A Smart Standalone Direct DC Green Residence

S.Surenderkumar[1], Karthik RP[1]

[1]Assistant Professor, Vidya Vikas Institute of Engineering and Technology, Mysore-570028, India

***Abstract*– This paper proposes the use of direct DC power from solar PV cells for DC home appliances. By using the DC appliances the conversion losses of AC to DC in rectifiers and DC to AC in the inverters can be eliminated and every individual house can be a standalone direct DC house. This method eliminates the use of inverters which is there in the currently available method where DC from the solar PV cell is inverted and utilized in the home or connected to the grid depending upon the capacity installed. A smart switching automation for selection of source as PV cell or AC mains as an alternate source for either battery charging or to the DC loads has been implemented.**

***Key words* – Photo Voltaic (PV), Alternating Current (AC), Direct Current (DC)**

I. INTRODUCTION

The standard of living of a country can be directly related to per capita energy consumption. Energy crisis is due to two reasons. The population of the world has increased rapidly. The standard of living of the people has increased.

If the annual per capita income of different countries is taken, it will show that the per capita energy consumption is a measure of the per capita income or the per capita energy consumption is a measure of the prosperity of the nation [4]. So, the power generation capacity needs to be increased every year which is a difficult task and also it depends on the availability of fuels required for power generation. Currently power generation from the renewable energy sources are being increased and the government provides subsidy for installing solar power plants and wind mills, as the installation cost is high.

Thus generating DC power and to utilize it directly at home or office is quite advantageous compared to inverting and utilizing the AC power. At present, almost all the domestic appliances are running on AC power source. We know that most of the home appliances that we use are DC powered. All the appliances that use DC power, has a rectifier in it to convert from AC to DC. So, DC power can be utilized directly without conversion from the AC source so that conversion losses can be eliminated. Harmonic issues and phase balancing problems are not present in DC system.

Renewable energy is used as a main source of energy. The project eliminates the dependence of AC power source what we are using today. DC motors can be used for the home appliances which are more efficient than the induction motors that are currently used. Wiring architecture is simple for homes and offices in case of direct DC implementation. A smart switching circuit which switches between the solar PV and AC, battery selection switch and battery to load switch is presented in this paper.

This paper is organized as follows; Section 2 shows the discussion about existing method. In section 3, the proposed method is discussed. Detailed explanation of the proposed system is explained in section 4. Switching scheme is discussed in section 5. Results and demonstration is done in section 6 followed by conclusion in section 7.

II. EXISTING SYSTEM

The block diagram of existing system is shown in the figure 1. In the existing system [1], some of the AC home appliances were made to works in DC supply after making some modifications to the appliances. The existing system uses 220V DC supply from PV array. 230V AC is used as an alternate source rectified to 220V DC.

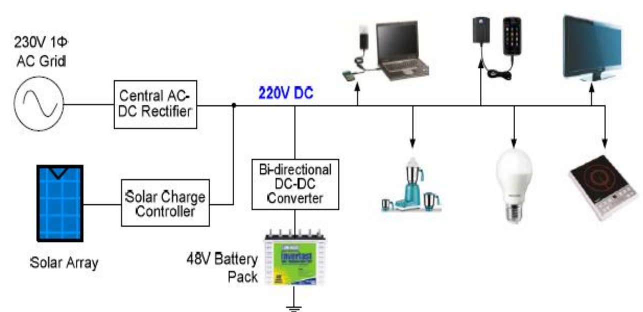

Figure 1 Existing Method- Usage of Direct 220V DC rectified from AC or Boosted from PV Panel

Some of the home appliances such as Mixer grinder, induction stove, LCD TV and LED lights are modeled and simulated to work in DC supply. As the heating appliance requires more power to generate heat, either more current or voltage is required. If low voltage is used, current need to be increased, so that the conductor thickness should also be more to withstand high current, which will be costly too. Thus 220V DC is preferred for high power appliances. The universal motor of the mixer grinder which works on AC needs to be altered [2] to reduce losses like eddy current loss and iron loss while working on DC.

III. PROPOSED SYSTEM

3.1 Block Diagram of Proposed System

The block diagram of the proposed system is shown in Figure 2. In this method, DC power is generated from PV panels is directly utilized by DC loads. As an alternative source AC is also used for charging the batteries whenever the solar radiation is less. Two battery banks are used, while bank1 connected to charging control, the bank2 will be connected to the DC loads and vice versa. This is to improve the life of the batteries and better operation of the system. Usually it is not recommended to use the batteries for charging and loading simultaneously. A smart switching scheme is used for three purposes, Switching between

- PV panel and AC source
- Battery banks 1 and 2
- Source to loads/Battery bank to Loads

The proposed smart switching system switches automatically between the above mentioned options as per the availability of the source and battery state of charge percentage. Whenever solar radiation is less than the desired value the battery charges from rectifier of AC source. If both the batteries are charged fully, then the source to charging circuit is switched off. When the battery connected to load reaches the 20% available charge, it starts charging from any of the source available at that time.

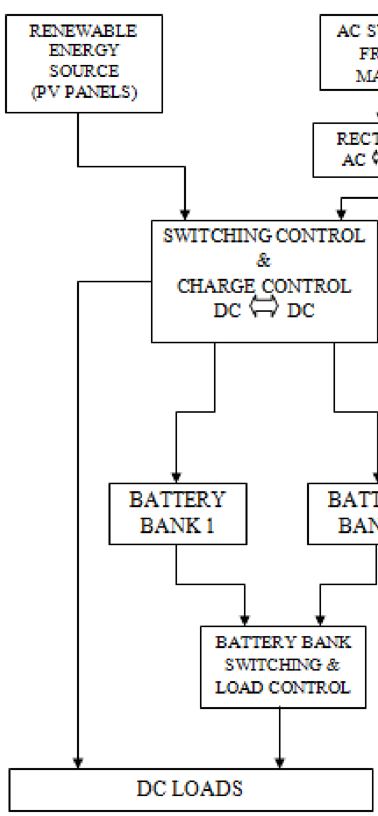

Figure2. *Proposed Method-Direct DC Systems with Smart Switching Unit*

This system is designed for low voltage DC loads, as a smart switching scheme is proposed and focused in this paper hence only two DC loads are used in this paper i.e. DC fan and LED lights. The detailed specifications and working of the system is discussed in the following sections. As low power DC appliances are considered here, wiring thickness and current ratings will not be a tedious task.

3.2 System Operation

The entire system operation is explained in sequence of steps as follows:

- The solar panel and the supply from AC mains are connected to the relay 1 in the switching unit.
- Controller is programmed such that it compares the voltage of solar panel with the pre-specified voltage values in the program.
- If the panel voltage is equal to the pre-specified voltage the batteries charge via solar.
- If it is less than the pre-specified voltage the relay 1 operates and the batteries charge via AC mains.
- The battery voltages are fed into the controller and then to the relay 2 terminals.
- If the first battery is discharged up to about 20% SOC, the relay 2 operates and the second battery gets connected to load by switching and first battery starts charging.
- The same condition is followed for the second battery also.
- The entire load operates continuously for all the above condition.

Table 1: Conditions to Select the Sources

SL.no	PV Panel voltage	AC voltage	Charging from PV Panel	AC charging
1	>12.6v	12.6v	ON	OFF
2	<12.6V	12.6V	OFF	ON

Table 2: Battery Selection and Operation Chart

SL.no	Battery1 Voltage	Battery2 Voltage	Battery1 condition	Battery2 condition
1	>11.66v	>11.66v	Connected to Load	Not Charging
2	<11.66v	>11.66v	Charging	Connected to Load
3	>11.66v	<11.66v	Connected to Load	Charging

IV. SOURCES AND LOADS

4.1 PV Panels

Normally during sunshine hours in a day the PV panel delivers maximum output and its efficiency is given by the equation

$$\eta = \frac{Vm * Im}{Irradiation * Area}$$

Where η is efficiency of the solar panel, Vm*Im is the maximum power output and Irradiation is incident intensity [3]. For maximum efficiency of the PV panel the angle of declination and tilt need to be calculated and the panel is placed accordingly to get maximum output power. For more efficiency, solar maximum power point trackers may be used to track the radiation and rotate the panel for direct incidence of the irradiation. The specification of the panel used in this work is mentioned below.

Specification:

Voltage: 12 V

Current: 0.83A

Power: 10 watts

4.1 Battery Selection with respect to panel

The capacity of a battery or cell is measured in amp hours. A 100 amp hour battery in theory can supply a current of 1 amp for 100hrs before becoming fully discharged (although a battery should never be discharged below 20% of full capacity, and on a regular daily basis should not be allowed to go below 60% of full capacity) which is mentioned in table 2. As the efficiency of a battery, and therefore it's amp hour rating varies according to how quickly it is discharged, a standard discharge time is used when quoting a batteries capacity.

4.2 DC Loads

Existing appliances like universal motors in the mixer grinder, induction stoves and LCD televisions can be used in a 220V DC system with slight modifications in the appliances [1]. The following subsections shows the DC loads used in the proposed system and its specifications

4.2.1 DC fan:

Direct current fans, or DC fans, have a variable, uneven flow. DC technology has become much more sophisticated in recent years, and it can now be applied to both residential and industrial purposes. DC technology is much power efficient than AC technology, as the rating of the DC fan used here is 12V and 1.4Amps. BLDC ceiling fans are available in the market which consumes only 35Watts power.

4.2.2 LED bulb:

LED lamps have a lifespan and electrical efficiency which are several times greater than incandescent lamps, and are significantly more efficient than most fluorescent lamps, with some chips able to emit more than 300 lumens per watt (as claimed by Cree and some other LED manufacturers). The LED lamp market is projected to grow by more in the next decade.

The rectification losses are reduced and lifetime of the lamps can be improved by using the LEDs with direct DC supply. Some LED lamps are made to be a directly compatible drop-in replacement for incandescent or fluorescent lamps. The light output of single LED is less than that of incandescent and compact fluorescent lamps; in most applications multiple LEDs are used to form a lamp, although high-power versions are becoming available.

V. SWITCHING SCHEME

5.1 Switching Control:

The switching control unit is shown in the block diagram Figure 3.

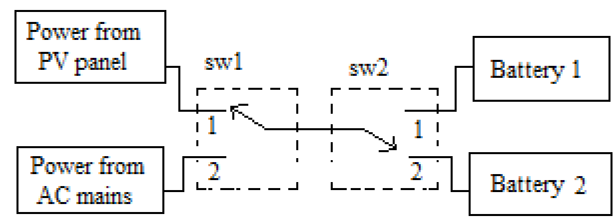

Figure 3: Switching Unit 1

As shown in the figure when the power supply from PV panel is available during day time the battery will start charging. The switching scheme is designed such that Battery 1 and Battery 2 are charged according to their state of charge (SOC). During night time the panel output will be very low, now the batteries will charge according to their SOC using power from mains. The controller will decide the switching scheme accordingly.

5.1.1. Switching between the two batteries.

- Comparison of voltage of both the batteries with the pre determined voltage occurs.
- The switching occurs to the highest voltage battery from the lower voltage battery.

The battery with the lower voltage starts charging via panel or AC mains

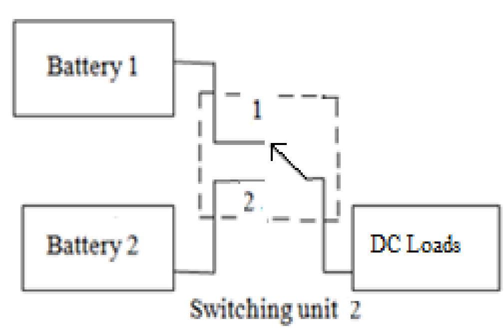

Figure 4: Switching between the batteries.

The above figure shows the controlling action of the switch between the two batteries. As per the load demand the batteries supply power to the load depending on their charge availability. If SOC of battery 1 is more than battery 2 then switch takes the position 1 and if the SOC of battery 2 is more then switch takes the position 2.

VI. RESULTS AND DISCUSSION

6.1 Analyzing result via switching:

The hardware set up for the work was carried out which is shown in the figure 5. From the experiment it is analyzed that this system is a prototype which uses fans and led lights. The system effectively involves the switching scheme there by influencing on different DC loads as well. As a prototype the capacity was restricted to 10W for lighter loads. Large DC loads works with the proposed switching scheme of the system by increasing the rating of source.

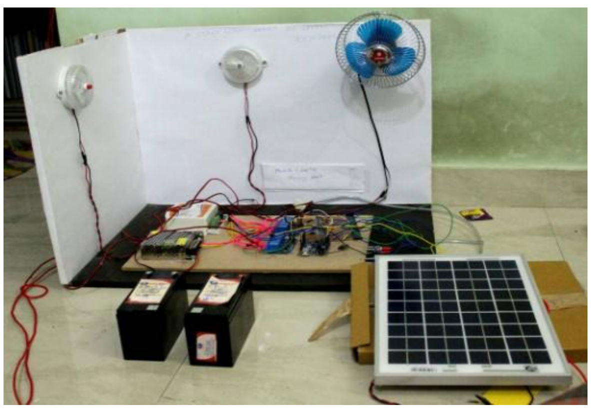

Figure 5: Hardware setup of the project

The experiment was conducted on real time basis taking fans and LED lights as load. Table 3 shows the comparison of these loads with respect to AC and DC power. The power consumed by the fan is calculated for duration of 10 hours and power consumed by the LED lights is calculated for 5 hours. It is seen that the power consumed by the DC loads are lesser than that of AC loads. There by increasing the efficiency of DC loads.

Table 3: LOAD COMPARISON OF AC AND DC POWER

Loads	**AC**			**DC**		
	Power (W)	Quantit y	Total (w)	Power (W)	Quantit y	Total (w)
Fans	80	4	320	35	4	140
LED lights	68	10	680	20	10	200

The efficiency of fans is slightly lesser than AC which is neglected since the major parts of other DC loads always give higher efficiency. The comparison of the efficiencies for AC and DC loads are shown in the Table 4.

Table 4: EFFICIENCY COMPARISON OF AC AND DC FOR THE LOADS

Loads	**AC**		**DC**	
	Power (kwhr/da y)	**% efficiency of AC**	**Power (kwhr/day)**	**% efficiency of DC**
Fans	3.2	100	1.4	90
LED lights	3.4	74	1	92

VII. CONCLUSIONS

The main objective of taking this project concept is to balance the power demand in the present situation. Also, utilization of renewable energy source is the main advantage of this project as DC power can be extracted directly from PV cells. But it is not limited, as we can include generating sources like windmills, DC power generation from other sources like swings, gym cycling equipment that we use at home. Thus the power demand from the AC grid may be reduced. A stand-alone PV system with storage battery covers many applications like lighting, refrigeration, TV and radio, Telecommunication, electric fencing and traffic control. The future scope of this paper is to use the standalone direct DC system in institutions and houses for all the DC loads.

REFERENCES

[1]. Girish Makarabbi, Vinay Gavade, RakeshBabu Panguloori, *and* PriyaRanjan Mishra, “Compatibility and Performance Study of Home Appliances in a DC Home Distribution System”, 2014 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES)

[2]. *Handbook of electric motors*, 2nd ed, Marcel Dekker Inc., Ny, 2004, pp. 156-158.

[3]. *Fundamentals of Renewable Energy Systems*, first edition 2004, New Age International Publishers.

[4]. Non-Conventional Energy Sources, by G D Rai, 2011, Khanna Publications.