

Interreg - IPA CBC Bulgaria - Serbia

Renewable Energy for Smart Growth and
protected Environment

Solar energy

Practical guide on how to use the solar energy



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Solar energy

A practical guide to using solar energy

Zajecar in 2022

ABBREVIATIONS AND THEIR MEANING:

OIE - Renewable energy sources

ROI - Return on investment

Offgrid – A power plant that is not connected to the grid

Ongrid – A power plant that is connected to the grid

Prosumer – Buyer/producer of electricity with a special status

PV panel – Photoelectric panel for the production of electricity from solar radiation

PVT panel – hybrid solar panel for the production of electricity and hot water from solar radiation

ICT - Information and communication technologies

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INTRODUCTION

1. IMPORTANCE OF ENERGY IN CONTEMPORARY WORLD AND TRENDS

Along with water, energy is one of the two most important resources that are crucial for the current and future survival of the human community. It may sound a bit scary, almost cataclysmic, but everyday life confirms that without one of these two resources, there can hardly be any sustainable development of society or even preserving of the existing state of the art. Energy has always been a significant factor that ensured progress, starting with very basic use for food preparation, light and heating, until today where there is NO activity that is feasible without more or less energy. The consumption of this key resource began to grow exponentially with technological development in the 17th and 19th centuries, especially after the First Industrial Revolution, where energy began to be used extensively in the mass production of goods for an increasingly demanding and growing human society. Consumption is proportional to the level of industrial development, but also to the level of living standards of individual countries. From 1965 to 2021, consumption in some countries increased up to 500 times (Oman), in a number of developing Asian countries ten or more times, while in a number of very poor countries it even fell by 50%, due to reduced industrial activity (Syria, Gabon, North Korea...) or the reductions are the result of the introduction of more efficient technologies and strict energy efficiency programs (Great Britain, Denmark, Luxembourg...).

During the last twenty years, the demand for electricity has been growing rapidly due to efforts to reduce the impact on climate change, i.e. because of increasingly strict measures for the introduction of decarbonisation, i.e. industries that do not emit or have a significantly lower emission of CO₂, as the main cause of the global warming. The consequences are already clear to everyone, because the increment average temperatures causes a change in the movement of air masses and water flows, which results in extreme climatic phenomena, large droughts throughout the year, and on the other hand, huge amounts of precipitation in a short time, even at the time of the year when it has never been such climate turmoil. Electricity is perceived as the cleanest form of energy that is not polluting the environment, although this is must not always be the case. Take, for example, the production of electricity from thermal power plants, where large amounts of polluting gases, especially CO₂ and PMs are emitted, even when the installations have very complex and very expensive air purification systems. At the same time, the use of hydro or nuclear energy are driving controversies because large hydroelectric plants do not emit CO₂, but have a great impact on the microclimate, < conditions on groundwater, on habitat and biotope and also at the social level when entire settlements and infrastructure are moved from areas where reservoirs are formed. Nuclear power plants are potentially at very high risk due to the even the lowest possibility of a nuclear accident or as well as due to the demanding storing of nuclear waste.

The events from recent years have only brought up all these issues to the fore front, particularly the conflict in Ukraine, which resulted with massive displacements and huge disruptions to the food and energy supply chains, therefore some almost forgotten capacities for dirty fuels, primarily coal, are resurrected by force of circumstances and returned to production.

For all these reasons, the whole world, and especially the European Union, has been trying for a number of years to introduce programs aimed at producing clean energy in sufficient quantities, aiming at sustainable development goals (RIO process, Kyoto Protocol, Green Agenda, Fit for 55).

2. WHAT ARE RENEWABLE ENERGY SOURCES

Renewable energy sources (RES) are sources that are renewed at least the same rate at which they are exploited. Everything in nature what could be renewed is done spontaneously and without side effects, thus RES are considered to be clean energy and the right choice for solving energy needs without polluting the environment and have no, or very little, impact on climate change. Unlike RES, non-renewable resources are depleted over time and cannot be renewed, at least not on timescales comparable to our understanding of time. Non-renewable energy sources are all fossil fuels (coal, oil, natural gas), for example, because they cannot be renewed even during the time that was sufficient for the creation of human civilization.

Renewable energy sources include:

The energy of water is the energy of rivers, the energy of waves and tides. It has been used to run mills or any other installations that require mechanical energy, threshing machines, saw mills, weaving mills... Since the 19th century, the production of electricity has emerged and since then, water is one of the most common way of using energy sources that are constantly renewed.

The energy of the sun is the energy that our star radiates to the earth's surface and is of both heat and light nature (although they are of the same, electromagnetic origin, but in different spectrums of radiation). This is also a form of energy that has always been available. In the beginning, the sun was only used as a thermal source, for heating homes, for boiling water and in very early stage to dry and preserve the food because, in addition to heat, the sun also radiates ultraviolet rays, which are excellent disinfectants, thus very good for preserving the food. For this reason, the sun is used to dry meat, plants and plant products. It was only in the 20th century when it was discovered that, when crystallized silicon is exposed to the sun, it causes electric voltage on its ends. This phenomenon is widely used today to make photoelectric panels that generate electricity.

Geothermal energy is the energy of the earth which is a huge heat reservoir. The earth radiates its own energy and the miners know this best because the temperature in the pits is much higher than on the surface. The earth is a great generator and this feature was used, above all, for balneological and health purposes. Each spa uses warm water from depth. Thermal waters, however, can be used for the production of electricity, for heating swimming pools, residential areas, for heating roads and streets (Iceland, which is all resting on geothermal springs, uses them abundantly for exactly these purposes), greenhouses and fish ponds. However, geothermal energy is not used only for heating, but for also electricity production and can be put to work with the help of heat pump technology for both heating and cooling, as well.

Biomass - Energy obtained by burning plant residues, using bio gas as a product of decomposition of plant mass and from bio fuel (fuel obtained from processing high oil content plants). Biomass is the oldest form of renewable energy since the humans used wood for heating, to prepare food and as a source of light ever since. Woods grow, so if used carefully, it will always be there. Biomass is both plants and residues from agricultural production and in general, all biological material that can be used as fuel. This is the primary way of using biomass (straw, residues from harvests, residues from vegetable crops, dry branches and plants, etc...). Biomass could be collected from special energy plants that are grown only for this purpose (fast-growing willows, for example). Today, biomass is commonly available as pellets, compressed plant residues that provide uniformity and easy way to use it as a fuel.

Wind energy - Wind is a result of the movement of large air masses in the earth's atmosphere, due to climatic, thermodynamic phenomena, differences in temperature and air pressure above the earth's surface. Wind occurs occasionally and we cannot precisely nor predict with certainty when it shall blow, albeit it was also used as a source of energy. In the beginning, it was a driving force for ships with sails which were energy "catchers", and later on, as a driver for mills and everything that could be powered by external energy (mills, water pumps, saw mills...). The energy that was initially used to propel vessels is now largely used to generate electricity with the help of wind generators.

3. WHICH ARE THE ADVANTAGES OF USING RENEWABLE ENERGY SOURCES

Renewable energy sources are available in some form everywhere and can be exploited in any place, immediately and without the need to transport energy sources. This means that the infrastructure for exploiting energy from renewable sources is more compact, simpler and less demanding. Large facilities such as large storage and/or reversible hydropower plants or facilities for the massive use of geothermal water, such as exist in Iceland, for example, are not considered in this publication.

The energy security status is much more favourable when it comes to dispersion of energy sources on smaller units, rather than large energy sources, with the capacity to overwhelm

significant consumption. Failure of a small plant shall not jeopardize the power system, while failure of a large power installation leads to very serious problems in the production and distribution of energy.

From purely technical perspective, the generation of energy in small plants provides distribution throughout the electrical grid at a lower voltage, which reduces losses in the grid and makes it more efficient.

The price of energy production from renewable sources has a downward trend and on the other hand, the market price of energy has a tendency to increase, which justifies investments in RES.

The green economy, and therefore the industry of renewable energy sources, is, in addition to ICT, the fastest growing industry, since the transition to RES requires development of new technologies and considerably greater production of equipment and services in this particular niche, so the benefit is twofold, on the one hand energy is significantly cleaner and safer to use than the one from conventional sources and on the other hand, the level of energy security is increased and the dependence on other sources and/or energy providers has been reduced. Finally, the price of energy production from renewable sources is falling down because of the number of equipment manufacturers increases, thus the equipment becomes cheaper.

4. WHICH ARE THE CHALLENGES IN USING RENEWABLE ENERGY SOURCES

The biggest challenge in using energy from renewable sources is the fact that the two most popular and easiest to exploit, wind and solar energy, are of such a nature that they are not produced continuously. Energy from those two sources is generated when it is available, that is, when there is sun or wind, which is predictable only to a certain extent. The electric power system, roughly speaking, rests on three key pillars: the producer, the distributor and the consumer. Energy distribution is carried out through the electrical distribution grid, which, in order to operate in an optimal mode, must have a constant load. An analogy could be made with water pipes where also must be water all the time. Otherwise, air can enter the pipe and reduce the flow, or impurities can accumulate in the pipe due to stagnant water, which reduces flow rates.

In order to ensure the optimal load of the grid, more or less the same amount of energy must flow through it, for which we need to have uniform or harmonized consumption and production. This requires energy contingency that will be introduced to the grid when lacking sun or no wind. That additional energy is the so-called "balance energy" and must be provided in whatever way. So far, the grid operator is required to provide balanced energy, in accordance with the regulations both in Serbia and Bulgaria. However, in the future, most likely part or all of the obligation will be transferred to energy producers from renewable

sources, which will make investments more expensive and less attractive, at least for large systems because small ones shall be exempted from it in whole or in part.

It is also necessary to secure environmental safety with no impact on the environment (this especially applies to small, run-off hydroelectric power plants and large scale installations on biomass)

Although the energy from renewable sources is cheap, the system must be regularly maintained (cleaning the panels, pruning trees so that they do not cast a shadow on the panels, checking the fluid in the solar collectors, checking the fluid in the heat pump system, maintaining the channels and catchment at the hydroelectric power plants, cleaning the stoves and chimneys in the case of biomass stoves...) and replacing parts that have passed their term (accumulators, for example).

SOLAR ENERGY

5. WHAT IS SOLAR ENERGY, ITS FORMS AND POTENTIALS

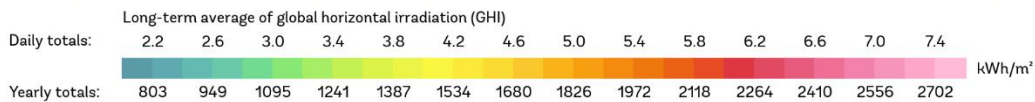
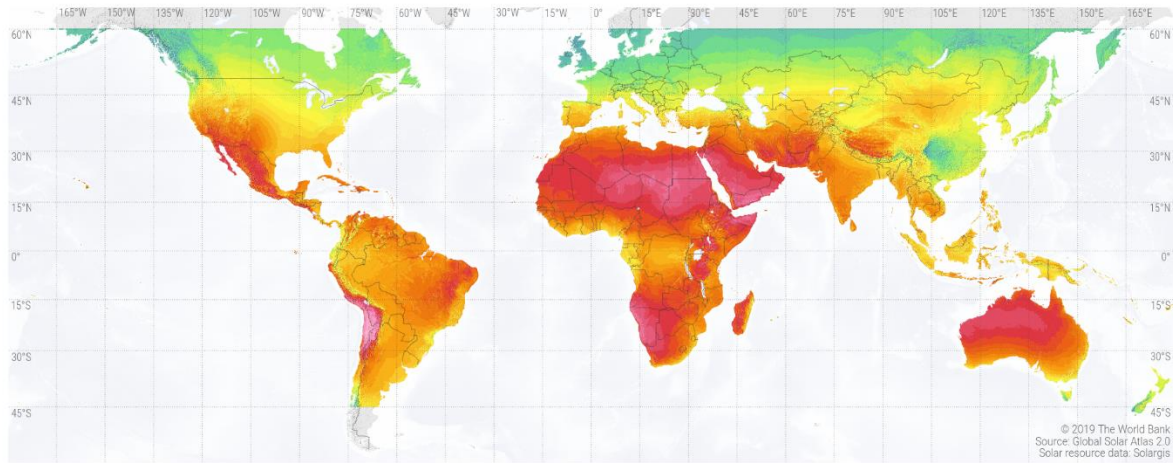
The energy that the sun radiates is essential for all life on earth, including human life, and it appears in several forms. The sun is the source of light and the rhythm of its appearance determines the bio-rhythm. A lot of research has been done on people's behaviour, efficiency and social interaction in relation to exposure to light, especially natural, sunlight, and all the results, without exception, have shown that a long-term lack of sunlight causes health problems and considerable negative impact to behaviour and work. Therefore, it is extremely important to provide enough light and particularly sunshine, in houses, apartments, workplaces and in general in all places where people stay or linger for a long time,

Another characteristic of solar radiation is heat. The entire part of infrared radiation, even shorter wavelengths than that, carry the energy that we feel as heat and without which there is also no life. Using both of these forms of energy from the sun is essential for a healthy life and people have been finding ways to use the resource that is constantly available to them, ever since. In the very beginning, mostly passive methods of heating water in the sun, drying food, building houses that stored heat were the ways to utilize the sun, and later on, especially in the 20th and 21st centuries, the methods of converting solar energy into electricity were developed. Finally, biomass and fossil fuels contain accumulated energy from the sun, which is released by combustion.

The average daily radiated solar energy on the earth's surface is about 6 kWh/m². This is energy that, if completely utilized, would be enough for a third of a home in today's most developed urban environment. If we follow this rationale, along with the data on the total world consumption of all types of energy, which is somewhere around 1480 million tons of

oil equivalent (Mtoe) per year, we will very quickly reach the conclusion that the entire

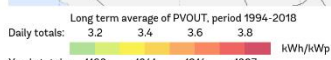
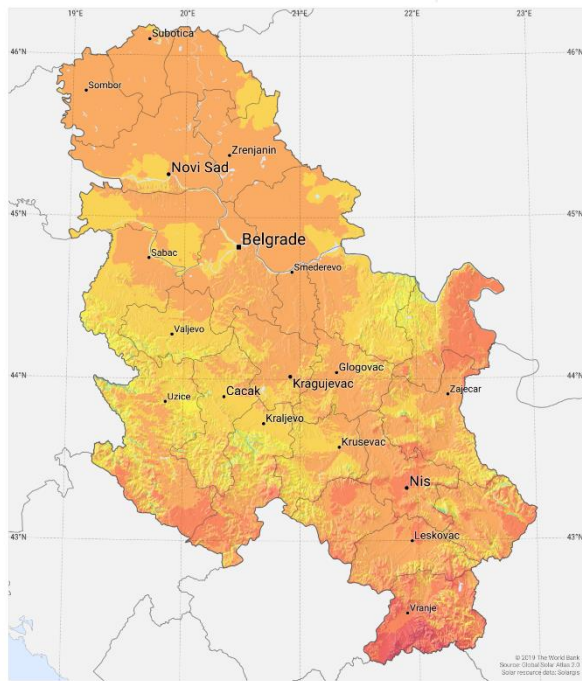
SOLAR RESOURCE MAP
GLOBAL HORIZONTAL IRRADIATION



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world's consumption of all forms of energy could be replaced from solar panels placed on surface that is slightly smaller than Serbia, for example, provided of course that we can use solar energy completely and with no losses. By the way, the entire globe has an area of over 6,000 Serbia. This is only a theoretical result because the efficiency of solar panels is significantly less than 100%, but it is very illustrative and shows how much of a resource is constantly available to us and that by using it, a large part of the needs of all humanity can be met, with minimal

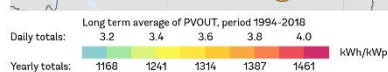
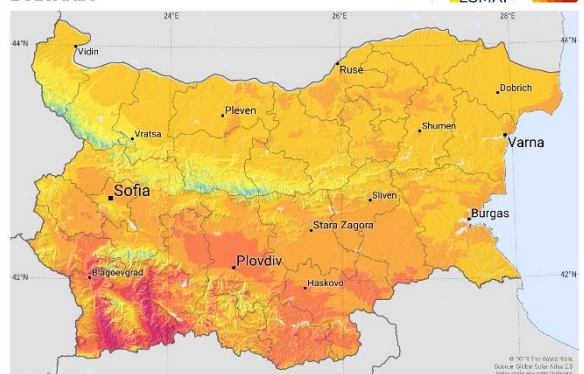
SOLAR RESOURCE MAP
PHOTOVOLTAIC POWER POTENTIAL
SERBIA



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SOLAR RESOURCE MAP
PHOTOVOLTAIC POWER POTENTIAL
BULGARIA



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(Map of photoelectric potential in Serbia and Bulgaria)

Impact to the environment .

Serbia and Bulgaria in the border area have an average of about 1400 kWh/m²/year of solar radiation and with a similar photoelectric conversion potential. This is a huge capacity, and in order to make it easier to understand what amounts of energy are at stake, we will make a small calculation.

Solar panels, i.e. passive elements that convert solar radiation into electrical energy, have an efficiency, that is, a degree of utilization between 18-22%. If we take into account the fact that the average consumption of electricity per capita in Serbia is very similar to one in Bulgaria and amounts to about 5.45 MWh/year and if we estimate the average efficiency of the panels and the average amount of solar radiation, we will get that to cover the complete energy needs of either Serbia or Bulgaria, about 7.5 m² of solar panels per person is required. If we adopt that there are about 7 million inhabitants in each of these two countries, in order to meet all the needs in electricity, there is a need to install solar panels on areas of 52,500 ha. In Serbia alone, the overall roof area amounts to 60,000 ha, while in Bulgaria it is certainly not less, bearing in mind the similar number of inhabitants and the level of GDP. Of course, this estimation is rather theoretical since one can never use all the surface available, but is good to illustrate the potential of solar energy. Only a fraction of this potential makes a huge contribution, not counting the potential of commercial solar power plants on unused, abandoned or agricultural land where solar panels can also be installed with the, so-called agro-solar types where cattle can be raised even under the panels or to have any kind of farming below the panels. Special solar panels are designed for this purpose, with 50% of transparency, thus provide enough sun beneath them and at the same time produce electricity.

In addition, other RES, hydropower and wind power plants, for example, should be taken into account. Both of these two countries could meet a large part of their needs of energy supply in the long term by producing electricity from renewable sources, coupled with an appropriate program of energy efficiency and rational consumption that would enable further growth of economies, with no or limited environmental footprint.

This proves exceptional opportunities not only when the electricity production is concerned, but these potentials are the same for the production of thermal energy that can be used for sanitary and industrial purposes, for agriculture, in food production for drying fruits and vegetables, for heating and cooling with utilization of heat pumps, for processing contemporary fuels, such as the so-called "green hydrogen", etc.

6. WAYS TO USE SOLAR ENERGY

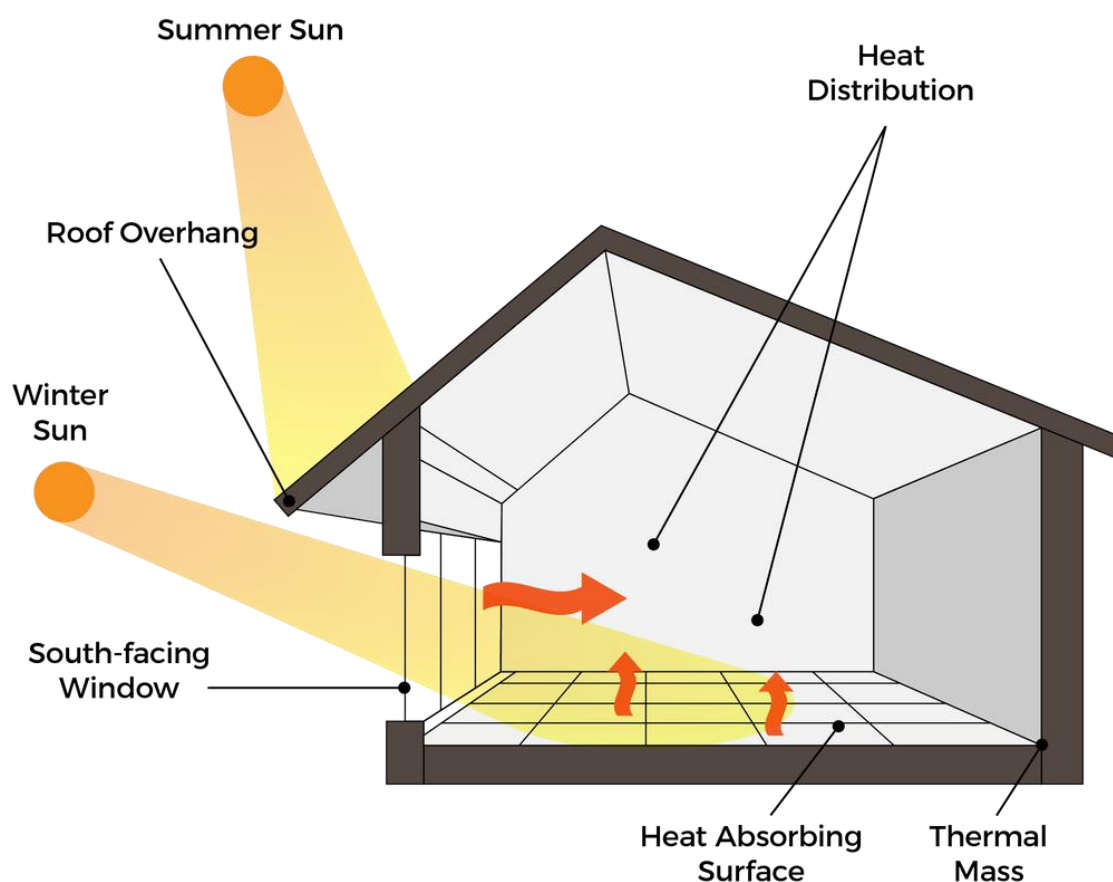
The most common forms are:

- Passive use of sun, both as light and for heating

- Use of thermal energy by utilization of solar collectors
- Conversion into electricity by using photovoltaic panels
- Using hybrid panels - for heat and electricity, simultaneously

Passive use

The simplest way is passive use, i.e. exposing objects to the sun in such a way that they will use energy radiation to the greatest extent or to protect from excessive radiation during summer time.



Passive solar building techniques are nothing new and have been practiced for thousands of years before the advent of mechanical air conditioning devices. Fully developed solar architecture and urbanism were applied in ancient Greece and ancient China. Roman baths had large windows facing south, thus enabling natural sun heating. In many early civilizations, houses were built to accumulate heat during the summer that could keep them warm during much of the winter. For example, the settlement built by the Anasazi tribe (southern part of the USA) was completely carved into a huge rock that was heated by the sun during the summer and was releasing the heat for several months in the winter.

In our area, mud houses were built for a long time, even until recently. Not only because it was a relatively affordable and easy-to-use material, but also because mud mixed with straw is an exceptional insulator, thus houses kept heat well in winter and protected against heat in summer.



A typical example of modern architecture are passive energy houses that are designed and oriented to have good exposure to the sun, have very good insulation to preserve heat in winter and prevent excessive heating in summer, with passive systems for ventilation with natural air circulation and natural light concentration for lighting the interior rooms.

In addition, the use of simple solar water heaters, solar cookers or the sun for drying plants and meat, have been known for a long time and are easy to use, so they are still widely exploited today, especially when it is necessary to find a quick, simple and effective solution.



Solar collectors - use of thermal energy

A more advanced version of heating water using solar radiation are thermal solar panels/collectors that are made in several varieties, from those that directly heat water to those that have a closed system with a liquid with a high boiling point and a low freezing point.



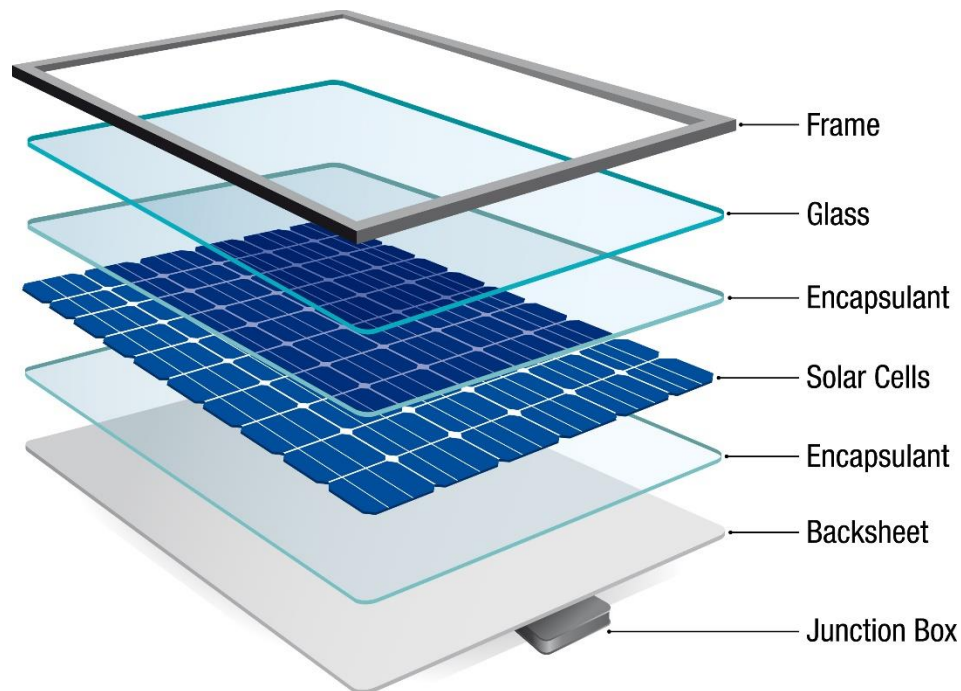
The panels can be plain, flat with pipes on the heating surface, or with vacuum pipes that allow use in practically all weather conditions, even in winter.

Solar panels - conversion to electricity

The most technologically advanced are solar panels that convert solar energy into electricity using the so-called photoelectric phenomenon that occurs with silicon crystals. This effect allowed an entire industry to literally flourish. The production of solar panels in the world for the last 10 years has increased almost ten times and reached the annual production capacity of about 180 GW of installed power in 2020. Therefore, anything that runs on electricity could be powered by solar panels.

How does a photo electric (PV) panel work and what does it look like? Solar photovoltaic cells consist of a positive and negative film of silicon placed between two polymer foils and under a layer of glass that is for protection from meteorological conditions. Solar cells are mostly

made of polycrystalline or monocrystalline silicon. As photons of sunlight hit these cells, they eject electrons from the silicon.

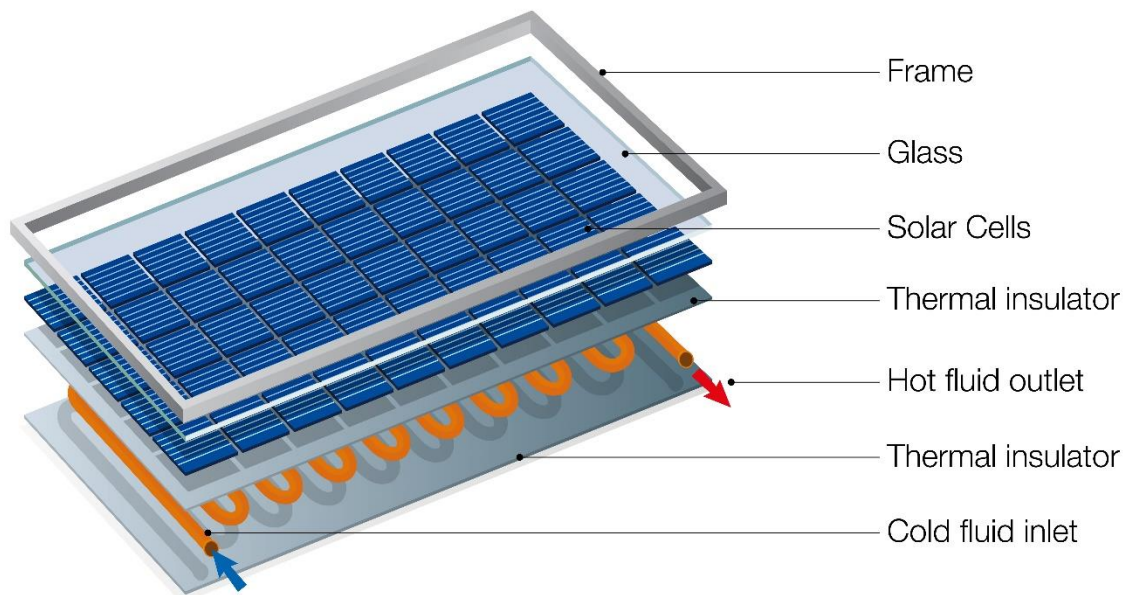


Negatively charged free electrons are attracted to one side of the silicon cell, which creates an electrical voltage that generates an electrical current when the panel is connected to a consumer. This is a short explanation of the photoelectric effect, which, as said, is very pronounced in silicon. The difference between monocrystalline and polycrystalline panels is that monocrystalline panels are more efficient with a degree of utilization of 18-22%, and are therefore more expensive compared to polycrystalline panels, which have a lower efficiency rate of 15-18%. Of course, the effectiveness of the panels themselves depends a lot on how they are installed. The more exposure to the sun, the more electricity they produce. Therefore, it is extremely important to carefully analyse how to and location where to install the solar system and its orientation towards the sun, whether it is placed on the roof, which is the most common case for small systems, or on the ground. The panels provide DC voltage of 12, 18 and 24V, depending on the size and type of the panel. If the energy is delivered to the electrical distribution grid, then is necessary to use inverters, devices that transform direct current into alternating current and at grid voltage.

In order to select and set up a system for the use of solar energy, the first step is to define the purpose of such a system, the type and conditions for its installation and, accordingly, the planned capacity.

An advanced system for using solar energy is combined panels that have both photoelectric and a fluid heating panels located directly behind them. This increases the productivity of the PV panels because they are cooled and therefore more efficient while hot water is obtained at the same time. In this way, the total degree of utilization can be up 50% higher, compared

to conventional models, which is an exceptional percentage, and you get two energy products at once.



The purpose of sun conversion can be for the production of electricity, heat or combined energy. Also, the system can be designed for commercial purposes, i.e. for the further sale of energy or for own needs, either for personal or for the industrial needs.

This guide shall be dealing with an example for a personal use system that can be connected to the grid as a producer/customer (prosumer) and with the case where the system for providing hot water is desired. Solar collectors for using thermal energy only are not subject to special legal measures, but they can be financed through banks that support this type of investment, with or without incentives from government programs.

7. TYPES OF SOLAR PHOTOELECTRIC (PV) SYSTEMS

Today, we can distinguish three basic categories of solar power generation systems, although in the future there might be more of them:

1. Offline, the so-called "off-grid", i.e. closed systems,
2. Systems connected to the distribution network, the so-called "on-grid" or open systems
3. Combined systems that have the possibility of internal energy storage, but are also connected to the network.

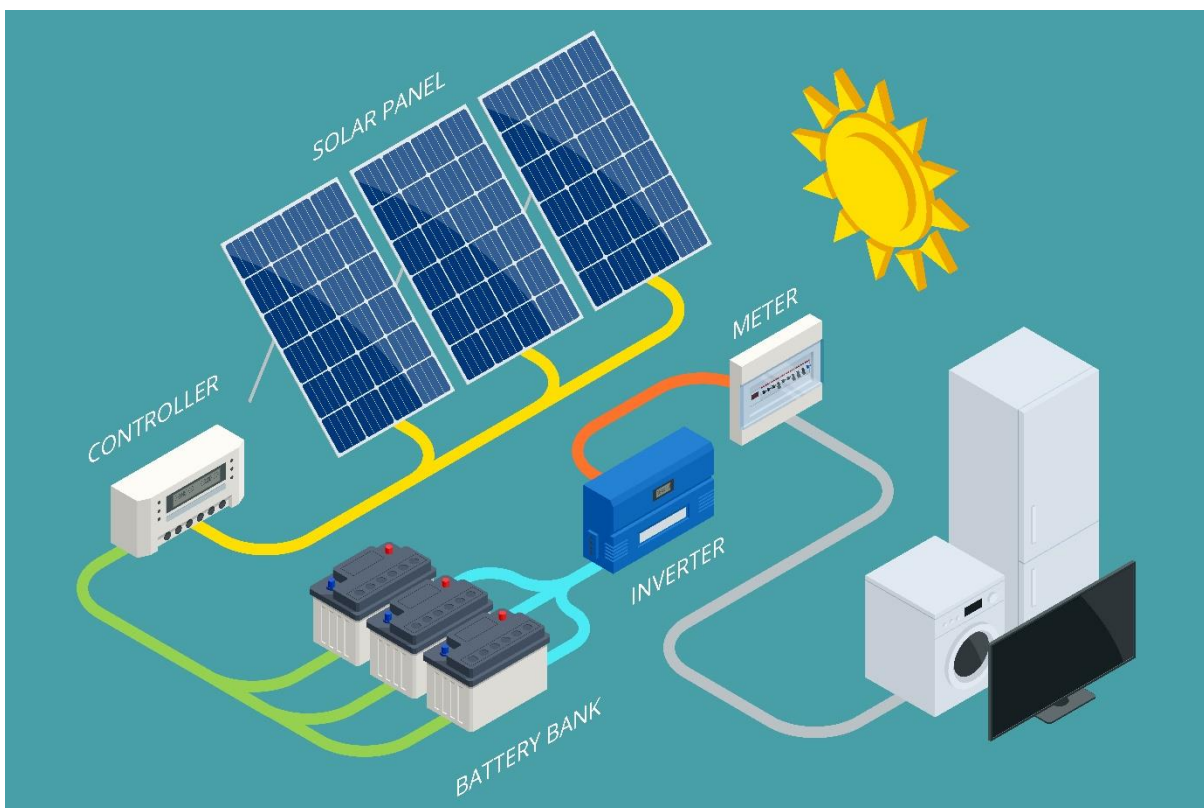
Which one to choose?

Off-grid (closed) systems

Independent, that is, closed solar systems outside the grid (off-grid systems) are completely independent from the electrical distribution network. With the exception of direct use, such as a water pump or PV-driven ventilation, stand-alone off-grid systems must have batteries to provide energy during night or times of low yield (cloudy days) or more intensive energy consumption.

The components of a closed system are as follows:

- Solar panels – a device for converting sunlight into electricity using the photoelectric effect.
- Battery – accumulators with a longer service life and increased capacity. They can be conventional or modern gel batteries that last longer and have a higher energy density per unit volume;
- Inverter - a device that transforms the low-voltage, direct current produced by the panel into alternating current of 220 V or 3x 400 V;
- Battery charge controller – a device that controls the rate of battery charging in relation to the degree to which the battery is charged;



- Electrical protective equipment such as switches, fuses and circuit breakers;
- System for monitoring and balancing energy consumption and production;

This type of system is suitable for objects that are outside the grid or do not have access to it.

Advantages:

Independence or inaccessibility to the grid are the main reasons why one decides for an off-grid system. Off-grid systems are not subject to changes in energy prices, cannot be part of a restriction program or are suffering from network failures. However, closed systems require a high degree of optimization of consumption and economical use of energy, because excessive consumption inevitably leads to a lack of energy that cannot be compensated from the network, but only from its own system or reserve energy source (special generator). Bridging such a scenario is possible with a somewhat oversized system with large storage capacities, but this leads to excessively high costs where the profitability is questionable.

On the other hand, closed, off-grid energy system guarantees a minimal environmental footprint and this can be one of the factors to determine the selection but also taking into account shortcomings, listed hereof.

Flaws:

The main disadvantage is the price of the system, which is higher due to the existence of batteries and devices for charging and discharging them. In addition, the capacity of the off-grid solution must be somewhat higher because it is necessary to have contingency energy at all times, either during direct consumption or when it is not produced enough (cloudy weather or at night). However, it may happen that when consumption is lower than production and energy surplus is stored until the capacity of the batteries is filled out then the system is turned off. In other words, when you don't consume energy, its production stops because you can't store it indefinitely.

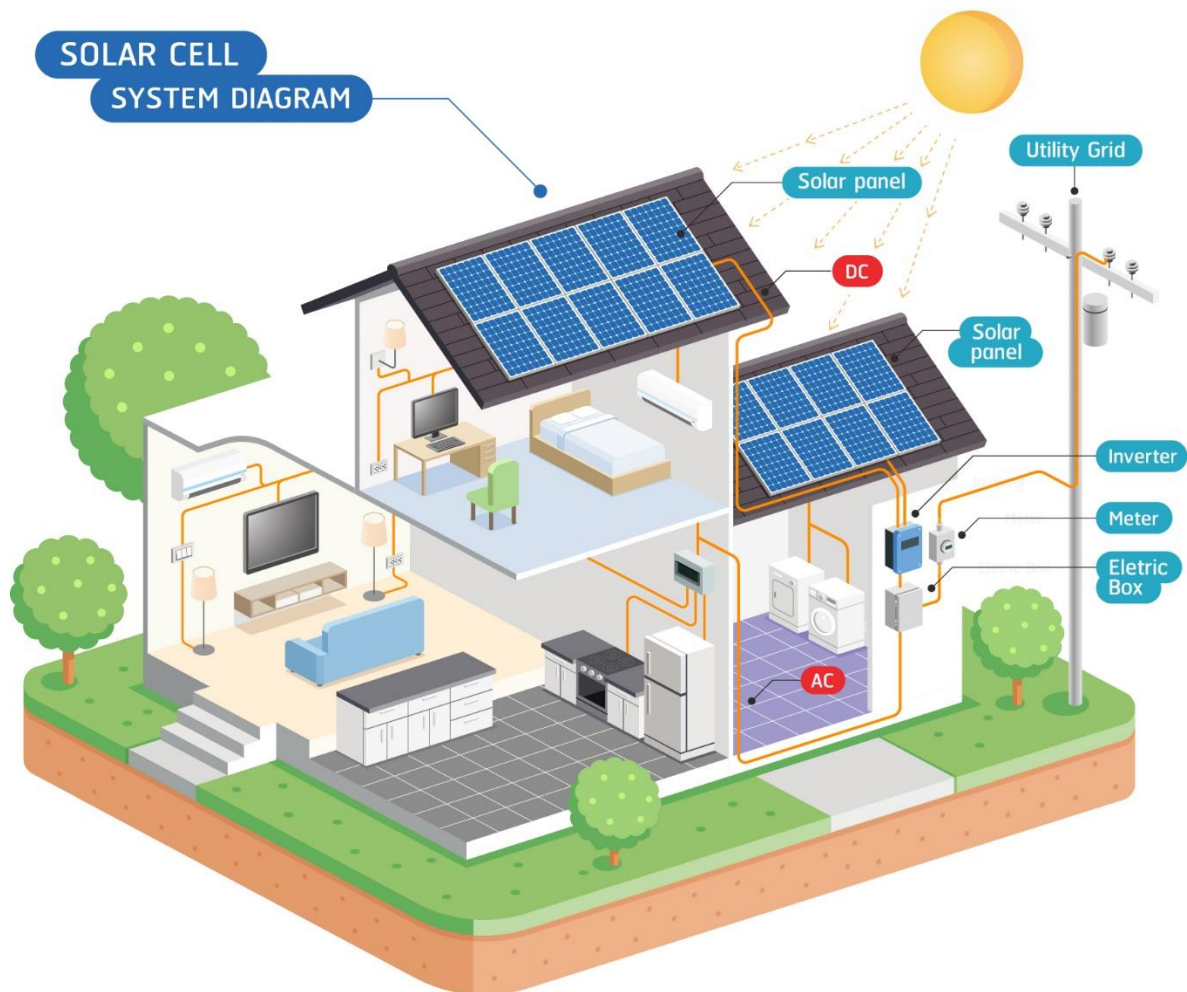
Accumulators have their own life time and they need to be changed every 5-10 years since their storage capacity decreases over time. One should take into consideration that disposing of old batteries might compromise environmental neutrality because batteries are toxic waste that must be treated in the proper way, which is an additional cost and potential threat to the environment.

On-grid (open) systems

On-grid differs from independent, closed, off-grid systems in the way in which they hand over all produced and not consumed energy to the grid at the moment it is produced.

When it comes to commercial power plants, then this handover to the grid is treated as the sale of energy which is then resold to someone else, and when the energy is handed over to the grid by the buyer/producer (prosumer), then the electrical grid plays the role of a virtual storage from which previously committed energy can be withdrawn, when and if necessary.

Open, on-grid systems are somewhat cheaper in their configuration and do not require special maintenance, except for running, because they do not have independent accumulators.



The components that make up an on-grid solar system are:

- Solar panels – a device for converting sunlight into electricity using the photoelectric effect.
- Inverter - a device that transforms the low-voltage, direct current produced by the panel, into alternating current of voltage 220 V or 3x 400 V
- Electrical protective equipment such as switches, fuses and circuit breakers
- System for monitoring energy production and transmission
- Two-way smart electric meter

Open, on-grid systems can be used anywhere there is a utility grid and make sense in cases of continuous energy consumption.

Advantages

This kind of system is investment-wise and technically more favourable than off-grid. With a solar system that is connected to the grid, one does not lessen the standard of living, but is just complementing the way of energy consumption compared to the conventional one, by producing part of the energy yourself for your needs. The rest of the production, if having the status of prosumer, one can hand over to the network and it counts as an energy credit that can be used when it suits, albeit within 12 months, after which an calculation and balancing consumption and production is made before the next period. One should be aware that energy can be handed over to the utility grid only up to the level of average consumption. If delivered more than you spent, that excess cannot be retrieved and is considered as a loss for prosumer. That is why it is important to pay a close attention when designing the power capacity of the installation, not to end up in a situation where producing significantly more than the needs are, with oversized installation and therefore too expensive since one cannot withdraw all the produced energy. This shortcoming can be corrected with hybrid systems, which will be discussed later.

For the construction of solar systems, there are certain incentives and relatively favourable financing methods through state support programs and/or commercial loans from certain banks, which makes the profitability of the system more certain.

Flaws

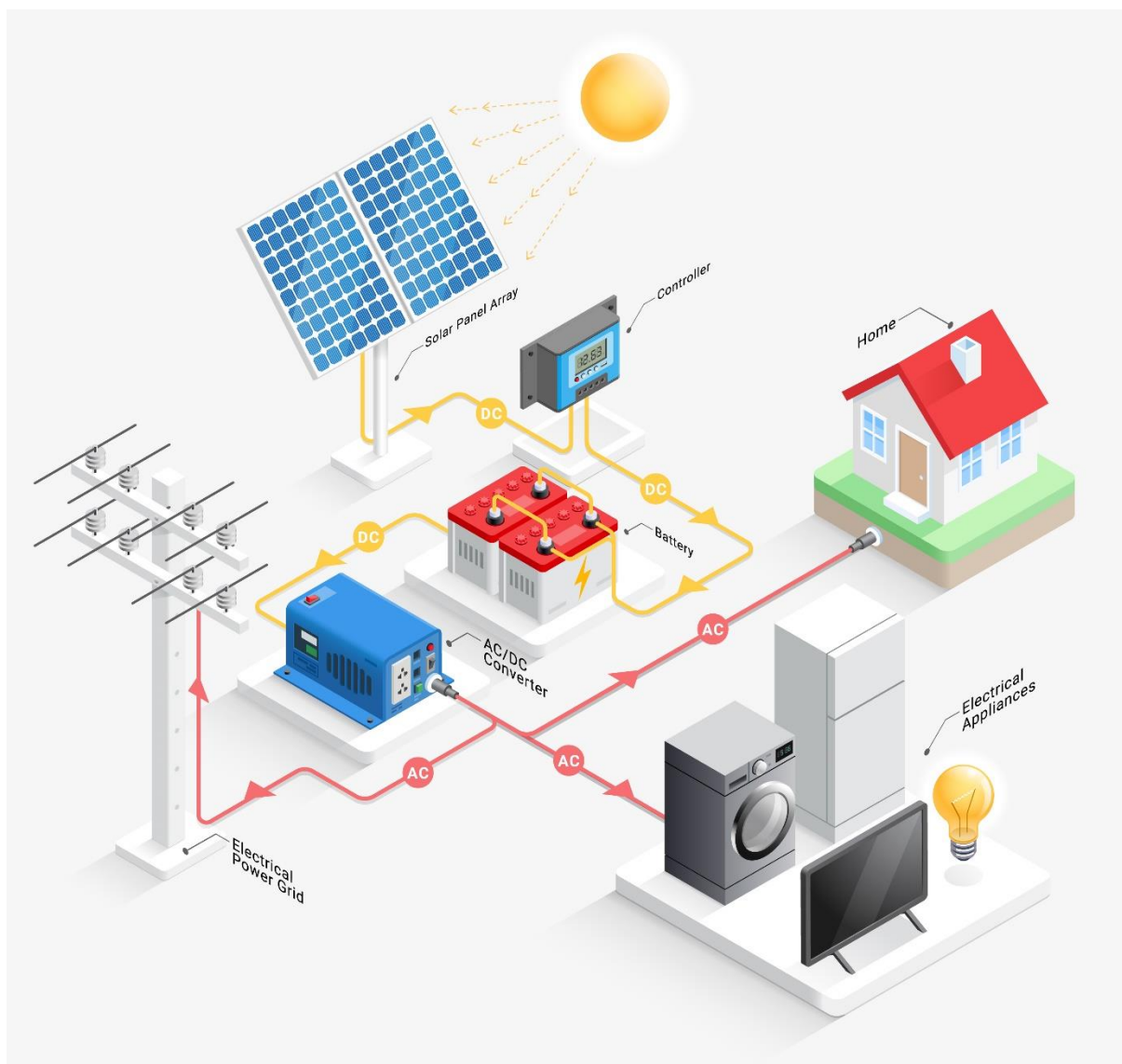
The construction and connection of an on-grid system requires certain procedural steps, permits and licenses that are not required for a closed system. The connection to the utility grid is approved by the grid operator, based on the technical documentation submitted by the authorized designer, or the contractor, so the whole procedure is somewhat more complicated and has certain costs. This is a particular problem in Bulgaria.

Another, but perhaps even more important drawback of this system is the current incompleteness of the regulations and their application in practice. It is unknown is how customers/producers will be treated if there is a shortage of energy, because the regulations do not regulate the priority level for this type of consumer. This will certainly shall change because the current situation is not sustainable aiming at more intensive investment in this area, especially considering the fact that energy will be more expensive and shortages are quite realistic.

Combined systems

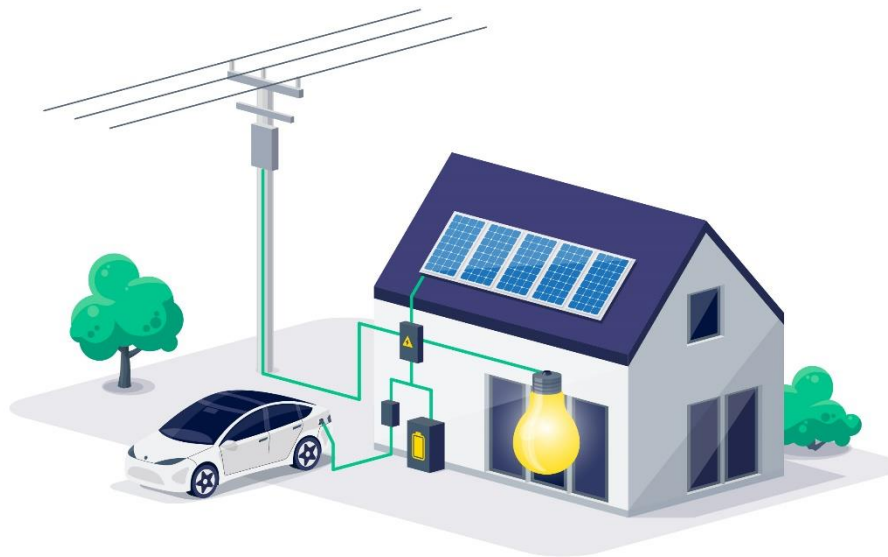
Clearly, these are the systems with photoelectric conversion that are connected to the grid but also have the possibility of autonomous storage in batteries. It is a combination which provides a very high degree of autonomy and maximum energy optimization. Surpluses can

be stored internally in case of breakdown or higher consumption at a time when it is not the most favourable to withdraw energy from the grid, and all the surplus is handed over for a time when consumption will be significantly higher than production. For example, during the summer months, daytime consumption can be fully covered by the autonomous system, and night-time consumption from the grid when energy is cheaper. During the winter, the leased energy surpluses can be used during the day, for heating and/or because insufficient production for current needs. Night consumption can be covered either from the grid or from your own energy storage. This type of system enables the installation of minimum capacities that, in combination with own storage and two-way use of the distribution network, can meet all consumption requirements. Thus, it is certainly the most effective solution, but it is also the most expensive one because it contains all the elements from both systems with the need for more frequent maintenance, thus higher running costs.



Such systems are suitable for remote locations with an unreliable network and/or for rural households that need to use energy in a scheme different to urban ones, that is, they have consumption peaks that can be many times higher than the average daily, so to supply the difference from their own storage capacities can be a great advantage, without increasing costs and with a greater degree of energy security.

As a temporary storage of electricity, an electric car can be used, from which, if necessary, energy can be used for consumption. This method is currently being intensively propagated in Western Europe and America, where there are already a large number of electric vehicles, thus giving them another function. Battery capacities in electric vehicles range from 18-118 kWh, but the most common capacities are around 70-80 kWh.



By connecting the vehicle to the energy system of the apartment or house, you practically get a hybrid model without buying additional batteries, although in this case you need to have a car charger and the possibility of taking energy from the car's batteries.

This means that a full car battery has energy for 3-4 days of the average consumption of an average household. This is rather important because, if you already own an electric car, it can provide you with increased energy stability and independence. You can charge the car, i.e. the battery in the car, during the day when you have excess energy production or at night, when energy is cheaper, and use it during the day as a supplement to the production of your panels.

The only flaw of this concept might be shortened life time of the battery that has limited life cycles and replacement is not an option due to their very high cost.

8. TYPES OF SOLAR COLLECTORS

Today there are two types and two types of solar collectors or solar heat/thermal panels for using solar energy:

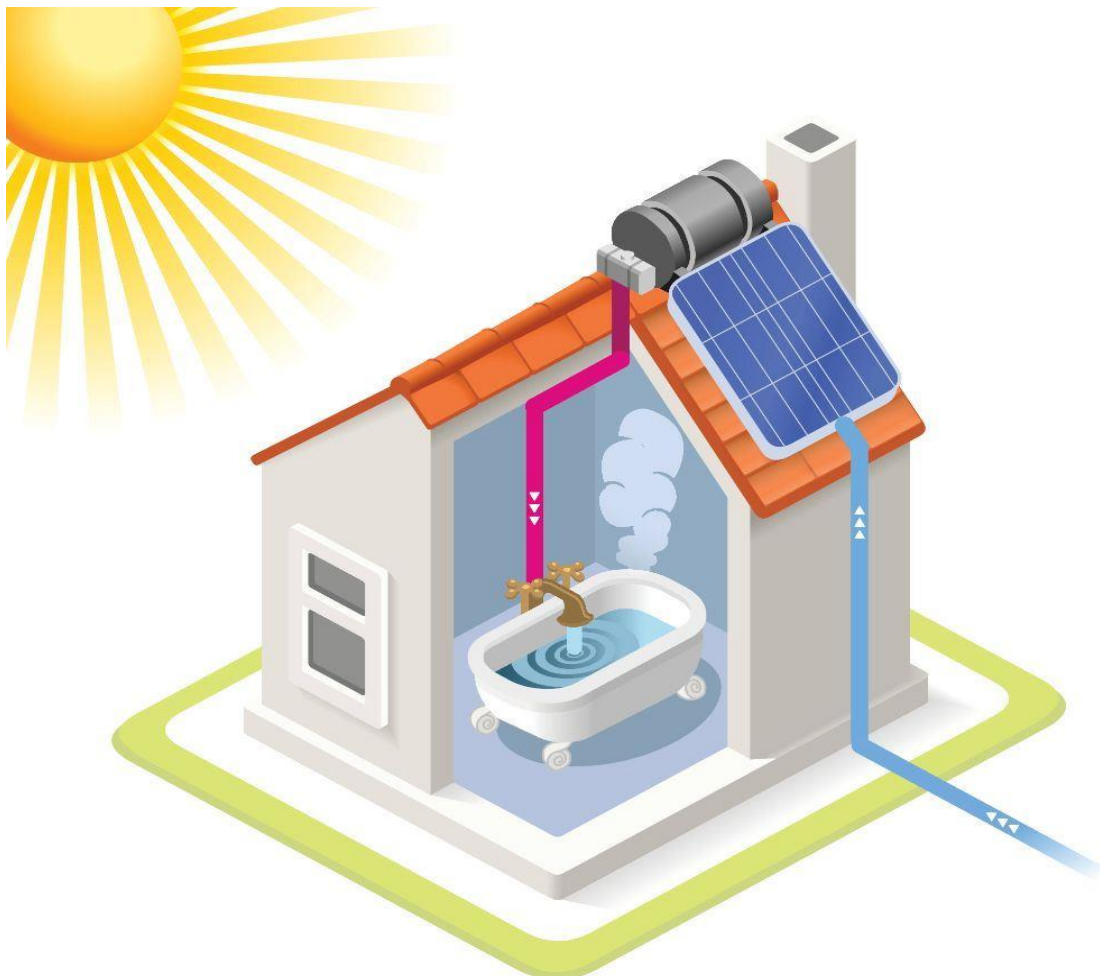
1. Plane solar collectors

- o Panel collectors, with simple system of pipes, whether with natural or forced water flow
- o Collectors with vacuum tubes, with or without a boiler, with or without forced water flow

2. Hybrid systems for the production of electricity and thermal energy - PVT panels

Use of thermal energy - solar collectors

The types of solar collectors were discussed earlier, and their cost-effectiveness for individual use can only be assessed indirectly, although the benefit is superior when we need larger amounts of hot water.



The water heated with the collector can be used for sanitary purposes, for room air conditioning, swimming pool heating, etc. Their price is somewhat higher than PV panels of the same surface, especially when it comes to collectors with vacuum tubes. In addition, the collectors require special boilers, in case they are active systems with a pump, or built-in tank-boilers that make the installation somewhat more complex, but certainly not complicated. Solar collectors are often installed together with PV panels and such creates a uniform system.

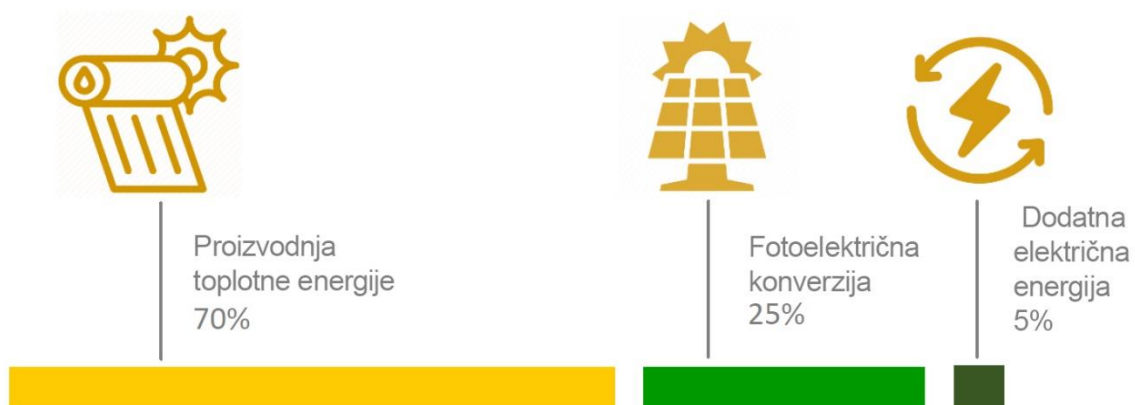
Advantages

Solar collectors can work without any external energy source, except in the case when they have built-in pumps for forced water circulation, but even that can be solved with a small PV panel that runs the pump.

Collectors, particularly with evacuated tubes provide the possibility of heating water in all weather conditions without any cost and are, therefore suitable for individual houses, touristic facilities of all sizes, sports facilities and swimming pools, small industrial plants, rural households and farms, for growing vegetables in greenhouses, for fish farming...

Flaws:

The installation of such a system also requires a special water installation, a solar water heater, if the system is not passive, i.e. gravity installations, a pump and an expansion tank make the solution somewhat more expensive, so the payback time for such an investment might be longer if the system is not designed well and unless there is a need for larger quantities hot water for, say, a swimming pool or for a facility with high hot water demands (for example, a health facility, catering, laundry, car wash, livestock farm, dairy plant, and the alike).



PVT panels (photoelectric conversion using thermal energy)

The latest generation of panels has the ability to deliver both heat and electricity from the same panel. There is a system of pipes behind the PVT cells through which the liquid cools the panels and heats up the hot water in boilers.

9. ENERGY STORAGE SYSTEMS

The biggest problem with energy from RES is its storage. Renewable sources are by their very nature, peak energy producers since we can use them when they are available and not by choice (exception is geothermal energy, which is always available). The release of energy from fossil fuels and biomass is most often by combustion or the process of transfer to another form of fuel that is later burned anyhow (gasification of the biomass, for example). We use fossil fuels and biomass when we need energy, and when we don't, energy storage is brought down to storing fuel.

However, for the energy we get from solar radiation, or from the wind or from the movement of water, the storage of the finished product, electricity or heat, is of paramount importance.

Hydro energy is of a somewhat different nature from sun and wind because it is continuous and any interruptions in operation can occur only in longer time intervals (due to drought, for example), but not on a daily basis, as is the case with solar and aeolian energy. Hydro-energy storage is carried out by means of reversible power plants (pumping stations) that, when there is enough energy, pump water into reservoirs/lakes, on a higher altitude than the power plant and thus store additional potential energy of the water, which is then used to run turbines when there is no or not enough water in the watercourse.



The biggest drawback of solar and wind energy is their impermanence and it is necessary to provide external energy to balance the transmission system when there is no energy production. It would be ideal if there were large, efficient and long-lasting electricity storages that would be used for supporting the consumption during periods with no production from RES.

Modern technologies make it possible to build storages with lithium-ion batteries of huge capacities, the largest of which is in Australia with a capacity of 450 MWh and another one, currently under construction, with capacity of even 2MWh. These are huge plants (enough to cover the energy consumption of about 350 average Serbian homes for a year!). Although this seems impressive, it is only less than two hours of operation of Djerdap HPP in Serbia or only an hour of Kozloduy nuclear power plant, in Bulgaria. Nowadays' cannot provide storage for large quantities of electricity, but it is possible to set up a large number of small storage facilities, so that solar power installations for households can more easily solve the problem of storing energy in their own batteries, still not for longer than a few days.

One practical solution for saving energy is to lend it to the network, that is, the power system. The consumer/producer (prosumer) hands over surpluses to the grid operator, and recover it that energy when needed, i.e. at any time when the „creditor“ requests it. This method of virtual storage has many advantages, however, the status of prosumers is not the same in Serbia and Bulgaria, even though it has been formally established in both countries. In Serbia, obtaining prosumer status is relatively easy, but the implementation of the Law and by-laws are still incomplete, which result in high costs and long ROI and in Bulgaria, if the producers



want to hand over excess electricity from their rooftop solar panels to the grid, they will have to go through a complex and lengthy procedure in order to register as prosumers, due to the insufficient capacity of the administration.

The advantage of this kind of installation is that there is no need for additional devices to store the energy, but it is delivered to the network and taken from it via a smart, two-way meter.

In the last few years, there has been a steep increase of interest in converting electricity from renewable sources into producing other forms of fuel that can be stored. The most advancing technology has been developed for the "green" hydrogen that is produced by simple electrolysis of water with the use of energy from renewable sources. Hydrogen is used for fuel cells that produce electricity from it and in this way, energy can be stored for a long time. The technology is not unknown, but it is still relatively expensive and raises the price of the final product because a double conversion is performed and the equipment required increases, thus the losses are higher, so "green" hydrogen is still many times more expensive than that obtained from natural gas.. However, even with all these limitations it still provides a way to save energy instead of losing it irretrievably, with technology constantly improving.



Heat storage in tanks with salt

10. SELECTION OF THE OPTIMAL SYSTEM AND ESTIMATION OF COSTS

1. Before we start to select, it is necessary to determine for what purpose you need a solar system, for the electricity production, to use of thermal energy or for both purposes.
2. The second step is to assess the needs or the projected consumption, whether it is electrical or thermal energy or combined systems.
3. The third step is to evaluate to what extent and in what way you want to use the solar system, that is, whether you have other sources of energy for the same purposes, so whether you need the solar system to meet all your needs or only as a complementary source. This assessment determines the type of system, costs and return of investment, i.e. its profitability considering the available sources of financing.
4. Based on the previous data, you determine the model of panels (PV or collectors for hot water or combined system) and the type, closed (off-grid), open (on-grid) or hybrid system, when it comes to photo electric panels while for solar heat collectors type can be a plate collector, a collector with vacuum/evacuated tubes or combined panels for both purposes.
5. When you have defined all the previous elements, you go for a rough calculation of costs and check their profitability, depending on the financing method. This step may require feedback adjustments in the choice of system type and its capacity, but it is the fine accommodation of needs and availability that finally lead you to the optimal solution.

Selection of the type of solar power plant

Here we will give an example of a small photoelectric (PV) power plant for a household as representation of the process from idea to realization.

If you do not have access to the grid, there is no other option than to go for an off-grid, closed system. If you have access to electricity from the grid, you have the choice between an open (on grid) or combined system. Each of these types of systems has its advantages and flows, as explained earlier.

To present a small case study, i.e. a simple business plan, we will give the comparative costs of building all three systems. The case study refers to individual consumption, but the principle and calculation of costs are the same for larger installations, with the fact that the cost decreases somewhat with the size of the power plant. When making these comparisons, it should be taken into account that they are made with the assumption of maximum exposure of the solar panels to the sun, so that they are oriented towards the south. If this is not the case, then it will be necessary to introduce a correction factor depending on the orientation of the roof on which the panels are located. Likewise, calculations were made for monocrystalline panels, which are more efficient and whose installed power is cca 200 Wp/m², which will allow reducing the roof area on which the panels will be installed.

Consumption estimation

When the consumer is connected to the grid, the consumption can be easily registered from the monthly electricity bills. We will assume that the average consumption of a household with four members is up to 500 kWh per month. It is the energy that enables comfortable use of energy and which can be higher in winter than in summer and depending on the month of the year, but with that amount of electricity one can organize a normal and comfortable life. An exception may be households that are heated by electricity in the winter, but for this small case study we will look at a household that has some other type of heating, municipal or individual with wood or pellets stove or even with heat pumps.

If the consumer does not have the possibility to connect to the grid, but needs completely independent, off-grid system, then the consumption should be looked at through the consumption throughout the daily routine. Most often, in these cases, it is a holiday house or a country home or a facility in an economic within the household with a relatively small installed power. The table shows the average installed power of individual devices and their daily/monthly consumption for the case of a slightly more equipped cottage or small residential house.

Device	Installed power (kW)	Daily operation (h)	Daily energy consumption (kWh)	Monthly energy consumption (kWh)
Boiler	2	1	3	90
Cooker with oven	2	1	2	60
Refrigerator/deep freeze	0,3	10 (compressor operation)	3	90
Washing machine	0,3+2 -heater	0,7	0,21	6,3
TV set	0,12	8	0,96	28,8
IT (tuner, router, etc.)	0,03	24	0,72	21,6
Small household appliances (iron, fan, mixer, coffee maker...)	4	0,1	0,4	12
Light bulbs (LED), all	0,1	8	0,8	24
TOTAL	4,85 (+2)		11,09	332,7

This table indicates comfort consumption with basic devices, but it can certainly be more or less than the above. Reducing the cost of used energy can be implemented in two directions. One is the optimization of consumption, that is, the rational use of energy (turning off the boiler when hot water is not needed, careful use of food preparation devices and turning them off before the end of cooking, using washing machines and dishes at full capacity, turning off unnecessary lights, etc.)

The second way is to use energy-efficient devices, class A, B or, in the worst case, C (the old designation A++, A+ and A). This saves consumption for the same beneficial effect.

These data are important to us for the calculation of profitability and return on investment (ROI).

Equipment selection

The rough calculation of costs and profitability of a solar power plant depends on how much energy we want to use from renewable from the sun, whether we want to acquire the status of buyer/producer (prosumer), what is the price of electricity and what is the price of equipment.

If we want to cover the entire consumption with energy from solar panels, then the approximated required power of the system is calculated in several ways, some of which take into account the radiated energy in a certain area, others the number of sunny hours, but in our case we will take into account the PHOTOELECTRIC POTENTIAL MAP which takes into account all the factors of panel installation, the average degree of utilization and the amount of radiated energy in a certain area. From that map, it can be seen that each installed kWp of solar panel can deliver 3.7 kWh of energy per day, i.e. 1350 kWh per year, in the border area of Serbia and Bulgaria.

Depending on the available surface on the roof of the house and our budget, we will choose the type of solar panels, monocrystalline or polycrystalline. The first ones are more efficient and occupy a smaller area, so with their use, a consumer who uses 500 kWh per month would need about 22 m². That is, approximately one whole side of the roof of a 100 m² house with a hipped roof. So, here the choice is narrowed down to more efficient and therefore somewhat more expensive solar panels. Of course, if the consumption is less, then also the required roof area is smaller.

Costs of the system

The price of small-sized solar systems in Serbia ranges from 800-1100 EUR/kW of installed power for power plants connected to the grid, while in Bulgaria the price ranges from 1700-2200 Lev/kW, which is very similar when converted to EUR, with the fact that the price includes the complete equipment and the installation itself. This price could also consist the costs of design and the production of certain documentation that is required in the process of approving the connection to the electric power system. However, to that should be added the prices of the two-way meter, which costs around 400 EUR, and the connection fee. The realistic price at the moment (September 2022) is around 1200 EUR/kW for a turnkey system and that estimation applies, more or less to both countries.

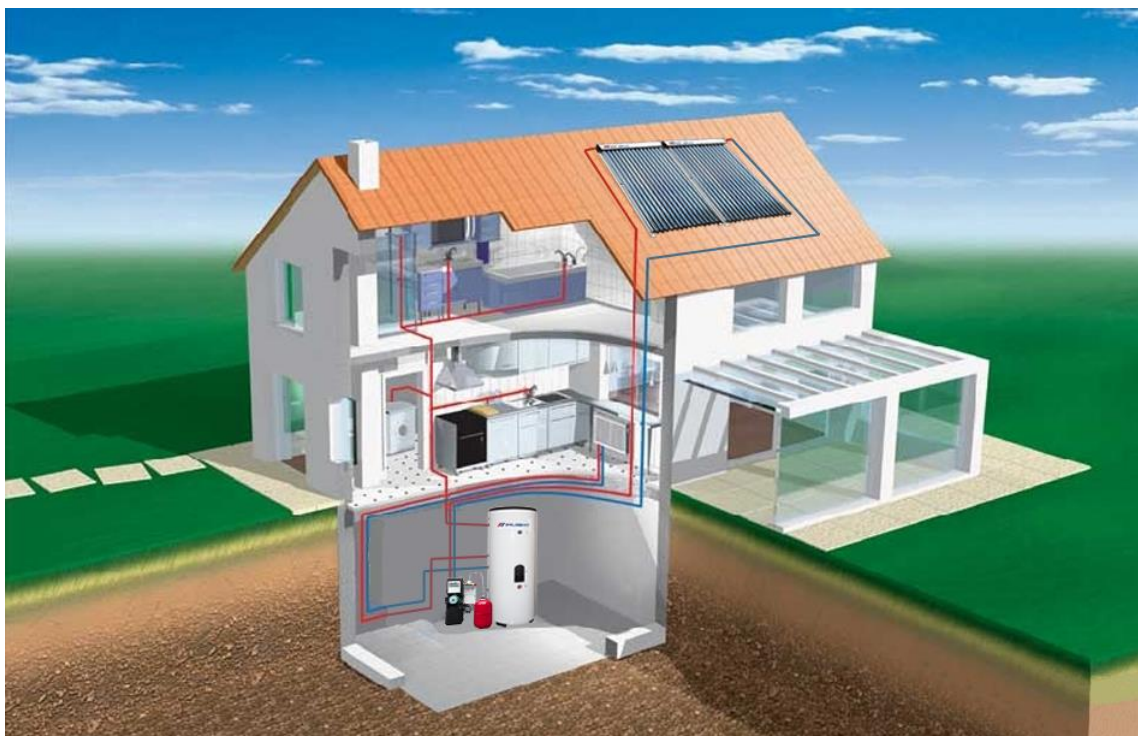
In case of independent, off-grid systems, the price is somewhat higher in accordance with the number and type of batteries that will be used, thus the price of a closed system in Serbia is around 1300 EUR/kW and in Bulgaria it is slightly lower, around 1200 EUR /kW. The price of

a system that can work on the grid but also independently is higher for the cost of the battery charging controller and for the batteries themselves, and for small systems the increase in investment is around 30-50% compared to the price of an open system. However, the autonomy of the hybrid system is extremely high and the longer investment return period is justified in this regards.

Of course, to have the proper design and installation of the system, the best is to hire a licensed company that can do it all for you.

It is rather difficult to provide accurate data on the speed of return on investment, since the price of electricity changes relatively quickly and has a growing trend. At the time of writing this guide, in September 2022, the price of electricity for households in Serbia is 0.08 EUR/kWh, although the real price including tax and additional fees is higher and amounts to 0.1 EUR/kWh. In Bulgaria, the basic price for a household is 0.12 EUR/kWh, but when taxes and contributions are added, the final amount is around 0.15 EUR/kWh. These are only illustrative data and are not relevant for the calculation of return on investment in the long run, but they give a certain ratio of prices and costs that can help evaluate the justification of the investment and the terms can only be shorter because the price of electricity will increase. Also, we will assume the most unfavourable way of financing - from our own funds and without subsidies and benefits. In practice, you can find ways for a more convenient investment, from loans with partial recovery of loans, to state subsidies. However, it really depends from case to case and from country to country, but trends are that ROI could be sliced down from those in the table hereof to up to 5 years or even less, which is very fast.

Solar water heaters



To make the calculation of the investment and profitability of solar water heaters, we need to know needs and capacity. Installing solar water heating systems do not make sense if the water is not consumed because, although there are no additional costs during operation in the case of gravity run systems, or the costs are very small when we have solar heating with forced circulation, they do not save energy if not in operation, i.e. the investment does not performs its function.

For this case study, we shall analyse the investment for an average household with a 150-liter boiler, which is enough for a three-person or even four-person household. The water in the boiler is heated to a temperature of 60oC and there is enough of it for all sanitary needs. The savings of using this system corresponds to the consumption of electricity for the same amount of delivered heat and annual savings are around 2000 kWh of electricity. The investment in such a system is estimated at 10 EUR/litre of water heater capacity, including installation and pipe insulation.

The thermal solar system that in this case contains:

- Solar evacuated tubes' collector
- Solar boiler INOX 150 litres with heat exchanger and electric heater
- Venting pot
- Controller with 5 sensors
- Pumps (two-line)
- Expansion vessel 25L

The system can also be used as a part of a facility for heating and cooling rooms with the help of heat pumps and thus maximally achieve energy self-sufficiency in the, so-called. "smart houses".

11. CALCULATION OF INVESTMENTS AND RETURN OF INVESTED CAPITAL

Solar photoelectric (PV) power plant and solar heating system

This calculation for solar panels is made for the case when using monocrystalline panels that are oriented so that they are fully exposed to the sun. If polycrystalline panels are used, solar power plants are cheaper by up to 30%, but the required area is also larger in that case. Since we have shown the return on investment with prices from September 2022 and for the case of the most unfavourable way of investment, other, more convenient options should be considered. In practice, the investment return time is usually still around 5-7 years, assuming that energy price will not increase in the meantime. However, the trends are at that the price shall go up in which case the ROI time is going to be shortened.

Solar panels

Type	Monthly consumption (kWh)	Annual consumption (kWh)	Installed power of the solar system (kWp)	Costs of equipment and installation labor (EUR)	Panel surface area (m ²)	ROI Serbia (year)	ROI Bulgaria (year)
On-grid	500	6000	4,5	5.400	22,5	9	6
Off-grid	332,7	4000	3	3.900	15	9,75	6,5
Combined	850	10.200	7,5	13.500	37,5	13.2	8,8

Solar heating

Evacuated pipes with forced circulation	200	2400	Boiler of 150 l.	1.500	5	6,25	4,2
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The calculation for a solar system for the use of hot water indicates a relatively short time for capital recovery and, accordingly, good profitability.

Note: the prices of electricity from September 2022 have been adopted at 0.1 EUR/kWh in Serbia and 0.15 EUR/kWh in Bulgaria

12. HOW TO GET BUYER/PRODUCER STATUS

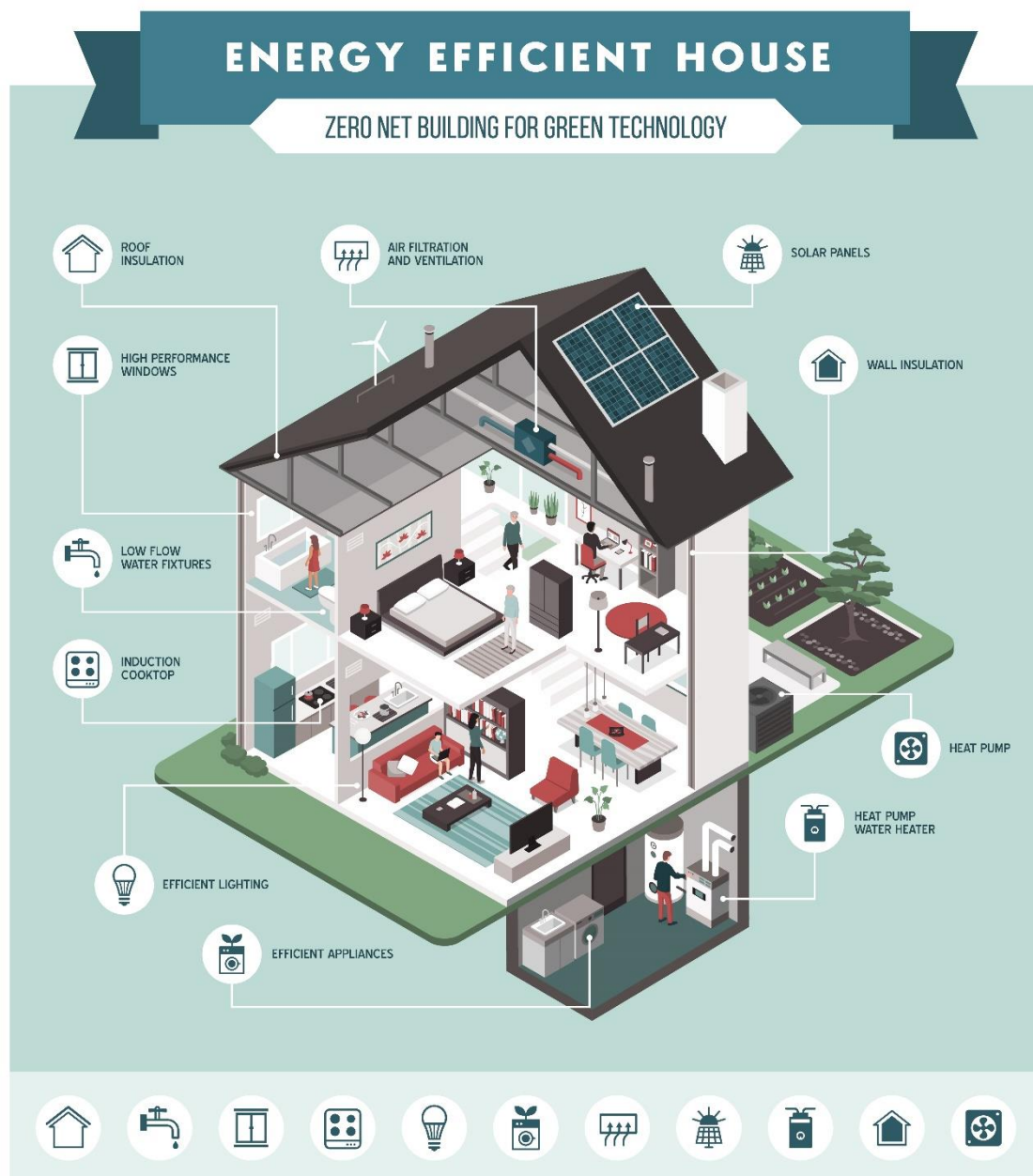
The procedure for obtaining the status of buyer/producer (prosumer) differs in Serbia and in Bulgaria, as well as the benefits that can be gained from this status. The regulations on the maximum size of the solar power plant for individual use also differ. In Serbia, the size of the individual power plant is limited by the so-called engaged force. It is a calculation parameter that corresponds to the consumption, but it cannot be higher than 10kW, so even power plants for own use, which are connected to the grid and hand over surpluses to the operator of the distribution system, cannot be higher than that. In Bulgaria, the procedure for obtaining the status of prosumer is much more complicated and takes time, however there is no limit for solar panels on roofs.

The prosumer status provides the possibility to hand over all the unused energy produced by individual solar power plant to the grid as your energy loan, which you can withdraw when needed, but only during the billing period. However, as a prosumer, one cannot store more than consumes. Produced and consumed energy are compared at the end of billing period by "net metering" and if the excess energy greater than consumed one, the difference is lost and cannot be retrieved, neither sold to someone else. Once a year, the calculation is made and

might be, at the best „0“ meaning that you produced and used all of the energy you need from RES and nothing from the grid which was used only for virtual storage to balance your consumption. If energy from sun was lesser than needs, then the consumer pays the difference for the purchased energy from the grid. For this reason, it is very important to design properly the solar system so that the investment is not disproportionately large, and the energy produced is not wasted.

13. SMART HOUSES

During the last two decades, the concept of the so-called "smart house" has evolved, a place to live and work that has an optimal consumption of resources, energy and water.



Smart houses, apart from using all the available renewable and clean energy sources (sun, geothermal, wind) and the most efficient technological solutions (heat pumps, low energy lighting, efficient home appliances) have very good thermal insulation and all the features of a passive house, as well which is extremely energy efficient. In addition, smart homes are homes that use water sparingly, collect rainwater for technical use and, for maximum optimization, use modern digital technologies to manage all the systems operation. Such facilities might be very close to model of completely self-sufficient and independent buildings in terms of energy as well as with a high degree of independence when it comes to water, whereby their ecological footprint, i.e. the impact on the environment and climate change through CO² emissions, is almost none or rather negligible.

14. HOW TO CONSTRUCT THE COMMERCIAL POWER PLANT

The process of building a commercial solar power plant is much more complex and takes several months. We shall not deal in this Guide with the detailed elaboration of the procedure and what and how is necessary to prepare and do, but one should know that the calculation of costs and income is similar to that for small systems, having in mind that the costs per installed Kw are dropping with the size of the installation. The capacity of commercial solar power plant is limited only by the available area and grid infrastructure. The largest photoelectric solar power plant is located in India and has an installed capacity of 2,245 GW while spreading over an area of 5,400 h.

In addition to PV, there are also big solar power plants that work like a huge concave mirror, concentrating the sun's rays into the focus where is a boiler in which superheated steam is generated and then used to run the turbine and electric generator. The largest power plant of this kind is located in Morocco and has an installed capacity of 500MW.



15. GOOD PRACTICE EXAMPLES

1. Project Exploitation of Different Energy sources for Green Energy production - X-DEGREE

Renewable energy plants will be erected on both sides of the border between Serbia and Croatia, thanks to cross-border cooperation between the two countries and supported by the EU. Several smaller solar power plants will be built in Vinkovci and a cogeneration plant in Sombor.

The agreement on partnership in construction of power plants and cogeneration plants (CHP) within the Exploitation of Different Energy sources for Green Energy production – X-DEGREE project was first signed in Novi Sad and then in Vinkovci. The project of around 1.6 million euros, is financed from the Interreg IPA fund, as part of the cross-border cooperation program between Croatia and Serbia in the area of renewable energy sources.

The project leader is the University of Novi Sad, in partnership with the utility company Vodokanal Sombor and the Fund for European Affairs of Vojvodina, the company Vinkovački vodovod i kanalizacija and the Osijek Agricultural Institute.

Six solar power plants, with a total installed power of 380 kilowatts, valued at cca 545,000 Euros will be installed on the Lipovac (50 kW), Vinkovce (140 kW) and Retkovce (40 kW) reservoirs, and the other three with a total power of 50 kilowatts will be at the wastewater treatment plants in Ivankovo, Cerna and Otok.

2. Solar cells on roads - a new direction of energy transition

Germany, Belgium and the Netherlands have more than 800,000 kilometres of roads, which they could use for their energy needs.

On a 400-meter-long stretch of highway in the Netherlands, sound barriers not only reduce noise, but also generate green energy for 60 local households, as they are equipped with solar panels.

This renewable energy pilot project served as the inspiration to create Rolling Solar, a European project that aims at generating more energy from roads in a cost-effective and efficient way of using solar panels.

One of the goals of the project is to develop sustainable cross-border cooperation and enable skill and experience share in R&D and industries that contribute to the efficiency and better characteristics of technologies for the utilization of solar energy.

3. Rescue cross-border project dedicated to the use of renewable energy sources.

The main goal of this project is to promote the extensive use of renewable energy sources as well as the improvement of energy efficiency measures in public buildings. The partners in the project are the Faculty of Technical Sciences from Novi Sad, the Clinical Centre of Vojvodina, the Faculty of Electrical Engineering, Computing and Information Technologies from Osijek, the Clinical Hospital Centre of Osijek and the Faculty of Mechanical Engineering from Slavonski Brod.

During the implementation of the project, photovoltaic power plants, a wind generator system, solar collectors, a charging station for electric vehicles, as well as electricity storage systems were built (or will be built). The project also supported by the Province of Vojvodina.

The project participants claimed that "In this way, we achieve great effects, we primarily erase the negative effects of the border, we exchange experiences and knowledge, we network with partners, institutions, and in addition, this issue is one of the priorities outlined by the European Union".

The total value of the RESCUE project is close to two million Euros, of which 85 percent is a grant from the European Union.

4. Solar off-grid system of 2040 W, Obrenovac, Serbia

The solar system was installed in June 2020 to power lighting, TV, refrigerator, water pump, small household appliances, occasionally washing machines and electric cooker (in the period of sunshine, due to its high consumption). The building is prefabricated one and has a total area of 23.5 m². The property is used as a holiday home and has its own water well.



The system can provide up to 4 days of autonomy for the above-mentioned consumers, even if there is no sun in the meantime, in regards with the capacity of the batteries in the system.

The system is composed from:

- 6-piece high-efficiency monocrystalline panel 340Wp
- 6-cell gel battery 120Ah/12V, 1500 cycles at 50% discharge
- 2 pcs-mppt150/35 (battery charging controller)
- 1 pc-invertor 24/375VA
- 1 aluminium panel support for inclined roofs,
- 1 set of cables with a span of 10m.

The single-phase solar system supply consumers on 220V AC. The maximum load power is 3000W. Energy available from batteries is 5224 Wh.

Expected average production from solar panels during the day:

Summer: 8400 Wh, Winter: 5160 Wh

The average daily production over the year is 7,344 Wh

Total cost: 2,850 EUR

5. Solar on-grid system, 5 kWp - Jakovo, Serbia

This is an example of a household with an average monthly consumption of 500 kWh. The annual expected production of the solar system is about 6000 kWh due to the slightly worse orientation of the roof east - west. The system can completely cover need for electricity with the gained status of a prosumer. The system was installed in 2022.

System components:

- Solar panel 340Wp - 15 pcs
- Solar three-phase inverter 5kW
- System for monitoring energy production and transmission
- Electrical protective equipment such as switches, fuses and circuit breakers
- Aluminium supports for solar panels
- Set of solar cables, connectors with the span of 15m



The total cost of the system is EUR 6,120

6. Hybrid solar system 5kW – Loznica, Serbia

The system was put into operation at the end of 2021. Thanks to the quality solar panels, high energy efficiency has been achieved. During the day, the consumers are supplied directly from the solar panels, bypassing the battery, which protects the long life solar GEL battery of 1500 charge/discharge cycles at DOD 50% and 3000 charge/discharge cycles at DOD 20%. The system can work in ON, OFF grid and in BackUp mode. Thanks to LCD monitoring the operation and respective data, this system is highly user friendly. If necessary, it is also possible to install software to prevent excessive discharge battery, short circuit damages on the consumer side and on the PV panel side, from reverse current during the night, from



increased temperature and overloads.

System components:

- Solar Monocrystalline Panel 340W- 15 pcs, total installed power is 5,100 Wp
- Annual production is 6700 kWh
- Solar GEL Battery - 1500 Cycles - (220Ah/12V-C20) - 4 pcs
- Hybrid Inverter - 1 pc

The cost of the system is EUR 9,870

16. INSTEAD OF CONCLUSION

Energy is crucial both for global development and for personal needs. Enabling stable and sustainable supply is of paramount importance.

The use of renewable energy sources provides an exceptional opportunity for energy security of the countries and its citizens, with relatively small investments.

The 10 most important advantages of RES are:

- 1) It is available everywhere
- 2) It is easy to use and suitable for both small and large consumers
- 3) Stimulates the local economy
- 4) Reduces dependence on energy imports and geopolitical influences
- 5) Low exploitation costs
- 6) Installations can be easily expanded.
- 7) Do not pollute the environment.
- 8) They are safe
- 9) Investment costs are dropping
- 10) They increase the living standard.

The 5 most important challenges in using RES are:

- 1) It is not there all the time
- 2) Relatively high initial investments
- 3) Lack of infrastructure
- 4) Insufficient knowledge, skills and practice
- 5) How to save the energy

This Guide aims at explaining the nature and usability of solar energy, to suggest practical solutions along with any challenges that may arise along the way.

For all types of solar power plants (open, closed or hybrid system) and facilities for the use of hot water, the investment pays off, some faster and some slower (within a period of 5 to 10 years), but the investment is definitely returned because life span of the solar power plants is 25 years and of solar thermal collectors, 30 years. After the investment payback time, the energy is practically harvested free of with relatively low running and maintenance costs, either for electricity, heat or both types of energy.

Investing in solar systems for individual energy use is definitely worth it for several reasons:

- Installing solar systems is relatively simple and can be done in a very short time.
- The level of one's own energy security increases and the dependence on external sources of energy decreases, thus also on disturbances in the energy market is reduced.
- Energy costs are less because after the investment payback time, energy is harvested only with the operating costs of the system, which are significantly lower than the final energy price.

Challenges

The price of the system itself is not negligible for the average household budget.

If a version with partial self-storage is selected, optimal consumption is achieved, but with a higher investment.

If the financing is obtained without loans and without incentives, then the solar power plant is a financial endeavour, although it will pay back off over time.

17. ABOUT THE PROJECT

Project name	Renewable energy for smart growth and protected environment
Leading partner	Vidin Chamber of Commerce, Bulgaria
Partner	RARIS, Regional Agency for the Development of Eastern Serbia, Serbia
Priority axis	Environment
Project objectives	The main objective of the project is to increase capacity and improve awareness of environmental issues such as renewable energy sources and energy efficiency among the target groups: SMEs, local authorities, environmental organizations and institutions, the general public



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