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Solar Pump (SP) is Life Time Partner (LTP) of Indian Farmer

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Abstract: ***The rooftop Solar (RTS) is a photovoltaic power plant station or rooftop PV system. It is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of any residential or commercial building or any supporting static structure. Rooftops is ideal for harnessing solar power in both urban and rural India, millions of homes and commercial buildings have un-used rooftops & that receive ample sunlight during the day and which is getting waste. These are ideal for harnessing the solar energy by converting it into Solar electric power. Again, this can be done by adding an interface known as an inverter to convert the DC power generated by the solar panels on the rooftop to AC power as most appliances/devices run on AC. Although un-used rooftops can be used for creating rooftop energy sources, there are various factors to be considered before deciding to install solar panels on a rooftop. Solar energy power from the sun is a vast, inexhaustible and clean green resource. Sunlight or solar energy can be used directly for heating and lighting homes and businesses, for generating electricity, and for hot water heating, solar cooling, and a variety of other commercial and industrial uses. The main benefit of installing rooftop solar panels is that it offer cost savings, a secure investment, increases access to energy, Support from the government, Reduces carbon footprints, Green source of energy, Low maintenance cost and Suitable for Indian climate etc and which will become an alternative sustainable income generation source for Indian farmers.***

Keywords: Roof Top Solar (RTS), photovoltaic power station, PV system, Indian climate, solar panels, Solar energy, un-used rooftops

I. INTRODUCTION

A. Rooftop Solar Power Generation System

A Grid Tied Solar Rooftop Photo Voltaic (SPV) power plant consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Inverter, and Controls & Protections, interconnect cables, Junction boxes, Distribution boxes and switches. PV Array is mounted on a suitable structure. Grid tied SPV system is without battery and should be designed with necessary features to supplement the grid power during day time. Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the BIS or IEC or international specifications, wherever such specifications are available and applicable. Solar PV system shall consist of following equipments/components[1].

1) Solar PV modules consisting of required number of Crystalline PV cells.
2) Grid interactive Power Conditioning Unit with Remote Monitoring System
3) Mounting structures
4) Junction Boxes.
5) Earthing and lightening protections.
6) IR/UV protected PVC Cables, pipes and accessories

First things first. Getting your home on the path to zero carbon/zero energy begins with minimizing your home's energy needs by making it as airtight, well insulated, and energy efficient as possible. Follow our 12 Steps to Affordable Zero Energy Design and Construction for new construction or our suggestions for Remodeling on the Path to Zero for existing homes and buildings. Once you've done that, you will be ready to install solar collectors to produce your own renewable energy.But what happens when there is no way that you can make solar work on your home or building site? This can happen when the roof or open area on the property is shaded by buildings or trees. Maybe the roof structure can't handle the weight or wind stress from solar panels. Or maybe you rent your home and can't install solar panels. In these situations, there are several options that can replace or compensate for the lack of solar panels on the site.

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B. Types of Roof Top Solar System (RTSS)

1) *On-grid Systems:* One of them is the on-grid system in which the rooftop solar system is integrated with the main grid supply. This system allows power to be used from the grid supply only when the rooftop solar system is unable to supply the required power. Thus, a well-planned rooftop system can efficiently supply power without using grid supply saving expenses otherwise incurred on using power from the grid. In fact, this system can earn revenues as any excess power generated can be fed to the grid for which DISCOMs pay compensation using 'Net Metering' system pricing charging to the home owner.
2) *Off-grid Systems:* The second one is the off-grid system in which the rooftop solar system is not linked to the main grid. This system can run on its own with its own battery. The solar power generated from the rooftop solar system charges the battery which is then used to power various applications. This system is very useful when there is no grid supply or when the supply is very erratic with frequent breakdowns.
3) *Hybrid Systems:* The third one is the hybrid system in which both on-grid and off-grid systems work in tandem. In this type of system, though a battery is used, the advantage here is that after the battery is fully charged the excess power generated is fed to the grid which generates additional revenues for the consumer.

Feasibility of rooftops for generating power. For home solar rooftop systems, the nature of the roof is very important to determine its feasibility.

1) The factors that need to be considered are as follows:The availability of sunlight throughout the year and the area available on the rooftop is important to calculate the power that can be generated. A typical home solar panel can produce about 300 watts by harnessing one hour of direct sunlight. If sunlight falls for 8 hours then the solar panel can produce 2400 watts electric power.
2) The orientation of the rooftop towards the sun is important. Exposure towards the south is the ideal orientation for the panel. If the roof is naturally sloping and facing south then it is very ideal for installing rooftop solar panels. This is because India is situated in the northern hemisphere and south facing rooftops receive the maximum amount of sunlight as the earth rotates on its own axis at an inclination. However, if the roof is flat solar panels will need to be placed at an angle facing south to receive the maximum possible sunlight. Further, high rise buildings should not hinder the exposure of the solar panels to sunlight.
3) The decision on choosing a suitable type of rooftop solar system impacts the cost of the system. Each type involves different components and the costs could vary depending on them.

C. Roof Top Solar Space Requirement

For estimation purpose, 70% of rooftop area can be used for the panel's installation. Certain solar panels in the market can use as high as 90% of rooftop area but have a much higher cost. As a thumb rule, requirement of 10sq meter(100SF) area for a 1kW solar system capacity. Based on the availability of sunlight and the space available on the rooftop the maximum power that can be generated can be determined. Further, based on the type of system –on-grid, off-grid or hybrid – the homeowner can decide on the space to be allocated on the rooftop for producing electric power[2].

II. SYSTEM SPECIFICATIONS OF THE COMPONENTS

The PV modules used must qualify to the latest edition of IEC PV module qualification test or equivalent BIS standards Crystalline Silicon Solar Cell Modules IEC 61215/IS14286. In addition, the modules must conform to IEC 61730 Part-1 - requirements for construction & Part 2 – requirements for testing, for safety qualification or equivalent IS[3].

A. For the PV modules to be used in a highly corrosive atmosphere throughout their lifetime, they must qualify to IEC 61701.
B. The total solar PV array capacity should not be less than allocated capacity (kWp) and should comprise of solar crystalline modules of minimum 250 Wp and above wattage. Module capacity less than minimum 250 watts shall not be accepted Protective devices against surges at the PV module shall be provided. Low voltage drop bypass diodes shall be provided.
C. PV Modules must be tested and approved by one of the IEC authorized test centers
D. The module frame shall be made of corrosion resistant materials, preferably having anodized aluminium.
E. The bidder shall carefully design & accommodate requisite numbers of the modules to achieve the rated power in his bid. SECI/owners shall allow only minor changes at the time of execution.
F. Other general requirement for the PV modules and subsystems shall be the Following:
G. The rated output power of any supplied module shall have tolerance within +/- 3%.

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H. The peak-power point voltage and the peak-power point current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case may be.

I. The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof lid with captive screws and cable gland entry points or may be of sealed type and IP-65 rated.

J. I-V curves at STC should be provided by bidder.

K. Plants installed in high dust geographies like Rajasthan and Gujarat must have the solar modules tested with relevant dust standards (Applicable standard would be IEC 60068-2-68).

III. OBJECTIVES

A. To save the energy by utilizing the Roof Top Solar energy.

B. To Improve the quality of life and alleviate rural poverty in the un-energized and off-grid areas by providing the four (4) basic needs such as lights, education, entertainment and communication through affordable and reliable source of Roof top Solar energy.

C. It will provide an alternative source of electricity with the help of grid also to companies, residential areas etc.

D. To make the eco-friendly environment by the reduction of CO2 emissions by reducing the dependence on fossil-fuel generated electricity etc.

E. To reduce the dependency level on grid supply.

F. To promote an alternative income source for home owner

IV. SIGNIFICANCE

A. They offer cost savings

B. It is a secure investment

C. Support from the government: In order to encourage people to adopt solar energy, the government offers tax credits to those who install rooftop solar panels whether it be for residential or commercial purposes. As per the Ministry of New and Renewable Energy, the government pays 30% of the installation cost as a subsidy to the installer

D. It increases access to energy

E. Reduces carbon footprints

F. Green source of energy

G. Low maintenance cost

H. Suitable for Indian climate

I. Multiple applications of solar power

J. It doesn't require additional space for installation

V. BARRIERS IN RTSS

A. Delamination and Internal Corrosion

B. Electrical Issues

C. Micro-Cracks

D. Hot Spots

E. PID(Potential Induced Degradation) effects

F. Birds

G. Snail Trails

H. Roof Issues

I. Inverter Problems

J. Cloudy weather

K. Shades

L. Dust

M. Panel efficiency

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The Roof Top Solar PV module: Modules deployed must use a RF identification tag. The following information must be mentioned in the RFID used on each modules. This should be inside the laminate only.

1) Name of the manufacturer of the PV module
2) Name of the manufacturer of Solar Cells.
3) Month & year of the manufacture (separate for solar cells and modules) Country of origin (separately for solar cells and module)
4) I-V curve for the module Wattage, Im, Vm and FF for the module
5) Unique Serial No and Model No of the module
6) Date and year of obtaining IEC PV module qualification certificate.
7) Name of the test lab issuing IEC certificate.
8) Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

VI. RTSSWARRANTIES

1) *Material Warranty:* Material Warranty is defined as: The manufacturer should warrant the Solar Module(s) to be free from the defects and/or failures specified below for a period not less than five (05) years from the date of sale to the original customer ("Customer")
a) Defects and/or failures due to manufacturing
b) Defects and/or failures due to quality of materials
c) Non conformity to specifications due to faulty manufacturing and/or inspection processes. If the solar Module(s) fails to conform to this warranty, the manufacturer will repair or replace the solar module(s), at the Owners sole option
2) *Performance Warranty:* The predicted electrical degradation of power generated not exceeding 20% of the minimum rated power over the 25 year period and not more than 10% after ten years period of the full rated original output.

A. AC side Desig

1) Number and Nominal AC Power As per design
2) Output AC Voltage 230 V, 415V+/- 10%
3) Frequency 50 Hz
4) Total harmonic distortion < 3% at nominal power.
5) AC over / under voltage, under Yes frequency protection
6) Phase SIFT (COS Phi)

B. DC Side Design

1) PV Power As per design
2) Maximum DC Voltage Not greater than 1000 V
3) MPPT Voltage range (Minimum range)
4) . Maximum DC Current * Design to be submitted
5) DC voltage ripple <3%
6) DC over voltage protection Yes

C. Other Parameters

1) Minimum efficiency (CE) >98%
2) Ambient temperature 0-50º C
3) Humidity (Non Condensing) 95%
4) Degree of protection for enclosure IP 64 (Outdoor type)
5) Dimension / Weight As per Manufacturer design.
6) Noise level < 65 dBA
7) Cooling Forced Air

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VII. MODULE MOUNTING STRUCTURE

1) Hot dip galvanized MS mounting structures may be used for mounting the modules/ panels/arrays. Each structure should have angle of inclination as per the site conditions to take maximum insolation. However, to accommodate more capacity the angle inclination may be reduced until the plant meets the specified performance ratio requirements
2) The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed (like Delhi-wind speed of 150 kM/ hour). It may be ensured that the design has been certified by a recognized Lab/ Institution in this regard and submit wind loading calculation sheet to SECI. Suitable fastening arrangement such as grouting and calming should be provided to secure the installation against the specific wind speed.
3) The mounting structure steel shall be as per latest IS 2062: 1992 and galvanization of the mounting structure shall be in compliance of latest IS 4759.
4) Structural material shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts. Aluminum structures also can be used which can withstand the wind speed of respective wind zone. Necessary protection towards rusting need to be provided either by coating or anodization.
5) Aluminum frames should be avoided for installations in coastal areas
6) The fasteners used should be made up of stainless steel. The structures shall be designed to allow easy replacement of any module. The array structure shall be so designed that it will occupy minimum space without sacrificing the output from the SPV panels
7) Regarding Civil structures the bidder need to take care of the load bearing capacity of the roof and need arrange suitable structures based on the quality of roof.
8) The total load of the structure (when installed with PV modules) on the terrace should be less than 60 kg/m2.
9) The minimum clearance of the structure from the roof level should be 300 mm.

A. *AC Distribution Board*

1) DC Distribution panel to receive the DC output from the array field.
2) DC DPBs shall have sheet from enclosure of dust & vermin proof conform to IP 65 protection. The bus bars are made of copper of desired size. Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the PCU along with necessary surge arrestors

B. *Cable (All type)*

Cables of appropriate size to be used in the system shall have the following characteristics:

1) Shall meet IEC 60227/IS 694, IEC 60502/IS1554 standards
2) Temp. Range: 10oC to +80oC.
3) Voltage rating: 660/1000V
4) Excellent resistance to heat, cold, water, oil, abrasion, UV radiation
5) Flexible
6) Sizes of cables between array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum (2%)
7) For the DC cabling, XLPE or, XLPO insulated and sheathed, UV-stabilized single core multi-stranded flexible copper cables shall be used; Multi-core cables shall not be used.
8) For the AC cabling, PVC or, XLPE insulated and PVC sheathed single or, multi-core multi-stranded flexible copper cables shall be used; Outdoor AC cables shall have a UV-stabilized outer sheath.
9) The cables (as per IS) should be insulated with a special grade PVC compound formulated for outdoor use. Outer sheath of cables shall be electron beam cross-linked XLPO type and black in colour.
10) The DC cables from the SPV module array shall run through a UV-stabilized PVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5mm.
11) Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors (MC4) and couplers
12) All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm; the minimum DC cable size shall be 4.0 mm2 copper; the minimum AC cable size shall be 4.0 mm2 copper. In three phase systems, the size of the neutral wire size shall be equal to the size of the phase wires.

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13) Cable Routing/ Marking: All cable/wires are to be routed in a GI cable tray and suitably tagged and marked with proper manner by good quality ferule or by other means so that the cable easily identified. In addition, cable drum no. / Batch no. to be embossed/ printed at every one meter.

14) Cable Jacket should also be electron beam cross-linked XLPO, flame retardant, UV resistant and black in colour.

VIII. EARTHING KIT (MAINTENANCE FREE)

Each array structure of the PV yard should be grounded/ earthed properly as per IS: 3043-1987. In addition tothis, the lighting arrester/masts should also be earthed inside the array field. Earth Resistance shall be tested in presence of the representative of Department/SECI as and when required after earthing by calibrated earth tester. PCU, ACDB and DCDB should also be earthed properly. Earth resistance shall not be more than 5 ohms. It shall be ensured that all the earthing points are bonded together to make them at the same potential. All the modules shall be appropriately earthed in accordance to the NEC. Grounding of the modules may be done as recommended by manufacturer[4].

A. LT Side

The earthing for array and LT power system shall be as required as per provisions of IS-3043. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance. Each Array structure of the SPV Yard shall be grounded separately and properly. The array structures are to be connected to earth pits as per IS standards.

B. MV Side

The earthing for the medium voltage equipment shall be made as per provisions of IS-3043. Separate and distinct earth pits and connections for neutral and body earthing shall be strictly in accordance with IS. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance. The complete earthing system shall be mechanically and electrically connected to provide independent return to earth. All three-phase equipment shall have two distinct earth connections. An Earth Bus shall be provided inside the control room.

C. Lightning & Over Voltage Protection

Lightning Protection for the entire plant area shall be carried out as per IS-3043. The MV stations comprising of transformers, inverters etc. shall be provided with fool proof lightning protection. The earthing stations for the lighting discharges will be provided with test links of phosphorus bronze and located at 150mm above ground level in an easily accessible position for testing.
Necessary concrete foundation for holding the lightning conductor in position will be made after giving due consideration to maximum wind speed and maintenance requirement at site in future. Each Lightning Conductor shall be fitted with individual separate earth pit as per required Standards including accessories, and providing masonry enclosure with cast iron cover plate having locking arrangement, watering pipe using charcoal or coke and salt as per required provisions of IS[5].
Installation Kit: As per engineering practice comprising of meggar for testing insulation resistance, thimbles, glands, tape, compass, level, crimping tools. In addition to the metering and monitoring arrangement in inverters through SCADA[6], monitoring of voltage, current and energy will be provided at the HV side shall also be equipped with voltmeter and ampere meter through CTs in order to correlate the energy generation and losses. Further metering for utility shall be at the main control room and check meters of 0.2S accuracy class or as required and specified by State Electricity Regulatory Norms.

D. Online Monitoring System

Data Acquisition System shall be provided for each of the solar PV plant above 10 kWp capacity. Data Logging Provision for plant control and monitoring, time and date stamped system data logs for analysis with the high quality, suitable PC. Metering and Instrumentation for display of systems parameters and status indication is to be provided [7].

IX. OPERATION AND MAINTENANCE ARRANGEMENTS

Details of Operation and Maintenance Arrangements
The main objectives of the plant maintenance are to keep the plant running reliably and efficiently as long as possible. Reliability is impaired when a plant undergoes forced and unforeseen outages.
Efficient operation implies close control not only over the cost of production but also over the cost of maintenance. There are two components in maintenance cost: Direct cost of maintenance, (i.e. the material and labor) &the cost of production loss.

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There are two categories of maintenance work.

1) One is the irksome breakdown maintenance which is expensive. Much as it is desirable to avoid or minimize this, its existence must be accepted.
2) It is the preventive maintenance with proper planning and execution of plant and equipment overhauls. This maintenance activity should be clearly planned with regard to the availability of material and labour. It is also essential to develop proper inspection procedures with non-destructive testing methods. Such inspections by trained personnel reveal defects not necessarily detected by mere visual inspection[8].

The following steps will help in reducing the breakdown maintenance and also in planning for preventive maintenance:

a) Careful logging of operation data/historical information from the Data Monitoring Systems, and periodically processing it to determine abnormal or slowly deteriorating conditions.
b) Walk down checks of the plant.
c) Careful control and supervision of operating conditions.

X. PAY BACK CALCULATION (WITH AN IMAGINARY EXAMPLE):

100kW capacity on-line (without Battery Backup) complete systems of solar PV power plant system's Installation, Commissioning, Testing(SITC) works including 5 Years Warrantee, operation & Maintenance in an Academic Institution, and it is one step for an alternative new renewable roof top solar energy utilization by an Academic Institution and also it is a conservation of energy. For the implementation of the same system, the budget of financial implication will be turning around of Rs.8500000/- (Eighty-Five lacks only) including five years O&M services. If the proposal is planned for Academic Institution On-Grid Systems and without Battery Backup since, the working availability hours in an Academic Institution building from defined period only i.e. from 8am(morning) to 6 pm(evening)

If, we installed the 100kW capacity on-line complete systems of solar PV power plant system in an Academic Institution, the payback period is as follows:

Total Connected Load= 90kW

Utilization of Loading Factor if @ 90% (max.) X90kW=81kW per day(Approx.)

Utilization hours of Load = 8am to 6pm in an Academic Institution= 10 hours per day(Approx.)

Annual utility savings from Solar=81 kW X 10 Hrs X 365 days=295650Kwhrs(Units).(Approx.)

(P)= Annual utility savings from Solar in term of total unit cost= 295650 kWhrs X @ Rs. 7/- per unit(approx) = Rs. 2069550/-(Twenty Lac fourteen sixty-nine thousand five hundred fifty only) (Approx.)

(Q)= Net Solar System Cost = Rs.8500000/(approx.) (as per present market price)

Hence, Payback in Years= Net Solar System Cost(Q)/(P)Annual Utility Savings from Solar =Rs.8500000/ Rs. 2069550/ = 4.1 years, so to say 4.5 years at the existing electricity tariff of an Electric Supply Company and getting five yrs O&M cost free service.

XI. LOAD CALCULATION OF AN ACADEMIC INSTITUTION:

Available average Load Current Iavg = 120A(approx.)

Input system Voltage Vm= 440(approx)

Hence, present utilized connected Load=1.732 X Vm X Iavg=1.732 X 440 X120=91449.6W =91.44kW(approx)

The total Load details of Academic Institution building is as under:

Avg. Load utilization demand @ 80% per day consumption i.e. 100kW @80% =80 kW(approx.) per day requirement.

So far Solar panel wattage is considered then, daily power requirement i.e. (Connected Load)/(Avg. sunlight Hrs X Efficiency of the system)=90kW/(10X0.9)=10kW(approx.) (90% efficiency as per MNRE)

Therefore, Solar power plant is proposed for 100kW. If the loading factor is considered maximum 90% then, 100kWX0.9 =90kW power per day consumption in an average.

It is proposed On-Grid Roof top solar power system. The Roof Top Solar power system is to be connected to the grid and the proposal is made for on-grid systems. The load change over to the grid at the time of no-use of power at Academic Institution Campus or to the other internal load connected network feeding system. By taking holidays and cloudy days and time beyond sunny periods particularly in this proposal has already been taken into consideration in an average of @80% power generation even though the efficiency of solar power plant as per MNRE is @90%.

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The difference energy whatever will generate during OFF campus period, the same will be feed to the Grid through Net-Metering of Electric Supply Company and accordingly money earning will be also created from Electric Supply Company by feeding extra surplus energy.

XII. RECOMMENDATION

On the basis above discussion, the researcher recommends as under:

A. The competent authority of Academic Institution is requested to install the 100kW RTS system at the existing campus building and after getting pay back period of 4.5yrs rest 20.5 yrs energy utilization will be completely free as per MNRE life.
B. Rather to this the above calculation not included the Govt. Support subsidies and that will be an one major step initiative for utilization of an alternative new renewable solar energy through RTS
C. It is also a solution step for cost control measures by generating solar energy, conserving and optimum utilizing at Academic Institution building.
D. It will be an additional diversification of line of business of income source for Academic Institution.
E. It will become eco-friendly for Institute campus by reducing CO2
F. It will be example for other university for implementation.
G. It will be one step forward for adopting Green technology.
H. By adopting RTSS, the Institute will facilitate the Nation towards getting the positive earning Carbon Credit.

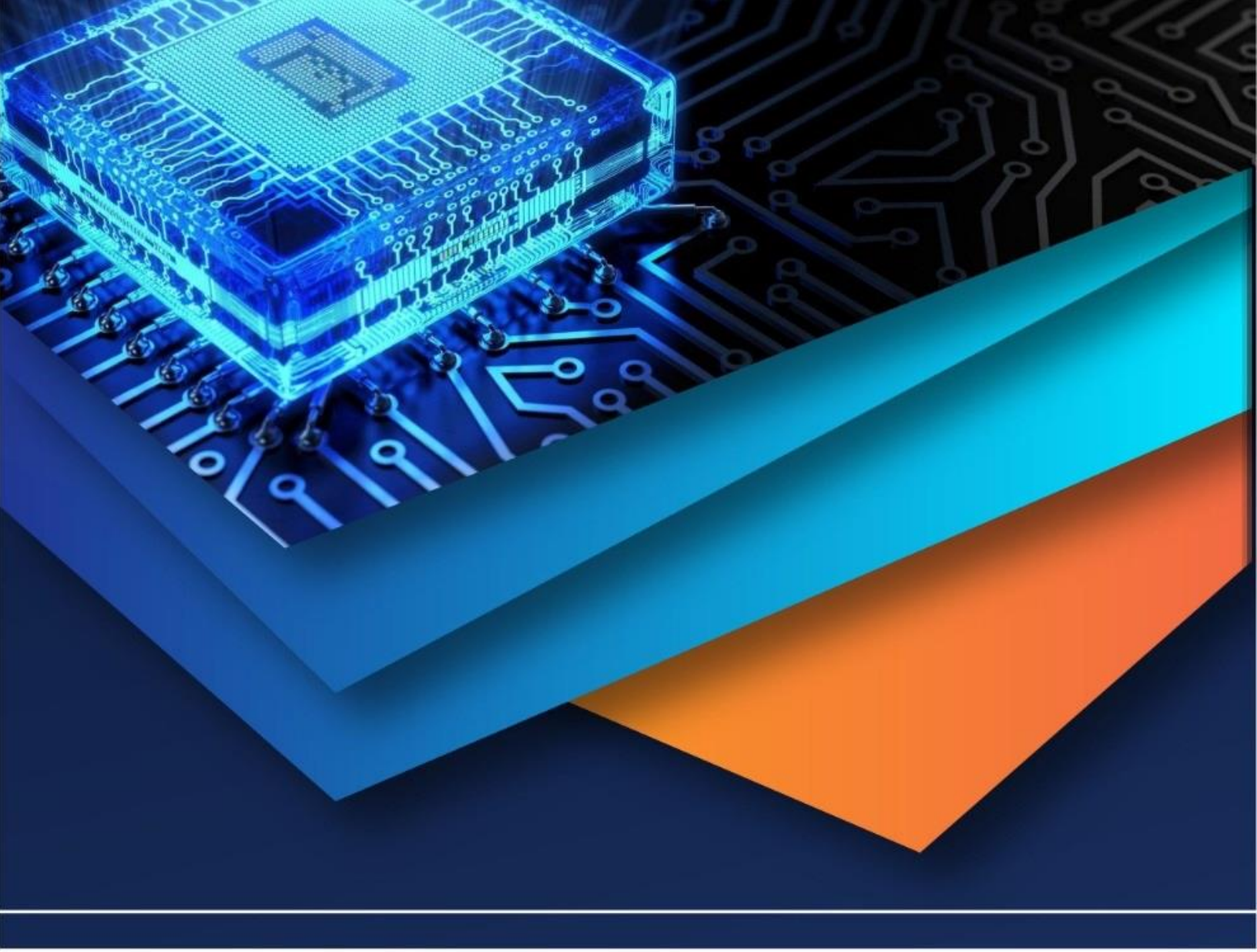
XIII. CONCLUSION

An important benefit of solar energy is the secure and independent energy supply in rural and remote areas that can advance the development process more rapidly at lower cost than comparable efforts based on non-renewable conventional energy sources. The Cost-benefit of the home owner can make a cost analysis and decide on the quantum of electricity to be produced so as to be profitable. This could include meeting the home owner's power needs and the amount of power that can be transferred to the grid to generate additional revenues. Rooftop solar systems are becoming a popular source of electric power because it is a renewable energy source and it is abundantly available during the day. With careful planning, implementing an appropriate rooftop solar system can translate into never-ending electric power supply at minimal recurring expenses. Depending upon the home owner's roof space, every home owner can be planned well for generating an alternative solar energy for their own use and to the communal society purposes including and it will become an additional income generation for every Indians.

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