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Solar Energy – An Eternal Renewable Power Resource

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ABSTRACT: There are many sources of energy that are renewable and considered to be environmentally friendly and harness natural processes. These sources of energy provide an alternate ‘cleaner’ source of energy, helping to negate the effects of certain forms of pollution. All of these power generation techniques can be described as renewable since they are not depleting any resource to create the energy. While there many large-scale renewable energy projects and production are in existence, renewable technologies are also suited to small off-grid applications, somewhere in rural and remote areas, where energy is often crucial in human development. Though the initial cost is high, central / state government should offer incentive programs to make “green” energy a more economically viable option. The main objectives are to bringing down the cost and component used in the power system through the enhancement of efficiency and reliability of the renewable energy sources with minimal maintenance & long life robust equipment to beat the future load-demand, to preserve the resources for last longing Universe for the sake of creature as well as to push India ahead from developing to developed country.

KEYWORDS: solar cell, PV arrangements, System description, do’s and don’ts, PV characteristics, string inverter, sensors.

1. INTRODUCTION

The present scenario of the Indian power sector is that the total installed capacity of Indian grid has 211765 MW. Out of this, 141715 MW is Thermal power, 39415 MW is Hydro power, and 4780 MW is Nuclear power & contribution of renewable energy sources are 25855 MW. Presently India is facing an energy deficit of 10% and a peak deficit of 15%. An average of 15 GW of power station installation is required annually till 2020 to chase the load-demand. The challenges that exist in India are

- Shortage of coal supply
- Erratic gas supply
- Land acquisition and environmental clearance
- Transmission losses (exceeding 30% in particular areas)
- Pitiabile financial condition of distributor sector
- Global competition

To overcome the challenges faced by the power sector few measures have been taken place during last two decades. Transmission grid comprises 77500 km of 765 kV / 400 kV lines; 114600 km of 220 kV / 132 kV lines; 3 HVDC bipoles; 7 HVDC back to back and 6 TCSC with inter regional capacity of 14600 MW. Transmission voltages have risen from 440 kV (in 1977) to 765 kV (in 2000); from +600 kV HVDC to +800 kV HVDC (in 2011); ongoing plan is to rise to 1200 kV UHVAC. Earlier Generating unit size was less than 200MW and currently the unit sizes are ranging from 660MW to 1000MW. New transmission technologies which have emerged are

- High voltage overhead transmission upto 1100 kV
- Gas insulated cables / Transmission lines
- HVDC light
- Flexible AC Transmission system.



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The developments in the generation sector are

- Power former Engineering System
- Distributed generations
- Combined Cycle Power Plants.

Operational changes which are emerging include Wide Area Measurement System (WAMS) using Phasor Measurement Units and Power System Restructuring (Deregulation).

Study of power system is necessary so that we can analyse the fragile section of the system design and hub on that segment to achieve the target. If we focus on the off-grid solar power at the same time we are gaining on-grid power and able to provide that power to the needy one. Our need of study is to overcome the load-demand in the near future and at the same time to save the Global environment & resources.

Photovoltaic (PV) Solar power is harnessing the sun's energy to produce electricity. One of the fastest growing energy sources are developing swiftly. Solar cells are becoming more efficient, transportable and even flexible, allowing for easy installation. PV has mainly been used for small and medium sized applications (calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array).

Oil crisis in the year 1973 stimulated a rapid rise in the production of PV module. Since the leadership in the PV sector has shifted from US to Japan and Germany in the mid 1990s, Japan increased R&D funding, established net metering guidelines, and introduced a subsidy program to encourage the installation of residential PV systems (Copper Indium Selenide – CIS type). Solar installation in recent years have also largely begun to expand into residential areas, with government offering incentive programs to make “green” energy a more economically viable option.

A. Facility Overview is as under.

- Modern state-of-the-art manufacturing automatic production line
- Production capacity of 100 MW.
- PV modules are manufactured by proven European technology
- PV modules range from 3 to 300 watts.
- Internationally recognized
- High Reliability and Quality

B. Customer Satisfaction Oriented Project is solved by

- Feasibility studies and technical/economic consulting
- Land acquisition
- Basic and detailed engineering
- Plant engineering
- Comprehensive plant management
- Systems integration
- Project direction, planning, construction, and start-up

C. Projects Completed in Gujarat

- 40MW solar power plant from ADANI POWER LTD. for engg. & supervision.
- 10 MW solar power plants for MONO STEEL (INDIA) LTD. UNA.
- 3 MW solar power plants for ABELLON CLEAN ENERGY LTD, Modasa.

D. Ongoing Projects in Gujarat

- 5 MW solar power plants for Avatar Solar
- 5 MW solar power plants for Taxus Infrastructure
- 2.25MW solar power plants for Claris Lifesciences, Surat

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E. Product Features Available

- International acceptance
- Screw less modules
- Designed for water drainage
- Customized modules available
- Low iron glass – option ARC
- Wind and snow resistant design

F. Various PV Panel Arrangements for Solar Power Plant is as under



Figure 1. Concentrated Solar Power System



Figure 3. Radial Solar Power Plant



Figure 2. Solar Green House



Figure 4. Solar Tracker

G. Various Off-grid Application of Solar power is as under.

- Street Lighting System
- Solar Water Pump
- Solar Education Kit
- Solar Lantern
- Solar Tube-well in the Farm
- Solar SCADA Solution in Oil & Gas Industries

H. Quality of Product

- Internationally certified
- In-house reliability
- Full Product warranty: 10 years
- Limited extended warranty:
 - 10 years: minimum 90% power output
 - 25 years: minimum 80% power output

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II. DESCRIPTION OF THE SYSTEM

It's a case study project done by me on rooftop type 100-kW, SOLAR GRID POWER PLANT at Vaihwakarma Government Engineering College, Chandkheda, Gandhinagar, Gujarat (India). Green Energy Development Agency (GEDA) is the pioneer organisation in Gujarat state for such a revolutionary task, whereas Waaree Engineers Private Limited (*Surat, Gujarat based*) was formed in 2007 by the promoters of the WAAREE Group of Companies to begin its foray into Renewable Energy Sources.

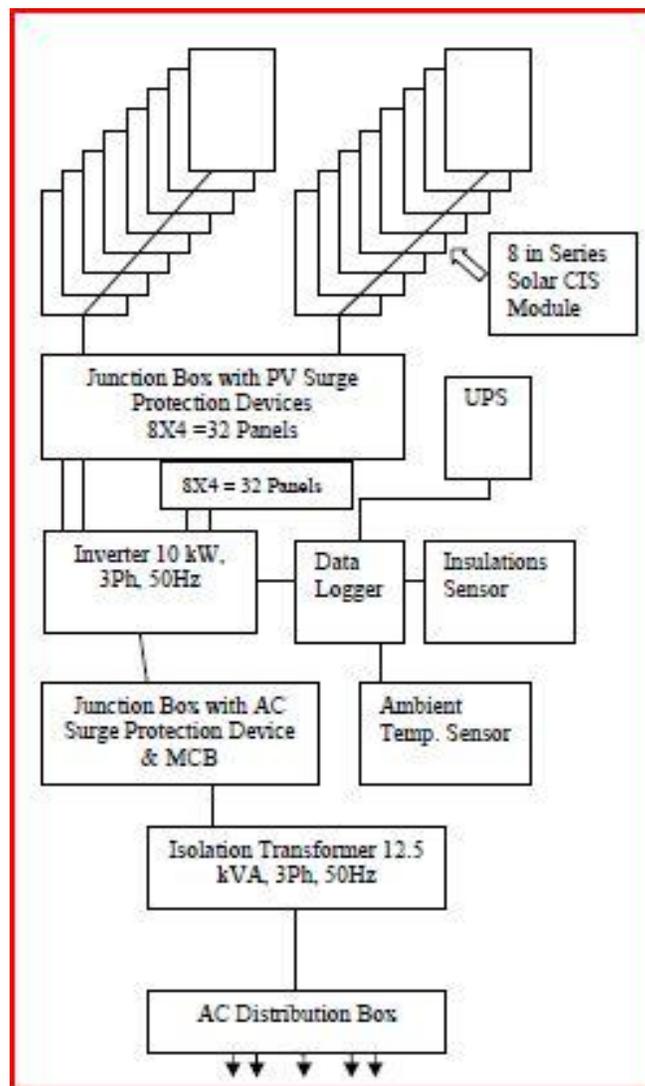


Figure 5. Block diagram of Solar Grid Power Plant

This system is a multi-string inverter that converts direct electric current from a photovoltaic generator into alternating electric current and feeds it into the national grid. Photovoltaic panels transform energy from the sun into direct current (DC) electrical energy (through a photovoltaic field, also called photo voltaic (PV) generator; however, to feed the grid



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it has to be transformed into alternating current (AC). This conversion, known as DC to AC inversion, is made efficiently without using rotating parts and only through static electronic devices (inverter).

When used in parallel with the grid, the alternating current generated by the inverter flows directly into the domestic electrical circuit, which is in turn connected, through a distributor, to the national grid. The solar energy system therefore powers all connected electrical devices, from lighting to household appliances, etc.

When the photovoltaic system is not supplying sufficient power, the power needed to ensure normal operation of the connected electrical devices is drawn from the national grid. If on the other hand excess power is produced, this is fed directly into the grid, so becoming available to other consumers. In accordance with local and national regulations, the power produced can be sold to the grid or credited toward the future consumption, so bringing down the cost. Block diagram of the system (Figure 5) is as above.

III. DO'S AND DON'TS FOR SOLAR SYSTEM

Do's

- ✓ Ensure the solar PV modules are installed in the shade free sun in a proper direction.
- ✓ The PV module connections should be done in last.
- ✓ Ensure the tap/paper is removed from the battery cell vent plug before connecting the battery.
- ✓ The solar PV modules are to be cleaned regularly to remove the dust.
- ✓ In case red LED marked "LOW" glows, charge the battery is regularly charged so that is in full charged condition.
- ✓ Ensure that the battery is fully topped up with distilled water. The electrolyte level conditions in the battery must be checked in 30 days and if the electrolyte level has gone down, it is to be topped up with distilled water. Ensure that the battery plates are always covered with electrolyte (Wherever Battery is applicable).
- ✓ Petroleum jelly (not grease) should be applied on the battery terminals to avoid corrosion of the terminals.

Don'ts

- X Do not use grease for applying to battery terminals (wherever applicable).
- X Do not use acid for topping up the battery (wherever applicable).
- X Do not clean the solar PV modules with acid/chemicals/detergent etc.
- X Don't temper with settings of Controller or the Solar Inverter.
- X In case of any problem contact the source from where one has procured the system.

IV. PV PANEL CHARACTERISTICS

From the Product Data Sheet SF150-L 150W module here summarizes few characteristic performances as follows.

TABLE – I. ELECTRICAL PERFORMANCE AT STANDARD TEST CONDITIONS

		SF150-L
Maximum power	P_{max}	150 W
Tolerance of Pmax	-	+10% / -5%
Open circuit Voltage	V_{oc}	110 V
Short Circuit Current	I_{sc}	2.10 A
Voltage at maximum power	V_{mpp}	79.0 V
Current at maximum power	I_{mpp}	1.90 A



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TABLE - II. MECHANICAL CHARACTERISTICS

Dimensions (L x W x H)*3	1.257 x 977 x 35 mm (49.5 X 38.5X 1.4 inch)
Weight	20kg (44.1 lbs)
Module Operating Temperature	-40°C to 85°C
Application Class on IEC61730	Class A
Fire Safety Class on IEC61730	Class C
Safety Class on IEC61140	II
Snow Load (to the front of module)*4	1,400 Pa (IEC61646)/12,600Pa design load (UL1703)
Wind Load (to the back of the module)	1,400 Pa (IEC61646)/12,600Pa design load (UL1703)
Cell type	CIS substrate glass (cadmium free)
Front Cover	3.2mm Clear tempered glass
Encapsulant	EVA
Back Sheet	Weatherproof plastic film (Color: Black & Silver)
Frame	Anodized aluminum alloy (Color: Black)
Edge Sealant	Butyl rubber
Junction Box	Protection rating: IP67 (with bypass diode)
Adhesive	Silicone
Output Cables (Conductor)	2.5mm ² /14AWG (Halogen free)
Cable Lengths (Symmetrical)	1,200mm (47.2 inch)
Connectors	MC4 compatible

V. 3-PHASE STRING INVERTER

The three phase string inverters in the 8-20 kW power classes are suitable for interior and exterior installations; from the 8kW rooftop system to the megawatt park. Their low weight and volume ensure simple handling and saved space during the installation. This is simplified further by a plug & play functionality together with an interface and Ethernet.

Even at a low irradiation, the inverters achieve a peak efficiency of up to 98.2%. This is ensured by an excellent MPP-tracking and a wide input voltage range of up to 380-850 V. Through the very low levels of loss over the complete input voltage range, it can be configured for convection cooling only. With the integrated data logger it is possible to monitor this system around the clock. These data can be transferred via the standard cable or an optional wireless connection via radio module.

VI. IRRADIANCE SENSOR AND INTEGRATED MODULE TEMPERATURE SENSOR

The sensors record variances between the possible and the actual power production levels and deliver key indicators relating to the quality of the system as a whole. Solar Log (one type of Data system) continuously compares the yield data from the solar data power plant with the measurement results from the various sensors. If a variance exists, the Solar-Log generates an error message. The most important element in the Sensor Box is the irradiance sensor. This delivers a reference value for solar radiation and enables conclusions to be drawn about possible power generation. Even at low levels of solarization, power dips can be identified reliably and error messages can be generated. Due to the installed internal module temperature sensor, a power “dip” is easier to analyze. Communication benefits between the Solar-Log and the Sensor Boxes are (1) Solar-Log generates an error message in response to any variance that

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occurs (2) Errors and malfunctions can be filtered out and analyzed rapidly and reliably (3) The sensor evaluation provides information about the cause of the fault (4) Up to 9 Sensor Boxes can be connected to the Solar-Log.

The irradiance sensor is equipped with a high-quality mono crystalline cell, which is rugged and specifically designed for long-term use in outdoor locations. The sensors are installed directly to the solar power plant connected to the Solar-Log via interface.

Our objectives are to bringing down the cost and component used in the power system through the enhancement of efficiency and reliability of the renewable energy sources with minimal maintenance & long life robust equipment to beat the future load-demand, to preserve the resources for last longing Universe for the sake of creature as well as to push India ahead from developing to developed country.

VII. OBSERVATION

Standard Test Condition (STC) for electrical performances is: 1000 W/m² Irradiance, module temperature 25°C and a spectral distribution of irradiance according to air mass 1.5. I_{sc} and V_{oc} are + 10% tolerance of the rated values at STC. Sorting range for P_{max} is within + 2.5W of the rated value at STC.

From typical I-V characteristics at STC (Figure 6) it is observed that Efficiency reduction of maximum power from an irradiance of 1000 W/m² to 200W/m² at 25°C is typically 3.0%. The standard deviation for the reduction of efficiency is 2.6%. Typical I-V Characteristics of a Solar cell is also shown in Figure 7.

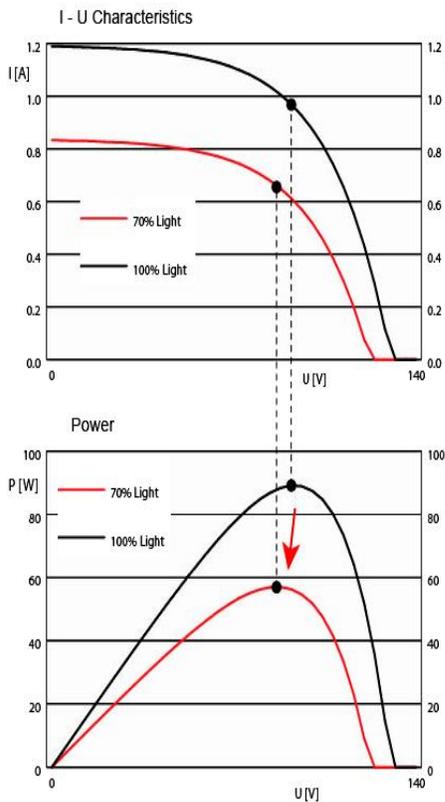


Figure 6. Typical I-V Characteristics of Solar System.

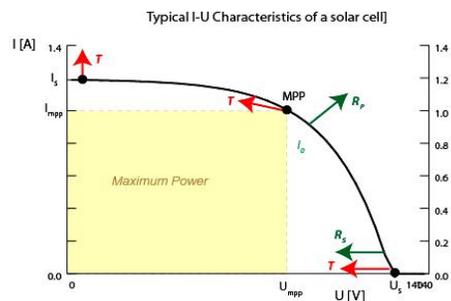


Figure 7. Typical V-I Characteristics of a Solar Cell.

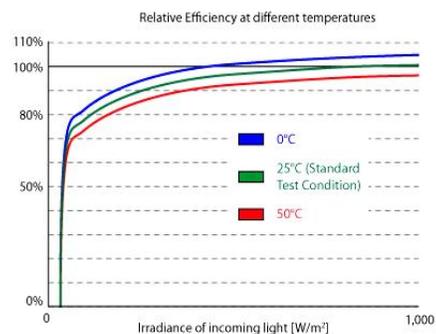


Figure 8. Relative Efficiency at different Temperature.



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From thermal characteristics it is observed that there is minor change in current with temperature variation but incredible voltage level increases with temperature. Relative Efficiency at different temperatures is as shown in the Figure 8.

Here 3 to 5 % variation in efficiency observed from morning to evening is implausible. With regular / periodic cleaning of PV panels a significant increase in rated output as well as in percentage efficiency is observed with respect to time.

VIII. FUTURE SCOPE

The ongoing development of interconnection standards and regulations will present both market opportunities and technology challenges for the power sector. Further trends and development efforts will need of focus on improving efficiency and reliability, communication and interface, reduce parts and points of failure, packaging and bringing down the cost.

IX. CONCLUSION

Indeed, global study of renewable energy sources is necessary so that one can analyse the fragile section of the system design and hub on that segment to achieve the target. If we focus on the off-grid solar power at the same time we are gaining on-grid power and able to provide that power to the needy one. Only the drawback is it requires huge area for installation and initial cost is high. There is neither fuel nor labour charges have to born to harness the Power. Therefore, Central Government or State Government should offer incentive programs to make “green” energy a more economically viable option.

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BIOGRAPHY



Anwarul Haque received his B.E (Power Electronics) from Lukhdhirji Engineering College, Morbi. Gujarat, and M.Tech (Electrical) from Manav Bharti University, Solan, HP, JNU, Jodhpur, Rajasthan. He is working as Assistant Professor in Power Electronics Department, L.E.College-Morbi, Gujarat. His areas of research are renewable energy sources, electrical power system and power electronics. He has published several technical papers in national/international conferences. He is life member of Indian society of Technical Education (ISTE), Life fellow member of the society of power engineers SPE-(India) and Life associate member of Institute of Electronics and Telecommunication Engineers (IETE).