 ISSN: 2454-4248
72 – 77

# Rooftop Solar Photovoltaic for CSIR-NPL at New Delhi: A Case Study

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***Abstract*** **-** Solar energy is an abundant and renewable energy source and the annual solar energy incident at the ground in India is about 20,000 times the current electrical energy consumption. The use of solar energy in India has been very limited. The average daily solar energy incident in India is 5 kWh/$m^2$ days, which can be utilize in electricity generation. There are many solar installations are already operational in India, however, due to the inefficient solar panels and their geometry limited the efficiency in terms of conversion of sunlight in to high unit power generation. In the current work, reduced the need of land to install the solar panel in the small area rather than existing larger area and increase solar panel efficiency in term of unit generation. A case study has been carried out by taking various kinds of panels (static and rotation/tracking) and 15 to 18% efficiency for static panel and 40 to 45% for tracking panel. This enhancement in efficiency was mainly due to the design and developed tracking solar panel with Light Dependent Resistors.

***Keywords***-*Solar Energy; Roof tops; Solar Photo Voltaics,Solar panel Tracker*

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## I. INTRODUCTION

India ranked third biggest consumer of the power in the world in term of energy demand. Thermal generation from exhaustible fuels such as coal, gas and oil, has the major share of total electricity generation in India. Among the commercial energy sources, coal accounts for 50% of the current energy source followed by oil (31%), natural gas (8%), and hydro (10%) and nuclear (1%) while the other renewable sources (solar, wind, biomass etc.) have a little share in the total energy production. Presently with increasing cost of fossil fuel and environmental concern solar, hydro, wind and biomass based power is commercially attractive.

Solar energy is considered an unlimited source of renewable energy. The solar energy is basically two type passive solar or active solar depending on the way they received and distributed solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic solar cell, concentrated solar power and heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. The India receives 5 to 7 kwh/$m^2$ solar energy in one year. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. With the growing demands for the energy, the Indian Government has also made significant efforts in developing the solar as an upcoming source for energy crises in the area of solar power. Development different Indian regions are growing with various solar project based on sharing the high electricity loads via installing solar power plants in the Government and commercial buildings. With the vision for the clean energy production through solar, Government has taken the significant initiatives for the solar power in various regions of the country with enormous funding proposals available for the solar power projects. In view rising demand for energy the vision for the alternative sources need the full implementation before energy crises. It is expected that the difference in demand and supply of electricity in Delhi that could rise in coming years, as a consequence of which the average electricity prices would eventually expected to be increase very fast in Delhi. Thus the need for the renewable and affordable source of energy is of the primary importance. Among which solar is the finest choice particularly for India in accordance to the available solar irradiance per year.

CSIR - National Physical Laboratory, New Delhi, is a national research & development laboratory under the Council of Scientific & Industrial Research (CSIR), Ministry of Science & Technology (Govt. of India) involved in multidisciplinary R&D programmers of both basic and applied nature across scientific disciplines for economic, environmental and societal benefits.

In NPL since most of the land is covered with the forest and the trees moreover the rooftops of the small area buildings are almost shaded thus cannot be suitable for the effective working of a rooftop PV Plant. Thus a survey for the selection of available shade free rooftop surface has been made in NPL on the basis of which some of the buildings were selected for further estimation of the financial saving and initial investment of the solar project.

 ISSN: 2454-4248
72 – 77

## II. SELECTION OF ROOFTOP SITE

The satellite image of the NPL with marked locations for PV installation is represented in Fig.1 where one can clearly see that only the specified locations are uncovered under forest area that is why chosen for present study. Out of the many existing locations for PV installation in NPL the rooftop of clean room complex is in having a slope mounting at an angle of ~ $5^o$. In accordance to the latitude for Delhi i.e $28^o$ N the tilt angle of the panel during installation is required to be so adjusted to minimize the solar losses in terms lost radiations. Therefore, the optimum tilts angle for Delhi lies below $28^o$. Further to note that, the barrier in front of the vision of expected solar power implementation Government has offered different solar plans in terms of attractive subsidies and proposals to initiate the participation of large number of Indian population towards the solar mission for clean and green energy. Under these schemes recently the benefit of solar power can be avail via most commonly adoptive methods under specified model for solar plants described in literature [1-4].


*Fig. 1: Identified places at NPL campus by satellite image*

## III. OBJECTIVES

- To propose a new approach, a new modal will be explained to arrange the solar panels in such a way which reduce the need of land.
- To investigate the improvement in the land use of solar panels, measurement of land would also be carried out along with having an eye on the consistency of solar panel's efficiency. The observation would be used to existing and proposed method.
- To analyze the different aspects i.e. Economic, social and environmental aspects of solar panels, it will prove the significance of the proposed model in our society.Maintaining the Integrity of the Specifications

## IV. SELECTION OF SOLAR PANELS AND MODELS

The current trend is to use the solar energy for generating electricity with the help of grid-tie roof top solar system. But due to improper harvesting technique, efficiency of this system is very poor. Therefore, different types of techniques have been developed. One of such techniques is the use of solar tracker which is very popular today. As we know sun is continuously changing its position in a day, the incident light on solar panels may vary accordingly, thereby varying the efficiency of the system. Hence, design and construction of a prototype for solar tracking system with single degree of freedom, which detects the sunlight using the Light Dependent Resistors (LDR) is most important. The control circuit for the solar tracker is based on an microcontroller. This is programmed to detect the sunlight through the LDRs and then actuate the stepper motor to position the solar panel where it can receive maximum sunlight. Compared with any other type of motor, the stepper motor is more controllable, more energy efficient, more steady and has high tracking accuracy and suffers little environmental effect. By using this system, precise automatic tracking of the sun and can greatly improve the utilization of solar energy.

Currently, there are two types of solar rooftop models are available. (a) CAPEX model, in which consumer have invest full capital cost of solar power plant and avail subsidy as per Govt. of India MNRE scheme which is available as per area of zone fall where CAPEX model is installed basically CAPEX model is suitable for Consumers who have suitable staff, Knowledge & expertise in operation as well as maintenance, Suitable roof top shad less area, Availability of fund initially and finally consumer have avail benefit of net metering in case of not use or excess power generation ..

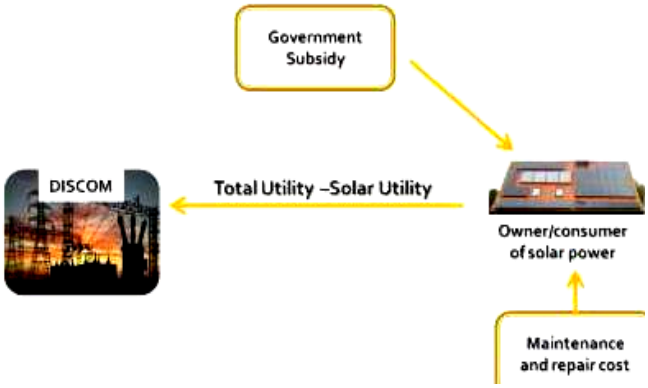


*Fig. 2: Layout for the energy transfer processing under CAPEX Model.*

(b) Renewal service company model means RESCO model. In this model, renewal service company provide supply, installation, testing and commissioning of solar plant and made contract agreement between consumer and service provider company on the basis of purchasing power agreement (PPA) for the time period of 25/20/15 year .In this agreement

 ISSN: 2454-4248
72 – 77

service provider company also take care of operation and maintenance of solar plant for said period. RESCO model is suitable for consumers who have less expertise in operation & maintenance of solar plant, consumer is not capable to invest capital cost of solar plant, consumer have to pay monthly basis(bill basis) not instantly pay capital cost. Further, consumers have free to any liability like solar panel security, maintenance etc., It is suitable for industries, office and commercial place. By going through the above said models,

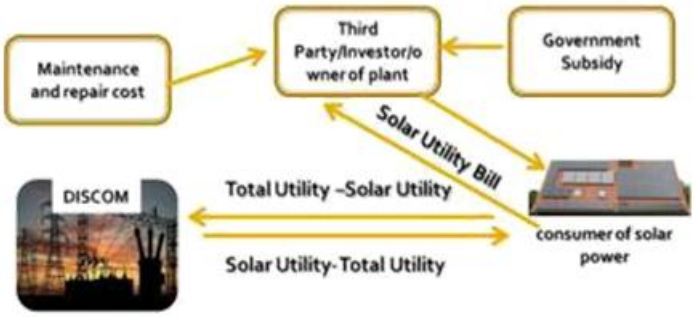


*Fig. 3: Layout for the energy transfer processing under RESCO Model.*

In the current study, we are proposing new RESCO Rooftop Solar Photovoltaic Model as a solar tree structure which is mounted 04 Nos. 250W Solar panel at tree branches and each solar panel is rotating by actuator motor for solar tracking system with one LDR (2 axis) . This model reduces 100 times less land area & increase solar power efficiency in term of unit generates. Further cost is also reducing in term of land, without battery bank (RESCO model).

## V. PROPOSED METHODOLOGY AND WORK PLAN

1. Understand the gaps in the existing models of solar panel.
2. Understanding, compiling and suitably presenting information and experience obtained through literature.
3. Problem selection and problem definition.
4. Recognize the tools, apparatus and equipment required for work
5. Setting up of equipment, method and technique.
6. Workout the experiments
7. Trial run and finalization of method.
8. Recoding of parameter of solar power
9. Compare of solar power data.
10. Conclusion.
11. Presentation of the result.

## VI. FABRICATION OF SOLAR PANEL TREE STRUCTURE

A Single pole made with M.S. pipe of 3"diameter and about 6 feet in height with fixing of suitable size of base plate and four nos. Solar PV Panel 250 Watt is mounted at tree branches (stem) as shown in Fig. 4. Each 250 watt solar PV Panel rotate by actuator motor using one LDR System as a solar panel tracker system

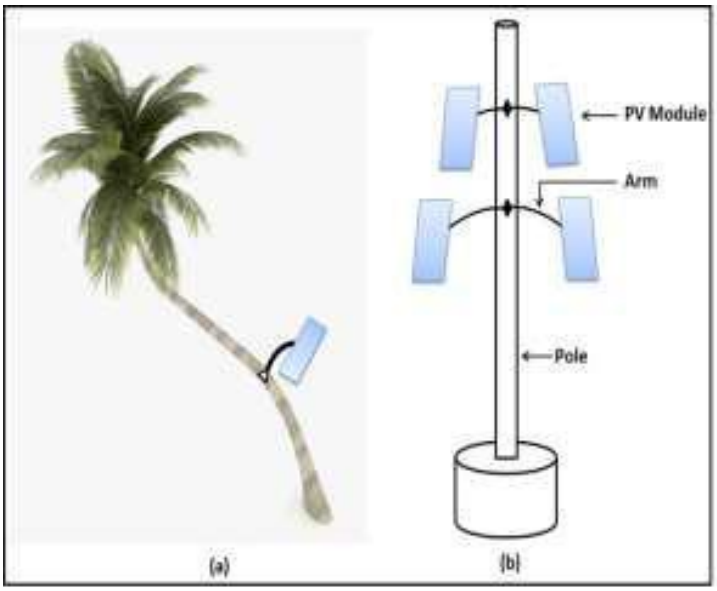


*Fig. 4: Solar tree structure roof top model*

Solar tracker provides one LDR (two-axis) of operation and control mechanism by the programmed written in microcontroller (Fig. 5). The operation of the dual axis tracking system totally depends on the light dependent resistor (LDR) which is used as a sensor whose resistance decreases with increasing light intensity. The fully control linear actuator motors are incorporated for the rotation (Fig. 6) of the solar panel in two different axes,

(a) *Day light condition:* - one photo resistor is used in the solar tracker to compare the output voltages parameter at junctions, where the sun rotates from east to west in the day time, small controller needs to provide higher voltage than LDR to sense the rotation of the sun. That condition is happen as normal day light condition and tracker rotates the panel as per one LDR signal.

 ISSN: 2454-4248
72 – 77


*Fig. 5: (a) Rotating solar panel of 1 Kw with one LDR (dual axis) (b) Static solar panel of 1 Kw installed at CSIR-NPL, New Delhi*

*(b) Bad weather light condition:* - When the sky gets cloudy, which will be less striking of light on the photo resistors and so sufficient voltages might not be available at junction point. The difference of voltage at junction point will not be greater than the threshold value to rotate the tracker. At the meantime, sun continues rotating in the western direction. To solve this problem, I can use the two axis system

(c) *Both directional rotation:* - At day time, the solar tracker will rotate in only east to west. Variable *I* will count the total rotation in day time and that is approximately calculated as 25 rotations considering 115° rotation. When the sun sets, no more rotation is needed in western direction. For the next day, the solar panel will be going to the initial position in the morning to track the sun's position again. When it goes to initial day morning position, power supply to the tracker will be turned off and the tracker will be in stand by till sunlight in the next morning.

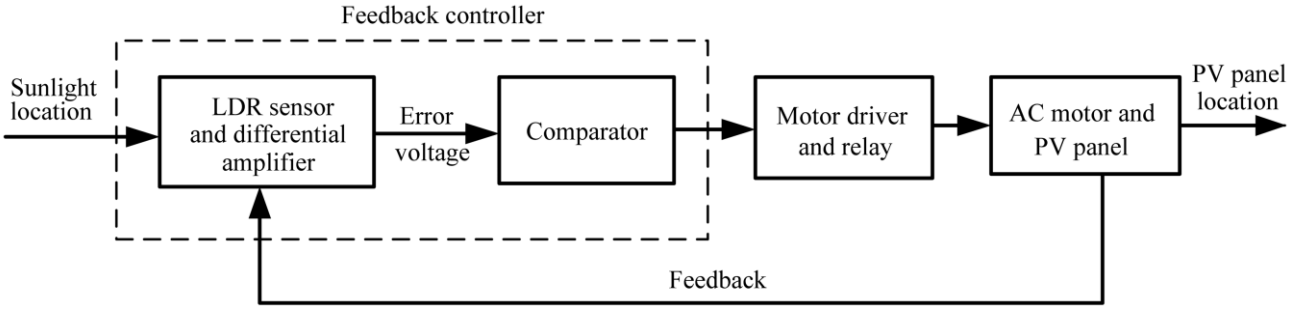


*Fig. 6: The operation of the dual axis tracking system totally depends on the LDR*

## VII. RESULTS AND DISCUSSION

Finally, the results were obtained from a 1000 watt solar panel which was mounted to a solar tree shape structure, while the panel attached to the moving (tracking) panel and the secondly, when attached to a fixed (non-tracking) panel. These results were taken over a period of sunny days 10th July 2018 The results were obtained satisfactorily, and were as shown in the Tables 1 and the comparison between tracking and non-tracking panels are shown in Fig. 7.

 ISSN: 2454-4248
72 – 77

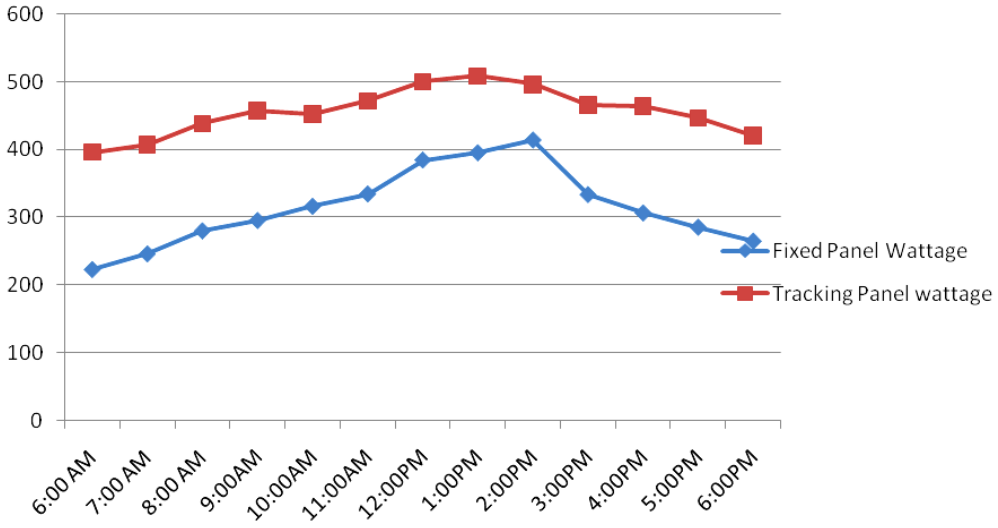


*Fig. 7: Units generate graph between fixed and tracking solar Panel.*

Further to note that, the proposed new solar panel tree structure land area for solar roof top panel is reduce 100 times in term of existing model ;i.e,5 KW solar panel required land area only 4 sq feet where existing model is required land area is 400sq feet.

TABLE 1: RESULTS OF 1 KW SOLAR TREE SOLAR TREE SHAPE STRUCTURE, WHILE THE PANEL ATTACHED TO THE MOVING (TRACKING) PANEL AND THE SECONDLY, WHEN ATTACHED TO A FIXED (NON-TRACKING) PANEL

| **Time of Day** | **Voltage across the Load** | | **Current through load** | | **Power** | **Power** |
|---|---|---|---|---|---|---|
| | Fixed Panel (volts) | Tracking Panel (volts) | Fixed Panel (Amps) | Tracking Panel (Amps) | Fixed Panel (Watts) | Tracking Panel (Watts) |
| 06:00 AM | 28.73 | 28.88 | 7.78 | 13.72 | 223.5194 | 396.2336 |
| 07:00 AM | 28.92 | 29.12 | 8.52 | 13.98 | 246.3984 | 407.0976 |
| 08:00 AM | 29.29 | 30.29 | 9.56 | 14.47 | 280.0124 | 438.2963 |
| 9:00AM | 29.75 | 30.75 | 9.93 | 14.86 | 295.4175 | 456.945 |
| 10:00AM | 30.34 | 31.34 | 10.42 | 14.42 | 316.1428 | 451.9228 |
| 11:00AM | 30.69 | 31.69 | 10.89 | 14.89 | 334.2141 | 471.8641 |
| 12:00PM | 31.41 | 32.41 | 12.23 | 15.42 | 384.1443 | 499.7622 |
| 1:00PM | 31.62 | 32.62 | 12.48 | 15.58 | 394.6176 | 508.2196 |
| 2:00PM | 31.87 | 32.87 | 12.97 | 15.1 | 413.3539 | 496.337 |
| 3:00PM | 30.37 | 31.37 | 10.98 | 14.84 | 333.4626 | 465.5308 |
| 4:00PM | 29.98 | 30.98 | 10.22 | 14.98 | 306.3956 | 464.0804 |
| 5:00PM | 29.34 | 30.34 | 9.73 | 14.72 | 285.4782 | 446.6048 |
| 6:00PM | 28.17 | 29.17 | 9.41 | 14.41 | 265.0797 | 420.3397 |

 ISSN: 2454-4248
72 – 77

Also, as per proposed RESCO Roof top model without battery bank is very beneficial to consumer who has not invest capital cost of plant and his maximum load is day time.

In conclusion, the designed and implemented dual axis solar tracking system proved to be sufficient and was seen to improve the efficiency sufficiently. Further, new solar panel tree structure land area for solar roof top panel is reduce 100 times in term of existing model. As per CSIR-NPL New Delhi Rooftop area which was study & Calculated in thesis report. So I am proposing 300 KW Solar rooftop panel in new solar tree structure (RASCO- without battery bank) model which is mentioned in thesis with solar panel tracking system (One LDR). The following comparison has been derived in existing and new proposed model. (a) Land Area: As per existing model of 300 KW solar rooftop plant required land area approx 26000 sq feet but new proposed model required land area approx 100 times less. (b) Solar panel efficiency: As per existing model of 300kw solar rooftop plant generate unit approx 1200 KWH per day but new proposed model generate unit approx 1950 KWH unit per day. (c) Reduce capital and maintenance cost: As per proposed model reduce capital cost in term of lesser land requirement further maintenance cost is also reduce in term of without battery bank plant. In view of above, it has been observed that overall efficiency of solar tracking panel is enhance 40 to 45 % in term of units generate by using one LDR (dual axis) solar tracking system.

Finally, we have achieved the solar panel efficiency in-terms of power generation is 15 to 18 % for fixed panel and 40 - 45 % for tracking panel. These results are beneficial to the future solar panel installations with dual-axis tracking system.

## ACKNOWLEDGMENT

The authors are grateful to Director, CSIR-NPL for financial support and Sh. C.M.S Rauthan,Sh RK Bindal ,Dr. Sanjay Kr. Srivastava,Dr. Pratap, Sh.Bhikam Singh,Sh Satish Mishra,Sh P K Gupta and Mr. Raju kumar for their technical support. I would like to thank Dr. G.S Virdi, Director, and Ms. Inderdeep Kaur, M.Tech Coordinator, PTU-Regional Centre GGS College of Modern Technology, Kharar for her kind support.

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