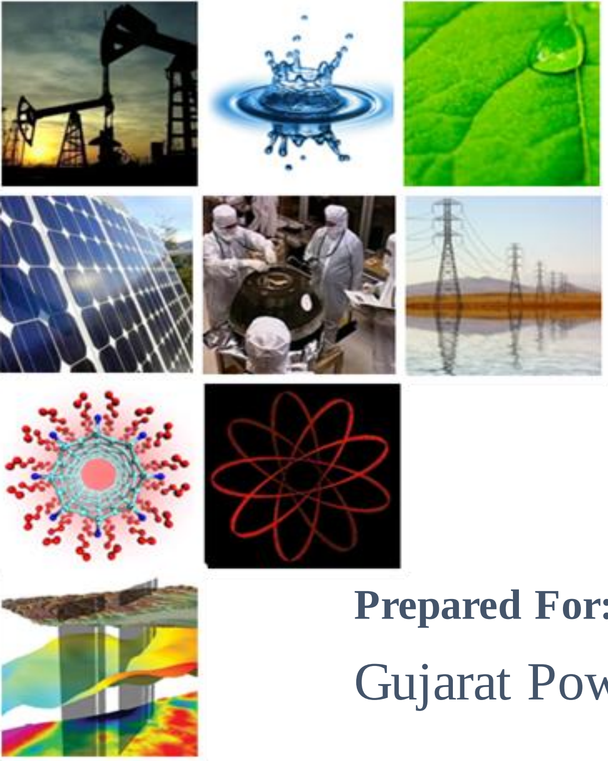

सत्यमेव जयते
Energy & Petrochemicals Department
Government of Gujarat

Report No. DRAFT – (July 2018 - Expression of Interest (EoI))

Prepared For:

Gujarat Power Corporation Limited (GPCL)

DRAFT DETAILED PROJECT REPORT: 5000 MW ULTRAMEGA SOLAR PARK, VILLAGE: DHOLERA, GUJARAT

Prepared By:

Gujarat Energy Research and Management Institute (GERMI), Gandhinagar

DISCLAIMER

Sourcing GERMI Information:

- Refer to this report as "DPR for 5000 MW Solar parks at Dholera" for GPCL.
- If you would like to quote data from this report in an external press release, please contact us at information@germi.org

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Executive Summary

Solar energy is the most readily available source of non-polluting renewable energy resource. It could be utilized in two ways viz. direct conversion in to electricity through solar photovoltaic (PV) cells and indirect conversion through generating high temperatures by concentrating collectors and thereby run the steam turbine in line with a conventional thermal power plant. The uniqueness of the solar technologies is that it offers a wide range of applications in solar PV as well as solar thermal technology in which case, the generated he at could be used for domestic as well as industrial applications and power generation.

India being a tropical country is blessed with good sunshine over most parts, and the number of clear sunny days in a year also being quite high. India is located in the sunny belt of the world. As per Ministry of New and Renewable Energy (MNRE), Government of India (GoI), the country receives solar energy equivalent to more than 5,000 trillion kWh per year with a daily average solar energy incident over India which varies from 4.0 to 7.0kWh/m2 depending upon the location. India's equivalent solar energy potential is about 6,000 million GWh of energy per year. Hot and Dry climatic regions have the best solar radiations in the country with around 300 sunny days; which makes these region very appropriate locations for harnessing solar energy.

World's Largest solar park is proposed to be developed in Dholera, Gujarat. There are around 34 such parks across the country in association with the Solar Energy Corporation of India (SECI); Government of India. Gujarat Power Corporation Limited(GPCL) has taken the advance initiative to develop the proposed world's largest Solar Park with cumulative capacity of 5000 MW, GPCL is also acting as the nodal agency for the development of the solar park The power evacuation facilities from Solar Park will be furnished by Power Grid Corporation of India Limited (POWERGRID).

The selected land for the proposed solar park required expert civil work to address the essential requirements of Solar Park. It has been noticed that the selected location satisfies most of the essential requirements towards setting up a Solar Park in the vicinity. The project is planned with multi-crystalline and CdTe based Thin Film Solar PV technologies (which are the well mature and proven technology across the globe) along with central type inverter for minimum project capacity of 50 MW. The present Detailed Project Report (DPR) contains all key aspects of a Solar Park of the capacity of 5000 MW in the Dholera town, of the state of Gujarat, India. The DPR contains covers the following major dimensions of the proposed project.

SITE ASSESSMENT

This section establishes the criteria for site assessment for establishing the Solar Park via addressing the key requirements and exhumations

SOLAR RADIATION RESOURCE ASSESSMENT

The selected project location is in 'Hot and Dry' climatic zone of the country and hence experiences high solar irradiance (high DNI as well) and high ambient temperature.

SOLAR PV TECHNOLOGY ASSESSMENT

Solar PV Modules and Inverters are the key components of any grid connected solar PV power plant. The global overview of solar PV technologies has been presented in the DPR via addressing their technical basis, advances and limitation, market shear (global and national), manufacturing, growth and projection and status of commercialization etc.

ENVIRONMENTAL AND SOCIAL IMPACT

The Solar Park is essentially being developed for Solar PV power projects which work on solar energy which is non-polluting source of energy; however, there might be several dimensions of project implementation where ESIA and SIA aspects are essential to address as per the applicable acts.

INFRASTRUCTURE PLAN OF SOLAR PARK

This section elaborates the infrastructure development over the conceptual plan of the Solar Park. There are five key dimensions of infrastructure addressed in the section

Introduction

1. Introduction

1.1 About the Project

Energy demand grows, while the conventional resources remain limited. Price of energy surging every moment with Oil & Gas market remains a volatile one. World is crying out for a clean, locally available and cost-efficient energy fix. It's time to get behind renewables!

Solar's moment is now. Being the best choice among all other renewable energy sources, Solar is the way forward. It is not as heavy in terms of the capital costs as tidal and geothermal (and much less risky); it is simple, but, unlike wind and waves, quite predictable.

The change is already happening. From solar-powered airports, railways, temples and cricket stadiums, to tiny villages with no electricity access we are seeing cost-efficient and environmentally-friendly solar power projects springing up everywhere. Some utility scale Solar park also being developed in non-agricultural land. This is helping in eliminating the issues like massive grid failures which plague the major cities.

Solar Parks are concentrated zone where various solar power plants are setup. Dholera Solar Park is one such project. Envisaged to be the world's largest solar park Dholera solar park will boast a capacity of 5000 MW. It is proposed to be developed in two phases, In the first phase Plots with potential combined capacity of 1000 MW will be developed and tender for the same will be floated in the market to invite Solar Project Developer (SPD), i.e. SPD contractor, to develop solar power plants on those plots. In the second phase plots with potential combined capacity of 4000 MW will be developed.

The Dholera Solar Park is a part of development plans of Dholera special investment region(DSIR), largest investment node on the Delhi Mumbai Industrial Corridor Development Corporation Ltd(DMICDC) growth corridor, which aims to create an economically and socially balanced, new age city with world-class infrastructure and a high quality of life. Adoption of a sustainable approach across key components such as transportation, waste recycling, overall urban form and resource efficiency form the cornerstones of this plan.

Gujarat Power Corporation Ltd (GPCL), Gujarat UrjaVikas Nigam Ltd (GUVNL) and Gujarat Electric Transmission Corporation (GETCO)along with Solar Energy Corporation of India (SECI) and the Central Transmission Unit (CTU) are on board for implementing the project. Gujarat Energy Research & Management Institute(GERMI) will work as an advisory to GPCL.

The Energy and Petroleum Department(EPD), Government of Gujarat has designated Gujarat Power Corporation Ltd as the nodal agency who will carry out the development of the solar park, while Gujarat UrjaVikas Nigam Ltd will be the off taker and sign Power Purchase Agreement(PPA) and Gujarat Electric Transmission Corporation will provide for the transmission of solar power generated by the solar park.

1.2 Dholera SIR

Dholera Special Investment Region (DSIR) is a Greenfield Industrial City planned and located approximately 100 km South West of Ahmedabad. The Government of Gujarat has created a legislative framework for the formation of a Special Investment Region Act 2009. Under the act, a regional development authority for DSIR has been established. An SPV named Dholera Industrial City Development Limited (DICDL) has been created between the Central Government (DMICDC Trust) and the State Government (DSIRDA) of Gujarat to implement the project. Delhi Mumbai Industrial Corridor Development Corporation Limited (DMICDC), a special purpose company, was incorporated to establish, promote and facilitate development of the DMIC Project. Dholera-SIR is envisaged to be well located and widely. Once completed Dholera-SIR will possess following characteristics:

Characteristics
• **Total Area: 920 Sq. km** • **Developable Area: 567.39 Sq. Km** • **High Access Corridor: City Center, Industrial, Logistic, Knowledge & IT, Recreation & Sports, Entertainment** • **World-class infrastructure & connectivity: within & outside** • **Central spine express way & Metro Rail to link the SIR with mega cities** • **Airport & Sea Port in the vicinity** • **Proximity to mega cities: Ahmedabad, Bhavnagar, Vadodara** • **Benefit of sea coast, nature park, golf course** • **Premium civic amenities** • **Capable to cater to both International & Domestic Market** • **Close to Gujarat International Finance TechCity (GIFT)** • **Close to Petro-chemicals and Petroleum Inv. Region (PCPIR)** • **Logistic support of the Dedicated Freight Corridor (DMIC)**

- **Benefits of the high impact Delhi Mumbai Industrial Corridor (DMIC)**
- **Public investment in core infrastructure**

1.2.1 Dholera Special Investment Regional Development Authority (DSIRDA)

The state Govt. constituted Dholera Special Investment Regional Development Authority (DSIRDA) for the development of Dholera SIR and to prepare the land use plan, town planning scheme and the development plan for the SIR. Along with the planning and development of DSIRresponsibilities of Dholera Special Investment Region Development Authority (DSIRDA) will encompass the function of administering government land within DSIR

1.2.2 Contribution of DSIRDA to the Project

Dholera Special Investment Regional Development Authority (DSIRDA) will be providing land for the proposed solar park project. The land in question is not suitable/permitted for any other use. Moreover, in return to their contribution they will avail annual revenue of Approximately INR 10 crore. In addition to this presence of solar park will attract solar power equipment developers to setup manufacturing or other facilities in Dholera SIR.

1.3 Overview of Gujarat Power Corporation Limited(GPCL)

Gujarat Power Corporation Limited (GPCL) incorporated on 28th day of June 1990 under the Companies Act, 1956, is a State Government Company promoted by the Government of Gujarat. The Company is primarily engaged in the business of generation and distribution of power through various sources and has been playing the role of developer and catalyzer in the energy sector in the state.

GPCL identifies the power projects based on various fuels, prepares techno-economic feasibility reports for such power projects, identifies suitable private joint sector parties and implements these jointly with the selected parties. After the power project is identified, GPCL obtains various statutory and non-statutory clearances to be obtained for implementation of the power project, such as, water and air pollution clearance, forest clearance, environmental and forest clearance, civil aviation clearance etc. It also pursues the formalities related to acquisition of land under the Land Acquisition Act and ties up the fuel linkages for the power project.

It has also been designated as Nodal Agency by the Government of Gujarat for development of Solar Park. GPCL has a popular history in Gujarat of being a successful Solar Park Developer. Hence, keeping this pro-activeness in pursuit GPCL approached MNRE for approval of setting up of another 5,000 MW capacity Solar Power Park. Seeing its well-established track record and good reputation MNRE took no time in approving the same and GPCL was awarded the responsibility of Solar Power Park Developer (SPPD).

Gujarat Power Corporation Limited (GPCL) has been playing the role of developer and catalyzer in the energy sector in the State of Gujarat. GPCL identifies the power projects based on various fuels, prepares techno-economic feasibility reports for such power projects, identifies suitable private joint sector parties and implements these jointly with the selected parties

After the power project is identified, GPCL obtains various statutory and non-statutory clearances for implementation of the power project, such as, water and air pollution clearance, forest clearance, environmental and forest clearance, civil aviation clearance etc. It also pursues the formalities related to acquisition of land under the Land Acquisition Act and ties up the fuel linkages for the power projects

The Gujarat Solar Park at village Charanka, District Patan, Gujarat developed by Gujarat Power Corporation Limited is the Asia's first Multi developer, Multi facility, Multi Technology and Multi beneficiary Solar Park. It is an integrated hub of Solar Power generation which is first of its kind in Asia.

The main objective of GPCL is to identify the power projects based on various fuels, prepare the techno-economic feasibility reports for power projects, identify suitable private sector/PSU parties and implement such power projects jointly with them of on its own if on party comes forth. GPCL also facilitates to private sector developer to set-up power projects in the State.

1.3.1 Contribution of GPCL to the Project

Gujarat Power Corporation Limited(GPCL)has been designated as the nodal agency i.e. Solar

Power Park Developer (SPPD) for the proposed project in Dholera. Being the SPPD, GPCL will be carrying out the following activities:

i. Plan, finance, develop, execute, operate and maintain the Solar Power Park.
ii. Identify potential site and acquire/leasehold/possess land for Solar Power Park.
iii. Carry out site related studies/investigations.
iv. Obtain statutory &non-statutory clearances and to make area development plan within Solar Power Park.
v. Design a plan for sharing development cost between the developers.
vi. Create necessary infrastructure like water, transmission lines, roads, drainage etc. to facilitate Solar Power Project developer for faster implementation of Solar Power Projects
vii. Frame out transparent plot allotment policy and specify procedures pursuant to the relevant State policies and their amendments thereof.
viii. Provide directives for technology-specific land requirements
ix. Engage the services of national agencies/global experts/consultants to promote Solar Power Park and related activities.
x. Facilitate the State Government to establish educational institutions/training facilities within Solar Power Park for development of manpower skill related to Solar Power
xi. Include any other activity related to Solar Power Park, such as manufacturing as per the directives from MNRE and the State Government.
xii. Conduct necessary evaluation of environmental and social impacts of utility scale solar deployment as per law and before allocating the land to prospective developers.

1.4 Overview of Gujarat Energy Research and Management Institute(GERMI)

Gujarat Energy Research & Management Institute (GERMI) is a center of excellence in industry learning and has set up to develop human resource assets to cater to the petroleum and allied energy sectors, improve knowledge base of policy makers and technologists and provide a competitive edge to leaders to compete in the global arena.

GERMI has executed various megawatt and kilowatt-scale ground-mounted and rooftop solar PV power plants in the capacity of advisor, implementing agency, project management consultant (PMC) and third-party engineer/ inspector (TPE/ TPI). GERMI has conducted various training programs for the solar industry professionals throughout the country and have gained wide knowledge in the sector.

1.4.1 Salient Features of GERMI

- GERMI is a registered Society and Trust under the Societies Registration Act, 1860 and the Bombay Trust Act,1950.
- GERMI is a recognized Scientific and Industrial Research Organization (SIRO) by the Department of Scientific and Industrial Research (DSIR), GoI.
- GERMI is a schedule-I Environment Auditor recognized by the Gujarat Pollution Control Board (GPCB) and an Energy Auditor Consultant recognized by the Gujarat Energy Development Agency(GEDA).
- GERMI is promoted by the Gujarat State Petroleum Corporation Limited (GSPC), a Government of Gujarat undertaking.

1.4.2 Vision and Mission of GERMI

Vision: GERMI's values and beliefs lead it to envision

- That young professionals in energy sector ought to have an access to the opportunities for being more competent, efficient, highly knowledgeable and courageous to innovate and experiment in the global arena,
- That the societal concern of a citizen will inspire productive and efficient use of energy with wider

perceptions of clean environment and awareness of futuristic scenario.

Mission: Train and retrain professional in Energy Sector:

- Provide facilities and opportunities for creation of knowledge, blue print of futuristic technologies and new business opportunities,
- Commit itself for societal good in all walks of human Endeavour at macro as well as grass root levels.

1.4.3 Contribution to the Project

GERMI services are hired by SPPD (GPCL) for preparation of Detailed Project Report. Based on the feasibility reports, Geo- Technical reports and Flood reports, GERMI is conducting mapping of the site for preparing DPR. GERMI is also evaluating the cost of whole project on basis of which a recovery model will be formulated. All of the above mentioned will be incorporated in Detailed Project Report(DPR) which will be prepared by GERMI itself. The Detailed Project Report(DPR) will also elucidate solar market Trends, RPO & REC, various PV technologies, possible project structure, possible infrastructure planning &possible plant configuration adopted by SPD and various risks associated in the project &corrective measures to be taken.

1.5 Overview of Solar Park

The solar park is a concentrated zone of development of solar power generation projects and provides developers an area that is well characterized, with proper infrastructure and access to amenities and where the risk of the projects can be minimized. Solar Park will also facilitate developers by reducing the number of required approvals.

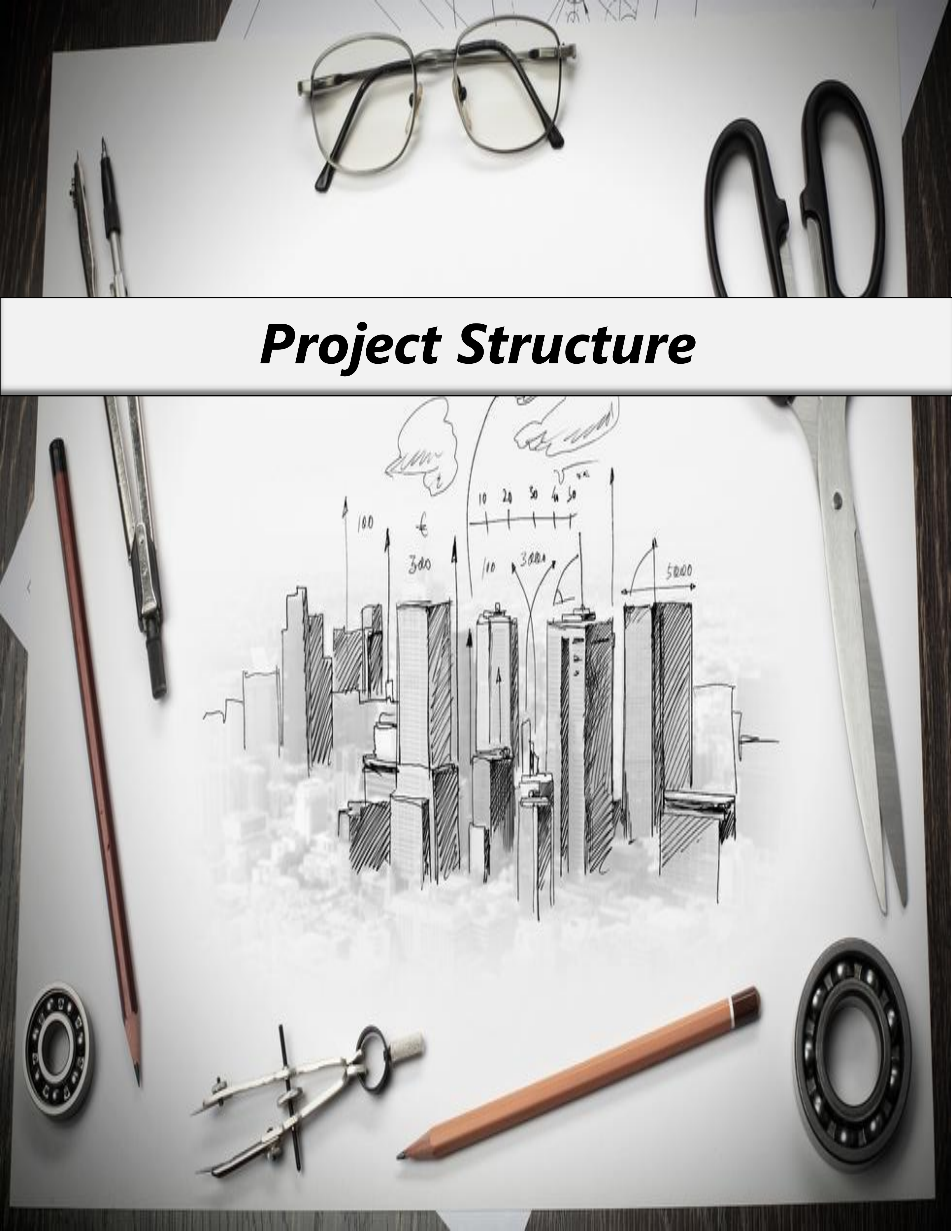
India, with its large population and rapidly growing economy, needs access to clean, cheap and reliable sources of energy. India lies in the high solar insulation region, endowed with huge solar energy potential with most of the country having about 300 days of sunshine per year with annual mean daily global solar radiation in the range of 4.5-6.5 kWh/m^2/day. Hereto, solar energy can be the solution to India’s clean energy requirement if she can realize its potential. One of the best ways to do it is through development of solar parks across the nation.

Figure 1-1Charanka Solar Park

Starting with the ‘Charanka Solar Park’ in Gujarat, and closely followed by the ‘Bhadla Solar Park’ in Rajasthan, solar parks have quickly emerged as a powerful mechanism for the rapid development of solar power projects in the country. These parks have obtained their initial impetus from the Jawaharlal Nehru National Solar Mission (JNNSM), which provided the policy framework and roadmap for solar power development in the country.

---- END OF SECTION ----

Project Structure



2 Project Structure

2.1 State Scenario

Gujarat is located on the western coast of India and has the longest coastline of 1,600 km among all states in the country. The state shares its borders with Rajasthan, Madhya Pradesh, Maharashtra and the Union Territories of Daman & Diu and Dadra & Nagar Haveli. The Arabian Sea borders the state both to the west and the south-west.

Gujarat is one of the leading industrialized states in India. At current prices, Gujarat's Gross State Domestic Product (GSDP) was about US$ 158.2 billion over 2015-16. Average annual GSDP growth rate from 2004-05 to 2015-16 was about 11.56 per cent. As of January 2018, Gujarat had a total installed power generation capacity of 30,394.29 megawatt (MW).

There are 45 ports, 18 domestic airports and one international airport. There are 106 product clusters and 60 notified special economic zones (SEZs). Large scale investment is expected in Gujarat as part of the US$ 90 billion Delhi-Mumbai Industrial Corridor (DMIC).

According to the Department of Industrial Policy & Promotion (DIPP), Foreign Direct Investments (FDI) inflows in the state of Gujarat reached US$ 17.44 billion during April 2000 - December 2017. Gujarat accounted for about 4.97 per cent share in the overall FDI inflows in India. The Vibrant Saurashtra Expo and Summit, was held in Rajkot in January 2016. MoUs worth US$ 341.88 million were realized for the development of various sectors of the state during the event

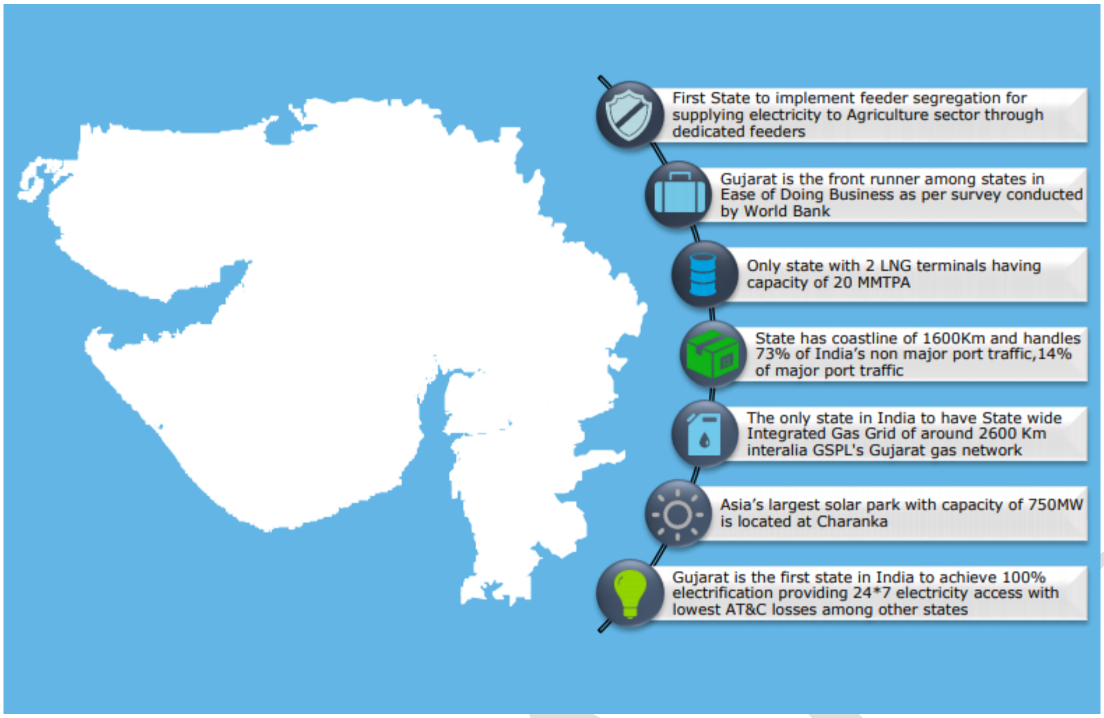


Figure 2-1: Gujarat State Scenario

2.1.1 Gujarat State Energy Scenario

During 1980s, GEB focused mostly on rural electrification, providing new connections and maintenance activities. But as it focused on the above, profitability & revenue recovery suffered hugely. GEB ran into huge losses for several years denting the image of public sector in Gujarat. No rays of hope were seen until the year 2001, when an initiative by the Government of Gujarat led by visionary politicians, proficient administrators and diligent employees took everyone by surprise. A major reformation which included multipronged strategies and tactics including unbundling of the board, renegotiation of power purchase agreements (PPA), reduction of interest rates on loans, curbing of power theft and reduction of huge transmission and distribution (T&D) losses without compromising with the quality of fuel.

2.1.2 Industry structure

Series of reforms in the 1990s and the EA 2003 has moved the power sector towards its vision of a competitive market with multiple buyers, sellers supported by regulatory, and oversight bodies. In context to this, organizations have been formed both at the central and state Government levels to facilitate development of the power sector

The State undertook structural reforms wherein the erstwhile Gujarat Electricity Board (GEB) was unbundled on 1st April 2005 into seven companies with functional responsibilities of trading, generation, transmission and distribution as follows:

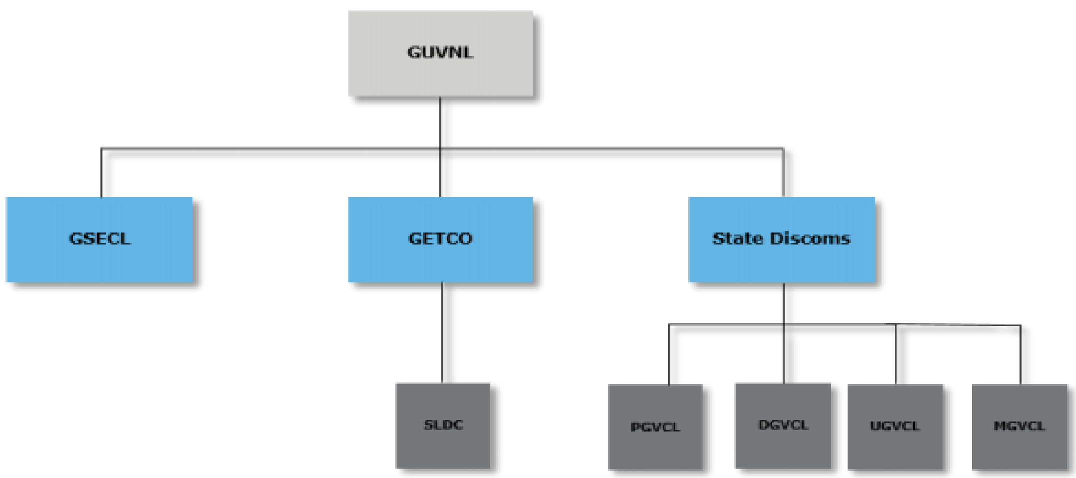


Figure 2-1:Hierarchy of Power Sector in Gujarat

Gujarat Electricity Regulatory Commission (GERC)

GERC, constituted in November 1998 is responsible to regulate & determine tariff, issue licenses, specify the Grid Code, specify and enforce standard for quality & reliability, etc. at intra-state level, Promote cogeneration and generation of electricity from renewable sources of energy and Adjudicate upon the disputes between the licensees, and generating companies and to refer any dispute for arbitration.

Gujarat UrjaVikas Nigam ltd (GUVNL)

GUVNL was incorporated as a Govt. of Gujarat Company. GUVNL is engaged in the business of bulk purchase and sale of electricity, Supervision, Co-ordination and facilitation of the activities of its six subsidiary companies. It is the single bulk buyer of power in the state as well as the bulk supplier to distribution companies.

Gujarat State Electricity Corporation Limited (GSECL)

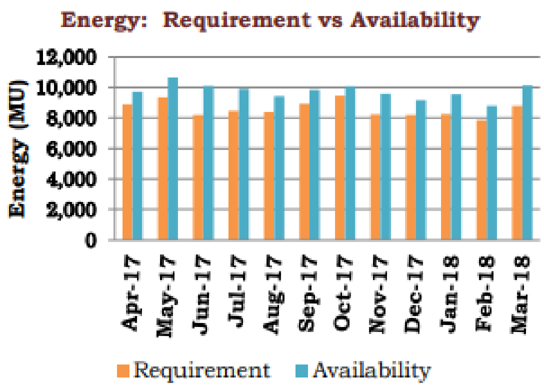
Post Electricity Act 2003, GEB was unbundled in 2005 & GSECL was given responsibility of electricity generation & to undertake new power projects in the state. It currently accounts for 31% (6132 MW) of the total installed conventional capacity of the state and has achieved highest ever PAF of around 83.65%.

Gujarat Energy Transmission Corporation Ltd (GETCO)

GETCO setup in 1999 builds, operate& maintains state transmission network, company has made significant progress in network capacity addition, transmission asset management, state grid operation, smart grid solutions and human resource development. Currently it has transmission network of about 55,468 ckm and 1,671 substations with transformation capacity of around 91,544 MVA.s

Table 2-1:Energy Requirement in Gujarat Source: (Load Generation Balance Report, CEA 2017)

Energy Requirement/Availability (inMU)			Peak Demand/Peak Met (in MW)		
Energy Requirement	:	102,983	**Peak Demand**	:	14,610
Energy Availability	:	116,897	**Peak Met**	:	15,213



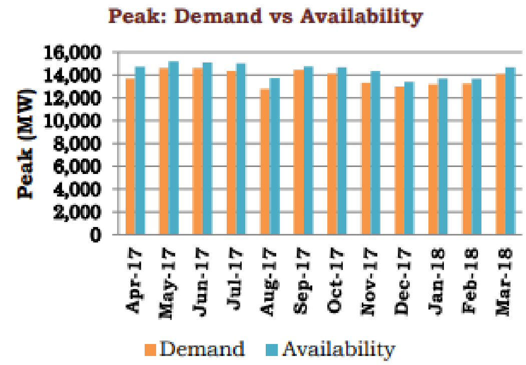


Figure 2-2:Solar Market Scenario in Gujarat (2017)

2.2 Solar Power as a Solution to the Indian Power Industry

In the present scenario, renewable resources emerge as the best alternative. At present, renewable energy accounts for about 20 % of India's installed generation capacity of 344 GW (as on 31.03.2018).

Much of this capacity is wind-based (about 34GW, as on 30.04.2018), with the share of solar power being only about 4GW. India is blessed with an abundance of non-depleting and environmentally friendly renewable resources, such as solar, wind, biomass, hydro and cogeneration and geothermal. Wind energy sector, which has shown tremendous growth in the recent year, dominates the renewable energy sector in India. India has an abundance of solar radiation, with the peninsula receiving more than 300 sunny days in a year. As of 31 March 2018, the installed capacity was 21.65 GW meeting 2% of the utility electricity generation.

Table 2-2: Installed Energy generation capacity in India (as on 30 April 2018)

	Installed capacity(MW)
Coal	196,957.50
Large Hydro	45,293.42
Small Hydro	4,485.81
Wind Power	34,046
Solar Power	21,651.48
Biomass	8,839.10

Nuclear	6,780
Gas	24,897.46
Diesel	837.63

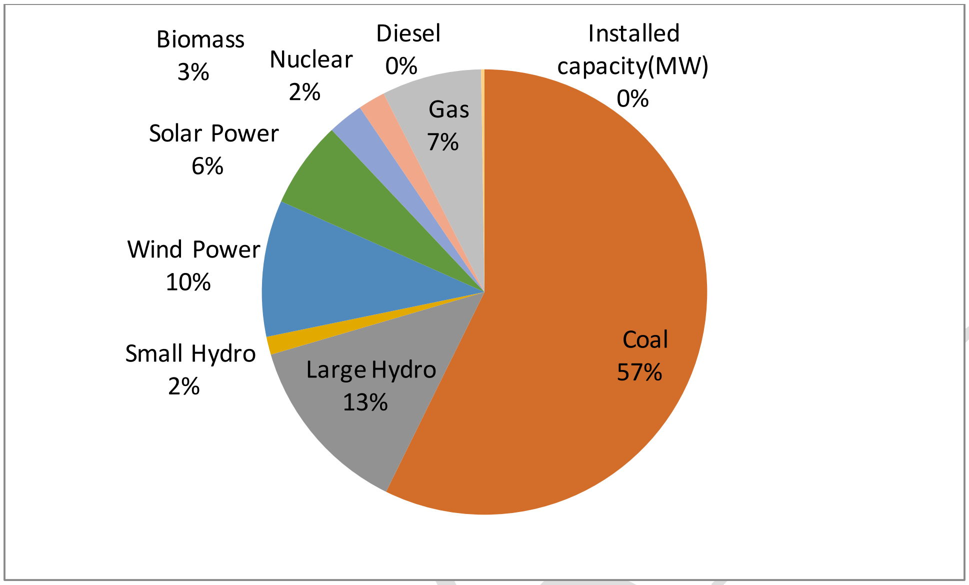


Figure 2-3:Installed energy generation capacity in India (as on 30 April 2018).

PV is progressively becoming more attractive, vis-a-vis other renewable sources of power, as its cost declines. The various factors leading to decline in cost includes setting up of large scale plants, integration across the value chain, declining cost of raw material, reducing material consumption and higher efficiency of modules.

Due to its proximity to the equator, India receives abundant sunlight throughout the year. Solar PV solution has the potential to transform the lives of 450 million people, who rely on highly subsidized kerosene oil and other fuels, primarily to light up their homes. Renewable energy source is a practical solution to address the persistent demand supply gap in the power industry.

The following features of solar power make it the most viable renewable source of energy for India:

- Solar energy is available in abundance
- Available across the country – unlike other renewable sources, which have geographical

limitations

- Available throughout the year
    - Decentralized / off-grid applications – addressing rural electrification issues
    - Modularity and scalability

Merits of the Solar PV Plant

i. Photovoltaic Power from the sun is clean, silent, abundant and free.

ii. Process releases no CO_2, SO_2 or NO_2 gases during energy generation, which are normally associated with burning finite fossil fuel reserves and don't contribute to global warming.

iii. Photovoltaic are now a proven technology which is inherently safe as opposed to other fossil fuel-based electricity generating technologies.

iv. No fuel is required for generation, so fuel cost of power generation is zero

v. Solar power shall augment the needs of peak power needs

vi. Solar Powered Grid Connect Plants can act as tail end energizers, which in turn reduces the transmission and distribution losses.

vii. Solar Power can be set up on barren / unproductive land with reasonable sun radiations. Solar PV plant do not require large Water source or effluent disposal system as required in the case of conventional thermal plants.

viii. Generation of electricity from Solar PV is totally free of Green House Gas emission.

ix. Routine O&M cost is comparatively very less.

x. Man- power requirement during O&M is very less.

Limitations of Solar PV Power Plant

i. Low efficiency of solar modules compared to solar thermal.

ii. Generation depends on climate. Low sunlight results in lesser generation

iii. Increase in module price will increase project cost and hence solar tariff.

iv. No generation during night time. To store generated power battery system must be develop which increase the cost of the system.

v. PV Module are fragile and can be easily damaged.

2.3 Financial Performance of GPCL

GPCL, a State Public Sector Undertaking (PSU) is presently engaged in the generation and distribution of power in the State of Gujarat. GPCL has been engaged in various projects of power generation through Gas, Nuclear, Solar, Wind, Tidal & Coal which caters energy requirements of the State of Gujarat. On back of GPCL, Gujarat has been able to fulfill its Renewable Purchase Obligation year on year.

GPCL identifies the power projects, prepares techno-economic feasibility reports for such power projects, identifies suitable private joint sector parties and implements those projects jointly with the selected parties after obtaining various statuary and non-statuary clearances for them.

Table 2-3:Financial position of GPCL during last three years

Sr. No.	Particulars/Year	Amount (Rs. in Crore)		
		2016-17	2015-16	2014-15
1	Share Capital	427.91	415.41	393.74
2	Reserves and Surplus	552.84	508.57	504.54
3	Fixed Assets (Gross Block)	479.43	472.95	472.82
4	Fixed Assets (Net Block)	403.69	413.79	428.83
5	Investments	198.99	136.06	127.06
6	Sundry debtors	150.12	13.89	30.82
7	Loans and Advances – Assets	299.20	191.13	140.10
8	Total Liabilities	293.50	312.32	289.79
9	Income	279.01	55.60	98.74
10	Total Expenditure	217.67	21.18	74.21
11	Depreciation on Fixed Assets	15.41	15.22	15.12
12	Profit Before Tax	45.93	19.19	9.41
13	Profit After Tax	29.38	11.58	2.38
14	Earnings Per Share (Amt. in Rs.)	10.99	2.73	0.62

From the extracts of financial statements of the GPCL during last three years, it can be seen that GPCL has a rich share capital. The loans and advances of the corporation have slightly increased, owing to their increased involvement in various projects which has in turn added significantly to their profit. The Earnings per Share available to the common shareholders of GPCL has also increased during the last three years. Overall, the table above establishes a fact about financial capabilities of GPCL take on the proposed solar park project.

2.4 Funding Structure

The cost of the Solar PV power plant, presented in this section of the report covers all the costs associated with the construction of the plant and included civil construction cost, cost of equipment for power generation, cost of auxiliaries and utilities. Detailed proposed cost estimates are given below for the entire 5000MW projects which are subject to change after the selection of all the contractors and the financial proposals received from those contractors. Current estimates have been built considering Rs.4.6 Cr/MW capacity, however, these shall be known with more accuracy only after selection of the SPD contractor.

Table 2-4:Funding Structure

Source of Funds	Percentage	Amount (Rs. In Lacs)
Equity Fund	70 %	
Debt Fund	30 %	
Total	**100%**	

--- End of Section --

Solar Market trends

3 Solar Market Trends

3.1 Global Solar Market Trends

Solar energy has been recognized as the most promising source of renewable energy all over the world. Solar energy possesses the potential to replace highly carbon intensive technology. As per the recent IEA declaration renewable is not a niche fuel any more it has become a mainstream fuel. Solar and wind is surpassing the other renewable energy sources, to be the largest share in renewable market. The drastic decline (> 10% annually) in the cost of solar PV modules has accelerated its growth and has led the energy enthusiasts all over the world to consider it.

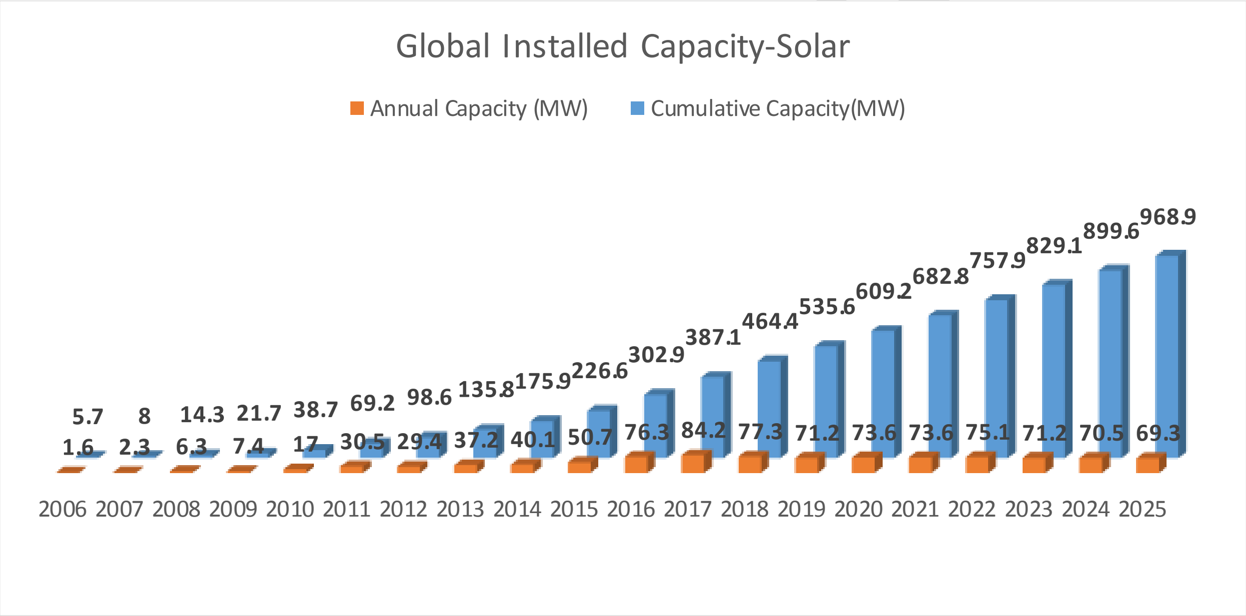


Figure 3-1:Global Installed Capacity

India's geographical position that is the region between tropic of Cancer and tropic of Capricorn is most suitable to harness solar energy. With this in mind, India has successfully created a collaborative platform for increased deployment of solar energy technologies and improved access to energy, India has laid the foundation stone to form the International Solar Alliance (ISA). About 120 countries have already ratified the agreement. India being the headquarters of ISA has the greatest potential to develop solar technologies in the years to come. Although, Land requirement is a big concern for the solar energy deployment, since solar PV plants require about 4.0 to 4.5 acres of land for a 1 MW power plant. Rooftop solar PV systems thereby become the most favorable option where the rooftop of a building can be utilized to put up a solar power plant.

Indian government has targeted 100 GW of solar PV by 2022 of which 60 GW is to be achieved though ground-mounted solar systems and 40 GW though rooftop solar systems. India's bold commitment at the COP21 in Paris last year, has been a game changer for not only the Indian solar market but will also place India's name in the global map. PV is rapidly emerging as the king of Indian renewable. The sector has seen an impressive 59% CAGR in the last four fiscal years to reach 12.2 GW installed capacity at the end of March 2017. The deployment of solar energy is seen across the country, unlike wind power which remains focused in the south-west of the country.

The more distributed nature of solar alleviates transmission bottlenecks and brings energy generation closer to the point of consumption. This brings liberty of behind the meter generation hence more power in the hands of the consumer, driving the market through net- metering and growing twice as fast as wind or coal.

In the global market China is aggressively look for an installation target of 110 GW till 2020. USA, China and India are the three gigantic markets with the highest business opportunity in the coming years.

The global investment in renewable power and fuels grew steadily from USD 39.5 billion in 2004 to USD 279.6 billion in 2011. Investment decreased in 2012 to USD 249.5 billion and further decreased to an all-time low at USD 214.4 billion in 2013. Total investment decreased by 11% in 2012 and was down 23% in 2013, in comparison to 2011 levels. The decline in investment after several years of steady growth resulted in downfall of the established markets like Europe and United States. However, the advantage of decrease in investment also resulted in a huge reduction in technology costs, especially in solar PV.

Due to these steep cost reductions, the wind and solar PV sectors make renewable technologies attractive for upcoming markets, particularly in developing countries where the need for continuous electricity is necessary to satisfy increasing energy demand. The photovoltaic industry is expected to attract approximately US$ 100 billion per year by 2020, which would increase to US$ 120 billion per year by 2030 under an accelerated scenario. The accelerated scenario is characterized by a moderate political commitment at a global level, which is similar to the current scenario. It is further predicted that in case of a paradigm shift, the global photovoltaic market will attract approximately US$ 160 billion per year by 2020, and US$ 190 billion per year by 2050. The paradigm shift implies a need over the next two decades to shift energy policies from conventional electricity generation to renewable energy in general, and photovoltaics in particular.

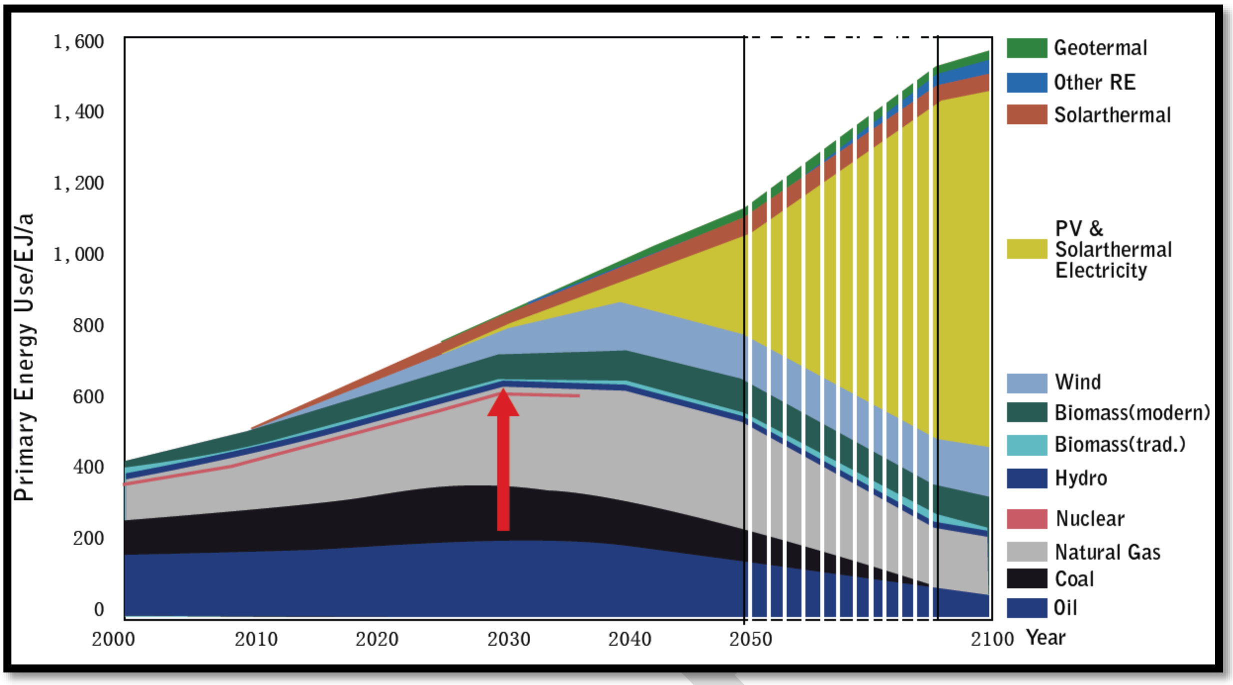


Figure 3-2:World energy supply projection up to 2050, 2100.
Source: European Commission's Joint Research Centre.

3.2 Photovoltaic Enabling Drivers

Feed-in Tariff

Feed-in Tariffs (FiT) have proved to be the most effective policy driver for the growth and development of the photovoltaic sector. The FiT model has been optimized and successfully implemented in Germany, and as a result has emerged as the largest market for photovoltaic (PV) in spite of a relatively low solar radiation. Today, over 40 countries have adopted the FiT model.

Appropriate FiTs ensure an attractive return for solar project investors. As FiTs are generation-based incentives, many governments are more comfortable with such an arrangement compared to upfront capital subsidies. Further, FiT arrangements are convenient to administer from a technological as well as an accountability standpoint.

Cost Reduction

The cost of photovoltaic systems is steadily decreasing. The cost trends are very well understood and are a function of scale of the industry as well as time period. It is expected that most parts of the world will achieve grid parity by 2020 as against those who already have achieved it. Grid parity is a phenomenon where the cost of solar power becomes equivalent to the cost of conventionally generated power. India is expected to reach grid parity by the end 2017-18. In some markets like the urban markets the grid parity has already been achieved. It is only after grid parity that the solar industry is expected to aggressively penetrate the market. The acceleration towards grid parity in order to expedite mainstream penetration of solar technology into the energy sector drives many governments to incentivize and deploy at an early stage. Solar power has already achieved grid parity in a few states and cities like commercial customers of Delhi, Gujarat, Mumbai, etc.

Capital Subsidies and Rebates

Certain solar markets are driven by capital or equivalent subsidies making the project viable. For example, many State Governments along with the Federal Government in the United States of America offer investment tax credits and property tax incentives upon installation of photovoltaic systems. Capital subsidies enable the project developer to trade solar energy at a lower cost, which is more agreeable to the utilities compared to the high FiTs. In India, the Ministry of New and Renewable (MNRE), Government of India (GoI) also provides capital subsidies under JNNSM in the form of subsidy, viability gap funding and achievement incentives. These subsidies are categorized based on the type of electricity customer. Government of India under a scheme to promote rooftop solar on government buildings is providing target-based achievement linked incentives.

Renewable Purchase Obligation (RPO)

In addition to the general RPO mandated on utilities, particularly Distribution Companies (DISCOMs), many national and state governments around the world have also started specifying the solar-specific RPO, often known as the ‘solar carve-out’. However, the success of such cases rest on the implementation of such obligations, which are usually in the form of enforcements.

Many states in India, through their respective State Electricity Regulatory Commissions, have also defined their RPOs. As per the current scenario, electricity utilities of only seven to eight states have been able to meet their RPO targets. Other states fail to attain their RPO targets due to lack of uniformity in providing longer trajectory for the RPO targets. With the new RPO targets a positive impact on pricing and tariff for electricity of solar and other renewable energy resources is visible.

Renewable Energy Certificate (REC)

REC is a mechanism to facilitate the compliance of RPOs across the states of the country and provides an option to obligated entities to fulfill their targets by purchasing RECs that are traded on the exchanges like Indian Energy Exchange (IEX) and Power Exchange India (PXIL). But mechanism could not take a big flight due to insufficient buyers and excess sellers. At on 8 September 2017, the prices of REC have fixed at₹1,000 (Floor price) and ₹2,500 (Forbearance price)

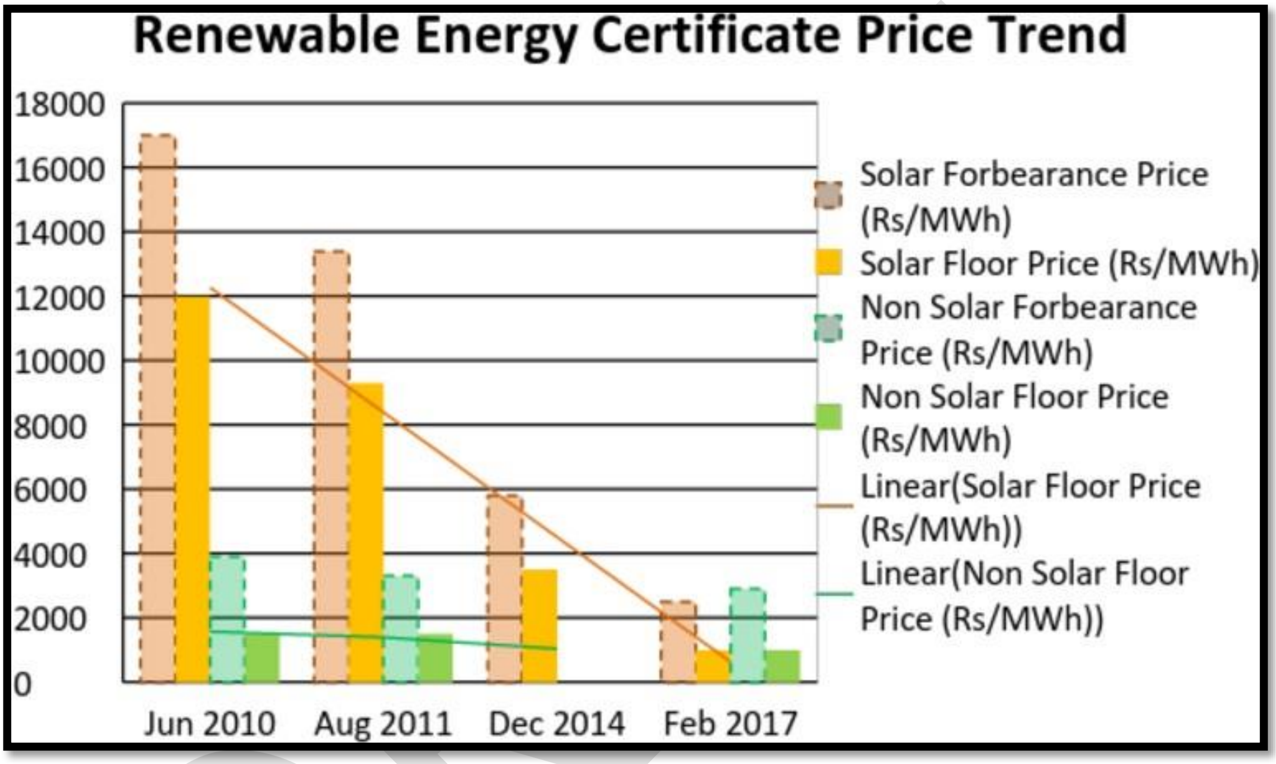


Figure 3-3Renewable Energy Certificate Price Trend (As on Feb. 2017)

Other Drivers

India is all set to become the fourth largest solar market globally in 2017 behind only China, Other drivers that signify the advantages of solar power and may have tangible benefits in one form or another include: -

- Infinite fuel source: The earth receives 6,000 times greater solar energy than the global requirement today. The practically infinite fuel source is one of the key advantages and promise of solar technology.

- Emission reduction: Solar energy technologies practically do not emit greenhouse gases, thus helping the global targets of such emission reductions. Additionally, typical photovoltaic systems are not involved in any combustion, radioactivity, high temperature/ pressure processes or disposal issues.

- Point of use: Photovoltaic and smaller solar thermal systems can be installed at the point of use, whether in a grid-connected mode or a stand-alone mode. This feature helps users to be self-sufficient in terms of energy, while reducing and transmission losses.

- Low maintenance: Typical photovoltaic systems are stationary at a fixed orientation. There are no moving parts involved, except in case of certain tracking systems. The major maintenance activity for a photovoltaic system is cleaning the dust off the photovoltaic modules, which is a very simple activity
- High reliability and predictability: The industry standard warranty for photovoltaic modules is for 25 years, which indicate its highly reliable nature. The balance of systems including inverters and transformers also has long respective guarantees. In addition, the output of solar energy systems can be predicted with a high level of confidence making it easy to integrate with energy sources in terms of dispatch ability.

- Modularity: Photovoltaic system can be tailored based on specific use, and due to the simplicity of connecting wires, newer capacities can easily be added if required.

- Net metering: Net metering allows residential and commercial customers who generate their own electricity from solar power to feed electricity they do not use back into the grid. Many states have passed net metering laws. For example, if a residential customer has a PV system on the home's rooftop, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods where the home's electricity use exceeds the system's output. Customers are only billed for their "net" energy use.

3.3 Indian Scenario

USA and Japan with approximately 5.4 GW of capacity addition in the last financial year. The tailwinds are exceptionally strong with rapidly falling costs and greater environmental agenda in the post COP21 world. The Indian solar market appears in full bloom right now with key policy changes being introduced and 25 GW of projects under different stages of development. 35 new tenders with a cumulative capacity of 15.5 GW have been announced in the last year.

An additional 5 GW of new tenders are awaiting release in the coming months. There is burgeoning investment interest both from Indian and international developers in the sector. This frenetic pace of activity is a big step-up in contrast to historic solar capacity addition of approximately 1 GW per annum for three straight years until 2014.

India's solar rooftop systems market is anticipated to grow on the back of government initiatives, subsidies, investments and consumer awareness. The government has set a target of 40 GW of power generation through solar rooftop systems by 2022.The rooftop market has not picked-up as it was expected but this market needs more focused policy support to ensure effective net-metering implementation and attraction of financial investors. Achievement Linked Incentive Schemes by government of India will give a push to this market and PSUs/ government agencies will come forward in developing solar rooftop system.

Overall, the growth prospects for the India solar market are very bright providing an immense opportunity for investors, developers and equipment suppliers. But a dose of caution is needed as the market will remain very price sensitive and with its share of challenges

The present installed power generating capacity in the country is 329+ GW (as on 31.04.2017), which is largely dominated by coal as depicted in the table below. Against this India's annual energy consumption per capita has increased from 734 kWh in 2009 to 1,075 kWh in 2015-16, an increase in 46%. The growth trend will remain the same as India is gearing up to increase its appetite for energy.

Table 3-1: Installed Capacity of india,30 April,2018(as per CEA)

Fuel	Installed Capacity (in GW)[4]
Coal	197.17
Gas	24.89
Diesel	0.84
Nuclear	6.78

Hydro	45.29
Renewable Energy Sources	69.02
Total	**344.002**

Indian economy, therefore, desperately needs a better functioning of the power sector that can meet the market's demand for quality power at a globally competitive rate. The current infrastructure would need the availability of assured and quality power at affordable price through reliable and adequate generation, transmission and distribution facilities.

Now, with the rise in awareness with regards to environmental protection and conservation, the future growth in energy sector must consider the adoption of renewable energy sources, in order to develop in an environmentally benign manner. The key issues having energy-related implications faced by a developing country like India are, rising population, need for economic growth, access to adequate commercial energy supplies and the financial resources needed to achieve it, rational energy pricing regime, improvements in energy efficiency of both the energy supply and consumption, technological up-gradation, energy security a matching R&D base and environmental protection.

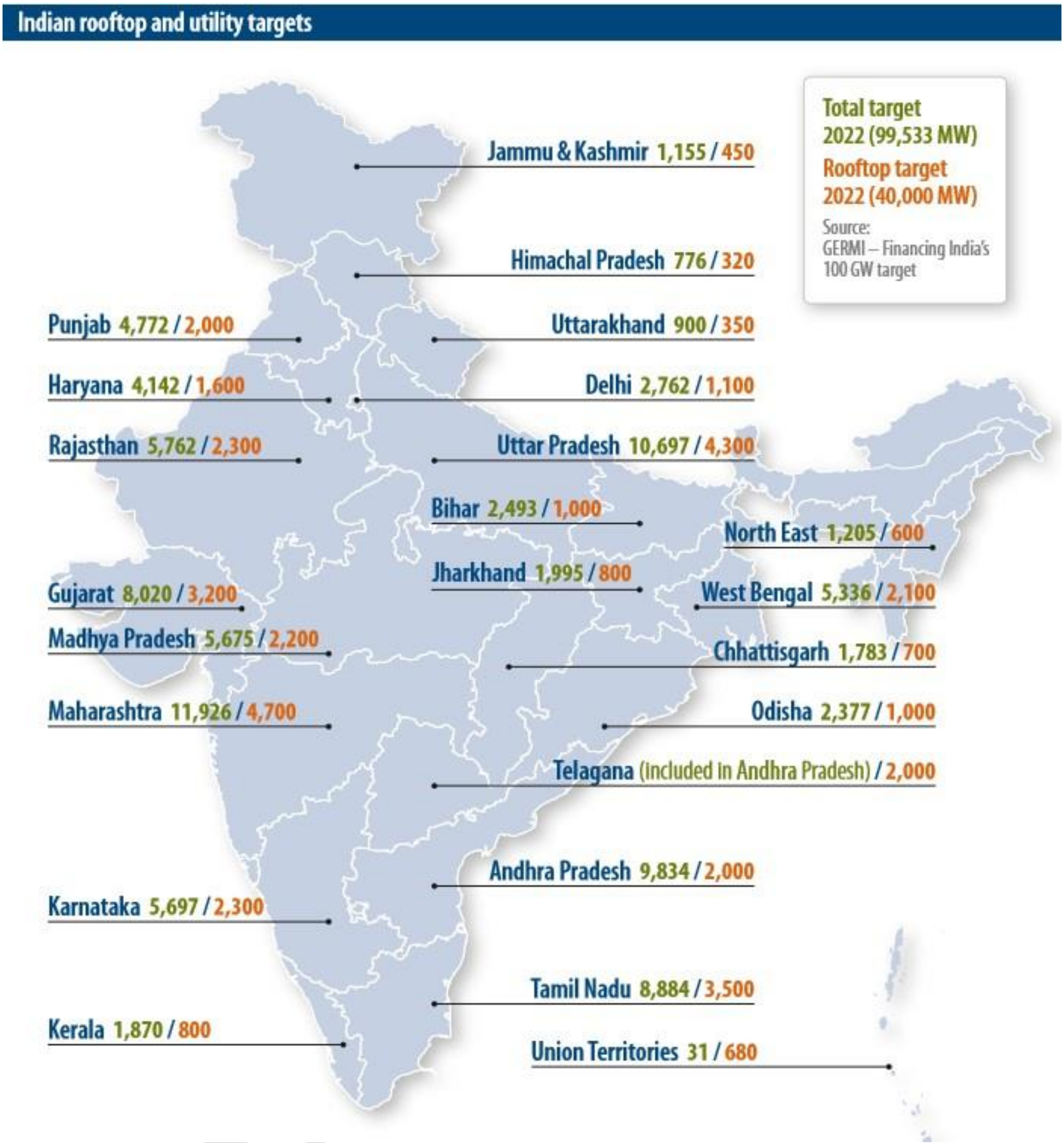


Figure 3-4The Indian government has apportioned the 100 GW target across various states of India –as on July 2016

However, development of renewable energy (RE) capacity remains limited to a few states like Gujarat, Tamil Nadu, Rajasthan, Andhra Pradesh, Telangana, Maharashtra and Karnataka, that can be attributed to having a favorable policy andframework implemented by respective state governments and also due to favorable climatic conditions. Given the importance of ensuring energy security and the focus on clean energy, the share of RE sources in the future is likely to increase. The total installed capacity of solar in India has also recently crossed 20 GW mark.

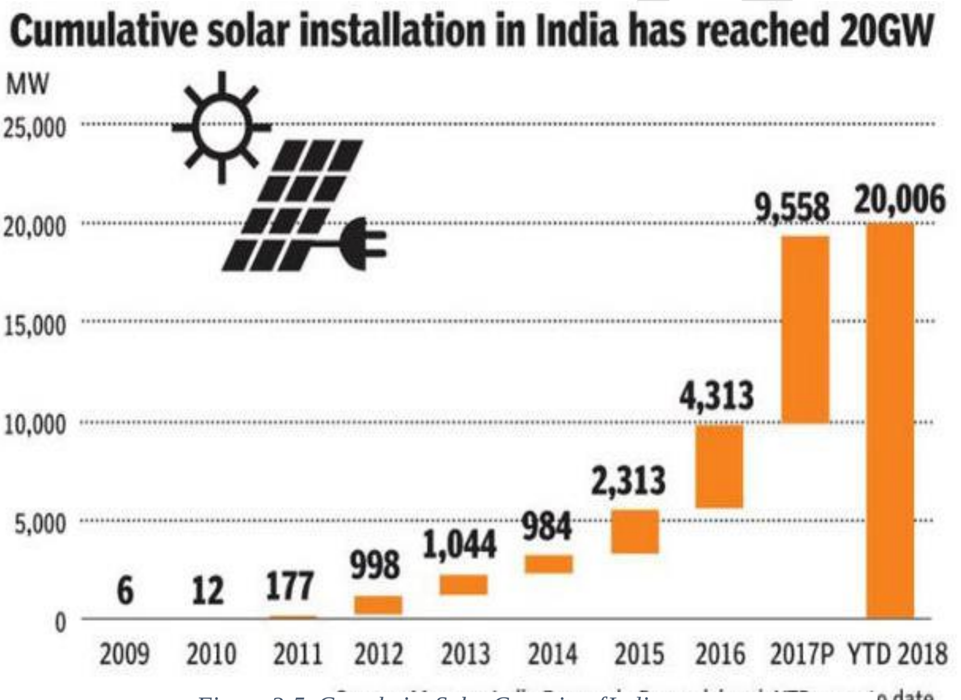
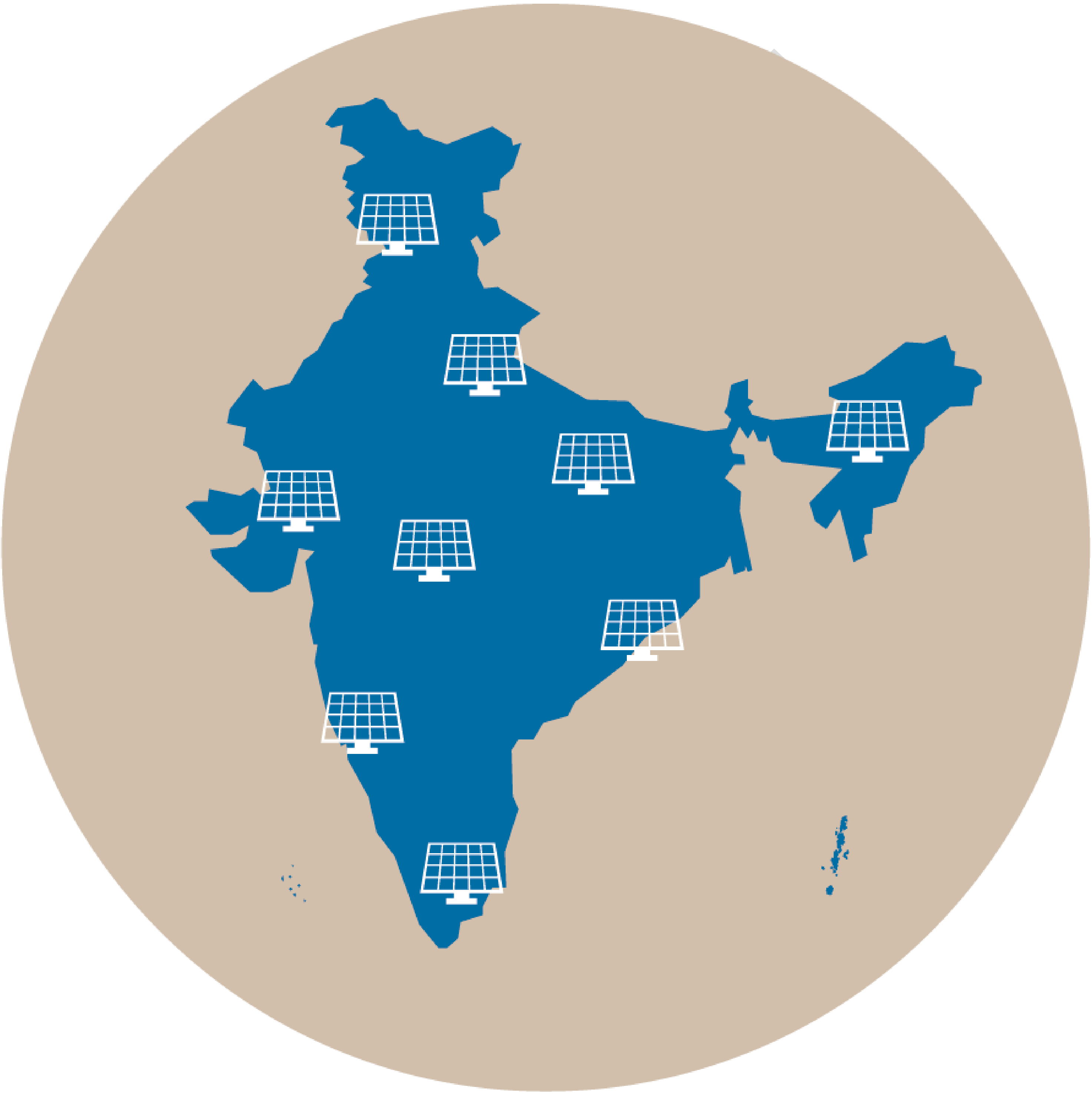


Figure 3-5: Cumulative Solar Capacity of India

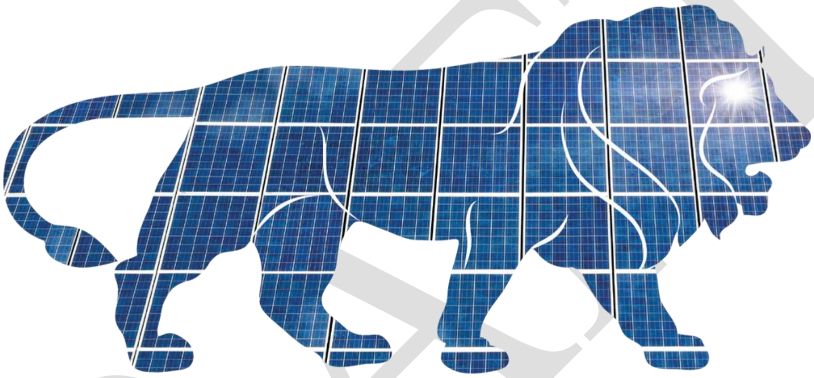
Solar Energy Development & Status in India



4 Solar Energy: Development& Status in India

4.1 Solar Energy Potential in India

India being a tropical country is blessed with good sunshine over most parts, and the number of clear sunny days in a year is also attractive in the range of 250-300. The country receives solar energy equivalent to more than 5,000 trillion kWh per year. The daily average global radiation in India is around 5.0 kWh/ m2/ day in north-eastern and hilly areas to about 7.0 kWh/m2/ day in western regions. The global horizontal irradiance (GHI) map of India is given as Fig 4-1. As on Feb 2018, India has recorded photovoltaic installation above 20 GW mark.



The National Institute of Solar Energy in India (NISE) has determined the country's solar power potential at about 750 GW, a recently released document by the Ministry of New & Renewable Energy (MNRE) shows5. The solar power potential has been estimated using only 3% of the total wasteland availability in every state and jurisdiction of India. The detailed state wise list solar potential is given in **Annexure 1**.

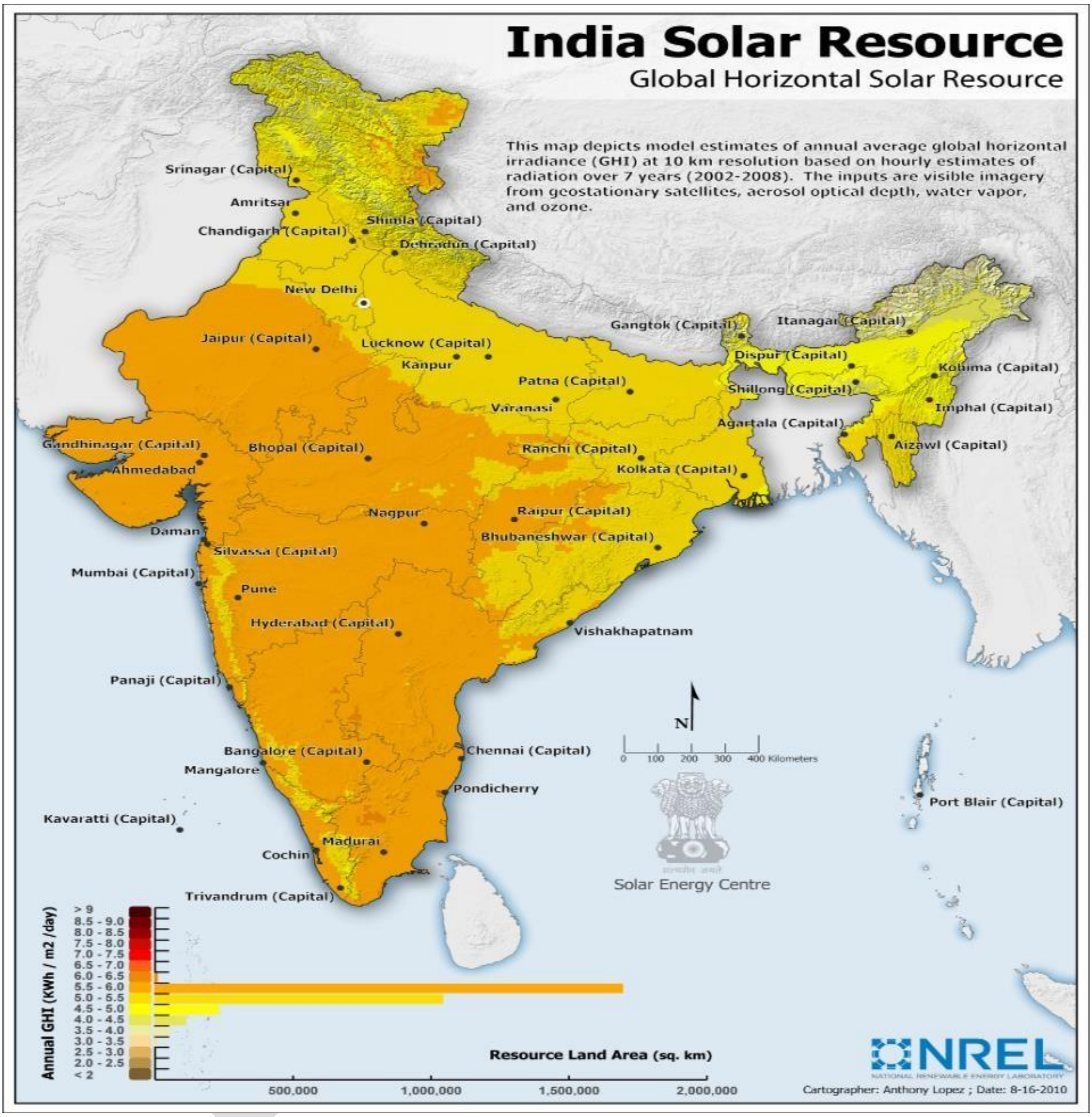


Figure 4-1:Global Horizontal Irradiance Map of India

Source:Solar Energy Centre, MNRE, Government of India, and National Renewable Energy Laboratory (NREL), USA.

Radiation terminology explained...

Solar radiation is quantified in many ways depending on the aspect it is used for. Terms like radiation, irradiance, insolation, GHI, DNI, etc. refer to the solar resource, and are commonly confused or misused.

Radiation:

Radiation is a qualitative term, which indicates the process through which energy is emitted from a body. *Radiation* does not have any units associated with it.

Irradiance:

Solar *irradiance* indicates the amount of solar power incident on a fixed area. *Irradiance* is typically expressed in watts per square meter (W/m^2). *Irradiance* is measured through an instrument called 'pyranometer,' which displays the instantaneous power available from the Sun.

When the *irradiance* from the Sun is 1,000 W/m^2 (which also corresponds to Standard Testing Conditions – STC), this value is called "1 Sun." If the *radiation* from Sun is concentrated 10 times using a lens or a mirror assembly and the incident power increases to 10,000 W/m^2, then the *irradiance* is called "10Suns."

Insolation:

Insolation is the amount of solar irradiance that is incident on a fixed area over a finite period of time, and hence corresponds to the physical unit of *energy*. *Insolation* is typically expressed in kilowatt-hours per square metre per day ($kWh/m^2/day$) or ($kWh/m^2/year$) for a particular location, orientation and tilt of a surface.

Since 1,000 W/m^2 is 1 Sun, 1 hour of this ideal *irradiance* produces 1,000 watt-hours per square metre (1 kWh/m^2), which is also known as "1 Sun Hour." Colorful maps of solar potential display solar energy in $kWh/m^2/day$, which is equivalent to the number of full Sun Hours per day.

Types of Insolation: GHI, GTI, andDNI:

When discussing the solar resource, it is most common to consider the insolation received by a flat, horizontal collector. Such an insolation received by a stationary horizontal collector is called the **Global Horizontal Insolation(GHI)**.

For most fixed plate solar collectors, they are oriented at an inclination angle approximately equal to the latitude of its location and facing south if in the northern hemisphere (or facing north if in the southern hemisphere) to maximize the insolation received. The insolation received by such an oriented surface is called the **Global Tilt Insolation (GTI)**.

Many solar technologies prefer tracking the Sun so that the collector surface always faces the Sun in order to maximize the irradiance and insolation received. Further, tracking of the Sun becomes mandatory when higher concentrations are required in order to focus the light at the appropriate collector location. The insolation received by any such surface that is constantly facing the Sun, i.e. 'normal' to the Sun, is called **Direct Normal Insolation (DNI)**.

One should keep in mind that it is only the normal component, i.e. DNI, of solar radiation that is effectively concentrated, and hence, becomes the primary factor for determining potential for various concentrated solar photovoltaic and thermal technologies.

4.2 National Action Plan on Climate Change

The Prime Minister of India released the country's National Action Plan on Climate Change (NAPCC) on 30th June 2008. There are Eight National Missions which form the core of the National

Action Plan. It consists of several targets on climate change issues and addresses the urgent and critical concerns of the country through a directional shift in the development pathway. It outlines measures on climate change related adaptation and mitigation while simultaneously advancing development. The Missions form the core of the Plan, representing multi-pronged, long-term and integrated strategies for achieving goals in the context of climate change. NAPCC set the target of 5% renewable energy purchase for FY 2009-10. Further, NAPCC envisages that such target will increase by 1% annually for the next 10 years. This would mean NAPCC envisages renewable energy to constitute approx. 15% of the energy mix of India.

4.3 Status: Jawaharlal Nehru National Solar Mission

The Jawaharlal Nehru National Solar Mission (JNNSM) is one of the eight missions under the NAPCC and was announced in 2009. JNNSM aims to promote the development of solar energy for grid connected and off-grid power generation. The ultimate objective is to make solar power competitive with fossil-based applications by 2020-2022.

Table 4-1:Proposed Roadmap by the Jawaharlal Nehru National Solar Mission

Category	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	Total (MW)
Rooftop	200	4,800	5,000	6,000	7,000	8,000	9,000	40,000
Ground-Mounted	1800	7200	10,000	10,000	10,000	9,500	8,500	57,000
Total	2,000	12,000	15,000	16,000	17,000	17,500	17,500	97,000

JNNSM was introduced as one of the eight national missions under the National Action Plan for Climate Change in 2009. JNNSM phase I (2010-2011) was divided in two batches with 150 MW and 350 MW of allocations, out of which 145 MW and 320 MW were commissioned respectively. During phase I bundling scheme of unallocated coal was introduced and NTPC VidyutVyapar Nigam Ltd (NVVN), a wholly owned subsidiary of NTPC was chosen as the nodal agency for entering into Power Purchase agreement (PPA) with solar power developers. In Phase II Batch I (2013-2014) a total of 750 MW was allotted under open category and domestic content requirement (DCR). Out of 750 MW of the allotted capacity 700MW was scheduled to be completed by 2015. As on 19 June 2015, 555 MW has been commissioned under this scheme and remaining capacity is supposed to be commissioned by September2015. Along with the announcement of increase in JNNSM targets to 100 GW till 2022 lot many changes have been introduced in the roadmap structure of JNNSM.

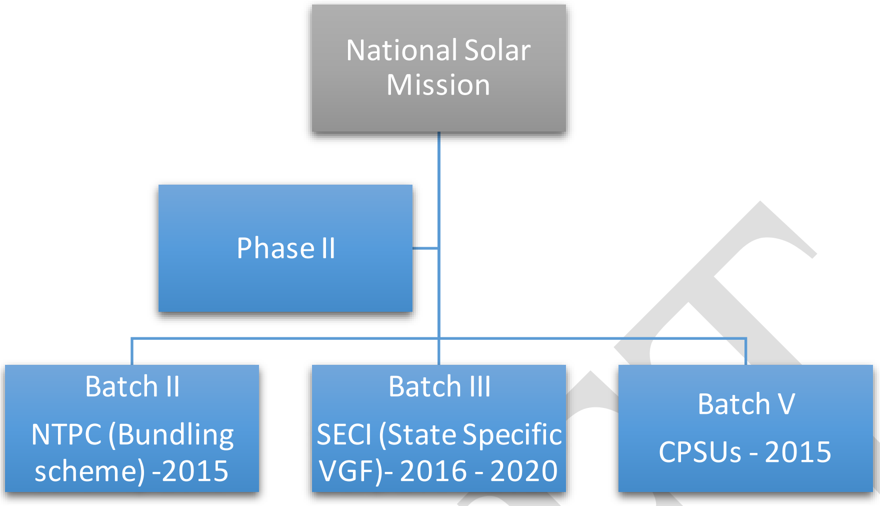


Figure 4-2:Structure of JNNSM

It is found that JNNSM has been successful in jumpstarting a nation-wide solar initiative to meet its targets. Lately many states have come forward by announcing their solar policy and enthusiastically willing to harness solar power in their state.

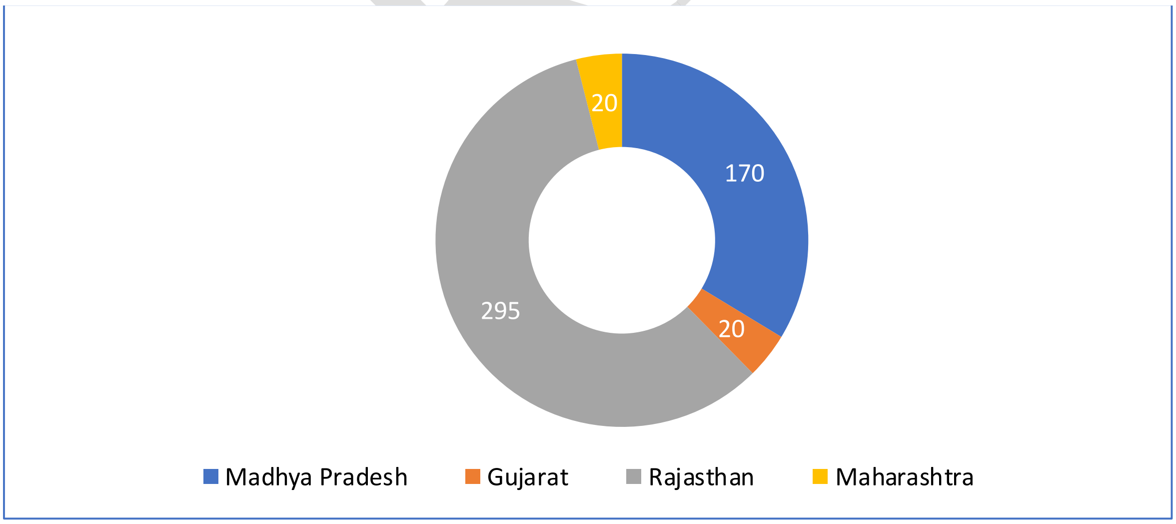


Figure 4-3:Summary of state-wise distribution of photovoltaic power projects under JNNSM Phase II Batch I

Phase II batch I was allocated under Viability Gap funding (VGF) the tariff having a fixed tariff of Rs 5.45 without AD benefits. The developers were selected on the basis of their desired VGF amount. In the open category a total of 375 MW was allotted out of which 260 MW is commissioned and under the DCR category a total of 245 MW out of the other 375 MW is commissioned as of May 2015. The Figure 4-4 and 4-5 describes the highest and lowest commissioned capacity along with its sanctioned VGF eligibility along with the developer and location of the plant.

i. Open Category

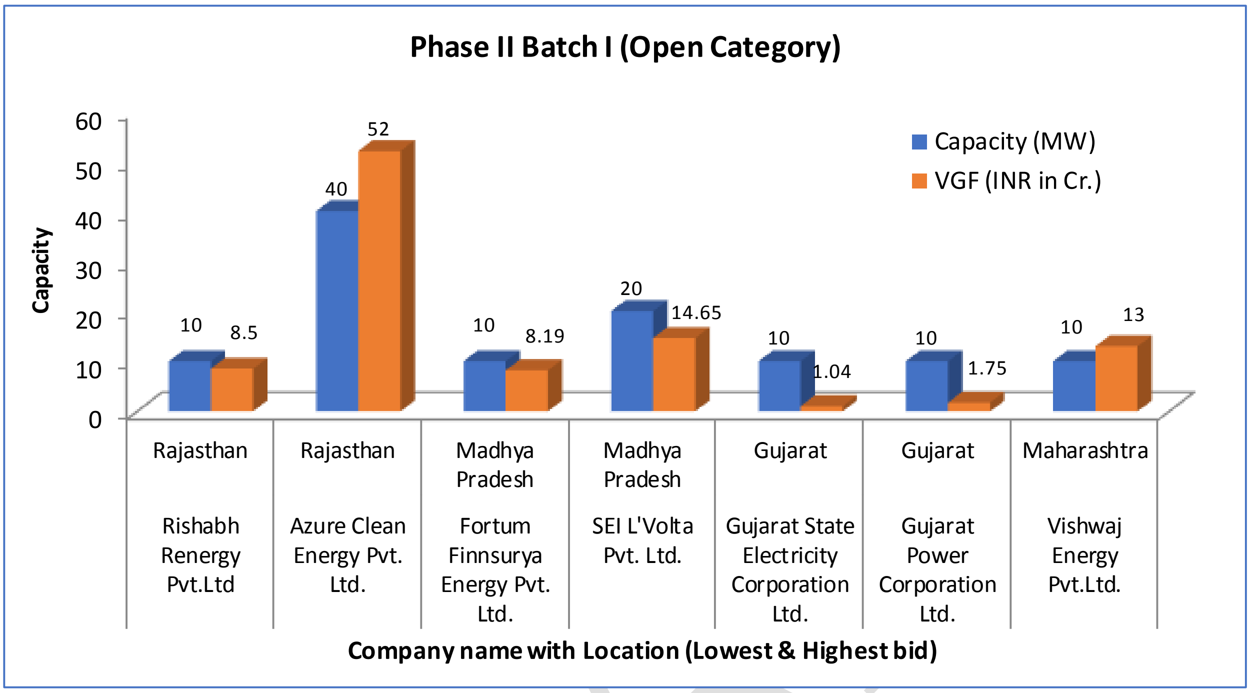


Figure 4-4:Successful VGF tariff and capacity distributed state-wise under JNNSM Phase II batch I- Open category

ii. DCR Category

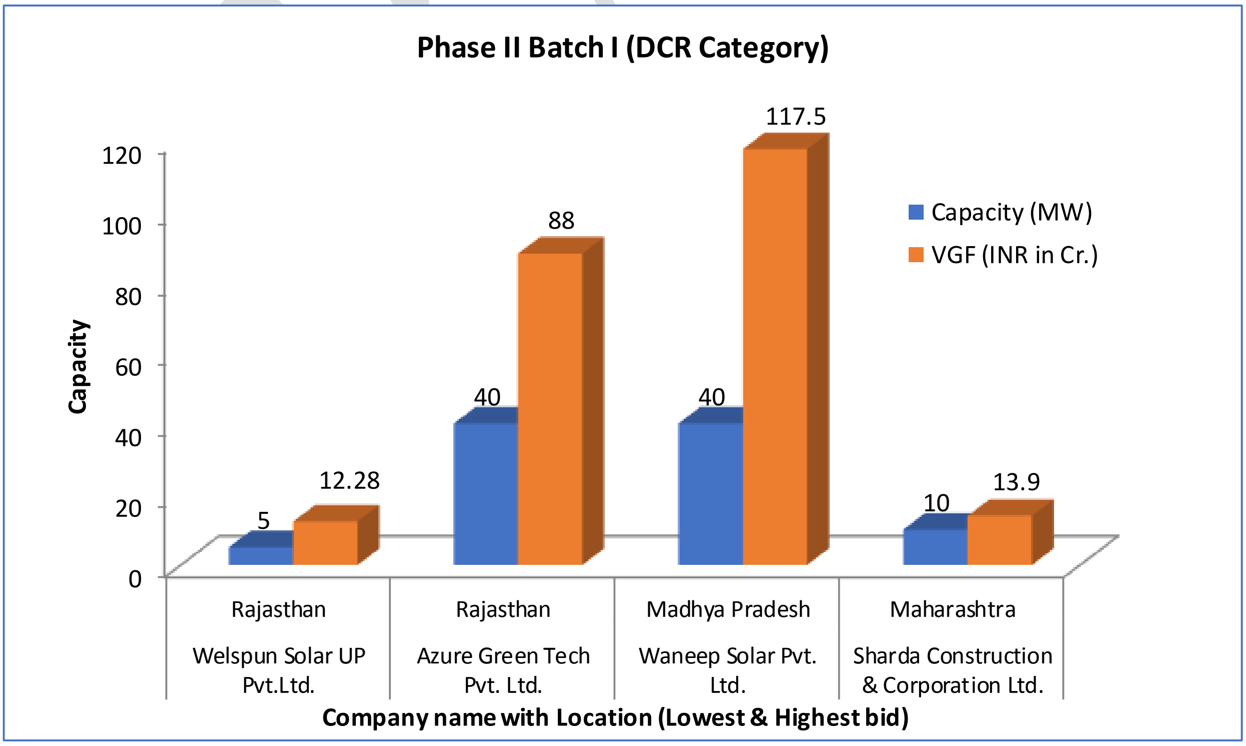


Figure 4-5:Successful VGF tariff and capacity distributed state-wise under JNNSM Phase II batch I- DCR category

4.4 Solar Park

The solar park is a concentrated zone of development of solar power generation projects and provides developers an area that is well characterized, with proper infrastructure and access to amenities and where the risk of the projects can be minimized. Solar Park will also facilitate developers by reducing the number of required approvals.

4.4.1 Development of Solar Park

Implementation Agencies

- SECI will be Nodal agency for MNRE on behalf of Govt. of India (GOI).
- State Govt. will designate an agency for development of Solar Park. Known as Solar Power Park Developer (SPPD).

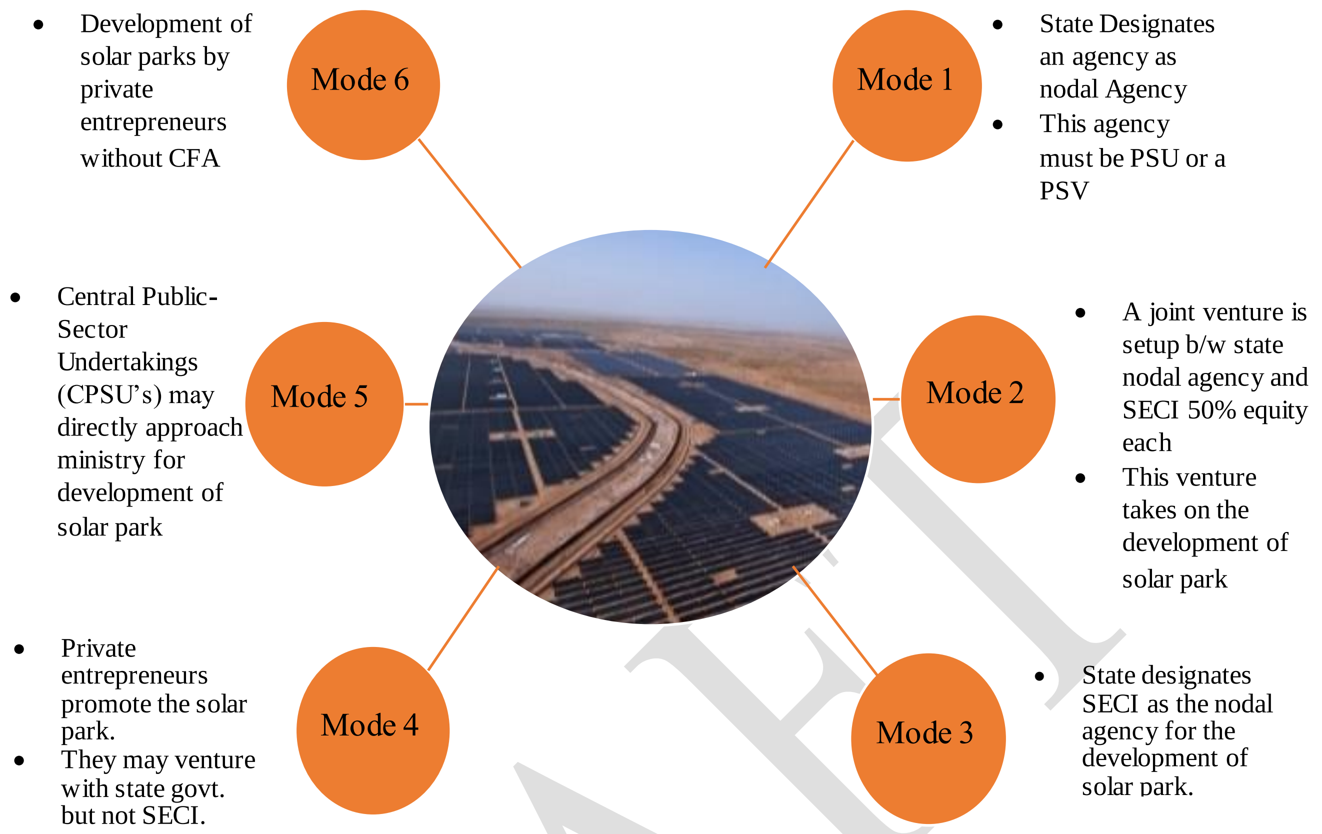


Figure 4-6: Mode of development of a Solar Park

4.4.2 Solar parks are envisaged to be developed in six modes

Mode-1

The State designates a nodal agency which takes on the development & management of the solar park. This agency could be a State Government Public Sector Undertaking (PSU) or a Special Purpose Vehicle (SPV) of the State Government.

Mode-2

The State designated nodal agency and Solar Energy Corporation of India (SECI) sets up a Joint Venture Company for the development & management of solar park Both, SECI and the State designated nodal agency will have 50% equity each.State Government may also allow more than one agency for the joint venture provided total equity from State Government remains 50%.

Mode-3

The State designates SECI as the nodal agency and SECI undertakes the development and management of solar park on behalf of State Government on mutually agreed terms.

Mode-4

The private entrepreneurs may carry out the development and management of the solar park. They may have equity participation from State Government

The private entrepreneurs may be selected in following manner:

- Mode 4A: If the land belongs to the Government or its agency, then Solar Power Park Developer (SPPD) would be selected based on open bidding & the bidder with the lowest quotation of development and O&M cost would be selected.
- Mode 4B: If the land is to be provided by the SPPD itself, then SPPD with the lowest quotation of developed land per MW and O&M charges per MW would be selected.

Mode-5

Central Public-Sector Companies (CPSUs) like NTPC & SECI may directly approach the Ministry for development of solar parks. They may do so in the following manner:

- Mode 5A: CPSUs having their own land may approach Ministry directly for setting up of solar parks. It may develop the park on its own or through an SPD contractor. CPSUs will be the SPPD. Further CPSUs can also develop their own plant in the park.
- Mode 5B: CPSUs having their own land may select an SPPD base on open bidding and select the lowest bidder.
- Mode 5C: CPSUs who don't own land may float a tender and invite third party for the selection of SPPD.

Mode-6

The private entrepreneurs may set-up a solar park without Central Finance Assistance(CFA) from the Ministry. The minimum capacity of the park shall be 100 MW, though 50 MW parks may be allowed in areas with difficult terrain or with scarce non-agricultural land. The private entrepreneurs may submit the proposal along with the Detailed Project Report (DPR) and documents in support of 100% land possession. Post examination of the DPR the principle approval will be awarded. Although the connectivity and LTA with CTU may be issued after financial closure, award of works for road, water and internal transmission. The solar park shall be completed in 18 months; otherwise their allotted gird connectivity maybe cancelled and might be given to someone else.

4.4.3 Site Selection & Land Acquisition

Sites receiving good amount of solar radiation and closer to the CTU (i.e. Power Grid Corporation of India) are usually selected for the setting up a solar park. State Govt. may provide Government waste/non-agricultural land to speed up the process. But good solar radiation and proximity to the CTU are not the only criteria for selection of land. The cost of land is a very important factor too. The cost of land should be kept as low as possible in order to make it attractive to the developers. Therefore, the site is selected is such a manner that inexpensive land can be made available. If land cannot be made available at one location, then land which are in close proximity are chosen for the development of solar park.

4.4.4 Facilities to Be Provided

The solar park will provide specialized services to incentivize private developers to invest in solar energy in the park. These services while not being unique to the park, are provided in a central, one-stop-shop, single window format, making it easier for investors to implement their projects within the park in a significantly shorter period of time.

i. Land approved for installation of solar power plants and necessary permissions including change of land use etc.
ii. Road connectivity to each plot of land.
iii. Water availability for construction as well as running of power plants and demineralization plant.
iv. Flood mitigation measures like flood discharge, internal drainage etc.
v. Construction power.
vi. Telecommunication facilities.
vii. Transmission facility consisting pooling station.
viii. Housing facility for basic manpower wherever possible.
ix. Parking, Warehouse.

4.4.5 Evacuation

Power evacuation is done in two parts:

1. Collecting and Transmitting power from each project to transmission sub-station at the boundary as first part. It is responsibility of SPPD to take care of this part.
2. From transmission sub-station at the boundary to the existing grid of CTU/STU as second part. It is responsibility of CTU/STU to take care of this part.

MNRE grants funds in ratio of 60:40 to SPPD & CTU/STU respectively, for setting up infrastructure for evacuation.

4.4.6 MNRE Support for a Solar Park

Under this scheme MNRE will provide subsidies for the development of a solar park. These subsidies will only be made available if certain milestones are achieved. Following financial assistance will be provided by MNRE for respective task.

- Up to 25 lakh/solar-park for preparation DPR of solar park, conducting surveys etc.
- Besides above, up to 20 lakh/MW or 30% of the project cost, including Grid connectivity (whichever is lower) will be provided in installments upon completion of different milestones.
- SECI will receive 1% of the total grant released by MNRE in a project for administering the scheme and managing the funds.

4.5 Solar Power Scenarios in other States of India

4.5.1 Solar Power Scenario in Haryana

Haryana in September 2014 announced its solar policy and announced allocation of 50 MW capacities to meet the RPO of the state's distribution companies in April 2014 and recently in May 2015 Haryana Power Purchase Centre on behalf of two distribution companies of Haryana floated a procurement of 150 of Solar Power. The capacity was to be commissioned by mid – 2015. Recently, in June HPPC floated RFP for procurement of energy from 150 MW of solar PV power plant. This RFP is in process and still not finalized.

Apart from utility scale power plant, the state of Haryana is also promoting net-metering based rooftop power plants by making it mandatory to install a minimum of 1kW capacity.

4.5.2 Solar Power Scenario in Gujarat

While the state has been the pioneer in solar and is still in top two solar installations in a state with 1,003 MW in terms of total installed capacity under state policy and national policy. There have been no new allocations under the state policy since the state has already met its RPO targets. With the new state policy recently announced in August 2015 and revised RPO targets, Gujarat will come back in the solar market to consolidate its position as market leader.

4.5.3 Solar Power Scenario in Rajasthan

As on date Rajasthan has the highest solar installed capacity combining JNNSM and state policy. Solar Power plant of 65MW capacity is commissioned under the state policy as of May2015 due to uncertainties in the state policy. Along with the new policy announced recently, the state hopes to harness huge solar potential it has in the coming years. The state is in the process of allocating 50 projects each of 1 MW capacity.

4.5.4 Solar Power Scenario in Madhya Pradesh

The state does not yet have a proper policy document, still is the 3rd largest state in terms of installed capacity. One of the country's biggest solar PV plant of 151 MW capacity was commissioned at Neemuch district in 2013. Another 100 MW of solar capacity was allotted in February 2014 under the state policy. Apart from that NTPC is coming up a UMSPP of 750 MW under JNNSM phase II batch II.

4.5.5 Solar Power Scenario in Andhra Pradesh

The state received an overwhelming response to its 1,000 MW allocation under the previous state policy in 2014. But due to some changes in the policy post the bidding process, there was loss of interest with the policy out in April 2015 the state is looking at better allocations. Also under the JNNSM Phase II Batch II Tranche I 1,500 MW is being implemented in Anantpur district of Andhra Pradesh.

4.5.6 Solar Power Scenario in Tamil Nadu

Tamil Nadu initially had an ambitious state policy with a target of 3 GW. There was an initial target of 1,000 MW in December 2012. However, due to lack of response from developers, Letter of Intent was only given to projects worth 700 MW. However, the entire state was caught in a fit due to regulatory uncertainties include the striking down of the SPO under the state policy by the Appellate Tribunal and lack of approval of the tariff for the PPA by State Electricity Regulatory Commission.

4.5.7 Solar Power Scenario in Karnataka

Karnataka announced its policy in 2011-2016 under which it proposed to install 200 MW grid-connected solar to 2015-2016 although the state could not meet this target in due time. Meanwhile the government revised the policy for 2014-2021, encouraging rooftop solar for households. The state has commissioned 50 MW under state policy till July 2015.

4.5.8 Solar Power Scenario in Odisha

The policy for this state was announced in 2013, the state has not done much under the state policy. At present only 5 MW has been commissioned under the state policy and 20 MW under JNNSM Phase II Batch I is under progress.

4.5.9 Solar Power Scenario in Uttar Pradesh

Under the state policy 130 MW was allotted in August 2013 and PPA was signed for 110 MW in December, out of which 42 MW is commissioned as of July 2015. Recently the government has also notified their Solar Policy.

4.5.10 Solar Power Scenario in Punjab

Punjab announced its Renewable Energy Policy in 2012, followed by an allocation for 250 MW of solar power to be completed in 2013. Out of the 250 MW at present 177 MW have been commissioned under the state policy. Punjab is very aggressively promoting net-metering based rooftop solar PV system in the state.

4.5.11 Solar Power Scenario in Kerala

Kerala is the only state which has only allotted off-grid projects under the state policy. Most of these projects are rooftops solar systems. Altogether 10 MW rooftop PV systems were allocated. The state intends to continue allocation of more capacity under the rooftop scheme in the coming year.

4.6 State wise Comparison of Power Produced from Solar Parks

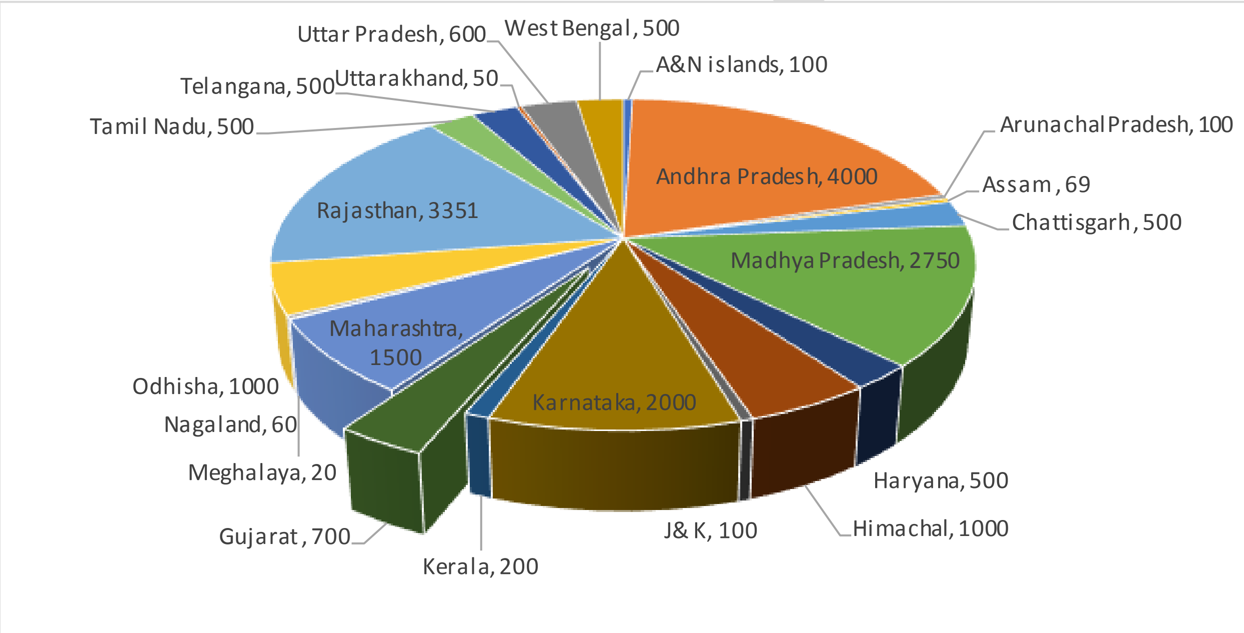
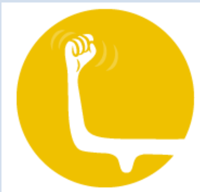


Figure 4-7: State Wise Comparison of Power Generation through Solar Park

4.7 SWOT Analysis of Solar Park

A comparative analysis of the strength, weakness, opportunity and threat of a utility level solar park.

Strength	• Solar Energy is in abundance all over the globe and as long as we have sun this abundance source of energy will be there. • Solar Park is a better prospect than a stand alone solar project due to the shared Development, O&M and security cost. Therefore, cost

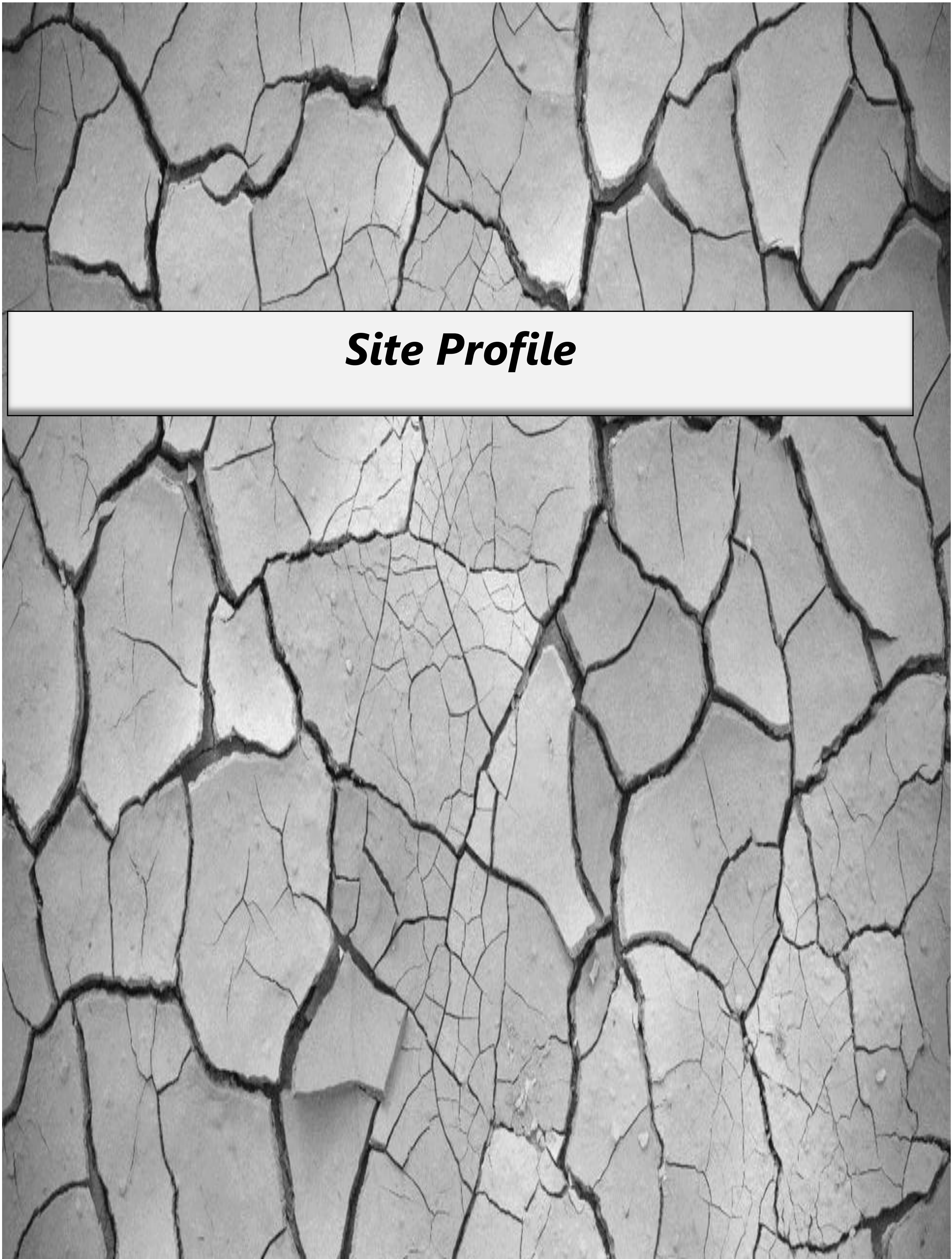
	commensurate to the power generated is lower in case of a solar park as compared to a standalone solar project. • Energy generated through Solar Parks are transmitted through high tension lines leading to lesser losses • Solar parks offer easy clearances to the solar power plant developer which encourages Investment by these developers. • Development of solar parks are backed by Government and is highly incentivized with Government providing support of around 30% of the total project cost. • India is blessed with high solar irradiance with more than 300 days of sunshine. Moreover, western India has vast masses of Infertile land which can be utilized for solar power generation, which makes Solar park a very good prospect. • People are much more aware of the impacts of climate change and demand for renewable energy is increasing rapidly with other source of technologies. Solar energy sits on top as its cheaper and more advanced as compared to wind and hydro.
Weakness 	• Installation cost of Solar Parks are very high. • India gets a good amount rain in monsoon season. Solar energy cannot replace convectional source of energy completely as it is not continuous. • Solar parks are usually build on waste infertile lands in remote locations which lacks technical support. • Contiguous land with appropriate insolation levels in close proximity for the development of a solar park are not always easy to find.
Opportunity 	• With solar power prices approaching grid parity, it is encouraging for anyone who wants to invest in solar power projects. • Ever Soaring oil prices provides opportunity to solar power generators to shoulder some of the burden. • Solar Park can help states achieve their renewable purchase obligation • Less losses in transmission as the generation source will be close to the consumption sources • Government of India's inclination towards the solar energy is a big motivating factor for Solar park developer. • Ever increasing demand for power provides opportunity for solar energy to fill the void.
Threats	• Emergence of foreign players in solar market may lead to decline in the cost which would ultimately may lead to compromise to quality

	as benchmark cost would reduce and people hardly have idea about the internalized costs. • The remote location of the parks may lead to theft of the solar components.

4.8 Conclusion

With the increased target of 100 GW till 2022, along with the targets from JNNSM, the states also need to take more such leads in putting up solar PV projects. As the market conditions seem to be improving with cost reduction and better investment options, India seems to be positioned well for growth of renewable energy sector especially solar.

------End of Section------



Site Profile

5 Site Profile

5.1 Site Location

The proposed solar park is located in the town of Dholerawithin the Saurashtra peninsula, bordering the Gulf of Khambhatand is about 100 km south of Ahmedabad and 130 km from Gandhinagar. Dholerais an ancient port-cityin Gulf of Khambhat, 30 km from Dhandhuka city of Ahmedabad district. One of the original six temples built by Swaminarayan is located here. Dholera shot into fame in 2009 after Chief Minister of Gujarat NarendraModi announced Special Investment Region (SIR) for Dholera and vowed to develop a world class green-field city in Dholera. The site is strategically situated between the main industrial centers of Ahmedabad, Vadodara, Surat, Rajkot and Bhavnagar.

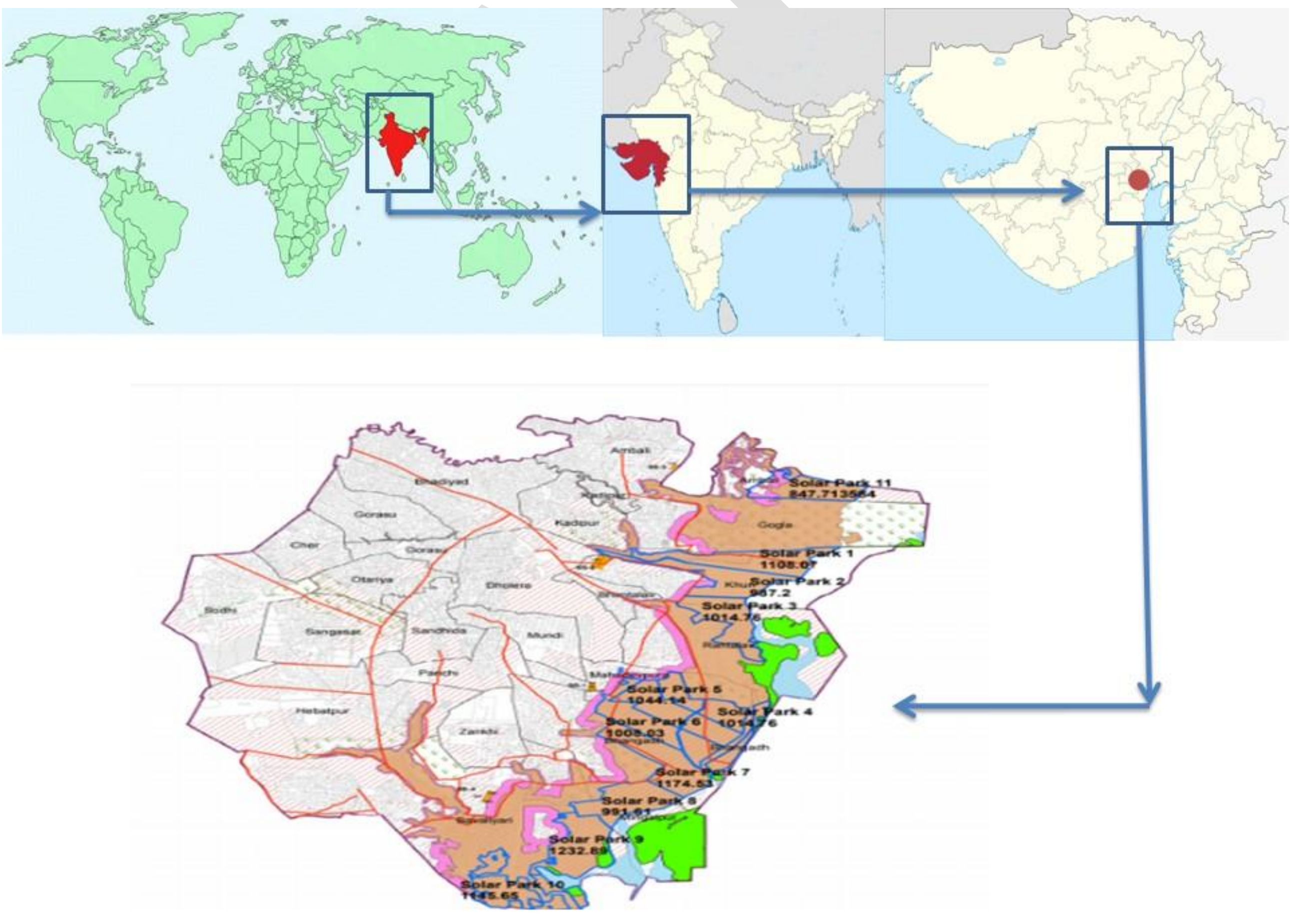


Figure 5-1: Geographical Location of the Proposed Solar Park

5.1.1 Geographical Location of the site

The geographical location details&measurement details of the sites and are tabulated below:

Parameter		Location
Site Location	:	Dholera SIR
Tehsil	:	Dholera
District	:	Ahmedabad
Latitude	:	29°23.269 N
Longitude	:	76°52.182 E
Elevation (m)	**:**	5.5
Area (acre)	:	20440 (approx.)

Figure 5-2:Dholera SIR Map

Connectivity & Salient Features

5.1.2 Road Connectivity

The site is best approached from State Highway (SH) 6 which connects the site to the National Highway (NH) 8. National Highway (NH) 8 which connects the site to Ahmedabad and Vadodara is 65 km. Nearest national expressway to the project site is National Expressway-1, From Ahmedabad to Vadodara which is 125km away in the north east direction.

5.1.3 Airport

The nearest airport to the site is Bhavnagar Airport which is can be best approached via State Highway-6. The site is also well connected to airports at Ahmedabad and Vadodara. Ahmedabad airport is the most suitable airport to facilitate cargo transportation.The distances to the airports from the site are as follows:

Table 5-1:Distance matrix for Nearby Airports

Nearby Airports		
Bhavnagar	Domestic	67 KM
Ahmedabad	Domestic& international	138 KM
Vadodara	Domestic	157 KM
Surat	Domestic	343km
Amreli	Airstrip	175km

5.1.4 Port Connectivity

The nearest port to the Project Site is Bhavnagar port in Gulf of Khambhat, which is located about 71 km to the south of the Site. The Bhavnagar pot and Dholera are well connected by SH-

Figure 5-3:Geographical Representation of the Connectivity of the Project Site

6 and broad-gauge railway line, and hence, movement of cargo, machineries, equipment, etc. using these corridors up to the project site is convenient.

Table 5-2:Distance matrix for Project Site; Dholera

Parameter	**Location**	**Distance (km)**
Nearest Urban Area	Dholera	0
Nearest National Highway	NH 8	65
Nearest State Highway	SH 6	20
Nearest Railway Station	Bhavnagar Terminus	62
Nearest Domestic Airport	Bhavnagar	67

Nearest International Airport	Ahmedabad	138
Nearest Port	Bhavnagar	71

5.2 Land & Land Usage

The land around the Gulf of Khambhat (Cambay) has been formed under Fluviomarine environments and therefore the soils of the area have inherent salts in their composition. The changing environmental conditions and human interventions have caused increase in the spread and concentration of soil salinity over the past several decades

The geomorphic processes of erosion, sediment transport, deposition and the extent and condition of tidal wetlands greatly influence the usage of land in the proposed area.

Since area is prone to high and low tides suitable measures shall be taken for the optimum usage of the land. For the development of Solar-park, the cost of land has to be kept as low as possible. The land for the proposed park has been leased at a very nominal annual price of Rs. 10,000/Ha for a time period of 30 years. The proposed park will be further divided into 11 parks which will be further divided into 27 plots of 100 MW, 160 MW& 200 MWcapacity. Landshall be used as such noflora or fauna would be harmed.

Total 5000 MW solar PV plant is planned at Dholera. Based on the available land 4,500 MW capacity is proposed and rest 500 MW shall be planned after identifying the land. The specified capacity mentioned above shall be executed in different phases and the quantities of various items requiredfor setting up of solar park may vary at the time of detailed engineering.

Figure 5-4: Site photographs

5.3 Physical Features

Landforms are the physical features of the earth. They are described with particular attention to the contours of the land -- slope, elevation and morphology -- as well as the context in which the landform resides. For instance, landforms may be categorized based on how they are formed (such as by erosion) or what surrounds them (such as surrounded by water or mountains). Landforms are distinct from the biota (plant and animal life) that inhabit the ecosystems contained within the landform.

5.3.1 Geology

Geological features of the site compose of Alluvium & mud flats. The area occupies soils deposited back in the quaternary period by the side of Khambhat basin for a thickness of about 100m over the tertiary sediments resting on Deccan Traps at a depth of about 500-600m. The Gulf of Khambhat though comprising a very small portion of the west coast provides fantastic geo-environmental diversity. This funnel shaped narrow sea inlet forms a Quaternary coast with very well defined geological and geo-morphological features in its different onshore segments and is marked by equally complex offshore processes. It forms an area characterized by strong and powerful tidal action, marking a site where the tide-rise is the highest along the west coast. The high and low tides during different parts of the season in combination with the extensive addition of the (detritus laden waters of the rivers of Mainland Gujarat have generated a very complex pattern of erosion and deposition of sediments since the advent of the Quaternary period.

5.3.2 Seismology

The site falls in Seismic Zone III of the seismic zone map of India – IS 1893-2002, which indicates Moderate Damage Risk Zone which is liable to MSK VII. This site lies to the west Cambay Fault but this does not appear to be active as only few shocks have occurred along it in historical times. Therefore, developers need to take adequate measures while installing the Solar Panels to ensure least damage during earthquake.

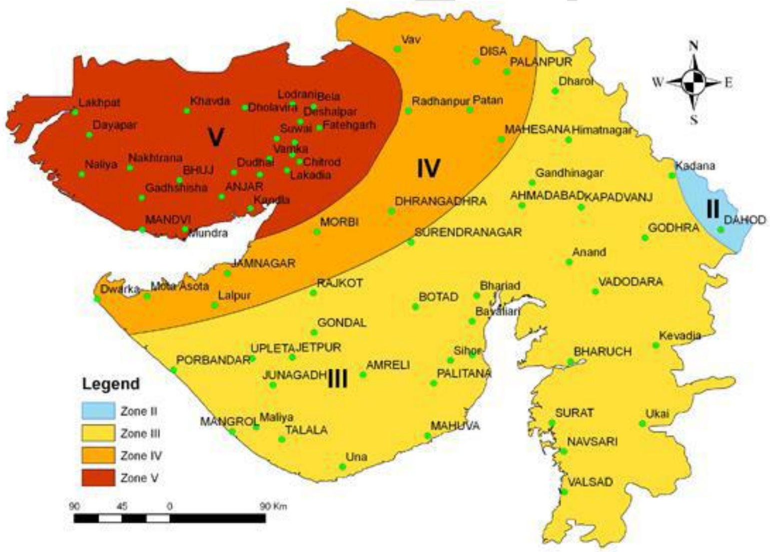


Figure 5-4: Seismological Graph of Gujarat

5.3.3 Soil & Minerals

The soils of Dholera region mainly consist of alternate layers of gravels, fine to coarse grained sand and clay. Chemically the soils are loamy, mixed montmorillonitic, calcareous and mostly saline. The soils of Dholera region is characterized by shrinking and swelling property.Fine

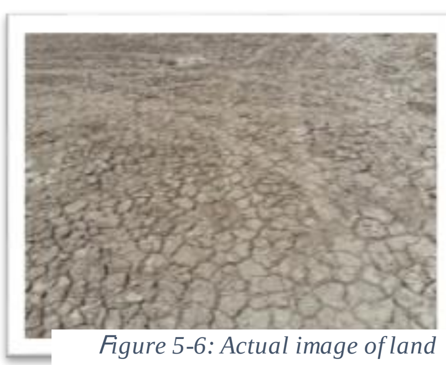


Figure 5-6: Actual image of land

Smontmorillonitic soil is found in the western part of area, central part is mainly dominated by fine lomey calcareous and coastal montmorillonitic and eastern part of the area is predominated by mud flat.

As per the Rocks and Minerals District Planning map of Ahmedabad &Gandhinagar (1999), prepared by National Atlas & Thematic Mapping Organization Department of Science and Technology, China Clay is the only mineral found in village Bhadiyad in the Dholera study area.

As the characteristic of soil is impermeable in nature, land is almost flat with mild slope. Hence during monsoon the rain water is getting accumulated on site at low line area resulting into water logging at several places. Maximum depth of water is observed up to 35cm to 40cm during monsoon which get evaporated within 25 to 30 days duration. If rainfall arrives at 15 to 20 days interval then water logging problem may pursue for 2 to 3 months. As it is not feasible to provide storm water drainage at every location of water logged area and the water gets dried by natural phenomena i.e evaporation. This problem may be taken care by EPC contractor for operation and maintenance (O&M) purpose.

5.3.4 Slope

Coastal slope is the major factor to be considered along with the coastal geomorphology in estimating the impacts of sea-level rise on a given coast. The land at project site has large contour spacing and hence lower slope value, areas with lower slope value have a high chance of getting inundation if sea level rises. gentle land slope facilitates penetration of seawater compared with locations which are steep and resulting land loss from inundation is simply a function of slope: the lower the slope, the greater the land loss.

To avoid that slope of the land at project site shall be altered to be a little steeper and in the eastern direction i.e. towards the sea.

5.3.5 Drainage

Natural Drainage

The western part of Gulf of Cambay presents an intricate network of creeks. These creeks make passage of fishing vessels and smaller crafts possible but in the ebb, they drain enormous amounts of sediments into the gulf These creeks play a vital role in the long-term geomorphological changes of the coast.

The site for the proposed solar park has a relatively flat and low-lying terrain profile, and is formed by sedimentary deposition of five rivers, namely Sukhbhadar, Lilka, Utavali, Padaliyo and Keri. These rivers flow eastwards and discharge into the Gulf of Khambhat.

The high tide level varies between R.L. 3.30m to 5.50m. The rivers in the DSIR area are rain-fed rivers and hence water flow in river is only during the rainy season or till rain water precipitated is disposed of. There might be floods generated in rivers depending upon the intensity, duration and spread of the rain storm.

5.4 Coastal Regulation Zone (CRZ)

Under the Environment Protection Act, 1986 of India, notification was issued in February 1991, for regulation of activities in the coastal area by the Ministry of Environment and Forests (MoEF). As per the notification, the coastal land up to 500m from the High Tide Line (HTL) and a stage of 100m along banks of creeks, estuaries, backwater and rivers subject to tidal fluctuations, is called the Coastal Regulation Zone(CRZ). CRZ along the country has been placed in four categories. The above notification includes only the inter-tidal zone and land part of the coastal area and does not include the ocean part. The notification-imposed restriction on the setting up and expansion of industries or processing plants etc. in the said CRZ. Coastal Regulation Zones(CRZ) are notified by the govt. of India in 1991 for the first time.

5.4.1 Classification of CRZ.

- CRZ-1: These are ecologically sensitive areas these are essential in maintaining the ecosystem of the coast. They lie between low and high tide line. Exploration of natural gas and extraction of salt are permitted

a) Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wild habitats, mangroves, corals/coral reefs, area close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty, historical and heritage areas, areas rich in genetic biodiversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such areas as may be declared by the authorities.

b) The Areas between the Low Tide Line and the High Tide Line Regulations:
No new constructions shall be permitted within 500m of the HTL

- CRZ-2: These areas form up to the shoreline of the coast. Unauthorized structures are not allowed to construct in this zone.
- CRZ-3: Rural and urban localities which fall outside the 1 and 2. Only certain activities related to agriculture even some public facilities are allowed in this zone
- CRZ-4: This lies in the aquatic area up to territorial limits. Fishing and allied activities are permitted in this zone. Solid waste should be let off in this zone.

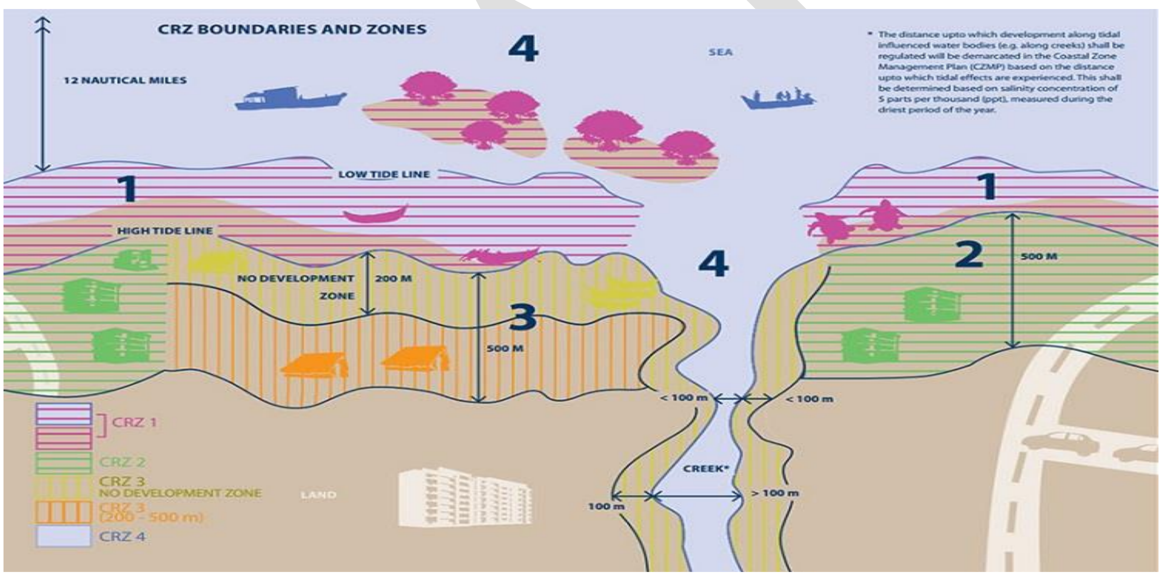


Figure 5-5:CRZ wise Segregation of the proposed project site

5.4.2 Objective of CRZ

- To conserve and protect coastal stretches;
- To ensure livelihood security to the fishing & local communities living in the coastal areas;
- To promote development in a sustainable manner based on scientific principles, taking into

account natural hazards and sea level rise.

Category I (CRZ -I):

a) Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wild habitats, mangroves, corals/coral reefs, area close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty, historical and heritage areas, areas rich in genetic biodiversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such areas as may be declared by the authorities.

b) Areas between the Low Tide Line and High Tide Line

Category II (CRZ -II):

The area that have already been developed up to or the shoreline. For this purpose, ' Developed Area' is referred to as that area within the municipal limits or in other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.

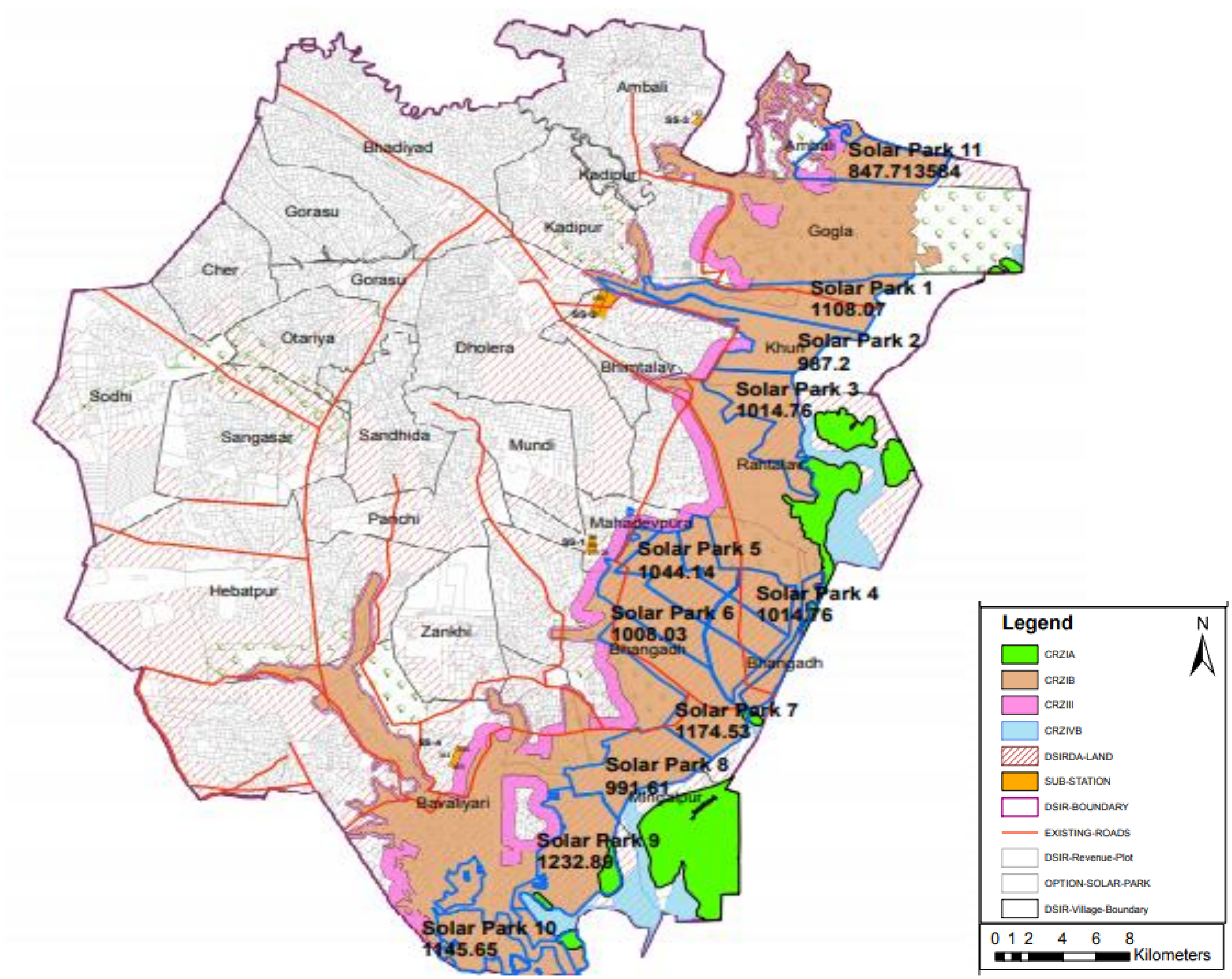
Category III (CRZ -III):

Areas that are relatively undisturbed and those which do not belong to either Category I or II. These will include coastal zone in the areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up.

Category IV (CRZ-IV):

Coastal stretches in the Andaman and Nicobar Islands, Lakshadweep and small islands, except those designated as CRZ I, CRZ II and CRZ III.

As per clause 3 of the notification, setting up of new industries and expansion of existing industries is prohibited with CRZ except, facilities for generating power by non-conventional energy sources and setting up of desalination plant in the areas not classified as CRZ-1(i) based on the impact assessment study including social impact. Therefore, impact assessment study is required to be carried out for initiating activities inCRZarea.



5.5 Climate & Meteorological Conditions

There are four seasons in Dholeranamely summer, south-west monsoon, post-monsoon and winter. Summer starts from March and lasts till end of June. Post-monsoon constitutes October & November. Weather is generally cold during December to February. Throughout the year, temperatures vary by 13.4 °C.

Table 5-3:Annual Temperature & Precipitation at town of Dholera

	Temperature			Precipitation
Months	**Average**	**Warmest**	**Coldest**	**Normal**
January	20.1°C	28.3°C	11.8°C	0
February	22.2°C	30.4°C	13.9°C	0
March	27.3°C	35.6°C	18.9°C	0
April	31.7°C	39.8°C	23.7°C	0
May	33.9°C	41.5°C	26.2°C	0
June	32.8°C	38.4°C	27.2°C	4
July	29.5°C	33.4°C	25.6°C	13
August	28.2°C	31.8°C	24.6°C	15
September	29.1°C	34.0°C	24.2°C	5
October	28.5°C	35.8°C	21.1°C	1
November	24.7°C	32.8°C	16.6°C	1
December	21.3°C	29.3°C	13.2°C	0

5.5.1 Rainfall

The average annual rainfall is 580 mm.Between the driest and wettest months, the difference in precipitation is 223 mm.

5.5.2 Temperature

The average temperature in Dholera is 27.4 °C. At an average temperature of 33.9 °C, may is the hottest month of the year. January is the coldest month, with temperatures averaging 19.9 °C

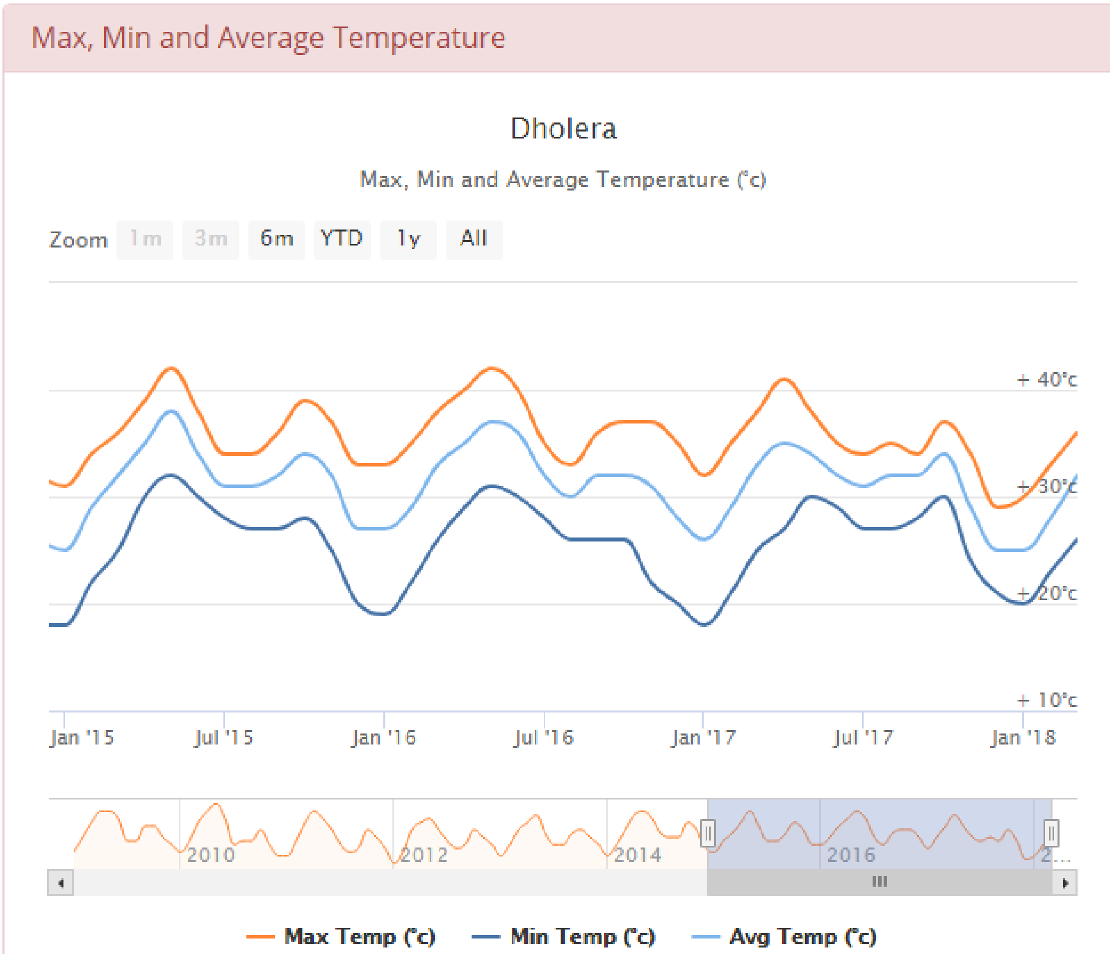


Figure 5-6:Maximum, Minimum & Average Temperature at Dholera for last three years

Source: Weatheronline.com

5.5.3 Wind

The wind speeds in the region are light to moderate with some strengthening during the south west monsoon. The wind speed is generally high during the period from April to August. Wind pattern indicates that wind blows from northeast in post monsoon and winter season, from southwest in monsoon and from northwest in summer season.

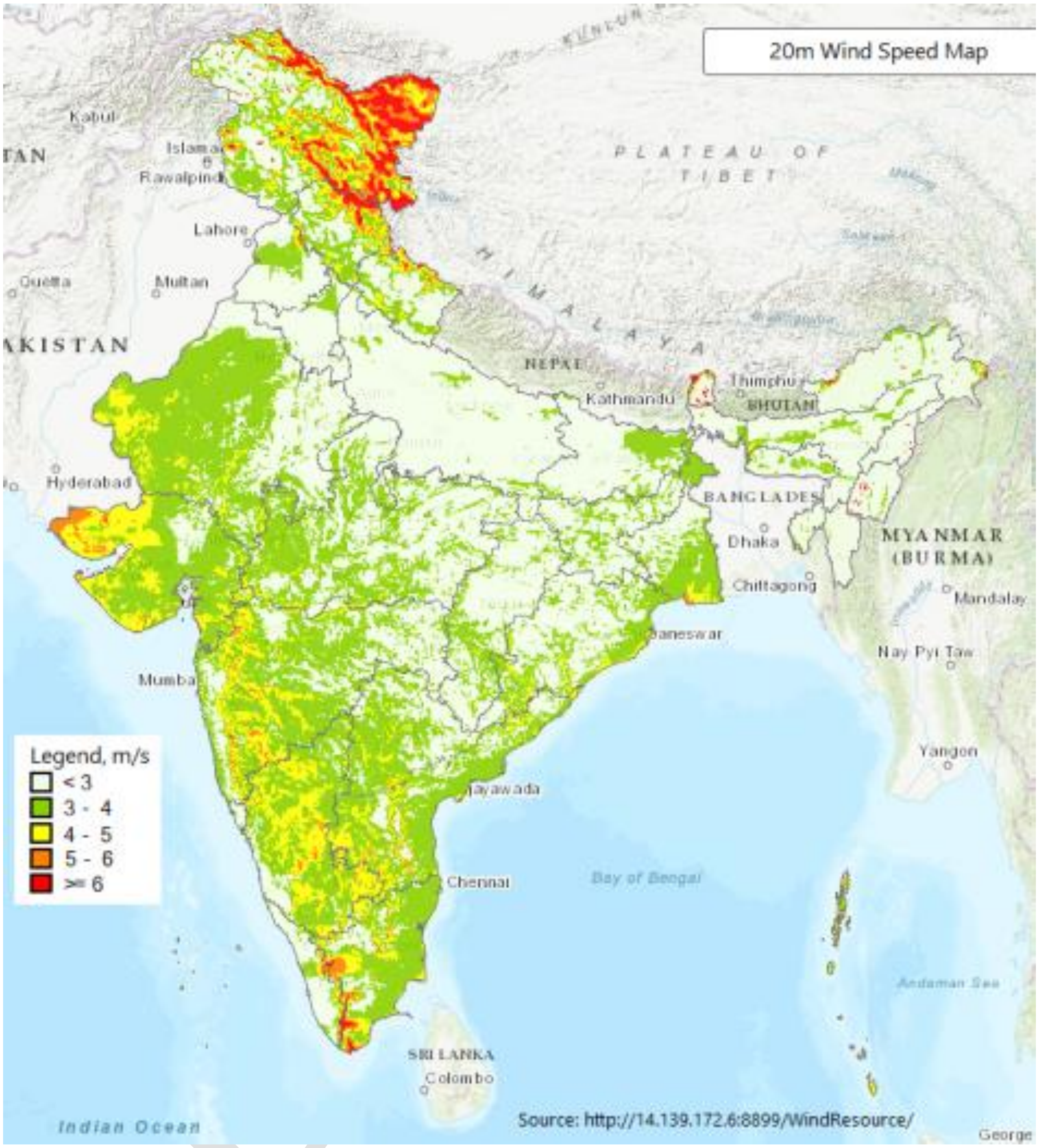


Figure 5-9: Wind map of India

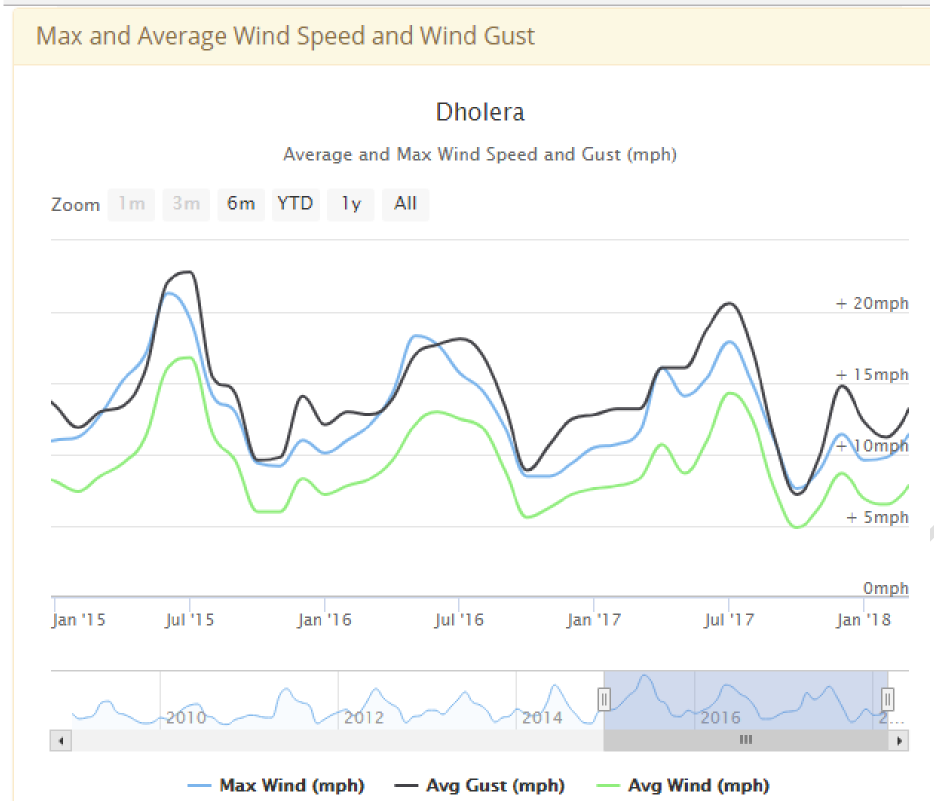


Figure 5-7: Maximum, Minimum & Average Wind Speed and Wind Gust at Dholera for last three years

Source: Weatheronline.com

5.6 Ecology

Dholera is located in the Bhal region of Gujarat. Bhal region is believed to have emerged from the sea during the late Tertiary and early Quaternary, much later than rest of Saurashtra that appeared during the Cretaceous period. Bhal region is flat, coastal alluvial plain consisting of agricultural land, saline wastelands, grasslands and marshes

The area supports very less percentage of the state flora. Certain patches on the coastal line of the area harbor stunted mangrove cover of Avicennia marina. The region mostly consists of mudflats which don't support much of flora. Although moving west, Flora can be found.

5.7 Flood Vulnerability Assessment &Mitigation Measures

The entire flood vulnerability report has been prepared by WAPCOS LTD, Gandhinagar. The rivers traversing the DSIR area are rain-fed rivers and hence water flow in river is only during the rainy season or till rain water precipitated is disposed of. The floods generated in rivers are dependent to the intensity, duration and spread of the rain storm and also the hydraulics of the river.

During high magnitude flood, the water level rises in river channel and overtops the low river banks inundating the surrounding lower area. This causes flood hazard to those areas which may be developed or being developed. The flood hazard is related to extent of development.

5.7.1 Pre DSIR-Scenario

In pre-DSIR development stage the flood level for different flood intervals are computed along the river length and result of Upleta rain storm for 1 in 100-year return period is shown in figure 5. The gist of the results is given in table 7 for 1 in 100-year return period.

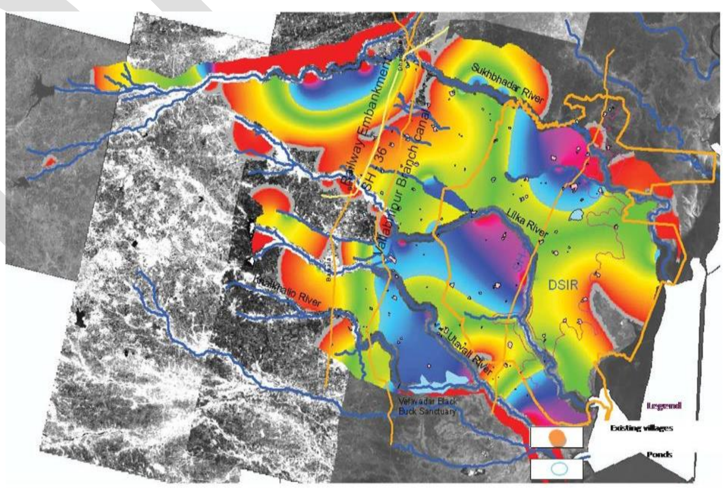


Figure 5-11 : Flood inundation map of DSIR study area due to Upleta rain storm for 1 in 100-year RP on satellite imaginary

5.7.2 Flood Mitigation Measures in Post DSIR Area

As seen from the figure – 5.8-1, there is spread of flood water in the area meant for DSIR development. This is not acceptable for DSIR development hence it is necessary to carry out flood mitigation measures such that inundation of the area even during the highest flood is avertedtosafeguardtheproperties,i.e.industries,businesscenters,etc.orif it is flooded, it is within the tolerable limits.

Considering the flood hazard at DSIR area, the only techno economical solution for flood mitigation is to provide river training with bunding, such that the flood water are confined within the banks of river passing through DSIR area and the sheet flow formed on upstream side is diverted into the river channel for disposal into sea as shown in figure 6. For flood mitigation purpose, the river training from SH-36/Valbhipur canal, DSIR area up to sea are proposed to be connected with the river bank embankments.

It may be mentioned here that river hydraulic for post DSIR development is computed for whole study area. The local area storm water is considered to be disposed of into sea by storm water disposal network system of the DSIR area which is independent system and is unaffectedduetoriverflood.Ifthisisnotdoneitwillrequireraisingofthe DSIRdevelopment area or some alternative arrangement.

However, if it is decided that local area storm water is to be disposed in river channel even afterrivertraining,theperimetersaffectingstormwaterdisposalsystemfromrivertraining aspect mentioned in this report shall be incorporated in storm water disposal system design.

The other aspect is effect of the tide on flood disposal system. The flood is a phenomenon wherein water level increase and then decreases in a long spell as per the rainstorm and hydraulic of the river which will be more than few days. The tide variation is cyclic and time spell is small say of 8 hours only. Both these parameters shall be combined to develop highest water level due to design flood. However, for simplicity constant tide level is taken which is on conservative side and all calculations are done accordingly, giving the highest flood water level in pre-& post Dholera SIR area development stage.

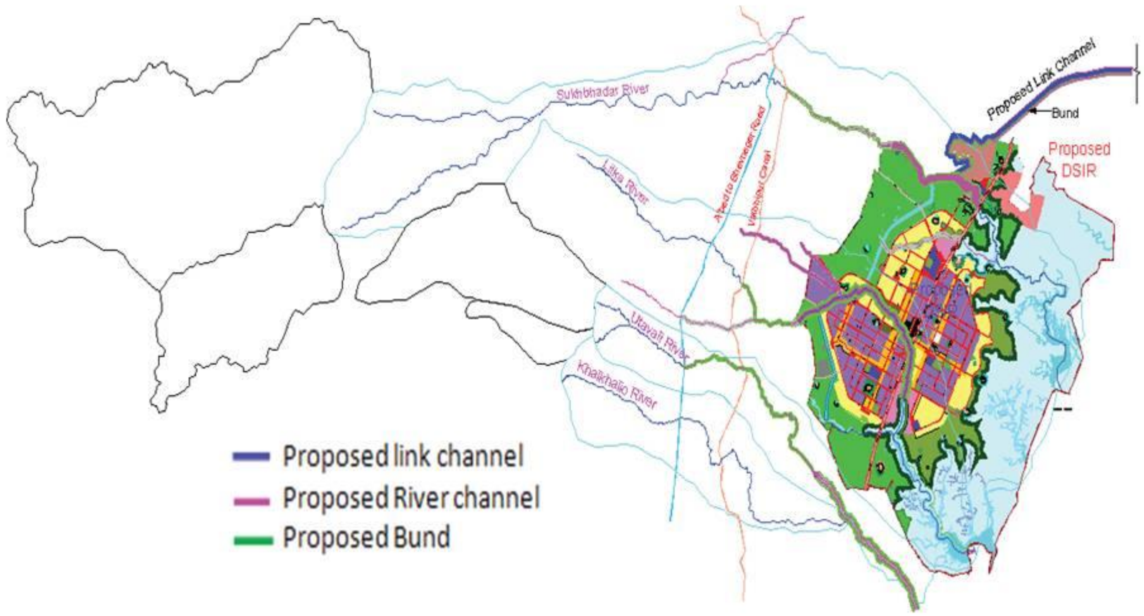


Figure 5-12: River stretch showing proposed bunding and link channel

5.7.3 Training of River Channel

In order to pass the design flood discharge within the river, the river channel is trained to carry the design flood discharge considering the prevailing hydraulic parameters.

It will be a better practice to use this bund as internal or peripheral road so that same are monitored and maintained regularly and are safe from breach due to rain cuts or piping etc. The pitching on both sides shall be provided for safety of bund.

For river training the depth of water in river channel is arrived of by considering natural condition of river water profile. The optimum preferable river channel section, is computed and considered to pass 1 in 100-year return period flood discharge.

Output results of 1 in 100-year return period for Upleta rain storm with river training are available and compared in table below with natural condition.

As may be seen that in the DSIR study area after river training there is no flooding due to upleta rain storm with tide water ingress (with HTL of 5.5m (figure 5.3-8)).

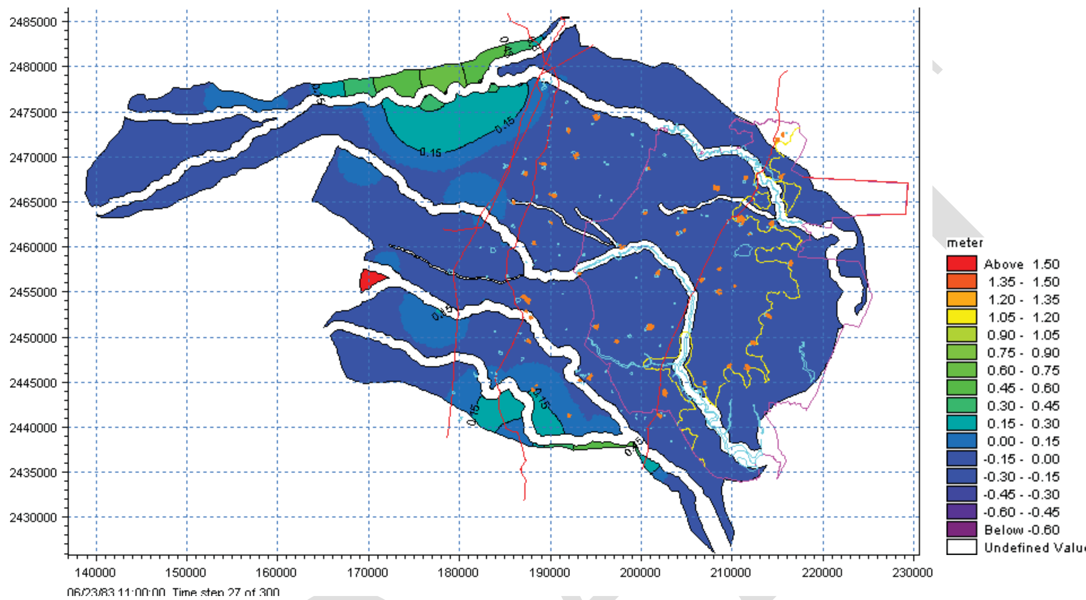


Figure 5-13: Two-dimensional map for Upleta rain storm for 1 in 100-year RP with river training

Link channel in order to divert the flood water forming sheet flow on U/S of airport area, a link channel onU/Softheairportshallbeprovided.Thischannelisdesignedtointerceptanddivertthe flood discharge of 100-year returnperiodintoriver.Thewaterlevel-HFL-forthe100year RP flood is considered for this study.

5.7.4 Connectivity of nallas and tributaries to pond and to river

From the study of the flooding scenario as per existing topography of DSIR and additional areauptoSH-36alongtheseembankments,the river training work is required up to SH-36 for all the rivers. Along with this the tributaries area is to be considered.

For safe disposal of local drainage, it is proposed to connect the nallas and tributaries with ponds coming in drainage path and further connecting the out-fall channel to other pond or to the tributary leading to river provided with river training shown in figure5.8-4anddescribed in report.

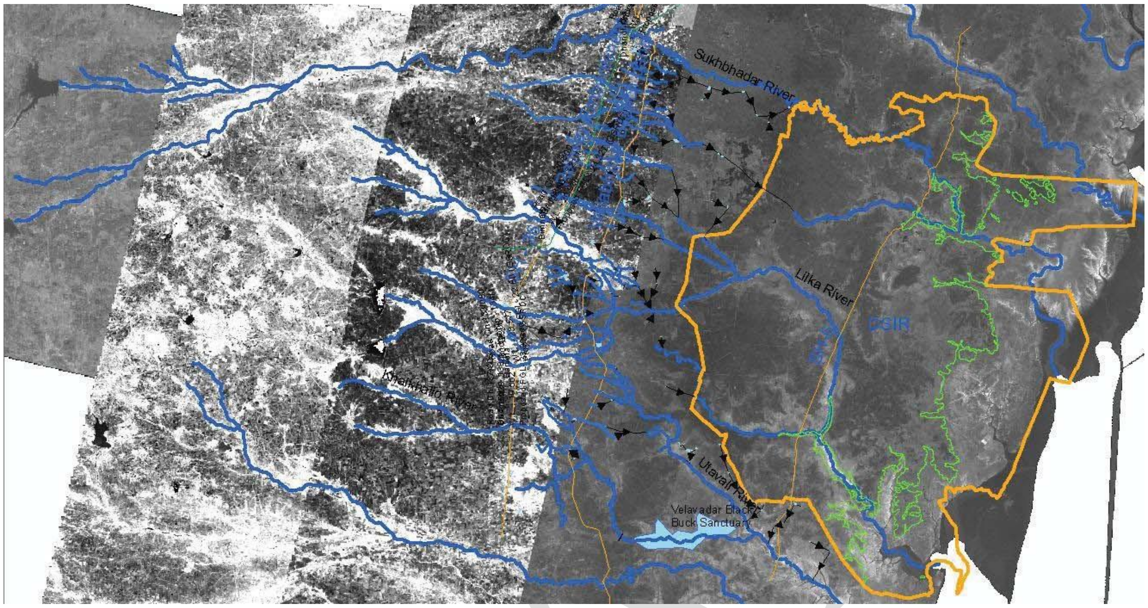


Figure 5-14: DSIR area and SH-36 showing river, tributaries, nallas& pond with connectivity

5.7.5 Disaster Management Plan

Preparation of detailed disaster management plan required inundation map for planning mitigation measure (Non structural) & for flood forecasting. Flood in undation map using the results obtained from MIKE FLOOD (MIKE 11 + MIKE 21) software is available and from the Disaster Management Plan for study area is prepared.

For disaster management plan the non-structural flood mitigation options as listed below can be considered.

5.7.6 Non-structural Mitigation Measures

The non-structural flood mitigation measures are as under.

- Instigation of planning controls to prevent floodplain encroachment in future developmentareas;
- Strict implementation ofbuildingcodesinrespectofnewbuildings;
- BuildingImprovements

5.7.7 Implementation of Measures – FloodMitigation

Flood Mitigation plan

The flood mitigation plan is prepared considering the post DSIR area development ensuring the maximum safety from the flood and tides. The proposed mitigation measures include:

i. Raising and strengthening of the Sh-36(Bhavnagar to Bagodarahighway)
ii. RivertrainingfromDownstreamoftheSh-36/Vallbhipurcanaluptosea
iii. LinkchannelwithbundingonupstreamsideofproposedAirportsite
iv. StrengtheningandraisingoftheSh-6(BhavnagartoDholerahighway)
v. Interlinkingofpondinadditionalarea,betweenSh-36andU/sboundaryofDSIR

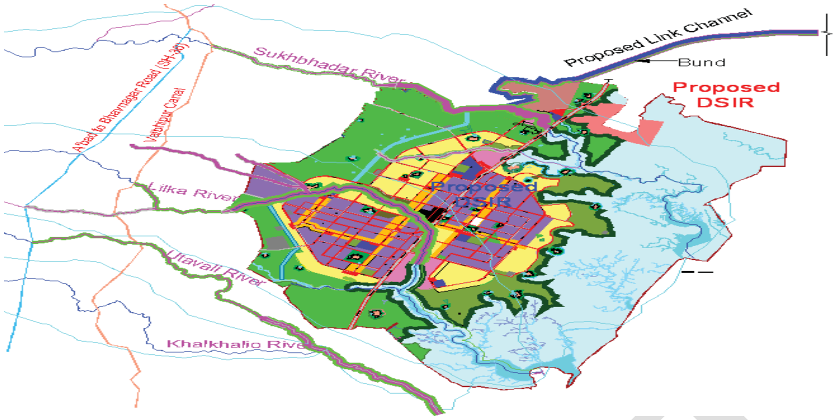


Figure 5-15: Mitigation measures on development plan

Energy & Petrochemicals Department
Government of Gujarat

GUJARAT POWER CORPORATION LTD.

GERMI

Selection of PV Technology

6 Selection of PV Technology

6.1 Background

Climate change is a derivative of unsustainable use of fossil fuels. To minimize this process of adverse alteration of weather phenomenon, it is imperative to reduce the use of fossil fuels by switching to renewable sources. Development of solar generation plants/parks is one such endeavor to mitigate the process of climate change. Globally, this initiative has been taken up to a level of commercial generation of power. And now India has taken a proactive approach to absorb the technology to harness the vast potential of solar energy.

This section presents a brief review of the technology options considered for electricity generation from Photovoltaic systems (PV) for the proposed Solar Park in the State of Gujarat, India.

For the PV technology we discuss the current state of the technology, its relevance to the Solar Park and a likely projection of future developments with respect to costs and efficiency. The review will allow the identification of the key technologies that are likely to be of most interest for the Solar Park.

6.2 Overview of Photovoltaic Technologies

Solar power technologies can primarily be classified under two distinct heads:

1. **Solar thermal technologies**, which utilize the 'heat' aspect of sunlight. Such technologies typically use concentrating mechanisms such as mirrors or lenses of various geometries like parabolic troughs, parabolic dishes, Fresnel mirrors or an array of mirrors spread over a field to concentrate light to heat up a working fluid. This working fluid may be used directly or indirectly to generate steam and run turbines to ultimately generate electricity.
2. **Solar PV technologies**, which utilize the 'light' aspect of sunlight. Photovoltaic technologies use a device called a solar cell to directly convert sunlight into electricity.

It is decided to venture into PV technologies and hence, only these technologies will be discussed in this Detailed Project Report. PV technologies can be classified into first generation bulk silicon technology, second generation thin film technology, and third generation high-efficiency concentrated PV technologies. There are also novel technologies like organic and Dye-Sensitized Solar Cell (DSSC) technologies, which are currently more in the research and development mode.

6.2.1 Bulk Silicon Technology

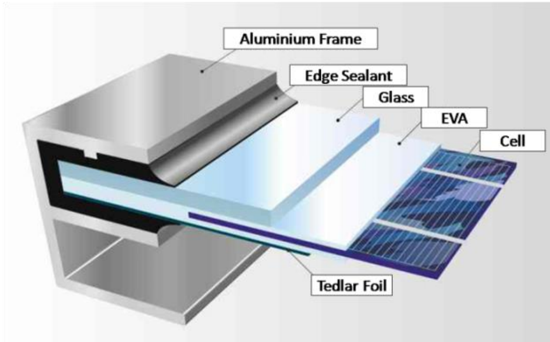
In the bulk silicon photovoltaic technology, the solar cells are derived from pure silicon ingots or blocks by slicing them into wafers. The type of solar cell produced depends upon the quality of silicon material used. Two main types of solar cells based on this principle are available in the market today: Crystalline silicon (c-Si), which is the same as single or mono-crystalline silicon solar cell, and Multi-crystalline silicon (mc-Si), which is the same as poly-crystalline silicon solar cell.

Bulk silicon is most common and mature technology and covers about 80% of the global market share. Solar cells are the heart of the photovoltaic power plant and convert sunlight directly into electricity. The industry standard for solar cell size today is 156 mm x 156 mm (or often called a 6-inch cell), and a thickness in the range of 160-180 micrometers (μm). Typical efficiencies of such cells vary from 14% to 22%, and give power outputs in the range of 3.4 watts (W) to 5.3 W. Standard crystalline and poly-crystalline silicon modules comprise of 60 or 72 solar cells, and are rated for power between 200 and 300 W.

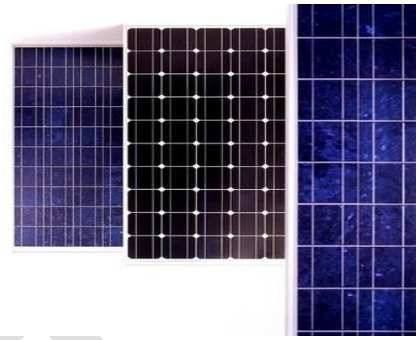
(a)

Figure 6-1: Crystalline and poly-crystalline silicon technology: (a) interconnection of solar cells, (b) cross section of photovoltaic module, and (c) typical photovoltaic modules.

(b)

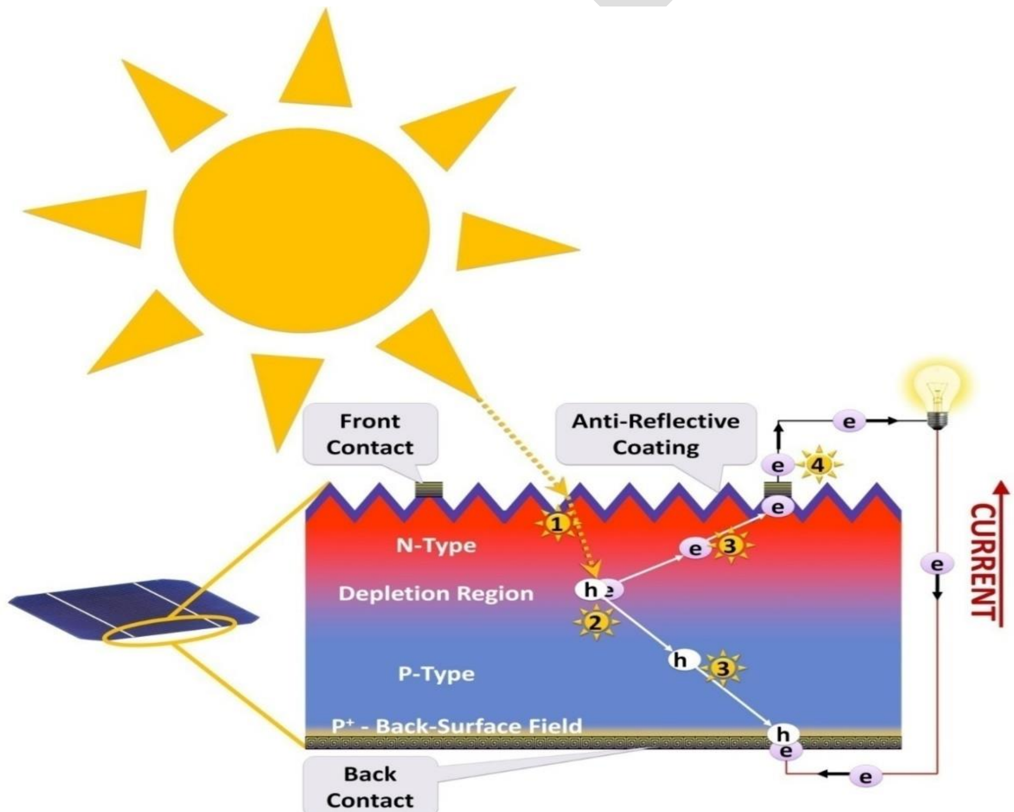


(c)



What happens inside a poly-crystalline silicon solar cell?

A solar cell is a device that <u>directly</u> converts light energy into electricity.



The working of a solar cell can be classified into the following major processes:

1. **Light incidence:** Light is incident on a solar cell.
2. **Electron-hole pair generation:** Light is absorbed in the solar cell and the energy of light is transferred to an electron.
3. **Carrier transport:** Electrons are transported to the n-junction, while holes are transported to the p-junction, thus creating a potential difference or ***'Voltage'***.
4. **External Current:** The p and n-junctions, which act as battery terminals, are connected to an external circuit to utilize the generated ***'Solar Electricity'.***

6.2.2 Thin Film Technology

Thin film photovoltaic modules are constructed by depositing extremely thin layers of photosensitive material on to a substrate like glass, stainless steel, metal foils or plastic. The photosensitive material can be silicon, other semiconductors or even combination of different metals.

Thin film photovoltaic modules are commercially available mainly in the following four categories: 1. Amorphous silicon (a-Si), 2. Multi-junction thin film silicon (a-Si/µc-Si), also commonly known as micro morphtechnology, 3. Cadmium Telluride (CdTe), and 4. Copper Indium Gallium SulphurSelenide (CIGSS) or its variants.

Thin film solar cells use absorber photosensitive material thickness around 1 µm compared to their bulk silicon counterparts with thicknesses around 160-180 µm. Thus, the thin film solar technology offers tremendous cost savings though economical use of expensive semiconductors. However, it is generally being observed that the crystalline quality of semiconductors deposited as thin films are not as high as those in bulk silicon solar cells. The inherent defects in the thin film material result generally into a lower efficiency. However, a substantial amount of research and development is carried out around the world to enhance thin film solar cell efficiencies, and positive results are gradually observed.

6.2.2.1 AmorphousSilicon Thin Film Technology

Amorphous silicon thin film layers, like other thin-film solar cells, are around 1 µm thick. However, on account of the non-crystalline (amorphous) structure of the material, the electron generation is lower resulting into lower efficiency. The present commercial efficiencies for this technology are in the range of 4 to 8%. Module sizes are available around 2 m2, while the maximum size available in this technology is 5.7 m2.

6.2.2.2 Multi-junction (a-Si/µc-Si) Thin Film Silicon Technology

Multi-junction thin film solar cells consist of additional layer of micro-crystalline silicon material (µc-Si). The µc-Si layer absorbs more sunlight in red and near IR region, which increases efficiency of the cell up to an absolute 10%. Current module sizes available with this technology are around 1.4 m^2

6.2.2.3 Cadmium Telluride (CdTe) Thin Film Technology

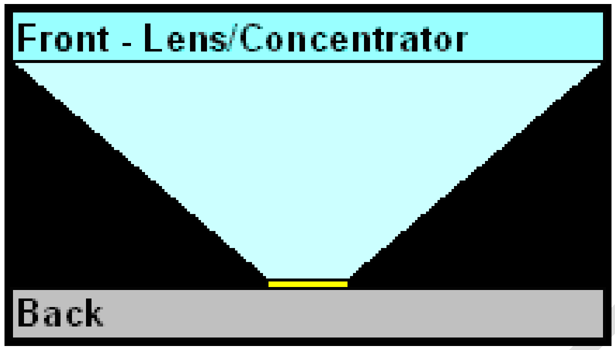
Cadmium Telluride is a very rapidly growing technology. This technology offers low cost for manufacturing and higher efficiency of around 9 to 11% at commercial level, hence making it one of the most economical photovoltaic technology and very attractive for investors.

6.2.2.4 Copper Indium Gallium SulphoSelenide (CIGSS) Technology

CIGSS solar cells have recorded up to 20% efficiency at a laboratory scale, which is very near to that of the commercial crystalline silicon technology. However, due to the involvement of multiple layers, the commercial production of large areas is complex process and is non-standardized. Commercially available CIGSS modules offer efficiencies around 10 to 12%. The module sizes range from 0.6 to 1.0 m^2

6.2.3 Third Generation PV Technology

Third-generation PV systems include technologies, such as concentrating PV (CPV) and



Organic PV cells that are still under demonstration or have not yet been widely commercialized.

	Low Concentration	Medium Concentration	High Concentration
Degree of concentration	2-10	10-100	>100
Tracking	Tracking sys may be required	I-axis tracking sufficient	Dual axis tracking required
Cooling	Minimal Cooling required	Passive cooling sufficient	Active cooling required in most cases

Figure 6-2:Third Generation PV Technology

Third-generation PV technologies are at the pre-commercial stage and vary from technologies under demonstration (e.g. multi-junction concentrating PV) to novel concepts still in need of basic R&D (e.g. quantum-structured PV cells). Some third-generation PV technologies are beginning to be commercialized, but it remains to be seen how successful they will be in taking market share from existing technologies.

6.3 There are four types of third-generation PV technologies

- Concentrating PV (CPV)
- Dye-sensitized solar cells (DSSC)
- Organic solar cells
- Novel and emerging solar cell concepts

Concentrating PV (CPV):

Technology Overview

CPV systems use optic lenses to focus sunlight onto high-efficiency solar cells. Due to the integration of lenses, CPV systems require direct sunlight to operate, so most systems employ single- or dual-axis trackers to follow the sun across the sky.

CPV technologies combine two components to generate electricity: concentrators, which can be either lenses or mirrors, and a semiconducting material based on the array of available PV technologies

CPV is of the most interest for power generation in sun-rich regions with Direct Normal Irradiance (DNI) values of more than 2,000 kWh/ (m^2a). High concentration PV (HCPV) with two-axis tracking concentrates the sunlight by a factor of between 300x to 1,000x4 onto a small cell area enables the use of highly efficient but comparatively expensive multi-junction solar cells based on III-V semiconductors (e.g. triple-junction solar cells made of Ga-

InP/GaInAs/Ge). Low concentration designs – those with concentration ratios below 100x are also being deployed in the solar market. These systems primarily use crystalline silicon (c-Si) solar cells and single-axis tracking, although dual axis tracking can also be used.

The most common classification of CPV- modules is by the degree of concentration, which is expressed in number of "suns".

Pros and Cons of CPV Technologies

Following pros and cons should be taken with a grain of salt because the tradeoffs are changing. Clever engineering is improving both technologies and removing the cons.

Table 6-1:Pros & Cons of Concentrated PV Technology

Strengths	Weaknesses
High efficiencies for direct-normal irradiance (DNI)	HCPV cannot utilize diffuse radiation. LCPV can only utilize a fraction of diffuse radiation
Low temperature coefficients	Tracking with sufficient accuracy and reliability is required for uniform radiation
No cooling water required for passively cooled systems	May require frequent cleaning to mitigate soiling losses, depending on the site
Additional use of waste heat possible for systems with active cooling possible (e.g. large mirror systems)	Limited market – can only be used in regions with high DNI, cannot be easily installed on rooftops
Modular – kW to GW scale	High upfront cost decreases its aspect for competing with technologies for electricity production
Increased and stable energy production throughout the day due to tracking	Bankability and perception issues

Very low energy payback time	New generation technologies, without a history of production (thus, it is perceived as a risk)
Potential double use of land e.g. for agriculture, low environmental impact	Optical losses
High potential for cost reduction	Lack of technology standardization
Opportunities for local manufacturing	–
Smaller cell sizes could prevent large fluctuations in module price due to variations in semiconductor prices	–
Greater potential for efficiency increase in the future compared to single-junction flat plate systems could lead to greater improvements in land area use, BOS costs.	–

Table 6-2:Commercially available solar technologies and market share

S. No.	Technology	Typical Commercial efficiency[1]	Record Laboratory efficiency[2]	Market Share[3]
1	**Mono-Crystalline Silicon**	**14-18%** **Selected: 22-23%**	**25%**	**4%**
2	**Poly-Crystalline Silicon**	**13-16%**	**20.4%**	**71 %**

[1]Source: Martin A. Green et. al., "Solar Cell Efficiency Tables (Version 38)," Progress in Photovoltaics: Research and Applications, Vol. 19, Pg. 565, 2011.
[2]Solar cells are fabricated in laboratories through more sophisticated, accurate and controlled processing compared to commercially- manufactured cells and modules, and hence yield higher efficiencies. Further, efficiencies achieved in laboratories indicate the benchmark for manufacturing processes.
[3]Source: PV News, 2010.

3	**Amorphous Silicon**	**6-9%**	**10.5%**	**5%**
4	**Amorphous/Microcrystalline Silicon**	**-**	**12.4%**	**6%**
5	**Cadmium Telluride**	**9-11%**	**16.7%**	**2%**
6	**Copper Indium Gallium selenide**	**10-12%**	**19.9%**	**Negligible**
7	**III-V Multi-junction**	**35%**	**43.5%**	**Negligible**
8	**Organic Photovoltaics**	**<1%**	**8.3%**	**Negligible**
9	**Dye-Sensitized Solar Cells**	**-**	**10.9%**	**6%**

The predominant c-Si technology is expected to maintain its market share at levels of around 80% principally because of the maturity of the technology and also because of the existing and growing capacity in China and APAC countries, which favor wafer-based technologies. The low production costs of c-Si technologies will allow it to remain the top PV technology in the coming years. Cost reductions and record efficiencies on cell and module level keep the Levelized Cost of Electricity (LCOE) values low and the attention ofthe existing and new industry players high, making c-Si appear to be a less risky investment under healthy market conditions.

After the huge growth expectations of Thin Film (TF) technologies some years ago, the competing market price of c-Si has slowed the development of TF. The latter are expected to grow anyway at a lower rate, and therefore will stabilize their market share over the next five years. Among emerging technologies, Organic PV technologies and especially Concentrated PV technologies both Low Concentrated PV (LCPV) and High Concentrated PV (HCPV) are expected to enjoy around 1% of the market share by 2017. As far as high-efficiency (above 20%) modules are concerned, due to lower competition within the respective players a 3% share could easily be reached. In addition, the overall efficiency of PV modules should increase thanks to the generalization of 20%-efficiency cells, in between the traditional c-Si and the high efficiency mentioned here

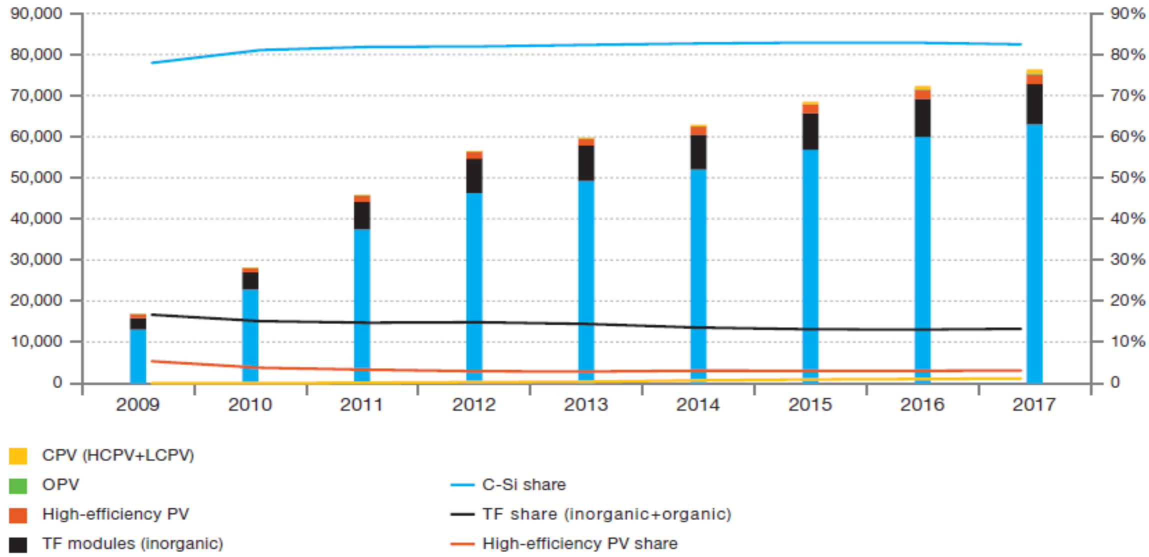


Figure 6-3:PV modules production capacity until 2017 (MW; %)

Source: EPIA, IHS Solar, PV Insider and SNE Research

6.4 PV effects on rise in atmospheric temperature.

The electrical performance is primarily influenced by the type of PV used. A typical PV module converts 6-20% of the incident solar radiation into electricity, depending upon the type of solar cells and climatic conditions. The rest of the incident solar radiation is converted into heat, which significantly increases the temperature of the PV module and reduces the PV efficiency of the module.

Like all other semiconductor devices, solar cells are sensitive to temperature. Increases in temperature reduce the band gap of a semiconductor, thereby effecting most of the semiconductor material parameters. The decrease in the band gap of a semiconductor with increasing temperature can be viewed as increasing the energy of the electrons in the material. Lower energy is therefore needed to break the bond. In the bond model of a semiconductor band gap, reduction in the bond energy also reduces the band gap. Therefore, increasing the temperature reduces the band gap.

In a solar cell, the parameter most affected by an increase in temperature is the open-circuit voltage. The impact of increasing temperature is shown in the figure below.

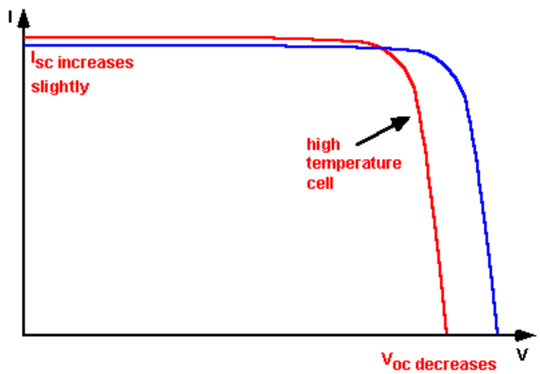


Figure6-4: The effect of temperature on the IV characteristics of a solar cell

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Solar cell performance decreases with increasing temperature, fundamentally owing to increased internal carrier recombination rates, caused by increased carrier concentrations. The operating temperature plays a key role in the photovoltaic conversion process. Both the electrical efficiency and the power output of a photovoltaic (PV) module depend linearly on the operating temperature.

6.5 Critical Balance of System (BoS) Components

All components of a solar PV power plant except the PV modules are collectively termed as the Balance of System (BoS). With the reducing costs of the PV modules, the cost of BoS may surpass the cost of PV modules. Thus, the selection of the BoS components is as critical as the selection of an appropriate PV technology.

The BoS includes components such as inverters, module mounting structures, power and communication cables, combiner/ junction boxes, transformers, power evacuation switchyard, Supervisory Control and Data Acquisition (SCADA) system, etc.

Inverters

All commercial PV modules today generate only Direct Current (DC), so inverters become essential to convert this DC into Alternating Current (AC), either for direct AC applications or feeding into the grid. PV modules are connected in series and parallel combinations, which are then connected to the inverter. The functionality of an inverter includes:

- Maximizing the output power from the modules by maximum power point tracking (MPPT)
- Converting the DC into AC
- Power factor adjustments;
- In case of grid-tied inverters, synchronizing the output voltage and frequency to match the grid parameters; and
- Offer safety and protection to and from the PV system.

Inverters are rated for their power handling capacity, and inverters ranging from less than 1 kW and more than 1 MW capacity are commercially available in market. Inverters for solar PV power projects are classified based on their operational philosophy, which also has an implication on its capacity.

Operational Philosophy and Design consideration of Inverter

If loads are AC driven, an inverter can be used to convert from DC from PV array and battery to AC. Commonly available inverters can output in Single or Three phase, 50 or 60 Hz and 117 or 220 volts.

Solar PV inverter use maximum power point tracking to get the maximum possible power from the PV Array. The inverters utilize **Maximum Power Point Tracking (MPPT)** technology as it allows the inverters to determine the peak power point on the IV curve of an array, given current environment and operating conditions.

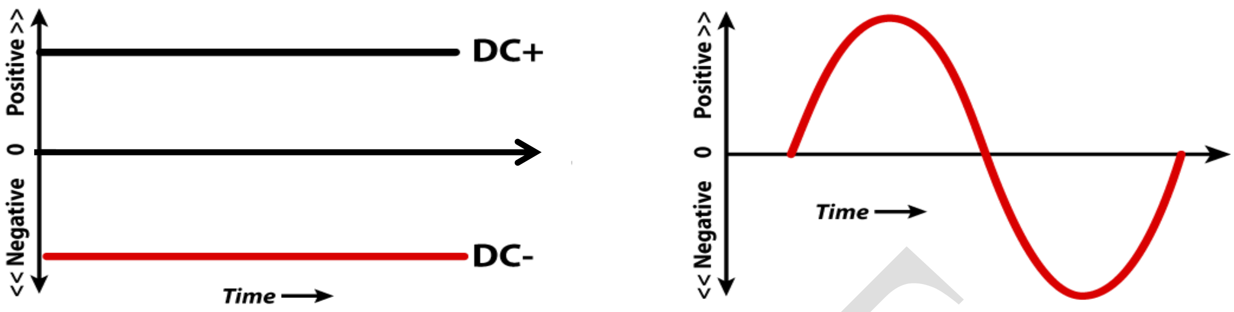


Figure 6-5:AC& DC current

Type based on the application of the inverters (system configuration):

- **Grid-connected inverters**: The Grid-connected inverters match the phase with utility supplied sine wave. If the utility supply fails, the inverter will automatically shut down. They don't supply backup power during grid outages.
- **Stand-alone inverters (off-grid)**: The Stand-alone inverters are used in isolated systems where the inverter draws DC from battery which is charged by Photovoltaic Array. These do not interface in any way with the utility grid.
- **Battery-backup inverters**: are special inverters which are designed to draw energy from a battery, manage the battery charge via an onboard charger, and export excess energy to the utility grid. These inverters are capable of supplying AC energy to selected loads during a utility outage and are required to have anti-islanding protection (explained later).

Type based on different topologies:

- **Central Inverter:** The total produced DC Voltage of entire PV Array is converted to AC Voltage Central Inverter.
- **Module Inverter:** The output of different PV Modules are converted to AC voltage with different Module level Inverters. They have excellent data monitoring system, which allow viewing information about each module/inverter unit.

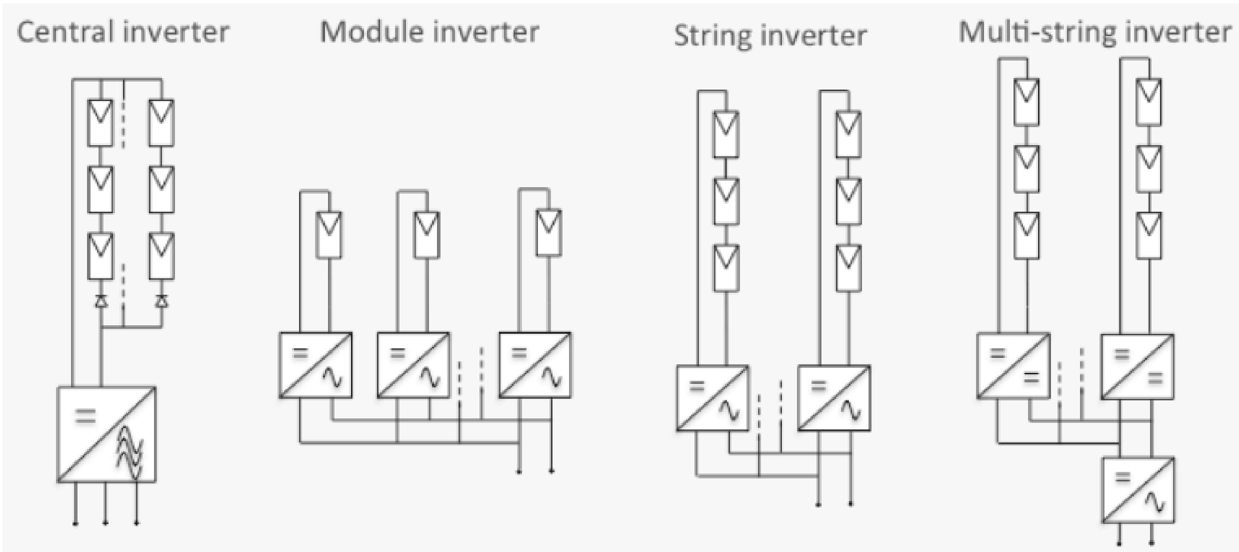


Figure 6-6:Types of inverters

- **String Inverter**: The output of PV Modules in a string is converted to AC voltage when connected to string inverters. These inverters are very good at a place where shading effect are prevalent.

The following are the list of important factors that needs to be considered in inverter design:

Inverter efficiency: The inverter should be as efficient as possible, certainly above 90% over most of its normal operating range. Many moderately priced inverters can achieve above 94% efficiency. Inverter efficiency varies with respect to the amount of power being converted.

Output Waveform: The wave form of the inverter output can be an important factor in matching inverter to load. The waveform describes the way the current and voltage vary over time. There are three different kinds of wave forms. They are Square wave, Sine wave, Modified square wave or Modified sine wave. Based on the type of wave quality inverters can be of three different types:

- Square wave: cheap, able to cope higher input harmonic content, output is same as RMS value but with noise
- Modified sine wave: Medium range quality
- Sine wave (best wave quality)

DC Input voltage: The input DC voltage tends to be a function of the size of the inverter. As the power through the inverter increases, more current flows and there is greater internal heating. Small inverters tend to operate in 12V while large inverters tend to operate in 24V.

Voltage Regulation: At higher power levels, the inverter draws large currents from the battery. This causes the battery voltage to fall. The inverter should be able to compensate for this voltage drop and maintain output AC voltage fairly well.

Serviceability: The inverter design should allow easy servicing in the field

Adjustable Threshold: Most Inverters have some threshold of load power requirement before they actually turn on and commutate to produce AC power. If the load threshold is higher than some small loads in a house, the inverter may not sense the load and it will not operate alone. Some inverter models offer an adjustable threshold level.

Surge Power: Inverter should be able to supply surge power for few seconds as required by the inductive load during starting.

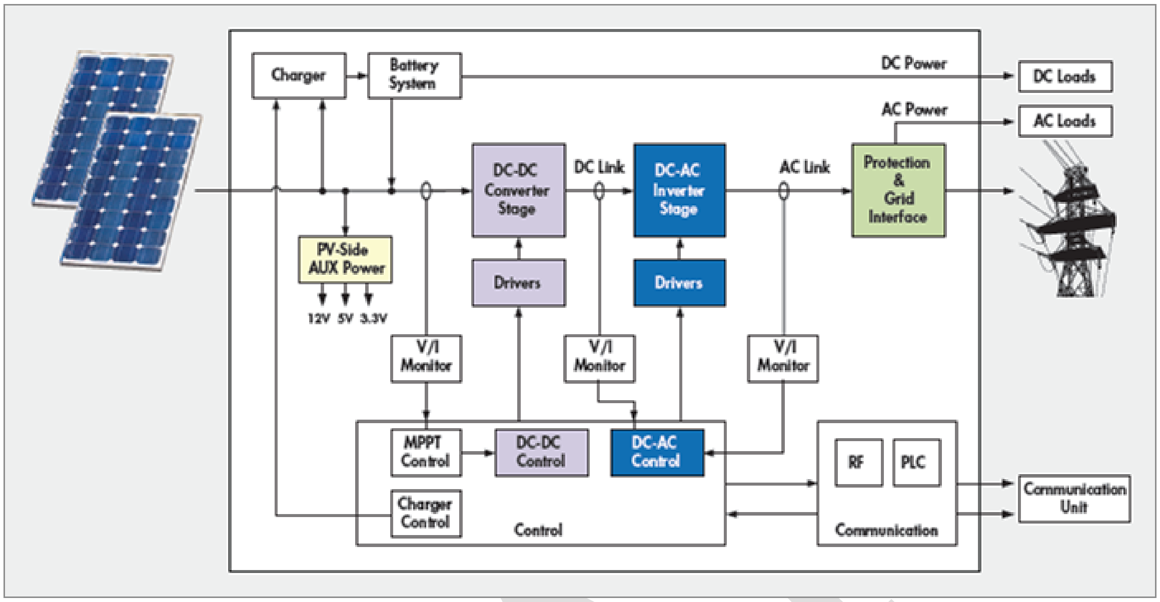
Frequency: inverter are designed for specific frequency depending on location. E.g. 50 Hz/ 60 Hz. The frequency variation of poor inverters can cause slow damage of the load.

Quality of Power in inverter: The quality of power is measured in terms of THD-Total Harmonic Distortion. The THD should be as low as possible. The THD value for good quality inverter is always less than 4%. Poor wave quality is not recommended because it can cause damages to the load or malfunctions (e.g. digital clock running fast or slow)

No Load Power Consumption: Power Consumed by Inverter under No Load Condition. Power Consumption under No Load Condition should be as small as possible to minimize the power loss.

Anti-islanding: This feature is required for the grid-tied inverters for the dangerous situation wherein the grid shuts down but a distribution generation like PV source continues to operate and provide electricity to the to the otherwise de-energized grid. The inverters are generally engineered to never create power islands.

Components of a grid-connected solar photovoltaic inverter.



The working of a typical megawatt-scale grid-connected central inverter can be described through its various blocks as follows:

The DC generated from the PV modules of an array is in the voltage range of 300-900 VDC depending on the solar plant design.

This DCissensed by the Voltage/ Current (V/I) monitoring circuit and the information is fed into the main Controller of the inverter.

The DC-DC converter block provides a stable DC output and also adjusts the input impedance for the incoming DC through a 'maximum power point tracking' (MPPT) algorithm in order to transfer maximum power from the photovoltaic array into the inverter.

The stable DC is then fed into the 'DC-AC Inverter Block,' which converts the DC into AC.The DC-AC inverter matches the frequency of the output taking referencefrom the grid.The Controller accurately controls the voltage, frequency and phase of the output AC.

The Controller is connected to a communication interface primarily for monitoring and sometimes also for controlling (e.g. for reactive power) the inverter.

A Charge Controller is often used to charge batteries for auxiliary DC loads.

Protection devices against surges, lightening, etc. are installed both at the incoming and grid-side of the inverter and are often guided by appropriate standards.

Power Evacuation Mechanism

In an electric power system, switchgear is the combinations of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment. Switchgears are used both to de-energize equipment to allow work to be done and to clear faults downstream. Such equipment's are important because they are directly linked to the reliability of the electricity supply.

Typically, switchgear in substations is located on both the high voltage and the low voltage side of large power transformers. The switchgear on the low voltage side of the transformers may be located in a building, with medium-voltage circuit breakers for distribution circuits, along with metering, control, and protection equipment. For high voltage applications, a transformer and switchgear line-up may be combined in a single housing, called a substation.

6.6 The Photovoltaic Industry Value Chain

The solar PV industry value chain can broadly be categorized into two segments:

- **Upstream:** It includes the manufacturing of various components including polysilicon, solar cells, PV modules, and other components such as inverters, transformers, module mounting structures, wires, SCADA and so on.
- **Downstream:** It includes activities such as retail, implementation of projects, and other services.

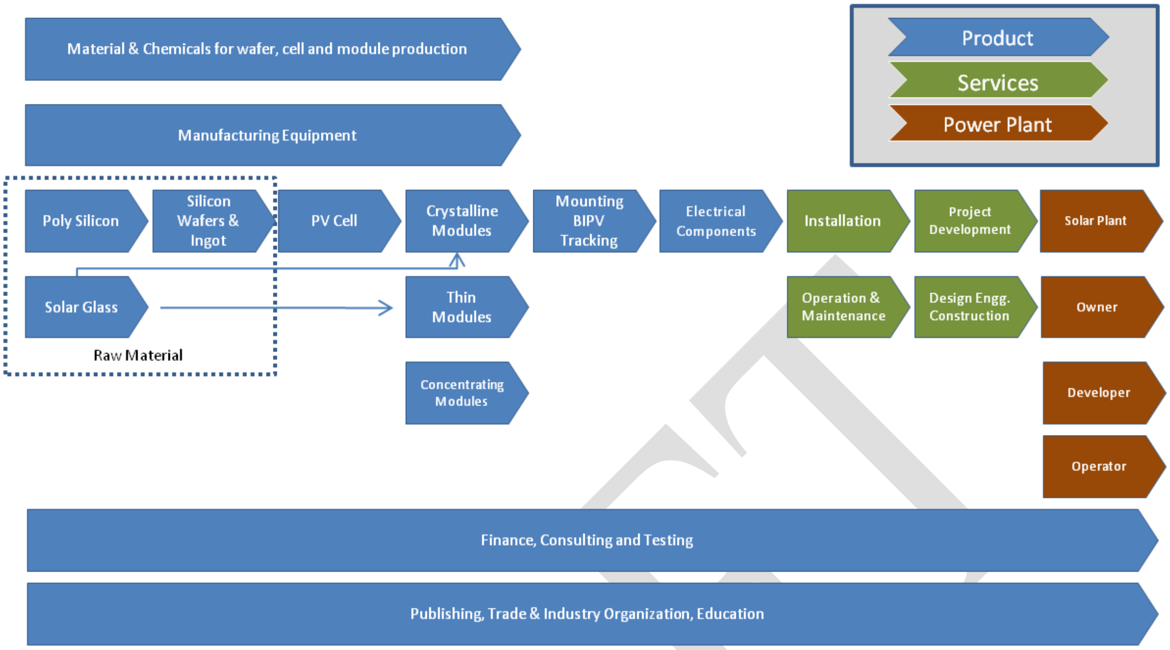


Figure 6-7:Photovoltaic industry value chain

6.6.1 Manufacturing of Polysilicon

Polysilicon is the first step in the PV value chain. Polysilicon contributes to one fourth of the cost of the crystalline or polycrystalline silicon PV module. Polysilicon production is primarily driven by two factors: (i) electricity requirement to the tune of 100 to 200 kWh per kg, and (ii) production yield, wherein about 1.2 to 1.6 tonnes of metallurgical-grade silicon (MG-Si) is required to produce one tonne of solar-grade silicon. Polysilicon used in the PV sector is of relatively lower quality at 99.9999% purity (i.e. 6N) compared to electronic grade silicon of 99.9999999% purity (9N).

Around three-fourth of the global silicon production is catered to the PV manufacturing sector. Globally, the industry is dominated by seven companies that supply to around 90% of the total polysilicon market, which are Hemlock, WackerChemie, REC, MEMC, Tokuyama, Mitsubishi and Osaka Titanium. Currently, there in no major polysilicon production in India. However, some companies such as Lanco Solar, Bhaskar Silicon and Yash Birla Group have announced plans to set up polysilicon manufacturing plants in India.

6.6.2 Preparation of Ingots and Wafers

The polysilicon is melted into large quartz crucibles, and then cooled down to form long solid blocks called ingots. The type and purity of ingot derived, whether crystalline or polycrystalline, depends upon the process used. These ingots are then sliced into wafers using wire-saws.
The global production capacity of wafers and ingots ranged between 30 and 35 GW in 2010. The wafer industry is dominated by five companies sharing over 90% of the market, with Shin-Etsu and Sumco. alone having a third each. Most of this production was concentrated in China, which accounted for about 60% of the global wafer production capacity in 2010. Currently, there is no significant production of wafer manufacturing in India.

6.6.3 Solar Glass

Solar glass is used for protection and performance enhancement of solar cells. In the case of thin film solar cells, this glass is also used as a substrate. The properties of solar glass are different from standard glass; solar glass requires specific designs for the glass manufacturer to cater for higher melting temperatures and prevent contamination by iron particles. While glass is a commodity, the solar industry is still experiencing regional imbalances in its demand and supply.

6.6.4 Solar Cells

Solar cell manufacturing is an important step in the value chain as significant technical differentiation is created in this stage. In case of bulk silicon technology, the silicon cell is fabricated into a solar cell. In case of thin film technologies, solar cell is fabricated on glass or any other substrate, wherein the semiconductor is transported in a vapor or gaseous state and deposited on the substrate.

6.6.5 Photovoltaic Modules

Multiple solar cells are connected in series and encapsulated between polymers and glass. Ethyl Vinyl Acetate (EVA) is common transparent gel-like encapsulant which encapsulates the solar cells through a lamination process, while tedlar is usually used as a back-strengthening sheet. For the end user, the nature of the cell technology used is seldom the main concern. The parameters they find more important are the price per watt-peak of the module, energy yield per watt-peak under field conditions, the module's size and weight, appearance, etc.

The list of top 10 solar photovoltaic module manufacturers in terms of market share in 2015 is provided in Annexure 6.

6.6.6 Integration and Other Services

It is through the integration that various components of the solar value chain including PV modules and BoS are brought together and a solar plant is constructed through the engineering, procurement and construction (SPD) process. The SPD would be followed by operation and maintenance (O&M) of the plant. The services involved in the project development process include various retail, design and financial services.

6.7 Cost Components of Photovoltaic Power Plant

6.7.1 Photovoltaic Modules

The cost of the PV modules account for more than half the cost of the entire photovoltaic power plant, and hence, have a substantial impact on the resultant Levelized Cost of Electricity (LCOE). However, the PV module prices, irrespective of module technology, have been steadily declining owing to research and development, industry adaptation and economies of scale. The module prices have declined by more than half over the last decade and are expected to drop at the same rate in the near future.

The short-term historic trends indicate a significant drop in crystalline silicon module costs over the last one year ranging from 14% to 31% depending on its origin. The JNNSM in Phase I mandate the use India-made modules in case of crystalline and poly-crystalline silicon modules, the costs for which are closer to their Chinese-made counterparts. In Phase II under various schemes the Government of India provided incentives on Indian make cells and modules. Recent quotations for such modules obtained from domestic and international suppliers have indicated a price range of INR 25 - 35 per watt.

Additionally, the results from the Solar Energy Corporation of India (SECI) tender under JNNSM Phase II Batch I showed that the average difference between Viability Gap Funding (VGF) stated by bidders in the Domestic category versus Open category was 1.061 Crore.

Table 6-3:Indicative prices of PV modules of various origins in 2014

r.	Module Type (Origin)	Price (Rs/W)
	Crystalline Silicon (Germany)	45.28
	Crystalline Silicon (Japan)	45.98
	Crystalline Silicon (China)	38.91
	Thin-film Amorphous/ Microcrystalline	26.88
	Thin-film Cs-Te/Cd-S	38.20

6.7.2 Inverters and Other BoS

The price of the inverter is substantially governed by the capacity of the inverter, and accounts for 8 -12 % of the cost for a megawatt-scale photovoltaic power plant. Typical central inverter costs are in the range of Rs. 5.2 to 8 per watt depending upon the make and capacity. As the share of the inverter cost is lower compared to the overall project cost, Developers tend to be conservative in ensuring high quality inverters even if at a slightly higher cost.

As the solar PV market has been exhibiting strong growth, the demand for inverters began to outgrow the supply causing a bottleneck around 2009. As a result, the inverter prices did not see an aggressive reduction recently. However, with major inverter suppliers in Europe, USA, Taiwan, etc. increasing their capacities, the prices of inverters have started coming down at an annual rate of 10-15%. Further, with a surge of manufacturers from China as well as the push for manufacturing from India, the inverter prices are further bottomed down in comparison to last couple of years and may further reduce in the near future.

Other BoS components such as transformers, module mounting structures, DC and AC power cables and civil-related activities can be sourced from the domestic market. Moreover, the costs associated with project engineering, module mounting structures, and civil works are expected to decline with more industry learning in the coming few years.

6.7.3 Land Requirement

The land requirement for solar PV power projects primarily depends upon:

- Efficiency of the PV technology
- Type of tracking used.

The land requirement for a particular technology will be inversely proportional to its PV module efficiency. It is an accepted rule of thumb that a 1 MW solar PV power plant with poly-crystalline silicon modules of 14% efficiency fixed at optimum inclination in Gujarat will utilize 4.5-5 acres of land. (This land requirement increases at higher latitudes and decreases while moving towards the equator.) Similarly, a 1 MW solar PV power plant with 9% efficient thin-film modules will utilize 7-7.75 acres of land.

Various types of tracking mechanisms are used in order to maximize the capture of sunlight by the PV modules. The tracking can be single-axis based on daily motion of the modules from morning to evening, or it can be in a seasonal manner where the inclination of the modules is changed only a limited number of times during the year based on the season. Daily tracking has to be automated using motors and drives, while seasonal tracking can be automated or manual. Further, two-axis tracking is typically used for high-efficiency (third-generation) PV modules, which further increases the yield compared to single-axis tracking.

However, various tracking technologies also require additional land area to be able to incorporate the flexibility of PV module orientation without casting shadow on each other.

Table 6-4:Comparison of Land Requirement for Various Type of Tracking Used

Type of Tracking	Energy Yield	Land Requirement
Fixed at optimum tilt	Reference case	Reference case
Fixed horizontal	Decreases by 8-9%	Decreases by 50-70%
Single-axis seasonal	Increases by 3-5%	Increases by 20-30%
Single-axis daily	Increases by 20-25%	Increases by 20-40%
Two-axis	Increase by 25-30%	Increases by 80-120%

6.7.4 Operation and Maintenance

Solar PV power plants are characterized by their simple and low-cost operation and maintenance (O&M). The O&M of a solar PV power plant mainly involves cleaning of the PV modules at a regular interval. The cleaning frequency of the modules of a commercial plant may be as high as once per week or as low as once per month.

In addition to cleaning staff, the solar PV power plants typically require security staff and site supervisors. Performance monitoring of such plants are typically done remotely, and an engineer is deployed onsite only during troubleshooting of issues.

6.8 Technical Specifications of the Main Equipment

Technical Specifications of Major Components of Solar PV Power Plant

i. Solar PV modules and array
ii. Module mounting structures
iii. Junction Box & Array junction box
iv. Power Conditioning Unit
v. Switchyard
vi. DC & AC distribution Boards
vii. Cables and installation accessories
viii. Main control room
ix. Earthing and lightning protection

6.8.1 Solar PV Module & Array

- Each solar module shall consist of redundantly interconnected photovoltaic cells and peak power rating shall not be less than **280 Wp.**
- To connect the solar modules interconnection cables shall be provided. Photoelectric conversion module-efficiency shall be greater than **15%.** Modules shall be made of high transmissivity glass front surface giving high encapsulation gain and silicon rubber edge sealant for module protection and mechanical support.
- All materials used shall have a proven history of reliable and stable operation in external applications. It shall perform satisfactorily in relative humidity up to 100% with temperatures between **-30°C and +85°C** and with stand gust up to 200 km/h from the backside of the panel.
- Modules must qualify latest edition of **IEC 61215** for quality of crystalline silicon solar cell modules and **IEC 61730** for safety qualification testing.
- The manufacturer must make it sure and should certify that the supplied module is also manufactured using same material design and process similar to that of certified PV module.
- The BOS items/ components of the SPV power plants/ systems deployed must conform to the latest edition of IEC/ Equivalent BIS Standards/ MNRE specifications/ as specified.
- PV modules to be used in a highly corrosive atmosphere (coastal areas etc.) must qualify Salt Mist Corrosion Testing as per **IEC 61701 / IS 61701**.
- PV module must be tested and approved by one of the IEC or MNRE authorized center. Authorized test centers are a) SEC, Gurgaon, b) ERTL, Kolkata, c) ETDC, Bangalore, d) UL, Bangalore and e) TUV, Rhineland
- **Warranty for Performance**: PV modules used in solar power plants/ systems must be warranted for their output peak watt capacity, which should not be less than 90% at the end of 12 years and 80% at the end of 25 years. If, under the standard test conditions, the module(s) is/ are not providing the warranted percentage of its/their specified minimum power output (as certified by an authorized test center of MNRE at the time of complaint) during the term of the warranty, then the manufacturer shall, repair or supply equivalent module(s) for replacement or provide additional module(s) to bring the aggregate power output to the warranted percentage of the specified minimum power output at his own cost.
- **Warranty for Manufacturing Defects**: The manufacturer must provide 10 years warranty for

manufacturing defects in materials and workmanship i.e.- If during the term of this warranty, the module(s) is/ are found to be having manufacturing defects, then manufacturer shall, either (i) repair, or (ii) replace with an equivalent module(s), or, (iii) refund the purchase price at his own cost.

- The module frame shall be made of corrosion resistant materials, which are electrolytically compatible with the structural material used for mounting the module. Module Junction box (weather resistant) shall be designed for long life outdoor operation in harsh environment.
- Necessary protection arrangements to PV module must be provided to protect the module against failure or from de-rate; such as protective devices against surges at the PV module, low voltage drop bypass and/ or blocking diode(s) etc.
- The solar modules shall have suitable encapsulation and sealing arrangements to protect the silicon cells from the environment. The arrangement and the material of encapsulation shall be compatible with the thermal expansion properties of the silicon cells and the module framing arrangement/material. The encapsulation arrangement shall ensure complete moisture proofing for the entire life of the solar modules.
- Each module shall have low iron tempered glass front for strength and superior light transmission. It shall also have tough multi layered polymer back sheet for environment protection against moisture and provide high voltage electrical insulation.
- The fill factor of modules shall not be less than **0.70.**
- Recently, it is observed that a problem of PID (Potential Induced Degradation) of solar modules occur due to leakage current under high voltage typically in PV power plant. This happened due to large potential difference between with the solar cell at high voltage and zero potential in the grounded frames. PID is not presently covered under IEC, however, it is critical for longer life of modules. The manufacturer should provide with the modules with minimum PID or PID free.
- Special care should be taken to make it sure that same capacity of modules are used throughout the power plant and all the modules are from single manufacturer to avoid inherent mismatching.
- Array capacity shall not be less than the designed capacity and number of modules required shall be worked out accordingly.
- Modules alignment and tilt angle shall be calculated to provide the maximum annual energy

output at site.

- Each PV module must have following information on back of the module in the form of RFID as well as label and the same must be able to withstand harsh environmental conditions.

i. Name of the manufacturer of PV Module

ii. Name of the Manufacturer of Solar cells

iii. Month and year of the manufacture (separately for solar cells and module)

iv. Country of origin (separately for solar cells and module)

v. I-V curve for the module

vi. Wattage, Im, Vm and FF for the module

vii. Unique Serial No and Model No of the module

viii. Date and year of obtaining IEC PV module qualification certificate

ix. Name of the test lab issuing IEC certificate

x. Other relevant information on traceability of solar cells and module as per ISO 9000 series.

6.8.2 Module Mounting Structure

- The structure shall be designed to allow easy replacement of any module and shall be in line with site requirements.
- The structure shall be designed for simple mechanical and electrical installation. It shall support SPV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly. There shall be no requirement of welding or complex machinery at site.
- The legs of the structures made with GI angles will be fixed and grouted in the PCC foundation columns made with M30 grade. Module mounting structure to be manufactured with steel angles and channels should be hot dip galvanized or steel pile foundations.
- The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panels. The minimum clearance of the lowest part of any module structure shall not be less than **50 cm** from ground level.
- While making the foundation design, due consideration shall be given to weight of module assembly, maximum wind speed of **180 km/hr** and seismic factors for the site.

6.8.3 Junction Box & Array Junction Box

The junction boxes should be of dust, vermin, and water proof and made of Thermo Plastic. The terminals should be connected to copper bus-bar arrangement of proper sizes. Suitable marking on the bus bars shall be provided to identify the bus bars etc. The junction boxes should have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.

Table 6-5:Technical Specification of various Junction boxes

Technical Specification – Junction Boxes	
Material	Thermoplastic
Type	Dust, Vermin & Water proof
Hardware	SS304
Cable Gland	Thermoplastic
Protection	IP 67

6.8.4 Structure Foundation

In foundation practices, the important aspect is bearing capacity of soil. Bearing capacity can be defined as the maximum load that can be carried by the soil strata. When the soil is strong enough that it can carry the whole load coming on it, in that case a shallow foundation can be used for Module Mounting Structures. In case the hard soil is available at a deeper level, and then some source is required to transfer the load of the structures to the hard soil strata. A deep foundation does this work and transfers the weight of Module and MMS to hard soil and stabilizes the structure.

Pile foundation is a type of foundation in which pile is usually used as the source to transfer the load to deep soil levels. Piles are long and slender members that transfer the load to hard soil ignoring the soil of low bearing capacity and transfer of load depends on capacity of pile. There is a need that pile should be strong enough to transfer the whole load coming on it to underlying hard strata. For this purpose, pile design is usually given much consideration in development of solar power plant and thus depending on the load, material is usually selected for the piles.

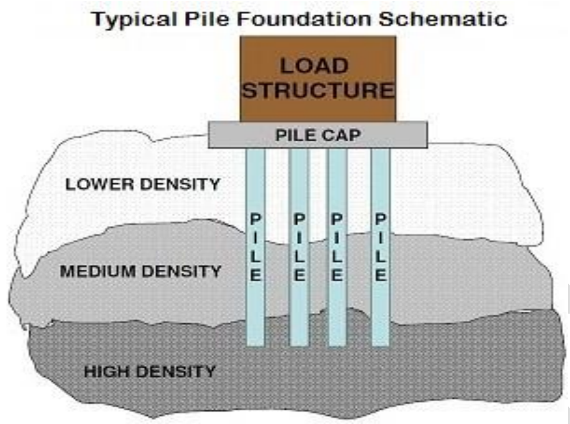


Figure 6-8:Schematic diagram of Pile Foundation

Piles can by classified on the basis of following characteristics

i. Mechanism of Load Transfer
ii. Method of Installation
iii. Type of Materials

6.8.4.1 Classification of Piles on the basis of load transfer

i. End/Point Bearing Piles

If a bedrock or rocklike material is present at a site within a reasonable depth, piles can be extended to the rock surface. In this case, the ultimate bearing capacity of the pile depends entirely on the underlying material; thus the piles are called end or point bearing piles. In most of these cases the necessary length of the pile can be fairly well established.

Instead of bedrock, if a fairly compact and hard stratum of soil is encountered at a reasonable depth, piles can be extended a few meters into the hard stratum.

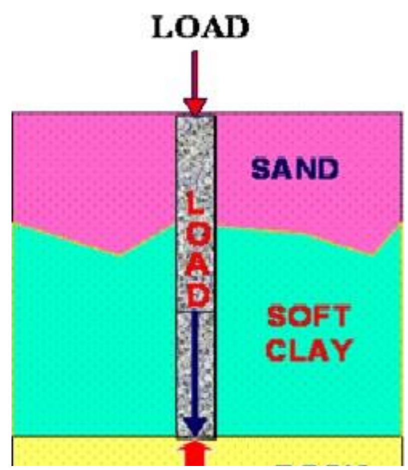


Figure 6-9:End/Point Bearing Pile

ii. Friction Piles

In these types of piles, the load on pile is resisted mainly by skin/friction resistance along the side of the pile (pile shaft). Pure friction piles tend to be quite long since the load-carrying.

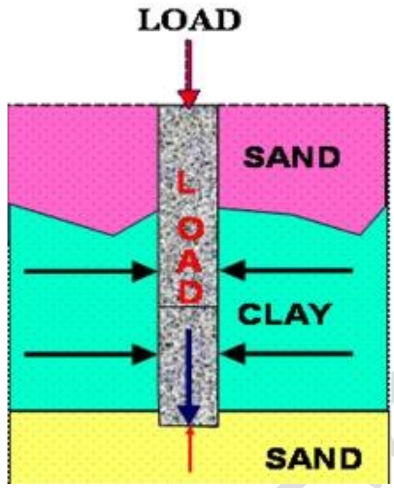


Figure 6-10:Schematic of Friction

Capacity is a function of the shaft area in contact with the soil. In cohesion less soils, such as sands of medium to low density, friction piles are often used to increase the density and thus the shear strength. When no layer of rock or rocklike material is present at a reasonable depth at a site, point/end bearing piles become very long and uneconomical. For this type of subsoil condition, piles are driven through the softer material to specified depth.

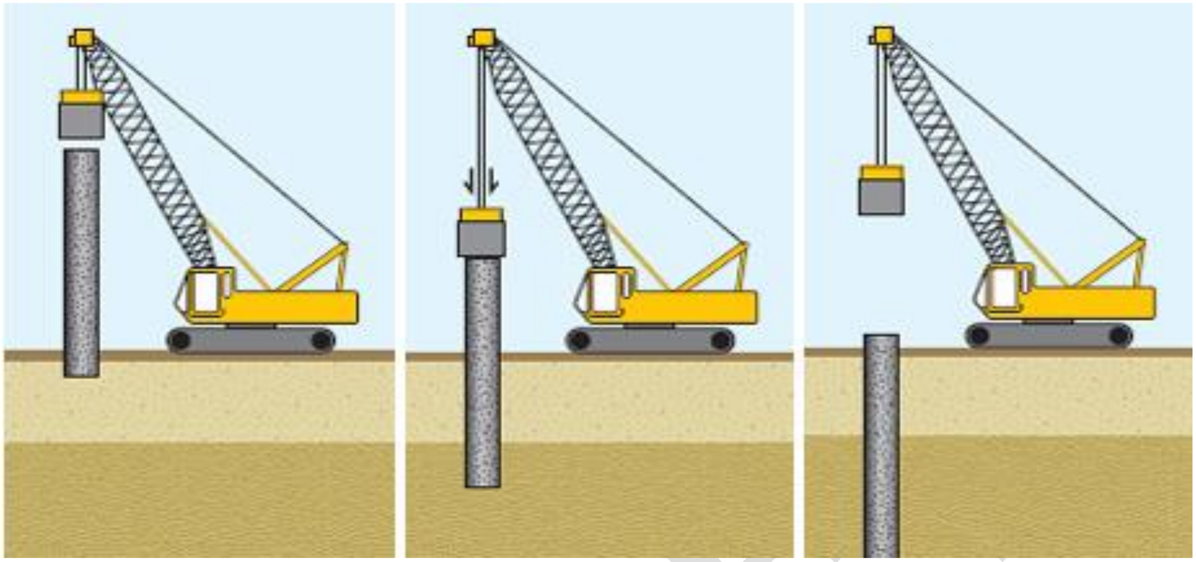
6.8.4.2 Classification of Piles based on Method of Installation of Piles

i. Driven or Rammed Piles

They are usually pre-formed before being driven, jacked, screwed or hammered into ground. This category consists of driven piles are of steel or precast concrete.

When these piles are driven into the granular soils, they displace the equal volume of soil.

This helps in compaction of soil around the sides of piles and results in the densification of soil. The piles which compact the soil adjacent to it is also called as compaction pile. This compaction of soil increases its bearing capacity.



Placing of Pile Ramming by Hamme Repetition of Process

Figure 6-11:Ramming in Cohesionless soil

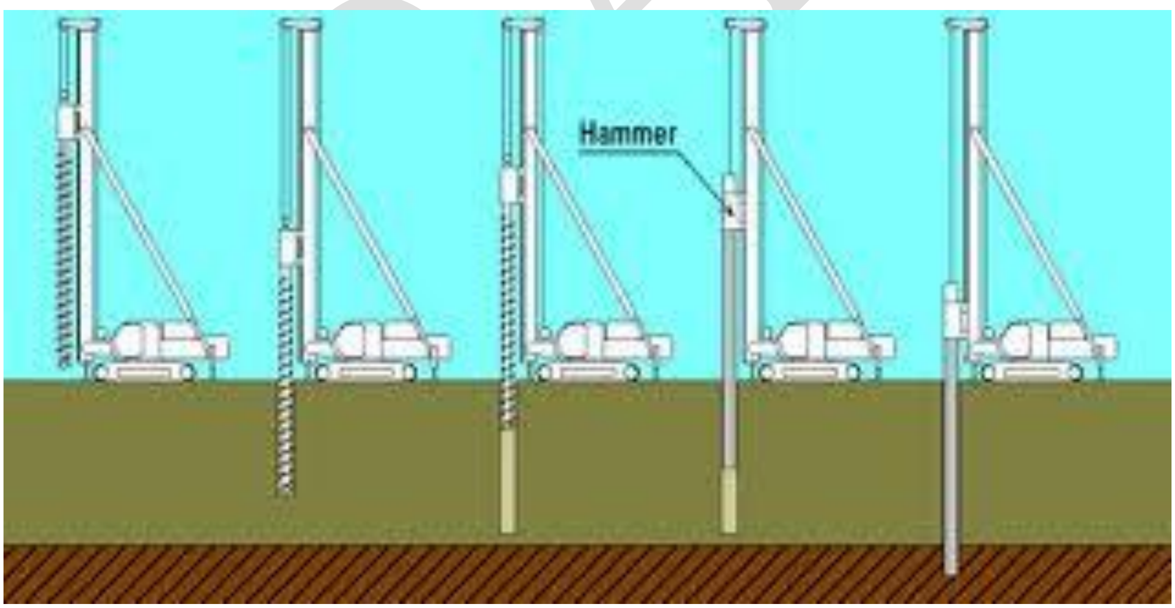


Figure 6-12:Ramming in Cohesive soil

Figure 6-13:Ramming of Vertical Steel Post

ii. Bored or Replacement piles

They require a hole to be first bored into which the pile is then formed usually of reinforced concrete. The shaft (bore) may be eased or uncased depending upon type of soil.

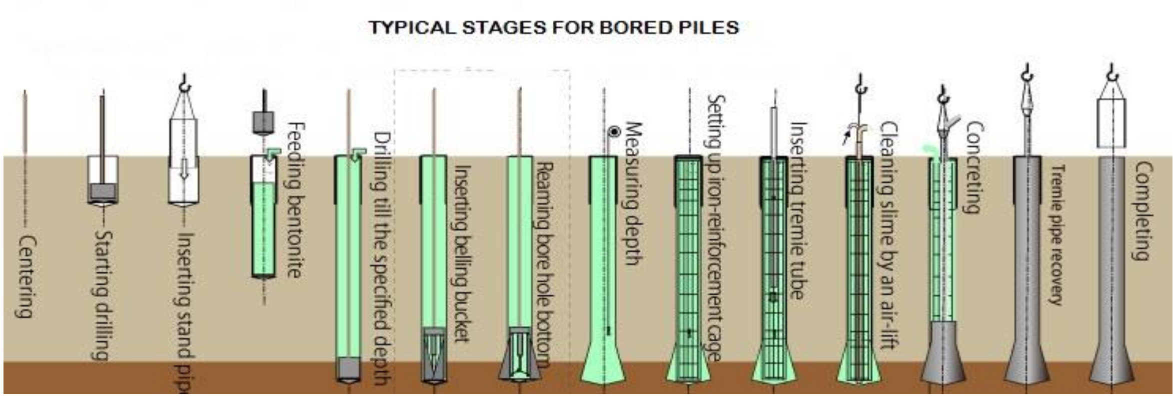


Figure 6-14:Stages of Bored Piles

6.8.4.3 Classification of Piles based on Materials

i. Timber Piles

- Timber piles are made of-tree trunks driven with small end as a point
- Maximum length: 35 m; optimum length: 9 - 20m

- Max load for usual conditions: 450 kN; optimum load range = 80 - 240 kN

Advantages:

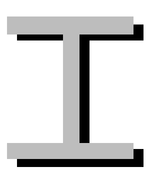
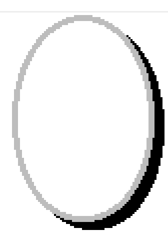
Comparatively low initial cost, permanently submerged piles are resistant to decay, easy to handle, best suited for friction piles in granular material.

Disadvantages:

Difficult to splice, vulnerable to damage in hard driving, vulnerable to decay unless treated with preservatives (If timber is below permanent Water table it will apparently last forever), if subjected to alternate wetting & drying, the useful life will be short, partly embedded piles or piles above Water table are susceptible to damage from wood borers and other insects unless treated.

ii. Steel Piles

- Maximum length practically unlimited, optimum length: 12-50m
- Load for usual conditions = maximum allowable stress x cross-sectional area
- Their relatively small cross-sectional area combined with their high strength makes penetration easier in firm soil. They can be easily cut off or joined by welding. If the pile is driven into a soil with low pH value, then there is a risk of corrosion, but riskof corrosion is not as great as one might think. Although tar coating or cathodic protection can be employed in permanent works.

	
a) H – cross-section	b) steel pipe

Advantages of steel piles:

Easy to cut in desired length, high load carrying capacity, small displacement, able to penetrate through light obstructions, best suited for end bearing on rock.

Disadvantages of steel piles:

- Vulnerable to corrosion.
- Are relatively expensive

iii. Concrete Piles

- Concrete piles may be precast, pre-stressed, cast in place.
- Cast in place Concrete Piles: Cast in place concrete piles are the most type commonly used for foundations due to the great diversity available for pouring concrete and the introduction of the pile into the soil. Driving and drilling piles are two types of cast in place concrete piles
- Precast concrete piles may be made using ordinary reinforcement or they may be pre-stressed.
- Precast piles using ordinary reinforcement are designed to resist bending stresses during picking up; transport to the site; bending moments from lateral loads; to provide sufficient resistance to vertical loads and any tension forces developed during driving.
- Prestressed piles are formed by tensioning high strength steel prestress cables and casting the concrete about the cable. When the concrete hardens, the prestress cables are cut, with the tension force in the cables now producing compressive stress in the concrete pile. It is common to higher-strength concrete (35 to 55 MPa) in prestressed piles because of the large initial compressive stresses from prestressing. Prestressing the piles, tend to counteract any tension stresses during either handling or driving.
- Max length: 10 - 15 m for precast, 20 - 30 m for prestressed
- Optimum length 10 - 12 m for precast. 18 - 25m prestressed
- Loads for usual conditions 900 for precast. 8500 kN for prestressed
- Optimum load range: 350 - 3500 kN

Advantages of Cast in place Piles:

- Can be inspected before casting can easily be cut or extended to the desired length.
- Relatively inexpensive.
- The piles can be cast before excavation.
- Pile lengths are readily adjustable.
- An enlarged base can be formed which can increase the relative density of a granular founding stratum leading to much higher end bearing capacity.
- Reinforcement is not determined by the effects of handling or driving stresses.

Disadvantages of Cast in Place Piles:

- Heave of neighboring ground surface, which could lead to re consolidation and the development of negative skin friction forces on piles.
- Tensile damage to unreinforced piles or piles consisting of green concrete, where forces at the toe have been sufficient to resist upward movements.
- Damage piles consisting of uncased or thinly cased green concrete due to the lateral forces set up in the soil. Concrete may be weakened if artesian flow pipes up shaft of piles when tube is withdrawn.
- Light steel section or Pre-cast concrete shells may be damaged or distorted by hard driving.
- Cannot be driven where headroom is limited.
- Time consuming; cannot be used immediately after the installation.
- Limited length.

Advantage of Pre-cast Piles:

- Are easy to splice. Relatively inexpensive.
- Stable in squeezing ground, for example, soft clays, silts and peats pile material can be inspected

before piling.

- Can be driven in long lengths.
- Can increase the relative density of a granular founding stratum.

Disadvantage of Pre-cast Piles:

- Displacement, heave, and disturbance of the soil during driving.
- Can be damaged during driving. Replacement piles may be required.
- Cannot be driven with very large diameters or in condition of limited headroom.

iv. Composite Piles

In general, a composite pile is made up of two or more sections of different materials or different pile types. The upper portion could be eased cast-in-place concrete combined with a lower portion of timber, steel H or concrete filled steel pipe pile. These piles have limited application and are employed under special conditions.

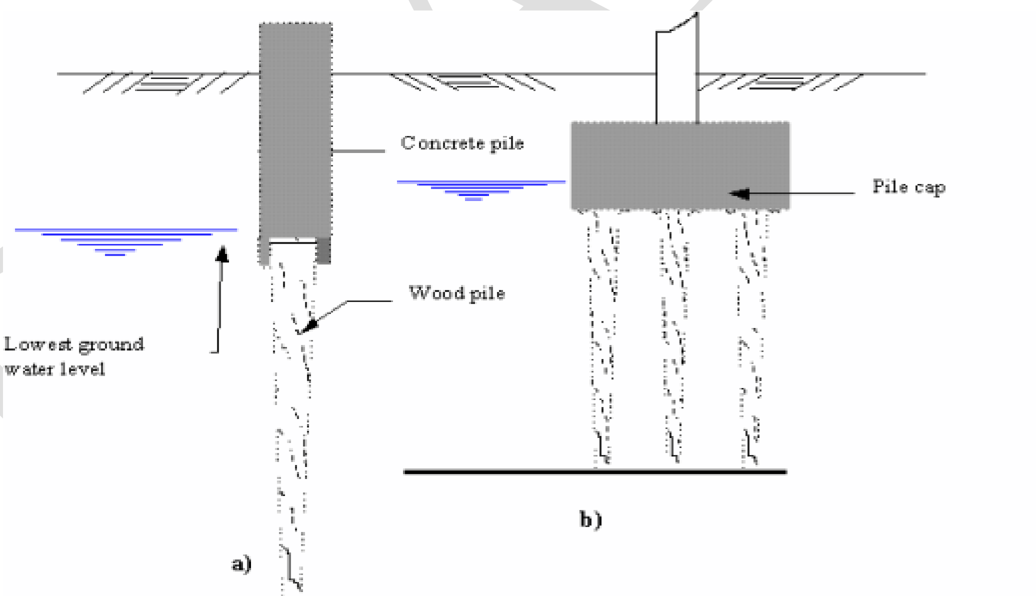


Figure 6-15:Schematic Diagram of Composite Pile

6.8.5 Conclusion

While there are dynamic developments in the PV technology, it is established that the basic technology is extremely mature and reliable. The developers usually have to make call based on a cost-benefit analysis of these technologies. It is decided to deploy poly-crystalline silicon technology for Solar park at Dholera, 5000 MW photovoltaic power plant owing to its technology maturity, higher efficiencies compared to thin-film technologies, and a proven track record over the last couple of decades. Further, this choice of module technology minimizes the risk of the PV modules deteriorating faster in extreme Indian climates. The general cost of establishing a megawatt-scale PV power plant is considered to be around Rs. 4.2 to 4.8crores per megawatt. The cost of components in photovoltaic power plants are experiencing a general downward trend, based on which solar electricity is expected to reach grid-parity in India around 2018.

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--- End of Section ---

Methodology of Infrastructure Development

7 Methodology of infrastructure Development - concept planning

7.1 Introduction

The projects involved all site establishment works, compliance with planning conditions, infrastructure, fencing, security, earthworks, trenching, support to the electrical and module construction contractors and provision of health and safety management

This chapter outlines the Concept Plan of the proposed Solar Park at Dholera. The conceptualization has been done on the basis of various factors of zoning which have been derived from technology evaluation, site analysis, developmental guidelines and regulations prevalent in the State.

7.2 Planning

Principles of Planning

The park has been designed with an aim to achieve a sustainable power generating hub which will ensure infrastructure availability for the processing area. To attain this objective following principle have been adopted:

- Integration with the region with adequate connectivity.
- Optimum use of land for power generation.
- Environmental Safeguard by provision of adequate buffers.
- Adequate basic infrastructure - concept plan is designed to ensure assured water supply, sewerage & drainage system, power supply, telecommunication, etc.
- Cost Minimization - Identification and augmentation strategy for existing infrastructure such as road, water supply, power supply etc.

Concept Plan:

To generate 5000 MW using PV technology about 9108hectares of land will be required. Considering the land area and plot orientation, the construction shall be executed in phase-wise. There proposed park shall be in two (2) phases. Plot sizes for Phase-1 and Phase-2 are proposed considering the site layout and connectivity features. PV technology is proposed for the said UMSPP.

The proposed land is divided in 27 plots for setting up Solar Power plant of various capacities and the overall park capacity is divided into two (2) phases as mentioned in Table – 16 below:

Table 6: Project phase

Sr. No.	Phases of procedure	Planned capacity
1	Phase 1	1160 MW
2	Phase 2	3840 MW

A prototype solar plant of capacity 100 kW shall be setup at the proposed site for conducting the feasibility study by SPPD. Based on the data from the feasibility study a comprehensive analysis shall be done by SPPD which will help the Solar Plant Developers to alter engineering, civil works, shore up safety to achieve best possible Performance Ratio(PR) & Capacity Utilization Factor(CUF).

Following are the basic Infrastructure that shall be developed for the proposed project:

i. Road connectivity
ii. Water supply infrastructure.
iii. Storm Water Drainage (SWD) Infrastructure
iv. Telecommunication facilities
v. Transmission facility consisting pooling station (with 400/220, 220/33 KV switchyard and respective transformers)
vi. Utility Corridor

7.3 Development

The park's proposed 5000 MW of grid-connected solar shall be developed in eleven blocks for better administration purpose. The eleven blocks shall be further divided into 27 plots of approximate capacity of 100MW, 160MW and 200MW. Four subs-stations (33 kV/220 kV/400 kV) have been proposed to be developed to evacuate the entire 5000MW of solar power generated at the park.It is proposed Power generated in Phase 1 will be evacuated by Gujarat

Energy Transmission Corporation Limited (GETCO) and in Phase 2 will be evacuated by Power Grid Corporation of India Limited (PGCIL)

The area for the proposed solar park project is low-lying area located in the delta formation of five rivers namely Padaliyo, Lilka, Utavali, Sukhbhadar and Keri. These east flowing rivers discharge in Gulf of Khambhat and meet the ocean. Most of this region lies in Costal Regulation Zone-1, The land is very muddy and mangrove cover can be found on some patches of the coast line.

Due to the high vulnerability of the site suitable measure has to be taken during engineering & development of the proposed solar park. Infrastructure has to be designed with by keep high factor of safety. This will add to the overall cost of development of the park.

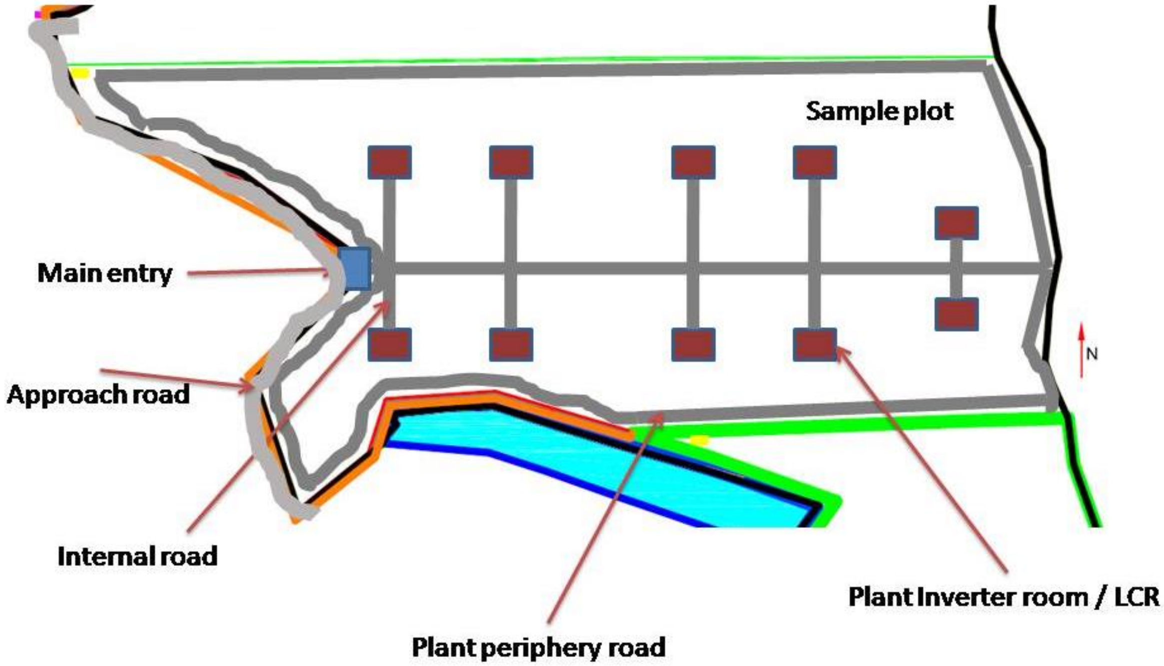
7.3.1 Internal Roads

The proposed Solar park has two hierarchies of roads (Internal Roads & Plant Roads). The internal road network is proposed along these plots for maximum accessibility to the plots.Development of the Plant roads network lies in the scope of Solar Plant Developer. Most of the roads in the internal road network already exists and rest of the roads shall be developed by the Solar Power Park Developer for it lies in theirscope. FollowingTable depicts the length of both types of roads. The proposed park shall have Grid-Iron Pattern roads of 250 to 300mts grid but it shall depend on the SPD contractor's layout.

Figure 7-1: Road

Sr. No.	Road hierarchy	Approx. Length (Km)
1.	Internal Road	53.57
2.	Plant Road*	380

*Plant road shall be planned, designed and constructed by SPD



It is proposed that the based on the conditions at the proposed site road network shall be of flexible pavement bitumen roads. The design of the pavement layers to be laid over sub-grade soil starts off with the estimation of sub-grade strength and the volume of traffic to be carried. The Indian Road Congress (IRC) encodes the exact design strategies of the pavement layers based upon the sub-grade strength which is most commonly expressed in terms of the California Bearing Ratio (CBR). For design of pavements, value of C.B.R& Traffic load is required. Value of C.B.R is on the lower side i.e. around 3-4%, Major traffic is running during construction and after that only maintenance and inspection vehicle will move. So, assuming MSA (Million Standard Axle) is 5. It is recommended to design the roads as per IRC 37:2012 Design for flexible pavements. For technical specification MORTH Technical Specification for Road & Bridge Work are adopted. A bridge of approx. length400m bridge over a river shall be constructed at plot no. 24 and 25.

Table 7-7: Tentative cross section

Thickness	Material
25 mm	SDBC
55 mm	DBM
250mm	WMM
250mm	GSB
500mm	Subgrade (CBR 5%)

The width of the topmost cross-section is 7.5m wide including 1.0m earthen shoulder on bothside. Strom water disposal along both sides of the road shall be provided.

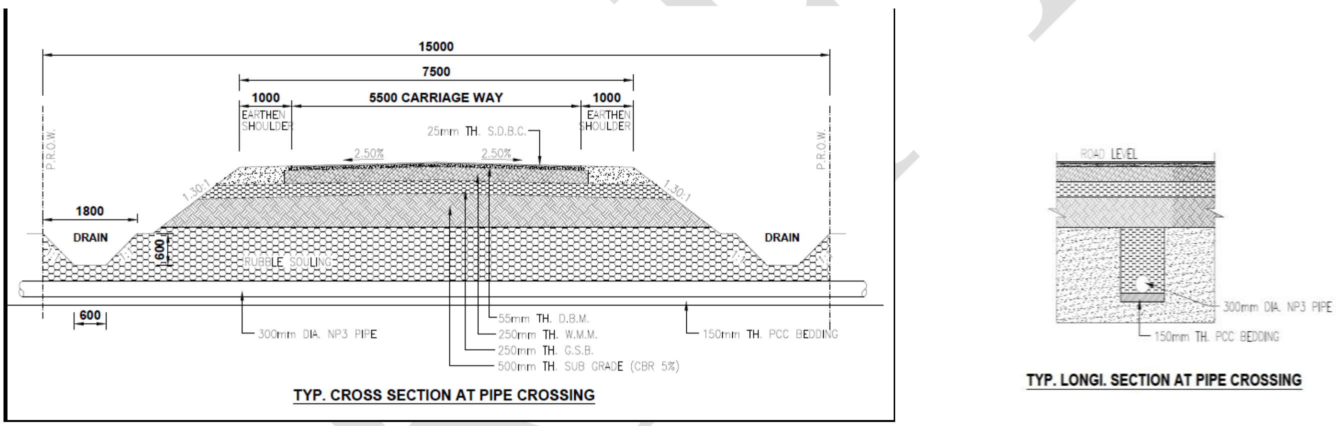


Figure 7-1: Typical Road Cross-Section

The internal road would connect to the nearest Village road or District road for regional connectivity while the internal road network would be inter-connecting the plots proposed in the solar park.

Opening like Hume pipe or culverts shall be provided in roads at various location as per the requirement.

7.3.2 Power Evacuation Infrastructure

The 5000 MW power would be evacuated through 33kV underground XLPE cable infrastructure network spread across the solar park which would culminate into 33/400kV substation to evacuate the generated power into main grid. There will four pooling substations in total which will evacuate the entire energy produced at the proposed park. The power carried by the XLPE cables would be stepped up twice, firstly from 33kV to 200kV at the pooling substation and then again up to 400 kV at the grid substation of PGCIL.

The cable structures shall be both underground and overhead. The underground cable structure connected to PV modules, inverters, transformers etc. may have armored cable with extra protection of conduit. Moreover, the proper drainage system shall be installed so that there is no standing water - making the underground cable structure very safe. The foundation structure of overhead transmission lines shall be engineered with high factor of safety and it is recommended that the foundation structures tested to withstand the wind of about 180 km/h shall be used.

7.3.2.1 Pooling Substations

A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions. Between the generating station and consumer, electric power may flow through several substations at different voltage levels. A substation may include transformers to change voltage levels between high transmission voltages and lower distribution voltages, or at the interconnection of two different transmission voltages.

Substations may be owned and operated by an electrical utility or may be owned by a large industrial or commercial customer. Generally, substations are unattended, relying on SCADA for remote supervision and control.

Substations are important components of the electrical infrastructure required to keep reliable electricity available for customers. Substations consist of high voltage electrical equipment like transformers, switchgear, circuit breakers and associated devices.

- **Transformers** step down the high voltage electricity coming in on the transmission lines, to a much lower voltage suitable to send out on distribution wires.
- **Circuit Switches** direct the flow of electricity, like the switches that turn the lights on and off in your home.
- **Breakers interrupt** the flow of electricity when unexpected surges or faults occur, in order to protect the system from damage -- like the breakers in the main service panel of your home.
- **Capacitors** improve the quality of the electricity supply to customers, in two important ways: they smooth out voltage depressions

Table 7-8:Proposed Substations of the solar park

Sr. No.	Sub-Station No.	For Plot no.
1	Sub-Station 3	1 to 3
2	Sub-Station 5*	4 to 13
3	Sub-Station 1	14 to 19
4	Sub-Station 4	20 to 27

** Substation 5 shall be the Master Sub-station for Sub station 3, 4 and 5 stations*

7.3.2.2 Cable Corridor

Electric power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. The interconnected lines which facilitate this movement are known as a transmission network and the region / path is known as cable corridor. A common Cable Corridor of 49 km (approx. length), containing both High voltage as well as low voltage line shall carry the power generated by various solar plants to the pooling substations, the cable corridor shall run adjacent to the internal road network of Solar Park.Electric power shall be transmitted by underground power cables instead of overhead power lines except at some places it may require over head transmission line. Underground cables take up less right-of-way than overhead lines, have lower visibility, and are less affected by bad weather. However, costs of insulated cable and excavation are much

Figure 7-3: Typical cable corridor

higher than overhead construction. Faults in buried transmission lines take longer to locate and repair.

7.3.3 Telecommunications

Telecommunications tower is the generic description of Radio masts and towers built primarily to hold telecommunications antennas. As such antennas often have a large area and must be precisely pointed out, such towers have to be built so, that they do not much swing in the wind. So very stable structure types like low lattice towers and towers built of reinforced concrete are used in most cases, although also guyed masts are used.

The objective is to provide integrated mobile, broadband, broadcast and surveillance services to the Solar Park at Dholera. Communications between substations shall be provided under the provision of SCADA. If required SPPD will appoint private players.

7.3.4 Water Supply Infrastructure

The primary source of water for the proposed Solar Park is Narmada River. It is proposed that Sardar Sarovar Narmada Nigam Limited (SSNNL) shall provide the water supply. If gravity flow water supply from the source is not a feasible option, then Pumps shall be installed to facilitate the supply. Water can be tapped 15 km away from the project site.

Figure 7-4: Pipeline

Civil structures such as canal off-take structure, underground sump, pump house and Ground service reservoir (WSR), water transmission pipeline to the project site, underground sump, pump house, GSR and internal water distribution network are proposed for water supply.

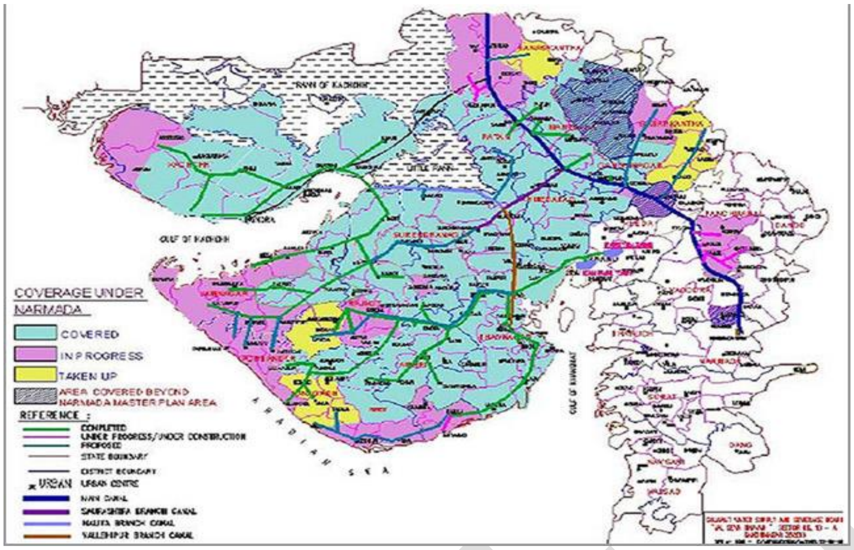


Figure 7-2: Coverage area of SSNL pipeline network

Sr. No.		Recommended
1	Pump capacity	10 Bars
2	Pipe (material)	HDPE
3	Pipe (size)	200mm dia.

7.3.4.1 Underground storage Water Tank/overhead tank

An estimated amount of 11.25 Million liters per Day (MLD) of water shall be required for the entire 5000 MW Solar Park. It is recommended to store water capacity equivalent to 1-day usage in advance for emergency purpose.

Table 8-4: Capacity of GSR

Sr. No.	GSR	Capacity
1	Ground Storage Reservoir 1	1.25 MLD
2	Ground Storage Reservoir 2	4 MLD
3	Ground Storage Reservoir 3	2.5MLD
4	Ground Storage Reservoir 4	3.5 MLD

The Underground tank shall be as per requirement.

Following points are the consideration of selecting circular tanks over rectangle tanks.

Circular tanks are preferred over rectangle tanks as there is no bending in circular tanks. Also, for underground tank having rectangle shape subjected to bending moments in empty conditions. While, Circular tanks in compression in empty condition and hence reinforcement requirement is lesser than rectangle tanks. It is proposed to develop four Ground Storage Reservoir Tank with 30 m of diameter and 3.5m deep adjacent to the substations. Pipeline profile shall be developed by DSIRDA; accordingly, pipeline network will be provided.

Table 7-9:Specification of the water tanks

Sr. No.	Recommendation	Specification
1	Shape	Circular tanks
2	Minimum Concrete Grade	M30
3	Reinforcement grade	Fe-500D

7.3.5 Storm Water Drainage (SWD) Infrastructure:

To discharge the rainwater, the SWD infrastructure shall be designed considering the natural topography to evacuate the said storm water. SWD with stone pitching shall be provided at both sides of the road.

Having high Coastal Vulnerability Index, the project site could be subject to flooding, a proper drainage system shall be constructed so as to avoid any loss either infrastructural or ecological.

7.3.6 Project Boundary Fencing &River training works

Since the solar parks are constructed in remote areas, it is difficult to monitor their security which leads to various thefts of components of Solar Power Plant. All of this calls for installation of boundary fencing.

For an uninterrupted operation of the proposed solar park, when faced with the possibility of downtime due to theft, floods or vandalism and ingress of tide water development of fencing & bund is very essential. The fence helps curbing out the thefts whereas bund helps mitigating the detrimental effects of flood or water logging in the solar park.

Opening like Hume pipe or culverts shall be provided in river training / Bund at various location as per the requirement.

7.3.6.1 Boundary fencing

The equipment used in a solar park can be very expensive and thus makes it a prime target for theft or vandalism. Fencing helps in maintainingperimeter security by keeping out trespassers and ultimately curbing solar park thefts.

To delineate the site boundary, a 3.0m barbed wire / chain link fencing shall be constructed. The fencing will not only curb the instances of solar theft but also stop the stray/wild animals from entering the site. Entry in and out of the site will be regulated by an entry-exit complex.

Figure 7-6: Boundary fencing

It is recommended that fencing shall be provided at the outer periphery of the solar park as due to solar theftsbills may run into lacks of rupees due to the damage caused and loss of income due to disruptions. When one set of solar cells is damaged or stolen it affects the whole row and reduces the power output significantly.

7.3.6.2 River training works:

The project site has a high Coastal Vulnerability Index (CVI) and is prone to flooding either through the high tides of the ocean or due to flooding in the nearby rivers. Moreover, the tide level is 5.5m and expected to rise if sea level rises. During flood & high tide, the flood water may cause loss to life and property. To prevent this, flood embankment might be constructed made up of homogeneous earthen bund using suitable local soil. For better results Hume Pipes can be added to the earthen bunds so as to reduce the impact of water. The bund needs to be constructed along the side facing the creek in order to prevent flooding of project site.

Detailed engineering solutions needs to be carried out for the construction of bunds. The top width of earthen bund will be 2m which incidentally work as a access roads. The height of the embankment is not more than 2.0m so normal homogeneous bund is sufficient. In earthen bund if required pipe culvert shall be provided to allow movement of tidal water and rain water.

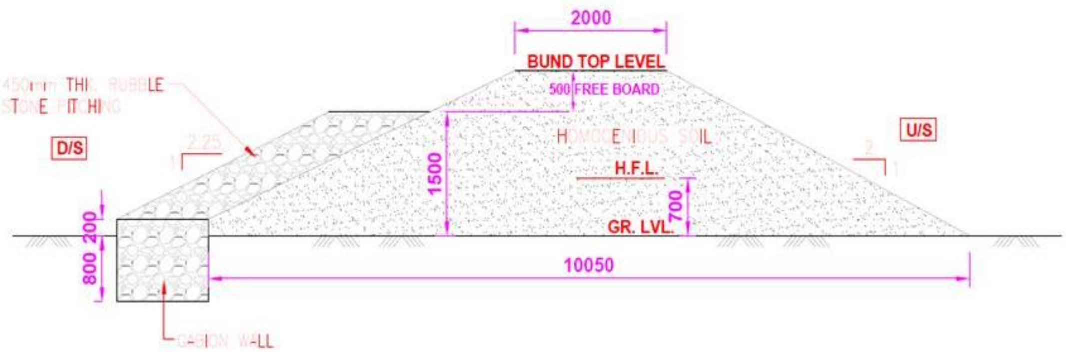
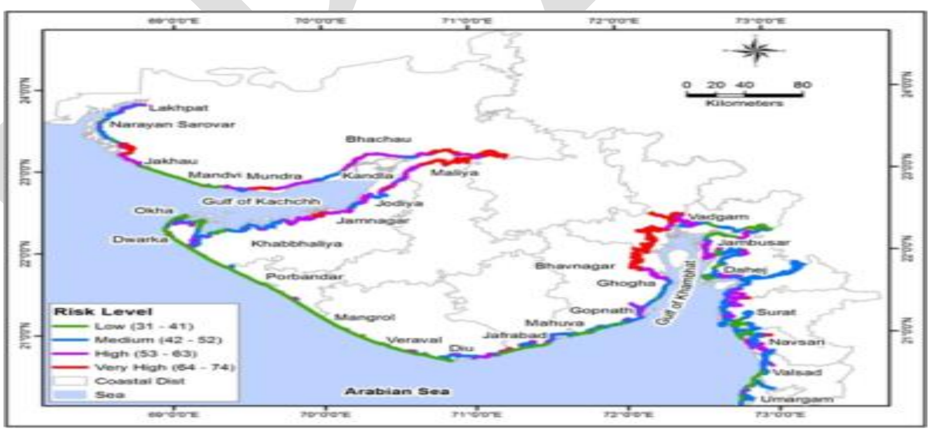


Figure 7-3: Typical earthen bund Section with gabion wall

7.3.7 Module Mounting Structure

Since the project site lies in the area with high Coastal Vulnerability Index and during the high tide the project site might get flooded. Module Mounting Structures shall be engineered to withstand the flood without corrosion and shall stand at a height where the PV panels do not submerge into the flood

To achieve this, the height of the pile with bulb& the structure shall be increased and to avoid



corrosion, hot dip galvanization shall be done. As per usual practice, the solar panel are supported on piles of 250-350mm diameter of required length shall be provided. Considering the tidal & flood effect in the area the pedestals height shall be kept 380-450mm above ground level which shall be finalized during engineering phase.

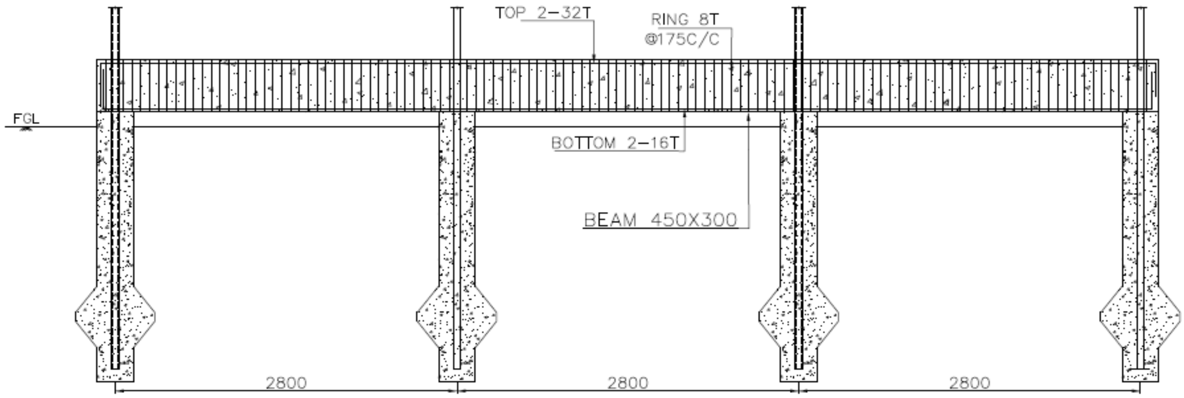


Figure 7-8: MMS Pile table

The soil which shall be excavated during the time of construction of the foundation of the MMS through Auguring shall be used in the construction of the river training works / earthen Bund if required.

7.3.8 Street light

A street light, light pole, lamppost, street lamp, light standard, or lamp standard is a raised source of light on the edge of a road or path. Street lighting increases the visibility on the solar park road. Street lighting also improves safety for driver and pedestrians working or passing by the solar park.

Light Emitting Diode (LED) is usually used as lighting source of modern solar street lights, as the LED provides much higher lumens with lower energy consumption. The energy consumption of LED fixture is on an average 50% lower than a High-Pressure Sodium Vapor (HPSV) fixture which is widely used as a lighting source in traditional street lights. LED's lack of warm up time also allows for use of motion detectors, which can help in dimming or brightening the light for additional efficiency gains

7.4 Solar Project Developer (SPD)

Solar Project Developer is also known as SPD Contractor who is usually involved in physically building the Solar PV power plant along with its necessary infrastructure. SPD is made responsible for all the activities from design, procurement, construction, to commissioning and handover of the project to the End-User or Owner.

ASPD is a company that will, typically, install the solar plant on a turnkey basis fr a developer/promoter. It is involved in all aspects starting from engineering design (including solar system, civil and structural, and electrical design), procurement and construction of a solar PV power plant. Some SPDs will also take responsibility for the operation and maintenance of the plant. The detailed roles of an SPD are as follows:

Engineering

Feasibility and site assessment, technology assessment and selection, and interconnection requirements

Procurement

Obtaining the necessary resources, clearances, equipment and industry partners for installations under specified time frames and budgets.

Construction

Construction of all aspects of the power plant, onsite supervision and monitoring, detailed project proposal and action plan, construction support and planning, quality management system, project management and planning

In India, there are currently too many SPD's for solar power plants. Zeroing in on the best one among the available options is an uphill task. At the same time, choosing the right SPD for power plant is a critical decision that can make or break the solar plant.

Choosing the right SPD ensures the following:

1. Maximum Power at Minimum Cost – A power plant that generates the maximum possible electricity during its lifetime (25 years) at the lowest possible cost per kWh over the lifetime.
2. Smooth Operations – A power plant that functions and buzzes along smoothly day in and day out for 365 days a year for 25 years, without giving any trouble at all to the developers.
3. Transparent and Resilient – A power plant that is highly transparent and resilient – in that the you can understand the performance of the power plant from wherever he or she is, and a power plant that can be up and running within the shortest possible time just in case of any issues that crop up at all.
4. Optimum Utilization of Space- With high design expertise SPDs will be able to make the maximum of available space by looking at panel, inverter, cable layout etc.

7.5 Tentative Infrastructure inside the solar plant:

Technology now gives us the opportunity to drastically increase energy production without having to overhaul our entire energy infrastructure. The Infrastructure inside the solar plant shall be in the scope of SPD contractor.

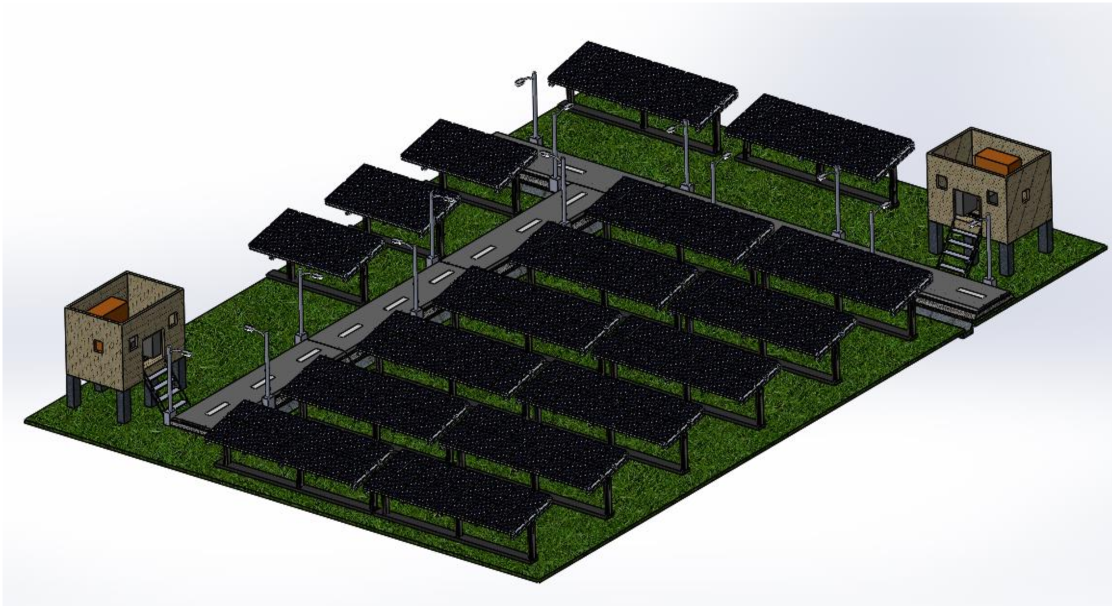


Figure 7-9: Typical layout of a solar plant

7.5.1 Master Control Room (MCR)/ Local Control Room (LCR)

The main control room is a masonry building which houses the control panels and the below mentioned equipment:

- AC Main Electrical board (Main ACEB)
- UPS with UPS DB and Battery Bank
- Battery and Float Cum Boost Charger
- Indoor HT Panel
- Main Data Logger for SCADA
- Fire Alarm Panel
- CCTV Monitoring Panel
- Ventilation Exhaust Fan
- Data Logger for SCADA
- Control Room Lighting & Peripheral Lighting

Elevated height of the sub-station reduces damage from flooding in two ways;

1) Allowing flood waters to easily enter and exit a structure in order to minimize structural damage;

2) Use of flood damage resistant materials.

Elevated substations better protect workers and keep the equipment high and dry, even in the case of devastating storms lapping against each other. Moreover, this design decreases the customer's risk and uncertainty associated with managing very complex projects containing numerous critical path actions, which facilitates success on (or under) time and budget. Hence, it is recommended for the developer/ SPD contractor to develop its sub-station / pooling station at an elevated height

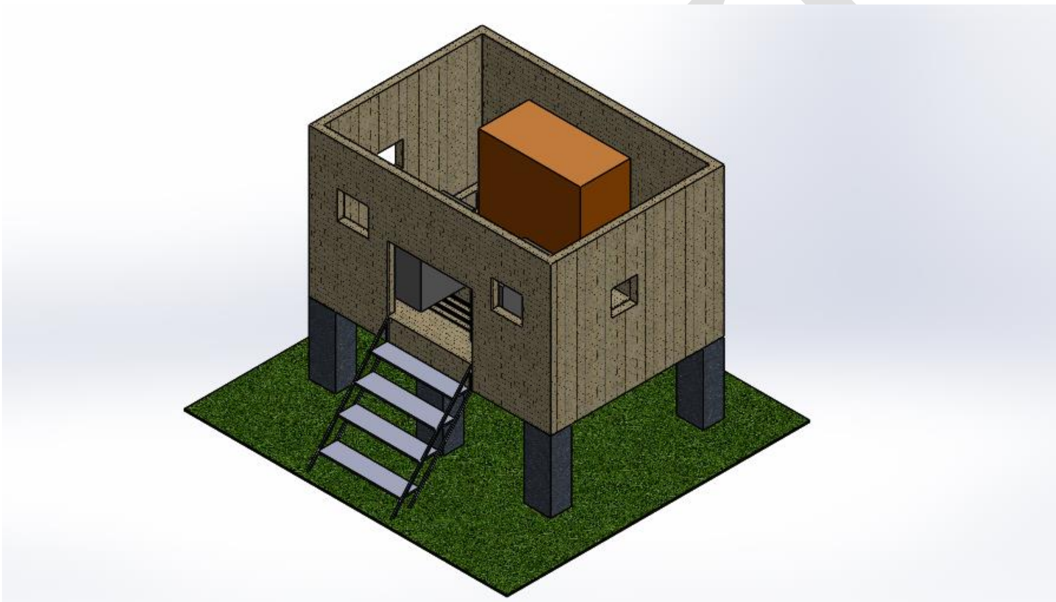


Figure 7-10: Typical diagram of Control room

7.5.2 MMS

Photovoltaic mounting systems (also called solar module racking) are used to fix solar panels on surfaces like roofs, building facades, or the ground. Ground-mounted PV systems are usually large, utility-scale photovoltaic power stations. The PV array consists of solar modules held in place by racks or frames that are attached to ground-based mounting supports.

Ground-based mounting supports include:

- Pole mounts, which are driven directly into the ground or embedded in concrete.

- Foundation mounts, such as concrete slabs or poured footings
- Ballasted footing mounts, such as concrete or steel bases that use weight to secure the solar module system in position and do not require ground penetration. This type of mounting system is well suited for sites where excavation is not possible such as capped landfills and simplifies decommissioning or relocation of solar module systems.

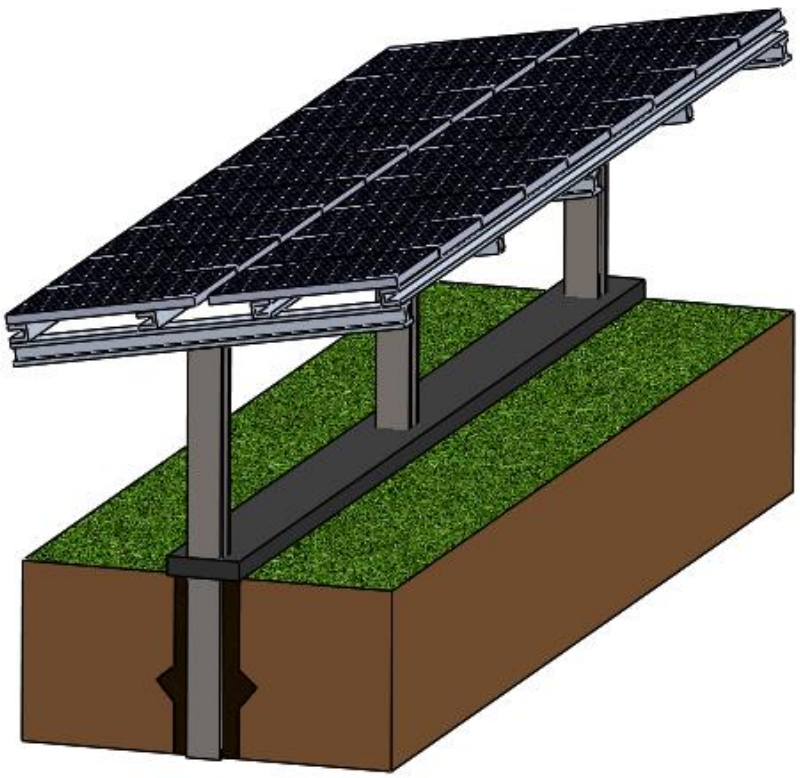
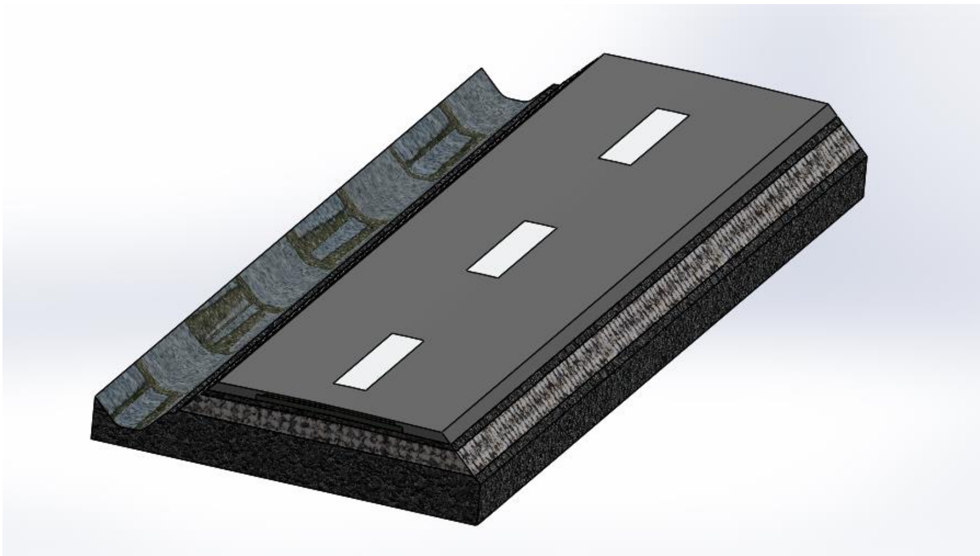


Figure 7-11: Typical Diagram of MMS table

7.5.3 Drainage

The storm water drainage shall be designed for smooth disposal of storm water from the Plant to the nearest available drainage outlet. The drainage system shall be designed for maximum rainfall intensity as per the provisions of relevant IRC standard. To discharge the rainwater, the drainage system shall be designed considering the natural topography of the plant.



7.5.4 Roads

Suitable access road from Main gate to Main control cum office room (MCR), internal access roads connecting MCR and other facilities/ buildings like Local control room(s) (LCR)/ Inverter room(s) (IR), Substation, Switch yard etc. and internal peripheral road along the boundary fence shall be provided.

7.5.5 Lightning Arresters for module area

Lightning arresters installed are devices used in solar power plant to protect the modules and other equipment in the power plant from the damaging effects of lightning. The lightning arrester has a high-voltage terminal which captures the Lightning within a radius of 107 meters as per its designed capacity. It is connected to the earth with the help of copper conductor. When a lightning surge travels along the power line to the arrester, the current from the surge is diverted through the arrestor to earth.

Each LA used in the plant has 3 maintenance free chemical earth pits. Inspection and any required maintenance are to be performed regularly and as listed below:

Schedule:

- After each known lightning strike to the terminal
- Once every twelve months minimum
- If changes have been made to the structure.

7.5.6 Fire-Fighting System.

Fire in power station may completely curtail supply of electrical power for considerable time in addition to causing extensive property damage to the building and equipment. The Fire Fighting & Detection System requirements regarding building construction, facilities and storage areas, etc. pertaining to electricity generating stations.

Fire alarm panel along with hooter, smoke detector, cable as per requirement and associated accessories along with cable in LCR & MCR.

The Fire Fighting System will involve installation of the Heat/smoke detectors, Fire alarm Panel, hooters, manual call points, Fire extinguishers and sand buckets.

Figure 7-12: Fire Fighting equipment

7.5.7 Water System For Module Cleaning & Other Site Activities.

Water supply shall get arrange from underground water tanks to Solar PV plant and then water may store in another water tanks located at nearest to LCR/MCR for RO plant and treated water shall be collected to another tank for final used. Water shall be pumped to plant through booster pumps which provides adequate pressure at the outlet for module cleaning.

Figure 7-13: Manual cleaning

Figure 7-14: Robotic cleaning

Dust and dirt particles accumulating on PV panels decrease the solar energy reaching the cells, thereby reducing their overall power output. Hence, cleaning the PV panels is a problem of great practical engineering interest in solar PV power generation. A portable robotic cleaning device which travels the entire length of a panel may be used. An microcontroller is used to implement the robot's control system. The robotic cleaning solution for PV is practical and may help in maintaining the clean PV panel efficiency.

7.5.8 Boundary Fencing

A fence is a structure that encloses an area, typically outdoors, and is usually constructedfrom posts that are connected by boards, wire, rails or netting. The fencing shall be done to enclose the plant area.

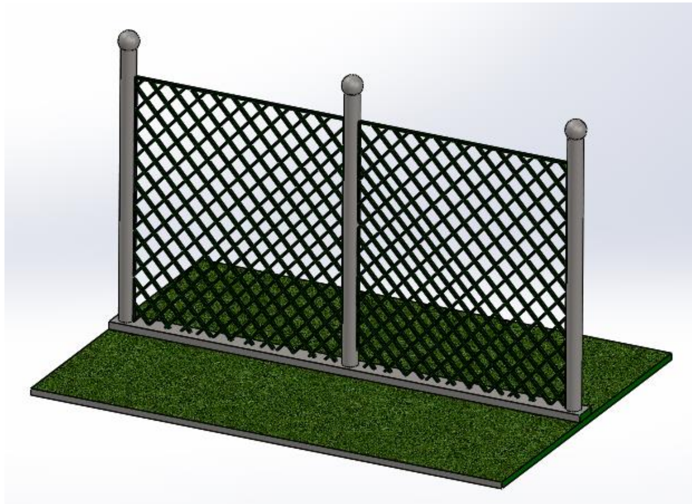


Figure 7-15: Typical diagram for fencing

7.5.9 Earthing

The earthing system shall be designed with consideration of the earth resistivity of the project area.The earth resistivity values shall be measured prior to designing the earthing system. Earthing system shall be in accordance with IS: 3043. The permissible system fault power level also shall be kept in consideration while designing the earthing system. Each array structure of the PV yard, LT power system, earthing grid for switchyard, all electrical equipment, controlroom, PCU, all junction boxes, ACDB &DCDB, all motors and pumps shall be grounded properly as per IS 3043 - 1987. The earthing for array and LT power system shall be made of 3.0 m long 40 mm diameter perforated GI pipe / chemical compound filled.

7.5.10 CCTV.

The CCTV system shall be designed as a standalone IP based network architecture. System shall use video signals from different cameras at defined locations, process the video signals for viewing on monitors at control room and simultaneously record all video streams using latest compression techniques. Camera shall be color, suitable for day and night surveillance and network compatible. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitor for live video. The CCTV server shall be provided with video storage and analytical engine. The system shall support video analytics in respect of the following:

- Video motion detection
- Object tracking
- Object classification

Camera server shall be provided with sufficient storage space to storage recordings of all cameras for a period of 15 days. All recordings shall have camera ID, location, date and time of recording.

7.5.11 SCADA

Supervisory control and data acquisition (SCADA) is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management to interface with the process plant or machinery. SCADA system shall be used to monitor the solar plant system.

The monitoring system allows recording of all the needed data registered in the power plant and visualizing them in real time basis. Equipments which are monitored in the solar plant are Weather Monitoring Station, SCB, Inverters, HT Switchgear, Transformer , ACDB & Fire Detection and Protection.

7.5.12 Weather Monitoring Station

The weather monitoring station shall be capable of measuring wind speed, wind direction, air temperature, and surface temperature of the module and solar radiation at site with help of the sensors. Complete weather monitoring stations of Solar PV Plant consist of Pyranometer, Anemometer, Thermometer and data logger.

The observations from various sensors will be taken automatically by data logger at user defined frequency. The data logger enables weather sensors data collection and transmission to SCADA system, making real-time information available at SCADA screen.

7.5.13 String Combiner Box

The String Combiner box (S.C.B.) made by Polycarbonate Box, is an electrical board to connect the strings. The S.C.B.s have protections against over-current and monitoring of current and voltage of each string, assessing the correct running of the strings and detecting possible faults that could reduce the energy output.

The monitoring is made by the interface RS485 utilizing MODBUS and is integrated in the SCADA system. It is possible to monitor the current of string, Voltage of Busbar at the SCB level. If any problem is detected within the string combiner box, which involves cable replacement, care should be taken of the polarity, type and loose connection during the replacement process.

7.6 Breakup of Solar PV Plant Cost

SPDshall develop the Park / plot. A typical SPV project setup cost ranges between Rs. 4.2 crores to 4.8 crores/ MW. For reference an estimated cost breakup of solar PV power plant is shown below:

Sr.	Head		Cost per MW (INR Crore)	Cost Fraction	
1.	Photovoltaic Modules	:	2.53	45-58%	SPD COST
2.	Inverters and Junction Boxes	:	0.322	5-10%	
3.	Module Mounting Structures	:	0.46	5-10%	
4.	Building and Civil Works	:	0.23	3-5%	
5.	Evacuation Switchyard	:	0.276	4-6%	

6.	Electrical Works and Monitoring	:	0.322	4-7%	
7.	Misc. Costs	:	0.138	1-3%	
8.	Engineering and Project Management	:	0.046	1-3%	**OTHER PROJECT COST**
9.	Land	:	0.138	1-3%	
10.	Other Charges/ Fees	:	0.138	1-3%	
	TOTAL	**:**	**4.6**	**100%**	

Indian National FourCrore and Sixty Lacs Only

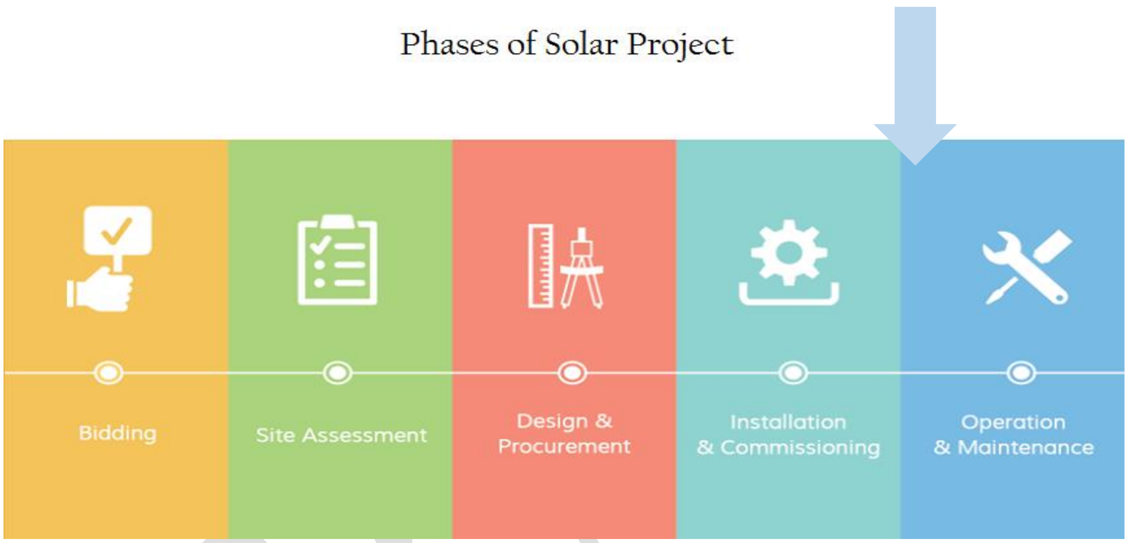
The revenue for the Project is envisioned from sale of power to the DisCom at mutually agreed price of approximately INRXXX per kWh for 25 years.

Project Execution

8 Project Execution and Performance

8.1.1 Project Execution Plan

The project shall be implemented in different stages to ensure proper management of material purchases and delivery, construction, logistics etc. Systematic execution of the initial stages ensures that subsequent stages would go quicker and smoother with the experience.



The major activities involved under the project development and implementation are listed below:

1. Possession of land.
2. Land inspection and related studies to be done.
3. Preparation of preliminary design.
4. Preparation of Detailed Project Report.
5. Signing of Power Purchase Agreement with power off-taker.
6. Formalities under the REC mechanism, if the project is to be registered under RED mechanism.
7. Selection of Project Management Consultant (PMC).
8. Preparation of the detailed tender document for selection of SPD Contractor.
9. Selection of the appropriate SPD Contractor with lowest evaluated bid value.

10. Preparation of detailed engineering design.
    - Preliminary civil works and construction (fencing, soil exploration, ground improvement, foundations, surfacing, grading, etc.).
    - Civil, structural and electrical works for the project.
    - All regulatory approvals for project and power evacuation.
    - Staff and client training.
    - Operational & maintenance services.

Overall project implementation shall have the five stages of activities. While these stages are not mutually exclusive, some degree of overlapping is always expected.

Stage I : Project Development

Stage II: Selection of the SPD Contractor through Tendering Process

Stage III: Procurement and Construction

Stage IV: Plant Commissioning

Stage V: Operation and Maintenance

8.1.2 Stage 1 – Project Development

Project development shall begin with one or more visits to the region with the objective of understanding regional ground conditions including socio- economic conditions, transportation and infrastructure facilities available in the region, the weather and soil conditions.

Following specific activities/tasks shall be completed during this stage:

- Corporate formalities
- Land acquisition
- Preparation of DPR
- Financial arrangements
- Preliminary permissions
- Signing of PPA
- Selection of PMC

During this phase, a project team consisting of engineers, logistics experts and project managers shall be formed for the execution of the project. This project team shall work together from the earliest stages of the project, according to member's specific expertise.

8.1.3 Stage II – Selection of the SPD Contractor

In this stage, the initial activity would be the preparation of the tender document with all the terms and conditions of the tender and the agreement to be signed with the successful bidder, i.e. the Contractor. The tender shall be floated and the bids received from different bidders shall be evaluated. An agreement shall be signed with the successful bidder having the

Lowest Evaluated Bid Value (EBV**).**

All the contractors shall be selected through competitive bidding process. It has been proposed that the bidder shall be required to fulfill minimum technical qualifying criteria i.e. in engineering, procurement, construction, commissioning, operation and maintenance of such solar power plant using multi/poly-crystalline PV technology. The bidder shall also be asked to give a Net Electrical Energy Generation Guaranteed (NEEGG), which is a metric of the quality and performance of the plant. The Evaluated Bid Value shall be calculated as follows:

Evaluated Bid Value= Net Present Value of Total Bid Amount

Salient features of the work involved in this project**:**

- The project involves comprehensive SPD work.
- The entire work is required to be completed within 190 days from accepting the Letter of Intent.
- The work of SPD Contractor shall be divided within these 190 days and the various activities involved in the entire act may overlap with each other in relation to time.
- The payment of all the contractors shall be linked to their timely performance.
- The bidders are required to submit a guaranteed performance ratio of the plant.
- Liquidated damages shall be assigned for:
- Non-timely completion of work,
- Non-achievement of guaranteed performance ratio at the time of taking over, and

- Non-achievement of guaranteed performance ratio during O&M contract period.

An alternate arrangement to selection of an SPD Contractor is to undertake the project in a 'package-mode.' In this case, instead of awarding the contract to a single Contractor, the Developer classifies the project into multiple activities and sub-activities or 'packages.' In this case, the Developer has better control over the activities and supplies, and often is able to achieve a lower project cost by avoiding the SPD Contractor's margins. However, undertaking a solar project in a package-mode demands heavy involvement and management from the Developer. It is advised to undertake such projects in package-modes only if the Developer has prior experience or in-house technical expertise to undertake such projects.

8.1.4 Stage III- Procurement and Construction

This stage includes procurement of all the equipment and construction of the plant at site under the supervision of the SPD Contractor, which is further supervised by the Project Developer and the Project Management Consultant. The plant shall be erected and commissioned in phases i.e. erection of the second megawatt section shall start immediately after the completion of construction work for the first megawatt, and so on. This is to reduce the total time requirement for the overall project.

8.1.5 Stage IV – Plant Commissioning

It is the commissioning phase where design, manufacturing, erection and quality assurance expertise are put to test. The PMC, and then the commissioning officials in presence of the Original Equipment Manufacturers (OEM) team shall check whether the equipment are properly installed after taking due care to the safety measure. Immediately after commissioning, the plant shall be subjected to a performance test under the supervision of professional engineers and consultants. The SPD Contractor shall demonstrate total megawatt capacity and also the guaranteed performance ratio.

8.1.6 Stage V - Operation and Maintenance

As the SPD Contractor gives the performance guarantee, it is a common practice to give the O&M contract to the same Contractor. In this stage, the O&M Contractor would regularly check the plant for maintenance. If there is any default or if any part of plant is judged not to be functioning, it would be immediately checked and corrected by the O&M Contractor. The O&M Contractor shall also be responsible for sending reports on continuous basis to GPCL on performance and repairs of the plant.

Major activity during this phase shall be the cleaning of the panels at regular intervals and monitoring the output in order to ensure consistent power generation from all the PV modules. Since there are no rotating parts involved, maintenance shall be far less than any other industrial activity.

8.1.7 Clearances Required for the Project

To set up a solar PV power plant project, a number of statutory and environmental clearances have to be obtained. For the proposed solar PV power park to be set up at the land owned by GoG consent from the relevant authorities of the Central government and Gujarat state government will be necessary.

Project Related Clearances

Statutory clearances have to be obtained before initiating the solar power project. Following is the critical clearances to be obtained for the solar PV power park proposed to be set up at by GPCL in the state of Gujarat.

As per MoEF's (Ministry of Environment & Forests, Government of India) Environmental Impact Assessment Notification of 14 September 2006, solar power projects are not in the list of the project requiring prior environmental clearance from MOE&F. "EIA Notification 14th September 2006, Page No 10, Item 1(d)." Hence environmental clearance for solar power projects from MoEF is not required. However, Dholera solar park is lying under CRZ area, hence construction/development clearance is required from MoEFMinistry of Environment & Forests), Government of India.

Various other clearances are required from the point of view of SPD during the time of construction and operations

8.1.8 Suggested Environmental Aspects

Pollution Control

Solar power involves hardly any of the polluting emissions or environmental safety concerns associated with conventional, fossil or nuclear-based power generation. There is very little pollution in the form of dust or fumes. Decommissioning a system is also not problematic. Most importantly, in terms of the wider environment, there are no emissions of carbon dioxide in operation of a solar power plant which is the main gas responsible for global climate change. Solar power can therefore make a substantial contribution towards international commitments to reducing the steady increase in the level of greenhouse gases and their contribution to climate change. The pollutant generated from the Solar Power Project is only sewage from the plant.

Environmental Management Plan Construction Phase

The industry shall ensure to minimize the pollution potential level in the construction phase. Wherever applicable, detailed procedures will be developed for control of pollution during project execution phase.

The following are the few important parameters to be appropriately managed to minimize the pollution load.

Site Preparation

During the preparation, considerable amount of soil movement is involved due to site leveling operations which will be carried out. During the dry season it is necessary to control the uplift of dust during the excavation, leveling and transportation by spraying water in the paths and along the temporary roads.

Sanitation

Considering the standards of hygiene, the workers involved in construction will be provided proper sanitation facilities. The facilities like toilets, drinking water and proper shelter for the persons staying at the construction site will be provided. The toilet will be attached to septic tank so as to minimize the percolation and to control the subsequent impact on the environment. These facilities will be properly designed and maintained to ensure minimum environmental impact.

Wastes from Construction Equipment

The construction activity may involve movement of heavy vehicles for earth moving and to move the equipment like earth movers and cranes. The vehicles will be maintained properly so as to minimize the emission from exhaust. Also, care will be taken to avoid oil spillage, which may contaminate the surface and groundwater resources. Combustible waste will be burnt in a controlled manner. Other waste will be disposed of in an approved dump.

Post Construction Phase

The major pollution from the proposed solar–radiation–based power plant will be in the form of water and solid waste. The sources of pollution and treatment plan are described in the following sections.

8.2 Solar E-Waste

Boosted through the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, solar power in India is taking big leaps and solar is approaching grid parity at a rapid pace.

With a target of 100GW of Solar installed capacity and multiple solar projects popping up here and there, cheap and clean energy is not a far cry anymore. The question is how will India dispose 100-gigawatt (GW) worth of solar panels in the next 25 years? Assuming that an average panel is sized 250 watts, 100 GW will amount to almost 7.76 million tonnes of e-waste (77.6 lakh tonnes to be exact) at the end of a lifetime (25 years) of a solar plant.

Life cycle of the proposed solar park is expected to be25 years. After completion of which There will heaps of Equipment likePV modules, invertors, HT panels etc. left behind as waste. This new age "E-waste" will have to be disposed of in such a way that they don't pose threat to human health or the environment, for these products contain materials that can be hazardous depending upon their condition and density.Solar modules for example contain potentially some of the very dangerous materials like silicon tetrachloride, cadmium, selenium, and sulfur hexafluoride, a potent greenhouse gas. Solar moves from the fringe to the mainstream and doubts about the its green credibility will creep in, if the waste management is not taken care of.

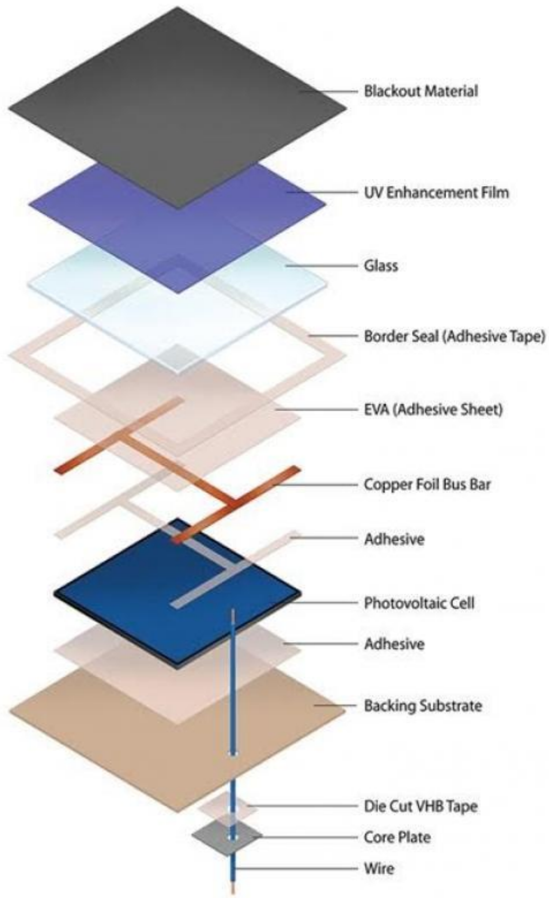


Figure 8-1:Components of a PV panel (credits: University of Maryland)

Recycling could be an attempt to sidestep the pitfalls of electronic waste and retain the industry's green credibility

At the end stage of the solar panels, the main concerns are:

1) Leaching of Lead: A highly toxic substance which can pollute the drinking water,
2) Leaching of Cadmium: Cadmium is a known carcinogen and is considered extremely toxic. Potential health impacts include kidney, liver, bone, and blood damage from ingestion and lung cancer from inhalation.
3) If the solar panels are not reused or recycled, overtime there will be a significant loss of precious resources such as glass and aluminum,

4) As solar panels also use some rare metals like indium and gallium, not recovering them at the end life could cause their permanent depletion.

8.2.1 Recommendations for reducing the environmental impacts of Solar Waste

- Recycle
- Expand recycling technology
- Ensure manufacturers are responsible for lifecycle impacts of the products
- Reduce/eliminate toxic materials used
- Ensure proper testing of materials

8.2.2 Recycling Solar Waste

At the end of the panel's life cycle, both solar modules and the various parts involved in manufacturing could be recycled. During the recycling process the semiconductor materials used to make the PV cells, as well as aluminum, copper, glass, and other materials used can reclaimed.

----- End of Section ------

Financial Analysis

9 Business Model

9.1.1 Introduction

The solar park is a concentrated zone of development of solar power generation projects and provides developers an area that is well characterized, with proper infrastructure and access to amenities and where the risk of the projects can be minimized. Solar Park will also facilitate developers by reducing the number of required approvals.

The solar park will provide a huge impetus to solar energy generation by acting as a flagship demonstration facility to encourage project developers and investors, prompting additional projects of similar nature, triggering economies of scale for cost-reductions, technical improvements and achieving large scale reductions in GHG emissions. Some Ultra Mega Solar Power Projects may be set up in these Parks or the entire park may individually be an Ultra Mega Solar Power Project.

9.2 Benefits from Solar Parks

For Stand Alone Solar Project, the following costs are incurred inside the power project which adds up to the production. The following cost heads are:

a) Land acquisition
b) Land development
c) Infrastructure development
d) Internal wiring and transmission line
e) O &M

In case of a Solar Park the Independent Power Producer (IPP) may save the total cost as the Solar Park Developers already set up the required infrastructure for the Power Projects. Power Developers just can avail the entire set up with a contract rate for a certain period.

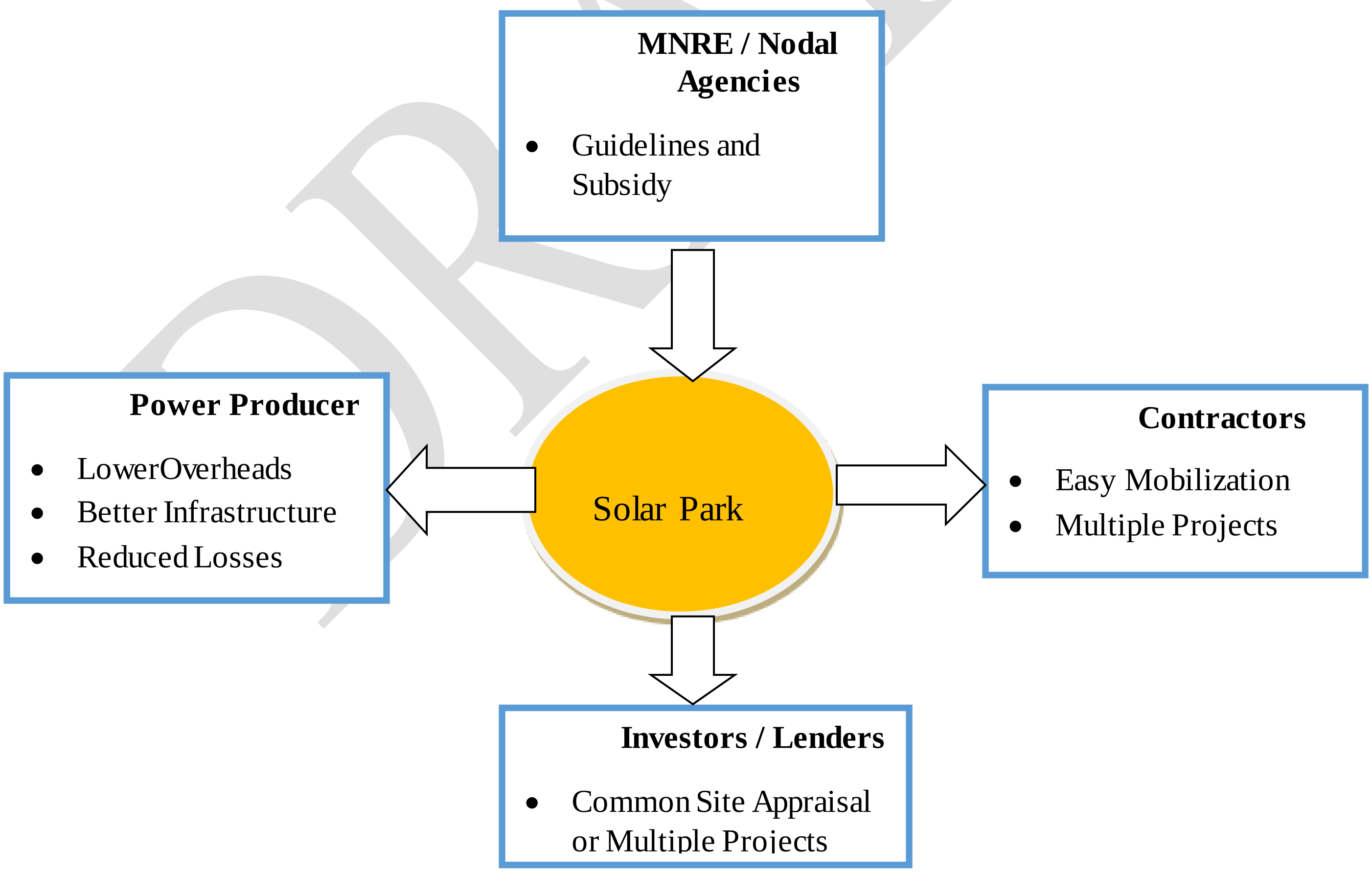
9.3 Dholera Solar Park

Gujarat Government with a vision of promoting clean energy has planned on to build solar parks which would invite solar power developers to build solar PV plants inside the park premises. The capacity of the total solar parks is 5000 MW. The capacity is divided into two (2) parts:

a) Phase 1: 1160 MW

b) Phase 2: 3840 MW

9.4 Value Proposition



9.5 Stakeholders

The different stakeholders associated with a solar park are:

a) **Power Producer:** The Independent Power Producer (IPP) are invited by tendering process by the nodal agencies and then selected based on the auction. The lowest tariff provider wins the contract of power generation. The power producer gets the following benefits from the solar parks:

   i) Large amount of land is accessible for power plant setup.

   ii) Better network optimization, better grid integration and reduced transmission losses

   iii) Huge potential for savings in terms of basic infrastructure facilities, water, construction power, roads, power evacuation system

   iv) The removal of regulatory hurdles allowing for accelerated deployment

b) **SPD Contractors:** Before allotment of land the park developers roll out SPD contracts for civil works, transmission line setup contracts, road construction contracts and other infrastructure development contracts. The time for setting up the infrastructure inside the park from the day of sanctioning is approximately 18 months. The SPD Contractors get the advantage of having multiple contracts from one site which is a profitable business deal.

c) **Investors / Lenders:** Different financial and non - financial corporation lends money for the power project in the solar parks against a fixed amount of return. There is a risk factor associated with the investors.

d) **GPCL:** GPCL is the nodal agency who is developing the solar park for the power generators. They will be the ones inviting the tender for SPD contracts and other construction related contracts for park infrastructure development.

9.6 Revenue Model

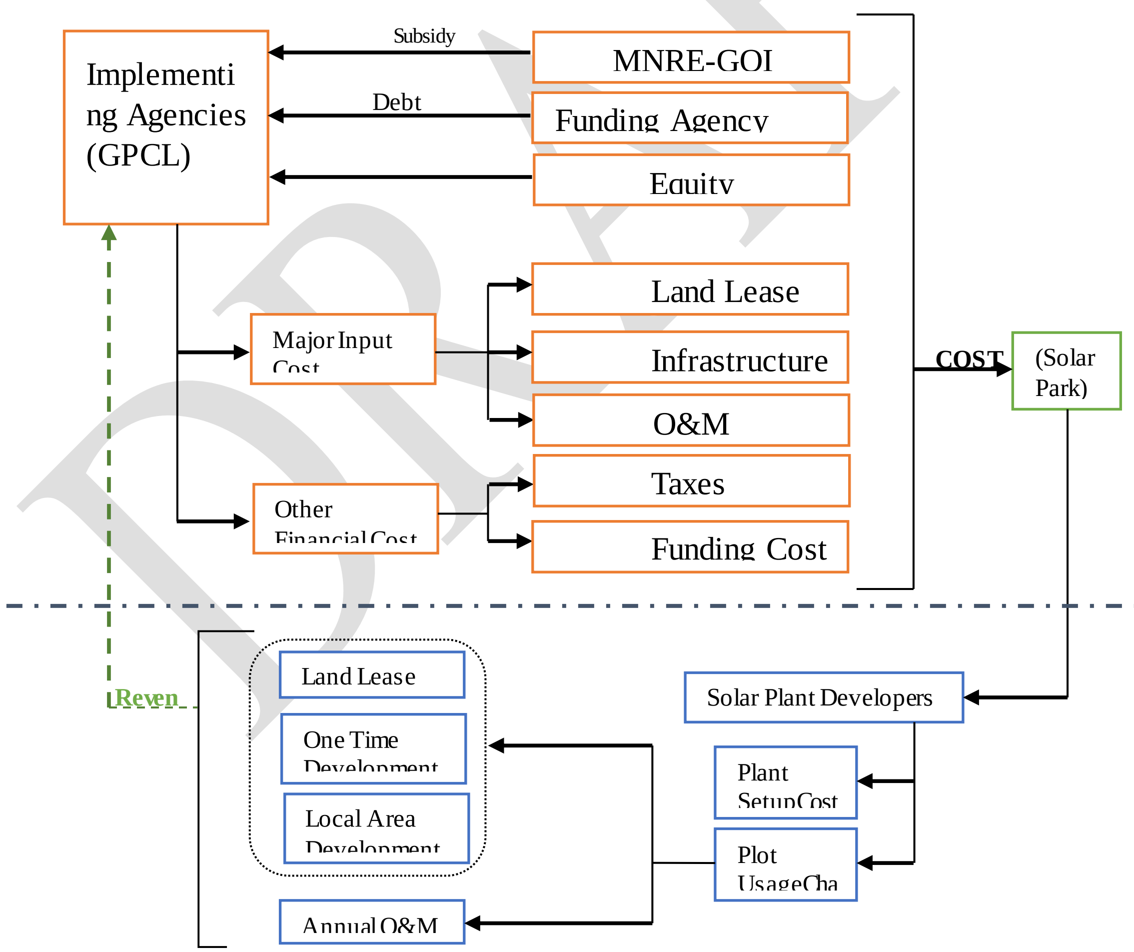
The revenue earned by the solar park developer will be based on the lease rate on the developed land. The source of revenue for GPCL shall be in two ways:

i. One will be a fixed one time charge which the power plant developers will have to pay in the initial phase

ii. A recurring charge which will be going on for the contracted lease period (here it is 25 years)

The revenue structure is designed in such a way that it becomes beneficial for both the park developer and the power plant developer benefits from the proposition. A schematic diagram of the revenue structure is shown below:

Figure 9 - 1 Revenue Model for Solar Park



9.7 Financial Analysis

9.7.1 Financial Principles Capital Cost

The norms for the Capital cost shall be inclusive of all capital work for machinery, civil work, erection and commissioning, financing and interest during construction, and evacuation infrastructure up to inter-connection point.

9.7.2 Debt Equity Ratio

The debt-equity ratio considered for calculation is taken as 70-30 as per common practice.

9.7.3 Interest Rate

Standard loan tenure of 12 years is considered at 10.50% interest rate per annum

9.8 Project Cost Analysis

9.8.1 Financial Principles Capital Cost

The norms for the Capital cost shall be inclusive of all capital work for machinery, civil work, erection and commissioning, financing and interest during construction, and evacuation infrastructure up to inter-connection point.

9.8.2 Debt Equity Ratio

The debt-equity ratio considered for calculation is taken as 70-30 as per common practice.

9.8.3 Interest Rate

Standard loan tenure of 12 years is considered at 10.50% interest rate per annum

9.8.4 Depreciation

Straight-line method for depreciation of the plant is considered for the financial calculations and is taken at 7% per annum for the first 10 years, and 1.33% per annum for the next 15 years.

9.8.5 Interest on Working Capital

The working capital to be considered in case of solar parks will be the sum of:

a) Operation & Maintenance expenses for one month.
b) Receivables equivalent to 1 month of energy charges for sale of electricity calculated.
c) Maintenance spare @ 15% of operation and maintenance expenses.

9.8.6 Operation and Maintenance Expenses

Operation and Maintenance or O&M expenses shall comprise repair and maintenance, establishment including employee expenses and administrative & general expenses.

Manpower and electricity consumption expenses as a part of O&M expenses shall be escalated at the rate of 3.00% per annum over the leasing tenure.

9.9 Financial Parameters

The financial parameters considered for preparing the financial model is listed below:

Table 9 - 1 Financial Parameters

#	Financial Aspect	Unit	Value
1	Capital Cost	Rs. (in Cr.)	
2	Lease period	Years	
3	Debt Equity Ratio	-	
4	Interest on Loan	%	
5	Loan Tenure	Years	
6	Tax rate	%	
7	O&M Cost	Rs. (In lacs) / MW	
8	Depreciation	%	
		%	
9	Interest on Working Capital	%	
10	Discount rate	%	

9.10 Model Layout

Financial Modeling (the "Model") was done on excel worksheet utilizingvarious tools and formulas of excel. The first sheet is the Input sheet, where the orange coded cells denote the input cells and the values of those parameters can be changed changing. Their effect will be reflected in the final result.

The Sheets included in the Model are:

a) Input (Refer: Annexure – 1)
b) Land Lease (Refer: Annexure – 2)
c) Revenue Structure (Refer: Annexure – 3)
d) Depreciation (Refer: Annexure – 4)
e) O&M (Refer: Annexure – 5)
f) Working Capital (Refer: Annexure – 6)
g) Debt Servicing (Refer: Annexure – 7)
h) Cash Flow Structure(Refer: Annexure – 8)

9.11 Summary Findings

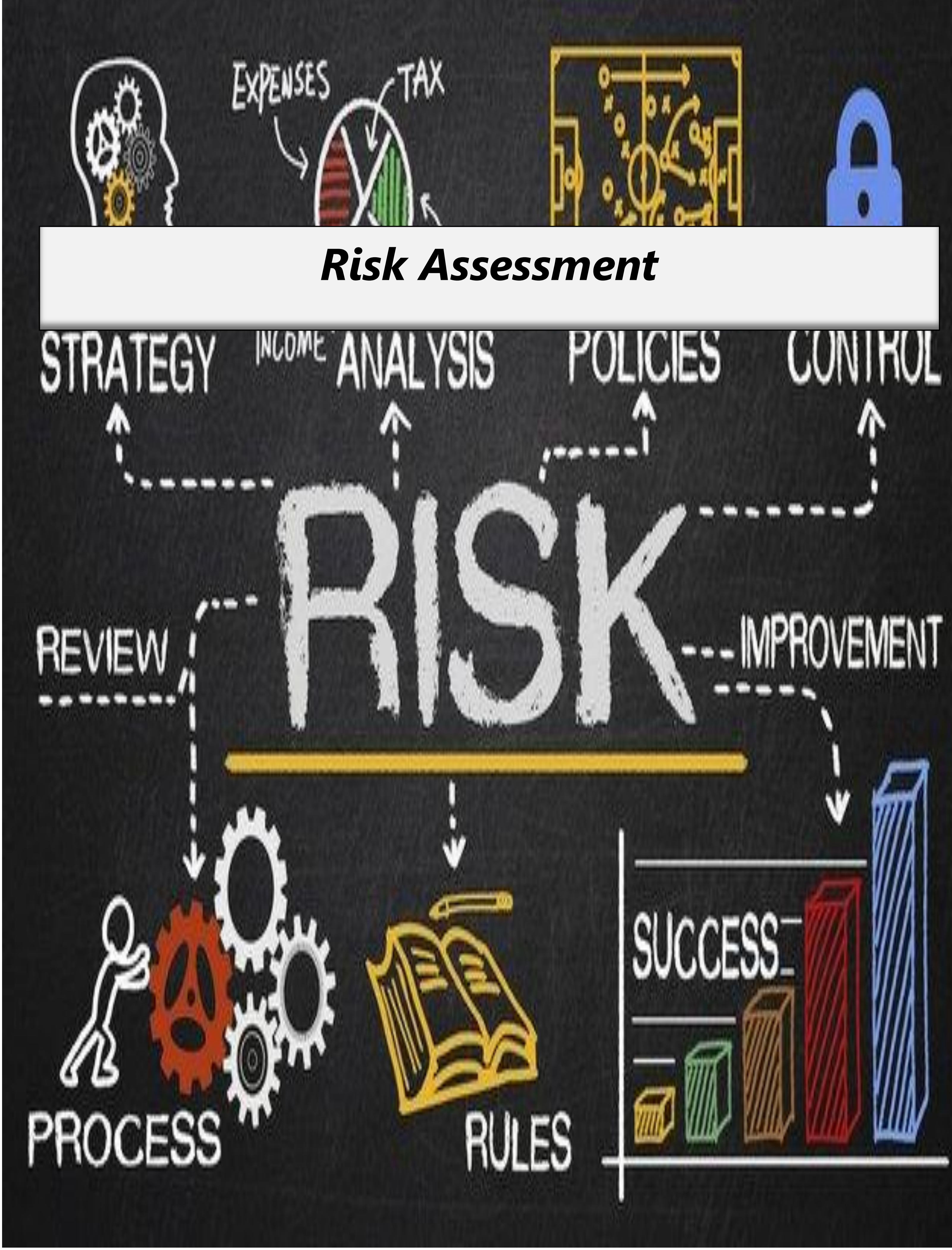
Based on the above-mentioned study and the financial model, the following results were obtained using and is summarized below:

Table 9 - 2 Financial Summary

Particulars	Unit	Value
Total Project Cost	Rs. Cr.	
Project IRR		
Project NPV	Rs. Cr.	
Equity IRR		
Equity NPV	Rs. Cr.	
DSCR		

--- End of Section ---

Risk Assessment



10 Risk Assessment & Mitigation Measures

The risks identification aims to detect in advance enough all those factors that may affect the project, in order to eliminate or reduce the negative risks and enhance positive risks or opportunities. Correct risks identification is essential since the rest of risks management processes, such as risk analysis and risk response strategies, may only take place on the identified potential risks. The identification of risks is an iterative process present throughout the project life cycle because the risks may evolve or appear new risks as the project advances. The frequency of iteration depends on the characteristics of the project.

Risk analysis which includes threat likelihood, impact, risk rating and mitigation measures are assessed by GERMI. Risks are categorized in following eight categories:

Project development risk	**Technical Risk (Plant location)**
Business risk	**Technical Risk (PV Technology)**
Operational risk	**Economic risk**
Financial risk	**Social Impact**

10.1 Risk Management

Risk Analysis and Management is a key project management practice to ensure that the least number of surprises occur while your project is underway. While we can never predict the future with certainty, we can apply a simple and streamlined risk management process to predict the uncertainties in the projects and minimize the occurrence or impact of these uncertainties. This improves the chance of successful project completion and reduces the consequences of those risks.

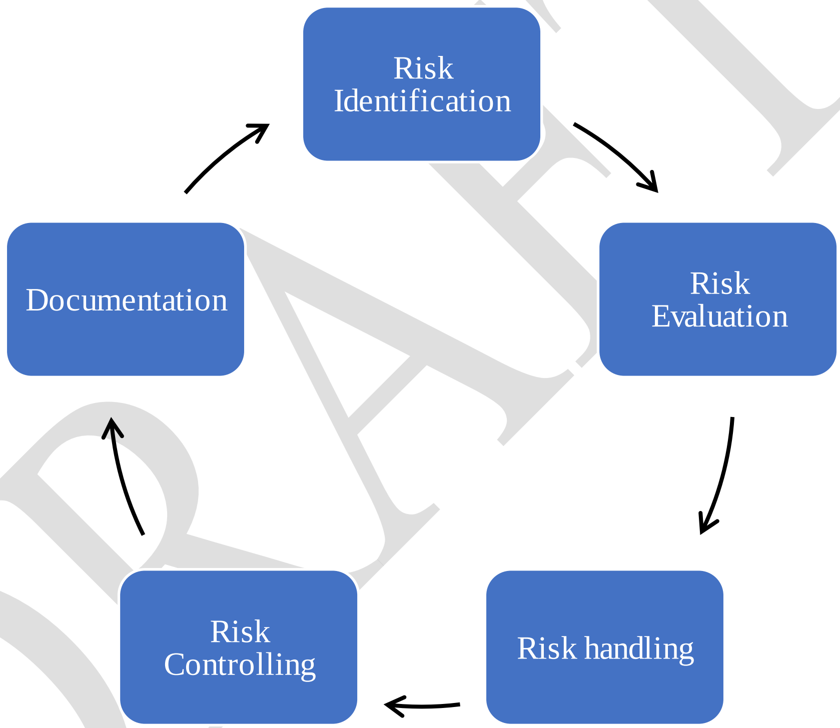


Figure 10-1: Flow Chart of Risk Management cycle

10.2 Potential Risk Associated with the Project & Mitigation Measures

Risks associated with the proposed Dholera Solar Park project

10.2.1 Project Development Risk

PM has little authority in the organization structure and little personal power to influence decision-making and resources, Priorities change on existing program, Project key success criteria not clearly defined to verify the successful completion of each project phase. Projects within the program often need the same resources at the same time

Date is being totally driven by need to meet marketing demo, trade show, or other mandate; little consideration of project team estimates

Sr. No.	**Risk classification**	**Likelihood of Threat**	**Impact of Threat**	**Risk rating**
1	Delay in Construction (Time over-run)	Medium	High	**High**
2	Local residents issue / opposition	Medium	Low	**Low**
3	Statutory and Environmental clearances	Low	High	**Low**
4	Permission from Border Security Force	Low	High	**Low**
5	Licensing, Commissioning and Approval	Low	Medium	**Low**
6	Procurement delay / issues	Low	High	**Low**
7	Environmental and Social	High	High	**High**
8	Project allotment to Developer	Low	High	**Low**
9	Availability of land	High	High	**High**

10.2.2 Business Risk

Business risk is the possibility of having lower than anticipated profits or experience a loss rather than taking a profit. Business risk is influenced by numerous factors, including sales volume, per-unit price, input costs, competition, the overall economic climate and government regulations. A company with a higher business risk should choose a capital structure that has a lower debt ratio to ensure it can meet its financial obligations at all times.

Sr. No.	Risk classification	Likelihood of Threat	Impact of Threat	Risk rating
1	Change in Government policy	Low	Medium	Low
2	Design Risk	Medium	High	High
3	Technology Risk	Medium	High	High
4	Force Majeure events	Medium	High	High
5	Recruiting and retaining Competent manpower	Medium	Medium	Medium
6	Inability to attract investors	Low	High	Low
7	Nearness to International Border	Low	High	Low

10.2.3 Operational Risk

Operational risk summarizes the risks a company undertakes when it attempts to operate within a given field or industry. Operational risk is the risk not inherent in financial, systematic or market-wide risk. It is the risk remaining after determining financing and systematic risk, and includes risks resulting from breakdowns in internal procedures, people and systems

Sr. No.	Risk classification	Likelihood of Threat	Impact of Threat	Risk rating
1	Operation and Maintenance	Low	High	Low
2	Incidents of theft	Medium	High	High
3	Availability of Water	High	High	High

10.2.4 Financial Risk

The cost of generating solar power in India is even higher than those for diesel generation therefore, solar power remains an uncertain and costly alternative for powergeneration. The central Government of India and the state governments offer a widerange of incentives, such as feed-in tariffs, generation incentives, renewable purchaseobligations (RPO), national and state capital subsidies, and tax incentives (World Bank2010). The lack of management and coordination between state and central programs makes it difficult for the contractors to adopt an economic approach, which makes ithard to attain their targets. It is expected that solar projects will reach grid parity in the coming years; however, that is a distant dream and the current costs of generation far exceeds the costs for conventional and other renewable energy sources.

Sr. No.	Risk classification	Likelihood of Threat	Impact of Threat	Risk rating
1	Cost inflation (Cost over-run)	Medium	Low	**Low**
2	Increase in finance cost	Low	Low	**Low**
3	PPA	High	High	**High**

10.2.5 Technical Risk (Plant Location)

Solar expertise also demands highly accurate engineering apparatus such as parabolic mirrors and receiver tubes, which are not obtainable locally. Data process consistency and quality standards are not consistent because of inadequate field knowledge, with each contractor imposing their own paradigm. The intensity of customization means that the solar apparatus has to be deployed on a project by-project basis, preventing companies from generating revenue on high-scale productivity. This risk develops due to a lack of expertise and little or no experience in stimulating capital.

Sr. No.	Risk classification	Likelihood of Threat	Impact of Threat	Risk rating
1	Technological climate change adequacy	Medium	High	**High**
2	Flood and storm risks	Medium	High	**High**
3	Estimation of effective solar radiation	Medium	High	**High**
4	Earthworks	Medium	High	**High**
5	Earthquake	Medium	High	**High**

6	Geotechnical study	Medium	High	**High**

10.2.6 Technical Risk (PV Technology)

The main generation components selection of the photovoltaic installation such as photovoltaic modules, structure support, power inverters, is a key to the successful achievement of the project, and entails certain risks

Sr. No.	**Risk classification**	**Likelihood of Threat**	**Impact of Threat**	**Risk rating**
1	New PV solar power systems	Low	Low	**Low**
2	PV cell selection	Low	Low	**Low**
3	Inverters selection	Low	Low	**Low**
4	Support panels structure selection	Medium	High	**High**
5	Connection to the electric grid	Medium	Medium	**Medium**

10.2.7 Economic Risk

As investment project, evaluation of economic risks is transcendental, even more in the case of a real investment project valued at 25000 cr. INR

Sr. No.	**Risk classification**	**Likelihood of Threat**	**Impact of Threat**	**Risk rating**
1	Connection to electric grid costs	High	High	**High**
2	Possibility of constructing the power connection infrastructure	Medium	High	**High**
3	Construction license	Low	Low	**Low**

10.2.8 Social Impact

Social acceptance of a utility scale solar park is an important issue and requires reasonable consideration and thorough analysis because their practical application increasingly affects people and states. Likelihood of any social backlash in proposed solar park project is very low. Local population of an area where a solar park is setup rarely opposes the development of such facilities. Moreover, there is sense of awareness among the people about climate change which further minimizes the probability of such event. Some of the land for the proposed project has been given by the residents of near-b villages on lease.

Sr. No.	**Risk classification**	**Likelihood of Threat**	**Impact of Threat**	**Risk rating**
1	Social acceptance	Low	Medium	**Low**

The above risks structure will be the basis for future research that develops the following stages of risk management for the construction project, such as risk assessment, risk response and risks monitoring and control throughout the project life cycle.

------ End of section -------

Environmental & Sociological Impact

11 Environmental & Sociological Impact

11.1 Introduction

Gujarat is one of the most developed states of India. The state is endowed by vast reserves of mineral and oil resources and characterized by high industrialization. With the advent of privatization during the first economic reform the state has observed the active role of private players in the economic development. The private investment in the infrastructure & urban development has given a new direction to the growth trend of the state.

With its growing industrialization, presently, the Gujarat state is all set to take off an exponential growth curve. Clearly, to facilitate such economic growth, increasing needs of the people for better quality of life and to cater to the burgeoning trade through the hinterland, the state has also drawn an infrastructure roadmap and intends to develop a world class infrastructure to help sustain the increasing rapid pace of economic growth.

11.2 Need of the project

World's Largest solar park is proposed to be developed in Dholera, Gujarat. There are around 34 such parks across the country in association with the Solar Energy Corporation of India (SECI); Government of India. Gujarat Power Corporation Limited(GPCL) has taken the advance initiative to develop the proposed world's largest Solar Park cumulative capacity of 5000 MW and the nodal agency for the development of the solar park is Gujarat Power Corporation Limited(GPCL). The power evacuation facilities from Solar Park will be furnished by Power Grid Corporation of India Limited (POWERGRID).

11.3 Resources

The major resources required for proposed expansion project identified areland, water, power and man-power, which are described briefly here under:

11.3.1 Land:

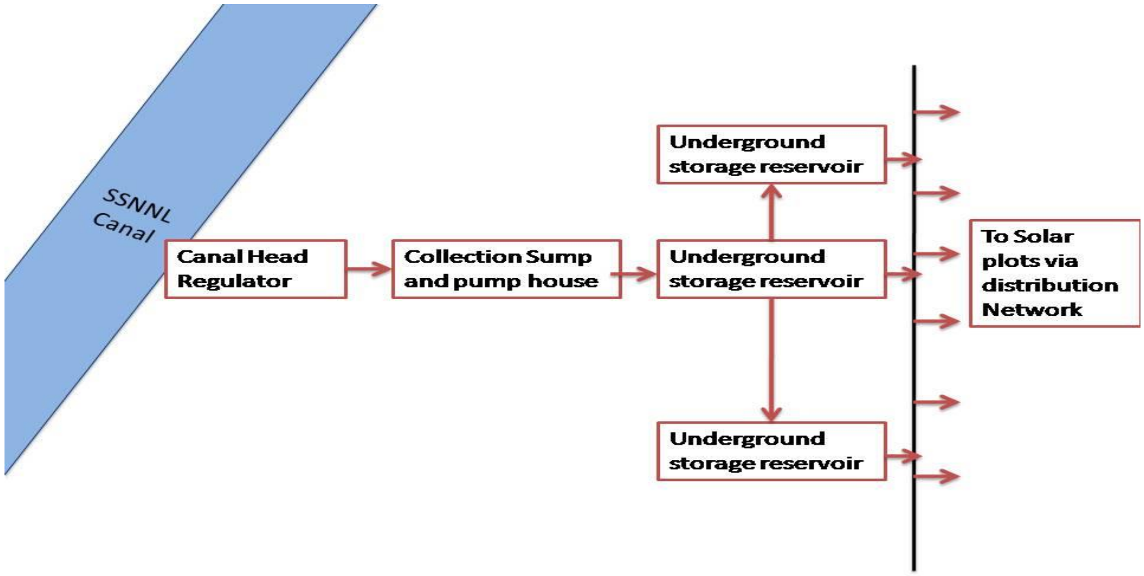
The land around the Gulf of Khambhat (Cambay) has been formed under Fluviomarine environments and therefore the soils of the area have inherent salts in their composition. The changing environmental conditions and human interventions have caused increase in the spread and concentration of soil salinity over the past several decades

The geomorphic processes of erosion, sediment transport, deposition, and the extent and condition of tidal wetlands greatly influence the usage of land in the proposed area.

11.3.2 Water

According to the information made available by the proponent, it is estimated that the fresh water procurement shall be about 1.25ML/D which will be satisfied through the water supply system of SSNNL. The present source of water supply i.e. the bore well will be occasionally used.

Thus, there will not be additional fresh water requirement. The water balance diagram indicating distribution of water is shown in Figure below.



11.3.3 Energy:

Power requirement will be limited to street lighting and general-purpose lighting during Operational and Maintenance phase of the project. But during the construction period, power requirement shall be fulfilled by using DG sets.

11.4 Description of Environment

The baseline environmental quality in the vicinity of the project site and the study area is useful for identification, prediction and evaluation of impacts due to proposed project activities. Prevailing environmental conditions served as an essential tool to determine the extent of impacts likely to occur due to proposed activity. The existing environmental conditions provides a datum to predict and assess the environmental changes likely to occur. The environmental quality with reference to different environmental attributes namely Air, Water, Soil, Biological has been described.

Sr No	Environment Attribute	Methodology

1	Topography	A topographic contour map for periphery need to be prepared using SRTM data.
2	Water quality	Surface Water: Grab sampling from River for the study. Ground Water: Grab sampling from bore wells in surrounding villages.
3	Climate & Meteorology	Primary data using weather monitoring station need to be installed within the study area.
4	Ambient Air Quality	Monitoring need to be carried out for a pre-defined period at different locations. Samples need to be collected twice in a week for 12 weeks at each location and need to beanalyzed for PM_{10}, $PM_{2.5}$,SO_2, NOx as per relevant sections of IS 5182.
5	Noise Levels	Measurement of Day and Night noise levels need to be carried out at different locations with Sound LevelMeter once during the study period.
6	Land use pattern	Satellite image from NRSA need to be utilized toestablish the land-use pattern in the area usingGIS software.
7	Biological layout	Primary and Secondary data for the list of local flora & fauna.
8	Socio-economic Study	Reviewing of the secondary data obtained from EIC.

The air quality, water quality, Noise, Land / soil quality and Biological shall be submitted in detailed environment report.

11.5 Environment and Social Impact of a Solar Park

Even though a solar power farm looks like a development that has vast impact on environment and is a step towards sustainable future but there is more to it than just environmental aspect. It affects life of habitats of the location where such plant is setup. Moreover, there are ways it can have a negative impact and corrective measures should be taken to minimize the negative impact it can have on the environment and the society. The implementation and operation of thesolar farm must be assessed with respect to its socio-economic and environmental issues and any negative impactmitigated.

11.6 Health Status

Based on the available information, the general prevailing diseases in the project region are malaria, diarrhea, dysentery and viral fever. The healthproblems as reported could be attributed to improper sanitation, mosquito nuisance and water logging in the villages. Specially the migrant populations ofthe study area are reported to be suffering from various diseases mostly becauseof inadequate primary health facilities.

The available records indicate that, the people in the region have no complaints regarding health problems arising out of the industries in the surrounding area.

11.7 Solar Park Impact on Environment

The sun provides a tremendous resource for generating clean and sustainable electricity without toxic pollution or global warming.

The potential environmental impacts associated with a solar park can be both positive and negative.

11.7.1 Positive Impact of Solar Parks

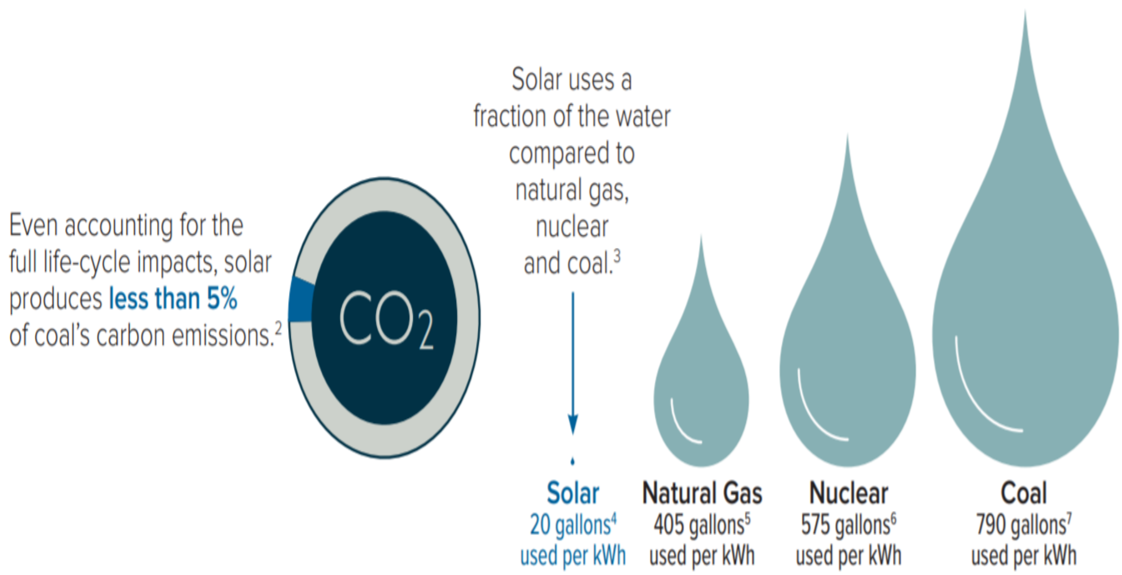
Solar Park has positive environmental impacts when compared to conventional energy, for instance, reduction of the greenhouse gas emissions (CO_2, N_2O, CH_4, etc.), and prevention of toxic gas emissions (SO_2, particulates).

Solar energy systems used in Solar Park are silent because they don’t have loud moving part. Hence, there is no any sort of disturbing noise pollution coming out from Solar Park.

Solar reduces the need for finite resources: Solar energy is renewable and once completed, it will not need any finite resource for its functioning unlike conventional based power plants.

Thus, having positive impact on environment.

Solar reduces water pollution: While all manufacturing processes require some water, solar PV cells don't need water to generate electricity. This is one of the biggest, yet least talked about environmental benefits of solar. Traditional biomass and geothermal power plants, such as natural gas and coal-fired facilities, require massive amounts of water to facilitate their vital cooling requirements. With solar energy there is no pollution of local water resources, nor does their operation (which again requires NO water) strain local supplies through the competition with agriculture, drinking systems, and other vital water needs.



The **two graphics below** compare some of the environmental impacts of common energy sources. Solar energy not only generates fewer lifecycle greenhouse gas emissions than coal, but also uses much less water.

11.7.2 Negative Impact of Solar Park

Land Use: Depending on their location, large utility-scale solar facilities can raise concerns about land degradation and habitat loss. Total land area requirements vary depending on the technology, the topography of the site, and the intensity of the solar resource. However, land impacts from utility-scale solar systems can be minimized by setting them at lower-quality locations such as that chosen for this project.

Hazardous Materials: PV panel production is energy intensive and causes depletion of some natural resources because bulk semiconductor material is needed in high quantities.

During the construction, soil is removed alongside its flora and fauna. Inherent biological soil crusts are turned over and the soil becomes vulnerable to soil erosion.

Solar Heat Island Effect

Although solar energy is the solution to the requirement of cheap & clean energy and solar parks are becoming popular all over the world as they bring power from solar energy closer to grid-parity by exploiting economies of scale. A growing concern that remains understudied is whether or not PV installations cause a "heat island" (PVHI) effect that warms surrounding areas, thereby potentially influencing wildlife habitat, ecosystem function in wildlands, and human health and even home values in residential areas. As with the Urban Heat Island (UHI) effect, large PV power plants induce a landscape change that reduces albedo so that the modified landscape is darker and, therefore, less reflective. Lowering the terrestrial albedo from ~20% in natural deserts to ~5% over PV panels alters the energy balance of absorption, storage, and release of short- and longwave radiation.

The PV Heat Island could be associated to the following reasons:

- PV installations shade a portion of the ground and therefore could reduce heat absorption in surface soils
- PV panels are thin and have little heat capacity per unit area but PV modules emit thermal radiation both up and down, and this is particularly significant during the day when PV modules are often 20 °C warmer than ambient temperatures
- Vegetation is usually removed from PV power plants, reducing the amount of cooling due to transpiration.
- PV panels reflect and absorb upwelling longwave radiation, and thus can prevent the soil from cooling as much as it might under a dark sky at night.

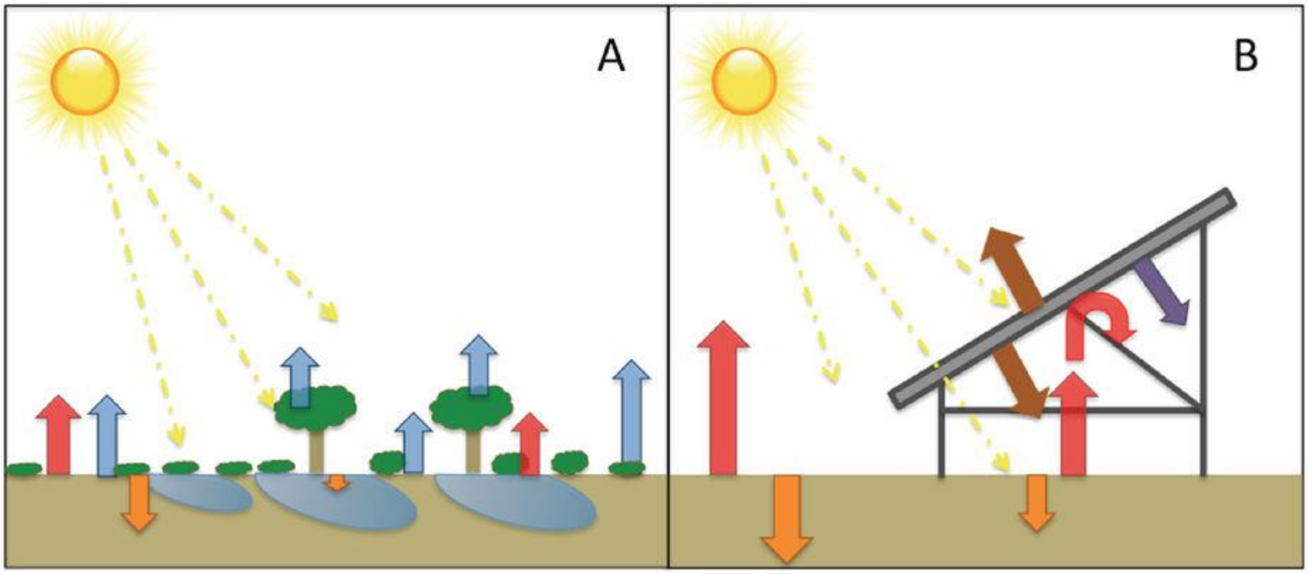


Figure 11-1:Solar incidence on Natural ecosystem vs PV modules

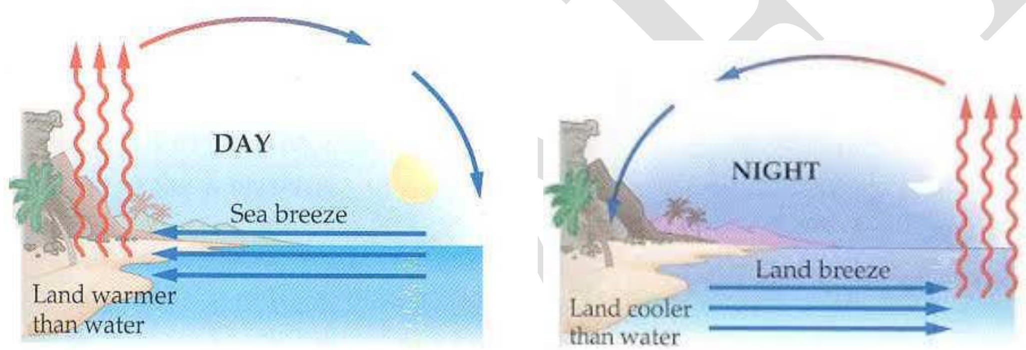
Within natural ecosystems, vegetation reduces heat gain and storage in soils by creating surface shading, though the degree of shading varies among plant types, Energy absorbed by vegetation and surface soils can be released as latent heat in the transition of liquid water to water vapor to the atmosphere through evapotranspiration – the combined water loss from soils (evaporation) and vegetation (transpiration). This heat dissipating latent energy exchange is dramatically reduced in a typical PV installation

The PVHI effect caused ambient temperature to regularly approach or be in excess of 4 °C warmer than the natural desert in the evenings, essentially doubling the temperature increase due to UHI measured here. This more significant warming under the PVHI than the UHI may be due to heat trapping of re-radiated sensible heat flux under PV arrays at night.

Land and sea breezes are wind and weather phenomena associated with coastal areas. A land breeze is a breeze blowing from land out toward a body of water. A sea breeze is a wind blowing from the water onto the land. Land breezes and sea breezes arise because of differential heating between land and water surfaces. Land and sea breezes can extend inland up to (161 km), or manifest as local phenomena that quickly weaken with a few hundred yards of the shoreline.

On average, the weather and cloud effects of land and sea breezes dissipate 32-48 km inland from the coast.

Air above the respective land and water surfaces is warmed or cooled by conduction with those surfaces. During the day, the warmer land temperature results in a warmer and therefore, less dense and lighter air mass above the coast as compared with the adjacent air mass over the surface of water. As the warmer air rises by convection, cooler air is drawn from the ocean to fill the void. The warmer air mass returns to sea at higher levels to complete a convective cell. Accordingly, during the day, there is usually a cooling sea breeze blowing from the ocean to the shore.



A relative study for Investigation of wind speed cooling effect on PV panels in windy locations indicates the cooling effect of wind speed to the PV operating temperature.

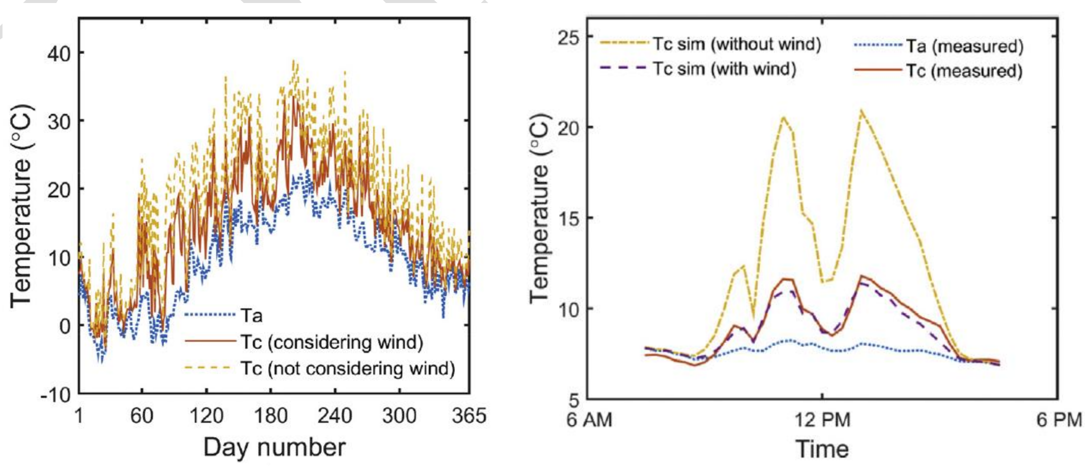


Figure 11-2:(a) Comparison of temperature estimation functions. (b) Comparison of experiment and simulation for temperature (Winter Day)

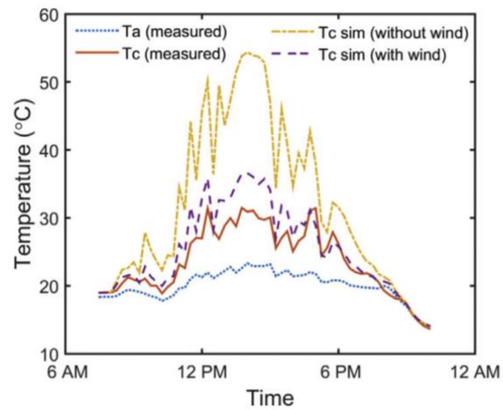


Figure.11-3: Comparison of experiment and simulation for temperature (Summer Day)

Simulation results show that wind speed helps PV to operate much cooler. Due to this, the rise in temperature will be negligible.

11.7.3 Conclusion:

Every solar panel that is built and successfully used in Solar Park as a substitute for fossil fuels is reducing the amount of pollutants released into the atmosphere. Overall, using solar energy as a substitute for fossil fuels will have a positive impact on the environment. Thus, Solar Park has net positive impact on environment compare to conventional based power stations.

11.7.4 Socio-economic Impact of Solar Park

Renewable energy provides substantial benefits for our climate, our health and our economy. Some of them are:

Job Creation: Compared with fossil fuel technologies, which are typically mechanized and capital intensive, the renewable energy industry is more labor-intensive. This means that, on average, more jobs are created for each unit of electricity generated from renewable sources than from fossil fuels. Dholera Solar Park Project will generate more than 20,000 jobs.

Table 11-1:Employment Generation During construction,operation& maintenance

Labor	Jobs Created
Skilled labor	5000
Unskilled labor	15000

Prosperity for nearby businesses: In addition to the jobs directly created in the renewable energy industry, growth in renewable energy industry creates positive economic "ripple" effects. For example, industries in the renewable energy supply chain will benefit, and unrelated local businesses will benefit from increased household and business incomes.

Air Quality Improvement: Generating electricity from renewable energy rather than fossil fuels offers significant public health benefits. The air and water pollution emitted by coal and natural gas plants are linked to breathing problems, neurological damage, heart attacks, and cancer. Replacing fossil fuels with renewable energy has been found to reduce premature mortality and lost workdays, and it reduces overall healthcare costs.

Solar power generation has no associated air pollution emissions. While other renewable source of energy such as geothermal and biomass energy systems emit some air pollutants, total air emissions are generally much lower than those of coal- and natural gas-fired power plants. The absence of air pollution contributes in the improvement of air quality and decrease in diseases associated with pollutants.

Sustainable Source of Energy: By tapping from the free source of energy which is the sun, the electricity production from other sources such as fossil fuel can be reduced. Fossil fuel is exhaustive and one day will be completed depleted. This will jeopardize future generation needs. By encouraging the use of renewable source of energy such as the sun, the dependency on fossil fuel can be reduced and the available stock can be used for a longer time.

Reliable Energy System: Energy from solar power is less prone to large scale failure because they are modular and not centralized. They are spread over a large geographical area. A problem in one location will not cut off power over an entire region or country. Modular system has the advantage of staying operational even if some of the equipment in the system is damaged. Renewable source of energy is more resilient than coal, crude oil or natural gas power plants because they can resist disruptive events.

Table 11-2: Impact of Solar Parks

S.No.	Function	Degree of Impact
1	Reduction of GHG	+++
2	Creating sustainable future	+++
3	Job Creation	++
4	Improving quality of life	++
5	Attracting Tourism	+

"+" Depicts little Positive impact, "++" depicts more than a little Positive impact "+++" Depicts high Positive impact+

11.8 Carbon footprints

Carbon footprint can be defined as the total amount of greenhouse gases produced to directly and indirectly support human activities and is usually expressed in equivalent tons of carbon dioxide (CO2). Greenhouse gases can be emitted through transport, land clearance, production and consumption of food, fuels, manufactured goods, wood, roads, buildings and services. An individual's, nation's, or organization's carbon footprint can be measured by undertaking a GHG emissions assessment or other calculative activities denoted as carbon accounting. Once the size of a carbon footprint is known, a strategy can be devised to reduce it, e.g. by technological developments, better process and product management, changed Green Public or Private Procurement (GPP), carbon capture, consumption strategies, carbon offsetting and others. Carbon Footprints can be reduced through the development of alternative projects, such as solar and wind energy, which are environment friendly, renewable resources, or reforestation, the restocking of existing forests or woodlands that have previously been depleted. These examples are known as Carbon Offsetting, the counteracting of carbon dioxide emissions with an equivalent reduction of carbon dioxide in the atmosphere.

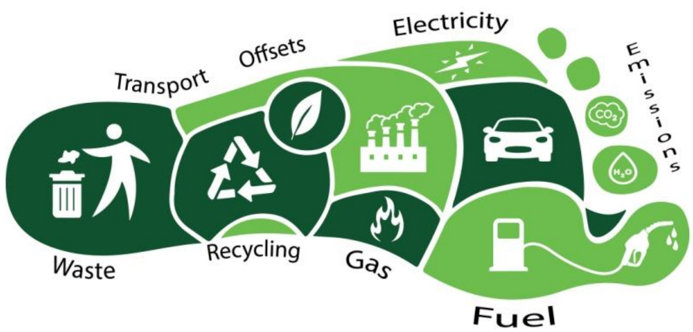


Figure 11-4: Carbon foot-prints

The main influences on carbon footprints include population, economic output, and energy and carbon intensity of the economy. These factors are the main targets of individuals and businesses in order to decrease carbon footprints. Production creates a large carbon foot-print, scholars suggest that decreasing the amount of energy needed for production would be one of the most effective ways to decrease a carbon footprint. This is due to the fact that Electricity is responsible for roughly 37% of Carbon Dioxide emissions. Coal production has been refined to greatly reduce carbon emissions; since the 1980s, the amount of energy used to produce a ton of steel has decreased by 50%.

Some Interesting Numbers:

- Each of the following activities add 1 kg of CO2 to your personal carbon footprint:

  - Travel by public transportation (train or bus) a distance of 10.5 to 11 Kms
  - Drive with your car a distance of 6 Kms.
  - Fly with a plane a distance of 2.2 Kms
  - Operate your computer for 32 hours (60-Watt consumption assumed)
  - Production of 5 plastic bags
  - Production of 2 plastic bottles

**(Source-https://www.greenmatch.co.uk/blog/2014/07/how-to-reduce-your-carbon-footprint-with-solar-power)*

- The carbon footprint of US households is about 5 times greater than the global average, which is around 10 tons CO2 annual emission per household. The most important action to reduce their carbon footprint is driving less or switching to more efficient vehicles.

11.8.1 Sources of Greenhouse Gases

Following are the primary sources for Greenhouse gasses emission in the atmosphere.

1. **Electricity Production** contributes to Carbon dioxide, ChloroFloro Carbons, Methane and Nitrous Oxide.
2. **Transportation** contributes to Carbon dioxide.
3. **Industry** contributes to Carbon dioxide, ChloroFloro Carbons, Methane and Nitrous Oxide.
4. **Commercial and Residential Buildings** contributes to Carbon dioxide and ChloroFluoro Carbons.
5. **Agriculture** contributes to Carbon dioxide and Nitrous Oxide
6. **Land Use and Forestry** contributes to Carbon dioxide.

11.8.2 Limitations of Greenhouse gases

Now-a-days nearly anything you do, from travelling to turning on the light in your house, produces greenhouse gases. The production of greenhouse gases should be controlled so it will stop from being a threat to our earth's environment. Limitations of the greenhouse gases are as follows:

- If produced in excess amount, these gases will trap more energy and eventually the earth`s temperature will rise.
- Rising temperatures will alter the whole eco-system of the earth.

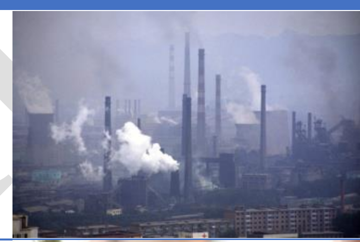
11.8.3 Factors Leading to Excess Greenhouse emission

Following factors mainly contribute to the excess emission of greenhouse gases in the atmosphere.

1. **Increasing Population** leads to greater demands for fossil fuels, machines and equipment which eventually leads to excess emissions of Greenhouse gases.
2. **Industrialization** is producing more greenhouse gases than required.
3. Human activities, such as **Deforestation,** burning fossil fuels, pollution and many others.

11.8.4 Result:

The sum of the greenhouse gas emissions for 5000 MW is of **11,485,024 T** of Carbon Dioxide Equivalent.

Sr. No.	greenhouse gas emissions	Quantity	Picture
1	CO2 emissions	**11,399,385,120** Pounds of coal burned	
		1,172,390,908 gallons of gasoline consumed	
		425,927,253 propane cylinders used for homes	

2	Greenhouse gas emissions	**22,31,057** Passenger vehicles driven for one year	
3	Carbon sequestered by	**270,021,291** tree seedlings grown for 10 years	

Calculation Source: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator (an official US government website) (environmental protection agency – EPA)

ANNEXURE & GLOSSARY

12 Annexure & Glossary

12.1 Abbreviations

AC- Alternating Current
APAC-Asia Pacific
ACEB-AC Electrical board
A-Si- Amorphous silicon
BoS-Balance of System
CAGR- Compound Annual Growth Rate
CBR-California Bearing Ratio
Cd-Te- Cadmium Telluride
CIGGS-Copper Indium Gallium Sulphur Selenide
CO_2- Carbon Dioxide
COD-Commercial Operation Date
COP21- Conference of Parties 21
CPSU-Central Public-Sector Company
CPV-Concentrating PV
CRZ-Coastal Regulation Zone
(C-Si)-Crystalline silicon
CTU-Central Transmission Unit
CUF-Capacity Utilization Factor
CVI-Coastal Vulnerability Index
DC-Direct Current
DCR-Debt Coverage Ratio
DHI- Diffuse Horizontal Irradiance
DisCom-Distribution Company
DICDL-Dholera Industrial City Development Limited
DMICDC-Delhi Mumbai Industrial Corridor Development Corporation Ltd
DNI- Direct Normal Incidence
DSIR-Dholera Special Investment Region
DSIRDA-Dholera Special Investment Region Development Association
DSSC-Dye-Sensitized Solar Cell
EA 2003- Electricity Act,2003
EBV- Evaluated Bid Value
ESAI- Environmental & Social Impact Assessment
EVA- Ethyl Vinyl Acetate
FDI-Foreign Direct Investment
FiT-Feed-in Tariffs
GEB-Gujarat Electricity Board
GETCO-Gujarat Energy Transmission Corporation
GHG-Green House Gas
GHI-Global Horizontal Irradiance
GPCL-Gujarat Power Corporation Limited
GPP-Green Public or Private Procurement
GOI- Government of India
GSPC-Gujarat State Petroleum Corporation Limited
GUVNL-Gujarat UrjaVikas Nigam Limited.
GW- Gigawatt
GWh-Gigawatt-Hour
Ha-Hectare
HCPV-High concentration PV
HPSV-High-Pressure Sodium Vapor
HTL-High Tide Line
IEA-International Energy Agency
IEX-Indian Energy Exchange
IPP-Independent Power Producer
IRC-Indian Road Congress
ISA-International Solar Alliance
kN- kilonewton
kW-Kilowatt
kWh-Kilowatt-hour
LCOE-Levelized Cost of Electricity
LCR-Local Control Room
LED-Light Emitting Diode
MCR-Master Control Room
MG-Si-Metallurgical-Grade Silicon
MLD-Million Liters Day
MMS-Module Mounting Structure
MNRE-Ministry of New & Renewable Energy
MOEF-Ministry of Environment and Forests
MoU-Memorandum of Understanding
MPPT-Maximum Power Point Tracking
MSA-Million Standard Axle
MW- Megawatt
NAPCC-National Action Plan on Climate Change
NEEG- Net Electrical Energy Generation Guaranteed

Energy & Petrochemicals Department
Government of Gujarat

NH-National Highway
NISE-National Institute of Solar Energy in India
NPVM-NTPC VidyutVyapar Nigam Ltd
NTPC- National Thermal Power Corporation
NO_2-Nitrogen Dioxide
O&M- Operation & Maintenance
PID-Potential Induced Degradation
PMC- Project Management Consultant
PPA-Power Purchase Agreement
PR-Performance Ratio
PSU-Public Sector Undertaking
PV-Photovoltaic
PVHI-PV Heat Island
PXIL-Power Exchange India Limited
RE-Renewable Energy
REC-Renewable Energy Certificate
RFID- Radio-frequency identification
RPO-Renewable Purchase Obligation
SCB- String Combiner box
SECI-Solar Energy Corporation of India
SH-State Highway
SIA- Social Impact Assessment
SIRO-Scientific and Industrial Research Organization
SCADA-Supervisory Control and Data Acquisition
SO_2-Sulphur Dioxide
SPD-Solar Project Developer
SPPD- Solar Power Park Developer
SPV- Special Purpose Vehicle
SWD-Storm Water Drainage
TF-Thin Film
THD-Total Harmonic Distortion
UHI-Urban Heat Island
UMSPP- Ultra Mega Solar Power Projects
VGF-Viability Gap funding

12.2 Annexure -1 (Input)

12.3 Annexure -2 (Land Lease)

12.4 Annexure -3 (Revenue Structure)

12.5 Annexure -4 (depreciation)

12.6 Annexure -5 (O&M)

12.7 Annexure -6 (Working Capital)

12.8 Annexure -7 (Debt Servicing)

12.9 Annexure -8 (Cash Flow Structure)

12.10 Annexure – 9 : List of Solar Parks in India

Sl. No.	State	Solar Park Implementation Status			
		Name / Location	Capacity (MW)	In-principle Approval (Date)	Implementing Agency (SPPD)
0	A and N Islands	A&N Solar Park, South Andaman Dist at 1. Mithakhari, 2. Havelock Island, 3. Neil Island, 4. Garacharama (AttamPahar), 5. Chidiyatapu	100	21-08-2015	NTPC

1	Andhra Pradesh	Anantpur Ultra Mega Solar Park, Location: N.P.Kunta and P.Kothapalli, N.P.KuntaMandal, Ananthapuramu District.	1500	28-11-2014	AP Solar Power Corporation Pvt. Ltd. (APSPCL), A JV of SECI, APGENCO & NREDCAP
2		Kadapa Solar Park, Thalamanchipatnam, Ponnampalli, Rama ChandrayaPalli, Dhondiam and Vaddirala villages of MylavaramMandal of Kadapa District	1000	28/07/2015 & 09/10/2015	
3		Kurnool Ultra Mega Solar Park, Gani and Sakunala Villages of Kurnool Distric	1000	28-11-2014	
4		Ananathapurumu II Solar Park, Talaricheruvu&Aluruvill. ofTadipatriMandal of Ananthapuramu District.	500	14.01.2016	
5	Arunachal Pradesh	Lohit Solar Park, LohitDist	100	29-04-2015	Arunachal Pradesh Energy Development Agency (APEDA)
6	Assam	Amguri Solar Park, Amguri&Sibsagar District	69	28-08-2015	JV of Assam Power Distribution Company Ltd. (APDCL), Assam Power Generation Corp. Ltd (APGCL)
7	Chhattisgarh	Rajnandgaon	500	29-09-2015	Chhattisgarh State Renewable Energy Development Agency (CREDA)
8	Gujarat	Radhanesda Solar Park, RadhanesdaVill. VavTehsi, District Banskantha	700	1/12/2014	Gujarat Power Corporation Limited (GPCL)
9	Haryana	At Bugan in Hisar Dist., Baralu&Singhani in Bhiwani Dist., Daukhera in Mahendergarh Dist.	500	15-01-2016	Saur Urja Nigam Haryana Ltd.(SUN Haryana), A SPV between HSIIDC and HPGCL

10	Himachal Pradesh	Kaza Solar Park, Spiti Valley	1000	9/4/2015	HP State Electricity Board Ltd.
11	J&K	Mohargarh and BadlaBrahmana, District Samba	100	29-09-2015	J&K Energy Dev. Agency (JAKEDA)
12	Karnataka	Tumkur Solar Park Vallur, Ballasamudra, Tirumani, Rayacherlu&Kyataganacherlu of NagalamadikeHobli, PavagadaTaluk, TumkurDist	2000	19-03-2015	Karnataka Solar Power Development Corporation Ltd. (KSPDCL) A JV of SECI & KREDL
13	Kerala	Kasargod Solar Park AtPaivalike, Meenja, Kinnoor, Kraindalam and Ambalathara Villages of KasargodeDist	200	19-03-2015	Renewable Energy Corporation of Kerala (JVC of SECI and KSEB)
14	Madhya Pradesh	Rewa Ultra Mega Solar Ltd. Vill.-Badwar, ItarPahad, Ramnagar, Barseta Tehsil-GurhDist- Rewa	750	1/12/2014	Rewa Ultra Mega Solar Ltd. A JV of SECI & MPUVNL
15		Neemuch-Mandsaur Solar Park (Neemuch-250 MW & Mandsaur-250 MW)	500	08.06.2016, 15-01-2016 & 06-10-15, 28-09-15	
		Chhatarpur Solar Park at ChhatarpurDistt.	500	08.06.2016, 15-01-2016	
16		Agar-Shajapur Solar Park (Agar-250 MW and Shajapur-250MW)	500	08.06.2016	
17		Rajgarh-Morena Solar Park (Rajgarh-250 MW & Morena-250MW)	500	08.06.2016, 15-01-2016	
18	Maharashtra	Pragat Mega Solar Park, TalukaSakri, District Dhule	500	29-09-2015	M/s. Sai Guru Mega Solar Power Pvt. Ltd (name changed)
19		Dondaicha, Dist. Dhule	500	17-12-2015	MAHAGENCO

20		Patoda Solar Park TalukaPatoda, DistBeed	500	17-12-2015	M/s. Paramount Solar Power Pvt. Ltd.
21	Meghalaya	Suchen&Thamar Solar Park Suchen&Thamar Village, East & West Jaintia	20	4/9/2015	Meghalaya Power Generation Corporation Ltd (MePGCL)
22	Nagaland	Nagaland Solar Park, Ganeshnagar-DimapurDist (35 MW), Zhadima-KohimaDist (20 MW), New Peren-PerenDist (5 MW)	60	29-04-2015	Directorate of New & Renewable Energy, Nagaland
23	Odisha	Odisha Solar Park Balasore, Boudh, Deograh, Kalahandi and Keonjhar	1000	28-10-2015	Green Energy Development Corporation Of Odisha (GEDCOL)
24	Rajasthan	Bhadla Phase II Vill.- Bhadla, Tehsil- Bap, Jodhpur	680	02-12-14 & 19-06-15	Raj. Solar Park Development Company Ltd. (RSDCL), A subsidiary of RRECL
25		Bhadla Phase III Vill.- Bhadla, Tehsil- Bap, Jodhpur	1000	12/12/2014	SauryaUrja Company of Rajasthan Ltd (SUCRL), A JV between GOR & IL&FS
26		EsselPhalodi-Pokran Solar Park (Phase 1A (Phalodi)-400 MW at Distt Jodhpur & Phase-1B (Pokaran)-350 MW at Jaiselmer)	750	30/116/2015-16/NSM 17-12-2015	Essel Surya Urja Com. of Raj Ltd. (JV of GOR &EsselInfraprojects Ltd)
27		Bhadla Phase IV, Village Bhadla, Tehsil Bap, Jodhpur	500	29-09-2015	Adani Renewable Energy Park Raj. Ltd. (A JVC between GOR & APEPRL)
28		Dawada&Rasla, Tehsil Fatehgarh and Village Nedan, Tehsil-Pokaran, Jaisalmer	421	01.02.2016	Adani Renewable Energy Park Raj. Ltd. (A JVC between GOR & APEPRL)
29	Tamil Nadu	Ramnathpuram Solar Park	500	11/12/2014	NF
30	Telangana	Gattu Solar Park GhattuMandal, Mehboobnagar Dist.	500	17-12-2015	Telangana New & Renewable Energy Development Corporation Ltd. (TNREDC)

31	Uttarakhand	Solar Park at 2 Location namely Sitarganj and Khurpia farm in U. S. Nagar Distt.	50	16-12-2015	State Industrial Development Corporation Uttarakhand Ltd. (SIDCUL)
32	Uttar Pradesh	UP Solar Park Jalaun, Allahabad, Mirzapur& Kanpur Dehat Districts of Uttar Pradesh	600	2/12/2014	Lucknow Solar Power Development Corporation Limited (JVC of SECI & UPNEDA)
33	West Bengal	PurabMedinapur, PaschimMedinapur, Bankura	500	14-07-2015	West Bengal State Electricity Distribution Company (WBSEDCL)
21 States and 34 Solar Parks			20000		

12.11 Annexure 10 : Plot area and capacity (in MW)

Plot No	Area (acre)	MW Capacity
Plot No 1	720.86286	160
Plot No 2	706.724501	160
Plot No 3	740.342642	160
Plot No 4	721.191757	160
Plot No 5	721.514229	160
Plot No 6	720.248805	160
Plot No 7	900.336952	200
Plot No 8	896.262437	200
Plot No 9	886.75186	200
Plot No 10	884.300331	200
Plot No 11 A	270.648917	160
Plot No 11 B	447.748824	
Plot No 12	899.848425	200
Plot No 13	358.58222	80
Plot No 14	900.89022	200
Plot No 15	901.84281	200
Plot No 16	900.562559	200
Plot No 17	458.811715	100
Plot No 18	491.485914	100
Plot No 19	722.574063	160
Plot No 20	900.450126	200

Plot No 21	900.48645	200
Plot No 22	438.35488	100
Plot No 23	720.16553	160
Plot No 24	720.290565	160
Plot No 25	715.483385	160
Plot No 26	781.142643	160
Plot No 27	1013.09764	200
TOTAL	**20441.0033**	**4500**

12.12 Annexure 10 : Typical Technical Specification Photovoltaic Modules

High Efficiency PV Modules

Strengths

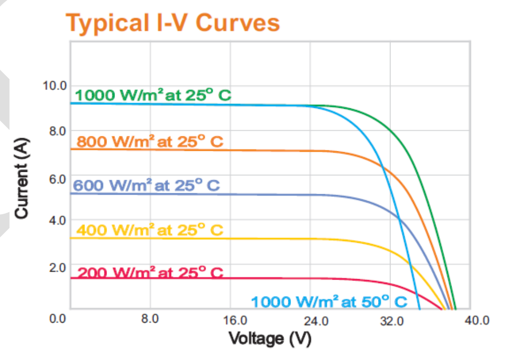
- Positive power tolerance
- High Efficiency Multi Crystalline Modules
- TUV Certifications
  EN IEC 61215 : 2005
  EN IEC 61730-1 : 2004 / 2007
  EN IEC 61730-2 : 2004 / 2007
  EN IEC 61701 : 2010-02
- Withstands heavy loading due to snow & ice; Has higher safety margin for storm weather and gale winds
- Qualified for Highly corrosive Wet Atmospheres & Environments

Product Guarantee : 5 years

Limited Power Warranty : 90% @ 12 Years
80% @ 25 Years

Typical Electrical Characteristics										
Type		TITAN M6-72								
Max Power	Pmp (W)	265	270	275	280	285	290	295	300	305
Power Tolerance	(W)	+0 to 4.9Wp or ±2.5%								
Max Power Voltage	Vmp(V)	34.33	34.75	35.04	35.18	35.63	36.12	36.51	36.72	36.97
Max Power Current	Imp (A)	7.72	7.77	7.85	7.96	8.00	8.03	8.08	8.17	8.25
Open Circuit Voltage	Voc (V)	43.27	43.70	43.99	44.28	44.42	44.78	45.00	45.50	45.58
Short Circuit Current	Isc (A)	8.30	8.34	8.39	8.46	8.49	8.53	8.58	8.65	8.68
Electrical parameters tolerance		±5%								
Max System Voltage	VDC	1000								
Number, type and arrangement of cells		72, Multi-Crystalline, 12 x 6 Matrix								
Cell Size		6"x 6" / 156 x 156 mm								
No. of By-pass Diodes		3								
Max Series Fuse	(A)	15								
Pm Temperature Co-efficient (γ)	(%/°C)	-0.41								
Isc Temperature Co-efficient (α)	(%/°C)	+0.04								
Voc Temperature Co-efficient (β)	(%/°C)	-0.32								
NOCT at STC	(°C)	45±1								

Typical I-V Curves



Current/voltage dependence on irradiance and module temperature.
These I-V curves indicate the effect of temperature and light intensity on module Performance.

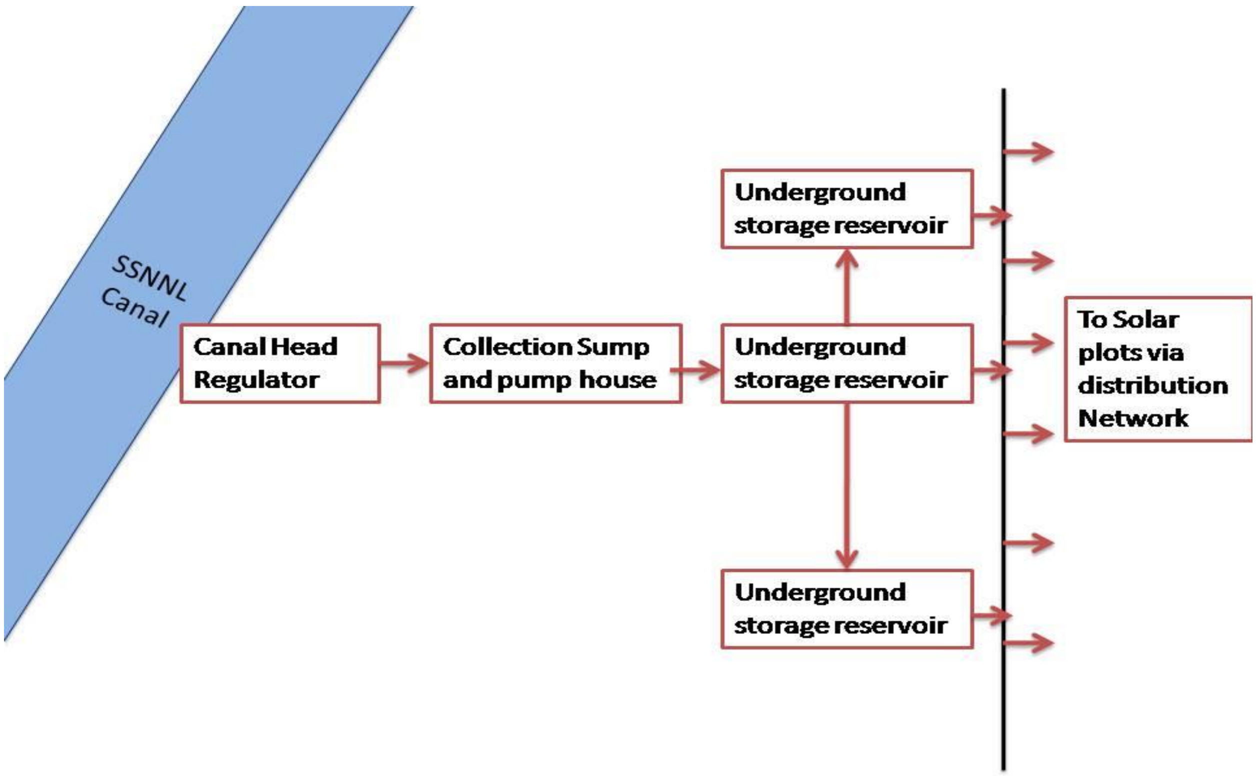
Mechanical Characteristics		
Junction Box		Tyco / ZJRH / Huber + Suhner
Type of connector		Tyco / MC4
Dimensions (L x W x Th)	mm	1975 x 988 x 50
Weight	Kg	27.0
No. of Drain Holes in Frame		12
Glass Type and Thickness		4 mm Thick, Low iron, Tempered

Packing Configuration	
Packing Configuration	20 Modules in each pallet
1 * 20 ft	200 Modules
1 * 40 ft STD/HQ	400 modules

Absolute Ratings		
Operating Temperature	(°C)	-40 ~ +85
Storage Temperature	(°C)	-40 ~ +85

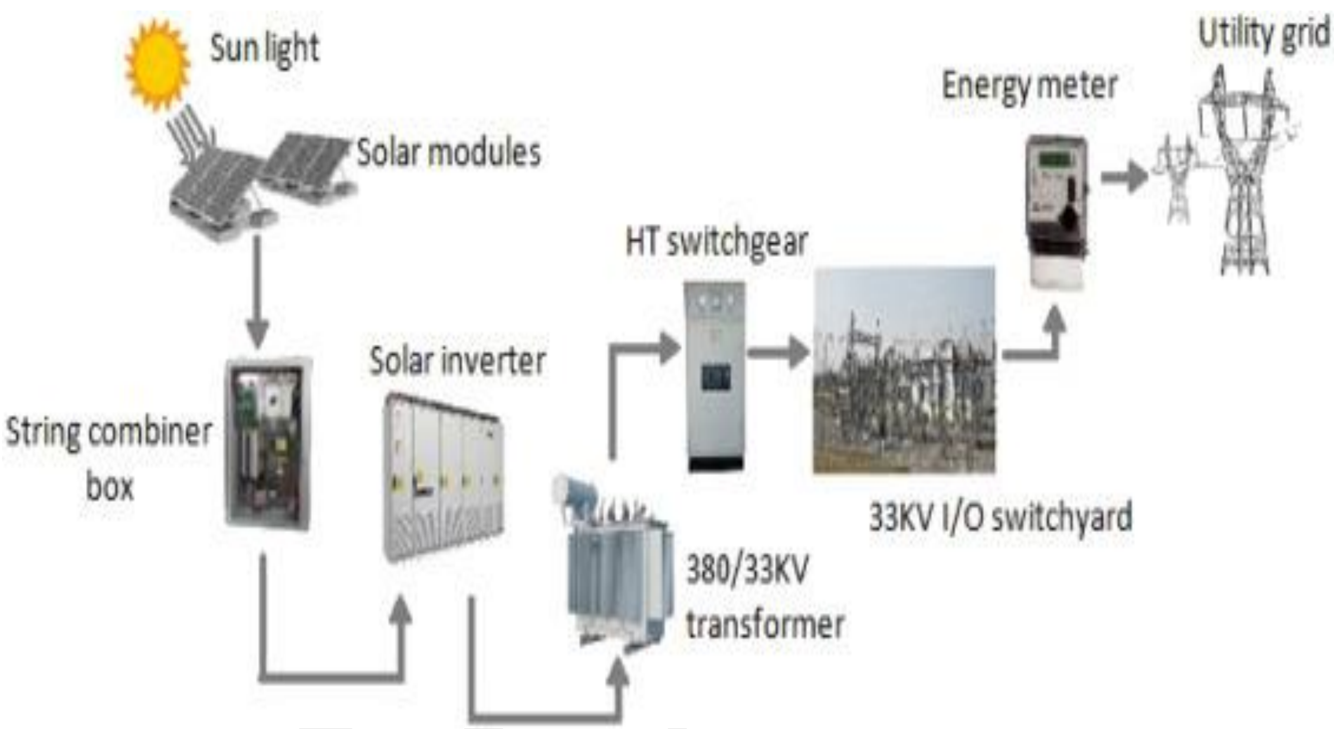
Appendix -A. Schematic Diagrams

Water pipeline schematic diagram



Notes:		
Canal Head regulator	:	For Water Demand of 1.25 MLD
Sump and Pump house	:	12 hrs of pumping with storage of 1 day in collection Sump.
Transmitting Pipeline	:	200mm dia. HDPE pipeline
Underground storage reserve	:	2.5 MLD of storage capacity. (per tank)

System flow diagram



Appendix-B-Drawings

Appendix-C-Photographs






Appendix-D Layouts