VOL-2 NO.1 January - June 2015

ISSN : 2348-6562

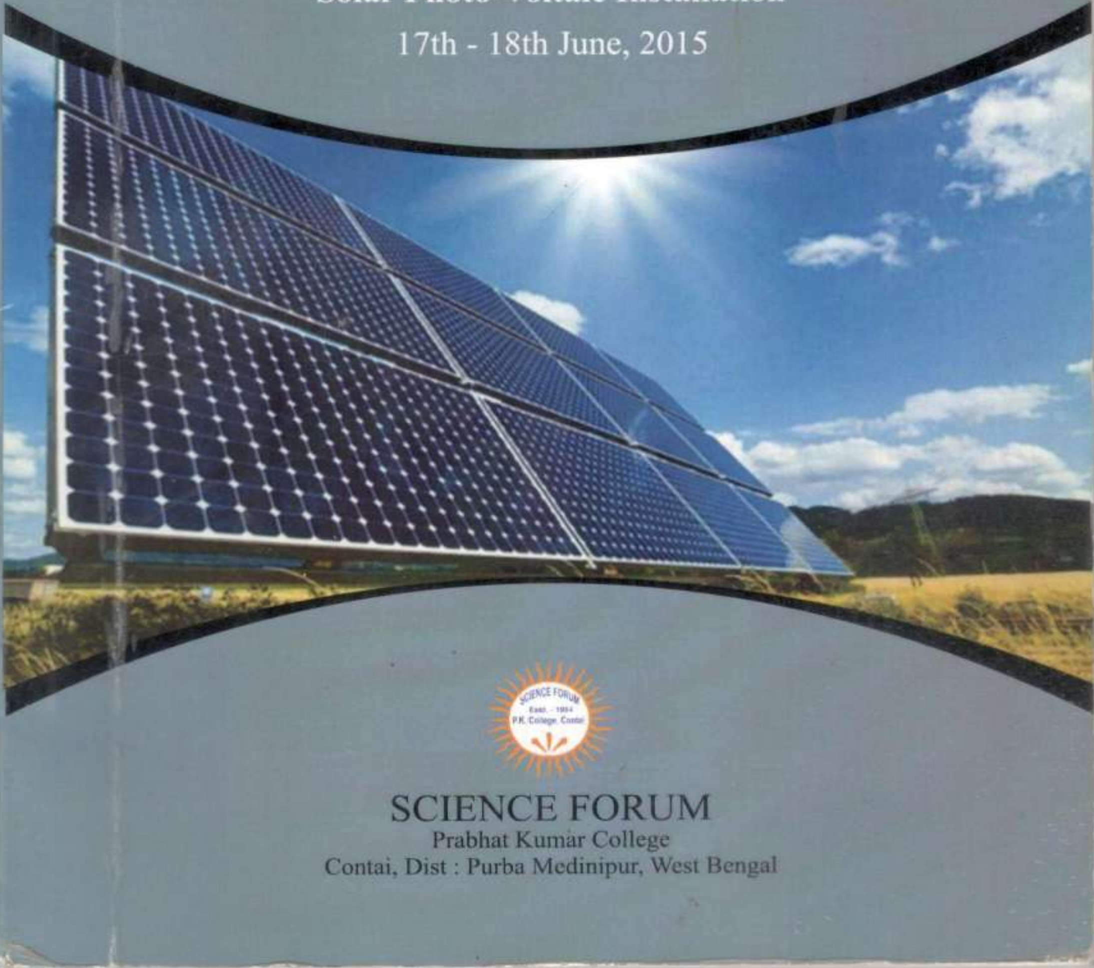
বিজ্ঞান বহ্নি

विज्ञान बह्नी

BIGYAN BANNHI

UGC Sponsored National Seminar & Workshop on
Solar Photo-Voltaic Installation

17th - 18th June, 2015



SCIENCE FORUM
Prabhat Kumar College
Contai, Dist : Purba Medinipur, West Bengal

ISSN: 2348-6562

বিজ্ঞান বহ্নি

विज्ञान बह्नी

BIGYAN BANNHI

(একটি বিজ্ঞা ন জনপ্রিয়করণ অর্দ্ধ বার্ষিক বাংলা ম্যাগাজিন)

UGC Sponsored National Seminar
& Workshop on
Solar Photo-Voltaic Installation

17th - 18th June, 2015

Organized by:

Prabhat Kumar College, Contai

(Affiliated to Vidyasagar University, West Bengal, India-721401)

Co-organizer:

Mugberia Gangadhar Mahavidyalaya

(Affiliated to Vidyasagar University, West Bengal, India)

Assisted by:

Soltech Energies Private Ltd, Salt Lake, Kolkata.

SCIENCE FORUM
Prabhat Kumar College
Contai, Dist : Purba Medinipur, West Bengal

Name of the Journal :
Bigyan Bannhi

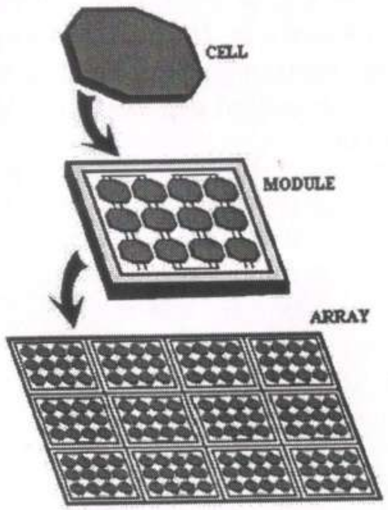
Type :
Bi-annual

CONTENT

Editorial

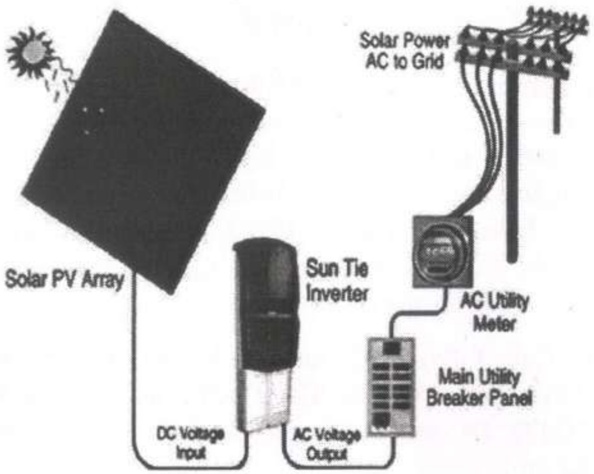
The Sun having 1.39×10^6 Kilometer diameter situating at a large distance 1.5×10^8 Kilometer away from this earth. The Sun is $109 \times 109 \times 109$ times bigger than this earth. Almost 54% of its light energy is absorbed before coming to earth. Out of which Ozone layer, Vapour dust (19%), Energy dispersed (8%), Clouds absorbs 4%, 17% light energy is reflected by cloud surface and 6% is reflected from earth's surface.

Solar Cells follows P-N Junction having Mono Crystalline or Multi Crystalline PV-cells. These cellse made up of Silica / $CuInSe_2$ / CdTe. DC-output of a photovoltaic array is converted to AC using an Inverter.



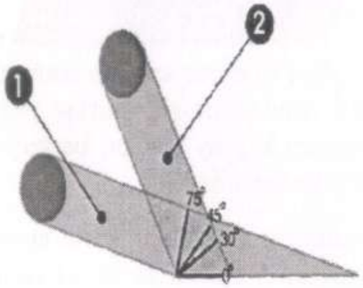
DC output of a photo-voltaic array is converted to AC with an Inverter. If the AC load must run during periods when the photovoltaic array cannot supply power, battery storage and a charge controller must be included AC.

Isolated mountaintops and other rural areas are ideal for stand-alone PV systems where maintenance and power accessibility makes PV the ideal technology.



Installation of a solar PV system can either be done on ground or either on roof tops. In both the cases shadow free area is required. For roof top mounted solar PV structures, the mounting structure can be categorized depending on the roof type and customer preference.

The sun moves across the sky from east to west. Solar panels are most effective when they are positioned facing the sun at a perpendicular angle at noon. Solar panels usually have a fixed position and cannot follow the movement of the sun along the sky. Therefore they will not face the sun with an optimal (90 degrees) angle all day. The angle between the horizontal plane and the solar panel is called the tilt angle.



1. Winter Sun   2. Summer Sun

To achieve the best year round performance solar panels should be installed at a fixed angle, which lies somewhere between the optimum angle for summer and for winter. For each latitude there is an optimum tilt angle. Only near to the equator the solar panels should be placed horizontally.

Over 500,000 homes worldwide use PV power as their only source of electricity. In terms of overall installed PV capacity, India comes fourth after Japan, Germany and U.S. (With Installed capacity of 110 MW). In the area of Photovoltaics India today is the second largest manufacturer in the world of PV panels based on crystalline solar cells. Industrial production in this area has reached a level of 11 MW per year which is about 10% of the world's total PV production. Arid regions receive plentiful solar radiation; regions like Rajasthan, Gujarat and Haryana receive sunlight in plenty.

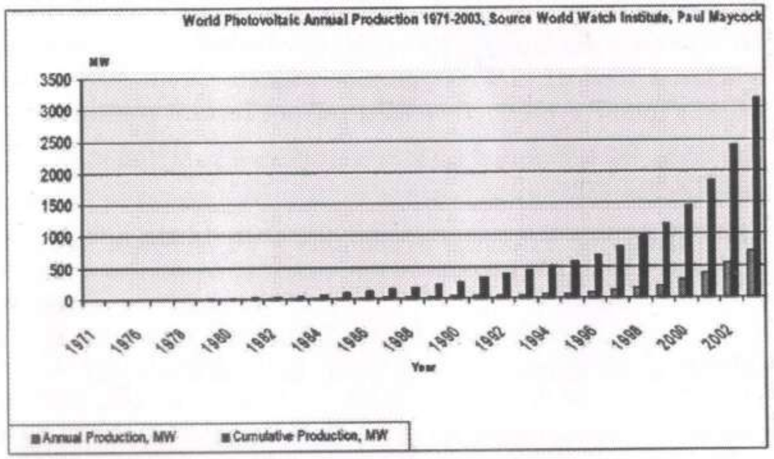
Thus the Potential availability - 20 MW/km^2 (source IREDA).

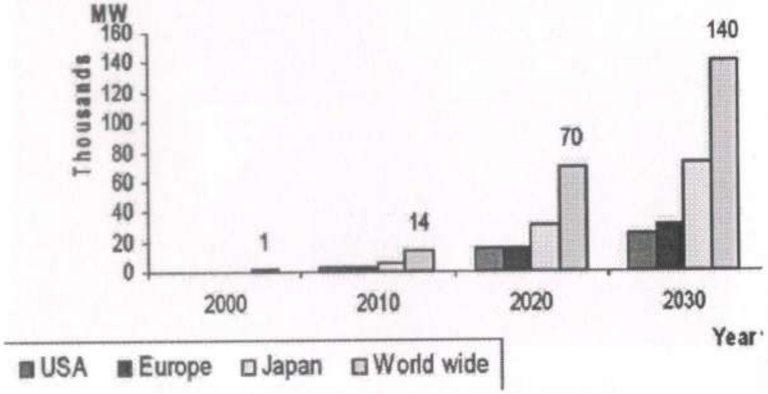
Targets have been set for the large scale utilization of PV technology by different sectors within the next five years.

Solar Street light at New Delhi

Present Scenario: Solar Electric Energy demand has grown consistently by 20-25% per annum over the past 20 years (from 26 MW back in 1980 to 127MW in 1997)

At present solar photovoltaic is not the prime contributor to the electrical capacities but the pace at which advancement of PV technology and with the rising demand of cleaner source of energy it is expected by 2030 solar PV will have a leading role in electricity generation.





By 2020 global solar output could be 276 Terawatt hours, which would equal 30% of Africa's energy needs or 1% of global demand. This would replace the output of 75 new coal fired power stations. The global solar infrastructure would have an investment value of US$75 billion a year. By 2040 global solar output could be more than 9000 Terawatt hours, or 26% of the expected global demand - Report European Photovoltaic Industry Association (EPIA) and Greenpeace.

-Dr. Prabhat Kumar Ray, Convener-Science Forum, P.K.College, Contai, P.O. Contai, Dist-Purba Medinipur, Pin-721401, E-mail : pkray.pkc@gmail.com

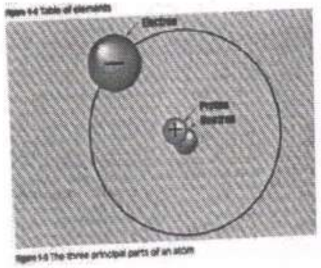
"By the year 2030, India should achieve Energy Independence through solar power and other forms of renewable energy."

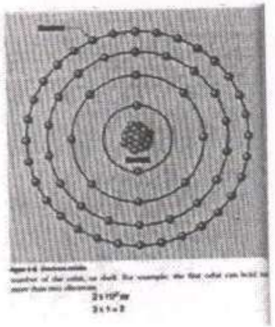
-Dr. A. P. J. Abdul Kalam, President of India, Independence Day Speech, 2005

BASICS OF ELECTRICITY

Dr Prabhat Kumar Ray

Greeks discovered electricity 2500 years ago. It is practically used only 100 years ago. We know three parts of an atom : Electron (-ve charge), Proton (+ve charge) and Neutron (Zero charge). Nucleus contains Protons and Neutrons.



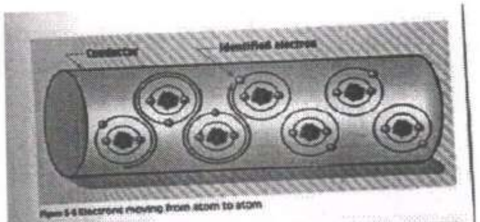


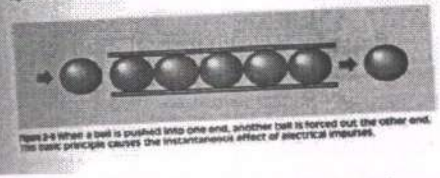
Outer shell of an atom is known as Valence Shell. Electrons are located in outer Shell and they are called Valence Electrons. The Valence Shell can't hold more than 8 electrons.

Conductors : Copper is a good conductor of electricity because of its only one valence electron. Conductors have only 1 or 2 valence electrons. They gave up electrons very easily with little effort and easy current flow occurs with low resistance.

Example of good conductors :

Silver :	1 Valence Electron
Copper :	1 Valence Electron
Gold :	1 Valence Electron
Aluminium :	3 Valence Electron
Platinum :	1 Valence Electron

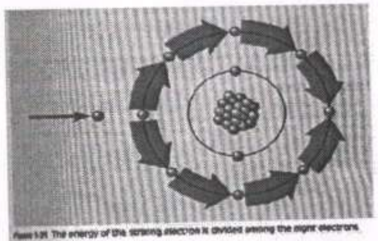


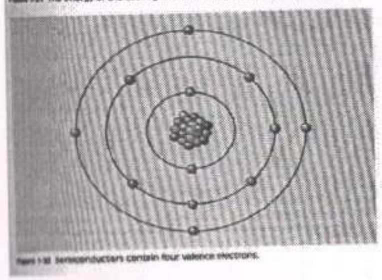


Insulators : Materials that have 7 or 8 valence electrons act as insulators. They resist flow of electricity. Here electrons are held tightly and are not given up easily.

Example of Insulators : Rubber, Plastic, Glass and Wood

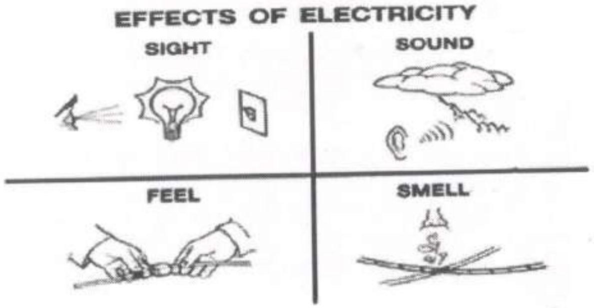
Semi-Conductors : These are materials that have 4 valence electrons. They are neither good for conductors or insulators. Diodes and Transistors are made of them. Computers are full of Semi-conductor materials. Silicon and Germanium are most commonly used semiconductors.





INSULATOR & SEMI-CONDUCTOR

Effects of Electricity :



Measurement of Electricity :

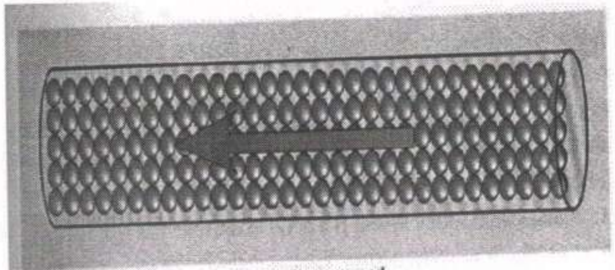
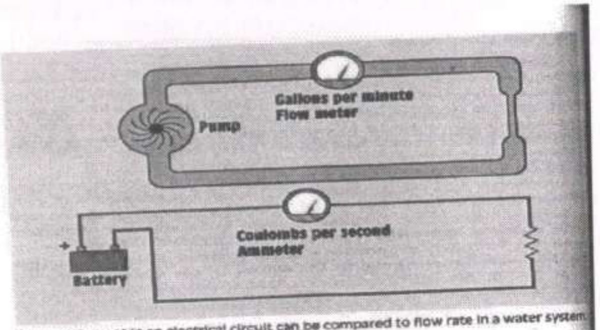


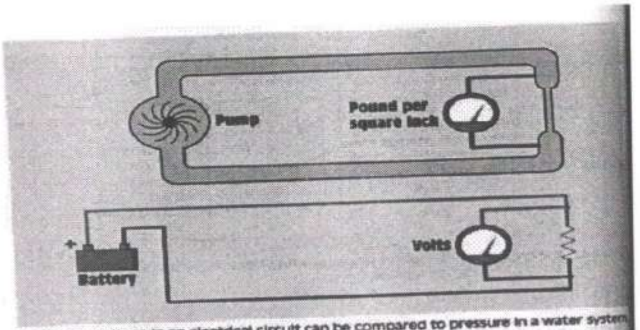
Figure 2-1 One ampere equals one coulomb per second.

<u>Coulomb</u>: Coulomb is a quantity of measurement of electrons = 6,250,000,000,000,000,000

<u>Ampere</u> : Electrical measurement of electrons = 1 Coulomb per second

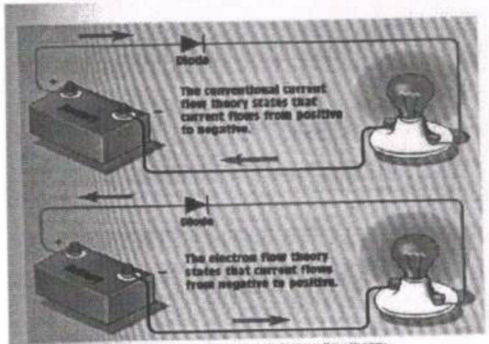


Current in an electrical circuit can be compared to flow rate in a water system

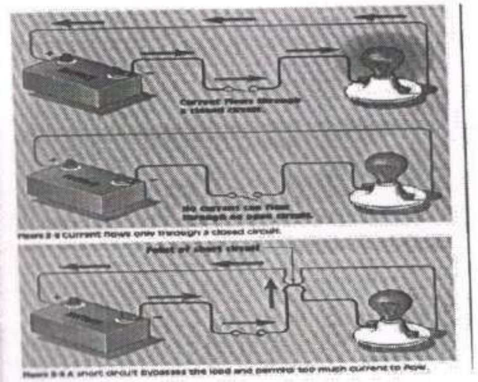


Voltage in an electrical circuit can be compared to pressure in a water system

Electromotive Force (EMF) : Electromotive force is the force that pushes electrons through a wire. It is the Electrical Pressure or Potential. In Ohm's Law, Symbol for Voltage is E.



Conventional current flow theory and electron flow theory



Current flows only through a closed circuit.

A short circuit bypasses the load and permits too much current to flow.

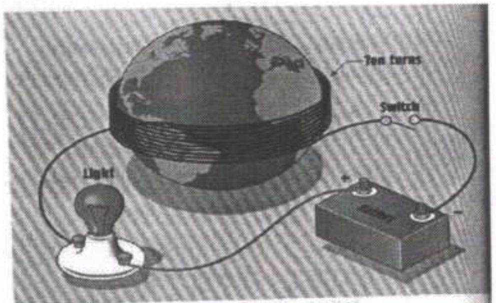


Figure 2-7 The impulse of electricity can travel faster than light.

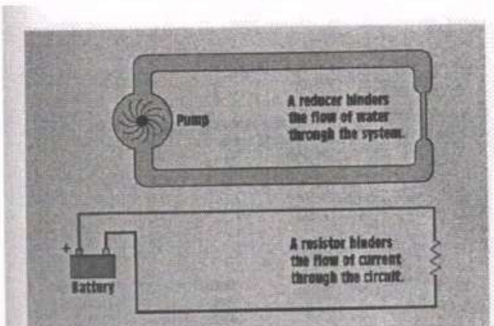


Figure 2-15 A resistor in an electrical circuit can be compared to a reducer in a water system.

OHM -_UNIT OF RESISTANCE TO CURRENT FLOW;
NAMED AFTER GEORGE OHM, OHM'S LAW SYMBOL IS **R**

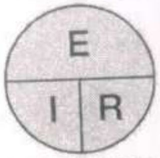


Figure 2-18 Chart for finding values of voltage, current, and resistance

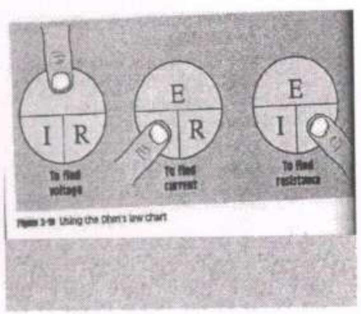
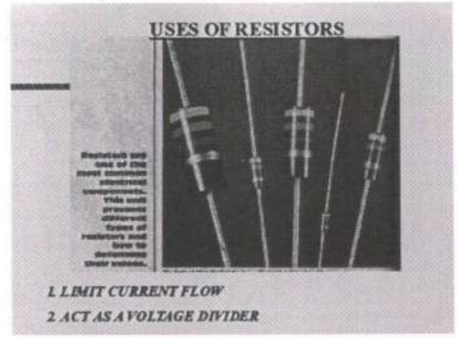
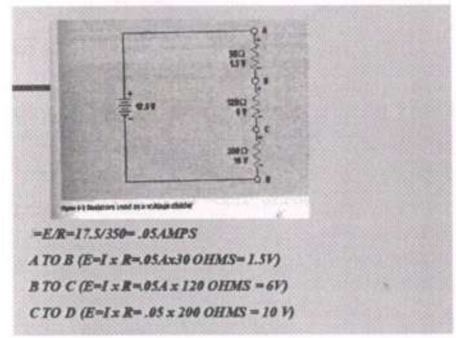


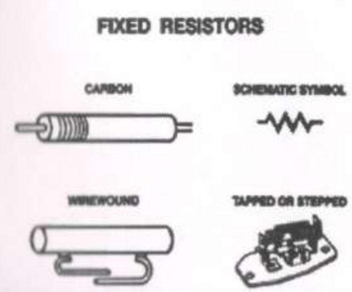
Figure 2-19 Using the Ohm's law chart





Resistors limits current flow. It act as a Voltage Divider.

Fixed Resistors : It is only 1 Ohmic value and can not be changed. Its composition includes Carbon , Metal film, Wire wound, Metal Glaze. Carbon film.



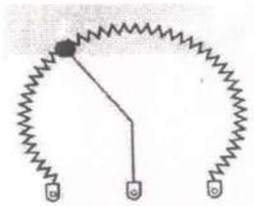
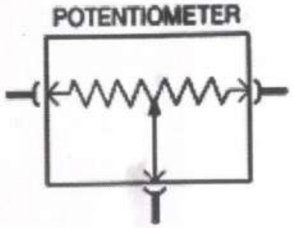


Figure 5-14 Variable resistor



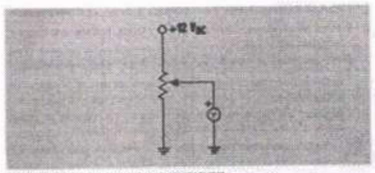


Figure 5-15 Variable resistor used as a potentiometer

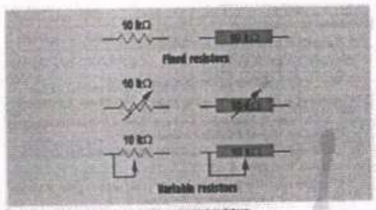


Figure 5-16 Schematic symbols used to represent resistors

Series Circuit : The current is same at any point in the circuit. The total resistance is the sum of the individual resistors. The applied voltage is equal to the sum of the voltage drops across all the resistors

A series circuit is a circuit that has only one path for current flow.

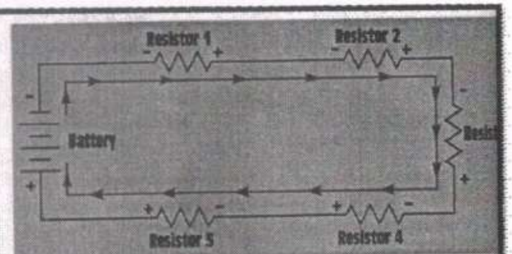


Figure 6-1 In a series circuit there is only one path for current flow.

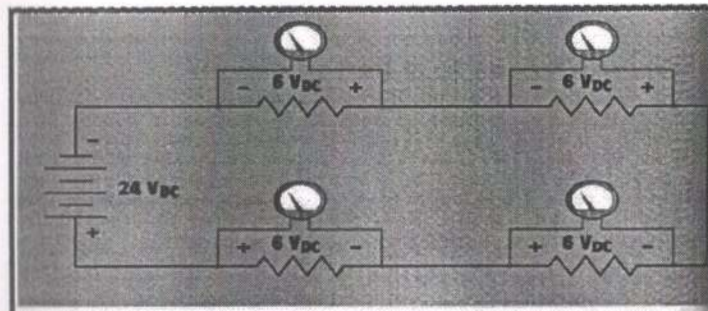


Figure 6-4 The voltage drop across each resistor is proportional to its resistance.

Series circuit values :

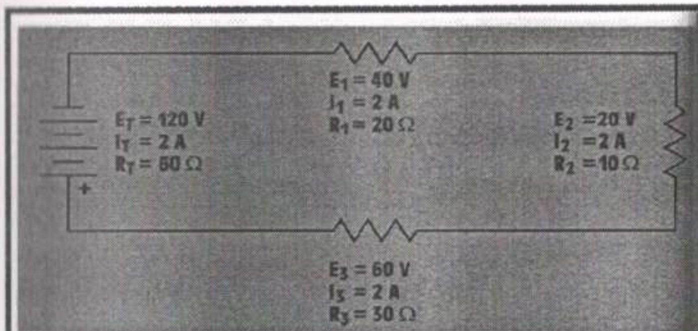


Figure 6-6 Series circuit values

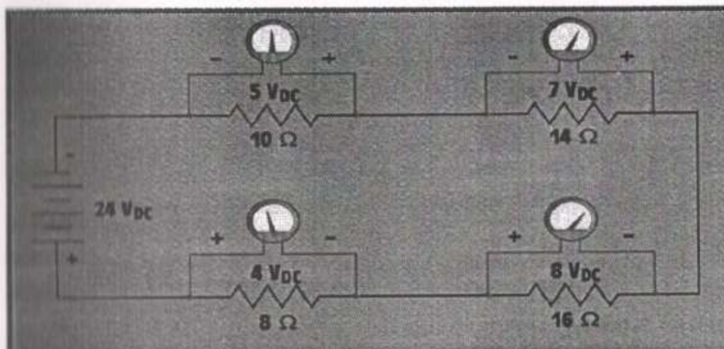


Figure 6-5 Series circuit with four resistors having different voltage drops

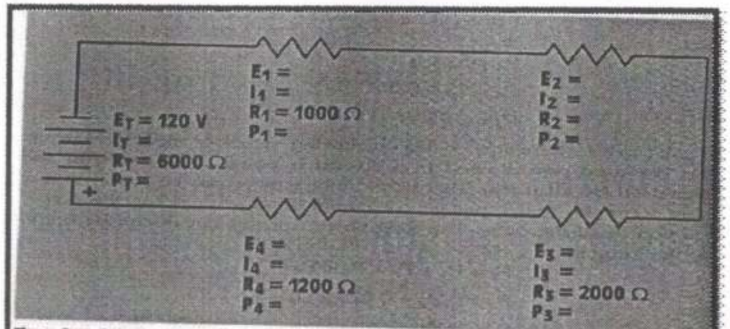


Figure 6-12 Series circuit, Example 2

Answer : R_2 = 1800 W

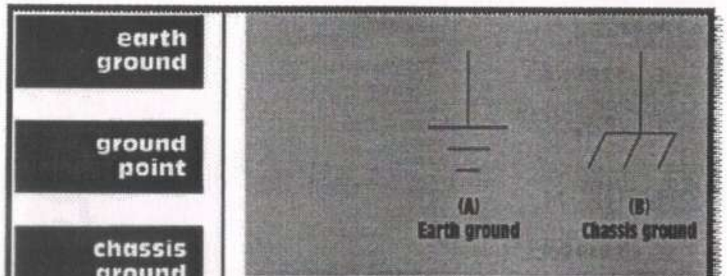


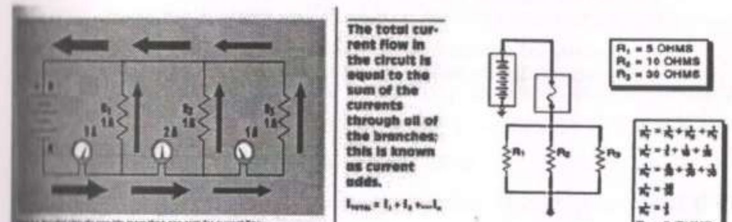
Figure 6-25 Ground symbols

Summary

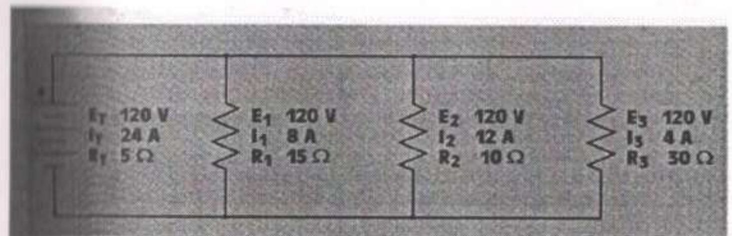
1. Series circuits have only one path for current flow.
2. The individual voltage drops in a series circuit can be added to equal the applied voltage.
3. The current is the same at any point in a series circuit.
4. The individual resistors can be added to equal the total resistance of the circuit.
5. Fuses and circuit breakers are connected in series with the devices they are intended to protect.
6. The total power in any circuit is equal to the sum of the power dissipated by all parts of the circuit.
7. When the source voltage and total resistance are known, the voltage drop across each element can be computed using the general voltage divider formula.

Parallel Circuit : A circuit that has more than one path for current flow.

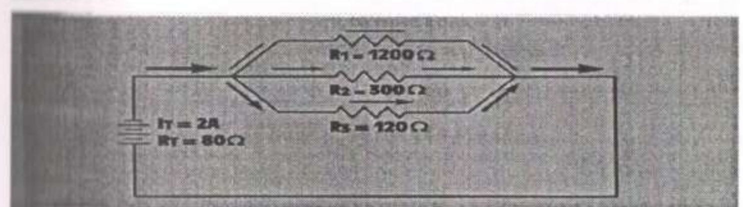
- TOTAL CURRENT IS SUM OF THE CURRENTS THROUGH ALL THE BRANCHES
- VOLTAGE ACROSS ANY BRANCH EQUALS APPLIED VOLTAGE
- TOTAL RESISTANCE IS THE RECIPROCAL OF THE SUM OF RECIPROCALS OF EACH BRANCH "AND" IS ALWAYS LESS THAN SMALLEST BRANC



Parallel circuits provide more than one path for current flow.



Parallel circuit values



The current divides through each branch of a parallel circuit

Summary

1. A parallel circuit is characterized by the fact that it has more than one path for current flow.
2. Three rules for solving parallel circuits are:
   - A. **The total current is the sum of the currents through all of the branches of the circuit.**
   - B. **The voltage across any part of the circuit is the same as the total voltage.**
   - C. **The total resistance is the reciprocal of the sum of the reciprocals of each individual branch.**
3. Circuits in homes are connected in parallel.
4. The total power in a parallel circuit is equal to the sum of the power dissipation of all the components.
5. Parallel circuits are current dividers.
6. The current flowing through each branch of a parallel circuit can be computed when the total resistance and total current are known.
7. The amount of current flow through each branch of a parallel circuit is inversely proportional to its resistance.

Pradhan Mantri Surya Shakti Yojana (PMSSY)

प्रधानमंत्री सूर्य शक्ती योजना

Presented by :Prof. Dr. Ajay Chandak*

Innovative business model for capacity building of solar power with zero government finance or subsidy.

Purpose of Pradhan Mantri Surya Shakti Yojana (PMSSY)

- To achieve target of 100 GW of solar power, set by honorable Prime Minister Narendraji Modi.
- This is new source of finance; the electricity consumer. Implementation of project is on the lines of 'Sabka Saath, Sabka Vikas' **सबका साथ सबका विकास.**
- All equity, no debt financing model. Banks can divert their funds to "Make in India" kind of projects.
- Scheme is neutral to variation in tariff structures in different states. Can be implemented by a single entity throughout the country.
- The scheme will provide Win- Win situation for all stakeholders.
- Will be first ever effort of large scale public participation for clean energy and climate change mitigation in the world.

This is a concept paper; operating details are worked out by the author on issues like banking of power,sell of surplus power, transfer or trading of bonds etc. It makes financial sense to opt for PMSSY scheme to obtain much higher solar power production for the same investment, as compared to production in decentralized systems like solar pumps and rooftop solar installations. Other projects like solar cities; solar parks can be merged in this scheme.

Policy makers need to think big and adopt such innovation to make India, a "Solar India". Let us show the world, 'We Can Do It".

---

*Prof. Dr. Ajay Chandak is an elected board of directors on International Solar Energy Society (ISES), which is apex advisory body of United Nations and World Bank for solar energy. He has worked as consultant to United Nations and also to MNRE. Possess a Ph.D. with research in Solar energy. Has global experience of consulting and promotion of renewable energy. Numerous Renewable energy &ENCON awards from Government of Maharashtra and other national bodies. Initiated 36 patents, many of these are commercialized. Published 12 research papers and 19 presentations in global conferences including on policy issues. Founder and chairperson of PRINCE (Promoters, Researchers & Innovators in New & Clean Energy).

PRADHANMANTRI SURYA SHAKTIYOJANA (PMSSY)

प्रधान मंत्री सूर्य शक्ती योजना

Prof. Dr. Ajay Chandak*

The proposed business model will fulfill dream of honorable Prime Minister NarendrajiModi and hence the name proposed as **"Pradhan Mantri Surya Shakti Yojana (PMSSY) प्रधान मंत्री सूर्य शक्ती योजना**

Prime Minister, Narendraji Modi, has committed solar power installations of 140 GW by 2022; 100 GW in centralized solar power plants and 40 GW of rooftop solar power plants. By 2014 India's installed capacity was slightly higher than 3 GW and achieving 140 GW by 2022 is a long way to go.

In FY 2014-15 India's power generation was around 1000 billion kWh and solar power contribution is around 0.25% in the mix. With current trends in FY 2021-22,power generation will be around2000 billion kWh. Even if all targeted 140 GW of solar power capacity is completed it will generate 200 billion kWh,which is just 10% of the energy mix. India needs to plan for more aggressive targets.

Solar power projects in centralized manner costs around Rs. 6 crores per MW and rooftop installations around Rs. 10 crores per MW. To achieve target of 140 GW of solar power,India needs to infuse capital of Rs. 10 lakh crores. Raising capital of this magnitude is a daunting task. Financial viability of solar power is still an issue and Government of India (GoI) currently provides different incentives like higher power purchase rates, accelerated depreciation, viability gap funding, direct capital subsidy and supportive mechanisms like renewable power obligation (RPO). Most of the states have ratified solar RPO at 0.25%, which is negligible.All these measures work well as long as solar power contribution is small. As the solar power capacity starts building up, it will not be possible for the GoI to provide financial incentives of this magnitude. Rise is power tariff because of solar power will be another issue that GoI need to tackle; if not handled well can lead to huge social unrest and political backlash.

EXISTING SOLAR POWER FINANCING MECHANISMS

Centralised MW Scale Solar Power Plants

Power generated in centralized plant can be sold through power purchase agreement (PPA) with distribution licensees (DLs), third party sell and open access sell. In all these options the financial viability of the project depends on the rate for solar power as well as cash inflow by way of sell of renewable energy certificates (REC). Almost none of the states have strictly enforced RPOs and hence the project viabilities are in jeopardy. Under Jawaharlal Nehru National Solar Mission (JNNSM) in year 2014-15 solar power plant capacity addition is only 1112 MW when almost 50% of renewable energy investment was made in solar power. As a result achieving 100 GW by 2022 will be a daunting task.

Projects are being executed with these mechanisms and have following hurdles to meet the target.

* For installation of 100 GW power if viability gap funding (VGF) is provided at Rs. 1 crore per MW, then GoI need to provide Rs. 1 lakh crores to the investors in cash, apart from revenue loss on account of accelerated depreciation. For rooftop power GoI is providing 15% subsidy. For 40 GW rooftop installation subsidy of Rs. 60000 croreswill be required. It's practically not possible for GoI to infuse such huge capital.
* As the projects are capital intensive and financial returns are based on the depreciation benefit and revenue from sell of RECs etc., there is no role for small investors.
* Under current policies investment in solar projects is possible only from big corporate who are very sensitive about return on investments (ROI). Current levels of investments are not attracting enough investors to meet the target by 2022. Some innovation in raising capital from new sources will be required.

Rooftop Solar Power Plants

* Rooftop installation ideas are promoted with a belief that the users will invest in the project and will get their own power. The governments will be relieved from raising capital for solar projects. However, careful evaluation of the financial impact of this mechanism will result in tariff hike for everybody. This is explained below. Rooftop installations will be adopted by elite consumers who have disposable capital and big rooftops available. These are the customers who pay premium tariff (Rs. 7 to Rs. 12 per kWh). DLs utilize this premium for cross subsidizing the farmers and deserving domestic consumers. **If 40000 MW of such installations come up in the country as planned then Distribution Licensees will have perpetual loss of Rs. 8800 crores per year** only on the premium they get (presuming they get Rs. 2 per kWh as premium). This is a direct loss to the distribution licensees.
* Distribution licensees are not compensated for reserving their infrastructure (@ 15%)and some losses they make as the solar plant interacts with the grid. Capacity utilization of DLs drop. Load factor drops. Administrative work for DL increases. All this results in huge indirect cost addition.

Direct and indirect loss of DL's has to be passed on the common consumers. Hence if somebody installs a rooftop solar power plant will actually affect all consumers in terms of price rise. It is expected that the consumers lost by the DLs (who opt for rooftop solar power) will burden DLs by Rs. 3 to 5 per kWh for the component of solar power he/she produces on his own. Such solar power producers become liability to the DLs and all other consumers.

Electricity is a state subject. As purchase of expensive solar power increases average cost of purchase of power, the burden has to be passed on to the consumer in terms of tariff hike. As the composition of solar power in the mix is less than half percent this impact is not noticeable at the moment. However as the contribution of solar power increases it will result in tariff hike. For this reason the state governments andDLs are not willing to add solar power to their kitty,anticipating unrest from common consumers andpolitical backlash. On other side the Prime Minister is raising the target bar for solar power and making these commitments at all global platforms. There is a state of confusion on how such aggressive targets can be achieved if states do not accept proportionate targets and increase their RPO component. With existing financing mechanisms it seemspractically impossible to get investment of Rs. 10 lakh crores for solar power projects, if state governments are not aggressive enough to opt for solar power. Efforts are required to device new methods of financing as well as innovations in business methods. Innovator has proposed a business method wherein capital for solar power projects can be raised from altogether new untapped source, the end user of electricity. Small and medium scale investments in the project from electricity consumers can be raised under this innovative business model. Adoption of this business model by GoI will help them to accomplish the target of 100 GW of solar installation, through Solar Energy Corporation of India (SECI) or National Thermal Power Corporation (NTPC) or similar public sector enterprise. For discussion purpose author is referring SECI as the lead company that will implement such project. The project involves participation of common man in raising capital for "Solar India" and is in line with prime minister's vision of "Sabka Saath Sabka Vikas" (**(सबका साथ सबका विकास)**| and hence the project is named as "Pradhan Mantri Surya Shakti Yojana (PMSSY)"**(प्रधान मंत्री सूर्य शक्ती योजना)**.This model provides a Win-Win situation to all stakeholders. This innovative business method is described in details separately. Also find excel sheets and presentations attached herewith.

PRADHAN MANTRI SURYA SHAKTI YOJANA (PMSSY)

प्रधान मंत्री सूर्य शक्तीयोजना|

Prof. Dr. Ajay Chandak

Details of proposed scheme are provided herewith. The scheme is proposed to fulfill the dream of "Solar India" of honorable Prime Minister NarendrajiModi and hence the name proposed as **"Pradhan Mantri**

Surya Shakti Yojana (PMSSY)" "प्रधान मंत्री सूर्य शक्ती योजना" |

This financing model has all equity participation with zero debt. All capital is raised from consumers of electricity from all categories, farmers, residential, industrial, commercial, institutional etc. This innovative financing mechanism has capacity to add thousands of MW of solar power by crowd-funding,i.e. raising capital from public participation. Following are the major steps on how the innovative scheme will work?

How does the innovative Scheme(PMSSY) will work?

- A company, preferably PSU, 'Solar Energy Corporation of India (SECI)', will execute the scheme.
- Raise capital through 'Solar Bonds'. Consumers from all categories can purchase any number of solar bonds as per their energy consumption. The bonds will have status of infrastructure bonds and can avail tax benefits. Bonds will be launched in phases of 1000 MW or so and will be sold all over the country. Capital so raised will be deployed in large MW solar projects.
- No bar on territory where the solar project will come up. Lower capital cost and higher power generation will be the criteria for selection of project sites.
- On the same lines as NTPC sells power to the states, SECI

will provide this solar power generated to the states in proportion of the bonds purchased in that state. The difference is that the power will not be sold, but will be made available to the state grid for distribution to the bond holders in that state. It is expected that out of total power generated 40% power will be provided/sold to meet the operating expenses and losses. The proposed distribution is as under.

- Operation and maintenance company: 18%
- Transmission charges and losses : 5%
- Distribution licensee : 13% (7% for losses and 6% for CSS.)
- Insurance and administrative company : 3%
- Innovator's share : 2%
- Miscellaneous : 2%
- SECI share : 3%

- Balance 54% of power will be made available to the bond holder in proportion of their investment. For this service (procuring power from SECI and supplying to bond holder) Distribution licensees (DL) will get compensation for losses and operative costs in terms of power and cash. It is proposed that bond holders in high tariff category will continue to pay 'Cross Subsidy Surcharge (CSS)' by parting off a slice of their share in the power (Approx. 10%). DLs will use this power from CSS for subsidizing farmers and weaker sections.For the solar power component wheeled to bond holders, DLs will not have responsibility to collect the payments and hence they get rid of the recovery issue.This issue is severe especially with farmers where recoveries are poor. Innovation works like a prepaid system with 100% recovery. **As power is distributed and not sold, the bond holder gets inflation free power for 20 years. This is the biggest innovative feature of the scheme.**
- Project envisages distribution of generated power in proportion of investment, and not sell of power; hence the business mechanism is insulated from the variation in tariff structure in **different states.** Irrespective of the fact in which state the bond holder lives, he/she will get his/her share of solar power through the grid to which he/she is connected.

The project will also generate cash by way of selling 'Renewable Energy Certificates' which will be shared by all stakeholders.Following distribution is proposed to different stakeholders.

- RECs/Cash to Transmission company : 5%
- RECs/Cash to Distribution licensee: 20%
- Share of SECI : 10%
- Share of Innovator : 2%
- Miscellaneous: 2%
- Cash incentive to Solar Bond holders: 61%

An illustrative Example is Explainedherewith

Project phase 1 for say 1000 MW.

Size of Project in one phase	**1000**	MW
Cost per MW	**6.12**	Cr Rs. Per MW
Capital cost of project	6120	crores
Cost of bond in Rs.	1.25	lakh
No. of bonds	489600	nos.
Power Produced per MW installation	**1660**	MWH per year
Total Power produced per year	1660000	MWh/year

<u>Distributing power generated to different stake holders</u>

Operation and maintenance company@ 18%	298800	MWh/year
Transmission charges and losses 5%	83000	MWh/year
Distribution charges and losses 7% 1	16200	MWh/year
Insurance and administrative company 3%	49800	MWh/year
Innovator's share 2%	33200	MWh/year
Miscellaneous 2%	33200	MWh/year
SECI Share 3%	49800	MWh/year
Balance available power	996000	MWh/year
Cross Subsidy Surcharge to DL 10%	99600	MWh/year
Effective share of power DL gets 13%	215800	MWh/year
Net Total MWh available to bondholders	896400	MWh/year
MWh available to every bondholder	1.83	MWh

kWh available to every bondholder	1831	kWh per year

Cash Earnings from Project

Revenue from REC sell etc	**3.5**	Rs./kWh
Total Cash revenue	**581**	**Cr. Rs./year**
RECs/Cash for payment to Transmission 5% company	**29.05**	**Cr. Rs./year**
RECs/Cash for payment to Distribution Licensee 20%	**116.2 Cr.**	**Rs./year**
Share of SECI	**10% 58.1**	**Cr. Rs./year**
Revenue to Innovator 2%	11.62	**Cr. Rs./year**
Miscellaneous 2%	11.62	**Cr. Rs./year**
Incentive to investors/bondholders	354.41	**Cr. Rs./year**
Cash Incentive to every bondholder	7239	**Rs./year**

Same illustration is shown schematically in Fig. 1

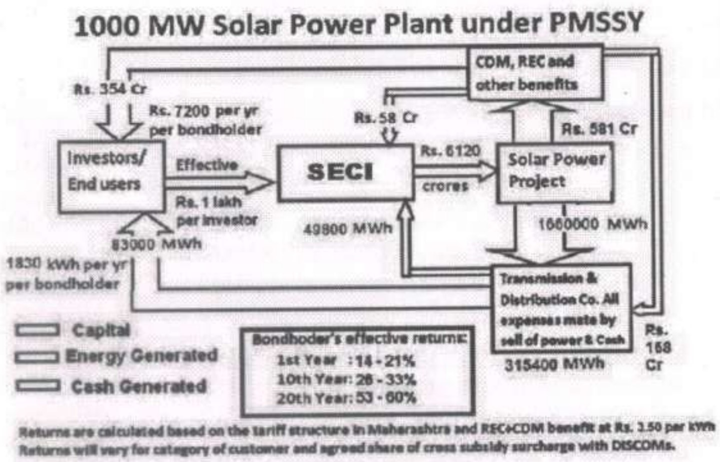


Fig. 1 : Scenario of returns to different stakeholders in terms of power and cash

In a nutshell, capital for centralized solar power plant is raised from thousands of retail investors and their share of generated power is wheeled to their campuses through conventional grid. Anybody who wants to invest in solar power can invest irrespective of the fact whether he/she has disposable rooftop or not. People who have rented properties can also participate in raising

capital.

Different series of bonds can be floated in multiples of 1000 MW solar plant or so.

How Every Stakeholder Benefits

a. **Solar Energy Corporation of India (SECI) & Government of India**: SECI gets cash revenue and share in solar power. Power may be utilized for SECI itself or by other government offices or may be sold in the market. Benefits to SECI and GoI are:

- ☆ Cash earnings of around Rs. 48 crores per year.
- ☆ Share of power around 48000 MWh per year.
- ☆ Altogether new way of raising finance from new investors. Very large amount of capital can be raised.
- ☆ No subsidy required. No burden on GoI's exchequer.
- ☆ Target of 100 GW of solar power can be accelerated if this model is adopted. It's practically impossible to achieve target of 100 GW without innovations in solar project financing.
- ☆ Participation of people in such projects is on the lines of "Sabka Sath Sabka Vikas'. All capital is "equity" raised from savings of people and no bank debt. Banks will have more funding available for social projects, for industries or for 'Make in India' kind of missions.
- ☆ Fulfilling global commitment on renewable energy and climate change mitigation.

b. **Transmission Company**: Transmission Company will also get cash revenue and share in power. It will get:

- ☆ Cash earnings of around Rs. 24 crores per year.
- ☆ Share of power around 48000 MWh per year.

c. **Distribution Licensee**: DL will also get cash revenue and share in power. It will get:

☆ Cash earnings of around Rs. 96 crores per year.

☆ Share of power around 208000 MWh per year.

Distribution licensee will get compensated for the losses as well as for the professional services. They get CSS to subsidise deserving consumers like farmers and low income groups and also get RECs to comply their RPO obligations. It's possible to keep the price rise in tariff in check even after adding solar power to the grid.

d. **The investor/Bond holder**: Every bond holder will also get his share in power and cash revenue as under for the first year on effective investment of Rs. 1 lakh post tax incentives.

☆ Cash earnings of around Rs. 6300 per year.

☆ Share of power around 1800 KWh per year.

Investors will get inflation free power for the life of project. As the power tariff increases, the return on investment increases. A scenario of 20 years for investors will be as shown in Table 1 (baseline rate of power for Maharashtra). Annual average returns on investment can be 35 to 50%.

Separate bonds for different category of customers

Return on Investment Scenario in % for Investors			
Category ➡	Residential	Industry	Commercial
1st Year	19	18	23
10th Year	31	30	40
20th Year	60	58	78
Avg. Return per year %	35	35	47

Table 1: Return on investment scenario for the investors

e. **State Government**

☆ Minimum tariff rise.

☆ State will get credit of big capacity addition in solar power and also climate change mitigation,with zero investment or subsidy.

☆ In case of substitution of solar pump project with solar power project under PMSSYproject cost reduces to 40% with many financial, social and environmental benefits.

Main advantages of "Pradhan Mantri Surya Shakti Yojana (PMSSY)" are summarized below.

a. Capital in for solar projects is raised from altogether new investors which are not tapped inconventional business models.100% equity participation. No debt.

b. People's participation is ensured. This is in line with the current government's policy of 'Sabka Saath, Sabka Vikas'सबका साथ सबका विकास. This can become public movement like 'Swachh Bharat Abhiyan"(स्वच्छ भारत अभियान)

c. Governments and Distribution licensee will get huge solar power capacity addition without investing a single rupee. No subsidy required.

d. Distribution licensee gets share in power, share in REC/or cash and also Cross Subsidy Surcharge.

e. **International commitments on climate change require measurable emission reductions. With centralized solar plants it is possible to comply with this requirement. However with decentralized solar plants like rooftop installations and solar pumps the benefit of REC or carbon emission can't be claimed. Hence it will make more sense to divert these investments in PMSSY scheme.**

f. 'People's solar power' projects under **PMSSY**will provide more revenue to the transmissioncompanies, Distribution licensees and SECI, while rooftop installations or solar pumps provide none. A comparison of different options of solar power projects is shown in table 2.

Table 2: Return on investment for different solar power projects

Comparison of Diff. Solar PV options			
Solar PV Projects	People's Power MW scale Grid tied	Rooftop Installation	Solar Pumps
Capital invested per MW in Crore Rs/MW	6	10	10
Power produced per year in MWh/MW installed	1650	1100	700* equi. Water pumping
First year ROI @ Rs. 7 per kWh	Approx. 13 %	7% max.	5% max.
Cash revenue generation through RPO, CDM etc.	Approx. 6%	Not Possible	Not Possible
Net Return on Investment for first year	Approx. 19%	7% max.	5% max.

Requirements from Government of India

For implementation of "Pradhan Mantri Surya Shakti Yojana (PMSSY)" following are requirements.

- ☆ Willingness of SECI to adopt the business model. In case SECI does not take the lead role then other PSUs like NTPC or BHEL should step in for the project. In case PSUs are not ready to take this responsibility then corporate can use the same business model. However in that case the returns will be lower by @ 10 %, as the corporate will charge their profit margins.
- ☆ Minor changes in Indian Electricity Act. Fixing responsibility of transmission and distribution of power on respective companies at national grid and state grid level.
- ☆ Accepting reasonable compensation for all agencies involved from generation of solar power to delivery of solar power to the end users.

This is a concept paper. Operating details have been chalked out by innovator on issues like banking of power, sell of surplus power, transfer or trading of bonds, financial security of investors etc. and can be discussed at length once the theme is approved.

Many innovations can be added to make the scheme popular. Major consumers of power can be forced by law to accept predefined component of power consumed through solar bonds. For all new projects where power consumption is substantial, like water supply schemes, waste treatment plants, commercial buildings etc.; budgeting provisions can be made in these projects to procurefew solar bonds as integral part of the project. Another flagship program of 'Prime Minister" is "Smart City Program". Complete energy requirement of the city can be fulfilled through solar bonds. New

housingprojects costing more than Rs. 25 lakh can be made compulsory to have at least one solar bond.

Policy makers need to think big and adopt such innovation. India will be the first nation to launch such large scale solar energy program with public participation. We can show theworld, yes 'We Can Do It'.

***All queries and questions are welcome.**

<u>QUOTATION.</u>

A. 12Watt LED Solar Street Light System consist of:

1.	12V 74Wp SPV-Module.	: 01 no.
2.	12V 100Ah SMF Battery.	: 01 no.
3.	12watt LED Luminary.	: 01 no.
4.	12V 10amp. Charge Controller.	: 01 no.
5.	4.5 Mtrs. G.I. Pole with Light Stand, Battery Box, Module Structure.	01 Set.
6.	Cable & Fitting.	: 01 Set.
	Cost Rs.	**22, 000.00**

B. 9Watt CFL Solar Home Lighting System consist of:

1.	12V 37Wp SPV-Module.	: 01 no.
2.	12V 42Ah SMF Battery.	: 01 no.
3.	9watt CFL Luminary.	: 02nos
4.	12V 5amp. Charge Controller.	: 01 no.
5.	Battery Box, Light clamp. Module Structure.	: 01 Set.
6.	Cable 15mtrs, Fitting, Socket & Switch.	: 01 Set.
Cost Rs.		**11,500.00**

Total Rs. (22,000 + 11,500) = 33,500.00

Materials Transportations cost Rs. 4,500.00

Total Rs. (33,500 + 4,500) = 38,000.00 (Thirty Eight Thousand Only)

Terms & Conditions:

1. Rate valid for 30 days. & inclusive of TAX, installation charge.
2. Payment: 100% advance through NEFT in our A/C, 7 days before despises of materials.
3. Foundation materials you will have to provide.

Please confirm as earliest so that we may provide you our Bank details.

USAGE OF SOLAR ENERGY IN THE DAIRY INDUSTRY

D.C.Sen
Professor of Dairy Technology
Department of Dairy Technology
West Bengal University of Animal and Fishery Sciences
Mohanpur Campus, Nadia – 741252. W.B.
e-mail : drdcsen@rediffmail.com

Usage of solar energy is not new. Even in seventh Century B.C., we get the reference of concentrating solar heat with glass and mirror to light fire. Today, we find the usage of solar heat in many places, starting from solar powered buildings to solar powered vehicles. The photovoltaic (PV) effect was first experimentally demonstrated by the French physicist, Edmond Becquerel in 1839 at the age of 19 years only. He built the world first PV cell in his father's laboratory. However, commercially PV technology was invented in USA in 1954. There three scientists Daryl Chapin, Calvin Fuller and Gerald Pearson developed the silicon PV cell at Bell Laboratories. It was the first solar cell which was capable of converting the sun's energy into power to run everyday's electrical equipments. Up to the year 2012, the world's largest solar energy plant was Golmud Solar Park of China with an installed capacity of 200 megawatts. Later on, this was surpassed by Gujarat Solar Park of India with a installed capacity of 605 megawatts.

India is one of the rapid growing dairy nations in the world. On an average the growth rate of dairying in India is 4.5%. With the fast increase in population and enhancement in lifestyle of people, the demand for milk and milk products is augmenting day by day. India ranks fifth in the world where about 49 % of the total energy is consumed by the industry.

Today, major electricity generation takes place at the central power stations where coal, oil, water, gas and nuclear materials are utilized as main fuel sources. These are not renewable and

have limitations, less efficient (65 – 75 %) and expensive. Renewable energy, is the energy that comes from the natural energy flows on the earth. Like conventional energy, the renewable energy will not be exhausted. Renewable energy is also known as many other names such as "Green Energy", "Clean Energy", "Alternative Energy" and "Sustainable Energy". In India, for energy production about 39 % Petroleum, 23 % Coal, 23 % Natural Gas, 8 % Nuclear and 7 % Renewable Energy Sources are used. Various types of renewable energy sources are : Solar energy, Wind energy, Hydropower, Biomass energy and Geothermal. Among these, sun is a reliable, non-polluting and inexhaustible source of energy. Sun rays will never be exhausted. India lies in the sunny regions of the world. In India, about 5 – 7 kWh/m^2 of solar energy is received for 300 – 330 days per year which is enough to set up 20 MW solar power plants per square kilometre land area.

The maximum annual radiation energy is received in western Rajasthan where as the minimum is received in north-eastern region of India. Solar energy can be used in many dairy operations like heating, cooling, pumping, lighting, drying, steam generation, etc. To use this technology in a cost effective way, it is necessary to understand the resource, component and system aspects of the PV plant including the load served by efficient end-use equipment with a high value service.

Photovoltaic (PV) Cell : A PV cell is a specialized semiconductor diode that converts visible light into direct current (DC). Some PV cells can also covert infrared (IR) or ultraviolet (UV) radiation into DC electricity. PV cells are integral parts of solar-electric energy systems which are becoming increasingly important as alternative sources of utility power. It is now well known that solar energy can be transformed into electrical energy with the use of PV devices. These devices have the ability to convert light energy into electrical energy through photo electric effect. These PV cells or so called solar cells are made of semi-conductor materials. In many types of solar cell materials silicon wafers, polycrystalline thin films and single-crystalline thin films are most common. Bulk silicon was used to make some of the earliest PV devices. Single crystal silicon-wafer based PV cells plated on the glass are more widely used compared to other materials. But their efficiency is relatively low and cost is comparatively high. Later on, with the advent of transistor and semi-conductor technology, various thin-film technologies have been developed. These thin film technologies have reduced the manufacturing cost and increased the efficiency. Poly crystalline thin film efficiency ranges from 10 – 20 % while single-crystalline thin film of multi-junction solar cell structure efficiency ranges from 15 – 20 %. The recent development for the single-crystalline film of multi-junction solar cell structure resulted a high conversion efficiency of 41 % in an optical concentrator solar cell. This PV device can be used for storing solar energy and utilized in the dairy plant for different unit operations like heating of water, air, pasteurization, cooling and pumping.

How Does a PV Cell Work to Generate Electricity ?

When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electron can be captured in the form of an electric current that is, electricity.

Why Should We Go for Solar Energy ?

- Abundant and free source of energy.
- Completely non-polluting and clean source.
- Ever increasing costs of fuel.
- Ever increasing pollution due to combustion of fossil fuels.
- Best suited for industrial applications in all renewable energies.
- Existing heating system can be used as back up during inclement weather conditions.
- Solar energy equipment can be easily incorporated in the existing process.

Cost Return on Investment

The approximate payback periods for the different systems are as follows.

- Low temperature : 1,5 – 2.0 years.
- Medium temperature : 2.5 – 3.5 years.
- High temperature : 3.5 – 5.0 years.

What are the Benefits of Solar Energy ?

- Answer to ever-increasing fuel bills.
- Proven indigenous technology.
- Easy operating systems.
- Abundantly available.
- Attractive paybacks.
- Low maintenance cost.

Present Scenario of the Dairy Industry in India

In 1950, the milk production of India was 17 million tonnes only. This has now increased to 140 million tonnes in 2014 and with this in milk production, India now ranks first in the world. It is an unprecedented growth for any country. The milk consumption in India is growing at around 6 %. India contributes about 17 % of the global milk production but its share in global export is 0.4 % only. Out of the total milk produced in India, about 20 % is handled by the organized sectors. Use of conventional energy is the common practice for major processing of milk. Presently, almost all dairy operations are performed using grid supply with diesel generator set as back up. To overcome this problem of continuous grid supply of electricity and diesel generator sets, solar based refrigeration system for milk cooling at society level is quiet feasible. The use of solar energy in the dairy is generally seen for hot water supply to the boiler, hot water generator for processing of milk and CIP cleaning.

Efforts have been made to construct PV modules that provide simple, reliable and independent electrical power source at remote locations. This can be seen in the areas of solar water heating for dairy farms and micro irrigation.

Case Studies

Mahanand dairy in Latur, Maharashtra is related to many breakthroughs in milk production and dairy technology in India. In view of its reputation, Mahanand dairy decided to go for solar energy to meet its thermal energy need for pasteurization of milk. In 2006 , an ARUN dish (Concentrating Solar Thermal System) indigenously developed and installed at the dairy premises. It has been estimated that a single dish can deliver energy which is sufficient to pasteurize 30,000 litres of milk and CIP (Cleaning-in-Place) of milk storage tanks on a clear sunny day. This system continues to save about 100 – 115 litres of furnace oil on a clear sunny day, totally avoiding the firing of the conventional boiler. Subsequently, at Chitale dairy, Sangli, two-dish Arun system was installed which generates steamfor milk pasteurization, can washing, CIP and crate washing. Both the dishes were installed on the terrace of its three-storyed building. The foot print area is less than 9.0 m^2 per dish. Both these dairies have set an example by pioneering the successful use of solar technology for satisfying their thermal energy need in various applications of dairies. Then at Dudhmansagar dairy, Manesar, Haryana, solar water heater is used for pasteurization of milk with insulated solar tank of 20000 litres. Similarly, at Milkfed dairy, Mandi, Himachal Pradesh, Solar water heaters are used for heating boiler feed water and cleaning. Insulated solar tank of 6000 litres is used for heating boiler feed water and insulated solar tank of 2500 litres is used for cleaning purpose.

Solar energy may be used in the dairy for preheating of air. It increases the temperature of air from 35 - 85°C with the use of solar energy. Thereby, it reduces the load of air heater, cost and pollution of air.

Solar pumping is one of the most important applications of PV in India. A solar PV pump is a DC or AC, surface –mounted or

submersible or floating pump which runs on power from a solar PV array. It may be used to run a hot water pump, chilled water pump, milk pump and CIP pump. Solar PV pumps are also used to draw water for irrigation and for drinking water. The solar PV array converts sunlight into electricity and delivers it to run the motor and pump. The water can be stored in tanks for use during non-sunny hours, if necessary.

Solar Energy to Lighten Dairy Offices and Premises

Solar PV lighting systems are becoming popular in both the rural and urban areas in India. In rural belts, solar PV lighting system is being used in the form of portable lanterns, home-lighting with one or more fixed lamps and street-lighting. A solar street-lighting system is an outdoor lighting system which is used to illuminate a street or an open area usually in dairy, garden, road approaches to dairy and chilling centre. The PV module is placed at the top of the pole and a battery is placed in a box at the base of the pole. The module is mounted facing towards south , so that, it receives solar radiation throughout the day without any shadow falling on it. This system is designed to operate from dusk to dawn. The compact fluorescent lamp (CFL) here automatically lights up when the surroundings become dark and switches off around sunrise time. The cost of a solar street lighting system is around Rs. 19000/-.

Solar Energy for Electric Fences

Solar electric fences are widely used in Dairy to prevent stock and predators from entering or leaving an enclosed field. These fences generally have one or two live wires which are maintained at about 500 volts DC. These impart a painful but harmless shock to any animal that touches them. These requirements can be met with a PV system solar cells, power conditioner and a battery.

CONCLUSION

On the whole, considering the pros and cons of the usage of solar energy in the dairy industry, it is learnt that there are some impediments of its applications in the dairy sector. These include like (i) Lack of awareness about the possible solar energy uses and economics. (ii) Limited number of suppliers for solar thermal solutions to dairies. (iii) Apprehensions about the performance and limited number of installations. (iv) High initial investments and (v) Long decision making process. Therefore, to overcome these hindrances, we all have to come forward with positive outlook for the successful implementation of solar energy utilization in the dairy industry.

REFERENCES

Bhasin, N. R. (2015) Presidential address. *Indian Dairyman*. **67**, (3), 27 – 29.

Bhasin, N. R. (2015) From the President's desk. *Indian Dairyman*, **67**, (4), 16 – 17.

Desai, D. D; Raol, J. B; Patel, S and Chauhan, I. (2013) Application of solar energy for sustainable dairy development. *European Journal of Sustainable Development*. **2**, (4), 131 – 140.

http : // www.cliquesolar.com/dairyIndustry.aspx

http : // www.en.wikipedia.org/wiki/Photovoltaics

http : // www.en.wikipedia.org/wiki/solar_cell

http : // www.google.co .in

http : // www.linkedin.com/pulse/possible-energy-savings-dairy-processing-plant-nalla-lion-2500-

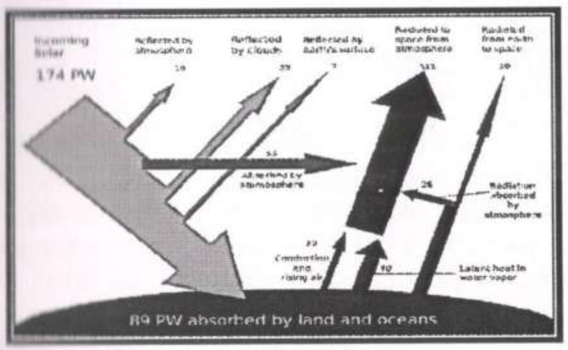
SOLAR ENERGY AND ITS FUTURE GOAL AS SOLAR LAMP AND STREET LIGHT

Sri Suprakash Pradhan,

Part-time Teacher, P.K.College, Contai, Purba Medinipur

Solar Energy a clean renewable resource with zero emission has got tremendous potential of energy which can be harnessed using a variety of devices. With recent developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. Solar energy could be made financially viable with government tax incentives and rebates. The National Solar Mission is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge

The Earth receives 174,000 terawatts (TW) of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. Most people around the world live in areas with insolation levels of 150 to 300 watt per square meter or 3.5 to 7.0 kWh/m^2 per day.



Sunlight absorbed by the oceans and land masses keeps the surface at an average temperature of 14 °C. By photosynthesis green plants convert solar energy into chemical energy, which produces food, wood and the biomass from which fossil fuels are derived.

The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ) per year. In 2002, this was more energy in one hour than the world used in one year. Photosynthesis captures approximately 3,000 EJ per year in biomass. The technical potential available from biomass is from 100–300 EJ/year. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined,

RURAL ELECTRIFICATION

Lack of electricity infrastructure is one of the main hurdles in the development of rural India. India's grid system is considerably under-developed, with major sections of its populace still surviving off-grid.

- As of 2004 there are about 80,000 unelectrified villages in the country. Of these villages, 18,000 could not be electrified through extension of the conventional grid.
- A target for electrifying 5,000 such villages was fixed for the Tenth National Five Year Plan (2002–2007). As on 2004, more than 2,700 villages and hamlets had been electrified mainly using SPV systems.

3000 villages of Odissa will be lighted with Solar power by 2014. The off-grid and rooftop segments will grow exponentially as price parity with consumer tariffs makes solar power an economically viable alternative, particularly for urban and semi-urban consumers. Distributed generation in rural areas and support for latent urban demand has the potential to reach 4 GW by 2020

and increase rapidly to more than 10 GW over the next three to four years.

A **solar lamp** is a light fixture composed of an LED lamp, a photovoltaic solar panel, and a rechargeable battery. Outdoor lamps may have a lamp, solar panel and battery integrated in one unit. Indoor solar lamps, also referred to as shaftless skylights or tubeless skylights, have separately-mounted solar panels and are used for general illumination where centrally generated power is not conveniently or economically available. Solar-powered household lighting may displace light sources such as kerosene lamps, saving money for the user, and reducing fire and pollution hazards.

Solar street lights are raised light sources which are powered by photovoltaic panelsgenerally mounted on the lighting structure. The photovoltaic panels charge a rechargeable battery, which powers a fluorescent or LED lamp during the night.

Each street light can have its own photo voltaic panel, independent of other street lights. Alternately, a number of panels can be installed as a central power source on a separate location and supply power to a number of street lights.

ADVANTAGES

- Its are independent of the utility grid. Hence, the operation costs are minimized.
- Its require much less maintenance compared to conventional street lights.
- Since external wires are eliminated, risk of accidents is minimized.
- This is a non polluting source of electricity
- Separate parts of solar system can be easily carried to the remote areas

DISADVANTAGES

- Initial investment is higher compared to conventional street lights.

- Risk of theft is higher as equipment costs are comparatively higher.
- Snow or dust, combined with moisture can accumulate on horizontal PV-panels and reduce or even stop energy production.
- Rechargeable batteries will need to be replaced several times over the lifetime of the fixtures adding to the total lifetime cost of the light.
- The batteries have to be replaced from time to time

Implementation in the Sunderbans in West Bengal

Solar street lights were installed in the Sundarban Tiger Reserve (STR) in August 2008 and April 2009 with assistance from the Forest Protection Committee and the STR officials. Each household in the region were provided with a home light connection by the WWF so that the people feel responsible for the security of the installed solar street lights.

Solar power is anticipated to become the world's largest source of electricity by 2050, with solar photovoltaic's and concentrated solar power contributing 16 and 11 percent to the global overall consumption, respectively.

REFERENCES

1. Somerville, Richard. "Historical Overview of Climate Change Science" (PDF). Intergovernmental Panel on Climate Change. Retrieved 2007-09-29.
2. "Natural Forcing of the Climate System". Intergovernmental Panel on Climate Change. Retrieved2007-09-29.
3. Vermass, Wim. "An Introduction to Photosynthesis and Its Applications". Arizona State University. Retrieved2007-09-29.
4. "Renewable Energy Sources" (PDF). Renewable and Appropriate Energy Laboratory. p. 12. Retrieved2012-12-06.
5. http://www.nature.com/nature/journal/v443/n7107/full/443019a.html
6. "Powering the Planet: Chemical challenges in solar energy utilization" (PDF). Retrieved 7 August 2008.

7. "Energy conversion by photosynthetic organisms". Food and Agriculture Organization of the United Nations. Retrieved 2008-05-25.
8. "Exergy Flow Charts - GCEP". stanford.edu.
9. TERI(2011): Towards Energy Security, 10 January, accessed on 15 Jan 2011(www.teri.in.org)
10. Singh Manmohan(2010): To create solar Village, Jan, Solar Energy Review, New Delhi
11. Delhi International Renewable Energy Conference(DIREC-2010): accessed on 12 Dec, 2010 (http:/www.direc2010.gov.in/)
12. http://www.energymile.com
13. International Energy Agency (2014). "Technology Roadmap: Solar Photovoltaic Energy" (PDF).http: //www. iea. org. IEA. Archived from the original on 7 October 2014. Retrieved 7 October 2014.

COLD LIGHT

Dr. Sumit Giri
P.K. College Contai.
Dept. of Zoology

INTRODUCTION:

Bioluminescence, otherwise called living light, is the radiation produced by living things. It is the emission of light as a consequence of the cellular oxidation of some substrate in the presence of an enzyme. The light produced by living organisms is distinguished as cold light because the heat produced by the light is less than 0.001^{0}C.

Occurrence of cold light:

The ability to emit light is very widely distributed among bacteria, fungi and some animals. They are as follows:

1. Plants:
   a. Bacteria : *Panus striptious*
   b. Fungi: *Mycenea* sp.
2. Animals:
   a. Protozoa: *Noctiluca* Sp
   b. Coelenterata: *Pennatula* sp
   c. Nemertinea : *Emplectonema* sp
   d. Annelida : *Chaetopterus* sp.
   e. Arthropoda: *Cypridina* sp.
   f. Mollusca : *Loligo* sp.
   g. Echinodermata: *Amphiura* sp.
   h. Fishes:*Harpodon* sp .

Biochemistry of cold light:

I	Luciferin + MgATP	$\xrightleftharpoons{\text{ligase}}$	Adenyl-luciferin + Pyrophosphate
II	Adenyl-luciferin + O_2	$\xrightarrow{\text{oxygenase}}$	[peroxy-luciferin] + AMP
III	[peroxy-luciferin]	$\dashrightarrow$	[Oxyluciferin]* + CO_2
IV	[Oxyluciferin]*	$\dashrightarrow$	Oxyluciferin + Light

Mechanism of the bioluminescence reaction catalyzed by firefly luciferase. The enzymatic steps I and II are catalyzed by luciferase. The following steps III and IV are spontaneous to bioluminescence.

Application in human welfare:

Biology and medicine:

Bioluminescent organisms are a target for many areas of research. Luciferase systems are widely used in genetic engineering as reporter genes, each producing a different colour by fluorescence, and for biomedical research sing bioluminescence imaging.

Light production:

The structures of photophores, the light producing organs in bioluminescent organisms, are being investigated by industrial designers. Engineered bioluminescence could perhaps one day be used to reduce the need for street lighting, or for decorative purposes, if it becomes possible to produce light that is both bright enough and can be sustained for long periods at a workable price. The gene that makes the tails of fireflies glow has been added to mustard plants. The plants glow faintly for an hour when touched. University of Wisconsin–Madison is researching the use of genetically engineered bioluminescent E. coli bacteria, for use as bioluminescent bacteria in a light bulb. A team from Cambridge (England) has started to address the problem that luciferin is consumed in the light-producing reaction by developing a genetic biotechnology part that codes for a luciferin regenerating enzyme from the North American firefly; this enzyme "helps to strengthen and sustain light output".

Suggested Reading

Bechara E. J. H. (1988) Luminescent elaterid beetles: biochemical, biological and ecological aspects. Adv. leading Oxygen. Process. 1:123-178.

Branchini B. R., Magyar R. A., Murtishaw M. H., Anderson S. M. and Zimmer M. (1998) Site-directed mutagenesis of Histidine 245 in firefly luciferase: a proposed model of the active site. Biochemistry 37: 15311-15319.

Desjardin, D., Oliveira A.G., Stevani C.V. (2008) Fungi Bioluminescence Revisited. Photochem. Photobiol. Sci 7: 170.

Ghirandella, H. (1998). The anatomy of light production: the fine structure of the firefly lantern. Microscopic anatomy of invertebrates. 11:363-381.

Harvey E. N. (1952) Bioluminescence. Academic Press, New York.

Hastings J.W. (1983) Biological diversity, chemical mechanisms and evolutionary origins of bioluminescent systems. J. Molecular Evolution 19:309-321.

Lall B. A., Seliger H. H., Biggley W. H. and Lloyd J. E. (1980) Ecology of colors of firefly bioluminescence. Science 225: 512-514.

Lloyd, J. E. (1978) Insect Bioluminescence. In: Bioluminescence in Action, Herring P. (ed.), Academic Press, New York.

Rees J. F., De Wergifosse B., Noiset O., Debuisson M., Janssens B. and Thompson E. M. (1998) The origins of marine bioluminescence: turning oxygen defence mechanisms into deep-sea communication tools. J. Exp. Biol. 201: 1211-1221.

Shimomura O. (2006). Bioluminescence: Chemical Principles and Methods, World Scientific, New Jersey.

Sivinski J. (1981) The nature and possible functions of luminescence in Coleoptera larvae. Coleopt. Bull. 35: 167-180.

Tu, S.C. (2007). Bacterial Luciferases. In "Luciferases and Fluorescent Proteins: Principles and advances in Biotechnology and Bioimaging". (V.R. Viviani and Y.Ohmiya eds) pp 1-18, Transworld Research Network, Kerala, India.

Viviani V. R., Hastings J. W. and T. Wilson (2002) Two bioluminescent Diptera: the North American *Orfelia fultoni* and the Australian*Arachnocampa flava*. Similar niche, different bioluminescent systems. Photochem. Photobiol. 75: 22-27.

Viviani, V. R. (2002) The origin, diversity and structure function relationships of insect luciferases. CMLS 59: 1833-1850

Viviani, V.R. (2007) Beetle luciferases: Origin, structure and function relationships and engineering for biotechnological applications. In "Luciferases and Fluorescent Proteins: Principles and advances in Biotechnology and Bioimaging". (V.R. Viviani and Y.Ohmiya eds) Pp 79-105, Transworld Research Network, Kerala, India.

Wood K. V. (1995) The chemical mechanism and evolutionary development of beetle bioluminescence. Photochem. Photobiol. 62: 662-673.

Wilson T. and Hastings J. W. (1998) Bioluminescence. Annu. Rev. Cell Dev. Biol. 14:197-230.

EFFECT OF SUMMER AND WINTER SUN IN INSTALLATION PROCESS OF PV CELL

Sri Nilanjan Samanta

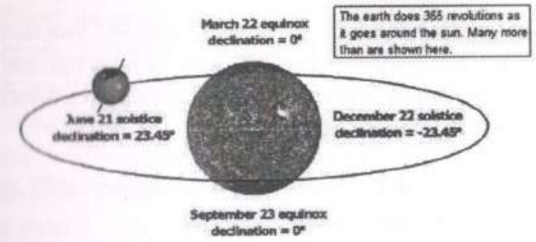
B.Tech, Electrical, Techno-India Campus, Kolkata

Photovoltaic (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry. A system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process take place involving crystallized atoms being ionized in a series, generating an electric current.

In the summer the sun is more directly overhead, while in the winter the angle is lower. This change has a direct impact on the amount of solar radiation absorbed by a solar thermal or PV collector. Most PV panels convert less than 20% of solar radiation to power.

Declination Angle:

The declination angle, denoted by δ, varies seasonally due to the tilt of the Earth on its axis of rotation and the rotation of the Earth around the sun. If the Earth were not tilted on its axis of rotation, the declination would always be 0°. However, the Earth is tilted by 23.45° and the declination angle varies plus or minus this amount. Only at the spring and fall equinoxes is the declination angle equal to 0°. The rotation of the Earth around the sun and the change in the declination angle is shown in the animation below.

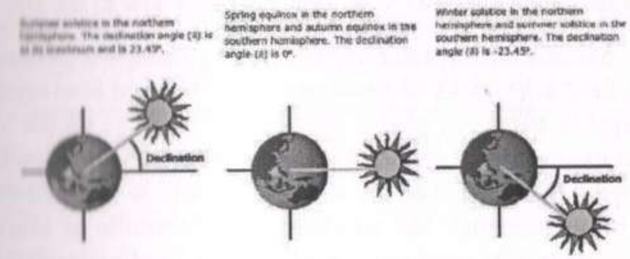


The declination angle can be calculated by the following equation:

$\delta = \sin^{-1}(\sin(23.45°)\sin(360365(d"81)))$

Where d is the day of the year with Jan 1 as d = 1

The declination is zero at the equinoxes (March 22 and September 22), positive during the northern hemisphere summer



and negative during the northern hemisphere winter. The declination reaches a maximum of 23.45° on June 22 (summer solstice in the northern hemisphere) and a minimum of -23.45° on December 22 (winter solstice in the northern hemisphere).

Deflection in Degrees	Loss
9	1.2%
18	4.9%
40	19.0%
45	29.0%

Tilt Angle:

The sun moves across the sky from east to west. Solar panels are most effective when they are positioned facing the sun at a perpendicular angle at noon. Solar panels are usually placed on a roof or a frame and have a fixed position and cannot follow the movement of the sun along the sky. Therefore they will not face the sun with an optimal (90 degrees) angle all day. The angle between the horizontal plane and the solar panel is called the tilt angle.

Panel Loss Due to Deflection(These losses will apply to all"square to sun" percentages.)

Why Tilt Angle:

Installing PV modules with the right compass orientation and tilt towards the sun is both a simple and complicated process. Simple, because the sun spends most of its time in the south, where a portion of your roof is probably already pointed. Complicated, because the sun doesn't climb very high in the sky between October and March. Its lower trek limits the amount of sunshine absorbed by the solar cells. Even worse, nearby trees and other obstructions will cast longer shadows whenever the sun is low in the sky.

Shade is the kryptonite of solar power. Electricity production stops dead in its tracks whenever sunlight is blocked from reaching the module glass. Of course, fleeting bits of shade on the outer edges of an array is not a big deal. But if tree shade shrouds an entire module at high noon, and that module is wired in series with other modules, the whole kit and kaboodle of kilowatt generation may be vanquished in a heartbeat. That's why choosing the right location for your array is a huge deal.

The first solution that comes to mind for anyone new to solar electric systems is a motorized tracking device that keeps modules in step with the elusive orb. Unfortunately, that requires a tilted array with swivel room to move back and forth. Most homes have modules installed flush across a sloping rooftop, so tracking's not an option. Instead, a shade assessment must be undertaken, along with measurements of the dimensions and pitch of the rooftops. Then, from the information gleaned, it's possible to estimate how many kilowatt hours will be generated by the array over the course of the year, and which spot on the roof will deliver the highest output.

PV designers refer to the sun's position in the sky as the solar altitude angle. In tandem with its daily movement from east to west, this trajectory must be plotted year-round in order for any shading scenario to be identified. Sun path charts and measuring devices are needed to get the whole picture, since the day you go out to check for shade won't reflect what's happening six months down the road.

Fixed or Adjustable:

It is simplest to mount your solar panels at a fixed tilt and just leave them there. But because the sun is higher in the summer and lower in the winter, you can capture more energy during the whole year by adjusting the tilt of the panels according to the season. The following table shows the effect of adjusting the angle, using a system at 40° latitude as an example. (The comparison would be a little different for different latitudes.) Each option is compared with the energy received by the best possible tracker that always keeps the panel pointed directly at the sun.

	Fixed	Adj. 2 seasons	Adj. 4 seasons	2-axis tracker
% of optimum	71.1%	75.2%	75.7%	100%

In short, adjusting the tilt twice a year gives you a meaningful boost in energy. Adjusting four times a year produces only a little more, but could be important if you need to optimize production in spring and fall. You can jump to the section on the best fixed tilt angle, or skip to the sections on two-season or four-season adjusting.

The graph below shows the effect of adjusting the tilt. The turquoise line shows the amount of solar energy you would get each day if the panel is fixed at the full year angle. The red line shows how much you would get by adjusting the tilt four times a year as described below. For comparison, the green line shows the energy you would get from two-axis tracking, which always points the panel directly at the sun. (The violet line is the solar energy per day if the panel is fixed at the winter angle, discussed below.) These figures are calculated for 40° latitude.

If your solar panels will have a fixed tilt angle, and you want to get the most energy over the whole year, then this section is for you. A fixed angle is convenient, but note that there are some disadvantages. As mentioned above, you'll get less power than if you adjusted the angle. Also, if you live where there is snow, adjusting the panels to a steeper angle in winter makes it more likely that they will shed snow. A panel covered in snow produces little or no power.

Use one of these formulas to find the best angle from the horizontal at which the panel should be tilted:

Latitude	Full year angle	Avg. insolation on panel	% of optimum
0° (Quito)	0.0	6.5	72%
5° (Bogotá)	4.4	6.5	72%
10° (Caracas)	8.7	6.5	72%
15° (Dakar)	13.1	6.4	72%
20° (Mérida)	17.4	6.3	72%
25° (Key West, Taipei)	22.1	6.2	72%
30° (Houston, Cairo)	25.9	6.1	71%
35° (Albuquerque, Tokyo)	29.7	6.0	71%
40° (Denver, Madrid)	33.5	5.7	71%
45° (Minneapolis, Milano)	37.3	5.4	71%
50° (Winnipeg, Prague)	41.1	5.1	70%

- If your latitude is below 25°, use the latitude times 0.87.
- If your latitude is between 25° and 50°, use the latitude, times 0.76, plus 3.1 degrees.
- If your latitude is above 50°, see Other Situations below.

This table gives some examples for different latitudes. It also shows the average insolation on the panel over the year (in kWh/m² per day), and the energy received compared to the best possible tracker.

	Northern hemisphere	Southern hemisphere
Adjust to summer angle on	March 30	September 29
Adjust to winter angle on	September 12	March 14

Adjusting the tilt twice a year

If you are going to adjust the tilt of your solar panels twice a year, and you want to get the most energy over the whole year, then this section is for you.

Latitude	Summer angle	Winter angle	Avg. insolation on panel	% of optimum
25°	2.3	41.1	6.6	76%
30°	6.9	45.5	6.4	76%
35°	11.6	49.8	6.2	76%
40°	16.2	54.2	6.0	75%
45°	20.9	58.6	5.7	75%
50°	25.5	63.0	5.3	74%

The following table gives the best dates on which to adjust:

If your latitude is between 25° and 50°, then the best tilt angle for summer is the latitude, times 0.93, minus 21 degrees. The best tilt angle for winter is the latitude, times 0.875, plus 19.2 degrees. If your latitude is outside this range, see Other Situations below. This table gives some examples:

	Northern hemisphere	Southern hemisphere
Adjust to summer angle on	April 18	October 18
Adjust to autumn angle on	August 24	February 23
Adjust to winter angle on	October 7	April 8
Adjust to spring angle on	March 5	September 4

Adjusting the tilt four times a year

If you are going to adjust the tilt of your solar panels four times a year, and you want to get the most energy over the whole year, then this section is for you. This would be your situation if you are connected to the grid and can use or sell all the power you produce.

The following table gives the best dates on which to adjust:

If your latitude is between 25° and 50°, then the best tilt angles are:

- For summer, take the latitude, multiply by 0.92, and subtract 24.3 degrees.
- For spring and autumn, take the latitude, multiply by 0.98, and subtract 2.3 degrees.
- For winter, take the latitude, multiply by 0.89, and add 24 degrees.

If your latitude is outside this range, see Other Situations below.

Latitude	Summer angle	Spring/autumn angle	Winter angle
25°	-1.3	22.2	46.3
30°	3.3	27.1	50.7
35°	7.9	32.0	55.2
40°	12.5	36.9	59.6
45°	17.1	41.8	64.1
50°	21.7	46.7	68.5

If you want to adjust the tilt of your panels four times a year, you can use these figures to keep capturing the most energy year-round. This table gives some examples:

In winter, a panel fixed at the winter angle will be relatively efficient, capturing 81 to 88 percent of the energy compared to optimum tracking. In the spring, summer, and autumn, the efficiency is lower (74-75% in spring/autumn, and 68-74% in summer), because in these seasons the sun travels a larger area of the sky, and a fixed panel can't capture as much of it. These are the seasons in which tracking systems give the most benefit.

Note that the winter angle is about 5° steeper than what has been commonly recommended. The reason is that in the winter, most of the solar energy comes at midday, so the panel should be pointed almost directly at the sun at noon. The angle is fine-tuned to gather the most total energy throughout the day.

The summer angles are about 12 degrees flatter than is usually recommended. In fact, at 25° latitude in summer, the panel should actually be tilted slightly away from the equator.

Latitude 30° Tilt 50.7°		
Season	Insolation on panel	% of winter insolation
Winter	5.6	100%
Spring, Autumn	6.0	107%
Summer	5.1	91%

Latitude 40° Tilt 59.6°		
Season	Insolation on panel	% of winter insolation
Winter	4.7	100%
Spring, Autumn	5.8	123%
Summer	5.1	109%

Latitude 50° Tilt 68.5°		
Season	Insolation on panel	% of winter insolation
Winter	3.4	100%
Spring, Autumn	5.4	158%
Summer	5.1	150%

Tilt Fixed at Winter Angle

If your need for energy is highest in the winter, or the same throughout the year, you may want to just leave the tilt at the winter setting. This could be the case if, for instance, you are using passive solar to heat a greenhouse. Although you could get more energy during other seasons by adjusting the tilt, you will get enough energy without making any adjustment. The following tables assume that the tilt is set at the winter optimum all year long. They show the amount of insolation (in kWh/m^2) on the panel each day, averaged over the season.

Solar Angle Calculator:

This solar angle calculator tells you the optimum angle to get the best out of your system. To get the best out of your photovoltaic panels, you need to angle them towards the sun. The optimum angle varies throughout the year, depending on the seasons and your location and this calculator shows the difference in sun height on a month-by-month basis.

Of course, the sun is continually moving throughout the day and to get the very best from your photovoltaic system you would need to angle your panels to track the sun minute by minute. You can buy an automated solar tracker to do this. Unfortunately, the expense of a tracker means that for most applications they are more expensive than buying additional panels to compensate. The amount of power a solar tracker uses in order to track the sun also negates much of its benefits.

This solar array tracks the sun across the sky throughout the day using a solar tracker. A sensor mounted on the top left hand corner of the array tracks the position of the sun and an electric motor moves the tracker so that the array can generate the maximum amount of power.

The sun is at its highest at solar noon each day (this occurs exactly half way between sunrise and sunset) and this calculator shows the angle at that time of day. At solar noon, the irradiance from the sun is at its very highest and you can generate the most power. In the northern hemisphere, the sun is due south at solar noon.

Therefore, to get the very best out of your photovoltaic panels, you would typically face them due south at the optimum angle so that the panel is receiving as much sunlight as possible at this time.

The correct angle for your project will depend very much as to when you want to get the best out of your photovoltaic system. If you want to get the best performance during the summer months, you would angle your photovoltaic panels according to the height of the sun in the sky during these months. If you want to improve your winter performance, you would angle your photovoltaic panels towards the winter months in order to get the best performance at that time of year.

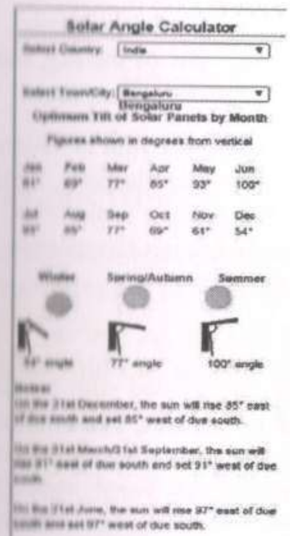
If you have the opportunity to adjust your photovoltaic panels throughout the year, you will benefit from having the optimum performance from your solar system all of the time.

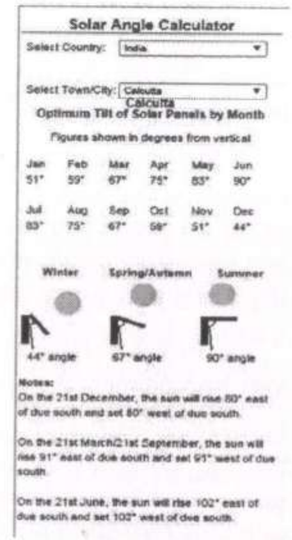
This solar angle calculator allows you to calculate the optimum angle on a month-by-month basis.

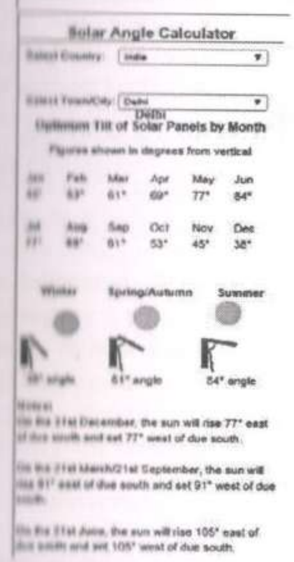
How to use solar angle calculator:

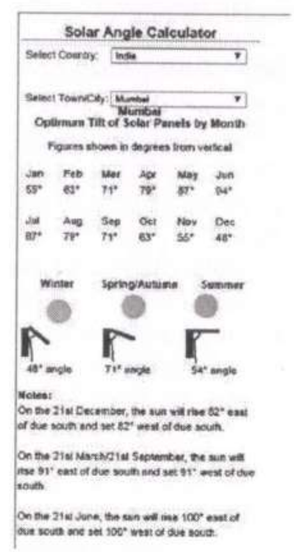
- Select your country from the list.
- If you have selected America or Canada, select your state or province.
- Select the town or city nearest where you live.
- The calculator will then show the optimum angle for the solar panel. The calculator shows the degreesfrom vertical.
- If you cannot change the angle of your panel throughout the year, angle your panel according to the time of year that you need to get the best performance out of your system.
- In the notes section, you can see the position of sunrise and sunset at different times of the year. This information

Here are some snapshots of solar angle calculator are given...









will help you during a site survey to identify any potential obstructions at different times of the year.

Assumptions:

These calculations are based on an idealized situation. They assume that you have an unobstructed view of the sky, with no trees, hills, clouds, dust, or haze ever blocking the sun.

You may need to make adjustments for your situation. For example, if you have trees to the east but not the west, it may be better for you to aim your solar panels slightly to the west. Or if you often have clouds in the afternoon but not the morning, you might aim your panels slightly to the east.

The calculations also assume that you are near sea level. At very high altitude, the optimum angle could be a little different.

If you are estimating energy output, remember that temperature affects the efficiency of photovoltaic panels. They produce less power at higher temperatures. Panels vary so you will need to contact your panel manufacturer for their specifications.

REFERENCES:

1. The Solar Electricity Handbook
2. http://www.thesolarplanner.com/array_placement.html
3. http://www.lrc.rpi.edu/programs/NLPIP/lightingAnswers/photovoltaic/14-photovoltaic-tilt-angle.asp
4. http://www.solarhome.ru/en/basics/pv/techtilt.htm

APPLICATION OF SOLAR CELL IN REFRIGERATION SYSTEM

S K Bag* and Abhisek Kar

*Associate Professor, Department of Dairy Engineering, West Bengal University of Animal and Fishery Sciences; Mohanpur, Nadia West Bengal – 741252

bagksub@gmail.com

INTRODUCTION:

The sun is a sphere of intensely hot gaseous matter, the solar energy strikes our planet a mere 8 min and 20 s after leaving the giant furnace. The sun has an effective blackbody temperature of 5762K. The sun is a continuous fusion reactor in which hydrogen is turned into helium. This energy radiates outwards in all directions. Only a tiny fraction of the total radiation emitted is intercepted by the earth. However, even with this small fraction it is estimated that 30 min of solar radiation falling on earth is equal to the world energy demand for one year. The greatest advantage of solar energy as compared with other forms of energy is that it is clean and can be supplied without any environmental pollution. Over the past century fossil fuels have provided most of our energy because theseare much cheaper and more convenient than energy from alternative energy sources, and until recently environmental pollution has been of little concern. In addition to the thousands of ways in which the sun's energy has been used by both nature and man through time,to grow food or dry clothes, it has also been deliberately harnessed to perform a number of other jobs. Solar energy is used to heat and cool buildings (both active and passive), to heat water for domestic and industrial uses, to heat swimming pools, to power refrigerators, to operate engines and pumps, to desalinate water for drinking purposes, to generate electricity, for chemical applications, and many more.

Solar collectors:

Solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. The major component of any solar system is the solar collector. This is a device which absorbs the incoming solar radiation, converts it into heat, and transfers this heat to a fluid (usually air, water or oil) flowing through the collector. The solar energy thus collected is carried from the circulating fluid either directly to the hot water or space conditioning equipment or to a thermal energy storage tank from which can be drawn for use at night and/or cloudy days.

There are basically two types of solar collectors: non-concentrating or stationary and concentrating. A non-concentrating collector has the same area for interceptingand for absorbing solar radiation, whereas a sun-tracking concentrating solar collector usually has concave reflecting surfaces to intercept and focus the sun's beam radiation to a smaller receiving area, thereby increasing the radiation flux. Some of the solar collectors are:

Stationary collector:

Solar energy collectors are basically distinguished bytheir motion, i.e. stationary, single axis tracking and twoaxestracking, and the operating temperature. Initially, the stationary solar collectors are examined. These collectorsare permanently fixed in position and do not track thesun. Three types of collectors fall in this category:

1. Flat plate collectors (FPC);
2. Stationary compound parabolic collectors (CPC);
3. Evacuated tube collectors (ETC)

Flat-plate collectors:

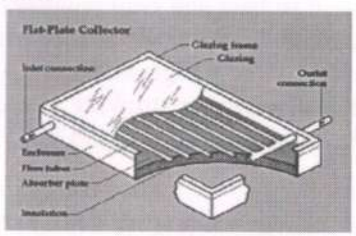


Fig. Flat-plate Collector

Solar radiation passes through a transparent cover and impinges on the blackened absorber surface of high absorptivity, a large portion of this energy is absorbed by the plate and then transferred to the transport medium in the fluid tubes to be carried away for storage or use. The underside of the absorber plate and the side of casing are well insulated to reduce conduction losses. The liquid tubes can be welded to the absorbing plate or they can be an integral part of the plate. The liquid tubes are connected at both ends by large diameter header tubes. The transparent cover is used to reduce convection lossesfrom the absorber plate through the restraint of the stagnantair layer between the absorber plate and the glass. It also reduces radiation losses from the collector as the glass is transparent to the short wave radiation received by the sun but it is nearly opaque to long-wave thermal radiation emitted by facing south in the northern hemisphere and north in the southern. The optimum tilt angle of the collector is equal to the latitude of the location with angle variations of 10–158 more or less depending on the application.

Glazing: One or more sheets of glass or other diathermanous (radiation-transmitting) material.

Tubes, fins, or passages: To conduct or direct the heat transfer fluid from the inlet to the outlet.

Absorber plates: Flat, corrugated, or grooved plates, to which the tubes, fins, or passages are attached. The plate may be integral with the tubes.

Headers or manifolds: To admit and discharge the fluid.

Insulation: To minimise the heat loss from the back and sides of the collector.

Container or casing: To surround the aforementionedcomponents and keep them free from dust, moisture, etc.

FPC have been built in a wide variety of designs and from many different materials. They have been used to heat fluids such as water, water plus antifreeze additive or air. Their major purpose is to collect as much solar energy aspossible at the lower possible total cost. The collector should also have a long effective life, despite the adverse effects of the sun's ultraviolet radiation, corrosion and clogging because of acidity, alkalinity or hardness of the heat transfer fluid, freezing of water or deposition of dust or moisture on the glazing, and breakage of the glazing because of thermal expansion, hail, vandalism or other causes. These causes can be minimised by the use of tempered glass.

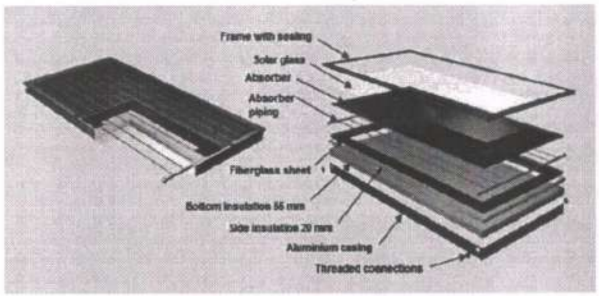


Fig. Section of Flat-plate Collector

Glass has been widely used to glaze solar collectors because it can transmit as much as 90% of the incoming short wave solar irradiation while transmitting virtually none of the long wave radiation emitted outward by the absorber plate. Glass with low ironcontent has a relatively high transmittance for solarradiation (approximately 0.85–0.90 at normal incidence), but its transmittance is essentially zero for the long wave thermal radiation (5–50 mm) emitted by sun-heated surfaces.

Plastic films and sheets also possess high short wave transmittance, but because most usable varieties also have transmission bands in the middle of the thermal radiation spectrum, they may have long wave transmittances as high as 0.40. Plastics are also generally limited in the temperatures they can sustain without deteriorating or undergoing dimensional changes. Only a few types of plastics can withstand the sun's ultraviolet radiation

for longperiods. However, they are not broken by hail or stones, and, in the form of thin films, they are completely flexible andhave low mass.

The commercially available grades of window and green-house glass have normal incidence transmittances of about 0.87 and 0.85, respectively. For direct radiation, the transmittance varies considerably with the angle of incidence. Anti-reflective coatings and surface texture can also improve transmission significantly. The effect of dirt and dust on collector glazing may be quite small, and the cleansing effect of an occasional rainfall is usually adequate to maintain the transmittance within 2–4% of its maximum value. The glazing should admit as much solar irradiation aspossible and reduce the upward loss of heat as much aspossible. Although glass is virtually opaque to the long wave radiation emitted by collector plates, absorption of that radiation causes an increase in the glass temperature and aloss of heat to the surrounding atmosphere by radiation and convection. Various prototypes of transparently insulated FPC andCPC have been built and tested in the last decade. Low cost and high temperature resistant transparent insulating (TI) materials have been developed so that the commercialisation of these collectors becomes feasible. A prototype FPC covered by TI was developed by Benz et al. It was experimentally proved that the efficiency of the collector was comparable with that of ETC. However, no commercial collectors of this type are available in themarket.

Collector absorbing plates:

The collector plate absorbs as much of the irradiation as possible through the glazing, while loosing as little heat as possible upward to theatmosphere and downward through the back of the casing. The collector plates transfer the retained heat to thetransport fluid. The absorptance of the collector surfacefor shortwave solar radiation depends on the nature andcolour of the coating and on the incident angle. Usuallyblack colour is used, however various colour coatings have been proposed in Refs.mainly for aestheticreasons.By suitable electrolytic or chemical treatments, surfacescan be produced with high values of solar radiation absorptance and low values of long wave emittance. Essentially, typical selective surfaces consist of a thinupper layer, which is highly absorbent to shortwave solarradiation but relatively transparent to longwave thermalradiation, deposited on a surface that has a high reflectance and a low emittance for long wave radiation. Selectivesurfaces are particularly important when the collectorsurface temperature is much higher than the ambient airtemperature. Lately, a low-cost mechanically manufacturedselective solar absorber surface method has beenproposed

Evacuated tube collectors Conventional simple flat-plate solar collectors weredeveloped for use in sunny and warm climates. Theirbenefits however are greatly reduced when conditionsbecome unfavourable during cold, cloudy and windy days.Furthermore, weathering influences such as condensationand moisture will cause early deterioration of internalmaterials resulting in reduced performance and systemfailure. Evacuated heat pipe solar collectors (tubes) operatedifferently than the other collectors available on the market.These solar collectors consist of a heat pipe inside a vacuum-sealed tube.ETC have demonstrated that the combination of aselective surface and an effective convection suppressorcan result in good performance at high temperatures.The vacuum envelope reduces convection and conductionlosses, so the collectors can operate at higher temperaturesthan FPC. Like FPC, they collect both direct and diffuseradiation. However, their efficiency is higher at lowincidence angles. This effect tends to give ETC anadvantage over FPC in day-long performance.ETC use liquid–vapour phase change materials totransfer heat at high efficiency. These collectors feature aheat pipe (a highly efficient thermal conductor) placedinside a vacuum-sealed tube. The pipe, which is a sealedcopper pipe, is then attached to a black copper fin that fillsthe tube (absorber plate). Protruding from the top of eachtube is a metal tip attached to the sealed pipe (condenser).The heat pipe contains a small amount of fluid (e.g. methanol) that undergoes an evaporating-condensingcycle. In this cycle, solar heat

evaporates the liquid, and thevapour travels to the heat sink region where it condenses andreleases its latent heat. The condensed fluid return back tothe solar collector and the process is repeated. When thesetubes are mounted, the metal tips up, into a heat exchanger (manifold). Water, or glycol, flows through the manifold and picks up the heat from the tubes.The heated liquid circulates through another heat exchangerand gives off its heat to a process or to water that is stored ina solar storage tank.Because no evaporation or condensation above thephase-change temperature is possible, the heat pipe offersinherent protection from freezing and overheating. This self limiting temperature control is a unique feature of theevacuated heat pipe collector.

Evacuated tube collector:

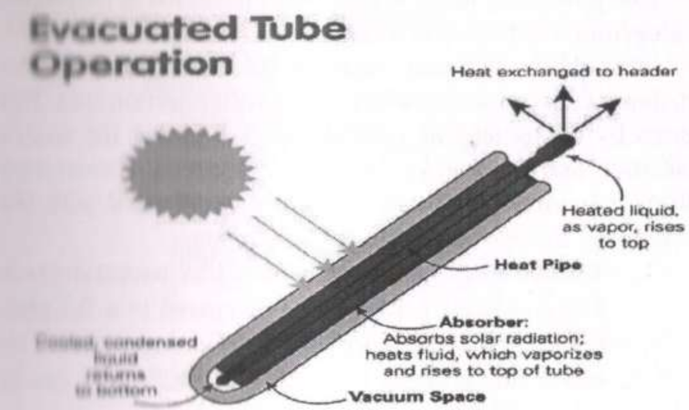


Fig. Evacuated tube collector

ETC basically consist of a heat pipe inside a vacuum sealed tube. A large number of variations of the absorber shape of ETC are on the market. Evacuated tubes with CPC-reflectors are also commercialised by several manufacturers.One manufacturers recently presented an all-glass ETC, which may be an important step to cost reductionand increase of lifetime. Another variation of this type ofcollector is what is called Dewar tubes. In this twoconcentric glass tubes are used and the space in betweenthe tubes is evacuated (vacuum jacket). The advantage ofthis design is that it is made entirely of glass and it is notnecessary to penetrate the glass envelope in order to extractheat from the tube thus leakage losses are not present and itis also less expensive than the single envelope system.Another type of collector developed recently is the integrated compound parabolic collector (ICPC). This is an ETC in which at the bottom part of the glass tube a reflective material is fixed. The collector combines the vacuuminsulation and non-imaging stationary concentration into asingle unit. In another design a tracking ICPC is developedwhich is suitable for high temperature applications.

Sun tracking concentrating collectors:

Energy delivery temperatures can be increased by decreasing the area from which the heat losses occur. Temperatures far above those attainable by FPC can bereached if a large amount of solar radiation is concentratedon a relatively small collection area. This is done by interposing an optical device between the source ofradiation and the energy absorbing surface. Concentrating collectors exhibit certain advantages as compared with the conventional flat-plate type. The main ones are:

1. The working fluid can achieve higher temperatures in a concentrator system when compared to a flat-plate system of the same solar energy collecting surface. This means that a higher thermodynamic efficiency can be achieved.

2. It is possible with a concentrator system, to achieve a thermodynamic match between temperature level and task. The task may be to operate thermionic, thermodynamic, or other higher temperature devices.

3. The thermal efficiency is greater because of the small heat loss area relative to the receiver area.

4. Reflecting surfaces require less material and are structurally simpler than FPC. For a concentrating

collector the cost per unit area of the solar collecting surface is therefore less than that of a FPC.

5. Owing to the relatively small area of receiver per unit of collected solar energy, selective surface treatment and vacuum insulation to reduce heat losses and improve the collector efficiency are economically viable.

Their disadvantages are:

1. Concentrator systems collect little diffuse radiation depending on the concentration ratio.

2. Some form of tracking system is required so as to enable the collector to follow the sun.

Refrigeration system by solar energy :

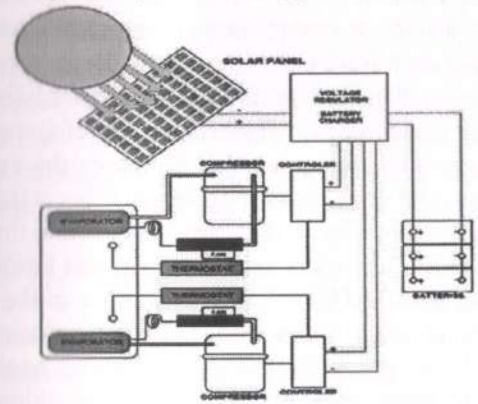


Fig. Schemetic diagram of solar energy Refrigeration system

3. Solar reflecting surfaces may loose their reflectance with time and may require periodic cleaning and refurbishing.

Absorption cooling is one of the first and oldest forms of air-conditioning and refrigeration systems used. The system uses thermal energy to produce cooling and thus solar energy, waste heat and other forms of low grate heat can be employed. As no CFCs are used, absorption systems are friendlier to the environment. Absorption is the process of attracting and holding moisture by substances called desiccants. Desiccants are sorbent materials that have an ability absorbent in the low pressure side absorbs an evaporating refrigerant (H_2O). The most usual combinations of chemical fluids used include lithium bromide–water (LiBr–H_2O), where water vapour is the refrigerant and ammonia–water (NH_3–H_2O) system where ammonia is the refrigerant. Computer modelling of thermal systems presents many advantages. The most importantare the elimination of the expense of building prototypes, the optimization of the system components and estimation of the amount of energy delivered from the system, and prediction of temperature variations of the system.

System description:

The basic energy flows of a solar-powered cooling system are shown schematically inThe collector receives energy from sunlight. The energy is then transferred through high temperature energy storage reservoir to the refrigeration system. In the absorption system, heat is taken from the evaporator or cold storage reservoir (from the water that flows in the evaporator and comes out as chilled water), which evaporate the refrigerant as water vapour. The water vapour then passes into the absorber and is being absorbed by the lithium bromide in the absorber to form a weak solution. The weak solution is then pumped into the generator. In the generator, the water from the weak solution is separated to form water vapour and strong lithium bromide solution. The generator requires heat from

the solar collector system to separate the water vapour from the solution. The water vapour thus generated is at high temperature and pressure. It is then passed to the condenser where heat is removed and the vapour cools down to form a liquid. The liquid water at high pressure is passed through the expansion valve to the low-pressure area in the evaporator where the water is turned into vapour again by drawing heat from the entering water in the

tube heat exchanger. The vapour then passes to the absorber again and the process is repeated. The strong solution from the generator is pumped through a heat exchanger to the absorber and the weak solution from the absorber is passed through the same heat exchanger to the generator. The heat is removed from the system by cooling water, which passes through the condenser and the absorber to a cooling tower where the heat is dissipated to the environment. In the case that the sun is not shining, the generator heatingenergy may be supplied from an auxiliary heat source such as electricity or conventional boiler to run the system.

There are many types of solar collectors, which are used in air-conditioning applications. These can be flat-plate collectors, evacuated tube collectors or compound parabolic collectors. In the present study, advanced evacuated tube collector with selective surface, which can be effective collectors for cooling applications, are considered. Evacuated tube collectors are highly efficient as they are made of an absorber pipe enclosed within a larger glass tube and the space between the glass and the absorber is evacuated. The absorber pipe may also be attached to a black copper fin that fills the tube (absorber plate). The performance equation of the collector considered is given by

$n=0.82-7.884(T_i-T_a)/IT$

where; T_i- inlet temperature of fluid to collector (8C)

T_a- ambient temperature (8C)

IT- total incident radiation on a flat surface per unit area (kJ/h m^2)

Air collectors are not cost-effective for solar cooling applications because the heat exchange surface areas required are very large. The complete schematic solar cooling diagram is presented in Fig. This schematic diagram represents the proposed conceptual design for the system under investigation. The system consists of two important parts: (a) the solar collector system and (b) the absorption cooling system.

In the present application, evacuated tube solar collectors are used to produce the vapour in the generator. An auxiliary heater is used when the solar heating is not sufficient. A storage tank is also needed to store hot water in order to increase the efficiency of system and allow the system to operate when there is no sunshine but heat is available in the storage tank.

Solar Mechanical Method:

In Solar Mechanical Method, the mechanical power required to drive the compressor is generated by solar driven heat power cycle. Rankine cycle is the heat power cycle considered for this process. In Rankine cycle, fluid is vaporized at an elevated pressure by heat exchange with a fluid heated by solar collectors. A storage tank can be included in this process to provide some high temperature thermal storage. The vapour flows through a turbine or piston expander to produce mechanical power. The fluid exiting the expander is condensed and pumped back to the boiler pressure where it is again vaporized. The efficiency of the Rankine cycle increases with increasing temperature of the vaporized fluid entering the expander. Whereas, the efficiency of a solar collector decreases with increasing temperature of the delivered energy. High temperatures can be obtained by employing concentrating solar collectors that track the sun's position in one or two dimensions.

The disadvantages of using solar trackers are cost, weight and complexity of the system. If tracking is to be avoided, evacuated tubular, compound parabolic or advanced multi-cover flat plate collectors can be used to produce fluid temperatures ranging between 100°C – 200°C. Both intensity of solar radiation as well as difference of temperature between entering fluid and ambient govern the efficiency of solar collector. The efficiency of such a system is lower than solar electric method using non-concentrating PV modules. Solar Mechanical is advantageous only when solar trackers are used but, the use of such systems is limited to large refrigeration systems only i.e. at least 1000 tons.

Solar Thermal Method

The main advantage of using Solar Thermal Method is that they can utilize more of the incoming sunlight than photovoltaic systems. In a conventional PV collector, 65% of the incident solar radiation is lost as heat whereas in solar collectors over 95% of the incoming solar radiation is absorbed. But all of this is absorbed energy is not converted to useful energy due to inefficiencies and losses. Collection efficiencies for commercial solar thermal collectors are generally more than double that of crystalline photovoltaic solar collectors. A typical solar thermal refrigeration system consists of four basic components - a solar collector array, a thermal storage tank, a thermal refrigeration unit and a heat exchange system to transfer energy between components and the refrigerated space. Selection of the solar array depends upon the temperature needed for refrigeration system. Generally for temperature range 60-100C, flat plate collectors, evacuated tube collectors and concentrating collectors of low concentration can be used. Concentrating collectors are avoided for residential purposes due to high cost of solar trackers. Selection of the thermal storage tank depends upon the type of storage medium and the temperatures desired. Water is mainly selected for its low environmental impact and high specific heat.

Desiccant:

A desiccant system is usually an open cycle where two wheels turn in tandem – a desiccant wheel containing a material which can effectively absorb water, and a thermal wheel which heats and cools inward and outward flows. Warm, humid, outside air enters the desiccant wheel where it is dried by the desiccant material. Next, it goes to the thermal wheel which pre-cools this dry, warm air. Next, the air is cooled further by being re-humidified. When leaving, cool, conditioned air is humidified to saturation and is used to cool off the thermal wheel. After the thermal wheel, the now warm humid air is heated further by solar heat in the regenerator. Lastly, this hot air passes through the desiccant wheel so that it can dry the desiccant material on its way out of the cycle.

Pre-packaged desiccant is most commonly used to remove excessive humidity that would normally degrade or even destroy products sensitive to moisture. Some commonly used desiccants are silica gel, activated charcoal, calcium sulphate, calcium chloride, montmorillonite clay and molecular sieves.

Absorption:

An absorption refrigerator is a refrigerator that uses a heat source (e.g., solar, kerosene-fueled flame, waste heat from factories or district heating systems) to provide the energy needed to drive the cooling system. Absorption refrigerators are a popular alternative to regular compressor refrigerators where electricity is unreliable, costly, or unavailable, where noise from the compressor is problematic, or where surplus heat is available (e.g., from turbine exhausts or industrial processes, or from solar plants). In absorption, two mainly used cycles are- LiBr (Lithium Bromide) and NH_3 (Ammonia Hydrogen). The main difference between them is which substances are used as the refrigerant and absorbent. In a LiBr system, LiBr is the absorbent and water is the refrigerant. In an NH3 absorption system, water is now the absorbent and NH3 is the refrigerant. In both cases, the job of the compressor (in a conventional vapour compression system) is replaced by an absorber and a generator. Concentrated absorbent enters the absorber, which is connected to the evaporator. When refrigerant is boiled off in the evaporator (removing heat from the refrigerated space), vapour (of relatively high pressure) then moves to the LiBr/water absorber where it is absorbed. Next, the mixture moves to the generator where solar heat is supplied to boil off the refrigerant. High-pressure refrigerant vapour then travels to the condenser where heat is rejected to the surroundings to condense the refrigerant back to liquid. Liquid refrigerant goes back into the evaporator, where it can be used again to take in heat from the refrigerated space, which completes the loop.

Adsorption:

In this cycle, solar heat is directed to a sealed container containing solid adsorbent saturated with refrigerant. Once this

reaches the proper temperature/pressure the refrigerant desorbs and leaves this container as pressurized vapour. That is, the vapour has been compressed with thermal energy. This vapour then travels to a condenser where it turns to liquid by rejecting heat to the surroundings. Expanded, low-pressure liquid refrigerant then flows over the evaporator which pulls heat from the conditioned space to boil off the refrigerant. The refrigerant vapour can then be adsorbed again by the cool adsorbent material easily at night. Although there are similarities between absorption and adsorption refrigeration, the latter is based on the interaction between gases and solids. The adsorption chamber of the chiller is filled with a solid material (for example zeolite, silica gel, alumina, active carbon and certain types of metal salts), which in its neutral state has adsorbed the refrigerant.

CONCLUSION:

The solar energy utilization can improve the quality and quantity of different types of products while reducing the greenhouse gas emissions. It has been reviewed that both the solar thermal and PV systems are suitable for various industrial process applications. However, the overall efficiency of the system depends upon appropriate integration of systems and proper design of the solar collectors. Solar energy systems can be considered either as the power supply or applied directly to a process. Large scale solar thermal systems with large collector fields are economically viable due to the usage of stationary collectors. Feasibility of integrating solar energy systems into conventional application depend on industries energy system, heating and cooling demand analysis and advantages over existing technologies. Solar PV systems are reliable substitutes to be considered as an innovative power source in building, process industries and other applications. The economic outlook for these systems is more viable when the system is operating in remote regions where there is no access to a public grid. In addition, other technical and economical variables such as wear and tear, initial and running costs, economic incentives, PV module diminishing price rate etc should be considered. Designers, researchers, scientists, engineers, architectures, service engineers, planners must consider solar energy installations as a sustainable energy development. Besides, policies by the governments these communities may play a great role to encourage domestic and industrial sector to apply the new technologies.

REFERENCE:

Abhishek Sinha and S R Karale (2013). A review on Solar Powered Refrigeration and the Various Cooling Thermal Energy Storage (CTES) Systems International Journal of Engineering Research & Technology (IJERT) 2 (2), ISSN: 2278-0181

DS Kima and CA Infante Ferreira (2008). Solar refrigeration options – a state-of-the-art review. International journal of refrigeration 31(3–15)

F Assilzadeha, SA Kalogiroub, Y Alia and K Sopiana (2005) Simulation and optimization of a LiBr solar absorption cooling system with evacuated tube collectors. Renewable Energy 30: 1143–1159

S A Kalogirou (2004). Solar thermal collectors and applications. Progress in Energy and Combustion Science 30: 231–295

SOLAR ENERGY

Puja Patra

Every hour the sun beams onto Earth more than enough energy to satisfy global energy needs for an entire year. Solar energy is the technology used to harness the sun's energy and make it useable. Today, the technology produces less than one tenth of one percent of global energy demand.

Many people are familiar with so-called photovoltaic cells, or solar panels, found on things like spacecraft, rooftops, and handheld calculators. The cells are made of semiconductor materials like those found in computer chips. When sunlight hits the cells, it knocks electrons loose from their atoms. As the electrons flow through the cell, they generate electricity.

On a much larger scale, solar thermal power plants employ various techniques to concentrate the sun's energy as a heat source. The heat is then used to boil water to drive a steam turbine that generates electricity in much the same fashion as coal and nuclear power plants, supplying electricity for thousands of people.

In one technique, long troughs of U-shaped mirrors focus sunlight on a pipe of oil that runs through the middle. The hot oil then boils water for electricity generation. Another technique uses moveable mirrors to focus the sun's rays on a collector tower, where a receiver sits. Molten salt flowing through the receiver is heated to run a generator.

Other solar technologies are passive. For example, big windows placed on the sunny side of a building allow sunlight to heat-absorbent materials on the floor and walls. These surfaces then release the heat at night to keep the building warm. Similarly, absorbent plates on a roof can heat liquid in tubes that supply a house with hot water.

Solar energy is lauded as an inexhaustible fuel source that is pollution and often noise free. The technology is also versatile. For example, solar cells generate energy for far-out places like satellites in Earth orbit and cabins deep in the Rocky Mountains as easily as they can power downtown buildings and futuristic cars.

But solar energy doesn't work at night without a storage device such as a battery, and cloudy weather can make the technology unreliable during the day. Solar technologies are also very expensive and require a lot of land area to collect the sun's energy at rates useful to lots of people.

Despite the drawbacks, solar energy use has surged at about 20 percent a year over the past 15 years, thanks to rapidly falling prices and gains in efficiency. Japan, Germany, and the United States are major markets for solar cells. With tax incentives, solar electricity can often pay for itself in five to ten years.

INAUGURAL SPEECH OF UGC SPONSORED 2-DAY NATIONAL WORKSHOP AND SEMINAR ON 'SOLAR PHOTO VOLTAICS' HELD AT

P. K. College, Contai during Jene17-18, 2015

Mr. Chairman Sir, my esteemed colleagues, guest, dignitaries, students; I feel extremely honoured for getting opportunity to inaugurate thisUGC sponsored 2-day National Workshop and Seminar on'Solar Photo Voltaics'scheduled to be held on June 17-18, 2015 on the campus ofPrabhat Kumar College,Contai jointly organized by this college and Mugberia Gangadhar Maha Vidyalay,Purba Medinipur with the assistance of bySoltech Energies Private Limited, Salt Lake Kolkata.

I am really grateful to the Teacher-in-Charge of Prabhat Kumar College andDr. Prabhat Kumar Roy, Convener, Science Forum of the same college for their cordial and heartiest invitation that stimulated me to attend thistimely organized National Workshop and Seminar. I also remain thankful to the authorities of Mugberia Gangadhar Maha Vidyalay, Purba Medinipur andSoltech Energies Private Limited, Salt Lake Kolkata since their efforts and cooperation extended to organize this National Workshop and Seminarmade it possible for me to witness this valuable academic venture.

Although I have no hesitation to claim myself a non-specialist in the field of energy resource utilization but I acknowledge and appreciate that the topic of the workshop and seminar selected by the organisers is not only intellectually exciting but also very much relevant to the contemporary issues related to present day power generating scenario of India in general and West Bengal in particular. It is needless to mention thatIndia is facing an acute energy scarcity which is hampering its industrial growth and economic progress.

Today most of the India's energy sources are derived from conventional or non-renewableenergy sources source likevolatilefossil fuels namely coal, oil, and natural gases.Although, the available quantity of these fuels are extremely large, they are nevertheless finite and so will in principle 'run out' at some time in the future since they are in essence, *stocks of energy*. Moreover,fossil fuel based power plants contribute heavily to greenhouse gases emission.

Therefore, considering the population pressure and industrial and/or urban growth of India one may be tempted to spell out that the time is ripe enough to intensify the harvest of renewable or non-conventional energy sources like solar energy, wind energy, bio energy, hydro energy, geothermal energy, wave and tidal energy which are essentially*flows* of energy andnonpolluting and silent sources of electricity and also low maintenance and long lasting energy.Moreover,apart from augmenting the energy supply, renewable resources of energy will help India in mitigating climate change.

Solar Power, a clean renewable resource with zero emission, has got tremendous potential of energy which can be harnessed using a variety of devices. Solar energy is the most readily available and free source of energy.Solar energy originates with the thermonuclear fusion reactions occurring in the Sun and it represents the entire electromagnetic radiation (visible light, infrared, ultraviolet, x-rays, and radio waves).The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ) per year. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

Solar energy can be utilized through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances etc.

Photovoltaic is the technical term for *solar electric*. Photo means "light" and voltaic means "electric". PV cells are usually made of silicon, an element that naturally releases electrons when exposed to light. Amount of electrons released from silicon cells depend upon intensity of light incident on it. The silicon cell is covered with a grid of metal that directs the electrons to flow in a

path to create an electric current. This current is guided into a wire that is connected to a battery or DC appliance.

With recent developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. Solar energy could be made financially viable with government tax incentives and rebates. Most of the developed countries are switching over to solar energy as one of the prime renewable energy source. The current architectural designs make provision for photovoltaic cells and necessary circuitry while making building plans. Because of its location between the Tropic of Cancer and the Equator, India has an average annual temperature that ranges from 25°C – 27.5 °C. This means that India has huge solar potential. The sunniest parts are situated in the south/east coast, from Calcutta to Madras.

The Rural Electrification Program of 2006 was the first step by the Indian Government in recognizing the importance of solar power. It gave guidelines for the implementation of off-grid solar applications. However, at this early stage, only 33.8MW (as on 14-2-2012) of capacity was installed through this policy. This primarily included solar lanterns, solar pumps, home lighting systems, street lighting systems and solar home systems. In 2007, as a next step, India introduced the Semiconductor Policy to encourage the electronic and IT industries. This included the Silicon and PV manufacturing industry as well. New manufacturers like Titan Energy Systems, Indo Solar Limited and KSK Surya Photovoltaic Venture Private Limited took advantage of the Special Incentive Scheme included in this policy and constructed plants for PV modules. This move helped the manufacturing industry to grow, but a majority of the production was still being exported. There were no PV projects being developed in India at that stage. There was also a need for a policy to incorporate solar power into the grid. The Generation Based Incentive (GBI) scheme, announced in January 2008 was the first step by the government to promote grid connected solar power plants.

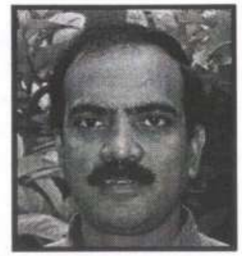
Solar power has so far played an almost non-existent role in the Indian energy mix. The grid-connected capacity (all PV) in India now stands at 481.48 MW as of 31st January 2012. However, the market is set to grow significantly in the next ten years, driven mainly by rising power demand and prices for fossil fuels, the ambitious National Solar Mission (NSM), various state level initiatives, renewable energy quotas including solar energy quotas for utilities as well as by falling international technology costs. However, aspects of cost-competition are a matter that needs serious attention. As of December 2011, solar power generation in India costs around RS.10/kWh, or over 2.5 times as much as power from coal

India's government has begun to acknowledge the importance of solar energy to the country's economic growth. Government of India launched a National Solar Mission in 2010. Initial growth has been dramatic, albeit from a tiny base. From less than 12 MW in 2009, solar-power generation in the country grew to 190 MW in 2011. By March 2013, it went to about 1,000 MW, but the country has a long way to go to reach its goal of increasing solar-power generation since across India, there are still thousands of villages with plenty of sun but not enough power.

For better ways of usage of the solar power the Governments at all level should take measures and see that solar lights are used as street lights in all the areas. Solar panels can be placed in the barren lands instead of keeping it away uselessly. Solar panels can be placed in the deserts and solar energy can be used with the help of a rechargeable battery.Building a new home is the best time to design and orient the home to take the advantage of the sun's rays.

With this few words I again covey my thanks to all the members and volunteers of the organizing committee of this National workshop and seminar, the dignitaries, guest, students and do hereby inaugurate the UGC sponsored 2-day National Workshop and Seminar on 'Solar Photo Voltaics'

Speech Delivered by:
Dr. Falguni Chakrabarty
Professor of Anthropology
Vidyasagar University
And
Chairman of the Subject Committee
On Environmental Science,
Directorate of Distance Education
Vidyasagar University



NAME: Ajay Girdharilal Chandak

Mission: ***Energy Independence through Renewable Sources.***

ADDRESS:

OFFICE: Deptt. of Mech. Engg. SSVPS BSD College of Engineering, DHULE: 424005

RESIDENCE: PRINCE (Promoters, Researchers & Innovators in New & Clean Energy), Suman Foundation, Shamgiri, Agra Road, Deopur, DHULE: 424 005. MAHARASHTRA PH/FAX: +91-2562-271795, MB: +91-9823033344,

Email: renewable.consultant@gmail.com, Web: http://www.princeindia.org

EDUCATION: **Ph.D. (Mech/Solar), M.Tech. (Mech) IIT Bombay, 1986, B.E. (Mech) COEP 1984.**

EXPERIENCE: a **Consultancy**: Experience of consultancy in the field of 'Renewable Energy & Energy Efficiency' for last 15 years. Major consultancy experience; **"Green Energy Consultant" for United Nations, New York for one year, Consultant to MNRE for an UNDP-GEF project on CSTs,** Binani cement in Dubai, for Limtech Corporation in US, for Project Surya for Dr. Ramnathan from California US, Many projects in India, in energy efficiency and renewable energy. One client, Jawahar Shetkari Sahakari Soot Girni, Morane, Won Energy conservation awards from Govt. of Maharashtra for five years, saving more than Rs. 3 crores per year.

b. Professor in Mechanical engineering and head of Consultancy, R & D cell and Energy Management Center at SSVPS BSD College of Engineering, Dhule.

c. **NGO experience**: Founder and chairperson of NGO PRINCE (Promoters, Researchers & Innovators in New & Clean Energy) under patronage of Suman Foundation. NGO is operative since 15 years. This NGO has the largest network of all stakeholders in the field of renewable energy in India. We specializes in 'Training Entrepreneurs', 'R & D', 'Networking' and 'Promotional Programs'. This NGO is acknowledged by Government of Maharashtra as the best working NGO with ENCON awards.

AWARDS:

- **First award in individual category "Energy conservation award", by Govt. of Maharashtra 2009-10 and also in 2008-09.**

- **National Innovation Award, runners up, for "PRINCE Biogas Plant", by CIPET, Govt. of India**
- **'Shirin Gadhia Sustainability Award 2011' by NGO ICNEER.**
- **'Renewable Energy Award 05' from Govt. of Maharashtra.**
- **'Engineering Achievement Award' for 2005, by Institute of Engineers.**
- Recipient of energy award (3rd), in project category, from Institute of Engineers Pune 2005.
- Recipient of two awards for technical papers at national level by under "Indo-German energy programme" of Bureau of Energy Efficiency.
- Recipient of best technical paper award by Indian Water Works Association.
- Best innovations in renewable energy: 'Solar Concentrators' at Innovation 2009, a national event by Alumni association of IIT Bombay, Pune Unit.
- Best innovations in renewable energy: 'PRINCE biogas plants' at Innovation 2011, a national event by Alumni association of IIT Bombay, Pune Unit.
- One client, Jawahar Shetkari Sahakari Soot Girni, Morane, Won Energy conservation awards from Govt. of Maharashtra for three years, saving more than Rs. 3 crores per year.
- 'Certificate of Merit' (This award is for outstanding work, above 1st award) for year 2011-12 for NGO, PRINCE Suman foundation by Govt. of Maharashtra. Dr. Ajay Chandak is founder and chairperson of this NGO.

PROFESSIONAL SERVICES OFFERED: Following services are offered.

1. Design, Development and preparation of project reports for Solar Concentrator technologies.
2. Research, Development, commercialization of "Renewable Energy products and systems"
3. Licensing patents for different products having commercial value.
4. Advisory services on investment decisions in new renewable energy products/projects.
5. Provide training to entrepreneurs in renewable energy.
6. Programs of "Entrepreneurship opportunities in Renewable Energy" for engineering students.
7. Assessment of existing projects and products in renewable energy sector.
8. Energy audits for industries, commercial buildings and residential complexes.

Dr Prabhat Kumar Ray

Associate Professor in Chemistry, P.K.College, Contai
West Bengal, India-721401
E-mail : pkray.pkc@gmail.com

Member :	1. Bio-gas Forum of India, IIT, New Delhi 2. Mithradham Solar Energy Centre, Kerala, India
Convener :	Science Forum & Eco-Club, P.K.College, Contai
Editor :	Bigyan Bannhi (ISSN 2348-6562), Recent Trends in Chromatographic Separations, Food Safety, Recent Trends in Green Chemistry.
Author :	Low Calorie Sweetener and Human Health

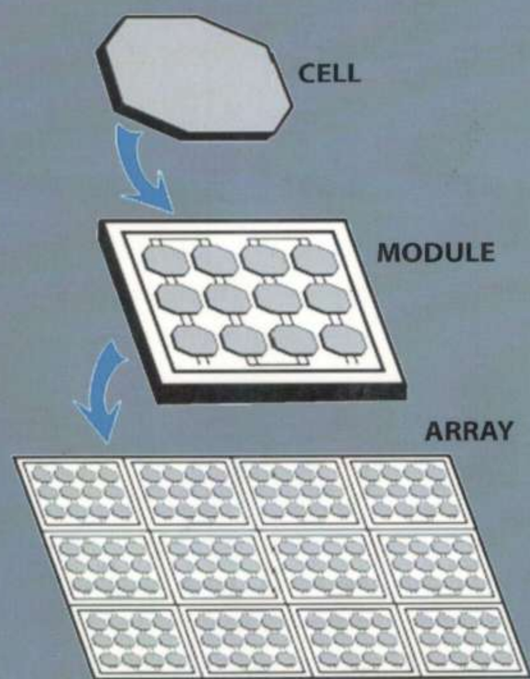
Sri Suprakash Pradhan

M.Sc. in Dietetics & Community Nutrition Management
E-mail : pradhansuprakash@gmail.com
Mobile : 9564956354/9475809265

- Presently Working at Prabhat Kumar College, Contai as a Approved Part Time Teacher(Nutrition), approved by Higher Education Department, Government of West Bengal.
- Earlier employed with Chhatri Vivekananda Vidyabhawan(H.S.) as Contractual teacher under West Bengal State Council Of Vocational Education & Training.
- Life Member, Indian Dietetic Association, Acharya Jagadish Chandra Bose Eco-Club, Science Forum, P.K. College, Contai

Dr. Dulal Chandra Sen

Dr. Dulal Chandra Sen is a Professor of Dairy Technology of West Bengal University of Animal and Fishery Sciences, Mohanpur Campus, Nadia – 741252. He is former Head of the department for two terms. He did his Graduation, Post-graduation and Ph.D. Degrees, all from National Dairy Research Institute , Karnal, Haryana. He has about two years industrial experience before joining to the university service. He is associated with the university teaching, research and extension activities for over the last 34 years. He has published around 80 research / review / technical papers in various reputed journals. In addition, he has published more than 100 popular scientific articles in several news papers / weekly magazines / monthly magazines etc., in Bengali. He received the best research paper award in Dairy Processing in 1998 from the Indian Dairy Association, New Delhi. He has also written a book titled "Textbook of Practical Dairy Chemistry". He has acted as a resource person for various universities and government Institutions like Jadavpur University, Kolkata; Indira Gandhi Open University, New Delhi; Indira Gandhi Agricultural University, Raipur; North Eastern Hill University, Shillong; Banaras Hindu University, Varanasi; Union Public Service Commission, New Delhi; West Bengal Public Service Commission, Kolkata; Agricultural Scientists Recruitment Board, New Delhi; National Dairy Research Institute, Haryana; Vidyasagar University, Medinipur, Bihar Agricultural University, Bhagalpur; etc. Recently, he was felicitated by the Banaras Hindu University (BAU) for his guest lecture on "Functional Foods" as a part of the Centenary Celebrations of BAU. Prof. Sen is a life member of Indian Dairy Association, New Delhi; Association of Food Scientists & Technologists (India), Mysore; Forum of Scientists, Engineers & Technologists, Kolkata; Oil Technologist Association of India (OTAI), Kanpur, etc. Of late, he has been elected as Honorary Secretary of OTAI (East Zone). He has delivered talks in many Seminars/Symposia/Workshops/ Conferences at National and International levels.



Published by :
Science Forum Prabhat Kumar College, Contai, Purba Medinipur
Printed by :
Readers Service, Kolkata-700 075, E-mail : readers.service@yahoo.com