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DESIGN OF ROOFTOP STANDALONE/OFF-GRID SOLAR POWER PLANT

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Abstract – *Electricity plays a vital role to human live that cannot be emphasis, starting from how man made his environment, food manufacturing as well as his health. All this can be achieved with the use of electricity. Today to generate most of electrical power conventional source like coal, gas, nuclear power generators are used. Some of conventional source are polluted the environment to generate the electricity. And nuclear energy is not much preferable because of its harmful radiation effect on the mankind. A non-conventional energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves and geothermal heat. Most of the fossil fuel energy sources we utilize today, oriented from harnessing the sun's solar energy by streamline today's current solar technologies; we are able to maximize the sun's resources by direct converting its energy into Heat or Electricity. The mathematical calculation for the 3.9MW grid connect solar is carried out in this system.*

Key Note – *Energy, Electricity, Solar energy*

1. Introduction

Electricity can be generated in many ways such as. Hydro power plant, nuclear power plants, gas power plant, thermal power plant, solar and wind power plants. The easiest alternative way is a stand by solar energy. A solar energy is the energy drive from the sun light strike the panel converts it to DC and can inverting circuit it converts dc to ac signal. Solar energy system always generates the electricity by the use of a photovoltaic system which consists of the solar cell connected in series.

Energy has always been vital need for all the organisms on this earth. Although, food clothing and shelter have been considered as the basic need for a human being, electricity has become prerequisite for the functioning of our world. Today, no other technology can thrive without electricity. Therefore, it is essential that that every person on our planet should be provided with electricity. Yet, this has become a very farfetched dream because, there are 1.3 billion people in the world without the access to power, out of which about 300 million people live in India. With the prolonged energy crisis that the world has been facing due to limited sources of fossil fuels and other political, economic, political barriers, we are forced to renew the means by which we meet our energy demands. Before inventions and technology invaded our life, we relied entirely on nature to meet our energy needs. Now, once again the interest in using renewable sources has given a new leash of life for this energy-starved world.

The major disadvantage in designing and development of solar plant is cost. Manufacturing of solar silica cells is more difficult. Our next future scope is reduction of cost and size of solar panels. The Government of Karnataka is planning to build a floating solar plant on rives.

Fig 1: Typical Solar Power System

2. Solar Photovoltaic Technologies

The mainly used solar module is polycrystalline. Although length & width varies slightly, most companies are manufacturing solar panels in standard size. The most typical size used for residential installations is 65inches by 39inches while the common size for commercial application is 77 inches by 39 inches.

Table 1: Classification of Solar Cells

Type of Solar Cell	Efficiency	Cost/Unit	Lifespan
Mono Crystalline	17 – 24%		25 -35
Poly Crystalline	15 -17%		23 -27
Thin Film	7- 10%		10 -15
Amorphous	8 – 13%		14 -17
Concentrator Photovoltaic technology	30 – 50%		40

Mono Crystalline Solar Cells are having more efficiency and lifespan, there for for commercial purpose these are mainly used. For the Grid connected system Concentrator Photovoltaic technology is very useful, but need of cost and area is more.

PV cell produce electricity

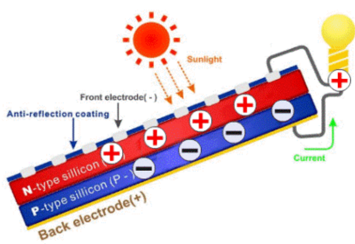

Fig 2: Electricity produced by PV cell

- When rays of sunlight hit the solar cell electrons as shown in fig3.1. they are ejected from the atoms.
- Electrons are knocked loose from their atoms, which allow them to flow through the PN Junction to produce electricity.

3. Main components used for Solar Power plant

- Solar Power Meter
- Lux Meter
- Anemometer
- Thermometer
- Hygrometer
- Multi meter
- Solar PV Module
- Battery

Power Meter it is used to measure the solar irradiance from all directions on planar surface. Light intensity is measured using Lux meter. Based on the data collection plant will be designed.

Solar Power meter, Thermometer and Hygrometer readings on the rooftop of KPCL office

Table 2: Solar Power meter, Thermometer and Hygrometer reading on the rooftop of KPCL office

SI. No	Time	Solar power in W/m^2	Temperature in °C	Humidity %
1	9:15	960	26	48
2	9:20	920	28.6	43
3	9:25	810	27.4	44
4	9:30	836	27.9	40
5	9:35	832	28.4	40
6	9:40	862	28.4	40
7	9:45	948	28	39
8	9:50	940	27.3	42
9	9:55	1010	27.7	41
10	10:00	1026	28.6	47
11	10:05	930	28.2	43
12	10:10	926	28.6	44
13	10:15	955	29	40

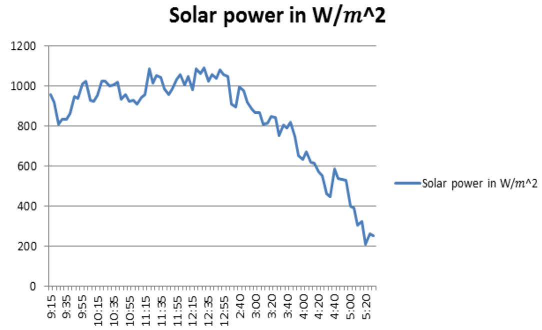

Fig 3: Graph of Time V/S solar power

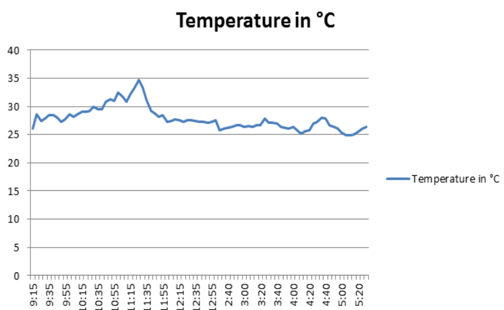

Fig 4: Graph of Time V/S Temperature

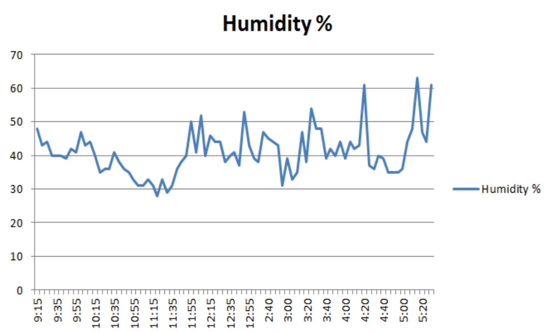

Fig 5: Graph of Time V/S Humidity

Light Intensity and Wind Speed readings on the rooftop of KPCL Office

Table 3: Light Intensity and Wind Speed readings on the rooftop of KPCL Office

Sl.No	Time	Light intensity in lux	Wind speed in mps
1	9:15	56800	4.2
2	9:20	54600	3.8
3	9:25	58400	0.8
4	9:30	61000	2.6
5	9:35	53000	1.8
6	9:40	54200	3.3
7	9:45	53800	4.2
8	9:50	55600	6.8
9	9:55	56000	5.9
10	10:00	52800	2.2
11	10:05	58600	3.2
12	10:10	54600	6.8
13	10:15	54200	7.6

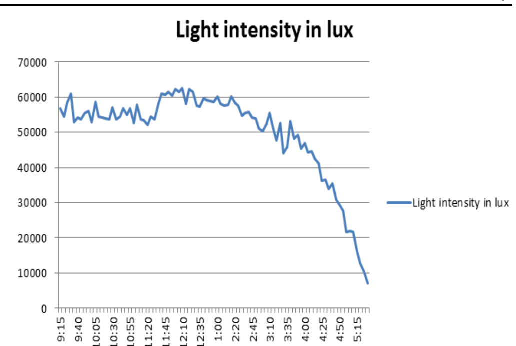

Fig 6: Graph of Time V/S Light intensity

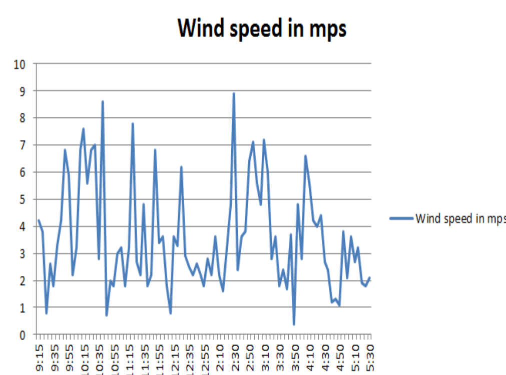

Fig 7: Graph of Time V/S Wind Speed

4. ROOFTOP STANDALONE/OF-GRID SOLAR POWER PLANT

A rooftop PV system is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure. The various components of such a system include photovoltaic modules, mounting systems, cables, solar inverters and other electrical accessories.

Rooftop mounted systems are small compared to ground-mounted photovoltaic power stations with capacities in the megawatt range. Rooftop PV systems on residential buildings typically feature a capacity of about 5 to 20 kilowatts (kW), while those mounted on commercial buildings often reach 100 kilowatts or more.

Advances in wind and solar power over the years has seen major improvements to **off grid power** technology – it's now cheaper and more efficient than ever; so just because you're living in a remote location, doesn't mean you need to sacrifice creature comforts.

Design of Rooftop Standalone/off-grid Solar Plant

1. Salient features

- Investment cost for 1MW is about 4 Crores
- Area required for 1MW each is 3.5 – 4 acres
- Life of the equipment is 25 years
- Tariff as per Karnataka Electricity Regulatory Commission is 6.51Rs
- Generation/Annum/MW is about 1.5 million units
- Subsidy facilities are also available as per individual policy
- 10 years tax holiday is available for the revenue generated
- CDM benefits are available
- Whatever the Power generated can be used for capital purpose or selling to third party or the government
- Government lands are also available to setup solar or any other renewable energy power plant

2. Technical Specification and Calculations:

2.1 Technical Specification of Solar PV Module:

- Module type =RI 250
- Module capacity = 250W_p
- Solar PV technology = Polycrystalline
- Open circuit voltage (Voc) = 43V
- Solar circuit current (Isc) = 7.62A
- Max voltage (Vmax) = 35V
- Max current (Imax0 = 7.15A

2.2 Technical Specification of Grid – tie Inverter/Power conditioning unit

- Inverter capacity = 1000kW
- Min input DC voltage (Vmin) = 450V
- Max input DC voltage (Vmax) = 850V
- Permissible Voltage limit (Vper) = 950V
- Output AC voltage = 440V, 3phase, 50Hz

2.3 Technical specification of utility Grid system

- Utility grid Voltage = 11/33/66/110Kv

2.4 Technical Specification of Power transformer

- Primary voltage = 440V
- Secondary voltage = 11/33kV
- Transformer capacity = 1250kVA

Design and Development of 3.9MW Grid – Connected Solar Power Plant

Step 1: Solar PV Grid connected Power Plant Capacity

- Solar PV Capacity = 3900kW = 3.9MW
- Solar module capacity = 285 W_p
- Maximum voltage = V_{max} = 26V
- Open Circuit voltage = V_{oc} = 32V
- Maximum current = I_{max} = 7.7A
- Short circuit current = I_{sc} = 8.13A
- Maximum voltage (terminal) = V_{max} = 1000V

Step 2: Solar power grid tie inverter–power conditioning unit Capacity= PGPU =1000kVA

- VDC maximum permissible voltage = 900V
- VDC maximum voltage = 850V
- VDC minimum voltage = 450V

Step 3: Average of DC Input

(V_{max} &V_{min}) to GPCU = $(VDC_{max} + VDC_{min})/2$
= (850 + 450)/2 = 650V

Step 4: To generate required voltage to GPCU consider V GPCU AVG(string) = 650V

- Each Solar module maximum voltage = V_{max} = 26V
- To generate required voltage
- The total no of SPV module to be connected in series = V GPCU AVG/ V_{max}
  = 650/26 = 25 No = 1 string
- Total power generation per string
  = string voltage X maximum current I_{max}
  = P String = 650 X 7.7
  = 5005 W = 5.005 kW
- Capacity of GPCU = 1000 kVA
- Total no of strings connected in parallel
  = T_{string} = GPCU/ P string
  = 1000/5.005 = 199.80
- Total no of string = T_{string} = 200 No.s

Step 5: String and SPV modules as per inverter

- No of string = 1string
- Total no of module in each string = 25 no.s
- Total no of string per inverter = 200 no.s
- Total no of module used per inverter
  = (no of string X no of modules in a string) per inverter
  = 199.80X25
  = 4995.005 ~ 4995no.s
- Power generation based on the no of modules =(Total no of module X each module capacity) per inverter
  = 4995.005 X 285
  = 1423576.4 W = 1424kW_P

Step 6: Energy calculation

- Total installed capacity per inverter
  = 1424kW_P
- Total energy generation at 5hours per day per inverter
  = 7118 kWh/day
- Total energy generation per year per inverter

= 2598027 kWh/year =2.60MU

Step 7:DC and AC Power Generation Considering losses

- Total power generation - DC per Inverter = DC
  = 1424kW_P = 1765.2(considering 24% losses)
- Total losses = 24%
- Total power generation - AC per Inverter = AC
  = 1082 kW = 1424(considering 24% losses)
- Total no of string per Inverter = 200no.s = 248
- Total no of module used(no of string × no of module in a string) per Inverter
  = 4995.005 no.s = 6193.81
- Total no of Array Junction box required per Inverter = 200no.s = 248

Step 8: Total Major/Minor Equipments

- Total installed capacity = 3900kW = 4836
- Total no of Inverters = 4 No's = 4
- Total no of string = 547 No's =679
- Total no of module used(no of string × no of module in a string) =13684 No's = 16968
- Total no of String Box/Array Junction box/ String Monitoring Box Required = 547 No = 679
- Unit transformer capacity = 4875 kVA = 6045
- Proposed Unit Transformer = 4875 kVA = 6045
- Total No. Of Unit Transformer = 1 No
  Total Energy Generation = 7.12 MU

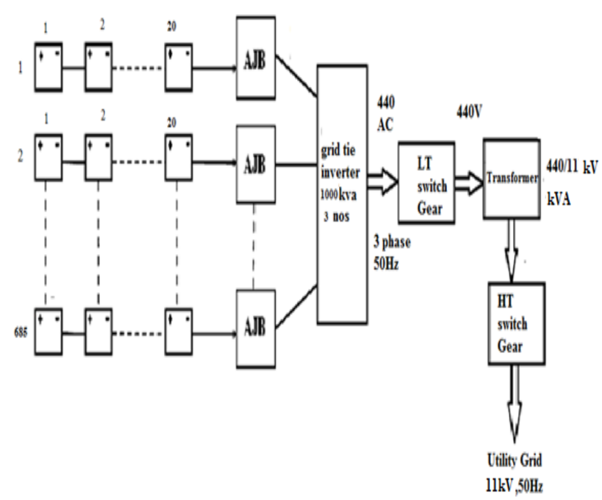

Fig 8: Design of 3.9MW grid connected solar PV power plant

Fig 9: 1 MW grid connected solar PV power plant

5. Conclusion

The functions of the measuring instruments and equipment used in a solar power plant were discussed. The different solar PV technologies and their functions are discussed in detail. The designing of rooftop standalone PV system and grid connected solar power plant was calculated for 3.9MW system.

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