Planing, Structure and Preparation of Cost Effective Sun Oriented Vitality Based Electrical Power Framework System at Alakh Prakash Goyal Shimla University, Himachal Pradesh

Vikas Sharma, Anand Mohan

Abstract: The vital reason behind this paper is to plan, structure and set up a perfect electric power age using feasible power source at Alakh Prakash Goyal Shimla University, Shimla. A daylight based crucial rate has been suggested that will cover the sun based power age cost, then again called the cost recovery program. Likewise one of the significant parts of this investigation is to diminish vitality utilization in Alakh Prakash Goyal Shimla University, Shimla; this paper endeavors to propose electrical power age with the utilization of sun powered vitality. The point was to show that sustainable power source can be a suitable elective hotspot for providing the required electrical power vitality. The photovoltaic power plant has a normal sun based radiation of 6.54 KWh/m² for most recent multi year. All out burden on college is around 200 KW and the college expends units between 40000 – 75000 units, bringing about a normal charging of INR. 2.0 – 3.5 Lakhs bill. After establishment of Solar PV modules power bill has been lessen by INR. 0.5-1.20 Lakhs.

Keywords: Solar energy, Photovoltaic cells, Tilt angle, Electrical power generation, Module efficiency.

I. INTRODUCTION: ABOUT SOLAR PANEL:

A sun based board is really a gathering of photovoltaic cells, which are used to make control through photovoltaic effect. This power is as radiation, the photon of light energize the electron

Fig.1. Different Layers in Photovoltaic cells

Cell of a sun oriented board cause to create power. Sun oriented boards are comprised of crystalline Silicon cells. Nowadays’ sun powered boards are utilized in wide-going electronic gear resembles divider light, Lantern adding structure light is mirrored on numerous occasions enabling approaching light to be utilized for all the more viably.

Fig.2. Pyramid Structure with Light Reflection

This survey of sun based photovoltaic structures will give the maker a fundamental appreciation of [1].
a) Assessing a structure site for its sun situated potential.
b) Common system related photovoltaic structure courses of action and sections.
c) Considerations in picking parts.
d) Considerations in plan and foundation of a photovoltaic system.
e) Typical costs and the work required to present a photovoltaic structure.
f) Building and electric code essentials.
g) Where to find more information.

1.1. STEPS IN SOLAR CELL PRODUCTION:

a) Construction of Photovoltaic: The field of Photovoltaic producing power with sand and salt. Sun powered vitality is final product of complex substance and physical procedures. In first step crude Silicon is separated from quartz sand, to use in PV industry, it is 99.99% unadulterated. To produce control photovoltaic, enterprises uses the semi-conducting properties of Silicon, in ovens crude Silicon is liquefied at a temperature of above 1400°C, a seed crystal is then submerged into the fluid Silicon crude material and pulled reinforcement in all respects gradually. In this procedure fluid Silicon lay up on the seed crystal and hardened and is currently cut into a rectangular shape of millimeter thin slices. The individual cuts are called as wafers and structure the base of sun powered cell. When they have been cut, and afterward put into wash tunnels, as littlest bit of biting dust can bargain sun oriented cell creation. Presently the wafer surface is level simply like a mirror, many beams of light is reflected back, so never again be utilized to produce power, to avert this reflection the surface is edged and roughened in chemical shower, bringing about pyramid structure with these pyramid tunnels, as littlest bit of dust can bargain sun oriented cell creation. Presently the wafer surface is level simply like a mirror, many beams of light is reflected back, so never again be utilized to produce power, to avert this reflection the surface is edged and roughened in chemical shower, bringing about pyramid structure with these pyramid structure light is mirrored on numerous occasions enabling approaching light to be utilized for all the more viably.
second step is diffusion; here a negative charged phosphorous layer is added to every wafer positively charged layer, in ovens warmed to fairly 900°C phosphorous atoms are infused with the assistance of nitrogen, a vaporeous phosphorous-nitrogen blend is stored on the wafer. The interface among positive and negative charge layer the free charge bearers made by the light are discharged. This creates an electric flow.

Figure 3. Diffusion Process in Silicon

Presently a stamp presses a Silver alloy onto the front of the cell this makes an average lattice design. This silver covering guarantees the power can be transported last on. The sun oriented cells are presently finished; they can create and transport control. In a procedure laminations cells are gathered behind a glass, subsequently they are shielded from the components for over 25 years. One module may contain 60 cells. At the point when various modules are associated with each other sun based power plant is made and control is created from the sun and the sand.

1.2. Working of Solar Cell:

One Hi-tech technique utilizes Solar cells to create power, when daylight strikes certain material to produces a little measure of electric flow through photovoltaic impact. The capacity of a sunlight based cell depends on the material called Silicon (Si). Silicon is the second most regular component in earth’s outside. In the periodic table of the elements, Silicon just underneath the carbon and guarantees numerous carbon highlights. The dot diagram as shown in fig.4 shows key highlights of Silicon.

Fig.4. Dot Diagram of Silicon

Carbon and Silicon each have 4 valence electrons. By sharing valence electrons a Silicon particle can bond with four other Silicon molecules. Along these lines main atom basically gets four external shells of 8 electrons. As a result of a four external shell is an increasingly steady design, accordingly silicon atoms joined to frame large Silicon precious crystals. Silicon crystals structure the bases of sun oriented cells.

In the event that the voltage is connected to the precious crystal the free electrons and holes relocates inverse way in electric field to appositively charged poles. This may speak to a little current stream. Rather than Silicon, a genuine channel, for example, copper (Cu) has considerably more failure hold on its electrons and with the voltage connected an expansive current will course through the copper wire as appeared in figure underneath. As sun oriented cell has explicit contaminations resulting N-type and P-type side.

In P-type side: some Silicon particles are swap with Boron (B) atoms. Therefore seven as opposed to 8 electrons are shared among Boron around the Silicon molecules in courses of action that is unstable.

In N-type side: it contains Phosphorous instead of some Silicon molecules. In P-N intersection the additional electron from Phosphorous endeavor to fill openings in nearby Boron atoms, along these lines electrons stream from N side to P-side. As electron leaves the Phosphorous atoms it abandons an unbalance charged on the Phosphorous particle. As positive and negative charges are isolated from one another, the voltage or electric field creates at the intersection known as depletion zone.

Fig.6. Flow of Current in Silicon Wafer and Copper Conductor

Presently think about a sun oriented cell is in a circuit with a load. At the point when photons of light strikes the crystals the vitality might be sufficient to thump the free electrons of the atoms, accordingly negative charged free electrons leaves positive charged openings in the gem. The free electrons endeavors to fill accessible gaps this may happen in couple of various ways.

- Electrons may essentially recombine with adjoining openings in the N-layer.
- Alternatively electron may endeavor to fill the numerous openings in the P-layer; anyway the bank of negative charges on the P side of exhaustion zone forestalls the contrarily charged electrons to going legitimately through it. This is the focal element of a sunlight based cell.
1.3. Daylight Based Photovoltaic Systems: Outline of cardinal Unit-

The difference in sun orchestrated scattering to useful electric power is a procedure of high concentrated all-round design. Photovoltaic modules are the focal point of the structure. This article will delineate the essential parts of a daylight based photovoltaic structure [2].

1.3.1. Photovoltaic Array: This is the focal point of the structure [3], made out of a couple of sun arranged modules which are accordingly made out of daylight based cells. Each sun controlled cell is an individual commission unit, which makes charge energy at whatever point it gets light. It is vital an observation that sunlight based photovoltaic modules produce charge energy in any light source. Crystal clear silicon Photovoltaic section makes larger part out of the photovoltaic wholesale. Utilizing substantial that is fit for giving a voltage yield in light of occasion light.

1.3.2. Batter Bank: Sun based PV structures hardly produce crucial energy now and again when it isn't needful. Like a bare house is right off production. In the event this occurs, the superfluous energy can be sold-out or set away in batteries. There are two essential clarifications behind using battery accumulating is expanding funds and battery reinforcement.

1.3.3. Potentiality work Out Unit: This bit of the system has three basic limits [4]:

a) Giving assurance against electric issues, for example, S.C. (short-circuits) or L-G (line-to-ground) imperfections. It is normally bored with warm appealing circuit breakers, which are open for D.C. (Direct Current), rotating current.
b) Joining energy supply generated by Photovoltaic unit and changing over an electrifying power supply that can integrate with the electric benefit or to control home appliances.
c) Controlling centrality information and yield of battery stock, by systems for a charge controller. On the off chance that the structure doesn't utilize batteries, this fragment is neglected.

1.3.4. D.C. and A.C. Disconnects:

Programmed and manual wellbeing separates shield the wiring and segments from power floods and other gear glitches [5]. They likewise guarantee the framework can be securely closed down and framework parts can be expelled for support and fix.

1.3.5. Main A.C. panel: This is the zone of each electric load in the structure are related, and guaranteed with circuit breakers. At the point when the yield from the Photovoltaic system has been changed over to A.C. force of the acceptable frequency.

1.3.6. Energy Meter: At the point when Photovoltaic frameworks are executed, the metering device must be modeled with final metering limits. That is, the meter ought to without a doubt check the vitality stream and its bearing. This permits the passed on energy to be subtracted from the ate-up energy when the home credit holder is charged by the electric organization affiliation.

II. FACTORS BEHIND ASSESSING SOLAR PHOTOVOLTAIC POTENTIAL:

1.4. Assessing Structure Site: The proposed site found is at A P Goyal Shimla University, Mehli-Shoghi Bypass Road, District Shimla, Himachal Pradesh 171009, Latitude 31.0628° N and Longitude 77.1648° E, Shimla is a standout among the peerless global University in Shimla, Himachal Pradesh that endeavor distinctive Learner and Alum courses, like Bachelors and Masters courses and also in the field if Legal studies and Journalism. The site is all around connected with road and airplane terminal. There is no wild life announced around there and this territory has no wellbeing dangers made due to sun based solar plant as it is eco inviting and very much associated with adjacent emergency clinics. There is no archeological and history of this spot.

Fig.7. Flow of Electron through Connected Load

Fig.8. Different Components used in Photovoltaic System

Fig.9. Site of Alakh Prakash Goyal Shimla University
1.5. Mounting Location: Sun put together units are commonly mounted with respect to housetops. If housetop zone isn’t open, photovoltaic units can be shaft, ground and divider mounted or presented as a part of a dusk skeleton.

1.6. Overshadowing: photo floods exhibits an inimically impacted by shading. A well-organized Photovoltaic structure needs clear and unhindered access to the sun’s shafts from around 09:00 to 15:00 hours reliably. Without a doubt, even little shadow would altogether be able to reduce the power yield of a sun based module even shading from the structure itself

1.7. Dome Types: For housetop mounted systems, ordinarily course of action shingles are less difficult to work with and slate and tile housetops are the trickiest. To present Photovoltaic modules on all housetop types, will require supplanting inside 8 -12 years, it should be displaced at the time the PV system is acquainted with evade the cost of removing and reinstalling the PV structure.

III. SOLAR POWER CALCULATIONS FOR ALAKH PRAKASH GOYAL UNIVERSITY:

A 4 Blocks, each 5 stories building has been selected in University. As University campus is spread in approx. 36 Bighas, out of which only the unused rooftops of building has been considered for installation of Solar system.

Table1. Solar panel Specifications

| Module Type | ASP-7-320 |
|-------------|-----------|
| Maximum Power (P_{mp}) | 320 Watt |
| Open Circuit Volt. (Voc) | 44.97 Volts |
| Short Circuit Curr. (Ioc) | 9.18 Amperes |
| Power voltage(Maximum) (Vmp) | 36.85 Volts |
| Power Current(Maximum) (Imp) | 8.65 Amperes |
| System Voltage(Maximum) | 1000 Volts |
| Maximum Resistance | 15 Amperes |
| Fuse Rating | 0-4.99 Watt |
| Power Tolerance | 1960×992×35 |
| Dimensions | 21.7 Kg |
| Class | Class A |

1.8. Tilt Angle Calculation: Tilt: The Tilt edge of the photovoltaic (PV) exhibit is the way to an ideal vitality yield. Sun oriented boards or PV exhibits are most proficient, when they are opposite the sun's beams. So as to augment the board effectiveness, we need to change the tilt angle β, to get extreme radiation by altering the tilt angle β, to get extreme radiation by altering the tilt angle β. In any case, because of the expanding cost and multifaceted nature have utilized a still tilt point to generate most vitality over the entire season utilized for ascertaining the tilt point is given by equations [6].

\[ \beta = 0.76 \times \phi + 3.1^\circ \] …………..Eqn.1

Where \( \phi \) = Topographical latitude.

Shimla Topographical latitude, \( \phi = 31.10^\circ \).

So the ideal tilt edge of this area is \( \beta = 0.76 \times 31.10 + 3.1^\circ = 26.73^\circ \approx 27^\circ \)

1.9. Distance between Row’s Calculations:

Fig.10. Row Spacing between Two Photovoltaic Modules

1.10. Determination of Module Efficiency:

So as to compute the array effectiveness, the accompanying recipe given beneath is utilized [7]:

\[ \eta = \frac{I_{sc} \times V_{oc}}{P_{in}} \times FF \] …………..Eqn.4

\[ FF = \frac{I_{mp} \times V_{mp}}{I_{sc} \times V_{oc}} \] …………..Eqn.5

Where, \( \eta \) = Efficiency of Module,
\( I_{sc} \) = Current (Short Circuit)
\( V_{oc} \) = Voltage (Open Circuit)
\( FF \) = Fill factor,
\( V_{mp} \) = Operating voltage (Optimum),
\( I_{mp} \) = Operating current (Optimum),
\( P_{in} \) = solar power (Input) [9].

For the above work, 320W monocrystalline module fabricated by Adani (Dimensions of the module: 1.960m × 0.992m × 0.035m) has been used. From specifications printed by manufacturer, we concluded that:

\[ P_{in} = 1000 W/m^2 \times \text{Module area (m)} \] …………..Eqn.6

\[ = 1000 \times 1.960 \times 0.992 = 1944.32 \text{ Watt} \]

\[ FF = \text{Fill factor} = 0.7721 \approx 0.77 \]

\[ \eta = 0.1634 \approx 16.34 \% \]

1.11. Output Power Calculations of Module:

The month to month normal yield control from a sunlight based module and the all out framework yield can be determined from the accompanying equations [6].

\[ P_{pv} = Y_{pv} \times f_{pv} \times (G_{T} / G_{T_{stc}}) \] …………..Eqn.7
Where, \( Y_{PV} \) = Evaluated limit of Photovoltaic cluster (which means its capacity yield under standard test conditions in kW)

\( t_{PV} \) = Framework (derating factor) = 0.8

\( G_T \) = radiation intent on array in the mean time (kW/m^2),

\( G_{T,STC} \) = Intent radiation (S.T.P.= 1 kW/m^2).

Table 2. Monthly average Cosmic Energy Incident from Solar Array

| Month   | Average cosmic energy incident / (KWh-Hr/m^2/day) | Average cosmic energy incident/KW/m^2 | Blue print of OP/power from system (KW) |
|---------|---------------------------------------------------|--------------------------------------|------------------------------------------|
| Jan-18 | 3.75                                              | 0.156                                | 95.74                                    |
| Feb-18 | 4.06                                              | 0.169                                | 103.66                                   |
| Mar-18 | 5.39                                              | 0.225                                | 137.62                                   |
| Apr-18 | 5.38                                              | 0.224                                | 137.36                                   |
| May-18 | 6.01                                              | 0.250                                | 153.45                                   |
| Jun-18 | 5.43                                              | 0.226                                | 138.64                                   |
| Jul-18 | 4.34                                              | 0.181                                | 110.81                                   |
| Aug-18 | 4.23                                              | 0.176                                | 108.00                                   |
| Sep-18 | 4.33                                              | 0.180                                | 110.55                                   |
| Oct-18 | 4.91                                              | 0.205                                | 125.36                                   |
| Nov-18 | 3.32                                              | 0.138                                | 84.77                                    |
| Dec-18 | 3.21                                              | 0.134                                | 81.96                                    |
| Jan-19 | 2.39                                              | 0.100                                | 61.02                                    |
| Feb-19 | 2.71                                              | 0.113                                | 69.19                                    |
| Average | 0.177                                           | 108.44                                |                                          |

As the temperature coefficient of intensity is little, we determined the framework yield dismissing the impact of temperature.

Rated capacity of PV module = 320 W
Numbers of modules mounted = 352 panels

While considering an operating factor for system as 0.85, then [2]

Genuine power yield of a PV board = Peak control rating \( \times \) operating factor = 320 \times 0.85 = 272 W

Vitality created by one board in multi day = Genuine power yield of a PV board \( \times \) 8 hours/day = 272 \times 8 = 2176 W = 2.176 KW

Total solar energy produced by system = Vitality created by one board in multi day \( \times \) no. of panels installed.

\[ \text{Number of sunlight based boards required to fulfill given evaluated every day load:} = (\text{Total watt-hour rating of the system}) \times (\text{Number of panels}) \]

\[ = 2176 \times 352 = 765952 \text{W} = 765.95\text{KW} \]

Total watt-hours rating of the system = Total connected load (watts) \( \times \) Operating hours = 200000 \times 8 = 1600000 Wh

Therefore, \( Y_{pv} \) = Rated capacity of PV arrays = 765.95KW

As, for the month of January, \( G_T \) = 0.156 kW/m^2 (From Table 2.)

Along these lines, to figure the normal yearly sunlight based generation, thinking about 8 hours of activity in multi day, however consequently aggregate of 2920 hours of activity in a year.

The average cosmic energy yielding/year = 108.44 \times 2920 = 316644.8 KWh.

2. Load Analysis:

Total connected load in university is 200 KW; from the survey number of electrical equipments with their consumptions and month to month power bills for peculiar year is considered.

From the gathered information normal utilization in university is determined as:

Table3. Normal Energy Avail every Spell in University

| Energy Consumed Month wise in the University | Year | Mont h | Total energy consumed for whole university (KWh) | Tariff Rs/ KWh | Amount in Rs | Meter rent/month (Rs.) | Total Cost (Rs.) |
|---------------------------------------------|------|--------|-------------------------------------------------|---------------|--------------|-----------------------|-----------------|
| 2018 Jan                                    | 4.7  | 352156.9 | 150 352307                                      |               |              |                       |                 |
| 2018 Feb                                    | 4.7  | 328125.8 | 150 328276                                      |               |              |                       |                 |
| 2018 Mar                                    | 4.7  | 260770.1 | 150 260920                                      |               |              |                       |                 |
| 2018 Apr                                    | 4.7  | 251379.5 | 150 251530                                      |               |              |                       |                 |
| 2018 May                                    | 4.7  | 190462.8 | 150 190613                                      |               |              |                       |                 |
| 2018 Jun                                    | 4.7  | 200473.8 | 150 200624                                      |               |              |                       |                 |
| 2018 Jul                                    | 4.7  | 193912.6 | 150 194063                                      |               |              |                       |                 |
| 2018 Aug                                    | 4.7  | 191543.8 | 150 191694                                      |               |              |                       |                 |
| 2018 Sep                                    | 4.7  | 209225.2 | 150 209375                                      |               |              |                       |                 |
| 2018 Oct                                    | 4.7  | 221736.6 | 150 221887                                      |               |              |                       |                 |
| 2018 Nov                                    | 4.7  | 240867   | 150 240837                                      |               |              |                       |                 |
| 2018 Dec                                    | 4.7  | 254600.7 | 150 254801                                      |               |              |                       |                 |

Number of units consumed (Average, 1 year) = 51332 units
Average expenditure = 51332 \times 4.7 = Rs. 241260.

Total Average expenditure = 241260 + 150 = Rs. 241410.

After commencement of solar system reduced energy consumption has been observed in the month of January and February 2019.

Table4. Average Energy Consumed per Month after Installation of Solar system in University

| Ye ar | Mont h | Total energy consumed for whole university (KWh) | Tariff Rs/ KWh | Amount in Rs | Meter rent/month (Rs.) | Total Cost (Rs.) |
|-------|--------|-------------------------------------------------|---------------|--------------|-----------------------|-----------------|
| 2019  | Jan    | 57208                                          | 4.7           | 268877.6     | 150                   | 269028          |
| 2019  | Feb    | 59210                                          | 4.7           | 278287       | 150                   | 278437          |

3. Cost Recovery Scheme:

Number of sunlight based boards required to fulfill the demand of energy consumption = 765952 W / 272 W = 2820 panels

= 1600000/2176 = 735 panels

4. Therefore, \( Y_{pv} \) = Rated capacity of PV arrays = 765.95KW

As, for the month of January, \( G_T \) = 0.156 kW/m^2 (From Table 2.)

Along these lines, to figure the normal yearly sunlight based generation, thinking about 8 hours of activity in multi day, however consequently aggregate of 2920 hours of activity in a year.

The average cosmic energy yielding/year = 108.44 \times 2920 = 316644.8 KWh.
4.1. Calculation of Cost- Capital Cost for installed Solar power system in University is calculated as:

Table5. Capitalized Calculation of the Schemed Cosmic Energy

| S. No. | Name of Item | Unit | Unit Cost (Rs.) | Total Cost (Rs.) | Ope- | Operation & Maintenanc- | Net total expen | Ope- | Operation & Maintenanc- | Net total expen | Cost Balancing |
|--------|---------------|------|-----------------|------------------|----|--------|----------------|----|--------|----------------|--------------|----------------|
| 1      | Adani Solar PV Array | 35 2 | 8543           | 300713           | 6% | 60143  | 30672         | 2% | 11200         | 57120         | 124018.9       |
| 2      | Delta 30 KW Solar Inverter | 4   | 1400 00 | 560000         | 2% | 960000       | 49600          | 2% | 392           | 19992         | 4.70           |
| 3      | PV combin er Box | 4   | 4900       | 19600           | 2% | 960000       | 49600          | 2% | 392           | 19992         | 4.70           |
| 4      | Fuse Box       | 4   | 1200       | 4800            | 2% | 960000       | 49600          | 2% | 392           | 19992         | 4.70           |
| Average |                |      |               |                 |    |               |                |    |               |                | 124018.9       |

In the above table system running and operating cost has also been considered, the Operation & Maintenance cost of solar system varies between 1-3% [10-11] of Capitalized price/year over 20-25 years.

4.2. Cost Balancing:

Photovoltaic panels have an average life span of 20-25 years. Their esteem and wattage yield decline relentlessly after some time. So on average a solar system life span is considered here as 20 years.

Table6. Calculation of Per Unit Cost of Solar Electricity

| Sr. no. | Findings                        | 20 years of life span for solar system |
|---------|---------------------------------|---------------------------------------|
| 1       | Average annual depreciation value | Rs. 183168.35                         |
| 2       | Operation & Maintenance cost    | Rs. 71831                             |
| 3       | O & M + Depreciation costs      | Rs. 254999.35                         |
| 4       | Average Solar energy production/year | 316644.8 Kwh                         |
| 5       | Average Solar energy production/month | 26387 units                       |
| 6       | Entity amount of Solar electricity = (O & M + Depreciation costs)/(Average Solar energy production/year) | Rs.0.80 |

4.3. Cost Benefits: The University consumes average of 51332 units per year from the utility. The latest tariff plan imposed on university by Electricity board is Rs 4.70/unit

Table7. Cost benefit analysis due to installed solar PV modules

| Solar generation units (Average) | Solar generation @ Rs. 0.80 | If purchased from Govt. @ Rs. 4.70 | Net savings (Rs.) |
|---------------------------------|-----------------------------|------------------------------------|-------------------|
| 26387                           | 21109.65                    | 124018.9                           | 102909.25         |

If we compare it with previous electricity bills, then the finds are as follows:

Table8. Cost Benefit after Installation of Solar System

| Yearly Montly | Total energy consumed by university (KWh) | Saved units | Tariff if not in Rs/KWh | Amount in Rs | Total Savings (Rs) |
|---------------|-------------------------------------------|-------------|------------------------|--------------|--------------------|
| 2018 Jan-Feb  | 144471                                   | 28323       | 4.70                   | 680282       | 133118             |
| 2019 Jan-Feb  | 116418                                   | 28323       | 4.70                   | 547164       | 133118             |

Conclusion

In this study Alakh Prakash Goyal Shimla University, Shimla is overviewed and normal power utilization for a year has been determined. Study has been done to evaluate the specialized and financial arability in university by methods for Photovoltaic control plant for gathering vitality request. For this a fresh project has been installed on the vacant rooftop to get new power connection for different utilities. Following conclusion can be made from study:

- It has been observed that this particular area gets an average of 6.54 KWh/m² of solar radiation and 8-9 hours of sunshine hours.
- Average solar energy production per year is 316644.8 KWh, and it resulted in avoiding tones of Co₂ emissions.
- It is observed from the tables, that net saving of Rs. 0.5 - 1.20 lack has been achieved every month.

REFERENCES

1. R. P. D. Carolyn. Ph.D., “Solar Electric System Design, Operation and Installation,” no. October, p. 35, 2009.
2. S. P. V. Systems, M. Components, and E. Efficiency, “Solar PV Systems: Overview of the Main Components - Wiki - Energy Efficiency,” pp. 2-5, 2019
3. M. Aghaee, Y. H. Md Thyooob, M. Imamzai, P. Piyous, and N. Amin, “Design of a cost-efficient solar energy based electrical power generation system for a remote Island - Pulau Perhentian Besar in Malaysia,” Proc. 2013 IEEE 7th Int. Power Eng. Optim. Conf. PEOCO 2013, no. June, pp. 203–208, 2013.
4. S. Kumarappa and H. Naganagouda, “Design and Development of 5MW Solar PV Grid Connected Power Plant Using PVsyst,” Int. Res. J. Eng. Technol., pp. 778–785, 2017.
5. M. Chakravarty, K. V. R. Murthy, and B. N. Devi, “Design, erection, testing and commissioning of 200Kwp rooftop grid tied solar photovoltaic system at Vasavi College of engineering,” Proc. - 2015 IEEE IAS Int. Ind. Commer. Power Syst. / Pet. Chem. Ind. Conf. ICSPSICIC 2015, pp. 146–152, 2017.
6. P. Roy, Y. Arafat, M. B. Upama, and A. Hoque, “Technical and financial aspects of solar PV system for city dwellers of Bangladesh where green energy installation is mandatory to get utility power supply,” 2012 7th Int. Conf. Electr. Comput. Eng. ICECE 2012, pp. 916–919, 2012.
AUTHORS PROFILE

Er. Vikas Sharma is perusing Post-Graduate (M.Tech, Power System, EE) course from the Department of Electrical Engineering, under the School of Technology and Sciences at Alakh Prakash Goyal Shimla University, Shimla (INDIA). He has got his B.Tech in the field of Electrical Engineering from Himachal Pradesh Technical University (HPTU), Hamirpur, India. Also got his Diploma in Electrical Engineering from Himachal Pradesh Takniki Shiksha Board (HPTSB) Dharamshala, Himachal Pradesh, India. He has one year experience in the field of maintenance in pharmacy sector.

Dr. Anand Mohan is currently working as Professor in the department of Electrical Engineering under the School of Technology and Sciences at Alakh Prakash Goyal Shimla University, Shimla (INDIA). He is also taking care of School of Technology and Sciences as Dean. He has more than 15 Years for academic, administrative and industrial experience in various renowned organizations of India. He has written more than 15 research manuscripts in International and National Journals and He has been the reviewer of many journals of repute in India as well as abroad. He has got his Ph. D in the field of Power System Engineering from University of Petroleum and Energy Studies, Dehradun, India.. Recently has been invited as Speaker in the International Conference on Machine Learning and Intelligent Systems (MLIS 2019) at National Dong Hwa University, Taiwan. He also speaking in the 6th Annual World Congress of InfoTech-2019, with the theme of “Launch a New Era of 5G and Global Future Network”. that will be hold during May 10-12, 2019 at Nanjing, China. He was the Special invited member of Board of Studies of Electrical Engineering for HPTU, Hamirpur.