EFFICIENCY ANALYSIS IN SOLAR PANEL ENERGY SYSTEMS: AC-DC CONVERSION COST AND DC-DC ENERGY USE

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Abstract

The use of renewable energy sources is increasing day by day. In parallel, the products used in this area are also increasing. Generating electricity with solar panels and using this energy has been preferred in places where grid energy is not available. The energy generated in the panels is direct current. However, many of the tools I use in daily life are designed to work with alternating current. Converting alternating current to direct current or direct current to alternating current causes various losses. In this study, the losses that will occur by converting the energy generated by the solar panel into alternating current will be examined. In addition, a system will be designed to use the generated DC energy as DC. Thus, the information will be given about minimizing losses for AC-DC conversion and using solar panels more efficiently.

Keywords: Solar Energy, AC-DC Conversion, DC-DC System Design.

INTRODUCTION

Electricity production with renewable energy sources is around 9% in the world. This ratio is planned to increase day by day [1, 2]. Generating electricity with solar panels has increased in recent years with the production of efficient panels and the development of devices used in conversion. Solar energy, which is used to meet daily energy needs, is sometimes used compulsively. Solar power plants are preferred in areas where there is no network and where it is difficult (costly) to bring. The power of the tools working with electricity is made with the energy to be obtained from the solar panels to be installed. However, the production of solar energy in panels is only in the sunlight. However, energy is needed throughout the day. In the absence of daylight, the energy requirement is provided by the energy stored in the batteries. In this study, the equipment that will be required in a solar system to be created independently from the grid will be discussed.

After examining solar panels and DC-AC converters, they will be evaluated on a sample system.

SOLAR PANEL

Solar panels have been used to generate DC electricity for many years. With the increase in efficiency and developments in electronics, high power panels have been started to be produced in recent years. The system output producing DC energy can be used with appropriate conversion. For this, solar panels are connected in series or in parallel and the appropriate configuration is made[3].

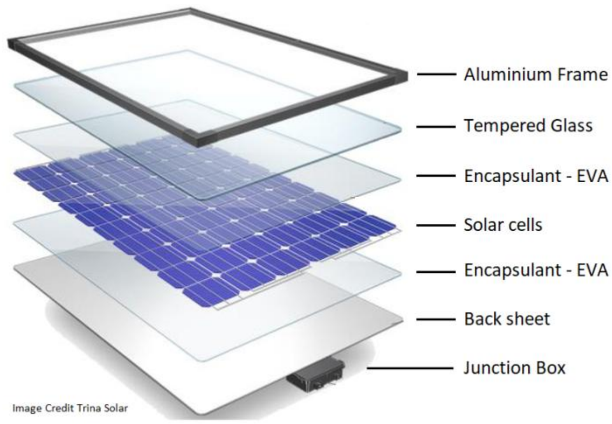

Fig. 1. *Solar Panel*

Solar panels are divided into two as monocrystalline and polycrystalline according to their structure. These panels vary according to the number of cells. Cell number is one of the main parameters determining power in panels. The cells are connected in parallel to each other in series to create the main solar panel. Solar panels are placed in a case suitable for outdoor conditions and made ready for sale. Since it will operate as dc, the current has one direction. The positive pole and the missing pole have different terminals to reduce the error in the connection. The number of panels for the required power is calculated and supplied. The panels provided are used in series or parallel depending on the converter or controller to be used in the conversion. A Sample solar panel is shown in Figure 1 [4, 5].

INVERTERS – RECTIFIERS

The energy produced in solar panels is direct current. Alternating current is preferred because it is easy to transport and transform. For this reason, many devices are designed to work with alternating current. The direct current generated in solar panels is converted to alternating current. This conversion is done with converters. Many inverters with different features and power have been produced[6]. It is also available in special purpose inverters for solar panels. These inverters convert the solar panel voltage to a constant 220V 50Hz (for EU) and can also be charged if batteries are present in the system. In high power systems, there are inverters with three phase outputs. At night or when the sun is insufficient, the energy stored in the batteries is used [7].

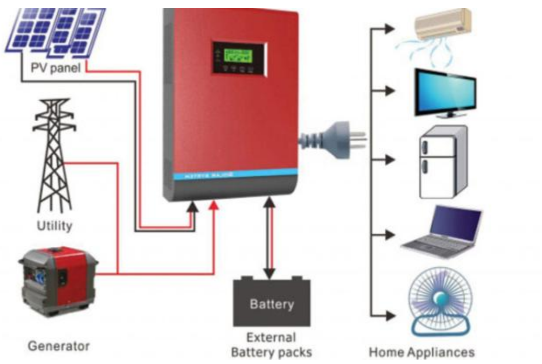

Fig. 2. *Solar Invertor connected to solar system*

Most electronic devices are manufactured to work with alternating current. However, direct current is used in electronic cards. A rectifier in the devices with alternating current provides AC-DC conversion. AC-DC conversion or DC-AC conversion works with 80-95% efficiency [8]. Reducing the amount of conversions can reduce losses. An example driver is shown in Figure 2. The driver gives the energy it receives from both the grid, solar panels, and batteries as alternating current. When it does not work from batteries, it charges the batteries with the energy it obtains from other sources. Solar panel inverters specially have maximum power point tracking [9]. In this way, the energy produced in solar panels is used more efficiently. The power obtained in the panels will be kept at the highest level by providing current voltage balance.

Inverters are used to convert direct current to alternating current, but in some cases direct current can be used without conversion. However, it is necessary to control the Direct current for this. In some cases, the voltage should be decreased and sometimes the current should be controlled. Batteries can be charged directly with the DC current generated from the panels. However, for the efficiency of the batteries, the battery charge current and battery charge voltage must be controlled. There are electronic circuits that do this process. Figure 3 shows charge control connected to solar system. Since there is no DC-AC conversion, the system is more efficient[10].

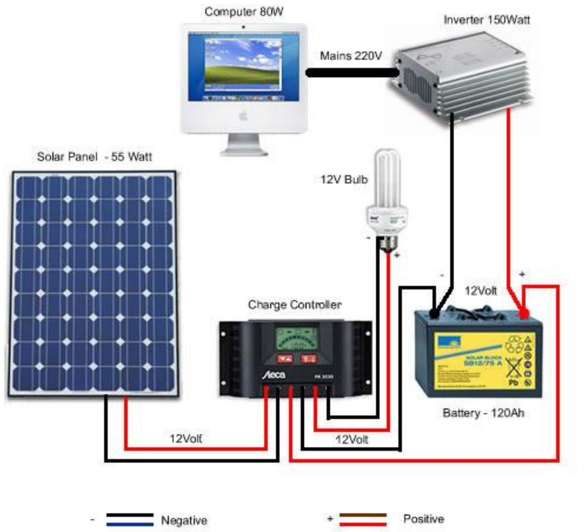

Fig. 3. *Solar charge controller connected to solar system*

Voltage generation and battery charging in solar panels can be done DC-DC. If the electronic devices in the system are planned to operate in a direct DC manner, the system can work more efficiently without AC conversion. In the next section, a sample solar system calculation will be made.

A SAMPLE SOLAR SYSTEM DESIGN

A system will be designed for night lighting only. LED lighting products operating with 12V voltage will be used for this design. The fifty-meter-long led product consumes 14.4W of energy per meter. If a 12V 100Ah battery is used in calculations for an average of 12 hours of operation per day[11, 12].

Total Power :14,4 x 50 = 720W
Energy : 720 x 12 = 8640Wh
Battery Need : 8640/12 = 7,2 pc

Battery Charge Time for 20Ah 5 hours

8 Battery 20Ah charge time =160Ah

Solar Panels :160A x 12V = 1920W

8.3 panels with 48 Cell Polycrystalline 230w power seem sufficient. However, it is more appropriate to use at least 10 panels for the efficiency of the system. If Edirne is the region to be established, the least amount of radiation in Edirne is in December. This value has been measured as 1180W / day[13]. Considering that the panels will be installed on a total area of 1.3m^2 and a total area of 10.4m^2, the calculated system will work for 12 months without any problem. With these choices;

Total Panels Power : 230W * 10 =2300W

The panels produce 26V voltage. In order to reduce the current and reduce the cable diameter, the batteries are planned as 2 series and 4 arms. Solar panels will be connected in parallel.

In this system, the energy generated from the panels will directly charge the batteries. 8 batteries can be charged for 5 hours a day. In the evenings, the LEDs powered by batteries will be able to deliver 36klm of light to an area of 50 meters for 12 hours. No conversion has been made. Only 12V LEDs will be connected to the batteries in the form of two separate arms. An additional circuit is required to control the efficiency of the system, turn on the lighting at night, and control the battery charge value. Some ready-made charge control units can be used for this process, which gives output at night. In this system, DC generated energy is used as DC without any conversion. The energy produced from solar panels can be converted to AC with the help of inverters. It could then be converted back to DC for LED control. However, since there may be 10% loss in each conversion, as a result of the first conversion, 230W of energy will be lost as a result of the second conversion, and an energy of 1860W will be obtained. Of course, these estimated values are calculated by taking the driver and rectifier features. It is also known that the panels did not work with 100% efficiency. The aim of this study is to draw attention to the losses. With the split DC-AC conversion, the cost and the cost of using DC-DC are comparatively given in the table 1 below.

Table. 1. *Cost Table*

Device	*DC-DC*	*DC-AC*
Solar Panels x10 (230W)	$874	$874
Construction	$600	$600
Battery x 8 (12V 100Ah)	$1760	$1760
Cable and Assembly	$200	$200
DC Control Card	$100	
DC-AC Invertor (3000W)		$300
AC-DC Adapter (3000W)		$165
Total	$3534	$3899

With the calculations in Table 1, it is seen that the system is both more efficient and more economical to work in DC, if possible. In some cases, DC-DC conversion may be required. Losses may also occur due to this transformation. But these conversions have less losses than DC-AC conversions

CONCLUSION

In this study, energy consumption and cost analysis has been made by installing a solar panel system. The losses that may occur if the energy produced in DC panels are converted to AC and used in this way have been examined. If the system to be installed works with DC or there are devices that can work, planning the system as DC is an efficient solution both for cost and to reduce losses in energy conversions. Many devices working with 12V-24V-48V can replace AC200V devices in our daily recording. Moreover, products such as TVs and computers work directly with DC.

Instead of AC-DC rectifier adapters of these devices, their losses can be minimized by feeding them directly with the generated DC voltage.

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