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Energy of the Sun

The growing environmental pollution, intensive climate changes, rise of the fossil fuels prices and predictions about their disappearance in the near future are affecting inhabitants of the Earth to turn towards the rational use of energy through the implementation of energy efficiency and renewable energy sources. The largest source of the renewable energy is the Sun. This fireball consists mostly of hydrogen and helium. Every second in the center of it, 600 millions tones of hydrogen transforms into helium in process of fusion, which caused the emission of large amounts of energy. In this way it generates more energy than mankind produces in one year. Due to the mentioned reaction, temperature in the interior of the Sun is more than 15 million °C. The energy obtained by the process of fusion is expanding through universe in the form o f light and heat so that only a small part of it comes to the Earth, where it converts to another forms of energy.

Because of the practically inexhaustible quantities of solar radiation energy, which represents the main source of life on Earth and great number of advantages over the other usable sources, today, with extreme care, are conducting researches for development of efficient technologies for usage of solar radiation in order to meet humans, every day more expressed, energy needs. In particular, great efforts are invested in many solar energy technologies, those already developed and those in laboratories, for their commercialization and compatibility with existing energy sources, in order to cover most of earth energy needs with solar energy, directly or transformed, by replacing unavailable and environmentally undesirable fossil fuels, or by replacing electricity and enabling its rational use.

Direct conversion of solar energy into other forms, particularly into electricity, is being performed relatively simple and easy, much easier than conversion of any other form of energy. Today solar energy is used by solar collectors for water and space heating, for producing electricity by photovoltaic cells or passively within the construction of architectural measures aimed at space heating and lighting.

Characteristics of solar energy in Montenegro

The insulation of each place on Earth is mostly affected by the latitude and local climate conditions. Our country has good conditions for using of solar systems due to the fact that on annual level, there are more than 2,000 sunshine hours per year for the most of Montenegrin territory and more than 2,500 hours per year along the coast. The amount of solar radiation in Montenegro, especially in the coastal and central zones can be compared with the amount of solar radiation in Greece or Southern Italy. Furthermore, Podgorica has a higher annual amount of solar energy (1602 kWh/m ²) compared to the other cities in S

outh East Europe (such as Rome or Athens). In coastal areas, the number of sunshine hours exceeds the amount of 2,500 sunshine hours per year, with the most intense solar radiation during the summer, late spring and early fall. Great number of sunshine hours is characteristic for lowland areas. There are major differences between the coastal areas and mountain and central regions where solar insulation may be insufficient.

Heat generation

Solar energy can be effectively used to produce the necessary heat for space and water heating. Even 75-80% of total consumed energy is allocated for heating of space and water.

Thermal energy can be produced by solar collectors and heating pumps. Solar systems can fully provide hot water needs for entire year and heating in significant amount. In the case of low energy facility or passive solar home, which is thermally well isolated, with installed floor or wall heating (required water temperature up to 35 °C), solar collectors can provide necessary heat for space and water heating.

Solar collectors use solar energy whereas heat pumps use energy from the earth, water and air.

Solar collectors

Solar collectors convert energy of sun into thermal energy of water or some other liquid. Water heating systems can be open, where heated water is running directly through the collector on the roof, or closed, where collectors are filled with non-freezing fluid like antifreeze. Closed systems can be used even when the outdoor temperature is below 0 °C. During the day, if the weather is nice, water can be heated just in c ollectors. If the weather is cloudy, collectors are helping to heat the water and thereby reduce power consumption.

There are collectors which directly heat the air. These collectors are performing air circulation and thus a large portion of energy is transferred to the air. The air later on, returns into the room that is heated and therefore maintains the temperature.

With combination of air and water heating, large energy savings are being achieved.

Solar collectors are very simple devices, with isolated box whose one side is transparent. Below this transparent side, there is network of pipes through which water passes. Pipes are consisted of connected sheet-metals, so-called wings, which are creating the interior of collector. The wings are made of aluminum (which is cheaper but less efficient) and copper (more expensive but more efficient). In both cases the wings were painted in black, which provides the "absorption" of solar radiation that passes through the transparent side of panel and hits the black metal surface of the wing converting itself into heating energy. Created heating energy is transferring from the metal wings to the tube which leads to heating of the water passing through pipes.

The heated water goes into the tank where it is being accumulated. It is important that the accumulation tank is well isolated because it helps reducing energy losses. What will be the temperature in the collector depends on several factors, including the seasons and weather conditions in a certain area.

People are often wondering whether we have enough â€œsunâ€• during the year so that the investment in the solar system would be economically payable. In fact, two thirds of the total solar radiation occurs between May and August, when solar systems meet 100% of total demand for water heating. But even in the months like April and September, results of the solar collectors are not negligible because these months can meet 80% of demand for sanitary water, and in months like March and October it is possible to meet the needs for more than 50% of the hot water. The difference which is necessary to compensate for additional water heating during the winter months can easily be compensated from conventional heating systems.

The collectors are usually being installed on the house roofs, terraces or gardens, and are directed towards the south side with the deviation of ±30 °. Hot water tank should not be too far from the collector in order to re duce as much as possible of heat losses in the connecting pipeline.

There are many ways to collect solar energy. Depending on the needs and use, solar collectors can be flat plate and evacuated tube solar collectors.

Flat plate collectors are suitable in moderate climate areas and areas where heating is required during the winter months. They are mostly used for water heating in households and space heating and are characterized as energy efficient and low cost. Highly selective Sol-Titanium coating makes a collector very efficient. It is entirely made of corrosion resistant materials such as stainless steel, aluminum, copper and special solar glass 4mm thick. It is resistant to all weather conditions.

Advantages of flat plate collectors

â€¢ High level of performance achieved by highly selective absorber coating

â€¢ High efficiency achieved by an integrated pipes and thermal isolation

â€¢ Short installation time achieved by connecting of flexible tube with system on which can be stringed up to 10 collectors

â€¢ Collector type 5DI integrates into the roof and replaces the roof surface

Evacuated tube collectors are the most effective and the most expensive type of solar collectors. Price of these collectors is twice higher than flat plate collectors. They are suitable in the moderate climate conditions. They are being used for commercial and industrial heating and cooling. They also can be used for space heating in households in areas with large cloudiness. In the special absorber medium is circulating, which is carrier of heat that evaporates because of the sunlight and delivers heat to solar medium through the heat exchanger, which ensures its effectiveness at low temperatures.

Advantages of evacuated tube collectors

â€¢ Extremely high level of activity achieved by Sol-Titanium layer and thermal losses reduced with vacuum tub es

â€¢ Full utilization of heat achieved by special heat exchanger with double tubes that surrounds condenser thr ough the entire surface

â€¢ Universally applicable for installation on flat and pitched roofs, facades and free standing objects. In add ition, tubes can be rotated for optimum alignment with the sun

â€¢ Made from high quality materials that are resistant to corrosion, such as borosilicate glass, copper and sta inless steel

â€¢ Integrated temperature limited to protect from overheating

Both types of collectors, flat plate and evacuated tube can be installed on flat and pitched roofs.

How does the solar systems for heating and additional heating work?

The solar system consists of solar collectors on the roof, water tank and regulator. In this closed system, pump is being used to circulate the fluid, which does not freeze in the winter, and transfer the energy to reservoir and through the tank exchanger delivers water in the tank. When installing a solar system it is important to take into account the real needs for energy, surface of the collectors, how much energy collectors can produce; system and the size of the reservoir, quality control and connection with the heating system.

Heat pumps

Heat pumps are reliable, economical and safe heating system that is environment friendly. They are especially efficient energy solution that meets the needs of central and water heating. Heat pumps are suitable for heat supply for all types of buildings, residential houses, hotels, hospitals, schools, offices and industrial buildings, in new constructions as well as in modernization of existing buildings. Energy efficient houses are practically unimaginable without heating pumps. Heat pumps can be used for winter heating and summer cooling.

Heat pump works on thermal energy collected from the environment (earth, water, air) rising it up on a desired level and using it for heating.

Heat pump cycle

During the usage of heat from the environment, liquid medium on low pressure is on the primary (cold) side of the evaporator. Level of outdoor temperature is higher than the temperature of fluid vaporization, which depends on the pressure, so that the working medium is evaporates using the heat from the environment. For this purpose, the temperature level of evaporation can be below 0 °C. The compressor v acuums working medium steam and compresses it, with increased pressure and temperature of the steam. From the compressor, working medium in the form of steam goes into the condenser which is connected to the heating system.

The water temperature for heating is lower than the condensation temperature of working medium. The steam is getting cooled and then passes into the liquid phase. The heat received by the evaporator, together with the additional heat generated during the compression process submits to the heating water and then working fluid returns through the expansion valve in the evaporator. Pressure of the working medium is getting down from high in condenser to low in the evaporator, where it cools. In this way heating pump cycle ends.

The heat pump takes the ¾ of the necessary heat from the surroundings for heating and ¼ in the form of the el ectricity that serves to start the compressor. Electricity is ultimately transformed into thermal energy and used for heating. The equation of submitted thermal energy for heating (including heat liberated due the work of compressor) and consumed energy results in coefficient of heat (3+1)/1=4.

Electricity for the heating pump can be obtained from the casual sources and from the solar system.

Heating pumps in addition to solar technology are the only heating systems that are producing heat without CO2 emissions.

For usage of available thermal energy in environment, there are earth thermal sources, underground and surface water, air or heat from emissions. In each case, the most suitable heat source depends on local conditions, building position and actual need for heating.

The earth is good heating accumulator, because temperature in it during the year is generally balanced from 7 â€“ 13 °C (2m depth). With horizontally installed collectors in the ground or vertical probes, accumulated heat , through mixture of water and antifreeze, is transferred to the evaporator.

Getting the heat out of the ground using horizontal collectors and probes

Water is also a good heat accumulator. Even in the cold winter underground water maintains constant temperature of 7-12 °C. Underground water is being taken from pumping wells and getting transferred to the e vaporator of the heat pump. At the end the cooled water drains back into the well. The quality of groundwater or surface water must comply with limit values prescribed by the manufacturer of heat pumps. If the limit values are exceeded, the appropriate heat exchanger must be applied, which is recommended because of possible changes in water quality.

The outdoor air as heating source is the most cost-effective solution. After the intake pipe, the air cools in the heat pump evaporator and then discharges into the environment. The heat air-water pump gives off the heat up to the outdoor air temperature of -20 °C. Since the heat air-water pumps are starting relatively large a ir flows (3000-4000m ³/h), when deploying of air valve in the building and while installing it outside, s hould be considered possible noise spreading.

In the ecological sense, today's heat pumps are the most cost effective way of heat. Using integrated management systems, efficient compressors and serial production, from one part of electricity heat pumps are producing up to five parts of the thermal energy. These heating pumps can supply the building completely with heating energy and hot water without additional heating source. Therefore, costs are much lower than costs for conventional heating installations.

The basic principle which applies to all heat pumps: the smaller temperature difference between water for heating and ambient temperature, the better efficiency. Therefore, heat pumps are particularly suitable for low temperature heating systems such as under floor heating, where the maximum required temperature is up to 38 °C.

Heat pumps, depending on the heat source and the initial temperature of heating water, achieves heating ratio from 3.5 to 5.5. This means that per kWh of engaged energy it can be produced 3.5 to 5.5 kWh of thermal energy for heating. In comparison with this, the efficiency coefficient of power plants is approximately 35%. How cost-effective are heat pumps, are showing their comparison with other energy sources. For example, if we start from the average value of electricity of 0.12 â‚¬ per kW/h, it follows that at the average coefficient of heat (annual coefficient of 4) operating costs of the heat pump are 0.03 â‚¬ per kW/h, whi le for the same purpose, for light distilled oil should be allocated 0.06 â‚¬ per kW/h or for natural gas 0.056 â‚¬ per kW /h.

Photovoltaic panels â€“ electricity production

Solar energy using photovoltaic panels is being converted into electrical energy. Photovoltaic panels are composed of modules, while modules consist of solar cells. Solar cells are made of mono-crystalline and poly-crystalline silicon, which provides electricity production. The compiled photovoltaic panel has a high efficiency, stability and durability. The range of the photovoltaic panels power 10-230W (Watts) meets the widest range and is being used for different needs.

Typical mono-crystalline Si (silicon) photocell produces a voltage of approximately 0.5V (volts) and electricity less than 3A (amp), so it is needed to connect several of these cells in order to obtain a voltage of 12V which is the normal voltage of most rechargeable batteries with the help of photovoltaic cells. Connected photovoltaic cells form modules that have a maximum power of 73 W (on the insulation of 1000 W/m ² and surface of about 0.5m ²). Therefore, the efficiency of these mono-crystalline photovoltaic cells is about 14.5%. It should be emphasized that the strength, but also the efficiency falls with increasing of temperature so that the previous values in real conditions of exploitation may be even lower.

Besides mono-crystalline Si cells there are less expensive poly-crystalline cells whose crystal structure is

less regular and the efficiency is 10%, as well as cells from amorphous Si, which are the cheapest but their efficiency is only 4%.

Solar batteries

Electricity produced by the photovoltaic cells is being stored in batteries that are similar to car batteries. Battery characteristics provide long lifetime of the system and are adjusted to constant charging and discharging. GEL batteries have great capacity for high temperatures and are highly resistant to vibration.

Charging/discharging is regulated with special controller. Usually, power converter from direct to alternate current is also being incorporated. Conversion of chemical energy back to electricity (20% of losses) and other losses in the inverters and the converters are additionally reducing the efficiency of conversion of solar into electrical energy. Because of its low efficiency and still high price (8-10 EUR/W) photovoltaic cells are being installed only when low power is needed or when there is no connection to the electricity network, whatsoever (mountain lodges, remote transmitters, street lighting, batteries for small boats, etc.).

Features of charge controller batteries:

â€¢ Regulation of the battery state of availability

â€¢ Incorporated Ah counter

â€¢ "Boost" and "float" charging regimes

â€¢ Automatic reconnection of charging

â€¢ Manual charge switcher

â€¢ Automatic section of voltage (12V/24V)

â€¢ Lighting control at night

Enable electronic protection against:

â€¢ To high and to low voltage and battery depth of discharge (HVD/LVD/DOD)

â€¢ Reverse polarity of solar modules, load and battery

â€¢ Solar modules short-circuit or load and open connections on the battery

â€¢ Over heating

â€¢ Protection from lighting strikes

â€¢ Low level of interference from other electro-magnetic devices (EMC)

Features of the inventor (AC/DC):

â€¢ Optional/Adjustable battery charger

â€¢ Good/Excellent overloading possibilities

â€¢ Automatic loading detection

â€¢ Can be used as a UPS â€“ highest reliability

â€¢ Multifunctional switch

Inverter provides electronic protection against:

â€¢ Over-voltage and depth of battery discharging

â€¢ Reverse polarity by internal fuse

â€¢ Overheating and overloading

â€¢ Short-circuit

Possibilities for installation of solar systems

Solar photovoltaic systems are applied to isolated objects, and for connecting to the distribution network for delivery of surplus energy.

This system can be used so that the accretion of energy produced during the day will deliver to the distribution network when the need for energy is greatest and when it is most expensive, and drowning from the network during the night when there is enough energy on the network and when it is cheapest,

which further make less expensive.

Due its longevity, low usage and maintenance costs, easy installation, flexibility to surroundings, flexible configuration, and capacity for long unattended operation, the solar systems are being used in a number of activities.

The most common area of solar systems installment:

â€¢ Lighting - traffic signs, signboards, public (street) lighting, security lighting, tunnels, parks and trails

â€¢ Distant areas - villages, cottages, tourist destinations, research centers

â€¢ Tourism - protruding objects, beach furniture, camping, boats, yachts, marines

â€¢ Housing - all consumers individually, integration with public networks, hybrid systems for heating and hot water

â€¢ Irrigation - water pumps, water supply, individual households

â€¢ Measurements - pipelines, power sensors, waters, weather stations, telemetry, battery charger for vehicle

â€¢ Telecommunications - repeaters, base stations, radio, telephone

â€¢ Signalling - masts, navigation, railway signalling systems

â€¢ Cathode protection - pipelines, reservoirs, bridges, piers

The advantages for using of solar photovoltaic systems:

â€¢ High reliability

â€¢ Longevity

â€¢ Low operating costs and cost-effective source of energy

â€¢ Minimal maintenance without using other energy sources

â€¢ Best urban renewable energy source

â€¢ Simple mechanics, there are no moving parts required for operation of the system

â€¢ Applicability of the system practically anywhere on Earth

â€¢ Noiseless and environmentally clean source of energy

â€¢ Provides opportunities of production and usage of electricity in places where it would be too expensive or imp ossible

â€¢ Architectural integration into any object

â€¢ Elements of the system are construction elements

Solar power plants

Solar power plants conduct focusing of solar energy, where the roles of drives have taken large generators or thermal plants. Focusing is being achieved by the mirrors arranged in a plate ("Dish") or those who have the configuration of the tower ("Power tower").

Power tower configurations are using computer controlled mirrors to focus the field of solar radiation on the central tower, which runs the main generator. These systems have possibilities to work at night and in bad weather conditions.

"Dish" systems track the movement of the sun and thereby focus solar radiation.

Due to the need of large space in which they would be placed, power plants are being built in deserts where the power of solar radiation is at its highest. One of the problems, when it comes to building of solar power plants, is the high price of the mirrors and the focusing system.

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