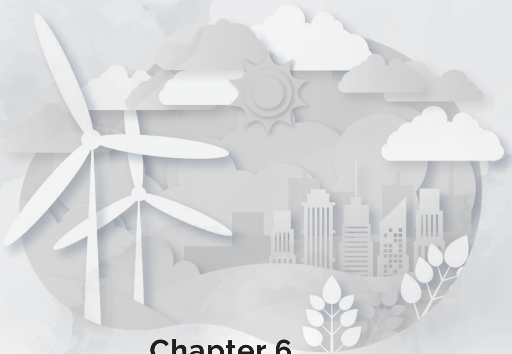

Chapter 6

Batteryless Solar Home System for Urban Area

Hasti Afianti

A. Flexy Energy for Urban Areas

The main advantages of renewable energy sources (RES) are stable energy supplies, and interruptions rarely occur. As enticing RES might be, they are still not widely accessible compared to conventional energies, especially in Indonesia. If so, what options do city residents have if they want to use RES for their homes? Fortunately, there is a well-known example of RES for urban residents. That is solar home system (SHS). Solar energy has many benefits for everyday life, one of the most profound uses is by converting sunlight into electricity.

Solar power plants (SPP) have an enormous potential in Indonesia because it is a tropical country, so that the sun always shines all year round. The main factor to support the operation of solar power plants

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is batteries. However, batteries are not cheap items so that prices and lifespan are very influential in the investment of SPP construction.

SHS is the diminutive form of SPP. SHS with an off-grid topology sometimes does not require other sources such as microgrid or wind turbin to produce electrical energy. This topology can rely on solar panels and batteries to support energy needs. Solar panels that are exposed to sunlight will produce DC electricity. This electricity will charge the battery, and then the electricity stored in the battery is then converted into AC electricity so that it can be used for household needs. On the other hand, SHS in on-grid topology can work without the use of battery. While the sun is still shining, SHS works to get electricity and if there is a shortage of electricity when the sun is not shining, electricity can be obtained from the grid, so there is no need to use batteries as a storage facility.

Therefore, this chapter proposes the use of on-grid, batteryless SHS for urban areas. One of the main reasons is due to the drawbacks from using batteries. First, hazardous materials in batteries, such as lead and magnesium, will become toxic, knows as hazardous waste (B3). This kind of waste is quite dangerous if not managed properly. Then, the lifetime of the current battery is only around 5 years, so new batteries are required for the continuity of SHS operations. Not to mention the high price of batteries, they are also quite large in dimensions so they require a large area for storage. These factors should be a concern for SHS users.

B. Electric Power System: An Overview

The electricity system is starting to change from traditional electricity to a modern one called microgrid. In traditional systems, electric power can only be distributed in one direction, starting from generation, transmission and distribution to consumers. Meanwhile, in a microgrid system, the electrical network is integrated between components connected to the system. There are distributed generators with small or large capacity renewable energy with communication devices that can regulate the flow of distributed electricity in both directions, making these systems more efficient, sustainable and highly reliable.

1. Traditional Electric Power System

In this modern era, electricity is a basic need that is essential for human life. Without electricity, humans will have difficulty carrying out their daily activities. The use of electricity in life is very broad, starting from the fields of industry, transportation, lighting, as well as a source of energy for electronic devices, such as TVs, refrigerators, air conditioners, and so on. In Indonesia, production and distribution of electrical energy is the responsibility of, State Electricity Company (PLN). The circuit of the electric power system can be seen in Figure 6.1.

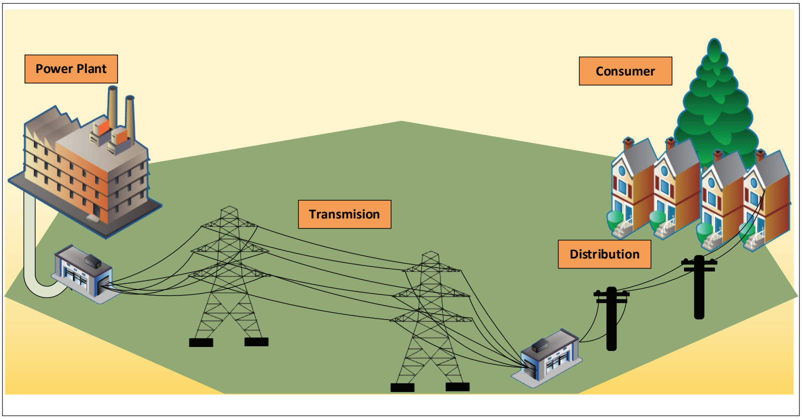
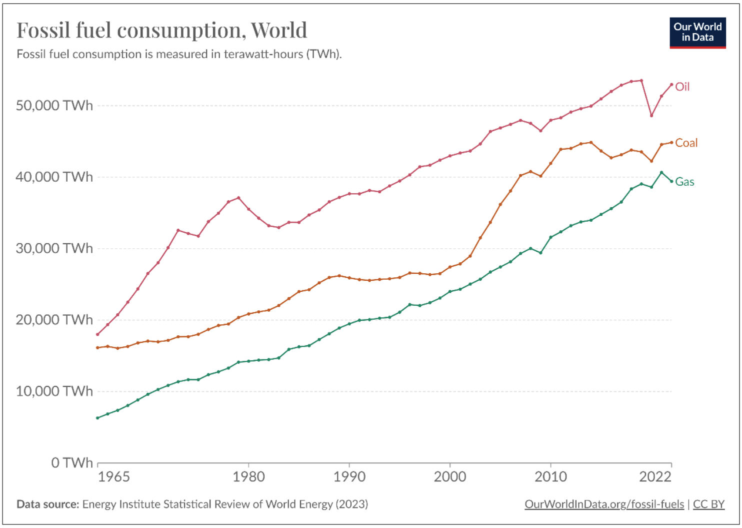


Figure 6.1 Electric Power System from the Producer (PLN) to Consumers

The following describes the main parts of the general electric power system. Electrical power system has several electrical installation circuits which are divided into four parts.

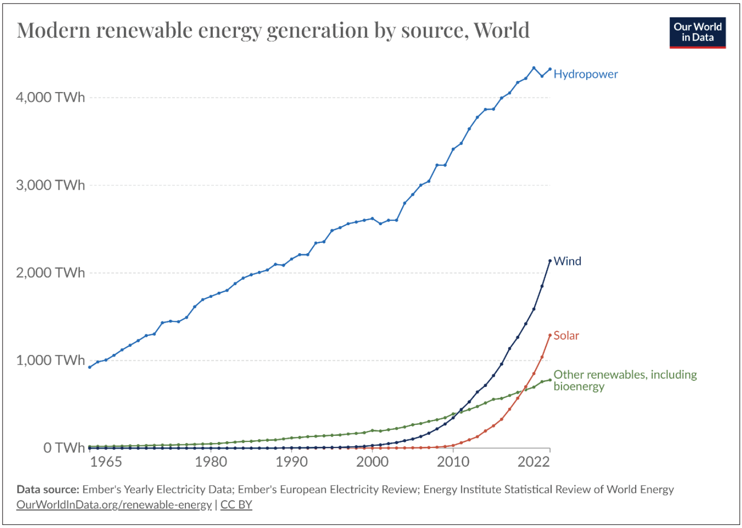
1) Power Plant

The process of converting energy into electricity occurs at the power plant. Turbines and generators are the main components in several types of power plant. A power plant (also referred to as a generating station, power station, powerhouse, or generating plant) is an industrial facility for the purpose of generating electric power. Most power plant contain one or more generators, a rotating machine that converts mechanical power into electric power. Most power plants in the world use fossil fuels, such as coal, oil, and natural gas to generate electricity as compared in in Figure 6.2 and Figure 6.3. Others use nuclear power, but there is an increasing use of cleaner renewable sources, such as solar, wind, wave, and hydro.



Source: Energy Institute Statistical Review of World Energy (2023)

Figure 6.2 Fossil Fuel Consumption



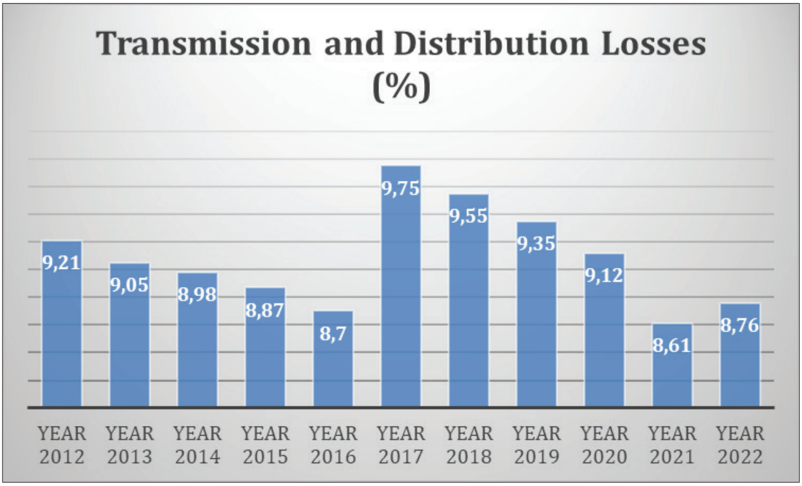
Source: Ritchie et al. (2020)

Figure 6.3 Renewable Energy Generation

2) Transmission

Transmission is a channel for distributing electrical energy, in the form of extra high voltage air duct (SUTET) and high voltage air duct (SUTT) which functions to distribute electricity from the central substation to another substation with long distances.

In high-voltage alternating-current (AC) grids, there is transmission loss of approximately 6–10% per 1,000 km. In high-voltage direct-current (DC) grids, which are subject only to ohmic losses, the loss is calculated at approximately 4% per 1,000 km. Figure 6.4 shows data from the Ministry of Energy and Mineral Resources (2022) which states the transmission and distribution of losses in Indonesian.



Source: Ministry of Energy and Mineral Resources Republic of Indonesia (2022)

Figure 6.4 Transmission and Distribution Losses in Indonesia Electricity in Percent

Power plants are usually located far from each other and connected to through a transmission system area to distribute electric power over a distributed load. This can be regarded as an interconnection system. This interconnection causes:

a) higher system reliability,
b) increment of the generating electricity efficiency,
c) simplification of generator scheduling, and
d) electrical power transmission.

Transmission of electric power is the process of distributing electricity from the generation center to the distribution channel so that later it can be distributed to consumers.

3) Distribution

This distribution system is a sub-system of electric power that deals directly with consumers. This sub-system consists of: control center or substation, substation connections, medium voltage lines or primary network (6 kilo volts and 20 kilo volts) in the form of overhead lines or underground cables, and low voltage lines or secondary network (380 volts and 220 volts). The distribution channel functions to distribute electricity from the substation to the consumer load.

4) Consumer

Consumers are users of electric power services. After going through the series of steps above, electrical energy finally reaches the house and can be used for daily needs, such as watching television, cooling the fridge, lighting the room, ironing, and so on. There are several types of consumers depending on the volt ampere (VA) used. Ordinary consumers, such as households or offices, use low voltage with power 1,300 VA, 2,200 VA, 3,500 up to. 5,500 VA, 6,600 VA and above but less than 200 kVA. Medium voltage consumers, such as malls, industries business, government with power more than 200 kVA. Meanwhile, for high voltage consumers used by industry with power more than 30,000 kVA.

2. Microgrid

It is likely that there are still many households that have difficulty obtaining electricity, especially those in remote areas, on mountain slopes, and areas that are very difficult to reach. Due to economic limitations and geographical conditions, a centralized electricity distribution system cannot cover all those areas. Economic, technological, and environmental breakthroughs have changed the pattern of electricity generation and distribution. Since the introduction of the microgrid by Lasseter (2004), the pattern of electricity generation has begun to change, from a centralized pattern to a smaller, distributed pattern. Microgrid is a distributed generation pattern that can cover a variety of energy sources, from fossil sources to renewable energy, such as wind, solar, biogas and so on (Afianti et al., 2016). Microgrid is a solution to the problem of electricity supply for remote and urban areas. This system consisting of at least one energy source connected to the load. It is capable of operating in grid-connection (on-grid) or

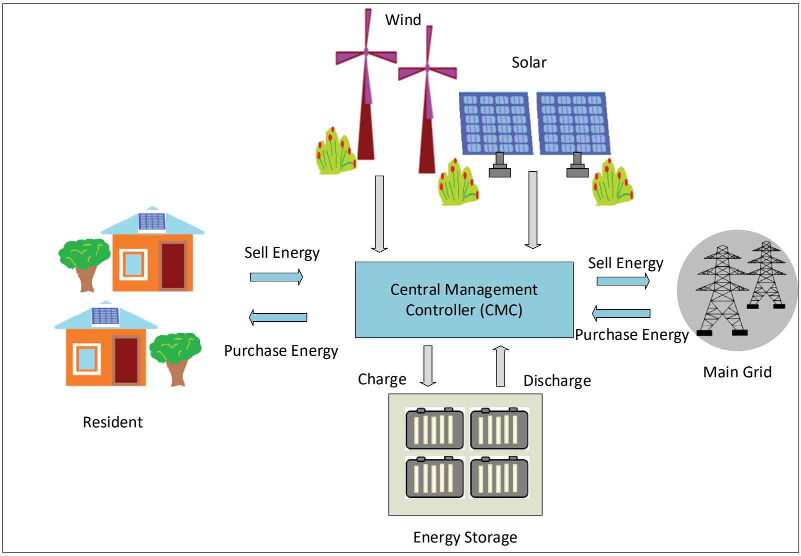


Figure 6.5 Microgrid System

stand-alone (off-grid/islanding). Based on the energy sources available from an area, microgrid can consist of several energy sources, for example solar cell with wind energy, solar cell with micro-hydro, solar cell with fuel cell, and other combinations which are formed as a distributed generator (DG). The microgrid structure consists of source, load, converter and storage system (Afianti et al., 2015). The illustration of microgrid system is illustrated in Figure 6.5.

The use of microgrids continues to grow rapidly and is an effective solution to overcome electricity shortages in various regions, especially remote areas. One of the driving factors is the decreasing investment costs for renewable energy-based generators. Solar panel and wind turbine technology have entered the mature phase this time, so it is possible to be produced in large quantities. Even though the energy source in a microgrid does not have to be renewable energy, the very rapid growth in the use of renewable energy will still be the main driving force for microgrid growth in the coming years.

C. Renewable Energy Potential in Indonesia

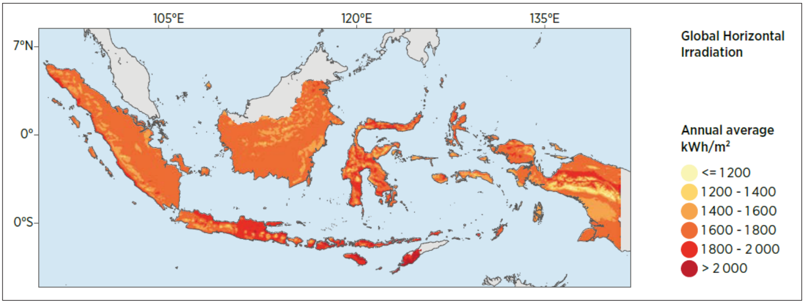
Indonesia has enormous renewable energy potential, especially in the five renewable energies: solar, water, wind, biomass, and geothermal. In 2022, International Renewable Energy Agency (IRENA) has launched a list of potential renewable energy in Indonesia in its book, Indonesia Energy Transition Outlook (IRENA, 2022). Table 6.1 shows the potential for renewable energy in Indonesia. By looking at this potential for renewable energy, the government continues to strive to accelerate the development of new renewable energy to achieve the target of 23% renewable energy in the national energy mix in 2025 as mandated by the National Energy General Plant (RUEN).

Table 6.1 Indonesia Renewable Energy Potential

No	Renewable energy	Total Potential (GW)	Total Installed Capacity 2021 (GW)
1	Biomass	43.3	19
2	Geothermal	29.5	21
3	Hydro	94.6	61
4	Ocean	17.9	0
5	Offshore Wind	589	0
6	Onshore Wind	19.6	0.2
7	Solar	2898	0.2

Source: IRENA (2022)

From Table 6.1, it is known that the largest potential for renewable energy in Indonesia is solar energy. This is understandable because Indonesia is located on the equator, which is abundant with sunlight, as evidenced in Figure 6.6. This figure shows the potential for sunlight exposure in Indonesia.



Source: IRENA (2022)

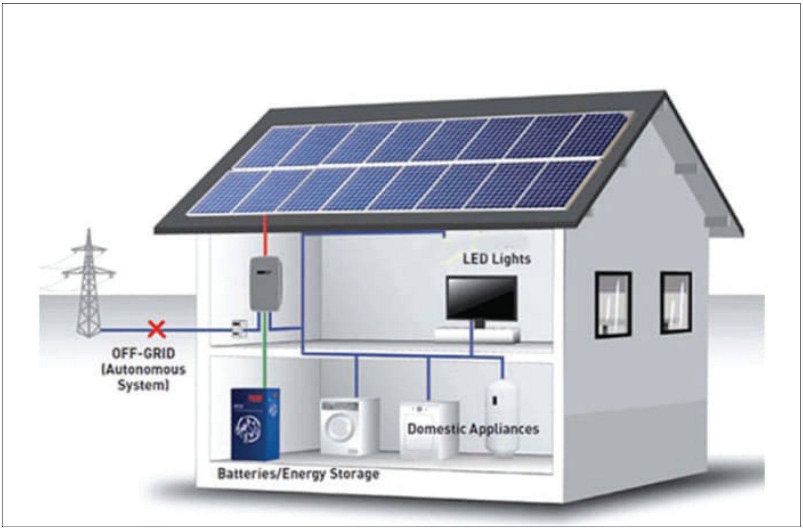
Figure 6.6 Global Horizontal Irradiation in Indonesia

With great potential in solar power, the government strongly supports the movement of people who want to use solar power as a substitute for electricity sourced from PLN electricity. This is evidenced by the issuance of Minister of Energy and Mineral Resources Regulation Number 49 of 2018 concerning use of Rooftop SHS by PLN Consumers which was revised with Minister of Energy and Mineral Resources (ESDM) Regulation Number 12 and Number 13 of 2019 concerning Power Generation Capacity for Self Interest. Substance in the latest Regulation of the Minister of Energy and Mineral Resources Number 26 of 2021 is rules for exporting and importing electricity from consumers to PLN.

From the regulations on the use and utilization of this solar energy source, of course people do not need to worry if they want to use SHS as a source of electrical energy for families at home. Besides all the regulations, the government has started using alternative energy from sunlight for public facilities. For example, using solar energy for outdoor lighting so that the budget can be more economical. Government support requires appreciation and community participation to help protect the surrounding natural environment through reducing gas emissions and global warming.

D. Solar Home System (SHS)

Referring to the microgrid concept, SHS have a topology similar to microgrid. The SHS can be connected to the grid (on-grid) or not connected to the grid (off-grid). An overview for both off-grid and on-grid SHS can be seen in Figure 6.7. SHS off grid conditions can be met if the solar panel circuit can meet all load requirements, so it does not require another electricity source, for this reason SHS does not need to be connected to the grid. If the solar panel circuit cannot meet the load requirements, it can be connected to the grid as an additional electricity source, this condition is known as the SHS on grid condition.



Source: Shopbwana (2021)

Figure 6.7 Solar Home System

1. The Main Equipment for Building SHS

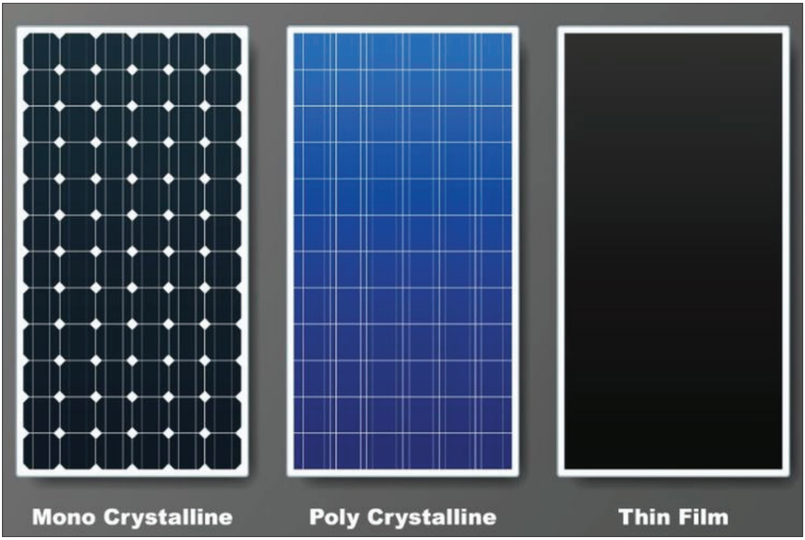
a. Photovoltaic (PV) Panel

Solar panels are devices that can convert sunlight energy into electrical energy. This equipment needs a wide place for better effect. Solar panels usually take place on the rooftop of the house or building as in Figure 6.8.

Source: Firdaus (2022)

Figure 6.8 Rooftop PV

Solar cell technology is currently very developed. Currently, there are 3 types of the most popular solar cells: monocrystalline, polycrystalline, and thin film solar cells, as show in Figure 6.9.



Source: Ruhulessin (2022)

Figure 6.9 Types of Solar Panel

1) Monocrystalline Silicon

This one is a type of solar panel that is widely used. It is made of pure silicon crystals which are thinly sliced using a machine to form a round shape. This solar cell is called "monocrystalline" because the silicon used is single crystalline silicon. The efficiency of monocrystalline silicon solar panels can reach more than 20%, much higher than other types of solar panels. This high efficiency indicates that this solar panel has the ability to convert energy from the sun into electricity so well that it only takes a smaller cross-sectional area to produce the same energy than other types of solar panels.

2) Polycrystalline Silicon

As the name implies, this type of solar panel is composed of many silicon crystal fragments, which makes the shape quite unique because there are cracks or fragments on its surface. The efficiency of polycrystalline silicon solar panels can reach 17%. Even though the efficiency is lower than monocrystalline silicon, this type of solar panel is widely used because the price is relatively more affordable.

3) Thin Film Solar Cells

This type of solar panel is called a "thin film" because it uses a fragile solar cell measuring about 10 nm, much thinner than other types of crystalline silicon which measures around 200–300 nm. A thin layer is added to glass, plastic, or metal surfaces. The advantage of this type of solar panel is that it is very light and flexible, and its performance does not decrease at high temperatures like other types. Unfortunately, energy conversion efficiency is still low, only around 10%.

Before deciding to install a solar home system, it's a good idea to know the number of solar panels needed. Larger homes require a lot of electrical energy; if a house has energy-efficient electronic equipment, it may consume significantly less power than a smaller-sized home.

Table 6.2 An Estimation of Household Electricity Needs per Day

Household Appliances	Amount	Long Usage (Hour)	Electrical Power (Watt)	Total Electricity Usage (Watt)
Lamp	10	10	10	1,000
Iron	1	1	300	300
Television	1	3	75	225
Water Pump	1	2	125	250
Rice Cooker	1	2	200	400
Refrigerator	1	24	90	2,160
Total Electricity Usage in a Day (Watt)				4,335

For example, a house uses 4,335 watts of electricity in one day, with details of usage in Table 6.2. When using solar panels, the energy produced cannot be used 100%; usually 40% of the electrical energy produced will be lost. Thus, it is necessary to add up the loss from the total power that will be used.

Total energy power = Home energy power + (40% home energy power shortage)

= 4,335 watts + (4,335 x 40%)

= 6.069 watts

The important thing to determine the amount of power of a home solar system is to know the watt peak (WP). It is the nominal value of the power in watts generated from a home solar system. Usually, the peak sun hour (PSH) in Indonesia takes 5 hours, so to calculate the amount of power from a solar home system as follows:

Power of solar home system = Total power : PSH
= 6,069 watts : 5 hours
= 1,214 WP

The house needs 1,214 WP. In the market, solar panel power variants ranging from 200 WP, 330 WP, 450 WP and 540 WP. For example, if the house owner choose 330 WP type, the number of panels needed are:

1,214 watts peak: 330 watts peak = 3,6 pieces

Hence, the number of solar panels needed is 4.

b. Inverter

The SHS system utilizes photovoltaic technology on solar panels which converts solar radiation and temperature into DC electricity. This electrical energy cannot be used directly to meet the load at home, because common electronical equipment at home, such as refrigerators, TVs, ACs, chargers, lights, water pumps, computers, and so on, use AC electricity. Thus, an inverter is needed to convert the DC from the solar panels into AC.

Source: RS Worldwide (n.d.)
Figure 6.10 Inverter

However, the are other functions of inverter on SHS except changing power flow:

1) Export Import Power

It can import excess electrical power produced by the solar panel system into the PLN network, and export electrical power from PLN to the house when the solar panels stop working at night. Additionally, some inverters will charge the batteries of on-grid solar panel systems.

2) Stabilize Voltage

The power that flows from the battery to the load must be at optimal conditions so that it can be utilized properly. The inverter has the ability to stabilize the voltage to take care of it.

The size of the solar panel is the most important factor in determining the appropriate size for the inverter. For solar inverter to convert DC electricity coming from the array, it needs to have the capacity to handle all the power that the array produces. In a 6 kilowatts system, the proposed inverter is to be around 6,000 watt, plus or minus a small percentage. Measuring the need for an inverter based on a ratio is done by comparing the inverter output, that is the

DC output power of the solar panel compared to the AC output power of the inverter. For example, if a 6 kilowatts solar panel is installed with a 6 kilowatts inverter, the ratio is 1. If the solar panel output is 6 kilowatts with a 5 kilowatts inverter, the ratio is 1,2. Selecting the best and most suitable inverter for installing solar panels has at least a ratio of 0,9 to 1,25, with the most ideal being 1. A good inverter also has a conversion efficiency rating of over 98% and has passed certification tests according to EN 50530, the European standard—the overall efficiency of grid-connected photovoltaic inverters.

c. Solar Charge Controller

The solar charge controller (SCC) is an important component in every solar panel installation. There are many variables that affect the amount of power that solar panels produce, such as sunlight levels, temperature, and the state of charge of the battery. The figure of SCC is shown in Figure 6.11.

Source: ICA Solar (2021)

Figure 6.11 Solar Charge Controller

SCC ensures the battery supplies power with a stable and optimal quality. One of the other functions of SCC is to prevent excessive battery charging by limiting the number and speed of battery charging. SCC also prevents battery to over-discharge by shutting down the system if the power stored in the battery drops below 50 percent capacity and charging the battery at the correct voltage level. This helps keep the battery life longer and healthier.

The Solar Charge Controller (SCC) also has several other important functions, such as:

1) protect the battery from overload, which can cause overheating and fire. If that happens, the SCC will break the circuit or fuse;
2) disconnect automatically the non-critical loads from the battery when the voltage drops below a predetermined threshold; and
3) backflow blocker through the battery to the solar panel.

There are two types of SCC under development today: pulse width modulation (PWM) controllers and maximum power point tracking (MPPT) controllers. PWM charge controllers are an older and cheaper technology that, unfortunately, less efficient than MPPT charge controllers (Putra et al., 2022). Both are widely used and perform similar functions to save battery life. Both PWM and MPPT have a lifespan of around 15 years, although durability varies based on use.

d. Batteries

The use of batteries is very important as solar power, which can be considered as intermittent renewable energy, is very dependable on. The function of the battery is to store solar energy captured by solar panels, then used when the solar panels cannot meet the load requirements. Solar panel battery life needs a delicate maintenance. With solar panel warranties ranging from 20–25 years, it is important to have long-lasting, reliable, and efficient batteries to match that lifespan.

There are at least three popular types of solar panel batteries available on the market:

1) **Lithium-ion battery**, which is the most common source of solar energy storage. This battery is light, compact, and have a longer life. Li-Ion battery depth of discharge (DoD), a provision that limits the maximum discharge can be applied to the battery, is also higher than others (Aji, 2021). DoD is an important parameter appearing in the context of rechargeable battery operation.
2) **Lead-acid battery**, which tends to be heavier and bulkier than Li-Ion, also with a shorter life and a lower DoD. However, lead-acid battery is some of the most affordable on the market and easy to find at any hardware store.
3) **Salt battery**, the most environmentally friendly option because it does not contain metal. It uses a saltwater electrolyte to generate charge.

The battery should be placed where the temperature is stable; not too hot or too cold. It is best to install the battery outdoors in the shade in the temperature climate. On the other hand, consider installing a solar battery in the basement or garage if the location has extreme cold or hot temperatures. Always avoid exposing the battery to extreme weather conditions.

DoD is provision that limits the maximum discharge depth can be applied to the battery. Most battery cycles are built to handle a 50% depth of discharge, but some batteries can handle up to 80% discharge. The battery cannot be continuously charged when it is less than 10% as this will prevent the battery from completing a full cycle and cause damage.

Charging the solar panel battery with a high voltage exceeding a predetermined limit can cause the battery to experience overcharging. In the long term, this can cause gas to escape from the battery and reduce the amount of battery fluid. Discharging current is a current of energy release that has quite a significant impact on the condition of the battery. If the battery is continuously supplied with high currents, it will decrease the usable capacity of the battery.

2. The Requirements Installing SHS for Housing in Indonesia

This is accordance with the requirements for installing SHS regulated in Permen ESDM No.49 of 2018 which was revised with Permen ESDM No. 12 and No. 13 of 2019.

1) **Use a postpaid meter**. For houses/buildings that will use SHS, PLN provides a condition, using a postpaid meter. Thus, customers who are currently using a prepaid meter must submit a change first, so that the electricity fee payment mechanism changes to a postpaid system.
2) **Use export-import (EXIM) kWh meter**. Apart from using a postpaid meter, the next SHS installation requirement requires customers to use an EXIM kWh meter. The function of the EXIM kWh meter is to record the amount of power used from PLN, and the amount of power exported to the PLN network.
3) **Maximum capacity of SHS that can be installed**. The next condition for installing SHS is that customers can only install SHS with a maximum power of 100% electricity connected to PLN. This means that for PLN customers who have homes with electricity needs of 1300 kWh, the maximum installed SHS capacity is 1300 kWh.

If the electricity generated during the day is greater than needed, then the electricity will automatically enter the PLN network and become "savings". Electrical power savings recorded on the EXIM meter will reduce the amount of electricity used by customers. The amount of electricity exported to PLN is multiplied by 65% of the electricity exported based on EXIM meter records. For SHS with a power of more than 500 kVA, it must be equipped with a Certificate of Operational Worthiness (SLO). The SLO is an absolute requirement for SHS installation for customers who plan to install SHS with a power of more than 500 kVA. This SLO permit and certification is only issued by the Technical Inspection Institute (LIT).

E. Batteryless Solar Home System: On-Grid SHS

On-grid SHS is the right solution for homeowners, as well as commercial and industrial buildings, who want to utilize solar energy without being dependent on battery. On-grid SHS that are supported by good grid conditions certainly make it very possible not to use batteries in this system, because if the solar panels with their intermittent nature cannot support the power requirements, they will be immediately covered by the grid.

The hassle of choosing, controlling, and maintaining battery that is a hassle in one factor why more people are adamant on using off-grid SHS. Plus, the price of batteries are not cheap, and the impact of battery waste on the environment becomes additional consideration.

SHS without battery offers a number of attractive advantages for its users. Here are some of the main advantages of this technology:

1) Environmentally Friendly and Sustainable

The use of SHS without batteries allows the conversion of solar energy into electricity without the emission of greenhouse gases or other environmental pollution. It is an environmentally friendly and sustainable solution, helping to reduce carbon footprint and supporting efforts to fight climate change.

2) Save Operational Costs

Once the solar panels are installed, the operating costs are almost zero. Solar energy as an unlimited natural resource allows the use of low-cost and stable electrical energy in the long term.

3) Energy Independence

With battery-free solar panels, homes or businesses can achieve partial or complete energy independence. They are no longer dependent on the public electricity network, especially in areas that are difficult to reach by traditional electricity infrastructure.

4) Easy Installation and Maintenance

Solar panels without batteries tend to be easier and cheaper to install than systems with batteries. Routine maintenance usually only requires cleaning the panel surface from dust and dirt so that its performance is optimal.

5) Requires No Battery Storage Space

By removing the storage battery from the system, battery-less solar panels free up significant physical space. This is particularly useful in areas where space is limited for installation.

6) Long Life and Long Lasting

Solar panels without batteries have a long service life and are durable. Usually, they come with warranties that last for decades, thus providing long-term investment security.

Before deciding to use SHS without a battery, there are several things to consider, such as:

1) Device power consumption: make sure the device to be connected has low power consumption in order to function properly.
2) Solar panel position: make sure the solar panel is placed in a position exposed to direct sunlight to produce maximum power.
3) Device protection: make sure the device connected to the solar panel is protected by a stable voltage to avoid the risk of damage to the SHS device.

1. Grid Tie Inverter (GTI)

The main component of SHS is the solar panel which is a series of photovoltaic solar modules. Solar panels must be coupled with an inverter. The inverter is essential because it converts the direct current (DC) input voltage generated by the solar module into an alternating current (AC) output voltage. It must be done because electrical energy is distributed only in the AC system. Loads such as household appliances also consume AC power. What the inverter will do is synchronize the voltage and frequency from the network with the inverter so that it can join the PLN network. Thus, an inverter is always put side-by-side with the panel.

SHS that is connected to the PLN network requires an inverter with high efficiency. The inverter must produce a current and voltage that has a frequency with a pure sinusoidal waveform to be in line with the current and voltage of the grid; for this, a GTI is needed. The GTI device contains a special circuit that can match the voltage, frequency, and phase of the grid. GTI are specifically designed for SHS that are connected to the electricity grid which do not require batteries.

Solar panels have a weakness in that their output power depends on sunlight conditions. When the sunlight is dim, the output current of the solar module can drop drastically, so that the output power of the solar panel is not optimal. If the load still requires a large amount of power while the output power from the solar panels is not sufficient, GTI will add to the shortage of power from the grid. One of the uses of GTI is to suck or draw electricity from the grid. This inverter will take electricity from PLN if the supply from the solar panels is unable to meet all load power requirements. Especially at night, the inverter will completely draw power from the PLN. An explanation of this power distribution is illustrated in Figure 6.12.

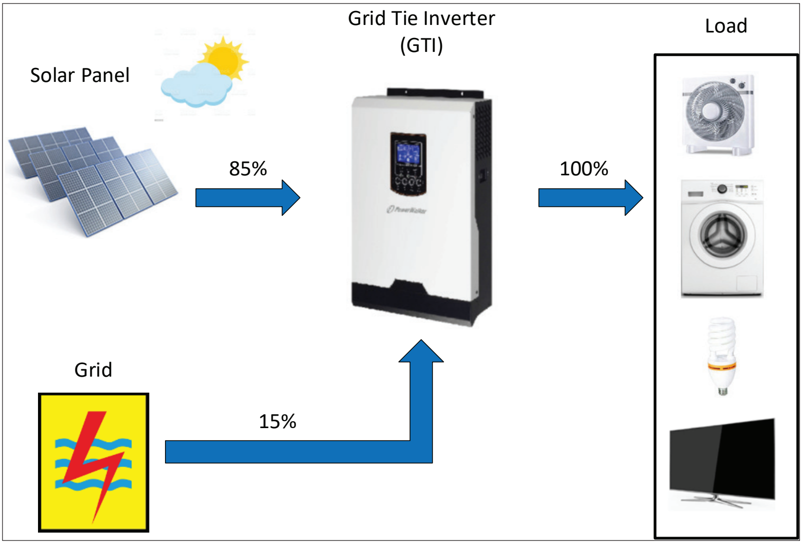


Figure 6.12 GTI drawing electricity from PLN when power is insufficient.

Meanwhile, when the sun is shining brightly, the solar panels will produce enough power to exceed the load power requirements. At this time, the GTI will feed excess power to the PLN grid, selling electricity to PLN. An explanation of this power distribution is illustrated in Figure 6.13.

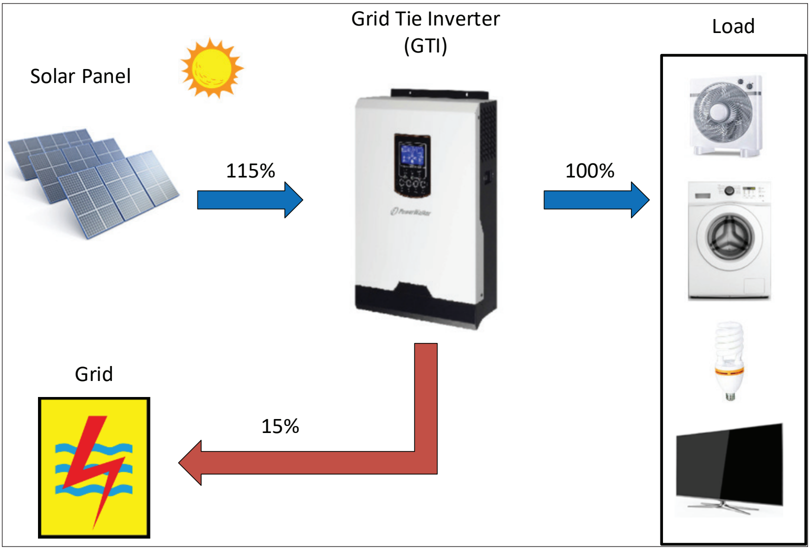
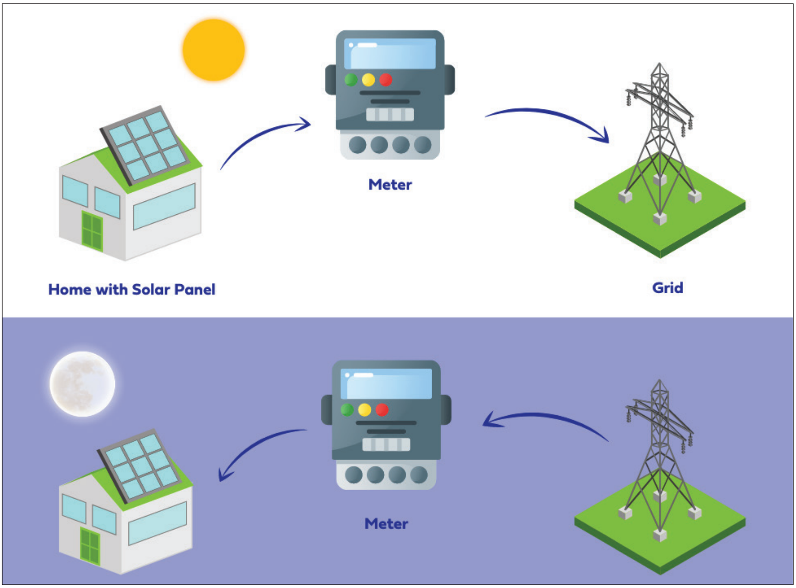


Figure 6.13 GTI selling electricity from PLN when power is excessive.

One important thing to know about the GTI is that it is designed to disconnect from the power grid if it goes down. The disconnection of the grid is done because it prevents the electricity generated by solar panels from entering the grid because it can endanger workers who carry out repairs on the grid.

2. Net Metering

Net metering is a system intended for PLN consumers who have SHS to send electricity produced by SHS to the PLN network. Net metering aims to provide opportunities for communities and companies that use solar panels to make maximum use of the electricity produced, especially when it is not in use. Net metering has the same meaning as EXIM metering, illustrated in Figure 6.14. It measures the electricity sent by SHS to PLN and the electricity taken by SHS from PLN. When monthly electricity bill is due, PLN will calculate how much electricity is sent to PLN and how much is taken from the PLN network. The results of this measurement will be used to determine the electricity bill each month. This program makes solar panel owners more economical because they are connected to the grid and do not require batteries.



Source: Solar Square (2022)

Figure 6.14 Net Metering Works

To get net metering, owners must have an SHS that has a certificate of operation. The SHS that is built must meet certain installation requirements and specified components. Considering that the electricity from SHS will be connected to the PLN network, SHS components such as inverters, SCC, solar panels, cabling, and all kinds of SHS electricity networks must really be recognized as feasible.

The usage of net metering refers to regulations:

1) PLN Board of Directors Regulation 0733.K/DIR/2013, 19 November 2013 concerning the Utilization of Electrical Energy from Photovoltaics by Customers.

2) SPLN D5.005-1:2015, 13 May 2016, Technical Requirements for Interconnection of Photovoltaic (PV) Systems on low voltage distribution networks with a capacity of up to 30 kWp.

With this reference, net metering can only be applied by customers who meet certain requirements.

F. Closing

Based on geographical conditions, which make our country get abundant sunlight throughout the year, SHS is expected to be one of the most potential alternative energies for Indonesian to participate in reducing carbon dioxide emissions and improving the environment, in addition to saving expenses for electricity needs. However, it is necessary to know and take into account the adverse effects of the B3 waste produced by off-grid SHS, so that the goal of reducing carbon dioxide emissions and maintaining a better environment can be optimally achieved. The use of batteryless SHS in an on-grid system is proven to be applicable in places where there is an electricity network. With this system, even though there is still waste produced, it can save up to 30% of the investment spent on making SHS.

Furthermore, batteryless SHS can be potentially used outside the on-grid conditions. By combining SHS with other energy such as diesel generators, it can also be applied to off-grid conditions. Research using the HOMER software has been carried out to compare the combination of batteryless SHS and diesel generators with stand-alone diesel generators. The results of this study prove that technically, the combined operation of batteryless SHS and diesel generators is cheaper than stand-alone diesel generators by up to 43% (Tsuanyo, et al., 2015). Evaluation of the environment also proves that the use of SHS is very environmentally friendly compared to diesel generators (Azoumah, 2011).

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