Off Grid Decentralized Solar Power System for Home Lighting Solutions with Energy Efficient Alternatives and Sustainable Development A Solar-DC Initiative

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Abstract— It is an effort in the direction of energy efficient alternative for home lighting system. It proposes the off grid decentralized solar power system. An Existing setup of electricity generation is centralized. It generates electricity centrally at one place (e.g. Thermal power plant) and it is transmitted and distributed everywhere. More over coal is the raw material for such thermal power plants and to save nature we have to put efforts to minimize the use of coal and initiate sustainable ways to generate power which reduces the CO_2 emission. One approach is to generate power at a place where we need it. If we are able to generate power in decentralized way, our dependency on grid power can be reduced. As we know that solar panel generates DC Voltage and we can develop 12V DC system or 24V DC system, which does not require conversion from DC to AC. So, use of inverter can be avoided. This is possible as DC bulb, DC LED tube lights, DC fans, BLDC ceiling fans are available. Focus areas of this project: Replicable, Low cost, Easy to install & maintain, Repairable, Easily available components, portable and compact.

Keywords—solar DC, off grid solar system, decentralize solar power, 12volt solar system, 24volt solar system, solar DC home appliances.

I. Introduction

Now a days in our country approximately 65% consumed electricity is generated by thermal power station. There is approximately 72% coal based thermal power station where coal is used as a raw material to generate electricity. Also efficiency of coal based thermal power station is approximately 32% to 42% which is very less and also power transmission and distribution from station to consumer there are power losses also occur is approximately 22% losses are there. So by these data we can understand that power generation and distribution by centralize power station is very tough and less efficient task also loading on power station is very much in this conventional system. So our solar DC initiative is one of the steps towards reducing the loading over power station by decentralizing them using solar power generation system. Another main purpose of doing this project is that, we are indirectly reducing CO2 emission by using this solar DC system.

Features of this approach are mentioned below:

- Solar DC design
- Inverter less design
- Easy to implement (Installation and maintenance possible with local electrician with little training)
- Focus areas of this project: Replicable, Low cost, Easy to install & maintain, Repairable, Easily available components, portable and compact.

II. Experiment

A large number of homes are still off-grid, and taking power lines to these homes may be just too expensive. Many more homes have long power cuts. Off grid decentralized solar power system will be more suitable. There are two possibilities for decentralized solar power system. One approach is developing decentralized solar power with DC to AC conversion and run a home. Another approach is to use energy efficient DC appliances for home and use Solar-DC. Here, this energy efficient DC approach is mentioned. A Solar-DC system would save about 35-40% of the power as compared to a solar-AC system. With DC appliances, energy savings is associated. Efficiency is also improved. With this improvement it is possible to have lower sized solar panel and smaller battery size. This leads to cost savings as compared to solar-AC system. Such a decentralized system offers economical, affordable and sustainable solution for off-grid homes and homes with large power cuts. This is also useful for grid-connected homes in saving power bills as well as providing back up power. Here we can explain one minimum model of this system in system design category.

III. System Design

The design component is mentioned below:

1. Solar Panel
2. Solar Charge Controller
3. Battery
4. Wire size

A. Specification

- One DC table fan/wall fan (12Volt,15Watt) running 3 hours daily
- One DC LED lamp (12Volt, 3Watts) running 10 hours daily
- One Solar panel of 20watt
- One Battery 12V, 12Ah

B. Load Calculation

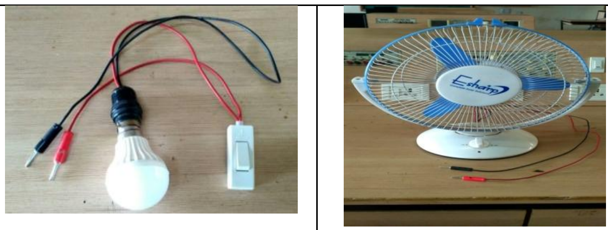

Fig.1DC LED lamp(12volt, 3watt) and DC table fan(12volt, 15 watt)

- 12VDC, 15Watt DC table fan/wall fan (1 nos.) to be used for 3 hours per day
- Watt-hour required is 15W*3hour=45Watt-hour
- 12VDC, 5Watt LED bulb to be used for 3 hours per day
- Watt-hour required is 5W*3hour=15Watt-hour
- USB Mobile Charging facility

Total Watt-hour required is 45+15=60Watt-hour

C. Battery Size Calculation

Fig.2 12volt, 12 Ah battery

To calculate the battery size we have to know the term depth of discharge (DOD). It is recommended to keep depth of discharge 50% (for lead acid battery) to increase the battery life. So, for calculation consider 120Watt-hour (Double than original calculation). If we assume battery 12V, 12Ah, then this battery watt-hour capacity is 12*12=144Watt-hour. This is acceptable.

One precaution is needed here. That is discharging rate of current. Typically for C/10 batteries 10% of Ah capacity is considered. So, here 10% of 12Ah is 1.2.It means maximum discharge current should be 1.2A for better battery life. The worst case in this design is at night when all the devices are running. In this case the maximum current will be (1.2A+0.5A=1.7A).

D. Solar Panel Size Calculation

Our consumption is 60Watt-hour per day. So solar panel must generate power more than the required power. Considering the sunshine for 6hours per day, 20Watt solar panel is capable to generate 20*6=120Watt-hour per day.

The maximum charging current from 20Watt solar panel is approximately 1.2A. This is also around 10% battery capacity.

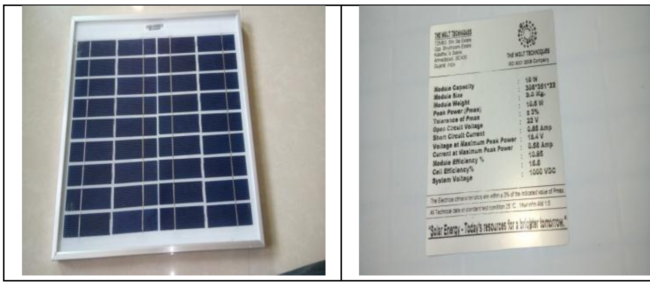

Fig.3 Solar panel front and back view

E. Wire Size Calculation

Wire size (cross-section area) is critical design parameter. The reason is **DC design**. As our design is 12VDC and voltage drop of even 1Volt-2Volt can affect the performance. So we have to decide the cross-section area of wire in such a way that voltage drop across the length of the wire should be as minimum as possible. Also information of approximate wire length from solar panel to the charge controller is required. If the wire length from solar panel to the battery is around 25meter then 1.5mm2 wire is enough. Because this wire has resistivity 12Ω/kilometer. So, for 25meter wire, resistance is **25*0.012=0.3Ω**.Now if the current is 1.2A, the voltage drop is **1.2A*0.3Ω=0.36Volt**.This is acceptable. For more wire length it will be better to use 2.5mm2 wire.

Considering standard copper wire, normally we use 1.5mm2, 2.5mm2, 4.00mm2, 6.00mm2 etc. wire sizes. Standard wire resistivity is given as maximum resistance per kilometer at 20 degree Celsius.

TABLE I
Wire Resistance per mm^2

Nominal area of conductor (mm^2)	*Resistance(Ω/km)at 20°C
1.5	12.1
2.5	7.41
4	4.95
6	3.30

IV. Solar Charge Controller

The typical solar panel puts out about 21V NL (No-Load) in full sunlight. If this solar panel is connected directly across a 12V battery, it will attempt to charge it to the no-load voltage, and if the available current is sufficiently high, it will boil the battery electrolyte and damage the battery due to overcharging.

The loss of electrolyte is also a consideration as it is not normally necessary to top off liquid electrolyte more than once or twice per year.

Solar controls also include a reverse polarity diode to prevent the battery from discharging into the solar panel under low light conditions.

There are three types of solar charge controller.

- Linear solar charge controller
- PWM solar charge controller
- MPPT solar charge controller

In this system we use linear solar charge controller.

A. Linear Solar Charge Controller

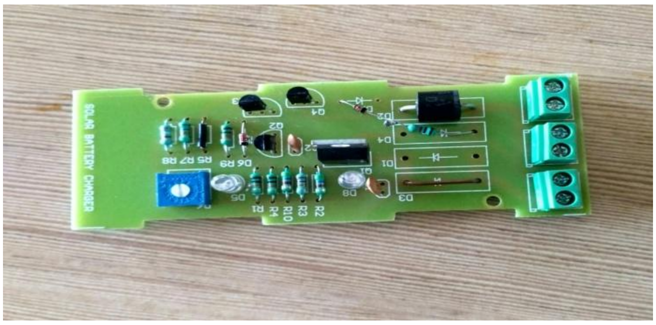

Fig.4 Linear Solar Charge Controller

- The linear solar charge Controller is the simplest form of charge controller. It is simply a series voltage regulator that drops the panel voltage to the desired battery maximum charge voltage. These are the only controls recommended for charging small batteries. They may also be used with large batteries. We have tested charging of 12Volt, 7Ah battery with 20watt solar panel successfully.
- This Low Dropout Voltage (LDO) solar charge controller uses a simple differential amplifier and series P channel MOSFET linear regulator. Voltage output is adjustable. It is mainly intended for charging 12V lead-acid batteries.
- 6.2Volt zener voltage reference is used. Two BC 547 transistors make up the classic differential amplifier that amplifies the difference between the reference voltage and the feedback voltage from the battery. The output is taken from the collector of BC 547 and drives the gate of P Channel MOSFET(IRF 4905). Differential voltage gain is probably in the order of 100 to 200. As the feedback voltage increases transistor turns on harder and steals some of the emitter current away from basic transistor. The overall effect is thus reducing Vgs (gate to source voltage of MOSFET) and turning it off. C2 provides frequency compensation to prevent the amplifier from oscillating.

V. Comparative Study

Above system is working satisfactorily. It is designed to run for day and night without grid. Comparing above system with existing 230V,AC system following observations are found. Assuming 230V,AC fan with power consumption of 80Watt and running for 3hours daily, one fan consumes 240Watt-hour energy. Similarly One AC CFL lamp of 18Watt running for 3 hours consumes 54Watt-hour. So, overall energy consumption will be around 134Watt-hour per day. If we use DC appliances it is found overall energy consumption will be around 60Watt-hour.So, almost more than 45-50% energy saving is found with DC appliances. So, while designing decentralized solar system for AC appliances it requires more than double size solar panel and double size battery for equal duration of usage.

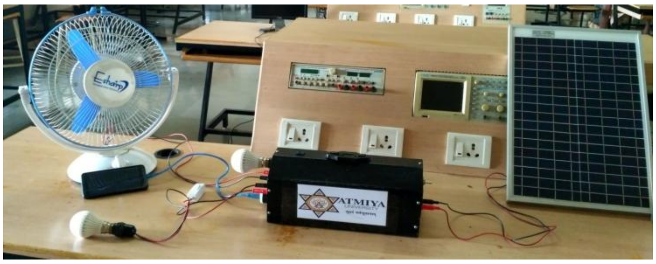

Fig.5 Minimum model developed on 12volt DC

VI. Conclusions

Conventional thermal power plant emits approximately 0.8Kg of CO2 per unit (1 kwh) energy consumption. Consider normal family energy consumption is approximately 5 units per day. So, average 4kg (0.8kg*5units) of CO2 is emitted indirectly by a normal family. Assume 50% of energy consumption of normal house is due to fan and tube light. So, 2.5 units per day are due to fans and lights only. We can provide 12V/24V DC solar solution for fans and tube lights and generate it locally at home itself. With this we can reduce energy consumption of 2.5 units per day and reduce CO2 emission by half. It means we are participating in reducing CO2 emission. In this way we can daily reduce 2kg CO2 emission. Monthly 60kg reduction in CO2 emission and annually 720kg reduction by only one family. From Carbon and tree facts it is found that one mature tree can absorb only 22kg of CO2 per year. So, indirectly one family will save around 32 trees per year. So, if we extend such concept to larger mass we can contribute to nature at good extent and participate for energy efficient and sustainable development.

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REFERENCES

[1] A. Nagraj, "Samadhanatmak Bhautikvad", 2nd ed., DivyapathSansthan., Dist. Anuppoor, Amarkantak, India: Jeevan Vidya Prakasan, 2009.

[2] https://powermin.nic.in/en/content/power-sector-glance-all-india

[3] https://en.wikipedia.org/wiki/Electricity_sector_in_India#cite_note-GES-4

[4] Growth of Electricity Sector in India from 1947-2018"(PDF). CEA. Retrieved 20 August 2018.

[5] https://www.brighthubengineering.com/power-plants/72369-compare-the-efficiency-of-different-power-plants/

[6] http://www.arborenvironmentalalliance.com/carbon-tree-facts.asp

[7] Professional Ethics", 3rd ed., Excel Books, New Delhi, 2013.