2014-15

GREEN AUDIT REPORT

Prepared for

M/s Yeshwant Mahavidyalaya
Nanded
Maharashtra state, India

Prepared by

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ABBREVIATIONS

Abbreviations	Full Form
°C	Degree Centigrade
A	Ampere
AC	Alternating Current
AHU	Air Handling Unit
APFC	Automatic Power Factor Controller
Avg.	Average
CHW.	Chilled Water
cm.	Centimeter
COP	Co-Efficient Of Performance
Cr.	Crores
CT	Cooling Tower
CW	Cooling Water
DBT	Dry Bulb Temperature
DC	Direct Current
DG	Diesel Generating
Dia.	Diameter
DSCR	Debt Service Coverage Ratio
Effn.	Efficiency
ETP	Effluent Treatment Plant
Ft. or ft	Feet
gm.	Gram
hr.	Hour
HVAC	Heating Ventilation and Air Conditioning
Ins.	Insulated
IRR	Internal Rate of Return
Kcal	Kilo Calories
Kg.	Kilogram
KL	Kilo Liter
KV	Kilo Volt
kVA	Kilo Volt Ampere
kVAr	Kilo Volt Ampere Reactive
kW	Kilo Watts
kWh	Kilo Watt Hour
LPD	Liters Per Day
lit	Liters
lt	Liters
Ltd.	Limited
M or m	Meter
Max.	Maximum
MD	Maximum Demand
Min.	Minimum
MITCON	MITCON Consultancy & Engineering Services Limited
Mm	Millimeter
MSEDCL	Maharashtra State Electricity Distribution Company Ltd.
MT	Metric Ton
MW	Mega Watts
No.	Number
OLTC	Online Tape Changer
p.a.	Per Annum
PF	Power Factor

Abbreviations	Full Form
YMN	Yeshwant Mahavidyalaya Nanded
REC	Renewable Energy Certificates
RH	Relative Humidity
Rpm	Revolutions per minute
Rs.	Rupees
Sec.	Second
SEC	Specific Energy Consumption
SWH	Solar Water Heater
TPA	Tons per Annum
Temp.	Temperature
TPH	Tones Per Hour
TR	Tons of Refrigeration
V	Voltage
VFD	Variable Frequency Drive
ECBC	Energy Conservation Building Code
yr.	Year

HIGHLIGHTS OF THE REPORT

A. Important Parameters

Important Parameters of the Plant

Yeshwant Mahavidyalaya, Nanded	**- A Profile**
Location	-Nanded, Maharashtra India
Business Activity	- Education
Facility	- Colleges & Hostels
Energy Scene	
Major Connected load	- Air Conditioners, Fans, Lighting, DG Sets & Other Equipment's
Annual Energy Bills	- Rs. 22.62134 Lacs
Major Energy Sources	- Grid Electricity, Diesel, Water

PREFACE

Yeshwant Mahavidyalaya Nanded was established in 1963 by Late. Shri Shankarraoji Chavan.

At present, under guidance of Honorable Mr. Ashok Raoji Chavan –Mentor & Dr. N.A. Kalankarji -Principal, YMN is one of academic excellence in both teaching and research. YMN are a unique initiative in science, commerce, Arts & Management education in India in which teaching and education will be totally integrated with the state-of-the-art research nurturing both curiosity and creativity in an intellectually vibrant atmosphere of research. YMN are destined to become Science Institutes of the highest caliber and reach the prestigious position in the National setting.

Yeshwant Mahavidyalaya has done exceptionally well in the recent reaccreditation process by NAAC Bangalore shooting up the table with 3.31 CGPA in the 4 point scale for overall excellent quality education. The many alumni of college contributed in national development.

The Institute is associate with the S.R.T.M. University, Nanded, offering 7 under graduate and 16 post graduate programs with flexible group combinations.

ACKNOWLEDGEMENTS

A Green Audit is a joint venture of consultant and Institute to account & contain maximum possibilities of utilization green energy and to make institute green by reducing wastages. The contribution of Institute's team is equally important in this venture. We sincerely acknowledge the contribution of the following dignitaries and site engineering personnel because of whom the study could progress smoothly –

- Mr. Ashok Raoji Chavan - Hon. President
- Mr. D. P. Sawant - Secretory
- Dr. N.V. Kalyankar - Principal
- Mr. Sandeep Patil - Register
- Dr. S.S. Bodke - Professor – H.O. Biology
- Dr. N.A. Pande - Professor- H. O. Mathematic
- Mr. Chandel - Sr. Electrical Engg.

We are also thankful to the other staff members who were actively involved while collecting the data and conducting the field studies.

CHAPTER 1

INTRODUCTION

1.1 Preamble

- The Yeshwant Mahavidyalaya is controlled by Shree Sharada Education society has a facility at Nanded. With increasing awareness on clean energy & wastage reduction, management approached MITCON for the green audit.

- This Green audit report for YMN, Nanded presents the analysis of the data collected, observations made and field trials undertaken. It is governed by the objectives, scope of work, and methodology discussed in ensuing paragraphs.

1.2 Objectives

- To undertake an Green audit so as to identify areas for reducing wastages and use green energy, both without and with investment.

- To prioritize distinct areas identified for energy conservation, water conservation and wastage reduction depending upon saving potential, skills, and time frame for execution, investment cost, paybacks etc.

1.3 Scope of Work

- To correlate monthly data of production with electricity, fuels & water consumption, for a period of 12 months of normal operation.

- To study present system and to recommend a suitable system for future monitoring.

- To identify possibilities of green energy utilization for the institute.

- To check present system for green energy uses and impacts on the environment.

- To prepare Green Audit report and submit to YMN.

1.4 Methodology

- MITCON deputed following team of experts for conducting the study and worked in close association with YMN unit personnel.

➢ Mr. Deepak Zade, Sr. Vice President
➢ Mr. Rajesh Patrikar, Principal Consultant
➢ Mr. Arjun Singh Parmar, Sr. Consultant
➢ Mr. Abhinath Joshi, Sr. Consultant
➢ Mr. Anant Ladukar, Chief Consultant

- MITCON submitted an execution work plan for the assignment for which YMN provided relevant data support

- YMN nominated specific persons from engg. / Maintenance sections along with a coordinator of senior managerial level for this audit.

- MITCON undertook an “Orientation Meeting” with management / engg. / Maintenance personnel prior to start of the audit.

- MITCON’s team conducted all necessary field trials and measurements.

- MITCON provided all the instruments necessary for conducting the field trials.
- Following instruments were used by MITCON's team.

Table 1: Instrument Used by Audit Team

Sr. No.	Instrument Name	Specification
1.	Demand Analyzer	Suitable for 1φ, 3φ. 156 electrical parameters like voltage, current, frequency, harmonics, active & reactive power, power factor etc.
2.	Clamp-on Power Meter	0 - 1200 kW 0 - 600 Voltage, AC 0 - 800 Voltage, DC 0 - 2000 A, Current, AC / DC
3.	Power Quality Analyzer	3 Ph 4 Wire Recording Parameters: Voltage, Current, Frequency, Harmonics/ Inter harmonics up to 50th, THD of V, I and KW with K Factor, Transients, Voltage Sag- Swells, All Power Parameters, Inrush current, Load Unbalance, Flicker Recording etc. enabling graphical, vectorial, numerical representation, trending of data, monitoring of events etc.
4.	Lux Meter	0 - 50,000 lux level Non Contact Type
5.	Digital Thermo Anemometer	0 - 45 m / sec. ± 3%
6.	Relative Humidity and Temperature Indicator	RH – 10% to 95% Temp. – 0 – 100 °C Handheld unit
7.	Infrared Thermometers	40 ^{0}C to 500 ^{0}C
8.	Portable Temperature Indicator	50 ^{0}C to 1200 ^{0}C
9.	Ultrasonic Flow Meter	0 – 15 m/sec 25 – 5000 mm homogeneous liquids without gas bubbles +/- 0.5 %
10.	Stop Watch	--
11.	Demand Analyzer	Suitable for 1φ, 3φ. 156 electrical parameters like voltage, current, frequency, harmonics, active & reactive power, power factor etc.
12.	Clamp-on Power Meter	0 - 1200 kW 0 - 600 Voltage, AC 0 - 800 Voltage, DC 0 - 2000 A, Current, AC / DC

CHAPTER 2

ENERGY SCENE OF THE INSTITUTE

2.1 ENERGY SCENE

- Primary energy sources utilized at the institute are electricity, diesel, and water. These sources are consumed electricity- Various Eqpts in labs, offices & lighting, Diesel for DG set & water for laboratories, gardening & domestic usage respectively.
- Electricity bill is largest contributor to total annual energy bill. Hence equipment's consuming electricity was focus during the study along with others.

2.2 ENERGY: SOURCES & UTILIZATION

2.2.1 Electrical Energy

- The source of electrical power for the plant is from MSEDCL grid at 11 KV. The power received is further stepped down to 433 V and 315 kVA transformer is used to distribute electricity to various electrical panels in the Institute.

- Contract demand for commercial feeder is 150KVA. Average registered maximum demand for industrial feeder is 111 kVA. For Institute peak demand was registered at 128 kVA in the month of May. The below tables indicates average consumption for the reference period.

Table 2: Monthly Electricity Consumption Details

Sr. No	Month	Contract Demand (KVA)	Billed demand (kVA)	Actual Demand (KVA)	Units Consumed (kWh)	Power Factor	Energy Charges (Rs.)	Demand Charge	TOD Traffic	FAC	Total Bill (Rs.)
1	Apr-14	150	75	113	22436	0.979	209185	21470	-3425	2003.3	229233
2	May-14	150	75	110	24436	0.953	228832	20900	-4103	8231	253860
3	Jun-14	150	75	104	24520	0.957	220561	19760	-2376	3691.6	241637
4	Jul-14	150	75	104	27272	0.948	242430	19760	1422	2912	266524
5	Aug-14	150	75	128	27494	0.96	227807	24382	3143	5592.6	260925
6	Sep-14	150	75	119	24662	0.97	222441	22560	1390	13048	259439
7	Oct-14	150	75	128	24662	0.934	192173	24320	3143	6928	226564
8	Nov-14	150	75	98	19621	0.926	230264	18620	1515	14693	265092
9	Dec-14	150	75	98	24158	0.898	230054	18630	-4515	14692	258861
	Total				**2,19,261**		**20,03,747**	**1,90,402**	**-3806**	**71,791**	**22,62,134**
	Avg.			**111**	**24362**	**0.947**	**222639**	**21156**			**250409**
	Min.			**98**	**19621**	**0.898**	**192173**	**18620**			**226564**
	Max.			**128**	**27494**	**0.979**	**242430**	**24382**			**266524**

- Average monthly YMN unit's consumption is 24,362 kWh and avg. monthly bill is Rs. 2, 50,409.

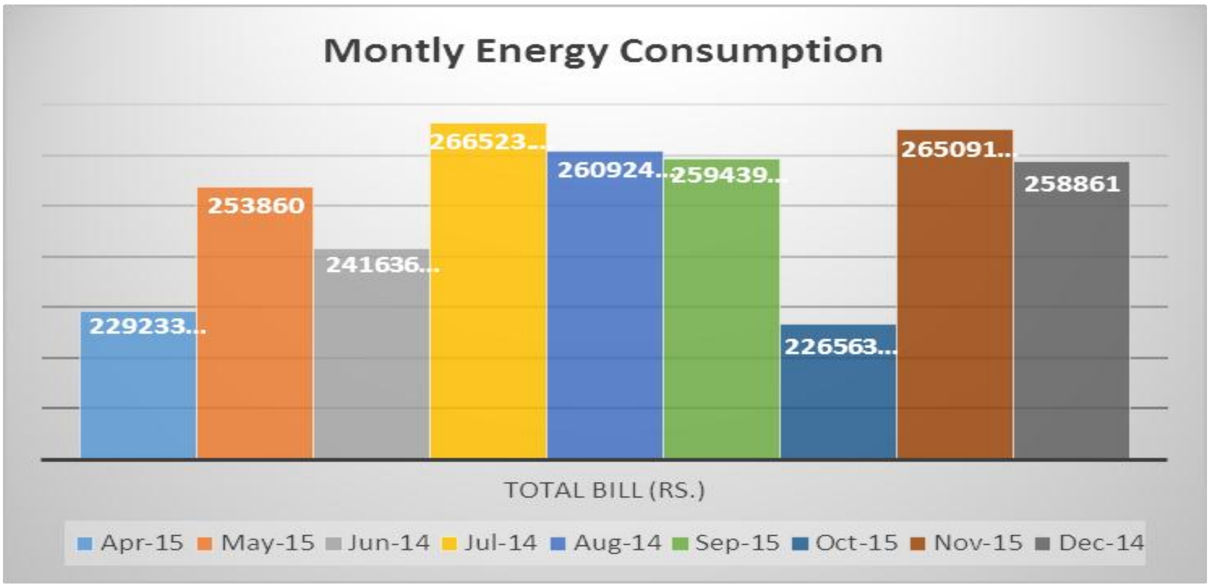
- Average of last 12 months per unit cost is Rs. 10.41/Kw.

Table 3: Monthly incentive/ penalty received against Power factor Details

Sr. No.	Month	Power Factor	Total Bill (Rs.)	Discount received	P.F Incentive (Rs.) If At unity	Loss Of Incentive for not maint. PF at Unity
1	Apr-15	0.979	229233	11461	16046	4585
2	May-15	0.953	253860	7511	17770	10259
3	Jun-14	0.957	241637	0	16915	16915
4	Jul-14	0.948	266524	2468	18657	16189
5	Aug-14	0.96	260925	0	18265	18265
6	Sep-15	0.97	259439	2383	18161	15778
7	Oct-15	0.934	226564	5282	15859	10577
8	Nov-15	0.926	265092	0	18556	18556
9	Dec-14	0.898	258861	0	18120	18120
	Total		**22,62,134**	**29,105**	**1,58,349**	**1,29,244**
	Avg.	**0.947**	**250409**		**17529**	**14360**
	Min.	**0.898**	**226564**		**15859**	**4585**
	Max.	**0.979**	**266524**		**18657**	**18556**

- As MSEDCL regulation commercial customer will be avail incentive of 7% of the total bill amount if maintained power factor (PF) at unity or 1.
- The PF maintained at YMN is very poor. The average PF maintained was .947 Min- .898 (Dec-14) & Max- .979 (March-14)
- From table no. -4 it clearly noted that total loss of incentive from Mar-14 to Jan-15 was 1, 29,244 Rs.
- Figure below presents monthly electricity consumption trend at the Institute. It can be noted, the energy consumption increases during academic session started and is lowest during holidays. The electric consumption was low in the month of March, June & Oct-14 and increases in remaining months.

Figure 1: Monthly Electricity Consumption Trend



2.2.2 Diesel

- Diesel is used to run DG sets during grid outages to ensure uninterrupted power supply to the Institute. The average monthly diesel consumption for the last 12 months reference period record is not maintained.

2.3 Energy Metering, Monitoring & Control System - Existing Status

2.3.1 Electricity

- Electrical energy consumption at the facility is measured on the main tri vector meter on monthly basis.
- Adequate instrumentation was not observed for voltage, current, power & power factor etc.

2.4 Level of Awareness

- The level of awareness for energy conservation in top & middle management is excellent. It is however felt necessary to make serious efforts to percolate the same up to the individual personnel level.
- Safety parameters maintained by the facility found in good condition.
- Good housekeeping and maintenance noted at all working areas.

Trainings on energy conservation are not found on records. It should be ensured that every operator / supervisor knows the operating energy conservation parameters & control / monitor energy consumption, continuously.

CHAPTER – 3

GREEN SYSTEM OPPORTUNITIES

(Observations, Field Trials, Analysis and Key Result Areas)

3.1 Introduction

- The study of Mahavidyalaya operations, data collection, observations, field trials and analysis of various areas was undertaken, keeping in view the clean energy scene at the unit, focus areas elaborated in the previous chapter and with a view to identity green system opportunities in the same. The basis for this is the orientation visit, discussions with the mahavidyalaya personnel and the agreed plan for data collection and field trials. All these trials were undertaken at normal operating conditions.

3.2 Clean Energy by Solar System

- Yeshvant Mahavidyalaya having good opportunity for generation power through solar photovoltaic system.
- Harnessing of non-polluting renewable energy resources to control greenhouse gases is receiving impetus from the government of India. The solar mission, which is part of the National Action Plan on climate change has been set up to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options.
- Ministry of New and Renewable Energy (MNRE), Govt. of India has issued Sanction Order for Implementation of the programme on “Off-grid and Decentralized Solar Applications” for first phase of the JNNSM till 31st March, 2013 during FY 2011-12 vide notification no. 5/23/2009-P&C dated May 06, 2011, which has subsidy scheme on off grid SPV.
- Central Financial Assistance (CFA) would be 30% of the project cost limited to Rs. 81/- per Wp for PV systems with battery back-up support and Rs.57/- for systems without battery back-up support.
- This includes Institutions, Govt. Buildings, commercial establishments, industry and housing complexes etc.
- The proposed 200 kWp off-grid solar photovoltaic power plant at Yeshwant Mahavidyalaya would utilize vacant area on the terrace of the building. The solar PV power plant would be off-grid type.
- The power generated from this SPV power plant shall be sold to the Mahavidyalaya by signing a private PPA with the Mahavidyalaya authority, at a mutually agreed price.
- The expected annual electrical energy generation from the proposed 200 kWp SPV power plant shall be 2,99,870 units (approx.) considering crystalline silicon modules and fixed tilting.
- Installation shall be modular with C-Si panels on roof-top of the Mahavidyalaya building. The construction period shall take about 2 to 4 months from commencement to completion.
- The 200 kWp SPV power generation scheme shall mainly consist of solar PV array, power conditioning unit (PCU) which convert DC power to AC power, module mounting structures, associated switch gears (with metering and protection). Additionally, the system shall consist of battery bank for storage of excessive generated electrical energy.
- Power shall be generated at 3-phase, 415 V AC, 50 Hz and fed to the mains distribution panel located at the basement of the building.

- The following table shows the salient features of the power plant:

Table 4: Salient Features of the Project

Sr. No.	Data	Description
1	**Project Capacity**	200 kWp off-grid Solar PV Plant
2	State	Maharashtra
3	Place	Nanded
4	Location	Maharashtra, INDIA
5	Owner	Yeshwant Mahavidyalaya
6	Latitude	19.170º N
7	Longitude	77.309º E
8	Altitude	351 m
9	Area Available	Total shadow-free roof-top area – 1. 1815 sq. mtrs on Extension building terrace 2. 472 sq. mtr on UGD/PGD building terrace 3. 1457 sq. mtr on wing A building terrace 4. 1460 sq. mtr on wing B building terrace 5. 492 sq. mtr on Microbiology terrace 6. 1935 sq. mtr on ladies hostel terrace 7. 870 sq. mtr on library building terrace
10	Total Shadow-free roof top area	7650 sq. meters on all building terrace (10% reduced for maintenance and other use of terrace)
11	**Connectivity**	
	Nearest Airport & Distance	Nanded Domestic airport @ 6 kms (approx.)
	Sea Port & Distance	Mumbai Port @ 582 kms (approx.)
12	Type of Solar PV System	Off-grid type with fixed tilted arrangement
13	Type of PV Technology Considered	Poly-crystalline Silicon technology
14	Solar PV Modules Capacity	295 Wp
15	Inverter Capacity	200 kW
16	**Plant Load Factor (PLF)**	17.12 %
17	**Total Project Cost**[1]	147 Lacs
18	**Name of the Consumer of Power**	Yeshwant Mahavidyalaya .
19	**Tariff applicable for Project**	Rs. 10.42/kWh
20	Expected Life of Power Plant	25 years

3.2.1 INDIAN ENERGY SCENARIO

- India ranks sixth in the world in total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations. The country, though rich in coal and abundantly endowed with renewable energy in the form of solar, wind, hydro and bio-energy has very small hydrocarbon reserves (0.4% of the world's reserve).

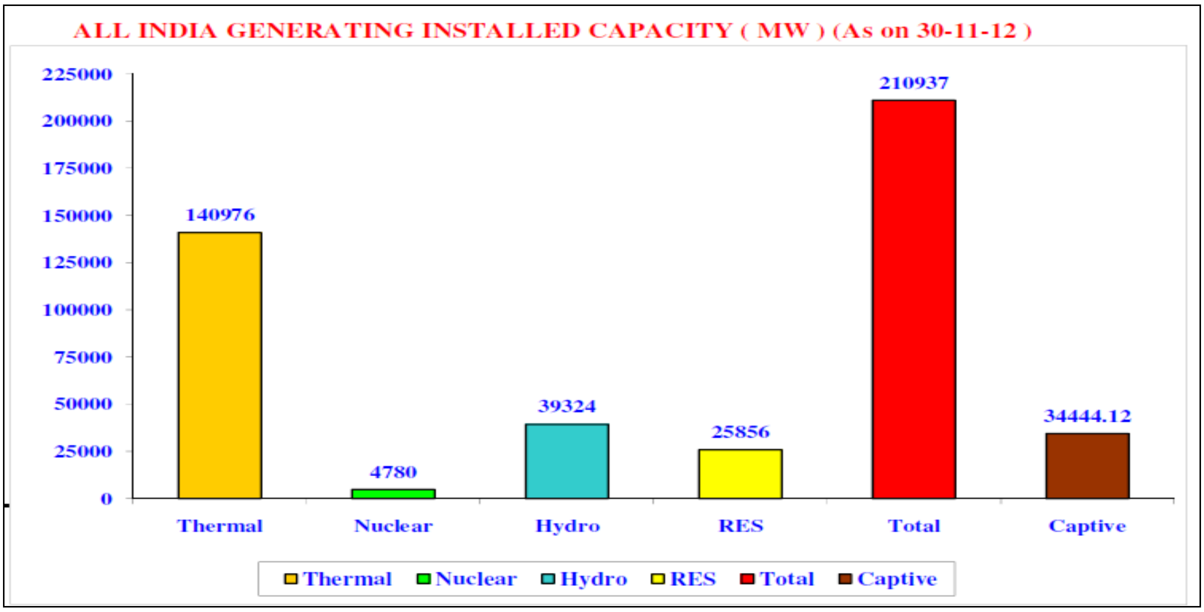
- India, like many other developing countries, is a net importer of energy, more than 25 percent of primary energy needs being met through imports mainly in the form of crude oil and natural gas.

[1] Approximate cost has been consider as per current market condition for without battery rooftop system.

- The rising oil import bill has been the focus of serious concerns due to the pressure it has placed on scarce foreign exchange resources and is also largely responsible for energy supply shortages. On the consumption front, the industrial sector in India is a major energy user accounting for about 52 percent of commercial energy consumption. Per capita energy consumption in India is one of the lowest in the world.

- The total installed capacity of electricity in India as on November 30, 2012 was 210,936.72 MW. The generation target for the year 2012-13 is 17,956 MW and as on November 30, 2012 is 9839 MW.

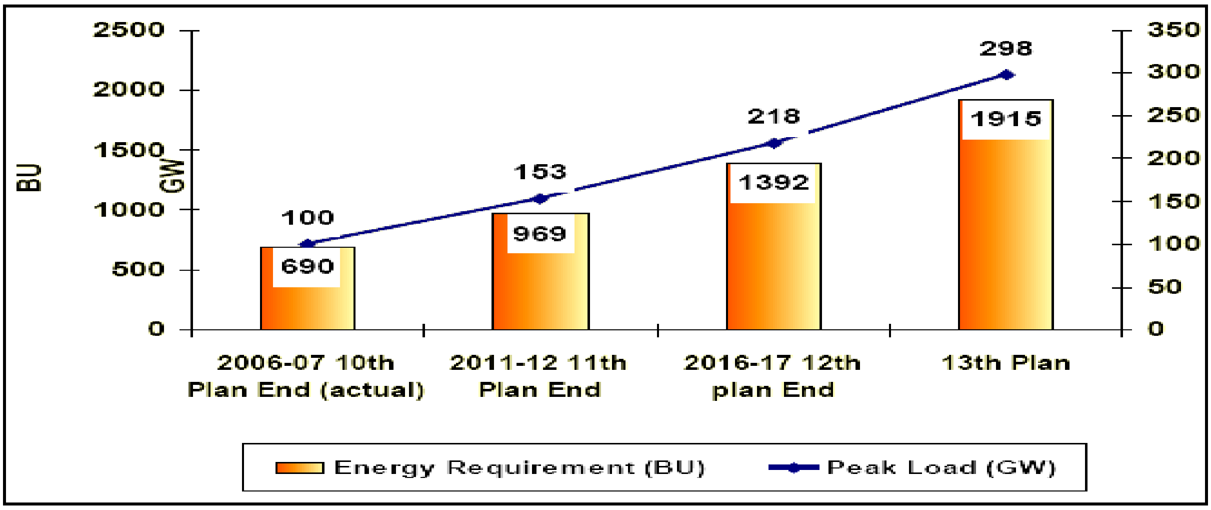
Figure 2: All India Generating Installed Capacity (MW) (As on 30-11-2012)



Source: Central Electricity Authority

- It is note-worthy that out of the total installed capacity of 210,937 MW as on November 30, 2012, 59% was from coal, 12% from natural gas, 0% from diesel, 3% from nuclear power, 12% from hydropower and about 14% was from RES (Renewable Energy Source).

Figure 3: All India Energy Demand Summary



Source: **17th EPS Report**

- As per 17th Electric Power Survey, the report has projected electrical energy demand of 969 Tera-Watt Hours for 2011-12 and peak electric demand of 153 Giga-Watts entailing capacity addition of 78,000 MW by 2011-12. The electrical energy demand for 2021 - 22 has been estimated as 1,915 Tera Watt Hours and peak electric demand of 298 Giga Watts. The demand projections have been made assuming that the utilities would be able to make rigorous efforts in containing T&D losses and adopting Demand Side Management Techniques to achieve high load factors.

3.2.2 RENEWABLE ENERGY IN INDIA

- India is one of the largest and fastest growing economies in the world, and has an expansive population of above 1.1 billion people.

- There is a very high demand for energy, which is currently satisfied mainly by coal, foreign oil and petroleum, which apart from being a non-renewable and therefore non-permanent solution to the energy crisis, it is also detrimental to the environment.

- India is blessed with an abundance of sunlight, water and biomass. Vigorous efforts during the past two decades are now bearing fruit as people in all walks of life are more aware of the benefits of renewable energy, especially decentralized energy requirements such as in villages and in urban or semi-urban centers. India has the world's largest programme for renewable energy.

- Indeed, it is the only country in the world to have an exclusive Ministry for renewable energy development, i.e. the Ministry of New and Renewable Energy (MNRE). Since its formation, the Ministry has launched one of the world's largest and most ambitious programmes on renewable energy. Based on various promotional efforts put in place by MNRE, significant progress is being made in power generation from renewable energy sources.

- India receives approximately 5000 trillion kWh per annum of equivalent energy from solar radiation as well as has approximately 300 clear sunny days in a year. In order to harness the solar potential and promote the deployment of solar energy for power generation and other uses, the Hon'ble Ministry of New and Renewable Energy (MNRE) has launched the Jawaharlal Nehru National Solar Mission (JNNSM).

- The Mission would be implemented in 3 stages and envisages deployment of 20,000MW of solar capacity by the end of 13th five year plan in 2022. Further, under Batch I of Phase I of the JNNSM, solar projects worth 620MW (PV - 150MW + CSP - 470MW) have been allotted and are under construction. Furthermore, the MNRE has announced guidelines, for solar project developers willing to participate in Batch II of Phase I of JNNSM. Solar photovoltaic capacity of 350MW has been allotted under Batch II of Phase I.

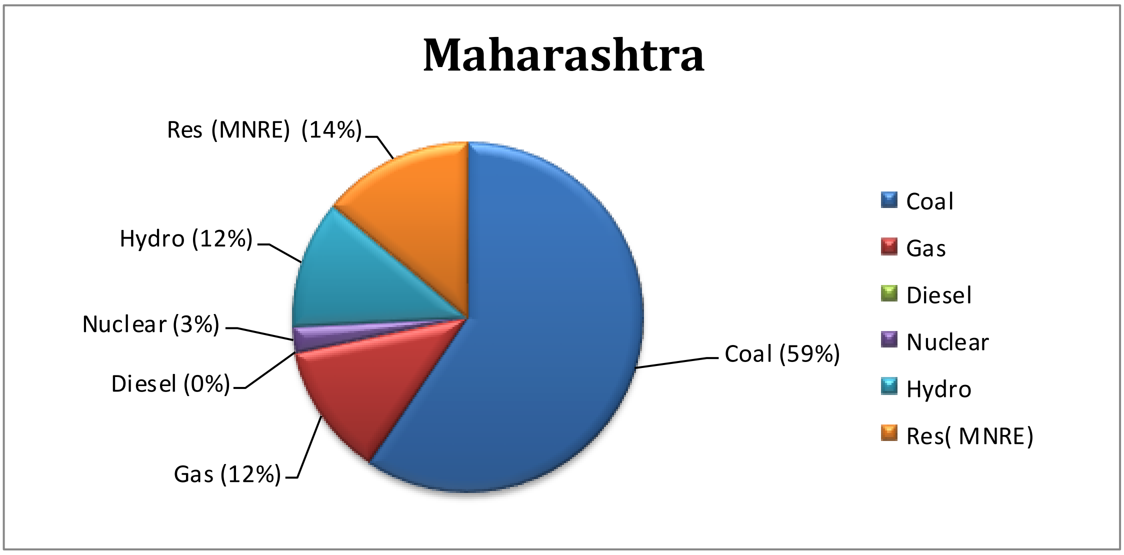
3.2.3 POWER SCENARIO OF MAHARASHTRA

- Maharashtra State has the highest installed capacity in India and accounts for 12.85% of India's total installed capacity in the power sector.

- The Maharashtra State Power Generation Company Ltd. handles the responsibility of generation in the state and is supported by the power projects such as Tata Power Company (TEC) and Reliance Energy formerly known as (Bombay Suburban Electric Supply Company) along with a Central share for Maharashtra by NTPC & NPC.

- The main source of power generation in Maharashtra is fossil fuels such as coal renewable energy sources (RES), natural gas and Hydro (Renewable). A little is being contributed by the nuclear.

Figure 4: Fuel wise installed capacity in Maharashtra.



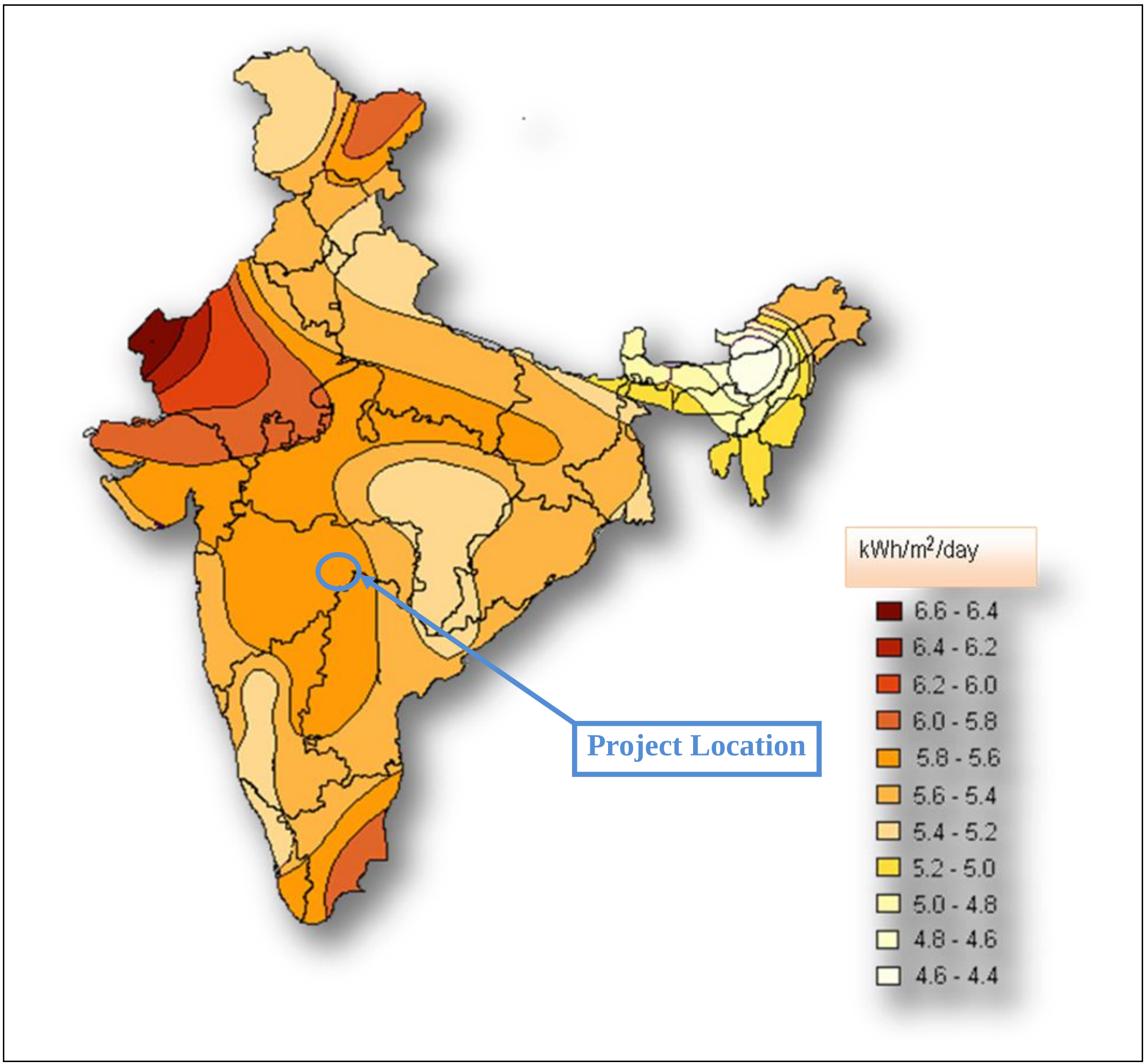
Source: CEA Monthly Report November, 2012

- It is note-worthy that out of the total installed capacity of 210,937 MW as on November 30, 2012, 59% was from coal, 12% from natural gas, 0% from diesel, 3% from nuclear power, 12% from hydropower and about 14% was from RES (Renewable Energy Source).

3.2.4 SOLAR POTENTIAL IN MAHARASHTRA

- Solar is one of the largest RE source in the country, based on mean annual solar radiation.
- India lies in the sunny regions of the world. Most parts of India receive 4 – 7 kWh (kilowatt-hour) of solar radiation per square meter per day with 250 – 300 sunny days in a year.
- The highest annual radiation energy is received in western Rajasthan while the north-eastern region of the country receives the lowest annual radiation.
- 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 Kolkata to Chennai.
- The annual mean daily solar radiation in Maharashtra varies from 5.4 – 5.8 kWh/ m2/day.

Figure 5: Annual Mean Daily Solar Radiation of India



Source: MNRE

3.2.5 SOLAR TECHNOLOGY OVERVIEW

3.2.5.1 SOLAR PHOTOVOLTAIC

- Photovoltaic (PV) is the technical word for solar panels that create electricity. Photovoltaic material, most commonly utilizing highly-purified silicon, converts sunlight directly into electricity.

- When sunlight strikes the material, electrons are dislodged, creating an electrical current which can be captured and harnessed. The photovoltaic materials can be several individual solar cells or a single thin layer, which make up a larger solar panel.

3.2.5.2 SOLAR PHOTOVOLTAIC TECHNOLOGIES

- Over the past three decades SPV technology has shown impressive growth towards technological and economic maturity. The major SPV technologies based on materials used are
  (i) Crystalline Technology
  (ii) Thin Film Technology
  (iii) Concentrated PV System.

3.2.5.2.1 CRYSTALLINE TECHNOLOGY

- Crystalline Silicon (mono & multi) cell technology continues to dominate and forms about 80% of market share. It is the current industry leader and almost all applications use crystalline silicon based PV technology. It is ideally suited for locations with space constraints due to high efficiency than thin-films.

- Crystalline Silicon (c-Si) was chosen as the first choice for solar cells, since this material formed the foundation for all advances in semiconductor technology. The technology led to development of stable solar cells with up to 21% efficiency.

- There are two types of crystalline silicon cells are used in the industry; viz., Mono Crystalline and Multi Crystalline.

- The Mono crystalline Si, produced by growing high purity, single crystal Si rods and slicing them into thin wafers.

- The Multi crystalline Si, made by sawing a cast block of silicon first into bars and then wafers. Major trend in PV industry is toward multi crystalline technology.

- In both mono and multi crystalline Si, a semiconductor junction is formed by diffusing phosphorus (an n-type dopant) into the top surface of an already boron-doped (p-type) Si wafer. Screen-printed contacts are formed on the top and bottom of the cell, with the top contact pattern specially designed to allow maximum light to enter the Si material and minimize electrical (resistive) losses in the cell.

- Most efficient solar cells are produced using mono crystalline Si with laser grooved, buried grid contacts for maximum light absorption and current collection. Some variants of c-Si technologies are also being tried by the industry. One of them is to grow ribbons of silicon from a silicon melt, either as a plain two-dimensional strip or as a hollow octagonal structure and laser cutting into strips.

- Another is to melt silicon powder on a cheap conducting substrate. Main advantage of this is the elimination of kerf-loss that prevails in other crystalline technologies. They have limitations by way of lower growth/pulling rates and poorer uniformity of surface evenness and scalability.

- Each c-Si cell typically generates about 0.5 V. Usually 36 cells are soldered together in series to generate voltage levels that can charge a standard 12 V battery. The cells are hermetically sealed with glass on the front side and plastic materials at the back to produce highly reliable, weather resistant c-Si modules with performance guarantees in excess of 25 years.

Figure 6: Crystalline silicon solar cell

1 Advantages:

- Highest efficiency levels (14.5% to 20%).
- Commercially most viable among PV technologies.
- Sustained dominance in PV industry for over 25 years.
- Higher current / lower voltage features enable easier system design.
- Project implementation can be done in stages starting with module assembly and backward integration to wafer fabrication stage or the other way from wafer to cell to module.
- Performance guarantee for c-Si modules is generally in excess of 25 years.

2 Disadvantages:

- In c-Si technology consumption of material (Silicon) is far more than what is actually needed for converting light into electricity.
- High dependence on poly silicon availability and pricing.
- Melting point of silicon being high (1415° C) power consumption is high in poly silicon production and wafer fabrication processes.

3 Merits of Multi Crystalline Technology

- From the historic trends on crystalline production, it can be observed that in the last decade, the share of multi - crystalline modules has gradually increased from 42.1% to 45.2%. This has been driven by primarily two reasons:

  (i) Aim to reduce energy consumption in the whole process.
  (ii) Shortage of silicon feedstock.

- Solar photovoltaic industry commenced using scrap silicon and off-grade silicon from semiconductor industry in the initial stages and solar photovoltaic industry also followed the highly energy intensive and delicate process for growing crystals to sliced wafers.

- However, as the size of the industry increased and as the scarcity of silicon feedstock started impacting the industry, in addition to the significant cost increases on account of electrical energy costs, the multi-crystalline silicon commenced carving out more share.

- This was basically due to the fact that for multi-crystalline process, the two initial steps, which are high energy consuming of silicon purification and crystal growing, are eliminated. Multi-crystalline process uses only off-grade and scarp silicon as feedstock.

- Over the years, due to continuous research, the efficiency levels of multi-crystalline have also almost got up with single crystalline cells at 14 - 15%.

- In the years to come, multi-crystalline is expected to grow at a much faster pace than single crystalline, due to the aforementioned reasons.

3.2.5.2.2 THIN FILM TECHNOLOGY

- The high cost of crystalline silicon wafers (they make up 40-50% of the cost of a finished module) has led the industry to look at cheaper materials to make solar cells. The selected materials are all strong light absorbers and only need to be about 1 micron thick, so materials costs are significantly reduced.

- Amorphous Silicon thin film solar cell is the earliest device developed in this area. Other types of thin film cells that followed are Cadmium Telluride (CdTe) and Copper Indium Gallium Diselenide (CIGS) solar cells. New developments in this field include 'Micromorph' cells (a combination of amorphous and microcrystalline silicon materials) that has yielded higher efficiencies and has better stability features.

- In thin film solar cell/module technology, very thin layers and a chosen semiconductor material (ranging from nanometer level to several micrometers in thickness) are deposited on to either coated glass or stainless steel or a polymer.

- Semiconductor junctions are formed in a different way, either as a p-i-n device structure in amorphous silicon, or as a hetero-junction. A transparent conducting oxide layer (such as tin oxide) forms the front electrical contact of the cell and a metal layer forms the rear contact.

- Thin film technologies are all complex. They have taken at least twenty years, supported by major corporations in some cases, to get from the stage of promising research to the first manufacturing plants producing early product.

- Amorphous silicon is the most well-developed of the thin film technologies. In its simplest form, the cell structure has a single sequence of p-i-n layers. Such cells suffer from significant degradation in their power output (in the range 15-35%) when exposed to the sun.

- The mechanism of degradation is called the Staebler–Wronski effect, after its discoverers. Better stability requires the use of thinner layers in order to increase the electric field strength across the material. However, this reduces light absorption and hence cell efficiency.

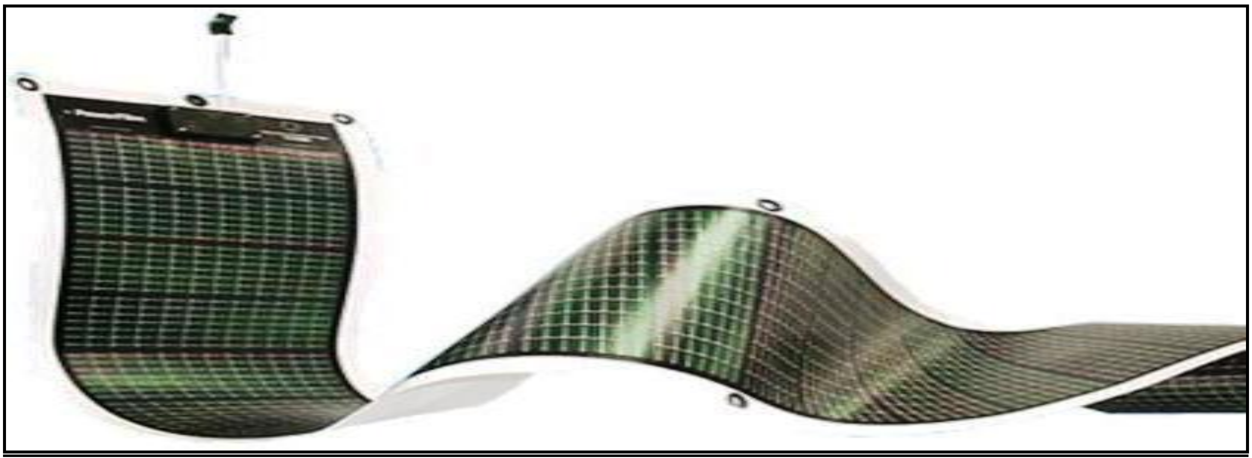
- However, some thin film materials have shown degradation of performance over time and stabilized efficiencies can be 15-35% lower than initial values. Many thin film technologies have demonstrated best cell efficiencies at research scale above 13%, and best prototype module efficiencies above 10%.

- The technology that is most successful in achieving low manufacturing costs in the long run is likely to be the one that can deliver the highest stable efficiencies (probably at least 10%) with the highest process yields.

- The emerging thin-film technologies are starting to make significant in-roads into grid-connect markets, particularly in Germany but crystalline technologies still dominate the market.

- Thin films have long held a niche position in low power (< 50 W) and consumer electronics applications and may offer particular design options for building integrated applications.

Figure 7: Thin film silicon solar cell



4 Advantages

- Significant lower material cost per Wp.
- Faster manufacturing processes with less number of steps.
- Comparatively lower energy consumption processes.
- Higher energy performance (Thin Film modules generate more electricity per unit of installed capacity than crystalline silicon modules).
- Lightweight and flexible substrate.

5 Disadvantages

- Suffers from less than adequate conversion efficiency.
- Poor long term stability.
- High capital costs.
- Scalability and control of uniformity over large area designs.
- Lower environmental compatibility in respect of CdTe and CIGS technologies.

Figure 8: Comparison of the total generated watt – power per month among various materials

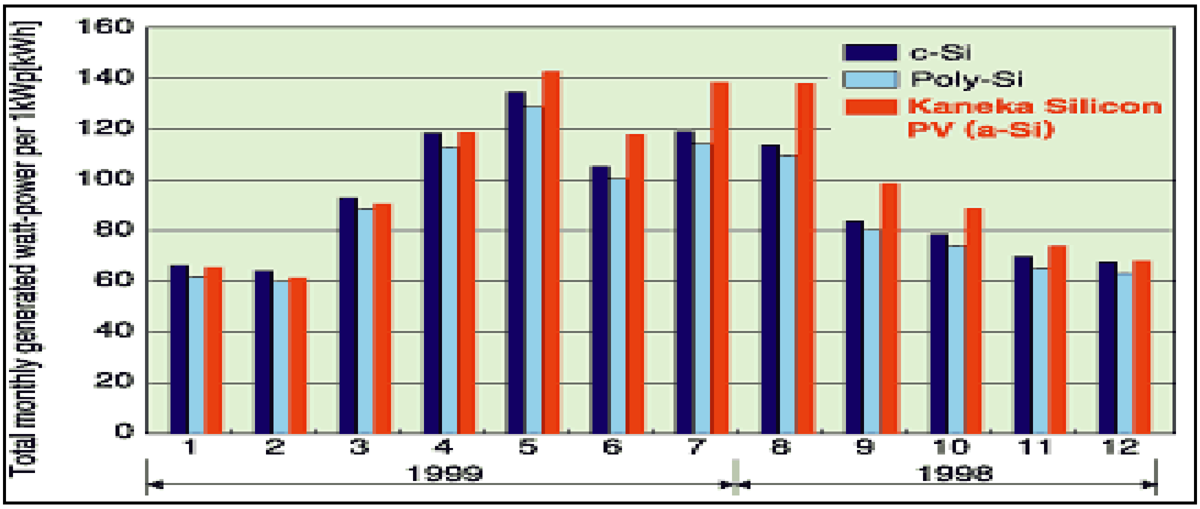
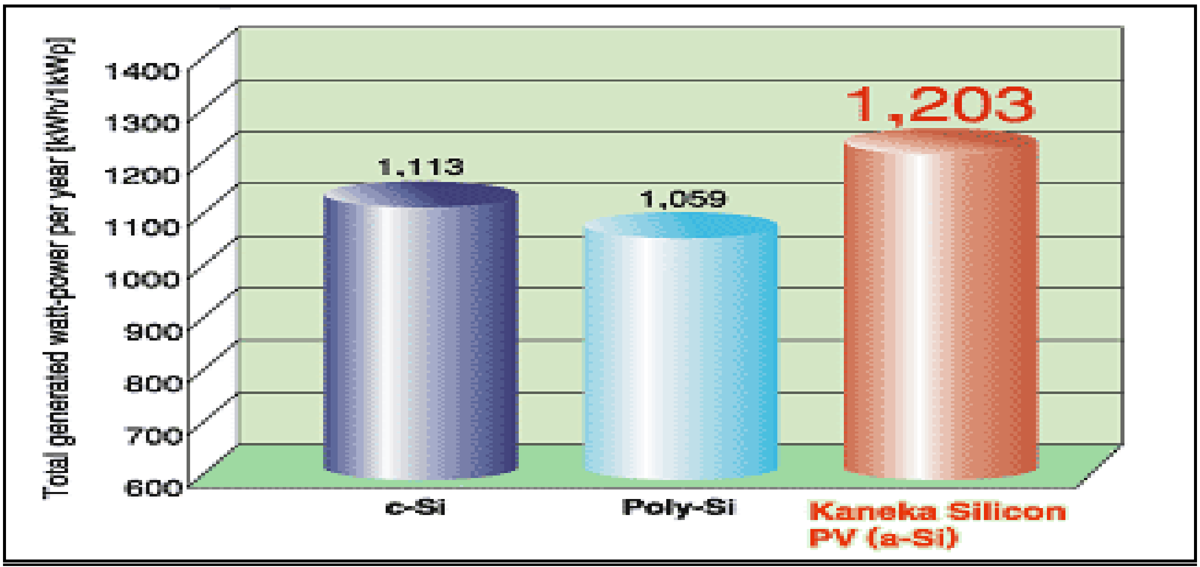


Figure 9: Comparison of the total generated watt – power per year among various materials



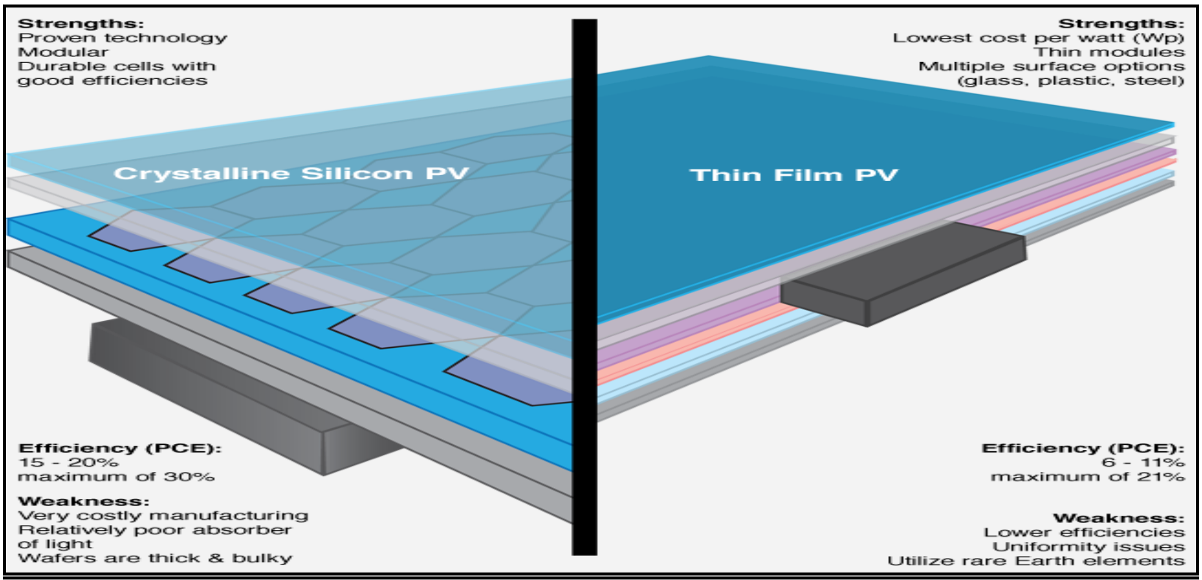
(**Source**: "NEDO/ Ritsumeikan University Module Field Test and Operational Analysis" presented at the International PV SEC-11, Sapporo, Hokkaido, Japan, 1999)

- **Comparison of crystalline and thin film technology-**

l. No.	Parameter	Crystalline	Thin Film
1	Types of Materials	Mono Crystalline, Multi Crystalline	Amorphous Silicon, CdS, CdTe, CIGS, Tandem Junction
2	Power Efficiency	12-16%	6-11%
3	Technology	Well developed	Initial stage of Development
4	Module Weight	Light weight modules	Heavier modules
5	Area utilization	Higher power generated per unit area due to high efficiency	Less power per unit area
6	Temperature Effects	Temperature variations affect output	Lesser impact of temperature variations, performs good in high temperature
7	Irradiance	Used particularly for normal radiations	Better performance with diffuse radiations
8	Module Quantity	Lesser nos. required due to high efficiency	More modules required due to lower efficiency
9	Output per MW Installed	High	Varies as per sunlight condition and various locations
10	Transportation Cost	Lower	Higher
11	Mounting Structure	Fewer mounting structure required per kW power	More mounting structures required
12	Approx. area Requirement	10 – 12 m^2 / kW	15 – 16 m^2 / kW
13	Cost	High cost per Watt	Lower cost per Watt
14	Environment	Less sensitive	Sensitive

l. No.	Parameter	Crystalline	Thin Film
	Effects		
15	Stabilization	Stable power output from initial stages	Stability achieved after 4-6 months
16	Availability	Easily available	Easily available
17	Health hazards	Made from non-toxic material (Si)	Toxic materials used (CdS, CdTe)
18	Power Degradation	Less degradation	High degradation for initial years
19	Plant Maintenance	Less maintenance required after installation, so lower maintenance cost	High maintenance required, so slightly high maintenance cost
20	Repair	Relatively easy	Difficult due to complex structure
21	Cabling	Well known, and lower cabling losses	Well understood but yet difficult due to higher number of arrays, along with high cabling losses
22	Suitability for Grid Technology	Good	Good

Figure 10: Comparison of Crystalline and Thin Film Module



- **Comparison of mono-crystalline and multi-crystalline technologies**

Table 5: Comparison of Mono Crystalline and Multi Crystalline Technologies

Sr. No.	Mono Crystalline	Multi Crystalline
1	The Mono Crystalline Si, produced by growing high purity, single crystal Si rods and slicing them into thin wafers.	The Multi Crystalline Si, made by sawing a cast block of silicon first into bars and then wafers.

Sr. No.	Mono Crystalline	Multi Crystalline
2	Consists of single and continuous crystal lattice structure with practically zero defects or impurities.	Consists of multiple small silicon crystals
3	Thickness of material is around 3 mm	Thickness of material is around 3 mm
4	Color: Dark blue, black with AR coating, grey without AR coating	Color: Blue with AR coating, silver-grey without AR coating
5	High Efficiency around 14-20%	Efficiency around 12 - 16%
6	Best researched solar cell material - highest power/area ratio	Most important production procedure at least for the next ten years
7	Lengthy production procedure to produce Mono Crystalline Silicon	Less Manufacturing work is involved to produce Multi Crystalline Technology
8	High cost / MW	Lower cost / MW
9	Market Share is less due to higher cost	Market share is about 45% - 50% because of lower cost
10	**Leading Manufactures:** BP Solar, CP Solar, Mage Solar, Schott Solar, Solar Watt, Solon, Sun Power	**Leading Manufactures:** BP Solar, Moserbaer, Solar Semiconductor, Yingli Solar, Schott, GE Energy, Power Film, Sun Film, Global Watt, BHEL, Titan Energy Systems

- **Comparison of thin film technologies**

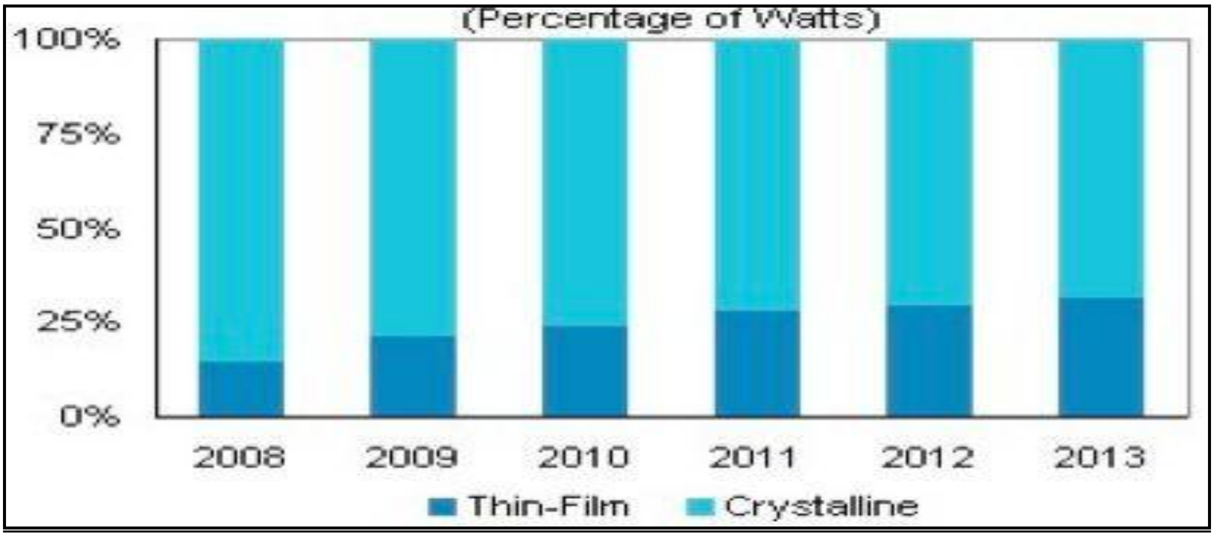
Table 6: Comparison of Thin Film Technologies

Sr. No.	a– Si	CdTe	CIS / CIGS
1	No sawing necessary, possible production in the form of band	Technology developed for application on glass - BIPV	Limited Indium supply in nature.
2	A Si suffer significant degradation (15 - 35%) in power output when they are exposed to the sun & Shorter life span	Lesser degradation	Lesser degradation
3	3 contributing factors for higher performance - Low Temperature Coefficient, Blue light absorption and thermal annealing	Structure: Glass + Window TCO (Transparent Conductive Oxide) + Absorber + Back Contact	Structure: Window TCO (Transparent Conductive Oxide) + Absorber + Back Contact + Glass
4	Overall efficiency around 6 - 9%	Overall efficiency around 8 - 11%	Overall efficiency around 9 - 13%
5	The temperature coefficients of a-Si are typically half those of c-Si or CIS at -0.2%/°K vs. -0.4 to -0.5%/°K, resulting in half of the power loss at elevated temperature	The temperature coefficients of CdTe are -0.25 to -0.3%/°K	The temperature coefficients of CIGS are typically -0.35 to - 0.5 %/°K
6	Color: Red-blue, Black	Color: Dark green, Black	Color: Black

Sr. No.	a– Si	CdTe	CIS / CIGS
7	Cell Thickness is around 0.3 - 0.7 µm	Total film thickness is 4 - 6 µm	Total film thickness is 3 - 4 µm
8	Lighter weight modules and less expensive	Lighter weight modules and significant decrease in production costs expected in the future.	Lighter weight modules and Significant decrease in production costs possible in the future.
9	Amorphous silicon (A- Si) thin film photovoltaics comprise about 61% of the thin film market and 13% PV market.	CdTe comprises with 34% of Thin film market.	CIS and CIGS comprises with only 4% of thin film market
10	Mostly used for smaller applications	CdTe material is hazardous to environment, Marketability (Greenpeace Opposed, Banned in Japan)	Immature manufacturing process
11	**Leading Manufactures:** Uni Solar, Schott Solar, Sharp, Fuji, Kaneka, Moser Baer, Signet Solar, EPV Solar, Mitsubishi, Sun Film	**Leading Manufactures:** First Solar, Antec Solar, AVA Solar, Primestar Solar, Q- Cells	**Leading Manufactures:** Wurth Solar, Ascent Solar, Bosch Solar, Global Solar, Miasole, Nano Solar, Solo Power, Solyandra

- **Market share of technologies**
  - At present the crystalline technology dominates the market with 78 – 80% market share, whereas thin film technology is with 18 – 20%.
  - Thin-film solar cells are rapidly taking market share away from the established crystalline technology, with their portion of photovoltaic (PV) wattage more than doubling by 2013.

Figure 11: Percent of solar panel production (Watts) by technology, thin-film vs. crystalline.



Source: iSuppli

Table 7: Percent of solar panel production (Watts) by technology, thin-film v/s crystalline

Technology	2008	2009	2010	2011	2012	2013
Thin Film	**14%**	**21%**	**24%**	**28%**	**29%**	**31%**
Crystaline	**86%**	**79%**	**76%**	**72%**	**71%**	**69%**

- As per the future projections thin-film shall grow to account for 31 percent of the global solar panel market in terms of watts by 2013, up from 18 – 20 percent in 2009.

- The main tradeoff between the two technologies is efficiency versus cost per watt of electricity generation. Thin-film panels are less efficient at converting sunlight to electricity, but they also cost significantly less to make.

3.2.7 SOLAR RESOURCE ASSESSMENT AND & TECHNOLOGY SELECTION

3.2.7.1 SITE SELECTION

- The site selection for a solar power plant is pre-dominantly determined by solar insolation & location for power evacuation point. Equally important are other essential factors / considerations such as:

- Availability of adequate land / rooftop for power plant.
- Availability of water & power during construction.
- Availability of labour force in the proximity.
- Availability of a developed village / district in the nearby area.
- Easy accessibility to the site.

- The proposed site for solar PV power plant development is found favoring all the above factors to a good extent.

3.2.7.2 ENERGY CONSUMPTION DATA ASSESSMENT

- The total energy consumption pattern from electricity bills of the Mahavidyalaya has been studied. The details are given below:

Table 8: Utility Power Source Details

Sr. No.	Particulars	Data
1	Utility Power distributer	MSDCL
2	Type of Consumer / Tariff Category	HT – II, Commercial
3	Type of Supply	3 Phase
4	Supply Voltage	11 kV
5	Contract Demand	150 KVA
6	Recorded Maximum Demand	128 kVA
7	Billed Maximum Demand	128 kVA
8	Load Factor	32.004
9	Sanctioned / Connected Load	245 kW
10	Approximate Running load at any point of the day	130 kW
11	Approximate monthly energy consumption	219261 kWh

- The transformer details in HT room are given below:

Table 9: Transformer Details

Sr. No.	Particulars	Data
1	Make	HI- Tech Transformers, Nagpur, INDIA.
2	Type	Dry Type Cast Iron Resin Transformer
3	Rated kVA	315 kVA
4	Voltage Rating (HV / LV)	11000 V / 433 V
5	Current Rating (HV / LV)	16.53 A / 420 A
6	Type of Cooling	Air Natural
7	Phase	Three
8	Frequency	50 Hz

3.2.7.3 SPACE AVAILABILITY AND POWER EVACUATION ARRANGEMENT

Table 10: Details of space availability and power evacuation arrangement

Sr. No.	Particulars	Data
1	Type of SPV system installation	Roof-mounted Off-Grid type SPV system, with private PPA
2	Location for SPV Installation	Roof-top
3	No. of Storeys of building	7 (Terrace at 3rd level)
4	Clear shadow-free area available on roof-top in south direction, for SPV installation	Total shadow-free roof-top area - 7650 sq. meters on all building terrace
5	Location of power evacuation point	Main power distribution panel at the ground level of building
6	Power evacuation voltage	3 phase, 415 V

3.2.7.4 SOLAR RADIATION ASSESSMENT

- The exact co-ordinates of the Mahavidyalaya location are as follows:

➢ Latitude : 19.170° North
➢ Longitude : 77.309° East
➢ Altitude : 351 meter
➢ Time Zone : GMT +5:30

- Variation in the average solar radiation throughout the year from various sources at Mahavidyalaya location are as follows:

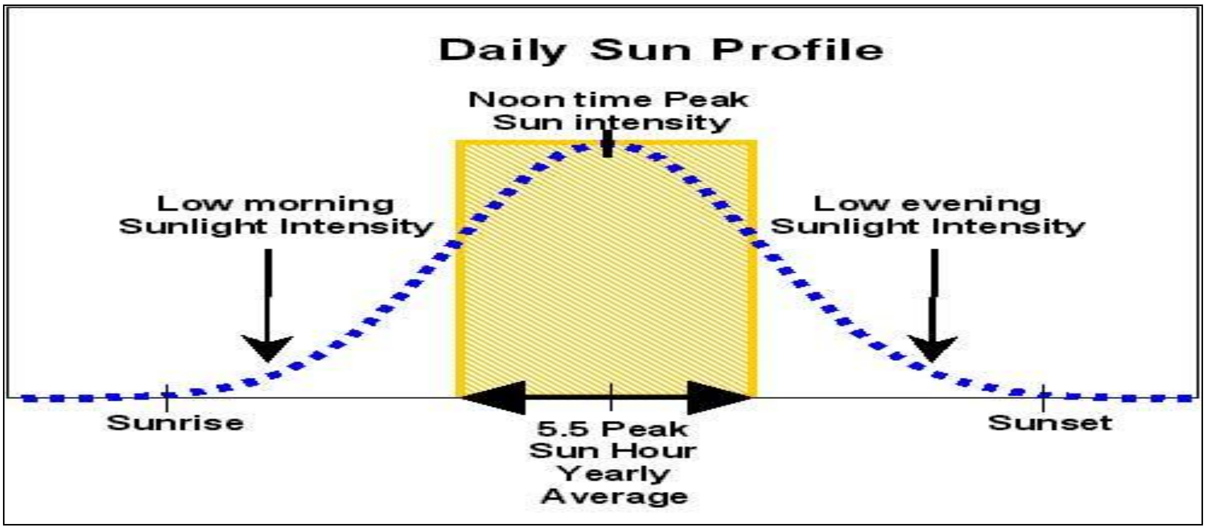
Table 11: Average Solar Radiation on Horizontal & Tilted Surface at Yeshwant Mahavidyalaya, Nanded

Months	Average ambient temp. °C	NASA Solar Radiation At Horizontal Surface kWh/m²/day	NASA Solar Radiation At 19° Tilted Surface kWh/m²/day
Jan	23.2	4.97	6.04
Feb	25.9	5.74	6.52
Mar	30.4	6.42	6.72
Apr	32.9	6.73	6.51
May	33.4	6.63	6.12
Jun	29.2	5.14	5.11
Jul	26.7	4.2	4.13
Aug	26.2	3.98	3.78
Sept	26.8	7.74	4.74
Oct	26.6	5.14	5.6
Nov	24.8	5	5.93
Dec	22.6	4.73	5.61
Average	**26.7**	**5.9**	**5.5675**

Data source: NASA Surface Meteorology and Solar Energy information & Meteonorm

- The above data is average of last 22 years for NASA (1883 – 2005) and for Meteonorm the radiation data (1981 – 2000) & for temperature (1961-1990).
- The annual average solar radiation on a horizontal surface is 5.90 kWh / m^2 / day as per NASA Surface Meteorology.
- On a tilted surface at 19°, annual average solar radiation is 5.56 kWh /m^2 /day as per NASA Surface Meteorology.
- The solar radiation details from NASA is attached as Annexure – V.

Figure 12: Daily Sun Profile for Solar Power Plant



3.2.7.5 TECHNOLOGY SELECTION FOR PROPOSED SITE

- After studying the factors like solar radiations, available area and temperature variations at the site, poly-crystalline silicon technology was found suitable for development of the proposed 200 kWp solar PV power plant at Yeshwant Mahavidyalaya.

- So crystalline technology option has been studied for development of the plant.

- Based on the above study, following points were observed –

- Crystalline (mono & multi) technology is proven and has track record of more than 15 years.
- Availability of sufficient area for project development.
- Energy generation is also assessed considering the site conditions.

- Considering all the above factors, MITCON suggests adopting poly-crystalline silicon technology for development of 200 kWp solar PV power plant at Yeshwant Mahavidyalaya.

3.2.8 PROJECT DESCREPTION

3.2.8.1 SOLAR POWER GENERATION SCHEME

- Electricity has become a very important aspect to satisfy day-to-day energy needs. Although electricity availability is continuous and undisrupted in most places, especially cities, it still gives a sense of dependency on the power utility/power provider as the continuity of supply is not in our control. Also, the cost of electricity is on the rise day-by-day. This compels the need of an independent power source. Diesel generator is a good option, as it is compact, but the cost of diesel is also increasing and it also contributes to global CO_2 emission. Hence, an independent source of electricity which is clean and cheap is necessary.

- As India is blessed with solar energy which is omnipresent in almost all parts of the country, micro-grid system which uses solar photo voltaic panels seems as the finest option. The solar photovoltaic system converts light energy into direct current power using photovoltaic effect. Battery is used to store the extra power generated during the day and used during nights. Inverters and power conditioning devices are used to convert direct current power generated by solar photovoltaic systems to alternative current, which is supplied to the load using power distribution network which adds to system cost.

- At present the capital cost and the land requirement for this system is higher than all other renewable energy power generation systems. But it has very less operation and maintenance cost which makes it superior to other system. Moreover additional modules can be added to it when the power demand increases.

3.2.8.2 ELECTRICAL SYSTEM TYPES

- Being intermittent, the electricity produced by solar PV array needs to be properly controlled, stored and distributed. The two major possibilities currently prevalent are (i) Stand–alone / off-grid systems (ii) Grid-connect systems.

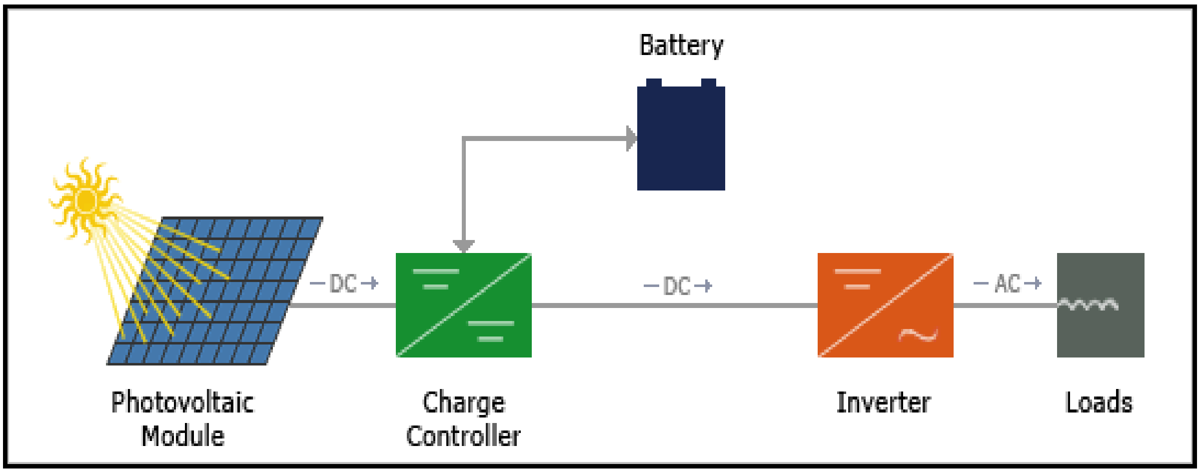
- It may be noted that many devices are needed between the array and the load to provide electrical power.

- A typical stand – alone / off-grid photovoltaic system is composed of an array converting sunlight into electricity. Electrical current flows into a bank of batteries through a charge controller (regulator) that protect the batteries from overcharge or over discharge. By using a DC–DC converter required levels of DC voltage can be obtained if the loads to be connected are of DC types; and if the loads are of AC type a DC–AC inverter may be needed.

- A stand-alone solar PV system can also be without a battery bank. In such a case, the power generated is inverted and directly fed to the electrical load connected. Such a system works only during day-time.

- Schematic diagram of a stand–alone / off-grid PV system is shown in figure below:

Figure 13: Schematic diagram of stand–alone/off-grid PV system



- A typical grid connected PV system is composed of a large field of SPV arrays converting sunlight into electricity. This electricity is then inverted through a DC-AC inverter. The voltage is then stepped-up to the utility voltage through a power transformer, and power is fed into the utility grid.

- Schematic diagram of a grid connect system is shown in figure below:

Figure 14**:** Schematic Diagram of Grid Connect System

- The proposed project is of the off-grid SPV system type. The system provides power to the electrical load during daytime. Any excess power generated is stored in the batteries, to be utilized when sunlight is unavailable. The system consists mainly of the following:
  - Solar PV array – that produces DC electricity when solar rays are incident on it.
  - Power Conditioning Unit (PCU) – that converts DC (Direct Current) electricity into AC (Alternating Current) electricity.

3.2.8.3 OPERATING PRINCIPLE OF OFF-GRID SOLAR PV SYSTEMS

- The system automatically 'wakes-up' in the morning and feeds-in power to the electrical load, through the mains power distribution panel. If the energy required by the electrical load is less than that being generated, excess energy gets stored to the battery bank. This ensures that the SPV system operates at its peak capacity, thus preventing under-generation.

- The maximum power point tracking (MPPT) circuit within the PCU extracts the maximum available power from the solar array.

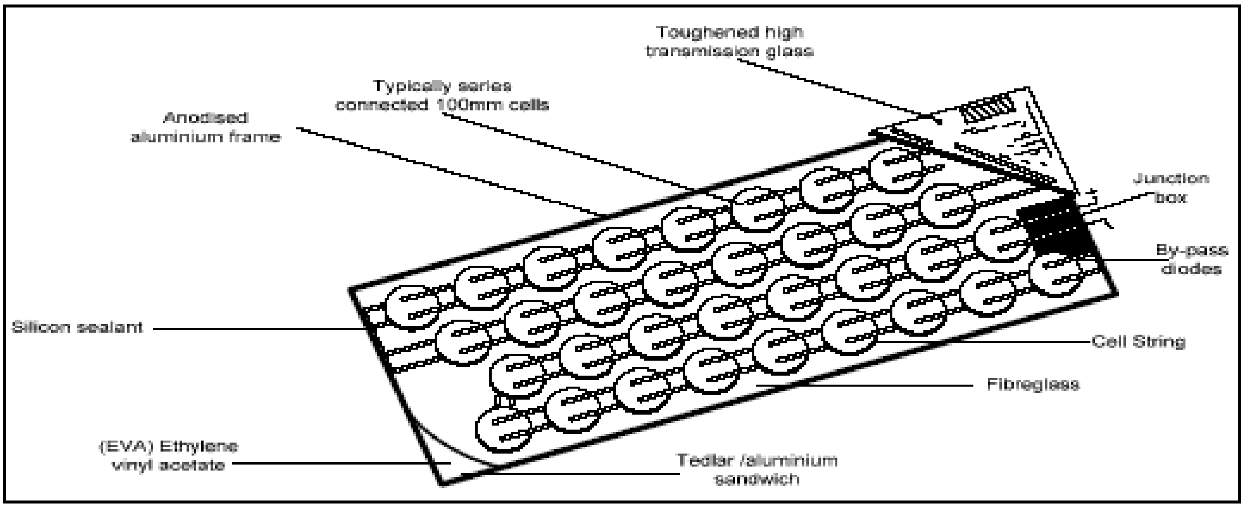
- When the solar PV feed-in power is below a predetermined level or when the solar insolation is below a selected value for a pre-determined period of time, the PCU draws energy from the battery bank for powering the load.

3.2.8.4 TYPICAL SYSTEM COMPONENTS OF OFF-GRID SPV SYSTEM

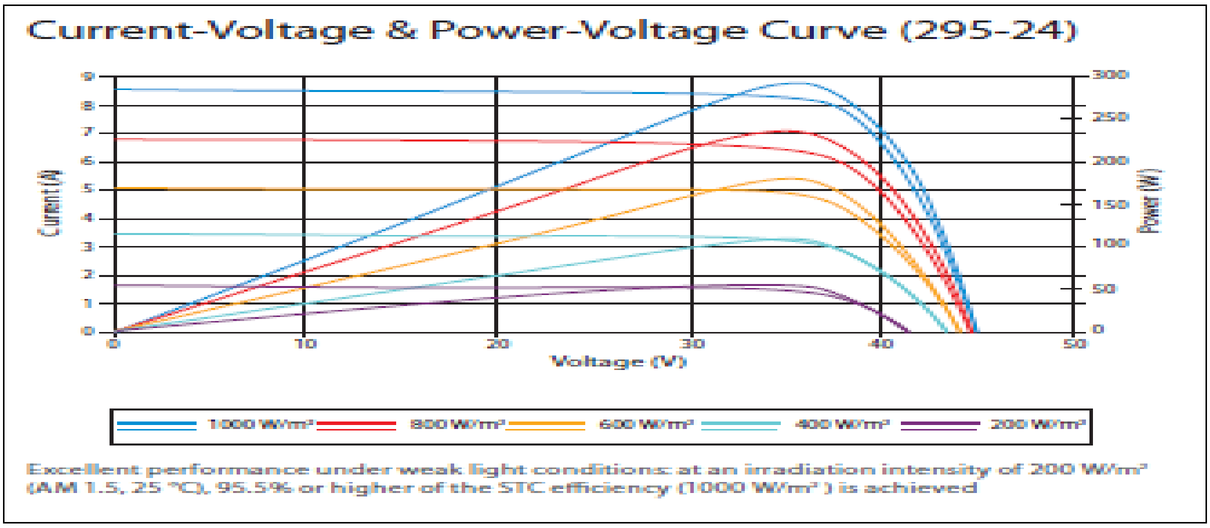
SOLAR PV MODULES / ARRAY

- As the solar cells have limited linear dimensions, a number of cells are to be interconnected to provide required voltage and current. These are encapsulated using a material such as Ethylene Vinyl Acetate (EVA) between a transparent window and moisture – proof backing to insulate and protect them.

- As the PV cells are less efficient at higher temperatures, modules are mechanically designed as not to retain the 'solar heat' and mounted so as to permit natural cooling. The figure below depicts the structure of a commercial module.



- The electrical performance of a module is more or less identical to a solar cell. It is shown in the figure below:



- The following parameters need to be considered for selecting a module for use:

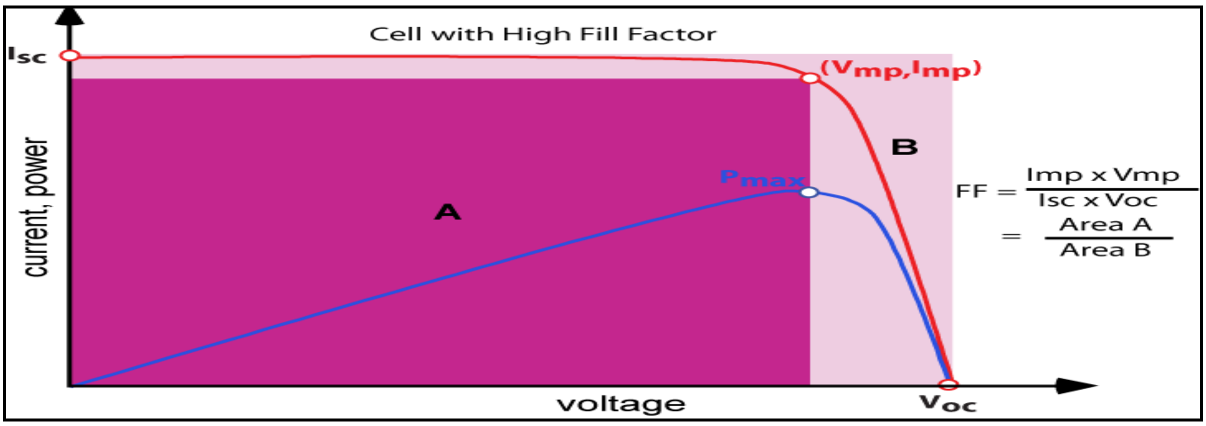
- Open–Circuit Voltage – Voc
- Short–Circuit Current – Isc
- Voltage Corresponding to MPP – Vmp
- Current Corresponding to MPP – Imp
- Maximum Power – Pmax

- Generally, the aforementioned values are compared to a solar irradiation of 1000 W/m^2 with a spectrum of AM 1.5 and solar cell temperature of 25°C.

- Another very important feature connected with solar PV module performance is the Normal Operating Cell Temperature (NOCT).

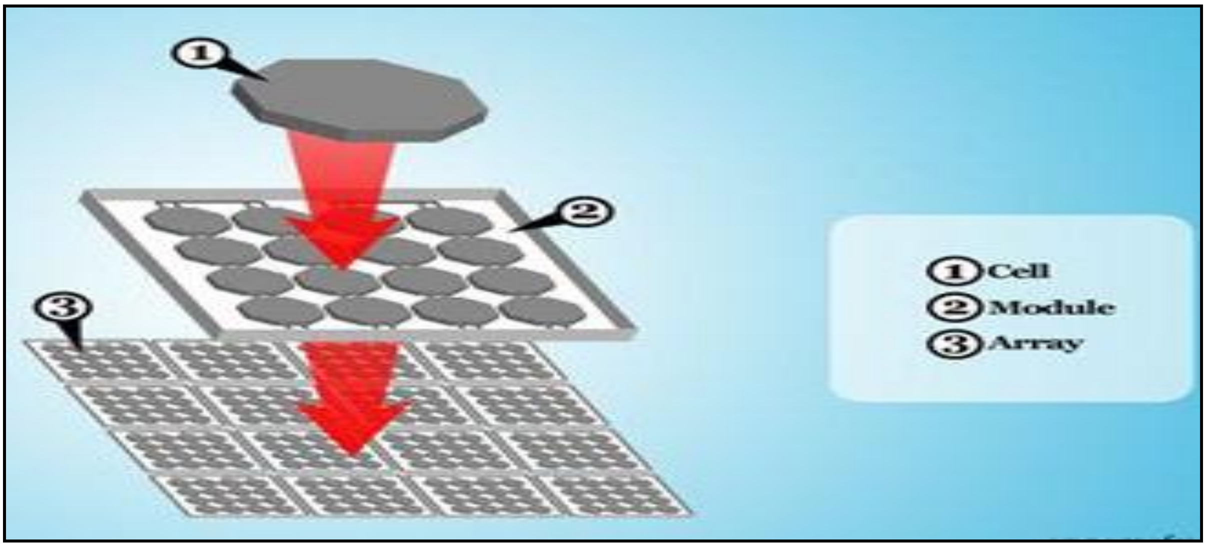
- NOCT is that value of cell temperature which is reached when the incident solar radiation is 800 W/m^2, ambient temperature is 45°C (±2°C) and wind velocity is 1 meter/second.

- The short-circuit current and the open-circuit voltage are the maximum current and voltage respectively from a solar cell. However, at both of these operating points, the power from the solar cell is zero. The "fill factor", more commonly known by its abbreviation "FF", is a parameter which, in conjunction with Voc and Isc, determines the maximum power from a solar cell. The FF is defined as the ratio of the maximum power from the solar cell to the product of Voc and Isc. Graphically, the FF is a measure of the "squareness" of the solar cell and is also the area of the largest rectangle which shall fit in the IV curve.

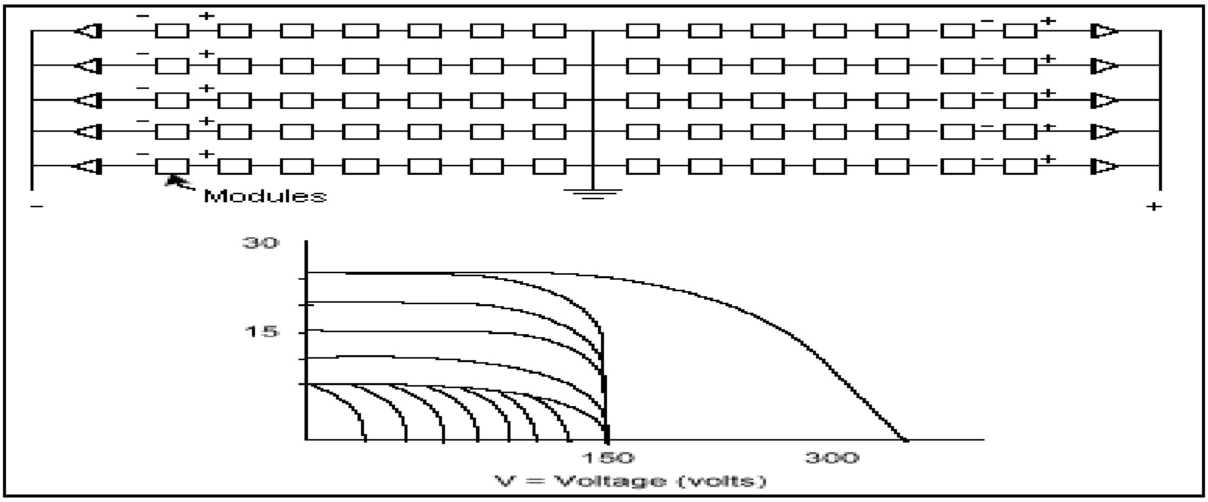


SOLAR PV ARRAY

- Depending on the load power requirements, modules are interconnected in series or parallel to constitute a PV array. The figure below is a representation of cell to module and module to array formation.



- Diagram of an array of modules and the resulting I–V characteristics is shown in figure below:



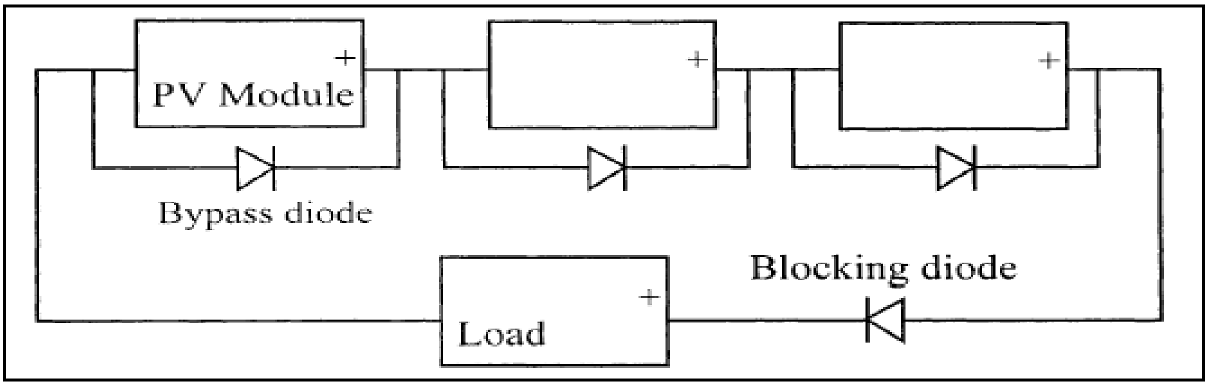
- Diodes are used in two ways in a photovoltaic array. Brief details are given below:

6 Blocking Diodes:

➢ These are placed in series with a module to prevent current from flowing 'backwards' through to modules.

7 By–pass Diodes:

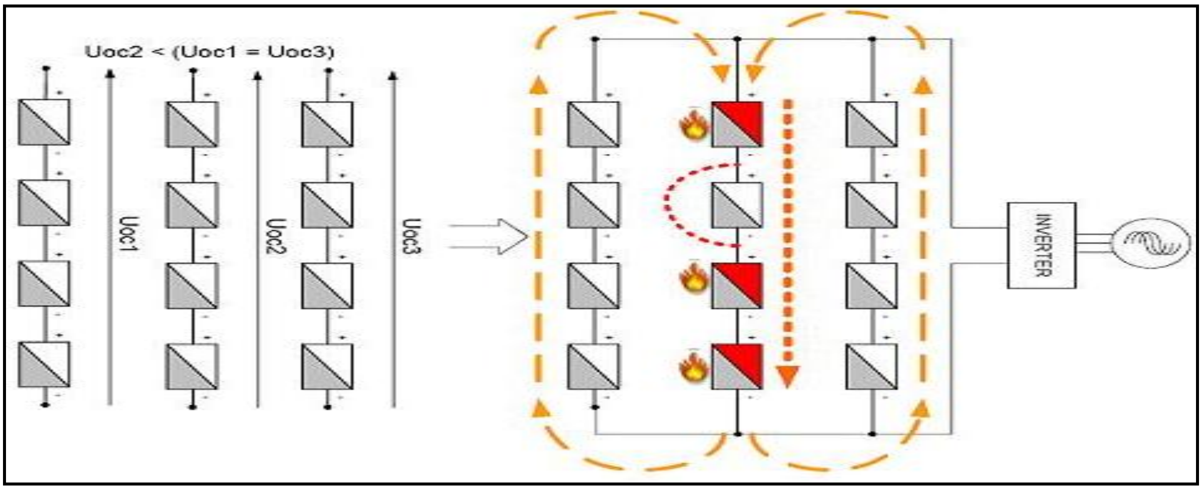
➢ When a cell gets shaded from the sun, an open–circuit can exist across it in which there is no current flow. By–pass (or shunt) diodes are used to shunt current, so that the other cells and modules continue to produce power in the PV array.



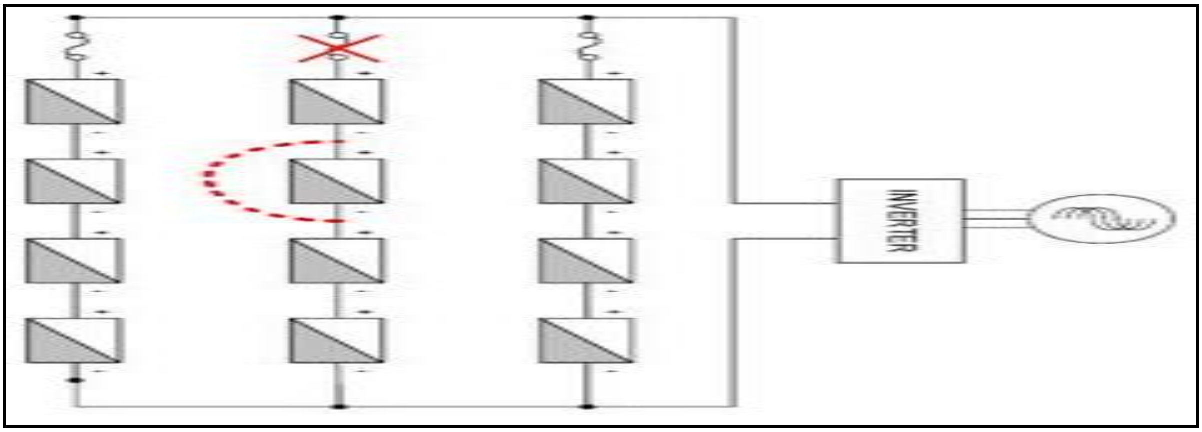
- If the inverted current exceeds the admissible limit of the panel, the panel shall overheat and may even be irreparably damaged. To avoid the problem, every string can be provided with a series of diodes. In this case, there are two disadvantages:

- The current of the string flows through the diode and therefore there is a considerable loss of power.

- If the diode short circuits, there shall be no protection whatsoever and a phenomenon as shown in the following figure can occur.



- The best solution is to use a fuse for every string. In case of excessive current inversion, the fuse shall open and protect the string. If the state of the fuse is monitored, distance control is also possible. Furthermore, power losses from a fuse are considerably less than those from a diode.



BALANCE OF SYSTEM (BOS)

8 Power Conditioning Units / Inverters

- A power conditioning unit (PCU) used in off-grid SPV systems consists of a charge controller for charging the batteries (also preventing over-charge and over-discharge of batteries), an inverter to convert DC to AC and other electronics for MPPT, synchronization and remote monitoring.

- The inverter is the most complicated part of the PV system. It has to act as the interface between the PV array and the load. As the PV array output varies with the solar radiation the inverter has to cope with the same.

- The main functions carried out by the PCU are as follows:

- Change the incoming DC received from PV modules into AC with suitable power quality. The inverter produces sinusoidal AC wave forms with low harmonic distortion.

- Change the incoming DC received from PV modules into DC of suitable voltage for charging the battery bank. This shall be suitably controlled through the charge controller.

- The inverter also has to act as a protective device of the system. It needs to trip out if the voltage, current or frequency goes outside acceptable ranges or in case of any overload or under-load conditions.

- Pulse width modulation (PWM) is used to generate a wave form as near as possible to a sine wave. High speed switching devices are used to generate pulses of the devices mainly used for inverter circuitry.

- Inverter efficiencies are now reaching about 95% commercially, mainly by deploying new switching topologies.

9 Other BOS Items

- Solar PV module mounting structures, interconnection systems and protection system which are used to integrate the solar PV modules into the structural and electrical systems are known as other BOS items.

- The SPV array (constituting solar PV modules of selected rating connected in series to build up the required voltage and in parallel to build up the required current) of the designed DC power produces DC electricity when solar insolation is incident on it. The DC power thus produced is taken through various junction boxes and isolators and connected to the PCU.

- PCU houses the inverter circuitry which converts DC power supply into AC power supply, the synchronization circuitry which actualizes the tie-up of solar PV source to the grid source (in case of load sharing) and the remote monitoring and control circuitry. A single or a number of PCUs are connected in parallel to build up the required AC power.

- PCU also houses the charge controller which regulates the charging the batteries, also preventing over charging or over discharging of the batteries.

- The protection and metering circuits play a very significant role. Appropriate current transformers and potential transformers are used to tap required feedback signals to initiate action on metering and protection. Various types of switchgear and protection equipment's are also involved for smooth and safe operation of the power plant.

PROJECT DESIGN

- The project shall be off-grid type solar photovoltaic power plant using following modules.

Sr. No.	Technology	Capacity of the plant	Makes	Wattage, Wp
1.	Poly Crystalline Modules	200 kWp	Vikram Solar/ Moserbaer/Schott Solar/Waaree solar/TATA BP solar/ Titan Energy Systems	295 Wp

- The modules shall be fixed on roof-top mounted structures with fixed tilted arrangement for entire life of project.

- The array shall be installed on steel racking structures that are anchored on pedestals /foundations. Racks shall be laid out in parallel matrices allowing for individuals to access the area between the racks for cleaning and other maintenance needs.

- DC power output from the solar panels shall be conducted through power conditioning units (PCUs) that meet the requirements. The power from the inverter of PCUs shall be of utility grid quality and capable of catering the electrical load requirements.

- The project shall be interconnected, metered and deliver electricity to the load. The project shall incorporate safety and protection devices as needed.
- Generally, following protections are provided:

  - Directional and non-directional relays
  - Over current & earth fault relay with under voltage & over voltage protection
  - Reverse power, under and over frequency protection relay.

- The project shall be designed to operate automatically with minimal human intervention. Built-in telemetry shall be incorporated to allow remote monitoring, control and problem diagnosis, thereby maximizing system availability and output of the project during its expected life.

- The 200 kWp SPV system is designed considering 295 Wp modules. It shall consist of 56 nos. of modules; 8 modules shall be connected in series and 7 such strings shall be in parallel. The 7 parallel connections shall be done by the help of String Combiner Box (SCB). 7 string outputs shall be connected to 1 SCB and the SCB output shall be connected to single PCU. There shall be total 1 SCB and 1 PCU. PCU considered is of capacity 20 kW.

- The DC voltage operating range of 200 kWp SPV array shall be 200 V to 400 V DC. This shall be converted to AC supply by 1 Nos. of power conditioning unit (PCU) to 3 phase, 415 V AC, 50 Hz frequency level, which shall be fed to the mains distribution panel, to be distributed to the electrical load.

MOUNTING ARRANGEMENT

- Mounting : Fixed Tilting Arrangement
- Surface azimuth angle of PV Module : 0°

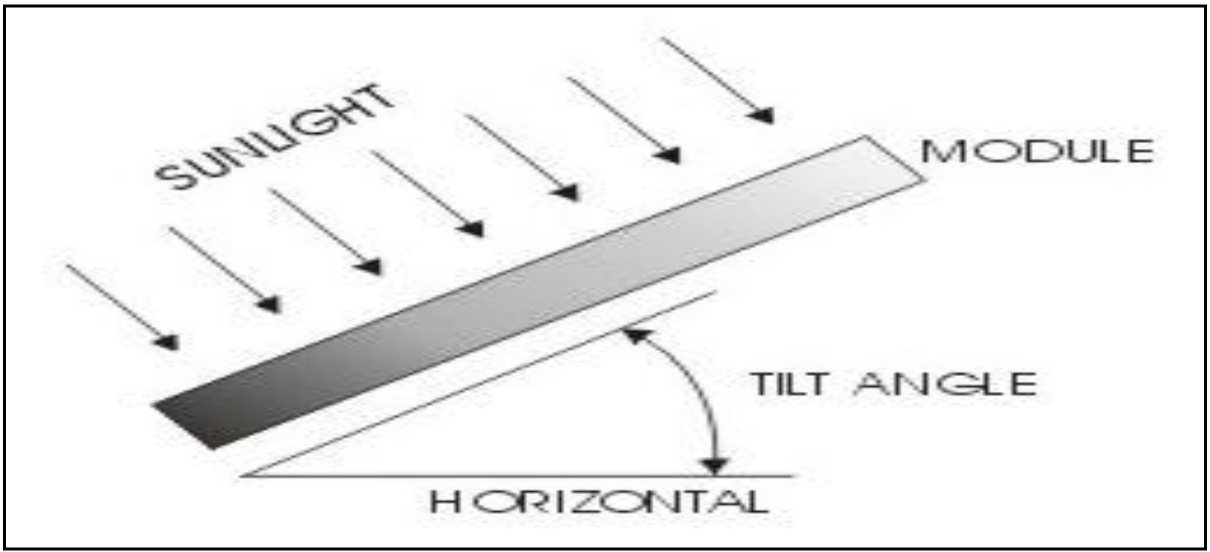
- Tilt angle (slope) of PV Module : 19°

MODULE TILT ANGLE

- Solar modules produce the most power when they are pointed directly at the sun. The table given below is to be followed as a general guideline while finalizing the module tilt during installation.

- For standalone installations, the solar modules should be tilted for optimum winter performance. The solar module tilt angle is measured between the solar modules and the ground.

- For grid interactive installations where the solar modules are attached to a permanent structure, the solar modules should be tilted at an angle equal to the site's latitude. This shall typically result in the highest annual energy output.



SOLAR PV POWER GENERATION

- The Solar Radiation available at the project site is 5.90 kWh/m^2/day on horizontal plane where as it works out to be 5.56 kWh/m^2/day at 19° tilted surface from NASA source.

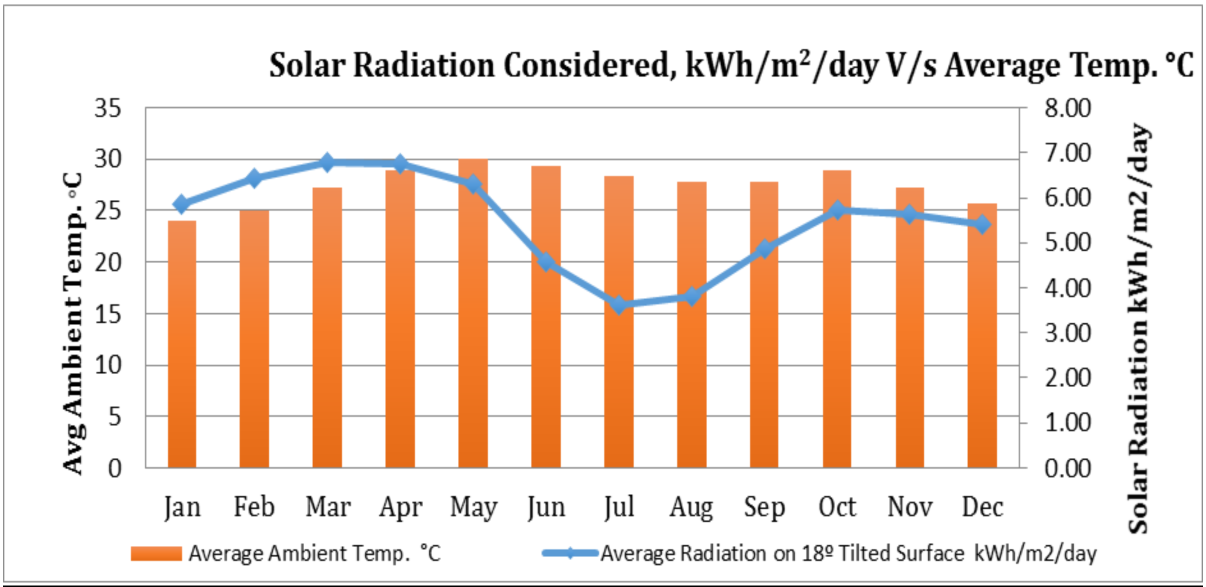
- Generation can be increased by providing fixed tilting for entire life of the project. Solar panels should always face true south tilted from the horizontal at a degree equal to your latitude.

Table 12: Solar radiation obtained from NASA source at horizontal surface and tilted surface

Months	Average ambient temp. °C	NASA Solar Radiation	
		At Horizontal Surface	At 19° Tilted Surface
		kWh/m^2/day	kWh/m^2/day
Jan	23.2	4.97	6.04
Feb	25.9	5.74	6.52
Mar	30.4	6.42	6.72
Apr	32.9	6.73	6.51
May	33.4	6.63	6.12
Jun	29.2	5.14	5.11

Jul	26.7	4.2	4.13
Aug	26.2	3.98	3.78
Sept	26.8	7.74	4.74
Oct	26.6	5.14	5.6
Nov	24.8	5	5.93
Dec	22.6	4.73	5.61
Average	**26.7**	**5.9**	**5.5675**

Figure 15: Solar Radiation, kWh/m^2/day V/S Average Ambient Temperature, °C

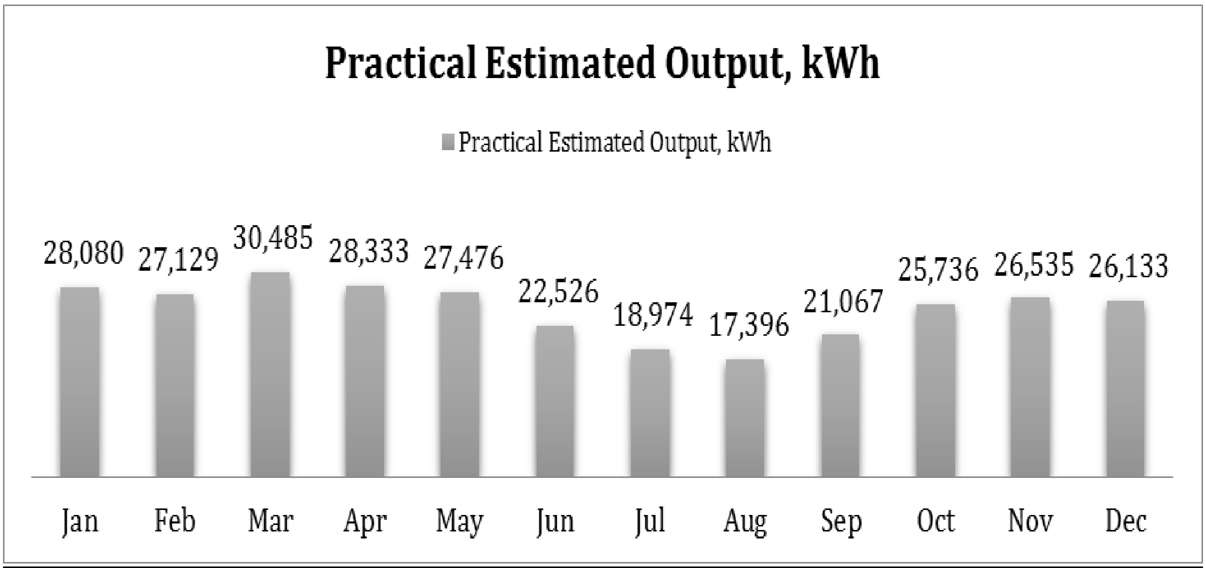


- **<u>The power generation and practical output energy of the proposed 200 kWp off-grid SPV system is given below:</u>**

Table 13: Practical output power generation – 200 kWp SPV project

Month	Solar Radiation Considered, kWh/m^2/day	Ambient Temp., °C	Total module Capacity Installed, kWp	Theoretical Output for the month, kWh	Overall Losses, %	Practical Output for the month, kWh
Jan	5.86	23.2	678	37,433	24.99%	28,080
Feb	6.47	25.9	678	36,497	25.67%	27,129
Mar	6.8	30.4	678	41,647	26.80%	30,485
Apr	6.74	32.9	678	39,044	27.43%	28,333
May	6.31	33.4	678	37,929	27.56%	27,476
Jun	4.58	29.2	678	30,648	26.50%	22,526
Jul	3.62	26.7	678	25,596	25.87%	18,974
Aug	3.83	26.2	678	23,427	25.74%	17,396
Sep	4.88	26.8	678	28,429	25.90%	21,067
Oct	5.7	26.6	678	34,706	25.84%	25,736
Nov	5.63	24.8	678	35,566	25.39%	26,535
Dec	5.46	22.6	678	34,768	24.84%	26,133
Total/ Avg	**5.48**	**26.7**	**678**	**405,691**	**26.04%**	**299,870**

Figure 16: Practical output power generation – 200 kWp SPV project



- The total practical losses considered at different stages are shown below:

IAM factor on global	2.00 %
PV loss due to irradiance	2.00 %
Loss due to Temperature variation (average)	8.40 %
Module quality loss	1.50 %
Array mismatch loss	1.50 %
Dust de-rating Losses	1.50 %
Cable drop de-rating	1.00 %
Inverter losses	10.00 %
Power evacuation losses	0.50 %

- The above losses accumulate up to 25.86%. (Overall average throughout the year).
- Hence the expected generation shall be about 24,506 Units. The detailed energy generation calculation is attached as Annexure - VII.
- The above methodology used for estimation of energy generation from solar project is basic methodology on which all the simulation software works, hence the same is adopted.

Different Losses Considered During Energy yield Calculation

- **Loss due to Temp variation (average)**:

➢ Temperature derating is counterintuitive, but photovoltaic modules actually produce less power when they get hotter. The energy is produced from the light, not the heat. This loss is depending upon power temperature coefficient per degree Celsius. Manufacturer specification sheet will usually have this information for their modules. Power per surface area - Since PV output varies greatly with light intensity and temperatures, Standard Test Conditions (STC) have been developed to rate modules – 1000 watts of light per square meter at 25 C. So a '295 watt' module will produce 295 watts at STC, and less as temperature climbs or light intensity drops.

- **Array mismatch:**

➢ This derating factor accounts for the fact that the current and voltage characteristics of every module are not identical. Although the MPPT in the inverter keeps the array at its maximum power point, each individual module does not operate at its maximum power point.

- **Dust Derating Losses:**

➢ Soiling, Dirt such as dust, snow, bird droppings, etc settling on the PV modules derating the performance of the installation. Regular cleaning of module increases performance of the plant.

- **Cable Drop Derating:**

➢ DC wiring losses is common for a wiring loss factor to be calculated using the current and voltage at the maximum power point at STC conditions, as specified on the manufacturer's data sheet. As with dc wiring, the losses due to resistance in ac wiring vary with the amount of current. In the case of ac current, loss factor calculations typically assume full power output from the inverter. This occurs for only a portion of the inverter's operating time.

- **PCU Losses**:

➢ It is not possible to convert power without losing some of it (it's like friction). Power is lost in the form of heat. Efficiency is the ratio of power out to power in, expressed as a percentage. If the efficiency is 95 percent, 5 percent of the power is lost in the inverter. The efficiency of an inverter varies with the load & working condition. Typically, it will be highest at about two thirds of the inverter's capacity. This is called its "peak efficiency." The inverter requires some power just to run itself, so the efficiency of a large inverter will be low when running very small loads. The perfect sun hours (PSH) in Maharashtra is 4-5 hours, inverter will work for 4-5 hrs with its full capacity.

3.2.9 SOCIAL & ENVIRONMENTAL IMPACT ASSESMENTS

3.2.9.1 SOCIAL IMPACT

- The envisaged benefits from development projects can be fully realized only if they are socially sound and environmentally sustainable.

- Solar PV power projects shall have social impact on the following:

➢ Creates local employment for installation and servicing.
➢ Supports rural development.
➢ Improves standard of living of the local people.
➢ Reduces fuel costs and pollution from fossil fuel use.
➢ Creates a symbol for sustainable development and green energy solution.
➢ Presents potential for international cooperation, collaboration, and long-term aid to developing countries.

3.2.9.2 ENVIRONMENTAL IMPACT

- It is well recognized that, for sustainable development and optimal use of natural resources, environmental considerations are required to be integrated in planning, designing and implementation of development projects.

- The envisaged benefits from development projects can be fully realized only if they are environmentally sustainable and socially sound.

- The environmental impacts can be categorized as either primary or secondary. Primary impacts are those that are attributed directly by the project, secondary impacts are those which are indirectly induced and typically include the associated investment and changed patterns of social and economic activities by the proposed action.

- Off-grid solar PV power projects would not create a greater impact on the environment, as the capacity involved and area requirement are smaller. Although, for ground mount systems of few 100 kW capacities, the impact can be observed in two distinct phases:

➢ During the construction phase and
➢ During the operation phase which would have long term effects.

- During the study of environmental impact assessment, a few additional mitigating measures have been identified to further minimize the net impact. These issues have been covered with each of the impacts below.

3.2.9.3 IMPACTS DURING CONSTRUCTION

- The impact from the construction phase is not envisaged to be serious. However, the following factors should be kept in mind to make certain that the impacts are minimal.

➢ **Sanitation**

- Cleanliness level is to be maintained ensuring proper standards of hygiene and minimum environmental impact.

➢ **Noise**

- The impact of noise on the nearest inhabitants during the construction activity shall be taken into account. High noise equipment shall be used with due care during the time that does not create disturbance to the inhabitants. It is advisable that on site workers using high noise equipment, use noise protection devices like ear muffs.

- Noise prone activities have to be restricted to the extent possible during night particularly during the period 10 p.m. to 6 a.m. in order to have minimum impact.

3.2.9.4 IMPACTS DURING OPERATION

- The operational phase shall involve power production using solar energy. The following activities in relation to the operational phase shall have varying impact on the environment and are considered for impact prediction.

➢ **Impact on Air Quality**

- The existing status of the ambient air quality of the area shall not be affected by the project. As we all know all renewable energy projects are environment friendly.

➢ **Impact on Soil**

- Most of the impacts on soil due to the project are negligible and restricted to the construction phase and shall get stabilized during the operational phase.

- **Impact on Water Resources**

- Except in the construction phase, there is no specific water requirement for solar power project other than cleaning of modules, which can be made available by bore well or local municipality water. Hence, there shall be no impact on water resources.

3.2.9.5 LIST OF APPROVALS REQUIRED FOR THE PROJECT

- Various clearances / permissions required for execution of the project are as follows.

- **State Electricity Board (MSEDCL)**

- Permission from State Electricity Board for implementation of solar project is required for eligibility of subsidy.

- **State Nodal Agency-Renewable**

- Permission from State Nodal agency for implementation of Solar Project is required for eligibility of subsidy.

- **Labor Department**

- The clearance from State Labor Department is required during construction which shall be in the scope of EPC contractor.

- **Electrical Inspector / Factory Inspector**

- Permissions / clearances from Electrical Inspector are required before implementation and before commissioning of the project.

3.3 RAIN WATER HARVESTING SYSTEM

- The rain water harvesting is a process to collect rain water from ground surface or from rooftop and store for future water requirement or recharge the ground water.

- It is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building. It can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly helps in augmenting the ground water level of the area.

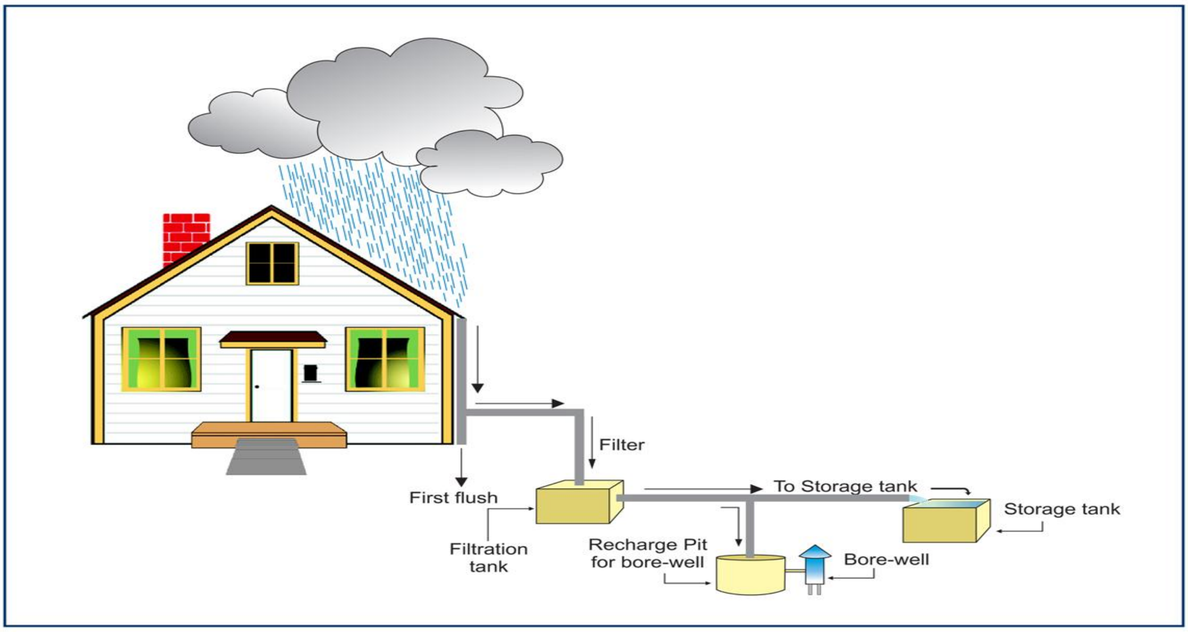
- The rainwater harvesting system is made for-

  - To arrest ground water
  - To beneficiate water quality in aquifers
  - To conserve surface water runoff
  - To reduce soil erosion

- There is two method of rain water harvesting-

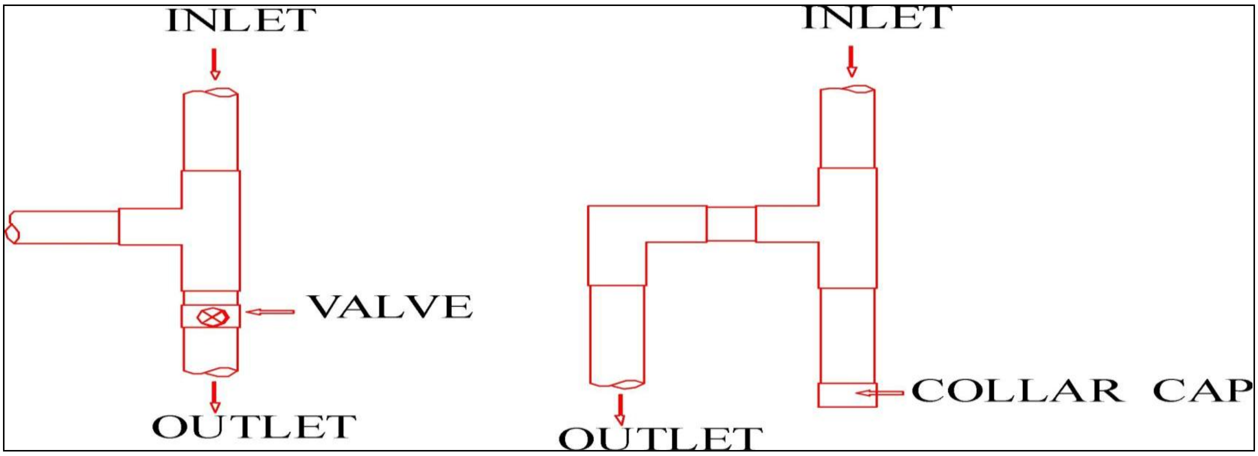
  1. Surface runoff harvesting
  2. Roof top rainwater harvesting (RTRWH)

- Schematic diagram of a of typical roof top rainwater harvesting system-



- **Components of roof top rain water harvesting is**:-
  - ➢ Catchment
  - ➢ Transportation
  - ➢ First flush
  - ➢ Filter
- **Catchment: -**
- The surface that receives rainfall directly is the catchment. Sloping roof or flat roof.
- The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard, or paved or unpaved open ground. The terrace may be flat RCC/stone roof or sloping roof. Therefore the catchment is the area, which actually contributes rainwater to the harvesting system.
- **Transportation: -**
- Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of required capacity. Water from sloping roofs could be caught through gutters and down take pipe. At terraces, mouth of the each drain should have wire mesh to restrict floating material.
- **First Flush: -**
- First flush is a device used to flush off the water received in first shower. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof. It will also help in

cleaning of silt and other material deposited on roof during dry seasons Provisions of first rain separator should be made at outlet of each drainpipe.



- **Filtration: -**

- There is always some skepticism regarding Roof Top Rainwater harvesting since doubts are raised that rainwater may contaminate groundwater. There is remote possibility of this fear coming true if proper filter mechanism is not adopted. Secondly all care must be taken to see that underground sewer drains are not punctured and no leakage is taking place in close vicinity. Filters are used fro treatment of water to effectively remove turbidity, color and microorganisms. After first flushing of rainfall, water should pass through filters. A gravel, sand and 'netlon' mesh filter is designed and placed on top of the storage tank. This filter is very important in keeping the rainwater in the storage tank clean. It removes silt, dust, leaves and other organic matter from entering the storage tank. The filter media should be cleaned daily after every rainfall event. Clogged filters prevent rainwater from easily entering the storage tank and the filter may overflow. The sand or gravel media should be taken out and washed before it is replaced in the filter.

- There are different types of filters in practice, but basic function is to purify water. Different types of filters are described in this section.

- Sand gravel filter
- Charcoal filter
- PVC –Pipe filter
- Sponge filter

- **Methods of Rooftop Water harvesting-**

- **Storage for Direct use**

- In this method rain water collected from the roof of the building is diverted to a storage tank. The storage tank has to be designed according to the water requirements, rainfall and catchment availability. Each drainpipe should have mesh filter at mouth and first flush device followed by filtration system before connecting to the storage tank. It is advisable that each tank should have excess water over flow system.

- Excess water could be diverted to recharge system. Water from storage tank can be used for secondary purposes such as washing and gardening etc. This is the most cost effective way of rainwater harvesting. The main advantage of collecting and using the rainwater during rainy season is not only to save water from conventional sources, but also to save energy incurred on transportation and distribution of water at the doorstep.

This also conserves groundwater, if it is being extracted to meet the demand when rains are on. A typical fig of storage tank

- Rain water collected from the roof is diverted to storage tank.
- Storage tank has to be designed according to the water requirements, rainfall and catchment availability.
- Each drainpipe should have mesh filter at mouth and first flush device before connecting to storage tank.
- Each tank should have excess water over flow system. Excess water could be diverted to recharge system.
- Water from storage tank can be used for domestic and gardening purpose. It is most cost effective way of rainwater harvesting.

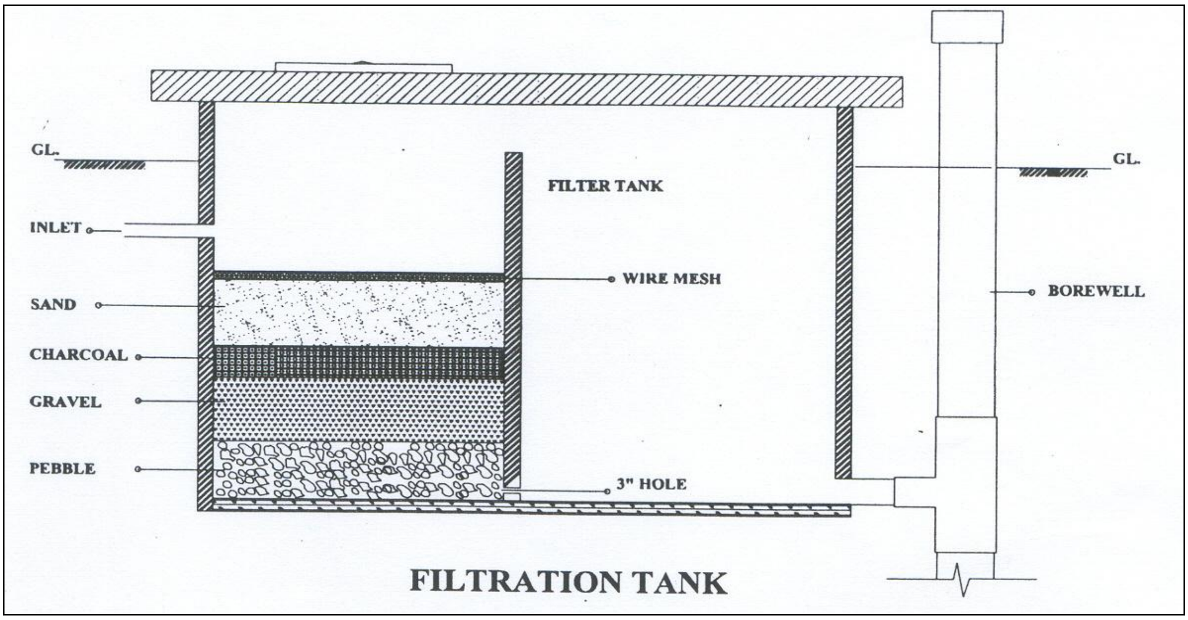
- **Recharging ground water aquifers-**

- Ground water aquifers can be recharged by various kinds of structures to ensure percolation of rainwater in the ground instead of draining away from the surface. Commonly used recharging methods are: -

1. **Recharging bore wells**-

- Rainwater collected from rooftop of the building is diverted through drainpipes to settlement or filtration tank. After settlement filtered water is diverted to bore wells to recharge deep aquifers. Abandoned bore wells can also be used for recharge.

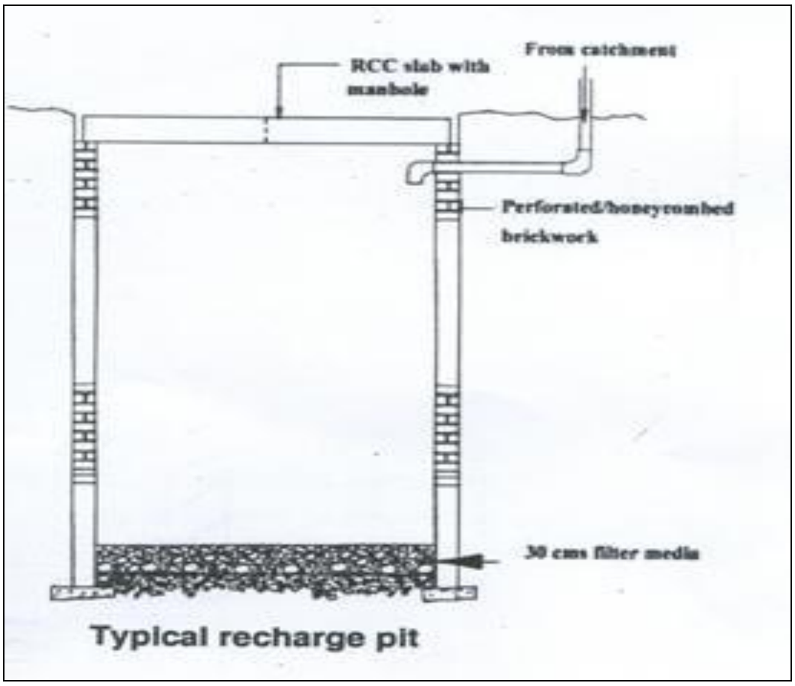
- Optimum capacity of settlement tank/filtration tank can be designed on the basis of area of catchment, intensity of rainfall and recharge rate. While recharging, entry of floating matter and silt should be restricted because it may clog the recharge structure. First one or two shower should be flushed out through rain separator to avoid contamination. A schematic diagram of filtration tank recharging to bore well is indicated in figure-



2. **Recharge pits-**

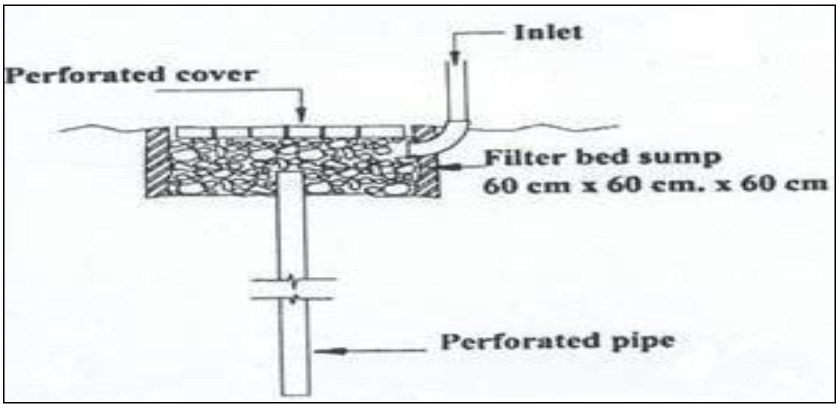
- Recharge pits are small pits of any shape rectangular, square or circular, contracted with brick or stone masonry wall with weep hole at regular intervals. Top of pit can be covered with perforated covers. Bottom of pit should be filled with filter media.

- The capacity of the pit can be designed on the basis of catchment area, rainfall intensity and recharge rate of soil. Usually the dimensions of the pit may be of 1 to 2 m width and 2 to 3 m deep depending on the depth of pervious strata. These pits are suitable for recharging of shallow aquifers, and small houses. A schematic diagram of recharge pit is shown in Figure-



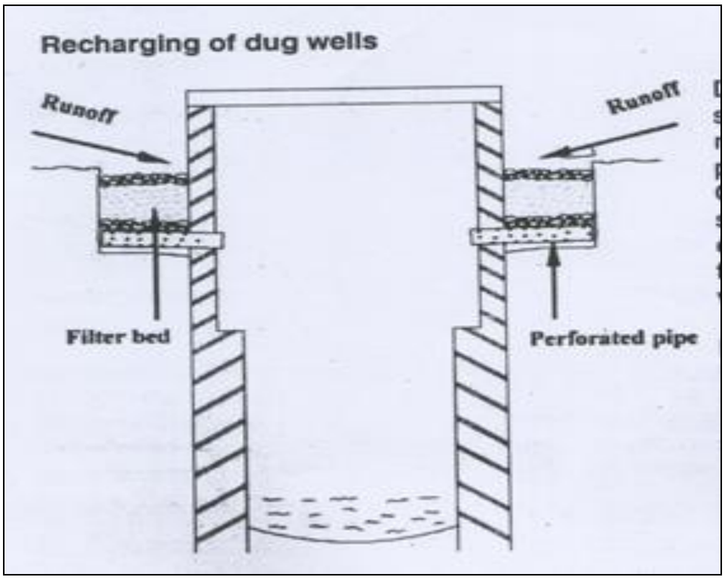
3. Soakaways or Recharge Shafts-

- Soak away or recharge shafts are provided where upper layer of soil is alluvial or less pervious. These are bored hole of 30 cm dia. up to 10 to 15 m deep, depending on depth of pervious layer. Bore should be lined with slotted/perforated PVC/MS pipe to prevent collapse of the vertical sides. At the top of soak away required size sump is constructed to retain runoff before the filters through soak away. Sump should be filled with filter media. A schematic diagram of recharge shaft is shown in Figure-



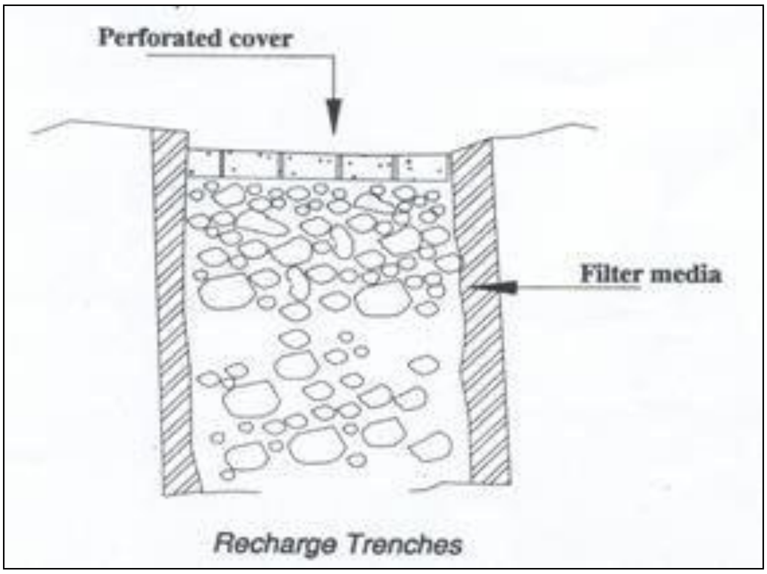
4. Recharging dug well-

- Dug well can be used as recharge structure. Rainwater from the rooftop is diverted to dug wells after passing it through filtration bed. Cleaning and desalting of dug well should be done regularly to enhance the recharge rate. The filtration method suggested for bore well recharging could be used. A schematic diagram of recharging into dug well is indicated in Figure-



5. Recharge Trench-

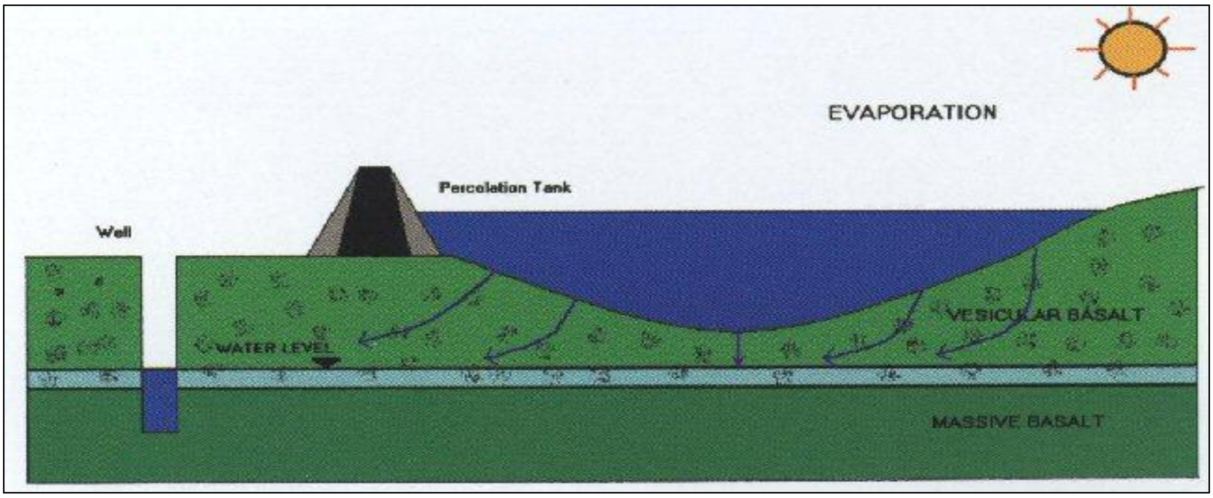
- Recharge trench in provided where upper impervious layer of soil is shallow. It is a trench excavated on the ground and refilled with porous media like pebbles, boulder or brickbats. it is usually made for harvesting the surface runoff. Bore wells can also be provided inside the trench as recharge shafts to enhance percolation. The length of the trench is decided as per the amount of runoff expected. This method is suitable for small houses, playgrounds, parks and roadside drains. The recharge trench can be of size 0.50 to 1.0 m wide and 1.0 to 1.5 m deep. A schematic diagram of recharging to trenches is shown in Figure-



6. Percolation Tank-

- Percolation tanks are artificially created surface water bodies, submerging a land area with adequate permeability to facilitate sufficient percolation to recharge the ground water. These can be built in big campuses where land is available and topography is suitable.

- Surface run-off and roof top water can be diverted to this tank. Water accumulating in the tank percolates in the solid to augment the ground water. The stored water can be used directly for gardening and raw use. Percolation tanks should be built in gardens, open spaces and roadside green belts of urban area



➢ WATER PERCOLATION AND WATER HARVESTING

- Water percolation will increase the ground water level and quality of water, thus to reduce the pumping cost, R.O. water generation cost and effluent treatment cost.

TYPICAL AERATORS FOR WATER TAP

➢ ADVANTAGES OF WATER PERCOLATION AND WATER HARVESTING:

- Rainwater harvesting is collecting the run-off from a structure or other impervious surface in order to store it for later use. Traditionally, this involves harvesting the rain from a roof. The rain will collect in gutters that channel the water into downspouts and then into some sort of storage vessel. Rainwater collection systems can be as simple as collecting rain in a rain barrel or as elaborate as harvesting rainwater into large cisterns to supply your entire household demand.

- The idea of rainwater harvesting usually conjures up images of an old farm cistern or thoughts of developing countries. The reality is that rainwater harvesting is becoming a viable alternative for supplying our households and businesses with water. It's not just for the farm anymore! There are many countries such as Germany and Australia where rainwater harvesting is a norm. Due to the green building movement, you will be seeing rainwater harvesting systems become more popular here in America.
- The collection of rainwater is known by many names throughout the world. It ranges from rainwater collection to rainwater harvesting to rainwater catchment. In addition, terms such as roof water collection or rooftop water collection is also used in other countries.
- We believe that rainwater harvesting is a viable technology in an urban setting. All that is necessary to take advantage of this resource is to capture the free water falling on your roof and direct it to a rainwater storage tank. By doing this, you can take control of your water supply and replace all or at least a substantial portion of your water needs. Rainwater harvesting systems can be configured to supply your whole house and/or your landscape needs.

➢ **What are the benefits of rainwater collection?**

- Rainwater is a relatively clean and absolutely free source of water
- You have total control over your water supply (ideal for cities with water restrictions)
- It is socially acceptable and environmentally responsible
- It promotes self-sufficiency and helps conserve water
- Rainwater is better for landscape plants and gardens because it is not chlorinated
- It reduces storm water runoff from homes and businesses
- It can solve the drainage problems on your property while providing you with free water
- It uses simple technologies that are inexpensive and easy to maintain
- It can be used as a main source of water or as a backup source to wells and municipal water
- The system can be easily retrofitted to an existing structure or built during new home construction
- System are very flexible and can be modular in nature, allowing expansion, reconfiguration, or relocation, if necessary
- It can provide an excellent back-up source of water for emergencies
- What are the uses of collected rainwater?
- You can essentially use rainwater anywhere you use tap water. The idea of using drinking water to flush our toilets and water our lawns is wasteful and irresponsible, especially in light of population growth and water shortages across the country. Rainwater collection is a technique to green your home and to lessen your environmental footprint.
- There are basically three areas where rainwater can be used:
- Irrigation use

- Indoor, non-potable use
- Whole house, potable use
- Here are some ideas for specific uses of rainwater:
- Hand water your lawn and garden
- Connect rainwater collection system to irrigation/sprinkler system
- Wash your vehicles
- Wash your pets
- Refill your fountains and fish ponds
- Refill your swimming pool
- Replace the use of tap water with rainwater to wash your driveways and sidewalks (if you don't use a broom)
- Use it for all indoor non-potable fixtures (toilets and clothes washer)
- Use it for all potable needs when properly filtered and disinfected
- Use it for industrial processes instead of municipally treated water

➢ **HOW MUCH RAIN CAN I COLLECT?**

- ➢ The amount of rainfall that you can collect is governed by the following formula:
- ➢ 1" of rain x 1 sq. ft. = 0.623 gallons
- ➢ Or put in an easy form to remember:
- ➢ 1" of rain from 1,000 sq. ft. will provide 623 gallons
- ➢ To calculate the amount of rainwater you can collect, you need to know your annual average precipitation for your area.

➢ **WATER PERCOLATION:**

- In this method rain water collected from the roof of the building is diverted to a storage tank. The storage tank has to be designed according to the water requirements, rainfall and catchment availability. Each drainpipe should have mesh filter at mouth and first flush device followed by filtration system before connecting to the storage tank. It is advisable that each tank should have excess water over flow system.
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- Roof or terraces uses for harvesting should be clean, free from dust, algal plants etc.
- Roof should not be painted since most paints contain toxic substances and may peel off.
- Do not store chemicals, rusting iron, manure or detergent on the roof.
- Nesting of birds on the roof should be prevented.

- Terraces should not be used for toilets either by human beings or by pets.
- Provide gratings at mouth of each drainpipe on terraces to trap leaves debris and floating materials.
- Provision of first rain separator should be made to flush off first rains.
- Do not use polluted water to recharge ground water.
- Ground water should only be recharged by rainwater.
- Before recharging, suitable arrangements of filtering should be provided.
- Filter media should be cleaned before every monsoon season.
- During rainy season, the whole system (roof catchment, pipes, screens, first flush, filters, and tanks) should be checked before and after each rain and preferably cleaned after every dry period exceeding a month.
- At the end of the dry season and just before the first shower of rain is anticipated, the storage tank should be scrubbed and flushed off all sediments and debris.

3.4 WATER CONSERVATION

- It is noted that the waste water treatment is not conducted in the mahavidyalaya. There should be install one ETP plant for reuse of waste water from college buildings and auditoriums. This water can utilized for gardening purpose which presently used raw water of bore wells.
- Monthly water consumption in mahavidyalaya is 1680000 liters per day approximately.
- Monthly water consumption for gardening is about 420000 liters per month approximately.
- Monthly water consumption for office, classrooms and auditoriums are approximately 1260000 liters per month.
- Total water can conserve by use of ETP in the Mahavidyalaya-
    - 35 % water of total used in office, classrooms and auditoriums = 440000 liters per month.
- Total water can conserve by use of ETP = 5040000 liters per year
- Total investment for ETP = 30 lacs (Approximately)

SECTION: 4

GENERAL AWARENESS & TIPS

4 GENERAL AWARENESS FOR GREEN SYSTEM

- Most of the tube lights and fans are on at the empty class rooms and offices. It should be switched off when rooms are empty. Occupancy sensors can be installed where very less movements are required.

- Old and inefficient Air conditioners should be replaced with BEE five star rated energy efficient air conditioners.

- ACs and fans should be switch off before leaving the rooms or office. Same instructions for energy conservation should be pasted in the office and rooms.

- Windows should be open for fresh air circulation and utilization of day light in the office and class rooms where air conditioners are not installed.

- Switch off lights when day light available in the office and class rooms and same instructions for energy conservation should be pasted in the office and rooms.

- Water should be conserved through close the valve/ nulls when not in use or after use for drinking and washrooms.

- Install level sensors for water storage tank to avoid overflow of water from the tank.

- Computer monitor and hardware should be switch off when not in use or in empty rooms.

- Declare YMN campuses a Bottled Water Free Zone. Bottled water may be healthier than pop for the human body, but it is as unhealthy as pop for the planet when you consider the carbon footprint of bottled water. This beverage is also an unnecessary cost to the average citizen, since property taxes are paying for excellent quality tap water in most YMN campus locations. Alternative to bottled water: well-designed drinking water fountains where reusable water bottles can be refilled. An education campaign on the negative impacts of bottled water would also be welcomed by many staff, students and community members.

- Go deeper with commitment to reducing paper use and purchasing requirements. Paper consumption can be reduced by printing only when necessary, using document layouts and report guidelines to minimize number of pages, and printing double-sided or on one-side used paper. Free and low cost software to assist with green printing is available. Adopt a purchasing policy that specifies that at least 50% of paper purchased must be FSI certified or tree-free and that printing service jobs and contracts follow this specification. Ask text book suppliers to adopt green printing practices.

- Conveniently co-locate recycling and trash bins to improve convenience and reduce cross-contamination. Existing trash cans can be re-used beside a multi-compartment recycling bin, converted to a compost collector or to a planter.

- Right size your garbage service to reduce frequency of collection and costs as diversion programs such as recycling and composting come on line. Include information on or near your dumpsters regarding what

items can be recycled and where, the social and environmental costs of landfilling, and dates of collection and % filled.

- Develop an idle-free campaign to reduce emissions from vehicle operations.

CHAPTER –5

GENERAL ENERGY CONSERVATION TIPS

5.1 General Energy Conservation Tips

- Apart from the above-mentioned areas, there are certain tips that plant should examine in future to increase energy efficiency and hence to cut down on energy costs.

5.2 Checklist & Tips for Energy Efficiency in Electrical Utilities

5.2.1 Electricity

- Optimise the tariff structure with utility supplier
- Schedule your operations to maintain a high load factor
- Minimise maximum demand by tripping loads through a demand controller
- Stagger star-up times for equipment with large starting currents to minimise load peaking.
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.95 under rated load conditions.
- Relocate transformers close to main loads.
- Set transformer taps to optimum settings.
- Disconnect primary power to transformers that do not serve any active loads
- Consider on-site electric generation or cogeneration.
- Export power to grid if you have any surplus in your captive generation.
- Check utility electric meter with your own meter.
- Shut off unnecessary computers, printers and copiers at night

5.2.2 Motors

- Properly size to the load for optimum efficiency.(High efficiency motors offer of 4 – 5% & higher efficiency than standard motors)
- Use energy-efficient motors where economical.
- Use synchronous motors to improve power factor.
- Check alignment.
- Provide proper ventilation (For every 10^0C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)
- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply. (An Imbalanced voltage can reduce 3 – 5% in motor input power)
- Demand efficiency restoration after motor rewinding. (If rewinding is not done properly, the efficiency can be reduced by 5 – 8%)

5.2.3 Drives

- Use variable-speed drives for large variable loads.
- Use high-efficiency gear sets.
- Use precision alignment.
- Check belt tension regularly.
- Eliminate variable-pitch pulleys.
- Use flat belts as alternatives to v-belts.
- Use synthetic lubricants for large gearboxes.
- Eliminate eddy current couplings.
- Shut them off when not needed.

5.2.4 Fans

- Use smooth, well-rounded air inlet cones for fan air intakes.

- Avoid poor flow distribution at the fan inlet.
- Minimise fan inlet and outlet obstructions.
- Clean screens, filters and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimise fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable sped drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimise bends in ductwork.
- Turn fans off when not needed

5.2.5 Blowers

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimise blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimise blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Eliminate ductwork leaks.
- Turn blowers off when they are not needed.

5.2.6 Pumps

- Operate pumping near best efficiency point.
- Modify pumping to minimise throttling.
- Adapt to side load variation with variable speed drives or sequenced control of smaller units.
- Stop running both pumps – add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small load as requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimise water waste.
- Balance the system to minimise flows and reduce pump power requirements.
- Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return.

5.2.7 Compressors

- Consider variable speed drive for variable load on positive displacement compressors.
- Use a synthetic lubricant if the compressor manufacturer permits it.
- Be sure lubricating oil temperature is not too high (oil degradation and lowered viscosity) and not too low (Condensation contamination).
- Change the oil filter regularly.
- Periodically inspect compressor intercoolers for proper functioning.
- Use water heat from a very large compressor to power an absorption chiller or preheat process or utility feeds.

- Establish a compressor efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressor efficiency-maintenance program a part of your continuous energy management program.

5.2.8 Compressed Air

- Install a control system to co-ordinate multiple air compressors.
- Study part-load characteristic and cycling costs to determine the most-efficient mode for operating multiple air compressors.
- Avoid over sizing – match the connected load.
- Load up modulation-controlled air compressors. (They use almost as much powerat partial load as at full load.)
- Turn off the back-up air compressor until it is needed.
- Reduce air compressor discharge pressure to the lowest acceptable setting. *(Reduction of 1 kg/cm² air pressure (8 kg/cm² to 7 kg/cm²) would result in 9% input power savings. This will also reduce compressed air leakage rates by 10%)*
- Use the highest reasonable dryer dew point settings.
- Turn off refrigerated and heated air dryers when the air compressors are off.
- Use a control system to minimise heatless desiccant dryer purging.
- Minimise purges, leaks, excessive pressure drops and condensation accumulation. *(Compressed air leak from 1 mm hole size at 7 kg/cm² pressure would mean power loss equivalent to 0.5 KW)*
- Use drain controls instead of continuous air bleeds through the drains.
- Consider engine-driven or steam-driven air compression to reduce electrical demand charges.
- Replace standard V-belts with high-efficiency flat belts as the old V-belts wear out.
- Use a small air compressor when major production load is off.
- Take air compressor intake air from the coolest (but not air conditioned) location. *(Every 5ºC reduction in intake air temperature would result in 1% reduction in compressor power consumption)*
- Use an air-cooled after cooler to heat building makeup air in winter.
- Be sure that heat exchangers are not fouled (eg. – with oil)
- Be sure that air / oil separators are not fouled.
- Monitor pressure drops across suction and discharge filters and clean or replace filters promptly upon alarm.
- Use a properly sized compressed air storage receiver.
- Minimise disposal costs by using lubricant that is fully demulsible and an effective oil-water separator.
- Consider alternatives to compressed air such as blowers for cooling, hydraulic rather than air cylinders, electric rather than air actuators and electronic rather than pneumatic controls.
- Use nozzles or venturi - type devices instead of blowing with open compressed air lines.
- Check for leaking drain valves on compressed air filter / regular sets. Certain rubber-type valves may leak continuously after they age and crack.
- Industry environments, control packaging lines with high-intensity photocell units instead of standard units with continuous air purging of lenses and reflectors.
- Establish a compressed air efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressed air efficiency-maintenance program a part of your continuous energy management program.

5.2.9 Chillers

- Increase the chilled water temperature set point if possible.

- Use the lowest temperature condenser water available that the chiller can handle. *(Reducing condensing temperature by 5.5ºC, results in a 20 – 25% decrease in compressor power consumption)*
- Increase the evaporator temperature *(5.5ºC increase in evaporator temperature reduces compressor power consumption by 20 – 25%)*
- Clean heat exchangers when fouled. *(1 mm scale build-up on condenser tubes can increase energy consumption by 40%)*
- Replace old chillers or compressors with new higher-efficiency models.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near-continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to co-ordinate multiple chillers.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest operating costs to near base load.
- Avoid over sizing – match the connected load.
- Isolate off-line chillers and cooling towers.
- Establish a chiller efficiency-maintenance program. Start with an energy audit and follow-up, then make a chiller efficiency-maintenance program a part of your continuous energy management program.

5.2.10 HVAC (Heating / Ventilation / Air Conditioning)

- Tune up the HVAC control system.
- Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimise flows and reduce blower / fan / pump power requirements.
- Eliminate or reduce reheat whenever possible.
- Use appropriate HVAC thermostat setback.
- Use morning pre-cooling in summer and pre-heating in winter (i.e. – before electrical peak hours).
- Use building thermal lag to minimise HVAC equipment operating time.
- In winter during unoccupied periods, allow temperature to fall as low as possible without damaging stored materials.
- Improve control and utilisation of outside air.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.
- Reduce HVAC system operating hours (e.g. – night, weekend).
- Optimise ventilation.
- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. – computer rooms).
- Provide dedicated outside air supply to cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use evaporative cooling in dry climates.
- Reduce humidification or dehumidification during unoccupied periods.
- Use atomization rather than steam for humidification where possible.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean / change if appropriate.
- Check pneumatic controls air compressors for proper operation, cycling, and maintenance.

- Isolate air conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimise thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally-designed industrial ventilation hoods for dust and vapour control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. – use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC window units.
- Put HVAC window units on timer control.
- Don't oversize cooling unit. (Oversized units will "short cycle" which results in poor humidity control.)
- Install multi-fuelling capability and run with the cheapest fuel available at the time.
- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you don't need to?)
- Minimise HVAC fan speeds.
- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Consider ground source heat pumps.
- Seal leaky HVAC ductwork.
- Seal all leaks around coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during seasonal transition periods.
- Zone HVAC air and water systems to minimise energy use.
- Inspect, clean, lubricate and adjust damper blades and linkages.
- Establish and HVAC efficiency-maintenance program. Start with an energy audit and follow-up, then make an HVAC efficiency-maintenance program a part of your continuous energy management program.

5.2.11 Refrigeration

- Use water-cooled condensers rather than air-cooled condensers.
- Challenge the need for refrigeration, particularly for old batch processes.
- Avoid over sizing – match the connected load.
- Consider gas-powered refrigeration equipment
  minimise electrical demand charges.
- Use "free cooling" to allow chiller shutdown in cold weather.
- Use refrigerated water loads in series if possible.
- Convert firewater or other tanks to thermal storage.
- Don't assume that the old way is still the best – particularly for energy-intensive low temperature systems.
- Correct inappropriate brine or glycol concentration that adversely affects heat transfer and / or pumping energy. If it sweats, insulate it, but if it is corroding, replace it first.
- Make adjustments to minimise hot gas bypass operation.
- Inspect moisture / liquid indicators.
- Consider change of refrigerant type if it will improve efficiency.
- Check for correct refrigerant charge level.
- Inspect the purge for air and water leaks.

- Establish a refrigeration efficiency-maintenance program. Start with an energy audit and follow-up, then make a refrigeration efficiency-maintenance program part of your continuous energy management program.

5.2.12 Cooling Towers

- Control cooling tower fans based on leaving water temperatures.
- Control to the optimum water temperature as determined from cooling tower and chiller performance data.
- Use two-speed or variable-speed drives for cooling tower fan control if the fans are few. Stage the cooling tower fans with on-off control if there are many.
- Turn off unnecessary cooling tower fans when loads are reduced.
- Cover hot water basins (to minimise algae growth that contributes to fouling).
- Balance flow to cooling tower hot water basins.
- Periodically clean plugged cooling tower water distribution nozzles.
- Install new nozzles to obtain a more-uniform water pattern.
- Replace splash bars with self-extinguishing PVC cellular-film fill.
- An old counter flow cooling towers, replace old spray-type nozzles with new square-spray ABS practically-non-clogging nozzles.
- Replace slat-type drift eliminators with high-efficiency, low-pressure-drop, self-extinguishing, PVC cellular units.
- If possible, follow manufacturer's recommended clearances around cooling towers and relocate or modify structures, signs, fences, dumpsters, etc. that interfere with air intake or exhaust.
- Optimise cooling tower fan blade angle on a seasonal and / or load basis.
- Correct excessive and / or uneven fan blade tip clearance and poor fan balance.
- Use a velocity pressure recovery fan ring.
- Divert clean air-conditioned building exhaust to the cooling tower during hot weather.
- Re-line leaking cooling tower cold water basins.
- Check water overflow pipes for proper operating level.
- Optimise chemical use.
- Consider side stream water treatment.
- Restrict flows through large loads to design values.
- Shut off loads that are not in service.
- Take blowdown water from the return water header.
- Optimise blowdown water from the return water header.
- Automate blowdown to minimise it.
- Send blowdown to other uses (Remembers, the blowdown does not have to be removed at the cooling tower. It can be removed anywhere in the piping system.)
- Implement a cooling tower winterisation plan to minimise ice build-up.
- Install interlocks to prevent fan operation when there is no water flow.
- Establish a cooling tower efficiency-maintenance program. Start with an energy audit and follow-up, then make a cooling tower efficiency-maintenance program a part of your continuous energy management program.

5.2.13 Lighting

- Reduce excessive illumination levels to standard levels using switching, delamping, etc. (Know the electrical effects before doing delamping.)
- Aggressively control lighting with clock timers, delay timers, photocells, and / or occupancy sensors.
- Install efficient alternatives to incandescent lighting, mercury vapour lighting, etc. as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapour, incandescent.

- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent systems to compact fluorescents and electronic ballasts.
- Consider lowering the fixtures to enable using less of them.
- Consider day lighting, skylights, etc.
- Consider painting the walls a lighter colour and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type and control. Control it aggressively.
- Change exit signs from incandescent to LED.

5.2.14 DG Sets

- Optimise loading.
- Use waste heat to generate steam / hot water / power an absorption chiller or preheat process or utility feeds.
- Use jacket and head cooling water for process needs.
- Clean air filters regularly.
- Insulate exhaust pipes to reduce DG set room temperatures.
- Use cheaper heavy fuel oil for capacities more than 1MW.

5.2.15 Buildings

- Seal exterior cracks / openings / gaps with caulk, gasketing, weather-stripping etc.
- Consider new thermal doors, thermal window, roofing insulation, etc.
- Install windbreaks near exterior doors.
- Replace single-pane glass with insulating glass.
- Consider covering some window and skylight areas with insulated wall panels inside the building.
- If visibility is not required but light is required, consider replacing exterior windows with insulated glass block.
- Consider tinted glass, reflective glass, coatings, awnings, overhangs, draperies, blinds and shades for sunlit exterior windows.
- Use landscaping to advantage.
- Add vestibules or revolving doors to primary exterior personnel doors.
- Consider automatic doors, air curtains, strip doors, etc. at high-traffic passages between conditioned and non-conditioned spaces. Use self-closing doors if possible.
- Use intermediate doors in stairways and vertical passages to minimise building stack effect.
- Use dock seals at shipping and receiving doors.
- Bring cleaning personnel in during the working day or as soon after as possible to minimise lighting and HVAC costs.

5.2.16 Waste & Waste Water

- Recycle water, particularly for uses with less-critical quality requirements.
- Recycle water, especially if sewer costs are based on water consumption.
- Balance closed systems to minimise flows and reduce pump power requirements.
- Eliminate once-through cooling with water.
- Use the least expensive type of water that will satisfy the requirement.
- Fix water leaks.
- Test for underground water leaks. (It’s easy to do over a holiday shutdown.)
- Check water overflow pipes for proper operating level.
- Automate blowdown to minimise it.

- Provide proper tools for wash down – especially self-closing nozzles.
- Install efficient irrigation.
- Reduce flows at water sampling stations.
- Eliminate continuous overflow at water tanks.
- Promptly repair leaking toilets and faucets.
- Use water restrictors on faucets, showers, etc.
- Use self-closing type faucets in restrooms.
- Use the lowest possible hot water temperature.
- Do not use a heating system hot water boiler to provide service hot water during the cooling season – install a smaller, more-efficient system for the cooling season service hot water.
- If water must be heated electrically, consider accumulation in a large insulated storage tank to minimise heating at on-peak electric rates.
- Use multiple, distributed, small water heaters to minimise thermal losses in large piping systems.
- Use freeze protection valves rather than manual bleeding of lines.
- Consider leased and mobile water treatment systems, especially for deionised water.
- Seal sumps to prevent seepage inward from necessitating extra sump pump operation.
- Install pre-treatment to reduce TOC and BOD surcharges.
- Verify the water meter readings.

5.2.17 Miscellaneous

- Meter any unmetered utilities. Know what is normal efficient use. Track down causes of deviations.
- Shut down spare, idling or unneeded equipment.
- Make sure that all of the utilities to redundant areas are turned off – including utilities like compressed air and cooling water.
- Install automatic control to efficiently co-ordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.
- Renegotiate utilities contracts to reflect current loads and variations.
- Consider buying utilities from neighbours, particularly to handle peaks.
- Leased space often has low-bid inefficient equipment. Consider upgrades if your lease will continue for several more years.
- Adjust fluid temperature within acceptable limits to minimise undesirable heat transfer in long pipelines.
- Minimise use of flow bypasses and minimise bypass flow rates.
- Provide restriction orifices in purges (nitrogen, steam, etc.).
- Eliminate unnecessary flow measurement orifices.
- Consider alternatives to high pressure drops across valves.
- Turn off winter heat tracing that is on in summer.