
SOLINTEG
Integrate Solar Intelligently
Residential Energy Storage Solution

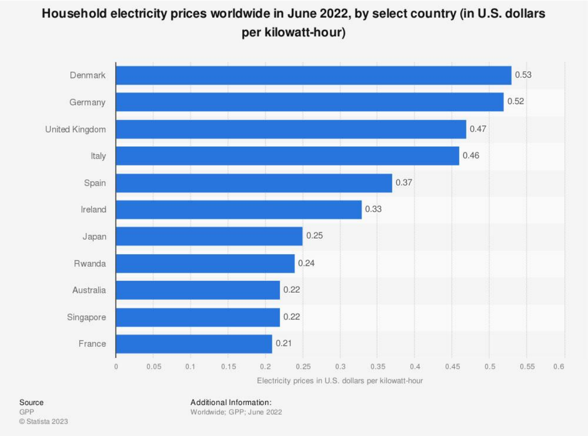
Content

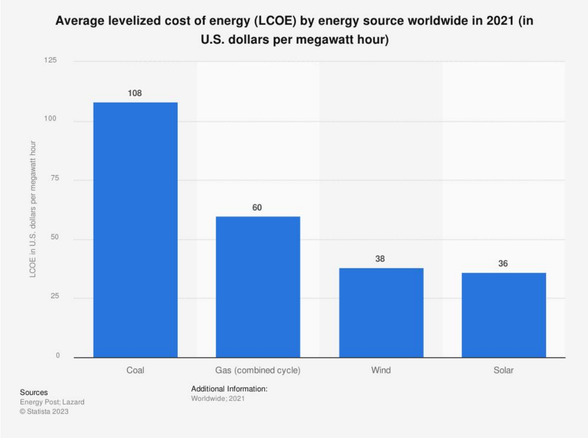
Brief introduction

Residential Solar is the Trend

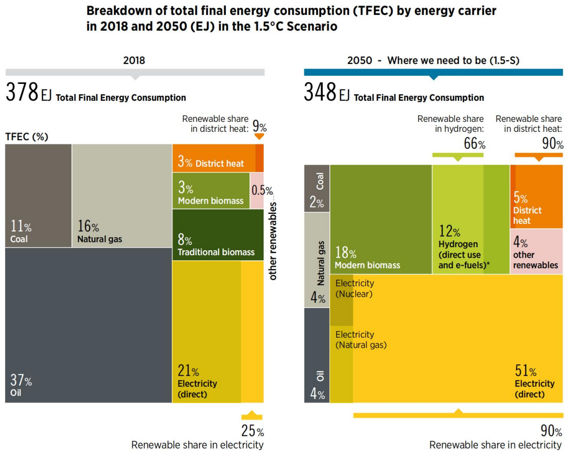
With the increasingly prominent environmental issues caused by global warming and the continuous rise in global electricity prices, the demand for renewable energy continues to expand.

According to Statista data, electricity prices have been continuously rising worldwide in the past 20 years. Taking the year 2021 as an example, the highest electricity price in the world has exceeded $0.5/kWh, and multiple regions are troubled by overpriced electricity.





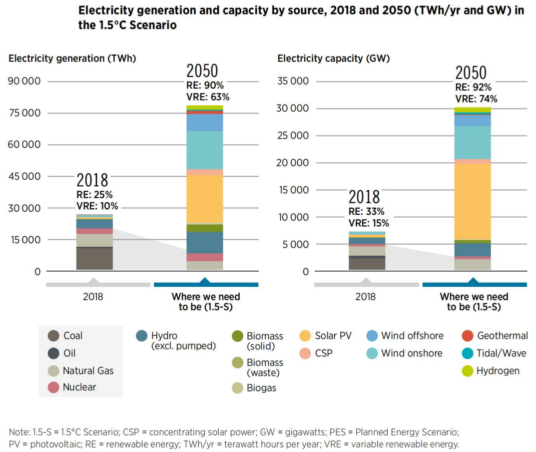
In terms of power generation, with the continuous progress of photovoltaic technology, the current cost of photovoltaic power generation is only 33% of the cost of coal-fired power.



On the other hand, in the context of global warming, the development of renewable energy is growing in importance. According to IRENA prediction, under the background of carbon neutrality in 2050, electricity will become the main form of terminal energy consumption by 2050, accounting for 51%. And 90% of the electricity will be supplied by renewable energy generation.

Among them, photovoltaic, as the most accessible and cost-effective renewable clean energy, is shouldering the responsibility of becoming the main global energy in the carbon neutrality era. According to IRENA's prediction, the cumulative installed capacity of global photovoltaics will reach 14000GW by 2050. Based on the global cumulative installed capacity of approximately 850GW in 2021, there is a growth potential of 16.5 times.

Therefore, photovoltaic has become the most ideal source of clean energy.



Source: World Energy Transitions Outlook, IRENA, 2021.10

Keep Walking of Residential Solar

With the worldwide continuous research and investment in the residential solar industry, there has been tremendous progress in the past few decades. Currently, it has gradually entered the age of energy storage solar systems, which can be roughly divided into the following levels:

- Level 1:

  Basic Level

- Level 2:

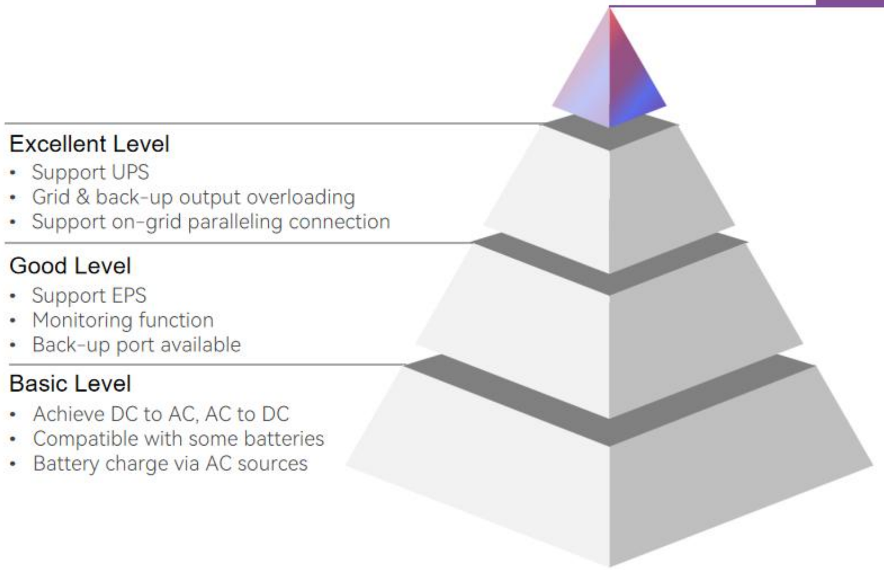
  Good Level

- Level 3:

  Excellent Level

- Level 4:

  Integ Level



Integ M Deliver World Class Performance

110% Max. Unbalanced Load

200% Back-up Overloading @60s

10ms UPS-level Switching

15-30A PV Input Current

25-100A Charge & Discharge

3-50kW Unparallel Power Range

With a continuing increase in user expectations and the evolution of home intelligence, the market has set higher standards for residential solar.

Smart Management

In an energy storage system, the inverter, as the hub of the system, needs to be able to efficiently schedule and distribute power among PV modules, batteries and loads to use power efficiently and intelligently. It should also have an intelligent cloud platform to help customers manage their power plants easily.

Integrated Design

After years of updates and iterations, residential solar systems have derived more and more functions. Traditional systems are more complex to install and operate, and hidden costs such as installation costs and labor costs are rising. As a result, consumers demand for equipment integration is increasing to improve the efficiency of the equipment installation and using.

Multiple Energy Sources

As the cleanest and most accessible energy source, however, solar energy has some drawbacks. It is seasonal and unstable, and is affected by irradiation, weather and other conditions. So there is a need for multiple sources for backup energy. Such as energy storage batteries, diesel generators, etc. can be used to supply power in emergencies.

Safe and Stable

The operation of the solar system requires a high level of safety and stability. On the one hand, for the user, it is required to be able to output power stably and ensure the safety of electricity use. Various safety protection for loads and people are needed. On the other hand, for the grid, it needs feed-in power with high quality. Various regions have strict requirements for PV grid access, such as zero export limitation, voltage regulation, and some grid scheduling regulations, such as RRCR in German, DRED in Australia, etc.

Selection and Matching

The residential solar market is expanding with energy restructuring and energy prices rising. There are so many solar products on the market, and how should we choose and build a suitable solar system for ourselves? We will introduce the selection and matching of these solar products in the following contents.

This article focuses on the following sections about selection and matching of household PV systems:

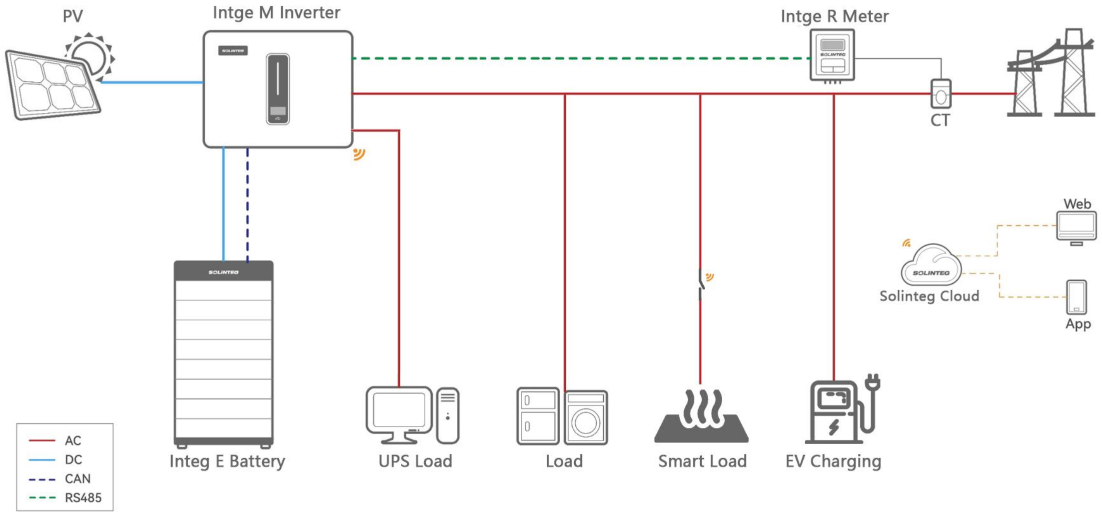
1. Introduction of residential solar system;

2. Estimation of system power;

3. System matching;

Introduction of Residential Energy Storage System

A residential solar system usually consist of solar panels, inverter, energy storage batteries, and accessories (such as smart meter, CT, etc.), as shown in the following figure:



From the diagram we can see that the core three items of a system are:

- **Inverter**: controlling all energy inputs and outputs, the brain of the system;
- **Solar panels**: converting light energy to DC power;
- **Energy storage batteries**: backup energy;

How these three core components are selected and matched is the most important aspect of a PV system.

Estimation of System Power

After learning about the solar system, let us consider another question:

How much PV power do we really need?

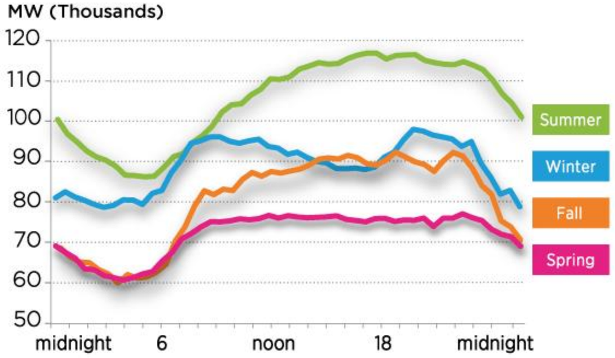
Since PV systems are affected by a variety of circumstances such as areas, local regulations, actual installation environment, and usage conditions. This paper only provides the idea of estimating a system solution by the customer's electricity consumption, and other circumstances are not taken into consideration.

Average Daily Electricity Consumption

The usual expectation of a household PV is that the power generated by the system can meet our daily consumption, with the excess stored in batteries or fed into the grid, so we calculate the system power from the electricity consumption.

Electricity consumption varies by time and people. In the winter and summer months, electricity consumption is often at its peak throughout the year, so the customer needs to decide which of the following values to use as reference for electricity consumption.

- ➢ Annual average daily electricity consumption
- ➢ Peak month average daily electricity consumption



Daily electricity consumption
in a European region in different seasons

System Efficiency

PV systems typically have a power loss of 10-15% when in use, generally for the following reasons:

- ➢ DC/DC power loss;
- ➢ DC/AC power loss;
- ➢ Battery charge and discharge power loss;
- ➢ Wire power loss;
- ➢ Control power loss;

Power loss is unavoidable, so we should take it into account when determining the efficiency of the system to ensure that the system has sufficient margin.

Average Daily Power Generation

From the above data we can estimate the minimum daily average output power we would expect from a PV system:

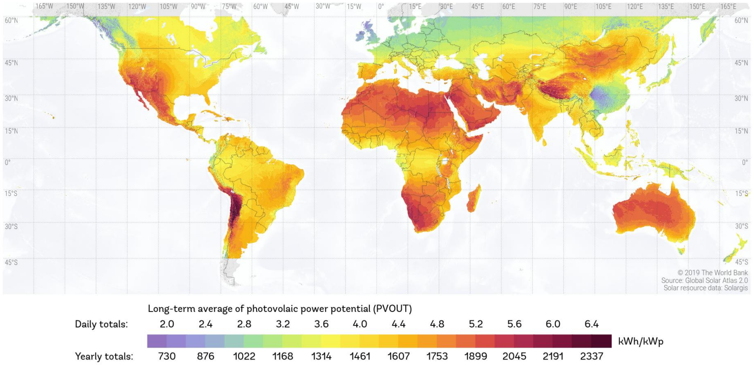
$$ADPG = \frac{ADEC}{SE}$$

ADEC: average daily electricity consumption; SE: system efficiency; ADPG: average daily power generation

In addition, we also need to consider the photovoltaic power potential. The rated power generation of PV panels is measured in a standard environment, but the intensity of irradiation and the duration of sunlight vary around the world, so the actual power generation is highly dependent on the location of installation.

PV Power Potential

The PV power potential varies from region to region, and we can obtain the PV power potential information of our location on specialized websites, as shown in the following chart:



PHOTOVOLTAIC POWER POTENTIAL

System Power

After determining the above data, we can estimate the power of a residential solar system:

$$SP = \frac{ADPG}{PVPP}$$

ADPG: average daily power generation; PVPP: PV Power Potential (Daily totals); SP: system power

System Matching

The selection and matching of products with appropriate parameters can not only effectively ensure the service life of the products, but also improve the efficiency and profitability of the system.

Matching Inverters with PV Panels

When matching inverters with PV modules, three important parameters are usually considered:

- **PV panel current at maximum power;**
- **Inverter maximum input power;**
- **Inverter MPPT voltage range;**

Here we use the parameters of a Solinteg 10kW inverter (model: MHT-10K-25) and a 550Wp brand PV module as an example to explain.

Model		MHT-10K-25
PV Input		
Recommended Max. input power	[kW]	15.0
Start-up voltage	[V]	135
Max. DC input voltage*	[V]	1000*
Rated DC input voltage	[V]	620
MPPT voltage range*	[V]	200-950*
No. of MPP trackers		2
No. of DC inputs per MPPT		1/1
Max. input current	[A]	15/15
Max. short-circuit current	[A]	20/20

Solinteg MHT-10K-25 PV Input parameters

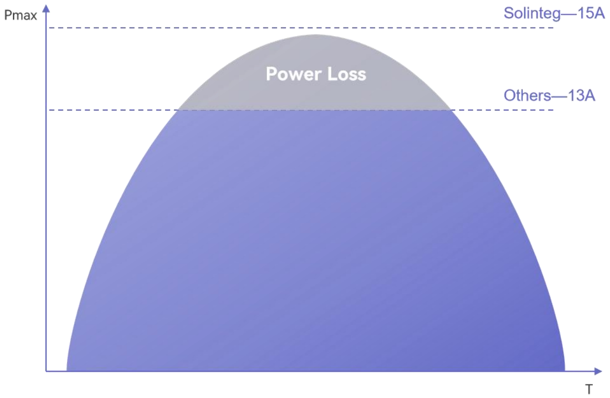
Electrical Characteristics STC : AM1.5 1000W/m² 25°C NOCT : AM1.5 800W/m² 20°C 1m/s Test uncertainty for Pmax: ±3%

Module Type	550M	
Testing Condition	STC	NOCT
Maximum Power (Pmax/W)	550	411.1
Open Circuit Voltage (Voc/V)	49.80	46.82
Short Circuit Current (Isc/A)	13.98	11.31
Voltage at Maximum Power (Vmp/V)	41.95	38.97
Current at Maximum Power (Imp/A)	13.12	10.56
Module Efficiency(%)	21.3	

550Wp Brand PV Panel Parameters

- **PV Panel Current at Maximum Power**

The PV panel current at maximum power is measured under the standard test condition, while the actual output current is greatly affected by the sunlight condition. In areas with good irradiation, the actual output current will exceed the rated one, and then the "peak power loss" phenomenon will occur, resulting in power waste. As shown in the right picture, this can be avoided if the maximum input current allowed by the inverter exceeds the output current of the PV panel as much as possible.

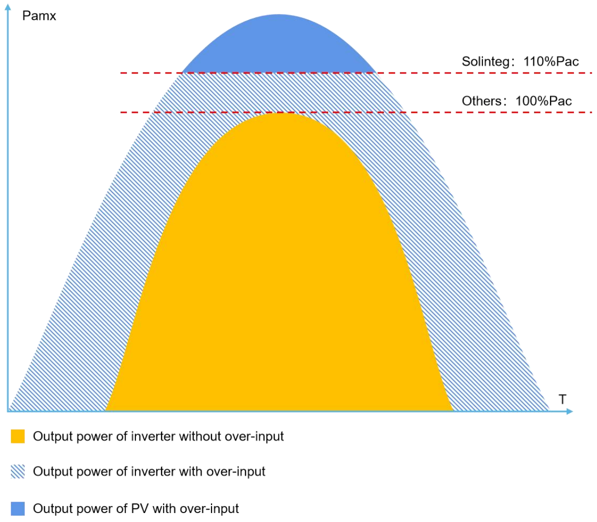


- **Inverter Maximum Input Power**

Since the power generation of PV systems is affected by irradiation and there are unavoidable losses during use, the DC input power of inverters is usually designed to be greater than its rated, which is the PV oversizing we called. Reflects on the inverter parameter is maximum input power.

A higher DC input limit not only means better performance and higher cost of internal components, but also some practical benefits:

- ✓ Greater power generation
- ✓ Longer power generation hours
- ✓ Reduce peak power loss
- ✓ Reduce system purchase cost



Excessive PV over-matching may lead to a reduction in inverter lifetime, but moderate use of it can significantly increase the efficiency of power generation, which allows us to have more power to use while also charging batteries or feeding into the grid, creating more revenue.

- **Inverter MPPT Voltage Range**

The MPPT of the inverter has a fixed operating voltage range, and within which the inverter could works properly and maintains efficient tracking of the maximum PV power.

Usually when we over-matching PV panels, we not only need the PV output power to be lower than the maximum DC input power of the inverter, but also need to ensure that the PV panel Voc is within the MPPT voltage range to ensure that the inverter can work normally.

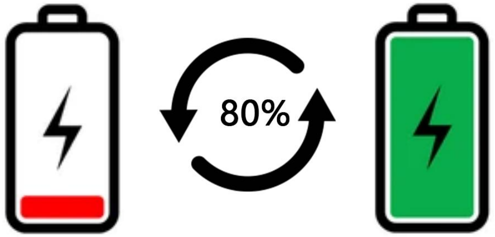
So the wider the MPPT voltage range, the better the flexibility of the inverter.

Matching Inverters with Batteries

The capacity and charging/discharging efficiency of energy storage batteries are usually the main concerns when designing solar energy storage systems.

- **Battery Capacity**

Usually we can choose the battery capacity according to the actual power consumption at night, power outages and other off-grid situations, with due consideration to extreme weather conditions such as fog and continuous rainfall.



The recommended depth of discharge (DOD) of a battery is usually around 80%, so we need to take this into account when determining the battery capacity. The appropriate depth of charge and discharge can effectively extend the life of the battery.

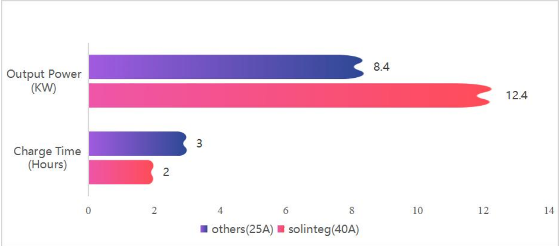
- **Battery Charging and Discharging Efficiency**

The charging and discharging efficiency of a battery is usually limited by two factors: one is the limit of the charging and discharging current of the battery itself, and the other is the limit of the inverter charging and discharging current. The battery operates at the lowest of these two values.

Parameter	XXX-74Ah
Battery capacity (Ah)	74
Battery voltage (V)	336
Charge and discharge current (A)	37

X Brand Battery Parameters

So choosing the right parameters products can ensure that the battery can be fully charged as soon as possible during the day and have maximum output power when in use.



As shown in the figure, when using the Solinteg 40A charge/discharge current inverter, the charging time is reduced by 1/3 and the output power is increased by about 47% compared to other brand of 25A inverters.

Matching Inverters with Loads

Residential PV systems usually require us to pay attention to the following points due to different installation situations:

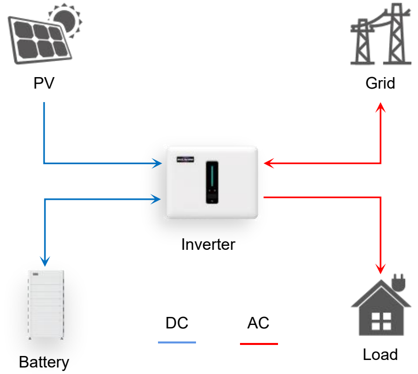
- The local grid situation: single-phase/three-phase, grid voltage, etc., to ensure compliance with the loads connecting situation;
- Maximum load power connected at the same time: to ensure that the inverter can power the load or has overload capacity in some degree;
- Working modes: scenarios in which the system works with loads for a long time, as described in detail below;

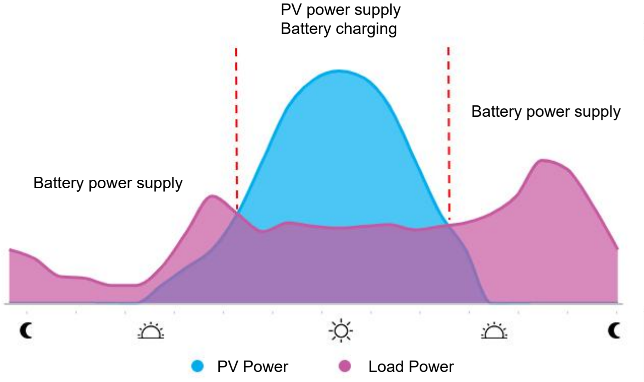
The above are some suggestions for building a residential solar system and hoping to provide some guidance for you.

Working Modes

General Mode

The most common working mode. The PV power will supply to the load first, and the excess will be stored in the storage battery and fed into the grid when the battery is full or still has excess power. When the PV power is insufficient, the storage battery will be activated to provide power to the load with PV together.

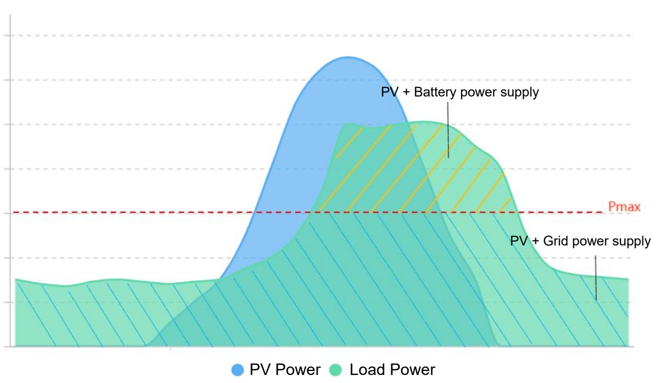




Peak Load Shifting

Usually, this mode is used in scenarios where there is an overload or a ladder electricity tariff. When the power of the load exceeds the maximum power contracted with the grid or when it will face grid fines after the overload, We can set an upper power limit (Pmax) in the inverter and make the system operate according to the following logic:

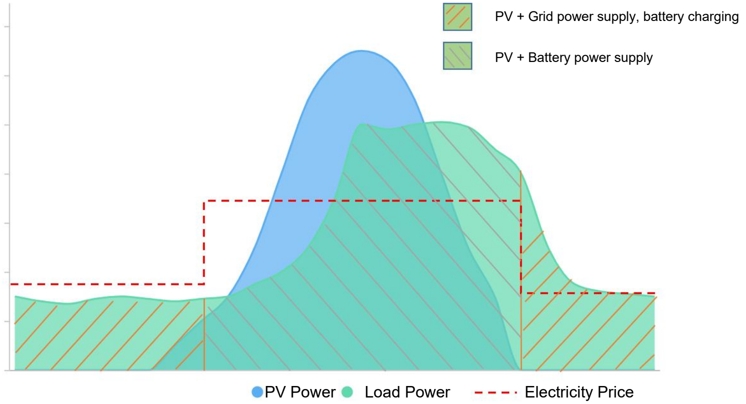
Pload≤Pmax, the PV system will charge batteries first and then power loads after batteries are full;
Pload>Pmax, the portion exceeding the Pmax will be powered by batteries and PV.



Economic Mode

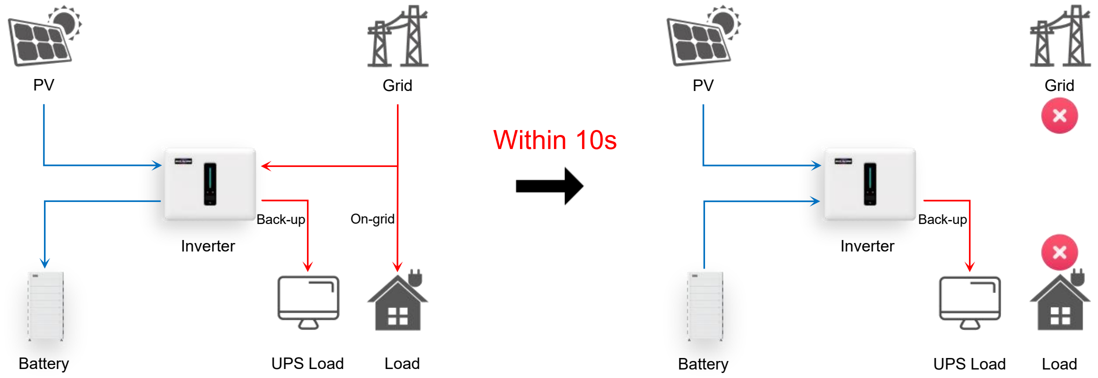
Usually, this mode is used in areas where peak and valley electricity prices exist, where the user can reduce the cost of electricity by setting the system to operate with different logic at different times of the day:

Peak hours: powered by batteries and PV systems;
Trough hours: the grid supplies power to loads and charges the batteries;



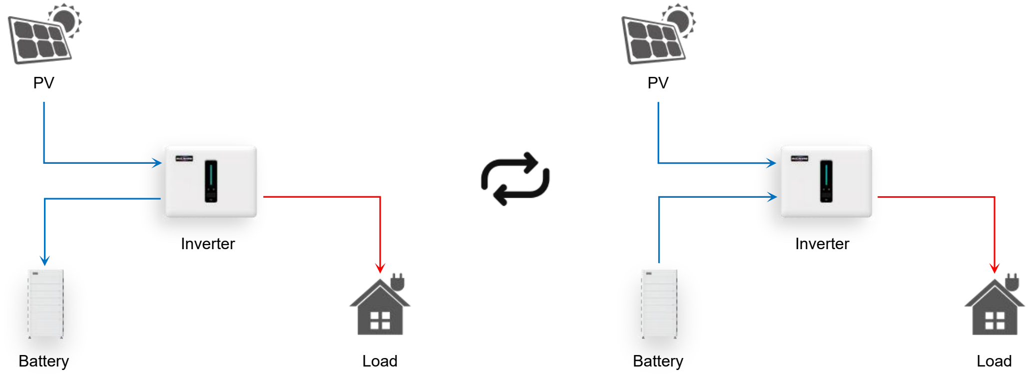
UPS Mode

UPS mode is mainly used in areas where the electric grid is unstable and intermittent power outages occur. Under normal conditions, batteries will always be fully charged and all loads will be powered by the grid and PV. When the grid fails and the PV power is insufficient, loads connected on the back-up side will be powered by batteries and PV within 10ms to ensure the important loads will be powered continuously during use.



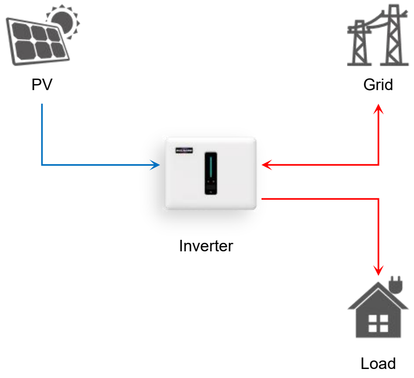
Off-grid Mode

The system usually works without grid for a long time. When the PV power is sufficient, it firstly supplies power to the load, and then charges the battery when there is excess power. And the battery will discharge to feed the loads when the PV power is insufficient. So in this case off-grid usage time will become the primary factor for battery capacity selection.



On-grid Mode

The on-grid system follows the principle of "self consumption first and surplus to grid". There is no energy storage battery in the system. When the PV power is sufficient, all the power generated is supplied to the load as a priority, and the surplus is delivered to the grid. When the PV power is insufficient, the grid will provide power to the load.



The above different working modes have practical significance. The proper use of the various working modes of the inverter can significantly improve the economic efficiency of the PV system and create more income for the users.

In the actual design of a residential solar system, all the above scenarios should be taken into account to cope with the different power consumption situations that may arise. At the same time, a reasonable increase in system power and battery capacity can effectively deal with unexpected situations.

Other Relevant Factors

There are some very important factors that influence the selection process of solar system, such as the ease of installation and use, the intelligence of system management, the efficiency of load control, the expandability of the system, etc. We will introduce some details below.

Intelligent Management

Intelligent management for PV systems is usually divided into two aspects: one is remote management through cloud platform and intelligent management of loads; the other is the intelligent management of energy use to improve energy utilization.

- **System Monitoring**

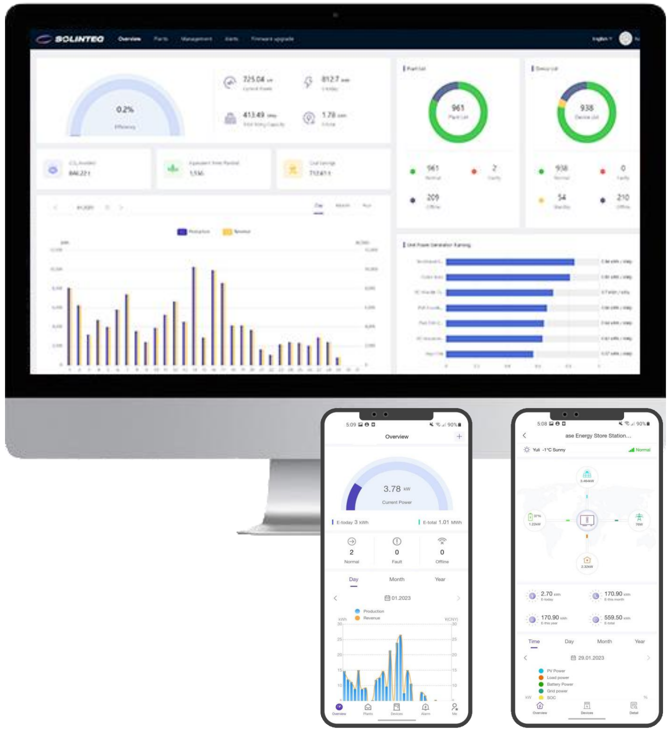
The PV system can be connected to the cloud platform through WIFI, LAN and other communication modules, and users can use the webpage or APP to view the operation of it in real time, such as the current status, power generation, loads consumption, etc.

- **Remote Management**

Users can manage the system remotely through the cloud platform, such as switching the system on and off, switching modes, modifying settings, etc. Or unify the management of multiple solar systems.

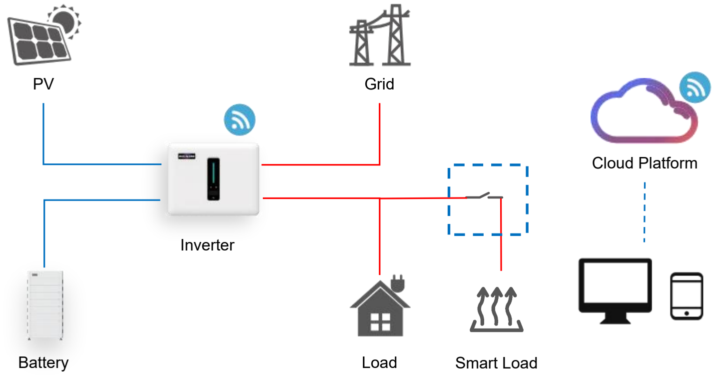
- **Remote Maintenance**

Users can remotely upgrade system firmware, push fault information and provide solutions in real time.



- **Intelligent Load Management**

The photovoltaic system can be used to control the automatic startup or shutdown of some loads. Such as heat pumps, in the situation of there’s surplus power in PV or in a set period, the inverter can automatically control the work mode of the heat pump and can also realize remote control through the cloud platform.



✓ **Timing Control**
Control the on and off of the load at specific times.

✓ **Efficiency Control**
Control load on and off when PV has surplus energy for efficient energy use.

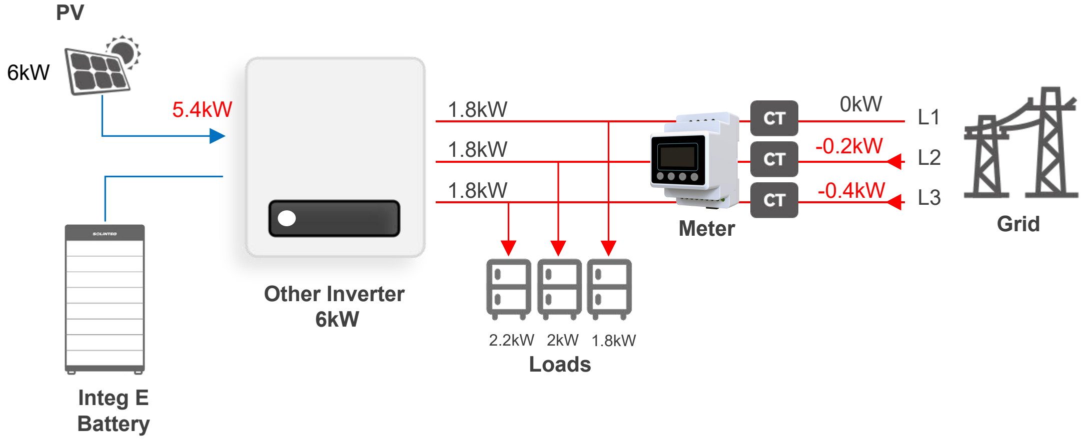
✓ **Manual Control**
Remote control of load start and stop.

110% Unbalanced Output

In some countries, the residential grid is three-phase, and the grid uses a three-phase independent metering model. In such cases, the ability of unbalanced output is particularly important, especially when power is not allowed to deliver to the grid.

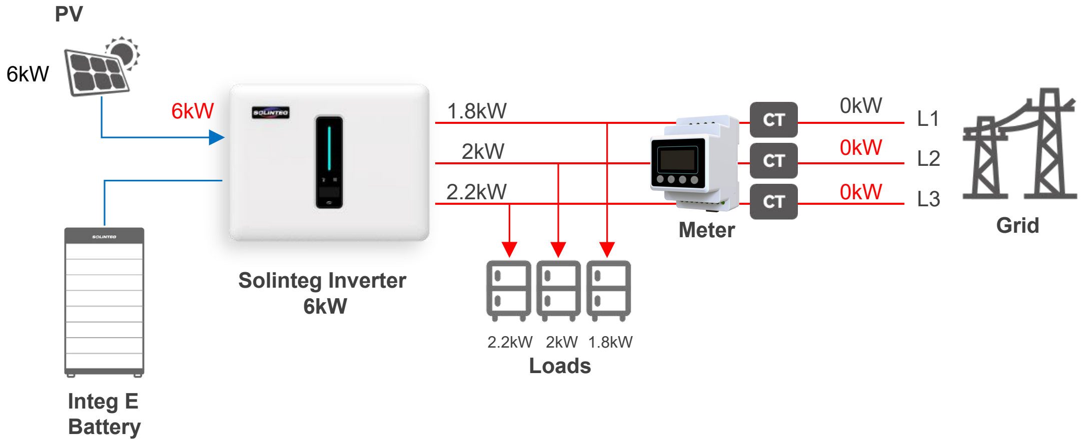
110% Unbalanced Output VS 100% Unbalanced Output

100% unbalanced output means that the output power of each phase of the inverter ranges from 0W to 1/3 of the rated output power, and the output gap of any two phases can also reach 1/3 of the rated, while 110% unbalanced output is a further step on this basis, and the output power of each phase can reach 1.1 times of the 100% unbalanced output one.



Without Unbalanced Output:

As shown in the figure, each phase of the inverter is connected to a load of different power. Although the PV output power is 6kw, the L1 phase load power is only 1.8kW. So in the case of the power export limit open, the inverter output limit of each phase can only be 1.8kW, and the total power limit is 5.4kW. At this time, the excess 0.6kW power from PV can only be used for battery charging. When the battery is full, the PV power will be derated to 5.4kW, and the insufficient power of L2 and L3 phase loads must be purchased from the grid, resulting in unnecessarily high electricity bills for customers.



With 110% Unbalanced Output:

As shown in the figure, each phase of the inverter is connected to different power load. Since 110% unbalanced output is available, the maximum power of each phase is 2.2kW, so each load can just be powered by the PV. The PV power will not be derated and no additional power needs to be taken from the grid.

Installation and Maintenance

The ease of installation and maintenance of the inverter is also an important factor. A good inverter should have an attractive appearance, reliable structure design and good heat dissipation to ensure that it can be used indoors and outdoors, work quietly and efficiently.

Highlights of Solinteg

IP65
Indoor and outdoor installation, stable and reliable

Safety Protections
Safe and secure

Breathing Solinteg
Unique breathing light design, easy to identify the working status

Perfect Industrial Design
Compact and elegant design with integrated die-casting technology, corrosion resistant and fast heat dissipation

Easy Installation
Plug&play terminal

Expansion and Compatibility

- **Communication Protocol**

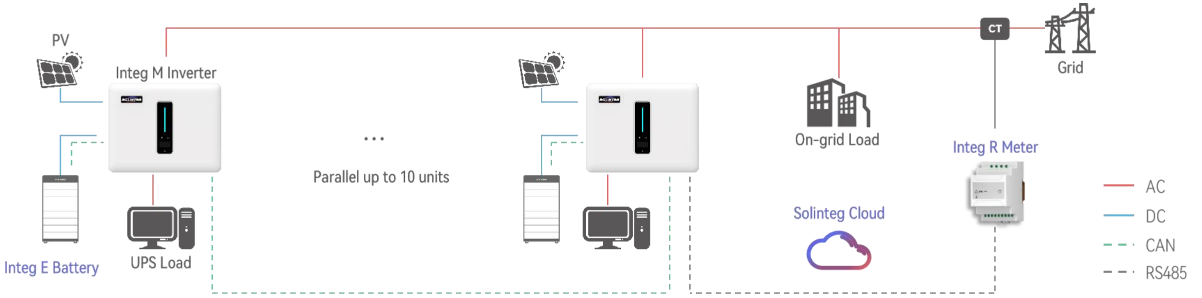
Common protocols include: WIFI, CAN, RS485, Modbus, etc.

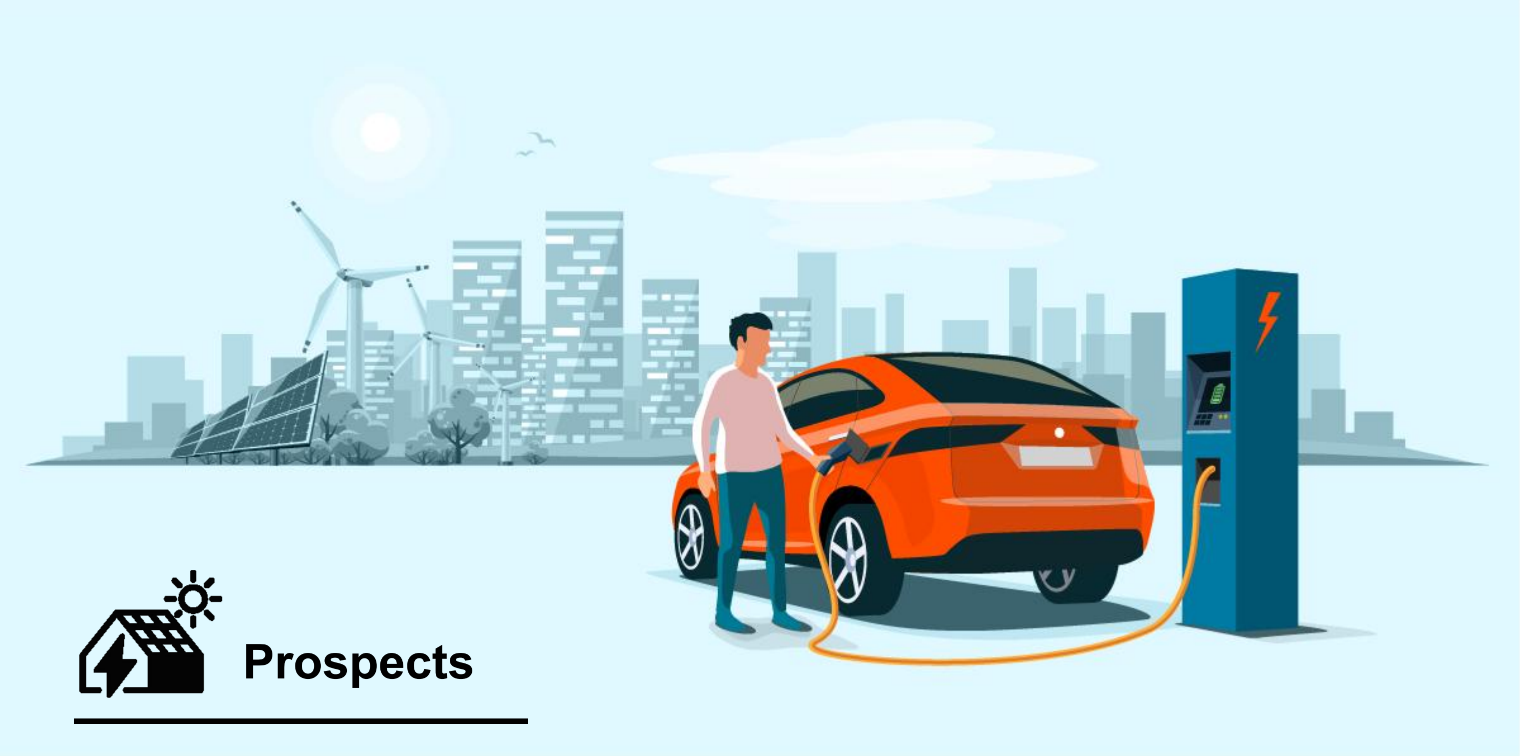
- **Connection of Battery and Load**

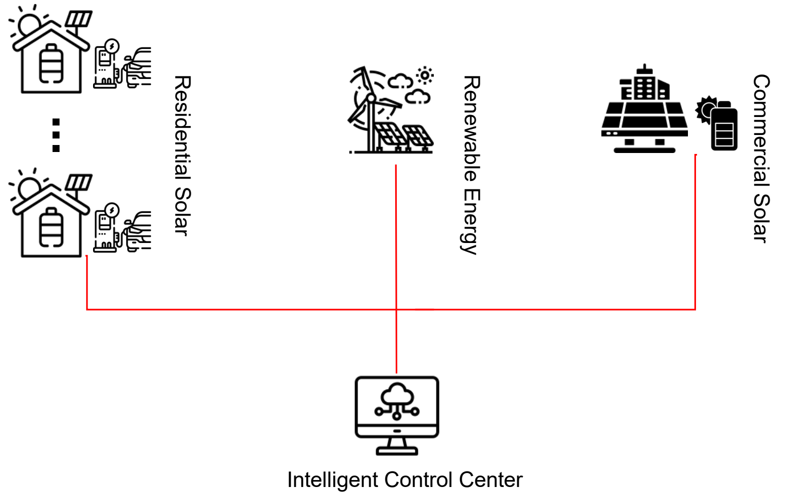
Compatible with many battery brands on the market, such as Pylontech, Dyness, Soluna, Weco, etc. There are dry contacts reserved for smart loads such as heat pumps, water heaters connection and control, and DI ports for external emergency stop switch connection.

- **System Expansion**

The inverter can be paralleled for various application scenarios.





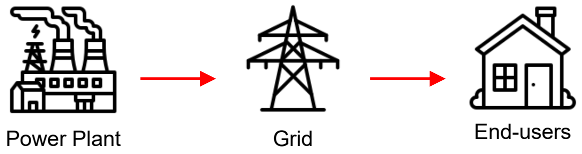


Prospects

A **micro-grid** can be as small as just three houses equipped with solar panels and energy storage batteries, or as large as to cover an entire community, city, or island. The efficient utilization and sharing of renewable energy through precise control of the system can not only bring benefits to environmental protection, but also reduce our energy costs, lower grid pressure, reduce dependence on the grid, and cope with more power shortages.

From Community Micro-grid to Virtual Power Plant

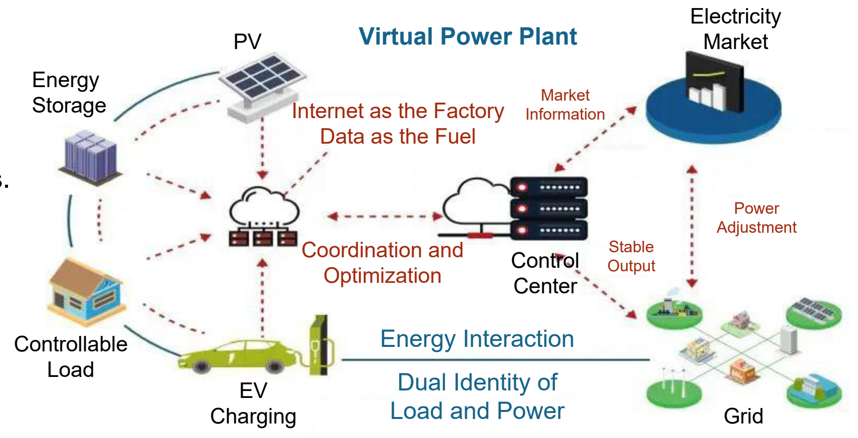
The continuous transformation of energy structure brings us more energy solutions, which allows us to use energy more efficiently and flexibly. Some concepts such as community micro-grid and virtual power plant are also getting closer to us with the popularization of distributed photovoltaic power stations and energy storage systems.



The traditional electricity is generated from a power plant, then transmitted through the power grid and finally provide it to end-users. In this process, the electricity used is largely constrained by the grid and plant. With the popularization of residential solar energy storage system, if we can connect several or even one region's household PV power stations, energy storage systems, and other renewable energy generation systems, then the power system can operate independently and provide power to users in the area in isolated situations.

Virtual power plants take the structure of microgrids further, scheduling and balancing all power generation, energy storage, and consumption device through a set of control and optimization systems, accurately controlling electricity demand and generation output balance.

A established virtual power plant can bring us many benefits, such as improving energy use efficiency, protecting the environment, reducing carbon emissions, and reducing electricity costs. Although the large-scale application of virtual power plants may still take some time since it has high requirements for energy control, power scheduling, information communication, and computing, we will eventually get there.



Thanks

INTEGRATE SOLAR INTELLIGENTLY