-grid system

The advantage is that there will be a production of power from both directions, one from the electric from an authority, and another from the production of solar panels. The power system produced by solar panels will convert into AC power by an inverter that are can be used with all kinds of electrical equipment. This system does not require a battery backup. can reduce electricity bill or it can be called free of cost because it can generate electricity by itself during the day and use it for free.

The disadvantage is that in the event of a power outage even though the solar system still supplies normal power the grid-tied inverter will stop working. without supplying power to the transmission line to prevent electric shock which is repairing the electrical wiring

¹ Department of Marine and Coastal Resources

² Fish Marketing Organization

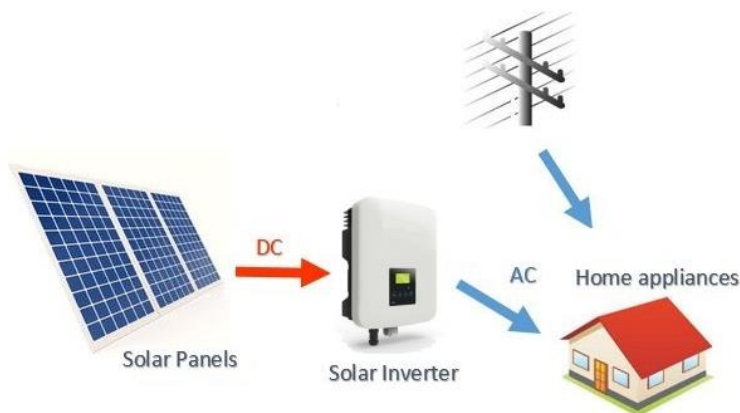
system on the road Using this system will be used in the area with access to electricity Used to reduce electricity bills which the way you want to install There must be space to support the solar panel. and know the amount of electricity used during the day by looking at the unit of electricity consumption that pays for electricity each month to design production capacity Find the size of the grid-tied³ inverter and the number of solar panels

The Earth revolves around itself and around the equator. So whichever country adjacent to the equator will receive the amount of sunlight more concentrated than other countries that are not close to the equator. Thailand is a very lucky country because of its terrain near the equator. Makes it receive the amount of sunlight density almost the whole year, because of the position that Thailand is located above the equator to the top make the sun in Thailand will rise from the east always indirectly to the south.

South is the best direction. To install the solar panel by making the angle as follows for example Bangkok, facing the panel to the south at an angle The tilt of the panel is approximately 13.5 degrees, from the horizontal, Chiang Mai the solar panel the panel is about degrees by raising the panel to a higher than Chaing Mai

In case of the south is blocked by trees or infrastructure, can avoid installing solar panels. by facing east or west instead but the performance of solar panels may be reduced to some. according to the amount of sunlight received but it's still better than installing it in an area that's blocked by trees or obstacles.

All solar power systems work on the same basic principles. Solar panels first convert solar energy or sunlight into DC power using what is known as the photovoltaic (PV) effect. The DC power will be converted by a solar inverter into AC power which can be used to run home/office appliances.



Illustrate 1. The principle On-grid solar roof system

³ Grid-tied inverters are designed to connect to your home to supplement mains power to provide energy wherever possible.

8. Solar Panels



Illustrate 2. On-grid solar roof system for Training Department

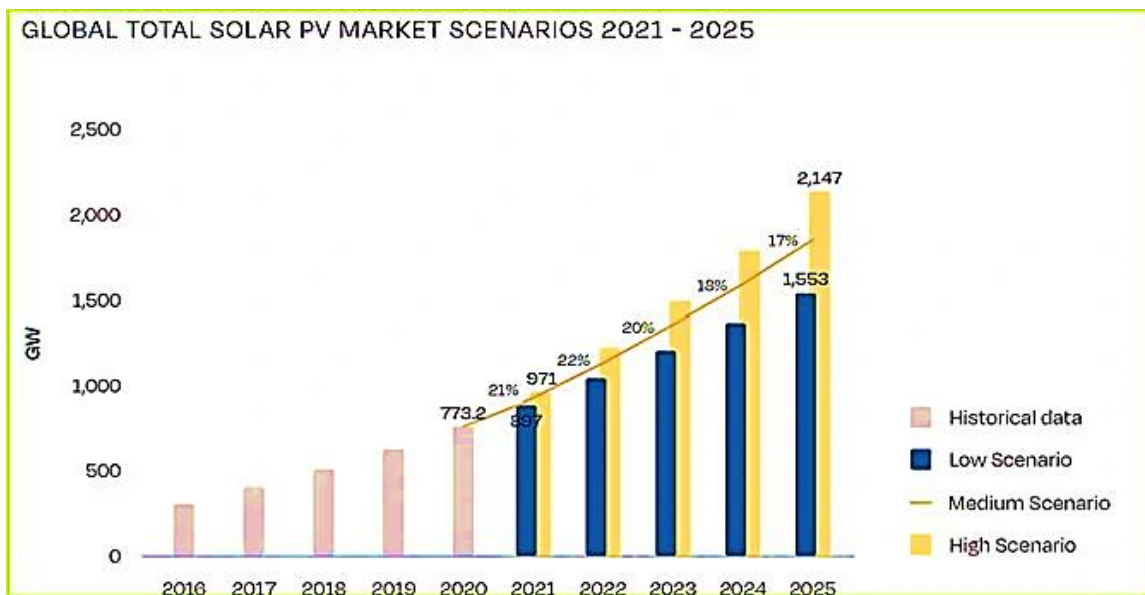
Solar Panels Most modern solar panels are made up of many silicon-based photovoltaic cells (⁴PV cells) which generate direct current (DC) electricity from sunlight. The PV cells are linked together within the solar panel and connected to adjacent panels using cables. Note: It is sunlight or irradiance, not heat, which produces electricity in photovoltaic cells. Solar panels, also known as solar modules, are generally connected in 'strings' to create what is known as a solar array. The amount of solar energy generated depends on several factors including the orientation and tilt angle of the solar panels, efficiency of the solar panel, plus any losses due to shading, dirt, and even ambient temperature. Solar panels can generate energy during cloudy and overcast weather, but the amount of energy depends on the 'thickness' and height of the clouds, which determines how much light can pass through.

⁴ photovoltaic (PV) cell is an energy harvesting technology, that converts solar energy into useful electricity through a process called the photovoltaic effect. There are several different types of PV cells which all use semiconductors to interact with incoming photons from the Sun in order to generate an electric current

9. Exclusive Discussion

Solar energy is not only a truly reliable and lasting energy source but also a very cost-effective and efficient one if the chosen types of solar panels and the environment are perfectly matched to one another. Such promising prospects have grown in an industry that has put a lot of effort into developing efficient techniques to generate, use, and store the sun's energy by using different types of solar panels and converting the sunlight into valuable electricity.

When looking at the graph below, it becomes easy to see the rapid increase in global total solar PV market scenario 2021-2025



Illustrate 3. The global total solar PV market scenario 2021-2025

Only a few people are aware of the different technologies that exist on the market for solar energy such as solar thermal and solar water heating.

The following detail will give a more detailed introduction to the different types of solar panels that are used for generating green electricity. Several decades of research, work, and development has led to the wide range of different types of solar panels now available on the market for solar panels.

Solar cell type	Efficiency rate	Advantage	Disadvantage
Monocrystalline Solar Panels (Mono-SI)	~20%	High-efficiency rate; optimized for commercial use; high lifetime value	Expensive
Polycrystalline Solar Panels (p-Si)	~15%	Lower price	Sensitive to high temperatures; lower lifespan & slightly less space efficiency
Thin-Film: Amorphous Silicon Solar Panels (A-SI)	~7-10%	Relatively low costs; easy to produce & flexible	shorter warranties & lifespan
Concentrated PV Cell (CVP)	~41%	Very high performance & efficiency rate	Solar tracker & cooling system needed (to reach high-efficiency rate)

Table 1. Efficiency rate in each type of solar panel

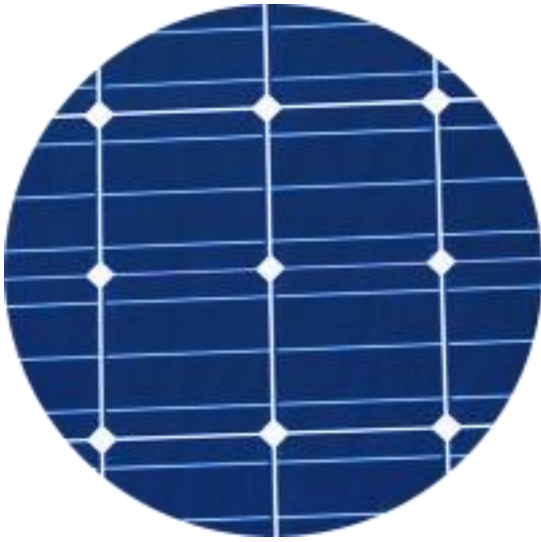
10. Categorize the different types of solar panels.

Different types of solar panels serve different needs and purposes. For a quick and general overview, check out our ultimate solar panel guide, for a detailed description of the different types of solar panels, keep reading.

Given that sunlight can be used differently whether on Earth or in space points to the fact that location, itself, is a significant factor when it comes to choosing one of the types of solar panels over another.

Distinguishing between different types of solar panels often means differentiating between single-junctions and multi-junctions' solar panels or first, second, or third generations. Single-junction and multi-junctions differ in the number of layers on the solar panel that will observe the sunlight, whereas the classification by generation focuses on the materials and efficiency of the different types of solar panels.

1st Generation Solar Panels



Illustrate 4. Monocrystalline Solar Panels (Mono-SI) This type of solar panel (made of monocrystalline silicon) is the purest one. You can easily recognize them from the uniform dark look and the rounded edges. The silicon's high purity causes this type of solar panel to have one of the highest efficiency rates, with the newest ones reaching above 20%.

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



Illustrate 5. Polycrystalline Solar Panels (Poly-SI) You can quickly distinguish these panels because this type of solar panel has squares, its angles are not cut, and it has a blue, speckled look. They are made by melting raw silicon, which is a faster and cheaper process than that used for monocrystalline panels.

This leads to a lower final price but also lower efficiency (around 15%), lower space efficiency, and a shorter lifespan since they are affected by hot temperatures to a greater

degree. However, the differences between mono- and polycrystalline types of solar panels are not so significant, and the choice will strongly depend on your specific situation. The first option offers a slightly higher space efficiency at a slightly higher price but power outputs are the same.

2nd Generation Solar Panels

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



Illustrate 6. Thin-Film Solar Cells (TFSC) If you are looking for a less expensive option, you might want to look into a thin film. Thin-film solar panels are manufactured by placing one or more films of photovoltaic material (such as silicon, cadmium, or copper) onto a substrate. These types of solar panels are the easiest to produce and economies of scale make them cheaper than the alternatives due to less material being needed for its production.

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

Amorphous Silicon Solar Cell (A-Si)

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

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

3rd Generation Solar Panels

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

Biohybrid Solar Cell

The Biohybrid solar cell is one of the types of solar panels, that is still in the research phase. It has been discovered by an expert team at Vanderbilt University. The idea behind the new technology is to take advantage of photosystem 1 and thus emulate the natural process of photosynthesis. In case you want to learn more about how the biohybrid solar cell works in detail, read more about it in the American Journal of Optics and Photonics. It explains

in more detail how these cells work. Many of the materials being used in this cell are similar to the traditional methods, but only by combining the multiple layers of photosystem 1, the conversion from chemical to electrical energy becomes much more effective (up to 1000 times more efficient than 1st generation types of solar panels).

Cadmium Telluride Solar Cell (CdTe)

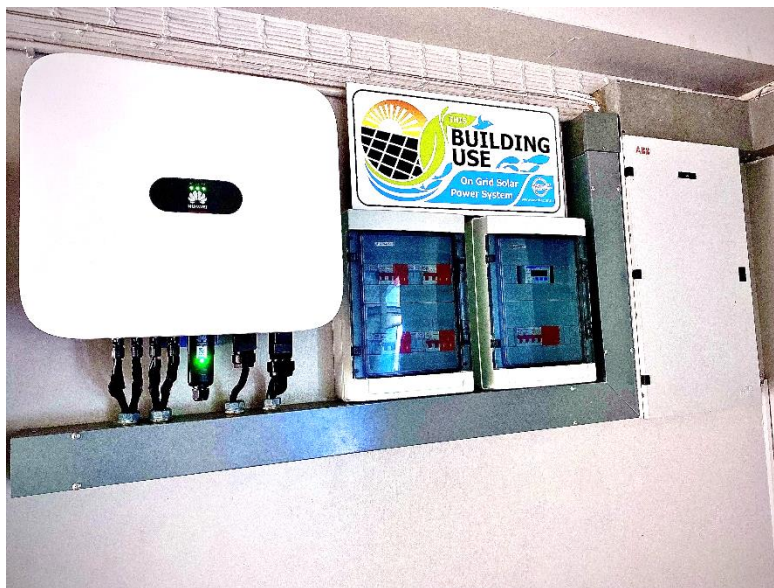
Among the collection of different types of solar panels, this photovoltaic technique uses Cadmium Telluride, which enables the production of solar cells at a relatively low cost and thus a shorter payback time (less than a year). Of all solar energy technologies, this is the one requiring the least amount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

Concentrated PV Cell (CVP and HCVP)

Concentrated PV cells generate electrical energy just as conventional photovoltaic systems do. Those multi-junction types of solar panels have an efficiency rate of up to 41%, which, among all photovoltaic systems, is the highest so far.

Remark: SEAFDEC/TD choose the concentrated PV cell for more efficiency

11. Solar inverter



Illustrate 7. Solar Inverter

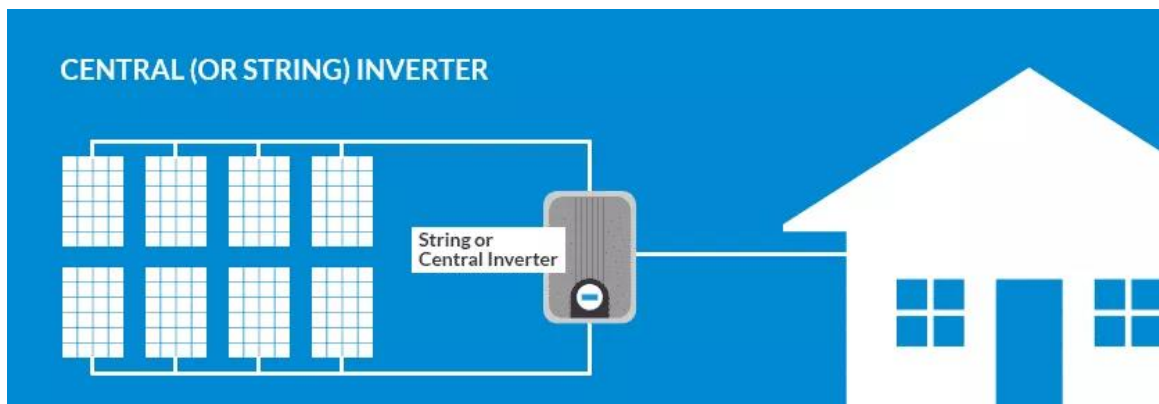
Solar panels generate DC electricity which must be converted to alternating current (AC) electricity for use in our homes and businesses. This is primary the role of the solar inverter. In a 'string' inverter system, the solar panels are linked together in series, and the DC electricity is brought to the inverter which converts the DC power to AC power. In a microinverter system, each panel has its micro-

inverter attached to the rear side of the panel. The panel still produces DC but is converted to AC on the roof and is fed straight to the electrical switchboard.

12. The different types of solar inverters

There are three types of solar inverters available to homeowners. These types are string (or central) inverters, power optimizers + inverter, and microinverters.

Each different type of solar inverter has its advantages and disadvantages. It's important to understand these differences, as well as the pros and cons of each solar inverter type, before choosing which is the right solar panel system.



Illustrate 8. The Central (or string) inverter

String inverters: pros and cons

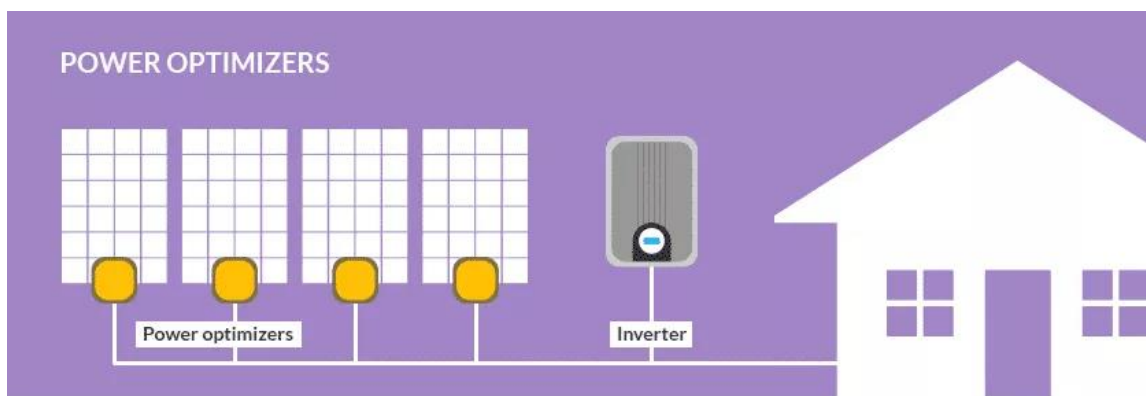
String inverters, also known as central inverters, are the oldest and most common type of solar inverter used today. They work by connecting a string of solar panels to one single inverter, which converts the total DC input into AC output.

Pros: Because string inverters are the oldest type of solar inverters, they are also the most reliable. After decades of being on the market, string inverters have had most of the kinks worked out. They are also the least expensive solar inverter option.

String inverters are also centrally located on the side of your house or near the side of a ground mount. This allows easier access to monitor, repair, or replace the inverter.

Cons: While string inverters are reliable, they are also less efficient at optimizing solar energy output. Because string inverters are connected to an entire string of solar panels, shading on one solar panel will cut the power output of the entire string.

Also, string inverters only offer total-system monitoring as opposed to panel-level monitoring. This can be a disadvantage when diagnosing issues with solar production, and it can also be unfortunate for those solar homeowners who want a more granular level of monitoring.



Illustrate 9. Power optimizer inverter

Power optimizers: pros and cons

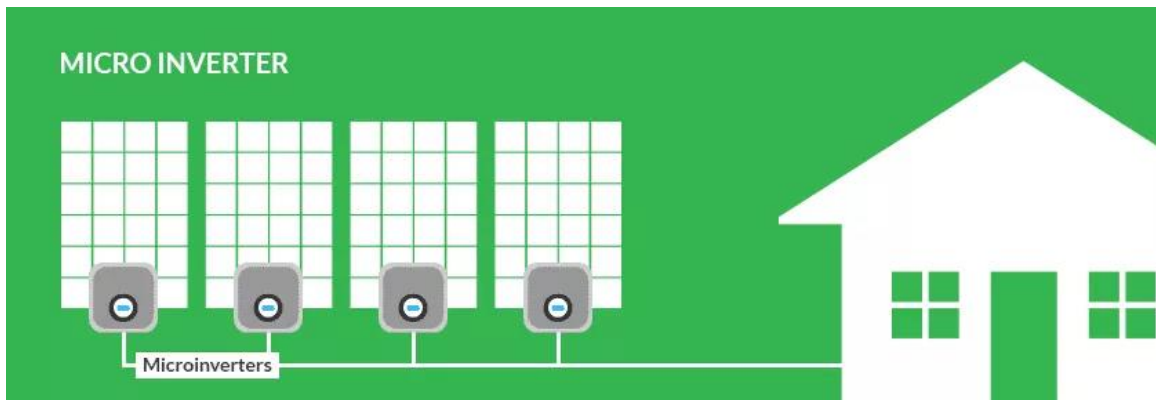
Power optimizers are located on the back of each solar panel, and they work in conjunction with a string inverter to convert DC to AC. They do this by conditioning the DC electricity from each panel and sending that conditioned DC to the string inverter to convert to AC electricity.

Pros: Because power optimizers can condition the DC electricity produced by each individual solar panel, they can decrease the impact of shading on individual panels. If one solar panel is partially shaded, it will not degrade the output of the entire string as with a simple string inverter setup.

Power optimizers also have the benefit of allowing panel-level monitoring, along with system-level monitoring thanks to the string inverter. This means any issues with solar output can be diagnosed more easily, with each solar panel being monitored individually. It also allows the homeowner to see a more detailed level of monitoring.

Cons: Power optimizers are more expensive than using just a string inverter, but they are still less expensive than microinverters.

Power optimizer systems also require additional power optimizers and potentially additional string inverters if you expand your solar panel system in the future. It is also important to note that because power optimizers are located on the roof, it is more difficult to repair and replace them if they would happen to have any issues.



Illustrate 10. Microinverter

Microinverters: pros and cons

The final type of solar inverter is the microinverter. Microinverters are the latest in solar inverter technology, and they work by converting DC to AC directly from the back of each solar panel. No string inverter is needed because each microinverter takes care of DC conversion on the spot.

Pros: Because each microinverter is handling the conversion from DC to AC on each panel, that allows the system to be minimally impacted by shading on individual panels. If shade covers one panel, only that panel will produce less power output as opposed to the whole system output decreasing, as in a string inverter setup.

Microinverters are also easy to expand with your solar system in the future. Any solar panel that is added to the system just needs to have a microinverter installed on the back of the panel.

Similar to power optimizers, microinverters also allow for panel-level monitoring of the solar system, allowing any solar output issues to be diagnosed more easily and accurately.

Cons: Microinverters are the most expensive of the solar inverter options. However, their benefits can easily outweigh the costs in certain situations, especially if shading is an issue.

And because microinverters are installed on the back of each solar panel, it is more difficult to repair or replace any microinverter that might have issues.

13. DC/AC Circuit breaker



Illustrate 11. DC/AC circuit breaker

DC/AC circuit breaker is an overcurrent protection device (OCPD) designed to protect electrical devices and individuals from overcurrent conditions. Unlike most fuses, circuit breakers can be reset, which makes them a popular choice for overcurrent protection. Circuit breakers use an electromagnet and/or a bimetallic switch to detect an overcurrent condition.

A circuit breaker may be reset by moving the trip lever handle to the full OFF position and then returning the handle to the ON position. Individuals must ensure the source of an overload is cleared before attempting to reset a breaker. DC/AC circuit breakers can be used to protect individual loads that work with direct current, or they can be used to protect main circuits such as those of inverters, solar PV arrays, or battery banks

14. Solar energy monitoring system



Illustrate 12. Solar energy monitoring system. The solar energy monitoring system will show how much electricity production in kWh. It also records the total amount of solar power they have produced in some cases the in-built monitoring that comes with the inverter offers far fewer features production monitoring system for tracking the following as follows:

- Solar energy production
- Solar energy consumption
- Grid exports and imports
- Overall consumption lever

This information is via an internet portal that can be used both of **IOS** and **Android** smartphone applications. The data should be updated in real-time or every few seconds.

15. Smart power sensor



Illustrate 13. The Huawei Smart Power Sensor DDSU666-H is a three-phase current sensor for connection to the inverter. It is easy to operate and readout data via the built-in LCD screen. In addition, the component supports communication via RS485, so that the measured values can also be evaluated elsewhere. Commissioning of the current sensor for PV systems is simple and safe - the digital wizard guides you through the integration process. Once installed with one click, the component meets the highest demands. The DDSU666-H smart power

sensor is designed for use at the industrial level and is particularly reliable.

The technical data of the sensor is also convincing, for example, its own power consumption is less than one watt - so the device works without consuming much power itself. The possible operating temperature is specified as $-25\text{ }^{\circ}\text{C}$ to $+60\text{ }^{\circ}\text{C}$, the relative humidity can be 5 % to 95 %. The dimensions of 100 x 36 x 65.5 mm show that this is a compact component. It is mounted on the DIN35 top-hat rail. The input voltage is 176 VAC~288 VAC (phase / N). In operation, the Smart Power Sensor DDSU666-H achieves a measurement accuracy of $\pm 1\%$ (current, power, and energy) and $\pm 0.01\text{ Hz}$ (frequency). The current sensor thus belongs to accuracy class >1 .

16. Proceeding

After the Marine Engineering Section was approved by the Japanese Trust Fund Manager to proceed to install On-grid Solar Roof System on the fourth floor of the SEAFDEC Training Department. Under cooperation between the marine engineering section/Training and Research Supporting Division and the procurement section/General Affair Division have recruited contractors to carry out the installation of On-grid Solar Roof System and select the companies/contractors that bid within under approved budget (20,000 USD) which the company/contractor to be considered to proceed On-grid Solar Roof System is the Pana Power Force., LTD. by offering the cost of installation and material including a warranty in under the budget amounting 20,000 USD. The Pana Power Force., LTD, and SEAFDEC/TD have made an installation employment contract within 60 days. (From 1 December 2021 to 29 January 2022) Maintenance of solar panel system.

It is important to perform regular maintenance is conducted on the solar panel system. Undertaking regular maintenance will ensure your solar panel system is operating safely, correctly, and efficiently. Over the past time especially in the area where the solar panel near the construction site dust will build upon the solar panels, which may compromise the performance of your solar panel system. In addition, water and moisture seepage, vermin, hail, wind, and sunlight can all cause damage or deterioration to your system.

By ensuring routine maintenance is undertaken, you can ensure your solar panel system is safe for everyone living on the premises, along with electrical workers working on the distribution network. Routine maintenance will also ensure system performance is maintained, allowing you to maximize savings on your power bills for many years. Regular servicing is the best way to ensure the solar panel system keeps operating safely, correctly, and efficiently.

17. Maintain the solar panel system

All applications are needs regular maintenance especially solar panel system is necessary. Take care of and follow the maintenance schedule provided frequently. Different from electrical appliances Turning off the solar panel system at the switch does not mean that the component will no longer pose an electrical hazard on the roof which poses hazards to the operators. In general, a distinction can be made between three types of maintenance:

- Corrective maintenance involves repairing the system when an error message is received.
- Preventive maintenance is still an option for the future since it involves intervention based on historical and real-time maintenance-relevant data, preventive maintenance is increasingly today. This has the advantage that maintenance is not only carried out in the event of a problem but takes place regularly to ensure the optimum operation of the system. This prevents breakdowns and therefore saves costs.
- Predictive maintenance uses historical and real-time data from various parts of your operation to anticipate problems before they happen. There are three main areas of your organization that factor into predictive maintenance:

18. Benefits of predictive maintenance

When predictive maintenance is working effectively as a maintenance strategy, maintenance is only performed on machines when it is required. That is, just before failure is likely to occur. This brings several cost savings:

- Minimizing the time, the equipment is being maintained
- Minimizing the production hours lost to maintenance
- Minimizing the cost of spare parts and supplies

19. Power cable for solar cells

The PV1-F cable is a DC power cable designed specifically for photovoltaic systems. It provides a tin-coated copper cable with a double insulated, heat-resistant system design. Care must take on when considering the appropriate type and size of the power cable. This will affect the performance of the battle. If the wrong power cord is selected may cause high damage and heated or fire from excessive current

Using the wrong type of cable, such as replacing the DC cable with AC, reduces costs for contractors. Reinstallation is no problem when submitting work. Because the new cable

still conducts electricity well. But if used indefinitely, heat, the humidity will occur on the copper surfaces because the cable was not coated. The load current will decrease with less power. Therefore, payback is longer because the DC power runs on the dirty surface. Therefore, the current is not easy to flow through. Many places have to demolish all new wiring systems. Use ⁵PV cables for solar cells especially. Installing a solar power generation system Requires a dedicated solar cable. Must be able to withstand temperatures of not less than 80 degrees Celsius, which is called the cable for solar cells that PV1-F consists of many small wires, making it suitable for DC power.

(DC) Power flows well. because of the direct current system, it runs at the edge of a small wire with less electrical loss. Using only one large wire and coated with tin to prevent corrosion or consciousness of the humidity This type of cable is temperature resistant. both inside and outside the power cable up to 90 degrees Celsius. including the selected safety throughout the lifespan by correct wire type and size will improve performance and the reliability of the photovoltaic system Including the power cable should be as short as necessary. Because the wires have resistance themselves.

Therefore, there must be pressure to push. Let the current flow through the wires. If the resistance of the wires is greater more pressure is required. The amount of voltage applied to push this current is called voltage drop in wires

$$\text{Voltage Dissipation} = \text{Current} \times [0.02 \times \text{Length (m)} / \text{Cross-sectional Area (mm}^2\text{)}]$$

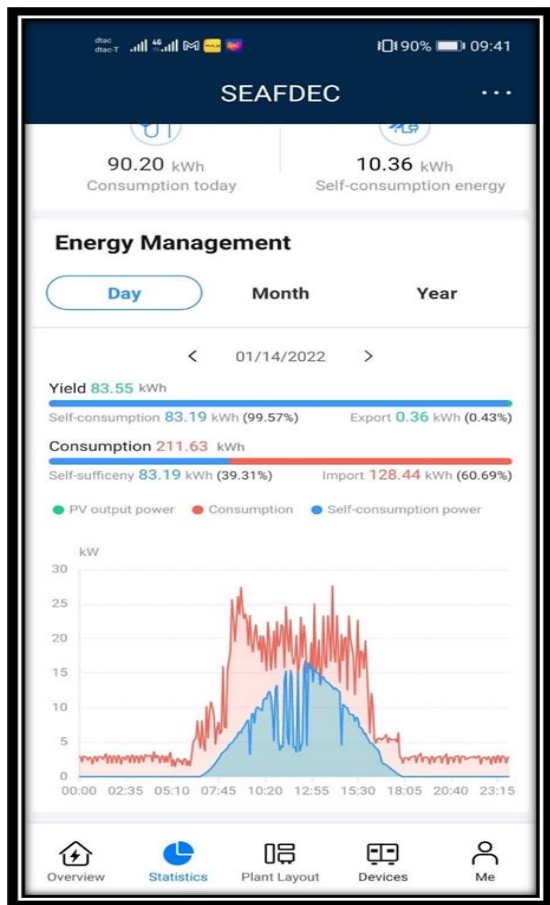
Rating current (amp)	Rating voltage (Volts)	Conductor cross-sectional area (mm ²)
30A	AC 0.6/1kV/ DC 1.8kV	PV1-F 1 Ø 1.5 ² mm.
41A	AC 0.6/1kV/ DC 1.8kV	PV1-F 1 Ø 2.5 ² mm.
55A	AC 0.6/1kV/ DC 1.8kV	PV1-F 1 Ø 4.0 ² mm.
70A	AC 0.6/1kV/ DC 1.8kV	PV1-F 1 Ø 1.6.0 ² mm.
98A	AC 0.6/1kV/ DC 1.8kV	PV1-F 1 Ø 1.10 ² mm.
132A	AC 0.6/1kV/ DC 1.8kV	PV1-F 1 Ø 1.6 ² mm.
218A	AC 0.6/1kV/ DC 1.8kV	PV1-F 1 Ø 35 ² mm.

Table 1. Comparison of electric wire size and current resistance

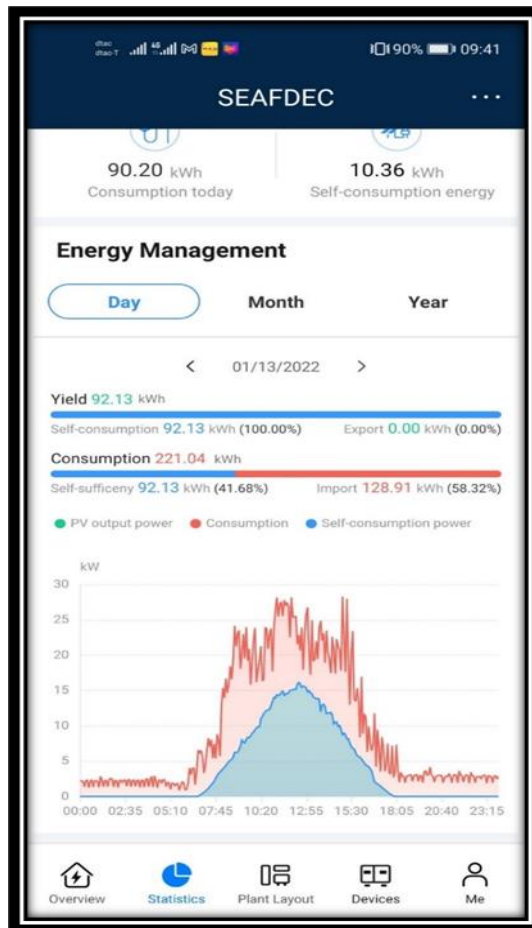
20. Implementation and results

On-grid Solar Roof System was started to supply electricity to the SEAFDEC/TD (office building) on 13 January 2022 till today which observation from mobile application found that as following:

⁵ Photovoltaic solar (PV) cables are intended for interconnecting power supplies within renewable energy photovoltaic systems



Illustrate 14. (Example 2) On 14 January 2022 On grid Solar Roof System can produce electricity 83.19 Kwh (39.31%) from the total electricity consumption of 211.63 Kwh. and use electricity from the Metropolitan Electricity Authority 128.44 Kwa (60.69 %).

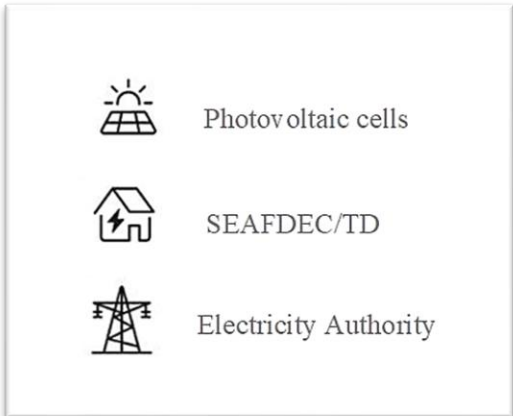


Illustrate 15. (Example 1) On 13 January 2022 on grid Solar Roof System can produce electricity of 92.13 Kwh (41.68%) from the total electricity consumption of 221.04 Kwh. and use electricity from the Metropolitan Electricity Authority 128.91 Kwh





The On-grid Solar Roof System as shown in example 3 the total load that SEAFDEC/TD (office building) uses is 29.378 Kw which is photovoltaic cells (PV) that can produce electricity 15.305 Kw for the Electricity from electricity Authority (Grid) it's used only 14.073 kW. which, when considered can be found that more than 50% save. This is likely to be able to save electricity costs for SEAFDEC/TD and can return the capital in near future.



Illustrate 16. (Example 3) On-grid Solar Roof systems can observed in real-time working conditions via mobile phone.

21. The way forward

- The Marine Engineering Section will continue to conduct a research study and collect the data of On-grid Solar Roof System to summarize within the year 2022 (6 months) from beginning February to the end of July 2022 including will calculate the cost of electricity use and compare the data before and after installation On-grid Solar Roof System if On-grid Solar Roof System can be reducing the cost of electricity satisfactorily. It will be able to extend to use with other buildings/offices in the future.
- Increasing the use of renewable energy is an essential element to achieve sustainable development at the national and regional levels. Renewable energy can provide important new ways to reduce pollution, diversify and secure energy supply and help provide access to energy in support of fishers' poverty eradication.
- Furthermore, the burning of fossil fuels is the biggest source of greenhouse gas emissions, and these emissions need to be reduced to mitigate the adverse effects of climate change to achieve Climate Change to prevent the danger from global warming.

22. Acknowledgment

On this occasion and successfully SEAFDEC and relevant SEAFDEC staff are appreciated. In the best wishes for the full support of the Japan Trust Fund Thank you very much for your full support under the project “Responsible Fishing Technology and Practices” for the year 2021. The Marine Engineering Section and Training and Research Supporting Division and Training Department would like to thank Mr.Koichi Honda the Deputy Chief of the Training Department for kindly supporting the activity under the project aforementioned. Training and Research Supporting Division looks forward to your continued support with all activities under funding from the Japanese Trust Fund in the future. And extremely important Ms. Malinee Smithrithee Chief of the Training Department kindly deliver support to all activities of the Marine Engineering Section till this project was a success.

Marine engineering will take these experiences and lessons learned from this project use for contributing further to the improvement of fisher’s livelihoods. It accounts as one of the important mechanisms used for sustainable fisheries development for both nationally and SEAFDEC member countries in the Southeast Asian region

23. Recommendations

Today, oil prices have adjusted the price higher. Making it affects the price of the product price and the standard of the occupation to all Personnel, such as currently, the electricity cost of the office building (TD office) is approximately 170,000 baht per month, which is noted that it's quite expensive. Therefore, introducing solar energy will create opportunities for SEAFDEC TD can save energy costs monthly from today. Onwards But it is well known that the material /components cost of the solar system and its installation is a quite high investment. Although the current cost of components is a bit low price down there is a possibility to refund by a few years so the support budget that is necessary to promote the utilization and energy distribution from the solar system. Including government policies, world and international concern with the possibility to achieve global warming by reducing the greenhouse and reducing the discharge of toxins from all types of activities by using energy that is environmentally friendly Maximum use of energy

24. References

<https://www.greenmatch.co.uk/blog/2015/09/types-of-solar-panels>

<https://news.energysage.com/types-of-solar-panels/>

<https://www.genusinnovation.com/blogs/different-types-of-solar-panels>

<https://www.renewableenergyhub.co.uk/main/solar-panels/types-of-solar-cell/>

..... *End Report*

Marine Engineering Section