SAFE
SOLAR
POWER
(Pvt.)Ltd.

The Registrar

National Electric Power Regulatory Authority,

NEPRA Tower Ataturk Avenue (East), Sector G-5/1,

Islamabad.

Subject: **APPLICATION FOR A GENERATION LICENSE**

I, Raja Naseer Ahmed being duly authorized representative of Safe Solar Power (Pvt.) Limited by virtue of Board Resolution hereby apply to the National Electric Power Regulatory Authority for grant of a Generation License to the Safe Solar Power (Pvt.) Limited pursuant to section 15 of the Regulation of the Generation, Transmission and Distribution of Electric Power Act, 1997.

I, Raja Naseer Ahmed duly certify that the documents-in-support attached with this application are prepared and submitted in conformity with the provisions of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 and undertake to abide by the terms

SAFE
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POWER
(Pvt.)Ltd.

and provisions of the above-said regulations. I further undertake and confirm that the information provided in the attached documents-in-support is true and correct to the best of my knowledge and belief.

National Bank of Pakistan Pay order No. NPO/A 0866982 of PKR. 1,31,632/ (One hundred thirty one thousand, six hundred and thirty two rupees only), being the non-refundable license application fee calculated in accordance with the Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 is also attached herewith.

Dated: March 10, 2014

SAFE SOLAR POWER (PVT) LTD.

Raja Naseer Ahmed
Director

Office: House 28, Street 24, F-8/2, Islamabad
Phone: +92 51 8358477 Fax: +92 51 8358499
Email: info@safesolarpower.com Website: www.safesolarpower.com

ANNEX-B

AUTHORIZATION

FROM

BOARD RESOLUTION

SAFE SOLAR POWER (Pvt.)Ltd.

BOARD RESOUTION PASSED BY THE BOARD OF DIRECTORSOF SAFE SOLAR POWER (PRIVATE) LIMITED IN ITS 2ND MEETING HELD ON FEBURARY 28 2014

Resolved that an application for a Generation License (the "G/L Application") be filed by and on behalf of Safe Solar Power (Pvt.) Limited (the "Company") with the National Electric Power Regulatory Authority (NEPRA) for grant of a generation license for the company's 10 MW Solar Power Project at Quaid-e-Azam Solar Park, Bahawalpur - Punjab (the Project).

Resolved further that Raja Naseer Ahmed, the Director of the Company, be and is hereby authorized to sign the G/L Application, and any documentation ancillary thereto, pay all filing fees, and provide any information required by NEPRA in respect of the Project, and do all acts and things necessary for the processing, completion and finalization of the G/L Application.

Afshan Asghar

1. **Mrs. Afshan Hamid Mir**
   (CEO/ Director)

2. **Raja Naseer Ahmed**
   (Director)

SAFE SOLAR POWER (PVT) LTD. ★

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67501

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

1st Floor SLIC Building No.7, Blue Area,
Islamabad

CERTIFICATE OF INCORPORATION

[Under Section 32 of the Companies Ordinance, 1984 (XLVII of 1984)

Corporate Universal Identification No. 0086424

I hereby certify that SAFE SOLAR POWER (PRIVATE) LIMITED is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is limited by shares.

Given under my hand at Islamabad this 7th day of January, Two Thousand and Fourteen.

Fee Rs. 5,000/-

(Shaukat Hussain)
Additional Registrar of Companies

CERTIFIED TO BE TRUE COPY

No. JRI 62834
Dated 7/1/14

JRI 67501
19/2/14

PARTICULARS OF DIRECTORS AND OFFICERS, INCLUDING THE CHIEF EXECUTIVE, MANAGING AGENT, SECRETARY, CHIEF ACCOUNTANT, AUDITORS AND LEGAL ADVISERS, OR OF ANY CHANGE THEREIN

THE COMPANIES ORDINANCE, 1984

[SECTION 205]

FORM 29

1. Incorporation Number	
2. Name of Company	SAFE SOLAR POWER (PVT.) LIMITED
3. Fee Paid (Rs.)	600.0
Name and Branch of Bank	ISLAMABAD, MCB - Main Civic Center [0613]
4. Receipt No.	E-2013-200388
Date	31/12/2013
5. Mode of Payment (Indicate)	Bank Challan

6. Particulars*:

6.1. New Appointment/Election

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation*** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)
AFSHAN HAMID MIR	13302-0502061-8	W/O HAMID MIR	House No. 28, Street No. 24, Sector F-8/2, Islamabad ISLAMABAD Islamabad Capital	Director	Pakistan	BUSINESS	Since Incorporation.	
RAJA NASEER AHMED	37405-1993999-5	S/O RAJA NASAR ULLAH KHAN	House No. 3, Street No. 20, Block F, Encrage, Islamabad ISLAMABAD Islamabad Capital	Director	Pakistan	Business	Since Incorporation.	

Company Registration Office Islamabad SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN SECP

6.2. Ceasing of Officer/Retirement/Resignation

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation*** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

6.3. Any other change in particulars relating to columns (a) to (g) above

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation*** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

Certified to be True Copy of the Original However this office bears no responsibility for the correctness of the contents of the documents

Assistant Registrar
Company Registration Office
Islamabad

Name of Signatory	AFSHAN HAMID MIR	Designation	Director
Signature of Chief Executive/Secretary		Date (DD/MM/YYYY)	31/12/2013

M. Abid
Stamp Vendor
Lic. No. 103 Distt.
Islamabad

14 02 2014

No. JRI ________
Dated ________

THE COMPANIES ORDINANCE, 1984

(COMPANY LIMITED BY SHARES)

MEMORANDUM OF ASSOCIATION

of

SAFE SOLAR POWER (PRIVATE) LIMITED

I. The name of the Company is **SAFE SOLAR POWER (PRIVATE) LIMITED.**

II. The Registered Office of the Company will be situated in Islamabad Capital Territory.

III. The objects for which the Company is established are all or any of the following:-

1. To carry on all or any of the businesses of generating, purchasing, importing, transforming, converting, distributing, supplying, exporting and dealing in electricity and all other forms of energy and products or services associated therewith and of promoting the conservation and efficient use of electricity and to perform all other acts which are necessary or incidental to the business of electricity generation, transmission, distribution and supply.

2. To locate, establish, construct, equip, operate, use, manage and maintain thermal power plants and coal fired power plants, power grid station, transforming, switching, conversion, and transmission facilities, grid stations, cables, overhead lines, sub-stations, switching stations, tunnels, cable bridges, link boxes, heat pumps, plant and equipment for combined heat and power schemes, offices, computer centres, shops, dispensing machines for pre-

payment cards and other devices, showrooms, depots, factories, workshops, plants, printing facilities, warehouses and other storage facilities.

3. To carry on all or any of the businesses of wholesalers, retailers, traders, importers, exporters, suppliers, distributors, designers, developers, manufacturers, installer, filters, testers, repairers, maintainers, contractors, constructors, operators, users, inspectors, reconditioners, improvers, alterers, protectors, removers, hirers, replacers, importers and exporters of and dealers in, electrical appliances, systems, products and services used for energy conservation, equipments, machinery, materials and installations, including but not limited to cables, wires, meters, pylons, tracks, rails, pipelines and any other plant, apparatus equipment, systems and things incidental to the efficient generation, procurement, transformation, supply and distribution of electricity.

4. To ascertain the tariff for bulk supply that will secure recovery of operating costs, interest charges and depreciation of assets, redemption at due time of loans other than those covered by depreciation, expansion projects, payment of taxes, and reasonable return on investment, to quote the tariff to bulk purchasers of electrical power, and to prefer petition to the appropriate authority for approval of the schedule of tariff and of adjustments or increases in its bulk supply tariff, where desirable or necessary.

5. For the purposes of achieving the above objects, the company is authorized:-

   a) to purchase/import raw materials and allied items required in connection thereto in any manner the company may think fit;

   b) to do and perform all other acts and things as are incidental or conducive to the attainment of the objects of the company.

Company Registration Office Islamabad
SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN
SECP

c) to own, establish or have and maintain shops, branches and agencies all over Pakistan or elsewhere for sale and distribution of cables, wires, meters, pylons, tracks, rails, pipelines and any other plant, apparatus equipment, systems and things incidental to the efficient generation, procurement, transformation, supply and distribution of electricity;

d) to make known and give publicity to the business and products of the company by such means as the company may think fit;

e) to purchase, acquire, protect, renew, improve, use and sell, whether in Pakistan or elsewhere any patent, right, invention, license, protection or concession which may appear advantageous or useful to the company for running the business;

f) to pay all costs, charges and expenses, if any, incidental to the promotion, formation, registration and establishment of the company;

g) to borrow and arrange the repayment of money from banks/financial institutions or any lawful sources whether in Pakistan or elsewhere and in such manner as the company may think fit, including the issue of debentures, preference shares, bonds, perpetual or otherwise charged upon the whole or any part of the company's property or assets, whether present or future, and to purchase, redeem or payoff such securities;

h) to purchase, hold and get redeemed shares, debentures, bonds of any business, company, financial institution or any Government institutions;

i) to guarantee the performance of contracts, agreements, obligations or discharge of any debt of the company or on behalf of any company or person in relation to the payment of any [illegible] including but not limited to loans, advances, letters of credit or other obligations through creation of any or all types of mortgages, charges, pledges, hypothecations, on execution of the usual banking documents or instruments or otherwise encumbrance on any or all of the movable and immovable properties of the company, either present or future or both and issuance of any other securities or sureties by any other means in favour of banks, Non-Banking Finance Companies (NBFCs) or any financial institutions and to borrow money for purpose of the company on such terms and conditions as may be considered proper.

6. Notwithstanding anything stated in any object clause the company shall obtain such other approval or license from competent authority as may be required under any law for the time being enforced to undertake a particular business

7. It is declared that notwithstanding anything contained in the foregoing object clauses of this Memorandum of Association nothing contained therein shall be construed as empowering the Company to undertake or to indulge in business of payment systems, Electronic funds transfers in and outside Pakistan, deposit taking from general public, network marketing, referral marketing & direct selling banking company, leasing, investment, managing agency, insurance business, any of the NBFC business, multi-level marketing (MLM), Pyramid and Ponzi Scheme, commodity, future contract or share trading business locally or internationally, directly or indirectly as restricted under the law or any unlawful operation.

IV. The liability of the members is limited.

V. The Authorized Share Capital of the Company is Rs. 100,000/- (Rupees One Hundred Thousands Only) divided into 10,000 (Ten Thousands Only) ordinary shares of Rs. 10 (Rupees Ten) each with powers to the company from time to time to increase and reduce its capital subject to any permission required under the law.

We the several persons, whose names and addresses are subscribed below are desirous of being formed into a Company in pursuance of the Memorandum of Association and we respectively agree to take the number of shares in the capital of the Company set opposite our respective names:-

Name and surname (present & former) in full (in Block Letters)	CNIC No. (in case of foreigner, Passport No)	Father's/ Husband's Name in full	Nationality with any former Nationality	Occupation	Residential Address in full	Number of shares taken by each subscriber	Signatures
AFSHAN HAMID MIR	13302-0502061-8	HAMID MIR	PAKISTANI	Business	House No 28, Street No. 24, Sector F-8/2, Islamabad	9,999	
RAJA NASEER AHMED	37405-1993999-5	RAJA NASR-ULLAH KHAN	PAKISTANI	Business	House No 13, Street No. 20, Block F, Encrage, Islamabad	1	

Total number of shares taken 10,000 (Ten Thousands Only)

Dated the 26th day of **December 2013**

Witness to above signatures.

CERTIFIED TO BE TRUE COPY

National Institutional Facilitation Technologies (Pvt) Ltd.
5th Floor, AWT Plaza I.I. Chundrigar Road,
Karachi, Pakistan.

Asstt. Registrar
Company Registration Office
Islamabad

THE COMPANIES ORDINANCE, 1984

(COMPANY LIMITED BY SHARES)

ARTICLES OF ASSOCIATION

Of

SAFE SOLAR POWER (PRIVATE) LIMITED

1. The regulations contained in Table "A" in the First Schedule to The Companies Ordinance, 1984 shall not apply to the Company except in so far as the same are expressly made applicable by the said Ordinance, or these Articles. The regulation for management of the Company, and for the observance thereof by the members of the Company, and their representatives shall, subject as aforesaid and to any exercise of the statutory power of the Company in reference to the repeal or alteration of or addition to its regulations by Special Resolution as prescribed by the said Ordinance; be such as are contained in these Articles.

INTERPRETATION

2. In the interpretation of these Articles the following expressions shall have the following meanings, unless repugnant to or inconsistent with the subject Articles.

"Articles" means these Articles of Association as originally framed or as may be amended from time to time.

"Board" means the Board of Directors of the Company, for the time being.

"Commission" means Securities and Exchange Commission of Pakistan.

"Chairman" means the Chairman of the Company, from time to time, duly under the provisions of these presents.

"Chief Executive" means the Chief Executive, for the time being, of the Company.

"Directors" means the Directors, for the time being, of the Company.

"Government" means the Government of the Islamic Republic of Pakistan.

"Memorandum" means the Memorandum of Association of the Company as originally framed or as may be altered from time to time in accordance with the provisions of the Ordinance.

"Month" means a calendar month according to Gregorian calendar;

"Ordinance" means the Companies Ordinance, 1984 or any statutory modification or re-enactment thereof for the time being enforced.

"Ordinary Resolution" means a resolution passed at a general meeting when the vote cast (whether on a show of hands or poll, as the case may be) in favour of the resolution including the casting vote, if any of the Chairman) by members who, being entitled to vote in person or by proxy, do so vote, exceed the votes, if any, cast against the resolution by members entitled and voting;

"Office" means the registered office, for the time being, of the Company.

"Managing Director" means the Chief Executive of the Company, by whatever name called, appointed pursuant to the section 198 of the Ordinance;

Stamp Vendor
No. 103 Distt.
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294

"Member" means the Member of the Company as defined in Section 2(1)(21) of the Ordinance;

"Register" means the Register of members to be kept pursuant to section 147 of the Ordinance;

"Registrar" means a Registrar, an Additional Registrar, A Joint Registrar, a Deputy Registrar or an Assistant Registrar, performing under the Ordinance;

"Seal" means the Common seal of the Company;

"Shares" means the share in the share capital of the Company;

Expressions referring to in "writing" and "written" includes printing, lithography, type-writing, telex, facsimile, (fax), and other modes of representing or reproducing words in a visible or audible form by modern electronic devices, including tape and video compact disc recordings;

Words importing singular number include the plural number and vice versa;

Words importing the masculine gender include the feminine gender;

PRIVATE COMPANY

3. The Company is "Private Company" within the meaning of sub section 2(1) (28) of the Ordinance and accordingly:

(1) No invitation shall be issued to the public to subscribe for any share of the Company.

(2) The numbers of the members of the Company (exclusive of persons in the employment of the Company), shall be limited to fifty, provided that for the purpose of this provision, where two or more persons hold one or more shares in the company jointly, they shall be treated as single member; and

(3) The right to transfer shares of the Company is restricted in manner and to the extent herein appearing.

BUSINESS

4. The company is entitled to commence business from the date of its incorporation. The business of the company shall include all or any of the objects enumerated in the Memorandum of Association. The business of the company shall be carried out at such place or places anywhere in Pakistan or elsewhere as the directors may deem proper or advisable from time to time.

SHARES AND CAPITAL

The nominal share capital of the Company is Rs.100,000/- (Rupees One Hundred Thousands Only), divided into 10,000 Ordinary Shares of Rs. 10/ each with powers of the Company to increase or reduce the same and to divide the shares into several classes.

The shares shall be under the control of the Board of Directors who may allot or otherwise dispose off the same to such persons, on such terms and conditions and at such times, as the Board of Directors think fit. Shares may also be allotted in consideration other than cash.

7. Fully paid shares shall be allotted to all subscribers in the first instance and the Company shall not be bound to recognize any equitable, contingent, future or partial claim to or interest in a share on the part of any person other than the registered share holder, save as herein provided or saves as ordered by some Court of competent jurisdiction.

8. The certificate of title to shares shall be issued under the seal of the Company.

9. Every member shall be entitled to one certificate for the shares registered in his name, or at the discretion of the directors to several certificates, each for one or more of such shares.

TRANSFER AND TRANSMISSION OF SHARES

10. Every person, whose name is entered as a member in the Register of Members shall without payment, be entitled to a certificate under the common seal of the Company specifying the shares held by several persons. The Company shall not be bound to issue more than one certificate and delivery of a share certificate to any one of several joint holders shall be sufficient delivery to all.

11. The directors may decline to register any transfer of shares to transferee of whom they do not approve and shall be bound to show any reasons for exercising their discretion subject to the provisions of Section 77 and 78 of the Ordinance.

12. No share can be mortgaged, pledged, sold, hypothecated, transferred or disposed off by any member to a non-member without the previous sanction of the Board of Directors or any authority under the law regulating the business of the company, as the case may be.

13. The legal heirs, executors or administrators of a deceased holder shall be the only persons to be recognized by the directors as having title to the shares. In case of shares registered in the name of two or more holders, the survivors and the executors of the deceased shall be the only persons to be recognized by the company as having any title to the shares.

BORROWING POWERS

14. Subject to the provision of the Ordinance, the Directors may from time to time at their absolute discretion raise or borrow any sum, or sums of money for the purpose of the company from banks, firms or companies, particularly a person holding the office of the director, and may secure the payment of money in such manner and upon such terms, and conditions in all respects as they think fit particularly by the issue of debentures of the company or by making, drawing, accepting or endorsing on behalf of the company any promissory note or bills of exchange or giving or issuing any other security of the Company.

15. Debentures and other securities may be made assignable free from any equities between the Company and the persons to whom the same may be issued.

16. Any debentures or other security may be issued at a discount, premium or otherwise and with any special privilege as to redemption, surrender, drawing, allotment of shares, attending and voting at general meeting of the Company or subject to compliance of the provisions of the Ordinance.

RESERVES

The directors may from time to time before recommending any dividend set aside out of the profit of the company such sums as they think fit as a reserve for redemption of debentures or to meet contingencies for equalization of or for special dividends or for rebuilding, repairing, restoring replacing, improving, maintaining or altering any of the property of the Company or for such other purpose as the directors may in their absolute discretion think conducive to the interest of the Company.

GENERAL MEETINGS

18. A General meeting, to be called annual general meeting shall be held, in accordance with the provisions of section 158, within eighteen months from the date of incorporation of the Company and thereafter once at least in every year within a period of four months following the close of its financial year and not more than fifteen months after the holding of its last preceding annual general meeting as may be determined by the directors.

19. The directors may, whenever, they think fit, call an extra ordinary general meeting, and extra ordinary general meetings shall also be called on such requisition, or in default, may be called by such requisitions, as is provided by section 159 of the Ordinance.

NOTICE AND PROCEEDINGS OF GENERAL MEETING

20. Twenty-One days' notice at the least (exclusive of the day on which the notice is served or deemed to be served, but inclusive of the day for which notice is given) specifying the place, the day and the hour of meeting and, in case of special business, the general nature of that business shall be given in manner provided by the Ordinance for the general meeting, to such persons as are, under the Ordinance or the regulation of the Company, entitled to receive such notice from the Company, but the accidental omission to give notice to, or the non-receipt or notice by, any member shall not invalidate the proceedings at any general meeting.

21. All business shall be deemed special that is transacted at an extraordinary general meeting, and also all that is transacted at annual general meeting with the exception of declaring dividend, the consideration of the accounts, balance sheet and the reports of the directors and auditors, the election of the directors, the appointment of, and the fixing of the remuneration of, the auditors.

QUORUM

22. No business shall be transacted at any general meeting unless a quorum of two members is present at that time when the meeting proceeds to business; save as herein otherwise provided, members having twenty-five percent of the voting power present in person or through proxy will be quorum of the Company's meeting.

23. If within half an hour from the time appointed for the meeting a quorum is not present, the meeting, if called upon the requisition of members, shall be dissolved: in any other case, it shall stand adjourned to the same day in the next week at the same time and place, and, if at the adjourned meeting quorum is not present within half an hour from the time appointed for the meeting, the members present being not less than two, shall be a quorum.

24. The Chairman of the Board of Directors, if any, shall preside as Chairman at every general meeting of the Company, but if there is no such Chairman, or if at any meeting he is not present within fifteen minutes after the time appointed for the meeting, or is unwilling to act as Chairman, any one of the Directors present may be elected to be Chairman, and if none of the directors is present, or willing to act as Chairman, the members present shall choose one of their number to be Chairman.

25. The Chairman may, with the consent of any meeting at which the quorum is present (and shall if so directed by the meeting), adjourn the meeting from time to time but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting from which the adjournment took place. When the meeting is adjourned for ten days or more, notice of the adjourned meeting shall be given as in the case of an original meeting. Save as aforesaid, it shall not be necessary to give any notice of an adjournment of the business to be transacted at an adjourned meeting.

26. At any general meeting a resolution put to the vote of the meeting shall be decided on a show of hands unless a poll is (before or on the declaration of the show of hands) demanded. Unless a poll is so demanded, a declaration by the Chairman that a resolution has, on a show of hands, being carried, or carried unanimously, or by particular majority, or lost an entry to that effect in the book of the proceedings of the company shall be conclusive evidence of the fact, without proof of the number or proportion of the votes recorded in favour of, or against that resolution.

27. A poll may be demanded only in accordance with the provisions of section 167 of the Ordinance.

28. If a poll is duly demanded, it shall be taken in accordance with the manner laid down in section 168 of the Ordinance and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded.

29. A poll demanded on the election of Chairman or on a question of adjournment shall be taken at once.

30. In the case of an equality of votes, whether on a show of hand or on a poll, the Chairman of the meeting at which the show of hands take place, or at which the poll is demanded, shall have and exercise a second or casting vote.

VOTES OF MEMBERS

31. Subject to any rights or restrictions for the time being attached to any class or classes of shares, on a show of hands every member present in person shall have one vote except for election of Directors in which case, the provisions of section 178 of the Ordinance shall apply. On a poll every member shall have voting rights as laid down in section 160 of the Ordinance.

32. A member of unsound mind, or in respect of whom an order has been made by any Court having jurisdiction in lunacy, may vote, whether on show of hands, or on a poll, by his committee or other legal guardian, and any such committee or guardian may, on a poll vote by proxy.

33. On a poll votes may be given either personally or by proxy.

34. (1) The instrument appointing a proxy shall be in writing under the hand of the appointer or of his attorney duly authorized in writing. A proxy must be a member.

(2) The instrument appointing a proxy and the power of attorney or other authority (if any) under which it is signed, or a notarially certified copy of that power or authority, shall be deposited at the registered office of the company not less than forty-eight hours before the time for holding the meeting at which the person named in the instrument proposes to vote and in default the instrument of proxy shall not be treated as valid.

35. An instrument appointing a proxy may be in the following form, or a form, as near thereto as may be:-

SAFE SOLAR POWER (PRIVATE) LIMITED

I ....of.......................................in the district of .... being a member of the **SAFE SOLAR POWER (PRIVATE) LIMITED** hereby appoint .... of .... as my proxy to vote for me and on my behalf at the (annual, extraordinary, as the case may be) general meeting of the company, to be held on the .... day of.......... and at any adjournment thereof.

DIRECTORS

36. The number of directors shall not be less than two. The following persons shall be the first directors of the Company and shall hold the office upto the date of the First Annual General Meeting.

1. **AFSHAN HAMID MIR**

2. **RAJA NASEER AHMED**

37. The remuneration of the directors shall from time to time be determined by the Company in general meeting subject to the provisions of the Ordinance.

38. Save as provided in Section 187 of the Ordinance, no person shall be appointed as a director unless he is a member of the Company.

POWERS AND DUTIES OF DIRECTORS

39. The business of the company shall be managed by the directors, who may pay all expenses incurred in promoting and registering the company, and may exercise all such powers of the company as are not by the Ordinance or any statutory modification thereof for the time being in force, or by these regulations, required to be exercised by the company in general meeting, subject nevertheless to the provisions of the Ordinance or to any of these regulations, and such regulations being not inconsistent with the aforesaid provisions, as may be prescribed by the company in general meeting but no regulations made by the company in general meeting shall invalidate any prior act of the directors which would have been valid if that regulation had not been made.

40. The directors shall appoint a chief executive in accordance with the provisions of sections 198 and 199 of the Ordinance.

41. The amount, for the time being remaining undischarged, of moneys borrowed or raised by the directors for the purposes of the company (otherwise than by the issue of share capital) shall not at any time without the sanction of the company in general meeting, exceed the issued share capital of the company.

42. The directors shall cause minutes to be made in books provided for the purpose:-

(a) of all appointments of officers made by the directors;

(b) of the names of the directors present at each meeting of the directors and of any committee of the directors;

(c) of all resolutions and proceedings at all meetings of the company and of the directors and of committees of directors.

DISQUALIFICATION OF DIRECTORS

43. No person shall become the director of a company if he suffers from any of the disabilities or disqualifications mentioned in section 187 of the Ordinance and, if already a director, shall cease to hold such office from the date he so becomes disqualified or disabled:

Provided, however, that no director shall vacate, his office by reason only of his being a member of any company which had entered into contracts with, or done any work for, the company of which he is director, but such director shall not vote in respect of any such contract or work, and if he does so vote, his vote shall not be counted.

PROCEEDINGS OF DIRECTORS

44. The directors may meet together for the dispatch of business, adjourn and otherwise regulate their meetings, as they think fit. Questions arising at any meeting shall be decided by a majority of votes. In case of an equality of votes, the chairman shall have and exercise a second or casting vote. A director may, and the secretary on the requisition of a director shall, at any time, summon a meeting of directors. It shall not be necessary to give notice of a meeting of directors to any director for the time being absent from Pakistan.

45. The directors may elect the chairman of their meetings and determine the period for which he is to hold office; but, if no such chairman is elected, or if at any meeting the chairman is not present within ten minutes after the time appointed for holding the same

or is unwilling to act as chairman, the directors present may choose one of their number to be chairman of the meeting.

46. A resolution in writing signed by all the directors for the time being entitled to receive notice of a meeting of the directors shall be as valid and effectual as if it had been passed at a meeting of the directors duly convened and held.

FILLING OF VACANCIES

47. At the first annual general meeting of the company, all the directors shall stand retired from office, and directors shall be elected in their place in accordance with section 178 of the Ordinance for a term of three years.

48. A retiring director shall be eligible for re-election.

49. The directors shall comply with the provisions of sections 174 to 178 and sections 180 and 184 of the Ordinance relating to the election of directors and matters ancillary thereto.

50. Any casual vacancy occurring on the board of directors may be filled up by the directors, but the person so chosen shall be subject to retirement at the same time as if he had become a director on the day on which the director in whose place he is chosen was last elected as director.

51. The company may remove a director but only in accordance with the provisions of the Ordinance.

CHIEF EXECUTIVE

52. The Chief Executive shall be the Chief Executive of the Company who shall be appointed by the Board of Directors of the Company. The Directors shall within 15 days of incorporation of the Company or from the date of election of directors or the office of the Chief Executive falling vacant, as the case may be, appoint, subject to the provisions of Section 198 of the Ordinance, a Chief Executive of the Company upto the date of first annual general meeting and subsequently he will hold office for a period of three years. The Board may revoke such appointment and appoint another person in place of the Chief Executive so removed or who may vacate office by reason of death, resignation or otherwise as the case may be. The Chief Executive of the Company, if required, may also be the Chairman of the Board of the Company.

53. The period for which the Chief Executive shall be appointed shall not exceed three years unless he ceases to hold office or a shorter time of appointment is fixed by the directors, or he earlier resigns or his services as Chief Executive has been terminated by the Board in accordance with the provisions of the Ordinance. On the expiry of his term of office, the Chief Executive shall be eligible for re-appointment in the manner provided in these Articles or in accordance with the provisions of the Ordinance. The terms and conditions of appointment of the Chief Executive, including his powers, duties, obligations and remuneration, shall be determined by the Board, subject to the provisions of the Ordinance and these Articles.

54. The Board shall have the powers to assess the performance of the Chief Executive every year and shall replace the Chief Executive, if his performance is found unsatisfactory in the opinion of the Board, subject to section 198 of the Companies Ordinance, 1984.

55. The Chief Executive shall hold office, enjoy and exercise such powers, duties, obligations and privileges as the Board may confer upon him from time to time and shall accordingly in exercise of such powers delegated to him, conform to any limits and restrictions which may be imposed by the Board from time to time in this respect. The Chief Executive may exercise all such powers and do all acts and things on behalf of the Company as he may be authorized to do by the Board.

56. The Chief Executive shall be entitled to remuneration and benefits commensurate with his performance, of which determination shall be made by the Board.

57. The Chief Executive may be removed in accordance with the provisions of Section 202 of the Ordinance.

58. The Chief Executive shall also be the head of the Executive Committee and responsible for the day to day management of the Company and without prejudice to the generality of the foregoing, he shall be responsible:

i. for ensuring that the Company's Governing Principles are adhered to;

ii. for the proper administration of the affairs, funds and resources of the Company;

iii. to make draw, endorse, sign, accept, negotiate and give all cheques, bills of lading, drafts, orders, bills of exchange, promissory notes, and other negotiable instruments as may be required by and be in the interest of the Company;

iv. to secure the fulfillment of any contract, agreements or engagements entered into by the Company by mortgage or charge of all or any of the properties of the Company from time to time or in such manner as he may think fit in the interest of the Company;

v. to appoint and at his discretion to remove or suspend managers, secretaries, officers, clerks and employees, either permanent or temporary, as he may think fit and to determine their powers and duties and fix their salaries or emoluments and to require security in such instances and to such amount as he thinks fit;

vi. to prescribe the duties of all employees and staff of the Company;

vii. to institute, conduct, defend or abandon any legal proceedings by or against the Company or its officers or otherwise concerning the affairs of the Company and also to compound and allow time for payment or satisfaction of any debts due and of any claims or demands by or against the Company and for the purpose to appoint advocate(s);

viii. to refer any claims or demands by or against the Company to Arbitration and observe and perform the awards;

ix. for exercising supervision and disciplinary control over the work and conduct of all employees of the Company;

x. for co-coordinating, and exercising general supervision over all the activities of the Company;

xi. for any other tasks as may be delegated by the Board.

xii. The Chief Executive may in writing delegate such of his powers, as he may consider necessary to any officer of the Company.

DIVIDENDS AND RESERVE

59. The company in general meeting may declare dividends but no dividend shall exceed the amount recommended by the directors. No dividends shall be paid otherwise than out of the profits of the Company.

THE SEAL

60. The directors shall provide for the safe custody of the seal and the seal shall not be affixed to any instrument except by the authority of a resolution of the board of directors or by a committee of directors authorized in that behalf by the directors and the presence of at least two directors; and those two directors shall sign every instrument to which the seal of the company is so affixed in their presence.

ACCOUNTS

61. The directors shall cause to be kept proper books of account as required under section 230 of the Ordinance.

62. The books of account shall be kept at the registered office of the company or at such other place as the directors shall think fit and shall be open to inspection by the directors during business hours.

63. The directors shall, under sections 233 and 236 of the Ordinance, cause to be prepared and to be laid before the company in general meeting such profit and loss accounts or income and expenditure accounts and balance sheets duly audited and reports as are referred to in those sections.

AUDIT

64. Once at least in every year the accounts of the Company shall be audited and the correctness of profit and loss accounts or income and expenditure accounts and balance sheet ascertained by an auditor or auditors and the provisions of the Ordinance in regard to audit and the appointment and qualification of auditors shall be observed.

65. Auditors shall be appointed and their duties regulated in accordance with sections 252 to 255 of the Ordinance.

WINDING UP

66. If the company is wound up, whether voluntarily or otherwise the liquidator may, with the sanction of a special resolution, divide amongst the contributories in specie or kind, the whole or any part of the assets and liabilities of the company, subject to the section 421 and other provisions of the Ordinance as may be applicable.

INDEMNITY

67. Every director and other officer or servant of the company shall be indemnified by the company against, and it shall be the duty of the directors to pay out of the funds of the company, all costs, losses and expenses which any such officer or servant may incur or become liable to be by reason of any contract entered into or thing done by such officer or servant as such in any way in the discharge of the duties of such officer or servant including traveling expenses.

68. No director or other officer of the company shall be liable for the acts, receipts, neglect or default of any other director or officer or for joining in any receipt or other act for conformity or for any loss or expenses happening to the company through the insufficiency or deficiency of title to any property acquired by order of the directors for or on behalf of the company or for the insufficiency or deficiency of any security or investment in or upon which any of the money of the company shall be invested or for any loss or damage arising from bankruptcy, insolvency or tortuous act of any person with whom any money, securities or effects shall be deposited or for any loss occasioned by any error of judgment or oversight on his part or for any other loss, damage or misfortune whatever which shall happen in the execution of his office or in relation thereto unless the same happens through his dishonesty.

NOTICES

69. (1) A notice may be given by the company to any member either personally or by sending it by post to him to his registered address or (if he has no registered address in Pakistan) to the address, if any, within Pakistan supplied by him to the company for giving of notices to him.

(2) Where a notice is sent by post, service of the notice shall be deemed to be effected by properly addressing, prepaying and posting a letter containing the notice and,

unless the contrary is proved, to have been effected at the time at which the letters would be delivered in the ordinary course of post.

70. A notice may be given by the company to the joint-holders of the share by giving the notice to the joint-holder named first in the register in respect of the share.

ARBITRATION

71. Whenever any difference arises between the company on the one hand and any of the members, their executors, administrators or assignees on the other hand touching the intent or construction or the incidence or consequences of these presents, or of the statute or touching anything then or thereafter done, executed, omitted, or suffered in pursuance of these presents or of the statute or touching breach or alleged breach or otherwise relating to the premises, or to any statute effecting the company, or to any of the affairs of the company, including the fixing of the fair value of the shares of the company, every such difference shall be referred to the decision of an arbitrator to be appointed by the parties in difference or if they cannot agree upon a single arbitrator to the decision of two arbitrators of whom one shall be appointed by each of the parties in difference or any umpire to be appointed by the two arbitrators.

SECRECY CLAUSE

72. Every director, manager, member of the committee, officer, servant, accountant or other person employed in the business of the Company shall if so require by the directors before entering upon his duties, sign a declaration pledging to observe a strict secrecy respecting all transactions of the company with the customers and the state of accounts with individuals, matters relating thereto and shall by such declaration pledge himself not to reveal any of the matters which come to his knowledge in the discharge of his duties except when required to do so by the directors or by a Court of Law and except so far as may be necessary in order to comply with any of the provisions in these presents contained.

We the several persons, whose names and addresses are subscribed below are desirous of being formed into a Company in pursuance of the Articles of Association and we respectively agree to take the number of shares in the capital of the Company set opposite our respective names:-

Name and surname (present & former) in full (in Block Letters)	**CNIC No. (in case of foreigner, Passport No)**	**Father's/ Husband's Name in full**	**Nationality with any former Nationality**	**Occupation**	**Residential Address in full**	**Number of shares taken by each subscriber**	**Signatures**
AFSHAN HAMID MIR	13302-0502061-8	HAMID MIR	PAKISTANI	Business	House No 28, Street No. 24, Sector F-8/2, Islamabad	9,999	
RAJA NASEER AHMED	37405-1993999-5	RAJA NASR-ULLAH KHAN	PAKISTANI	Business	House No 13, Street No. 20, Block F, Encrage, Islamabad	1	

Total number of shares taken 10,000
(Ten Thousands Only)

Dated the 26th day of December 2013

Witness to above signatures.

National Institutional Facilitation Technologies (Pvt) Ltd.
5th Floor, AWT Plaza I.I. Chundrigar Road,
Karachi, Pakistan.

CERTIFIED ... COPY

Assistant Registrar
Comp... Office

No. JRI
Dated

ANNEX-D

DETAILS OF THE APPLICANT

ANNEX-D

DETAILS OF THE APPLICANT:

Company Name	**M/S SAFE SOLAR POWER PRIVATE LIMITED**
Address:	**House 28, Street 24, F-8/2 Islamabad.**
Email:	**info@safesolarpower.com**
Telephone:	**+92 51 835 8477**
Fax:	**+92 51 835 8499**
Authorized Representative:	**Raja Naseer Ahmed**

ANNEX-E

COPY OF LOI

Government of Pakistan
ALTERNATIVE ENERGY DEVELOPMENT BOARD
2nd Floor, OPF Building,
Shahrahe Jamhoriat, Sector G-5/2
Islamabad.
Tel: 051 9222360 Fax: 051 9222364

AEDB

B/3/2/SPV/SSP/28 January 13, 2014

Ms. Afshan Hamid Mir
Chief Executive Officer
M/s Safe Solar Power (Pvt.) Ltd.
28, Street 24, Sector F-8/2
Islamabad.

Subject: **LETTER OF INTENT FOR 10 MW SOLAR PV POWER GENERATION PROJECT**

Reference: Your Proposal dated December 27, 2013.

In terms of the Policy for Development of Renewable Energy for Power Generation 2006 ("Policy"), the Alternative Energy Development Board ("AEDB") hereby confirms its interest in your proposal for establishing an approximately 10 MW solar PV power generation project in Bahawalpur, Punjab province. The Sponsor(s) is responsible for arranging the land for the project. AEDB may facilitate the Sponsor(s) in arranging the land for the project; however, AEDB has no obligation to provide land to the Sponsor(s) for the project. AEDB acknowledges receipt of the bank guarantee Cheque No. 90541109 dated January 07, 2014 in the sum of US Dollar (US $ 5000/-).

2. The Sponsor(s) is required to complete the feasibility study and achieve the milestones listed at the Annex to this LOI ("LOI Milestones") for the subject project, at no risk and at no cost to, and without any obligation on the part of the AEDB, the Government of Pakistan, any Provincial Government or their respective agencies, within a period of Eighteen (18) months from the date of issuance of this Letter of Intent ("LOI").

3. The Sponsor(s) is required to carry out and complete the feasibility study at internationally acceptable standards and in accordance with the terms and conditions stipulated in the Policy and this LOI. The feasibility study must include, inter alia, Solar PV Plant equipment siting details, detailed power production estimates based on solar irradiance data of project site, soil tests reports, technical details pertaining to solar PV panels and other allied equipment to be used in the Solar PV Plant, grid tied solar PV project, electrical studies (including but not limited to short-circuit study, power quality study, load flow study and stability study) environmental study, project costing, financing plan, carbon credits, financing terms tariff calculations and assumptions for financial calculations including economic/financial analysis. The Sponsor is also advised to liaise with the power purchaser while determining the site, project layout, sub-station design and layout the transmission line, interconnection arrangements, and other related matters.

4. The validity of this LOI is not more than 18 months from the date of its issue, where after it will automatically lapse immediately (unless extended pursuant to clauses 5 or 6), being the 13th July, 2015 (the "**Expiry Date**"). Issuance of this LOI or the lapsing of its validity, or your conducting a feasibility study there under, cannot form the basis of any claim for compensation or damages by the Sponsor(s) or the project company or any party claiming through or under them against the Government of Pakistan, the Provincial Government, AEDB or any of their agencies, employees or consultants on any grounds whatsoever, during or after the expiry of the validity of the LOI.

5. The Sponsor(s) is therefore required to complete the feasibility study and achieve the LOI Milestones for the subject project within the validity of this LOI. The Sponsor(s) is also required to submit quarterly progress reports. Provided the Sponsor(s) meets the LOI Milestones on the stated dates, the Expiry Date of this LOI shall be extended on a day-for-day basis for the number of days of delay by which the approval or review by the relevant public sector entity listed in the LOI Milestones is delayed beyond the corresponding period stated in the LOI Milestones. In case there is a delay in completion of the feasibility study within the validity of this LOI for reasons not attributable to a public sector entity, a one-time extension may be granted up to a maximum period of one hundred eighty (180) days if AEDB is satisfied that the feasibility study is being conducted in a satisfactory manner and is likely to be completed shortly, and provided the Sponsor(s) enhance the amount of the bank guarantee to twice its original amount and extend its validity for a period six (6) months beyond the extended Expiry Date. Furthermore, if the said feasibility study is technically approved by the Panel of Experts and later the tariff awarded by NEPRA is not agreed by the Sponsor(s) (such decision to be made within thirty (30) days of the award of the tariff, and in any event within the validity of the LOI), the bank guarantee less 10% deduction for administrative and ancillary charges, would be returned to the Sponsor(s).

6. The Sponsor(s) shall apply to NEPRA for award of tariff within the period of validity of this LOI. Upon tariff being given, the Sponsor(s) shall forthwith submit a new Performance Guarantee in the sum of US Dollars (USD 25000/-) and obtain the Letter of Support ("LOS") from AEDB within the validity period of this LOI, provided, if the award of the tariff is delayed beyond the initial validity of the LOI, the Sponsor(s) shall extend the bank guarantee for a further period of six (6) months and the Expiry Date shall be extended *ipso facto* for a further period of six (6) months, and the Sponsor(s) shall obtain the LOS and submit the Performance Guarantee within the extended period afore-said. For the avoidance of doubt, the afore-said extension process may be repeated if the tariff is not announced (including on any review petition filed by the Sponsor(s), such review (if any) to be filed within the period prescribed in the NEPRA (Tariff Procedures and Standards) Rules) up to fifteen (15) days before the then prevailing Expiry Date.

7. In case the Sponsor(s) fails to meet the LOI Milestones or perform any other obligations set forth in the Policy and this LOI, including the extension of the date of expiry of bank guarantee as provided herein, AEDB will terminate this LOI and encash the bank guarantee.

8. (A) Pending the nomination of the Main Sponsor per sub-clause (B), the M/s Safe Solar Power (SSP) is liable for all obligations and liabilities of and on behalf of all other shareholders/ Sponsor(s) (without relieving the other

shareholders/Sponsor(s) of their obligations and liabilities under this LOI). Accordingly, M/s Safe Solar Power (SSP). shall not transfer or assign its shareholding (or other participatory interest, if the project company is not formed by the date of issue of the LOI) in the project or the project company without the prior written approval of AEDB, which approval may be declined by AEDB in its discretion if the proposed transferee's financial and other relevant credentials are found unsatisfactory.

(B) The Sponsor(s) is advised to nominate the Main Sponsor *(being the individual or group holding at least 20% equity or participatory interest in the IPP project)* no later than the Expiry Date of the LOI. In default of nomination as aforesaid, the M/s Safe Solar Power (SSP) will be deemed the Main Sponsor for all intents and purposes. The Main Sponsor, together with other initial project shareholders/Sponsor(s) (which shall, subject in each case to sub-clause (A) above, be firmly settled and announced to AEDB by the Expiry Date of the LOI), must hold 51% of the project equity for a period up to the project's Commercial Operations Date (COD).

(C) Any actual or purported transfer or assignment of the shares or other participatory interests by the Sponsor(s) / shareholders in contravention of the foregoing restrictions without prior written consent of the AEDB shall render this LOI void and the bank guarantee will be enchased in such case by AEDB.

9. This LOI is not assignable and non-transferable. This LOI shall be void upon any actual or purported assignment or transfer hereof without the prior written consent of AEDB.

10. This LOI is issued subject to the grant of a generation license and award of tariff by the National Electric Power Regulatory Authority ("NEPRA") to the subject project under the provisions of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (the "NEPRA Act"). While AEDB shall extend its offices to support applications by the subject project before NEPRA under the current or any amended policy framework, by granting this LOI, AEDB does not make any representation or warranty on behalf of itself or the Government of Pakistan that the subject project will be granted a generation license or a tariff acceptable to the subject project or at all.

11. This LOI is issued in duplicate on the date hereof, and it shall come into effect when one copy is received by AEDB after being duly countersigned by you. Nevertheless, this LOI shall lapse if the countersigned copy is not received at AEDB within 15 days of its issuance.

13/01/2014

(Afshan Hamid Mir)
(Chief Executive Officer)
M/s Safe Solar Power Pvt. Ltd. (SSP)

(Asjad Imtiaz Ali)
(Chief Executive Officer
AEDB

Annex-I

Milestones for the Letter of Intent (LOI)

Sr. No.	Milestones	Time Frame (in Months)
1.	Issuance of Letter of Intent (LOI)	T0
2.	Submission of complete Feasibility Study to AEDB, comprising of; (i) Technical study including resource assessment, plant & equipment details, layout and energy production analysis. (ii) Grid Interconnection Study (approved by NTDC) (iii) EIA / IEE study (approved by provincial Environmental Protection Agency)	No later than ten (10) months after issuance of LOI
3.	Vetting and approval of Feasibility Study by AEDB (*including verification of production estimates through third party consultant, if required, cost of which shall be borne by the Sponsor(s)*)	Within two (2) months after submission to AEDB. (*provided any requisite modifications are timely made by the Sponsor(s) and the modified feasibility study is resubmitted within 15 days of a letter by AEDB requiring the modifications)*
4.	Tariff and Generation from NEPRA	Within four (4) months of approval of Feasibility Study by AEDB
5.	Acceptance of Tariff by IPP	Within fifteen (30) days of determination of tariff by NEPRA
6.	Posting of Performance Guarantee for Issuance of Letter of Support (LOS)	Within fifteen (15) day of acceptance of Tariff by IPP
7.	Issuance of Letter of Support (LOS) by AEDB	Within fifteen (15) days of posting of Performance Guarantee (PG)

ANNEX-F

PROPOSED
ORGANIZATIONAL STRUCTURE
AND
CVs OF APPLICANT'S STAFF

PROPOSED TEAM

FOR

SAFE SOLAR POWER (PVT) LTD.

1. Raja Naseer Ahmed	Project Director
2. Mr. Zahid Aslam Ranjha	(Manager HR/Admin)
3. Muhammad Kamran Baloch	Manager (Account & Finance)
4. Mrs. Rabia Tahir	Manager (Public Relations)
5. Mrs. Mariam Mahmood	Project Engineer
6. Mr. Fazal ur Rehman	Project Engineer
7. Mr. Muhammad Nafees	Project Engineer
8. Mr. Rehan Haider	Project Engineer
9. Muhammad Tahir Saleem	Company Secretary

SAFE
SOLAR
POWER

Date: March 6, 2014

The Chief Executive Officer,
MEPCO,
MULTAN.

Subject : **Electrical Grid Studies for 10 MW Safe Solar Power Project in Quaid-e-Azam Solar Park, Bahawalpur**

Sir,

Please find herewith for your approval, the Grid Interconnection Studies Report (in duplicate) of Our 10 MW Power Plant, Safe Solar, in Quaid-e-Azam Solar Park near Lal-Sohanra, Punjab. The Report includes all the necessary studies required for the feasibility of interconnection of Safe Solar with the main grid as follows;

1. Load flow analysis
2. Short circuit analysis
3. Dynamic and transient stability analysis

Thanks and best regards.

Raja Naseer Ahmed
Director

cc: a. Chairman, NEPRA.
b. CEO, AEDB>
c. MD, CPPA.
d. MD, NTDC.
e. CEO, QA Solar Park
f. CEO, Power Planners Intl

Phone: +92 51 8358477 Fax: +92 51 8358499 Email: info@safesolarpower.com Website: www.safesolarpower.com
Office: House 28, Street 24, F-8/2, Islamabad

Received
7/3/14

SAFE
SOLAR
POWER
(Pvt.)Ltd.

PROPOSED INVESTMENT

The proposed investment will be in line with the costs that have been determined by the NEPRA in their determination.

Our estimated

EPC Cost is about US S 1.5 Million ./ MW

Non-EPC: 1.52 Million / 10 MWp

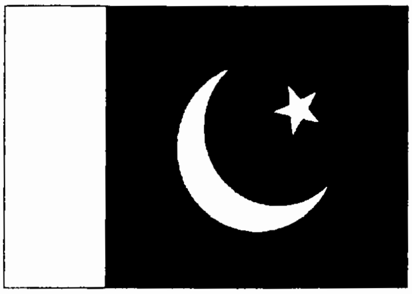
Financing cost, Insurance and interest: 750.000

Expected Total Project Cost for the 10 MWp Power Plant: US $20 Million

Equity:	30%	6, 000, 000
Financing:	70%	14,000,000

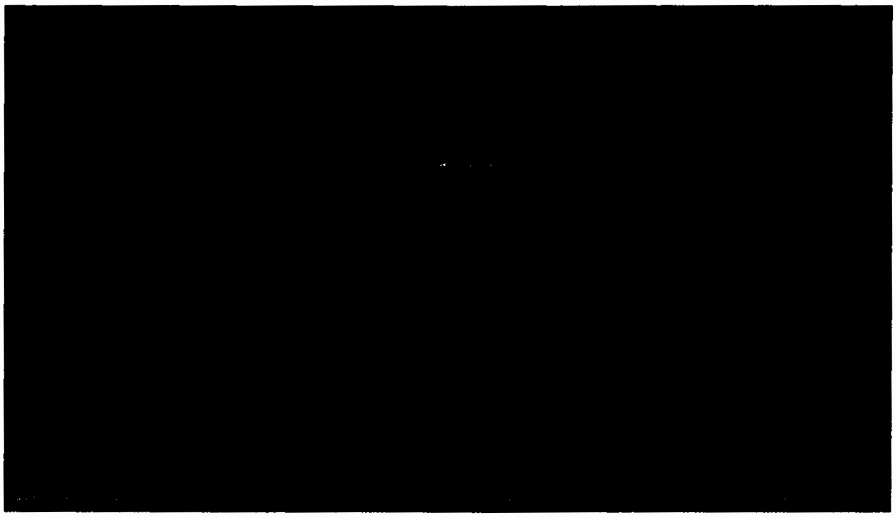
ROE: 17.2%

Office: House 28, Street 24, F-8/2, Islamabad
Phone: +92 51 8358477 Fax: +92 51 8358499
Email: info@safesolarpower.com Website: www.safesolarpower.com



Feasibility Study Report
10 MW Solar PV Power Project in Quaid E Azam Solar Park

February, 2014



Volume 1
Main Report - Part 1

by

WELT KONNECT (PVT) LTD

WELT KONNECT
Driving You Into The Future

APPROVAL SHEET

TITLE : Feasibility Report
10 MW Solar Power Project in Quaid E Azam Solar Park, Cholistan

DOCUMENT NUMBER : 01-0786-02

CLASSIFICATION : **Un-Classified**

SYNOPSIS

This document is a feasibility study report of 10 MW Solar PV Power Project and is divided into 7 Volumes for ease of review and approvals.

Volume 1: Main Report Part 1: of this report contains detailed information regarding the geographic features of Pakistan, along with the insight to Pakistan's Energy and Electricity market. After discussing the solar energy industry and carbon credit details for information purposes, the volume focuses on mentioning the regulatory regime of the country that is applicable to the project and all legal requirements. The volume also summarizes the salient features of the project.

Volume 2: Main Report Part 2: of the report focuses entirely on the specific details of the project. It provides information on the selected site, the description of the technical equipment and the layout of plant. The report further includes the basis for calculations and designing, by giving details of the grid connections available and yield of power. Prior to conclusion, the report also gives details of the policies and procedures for O&M, Project Management, and tariff calculation. The report concludes with details of the ecological and socio-economic benefits of the project.

Volume 3: Geo-Technical Study Topographic Survey: of the Project Site, with detailed analysis.

Volume 4: Geo-Technical Investigation Report: for the Project Site, including Soil Testing

Volume 5: Environmental Study: contains the Initial Environmental Examination Report (IEE), the Environmental Impact Assessment Report (EIA), and the No Objection Certificate (NOC) for the project issued by the Environmental Protection Agency (EPA) of Punjab.

Volume 6: Grid Interconnection Study being developed by National Transmission Dispatch Company (NTDC) and to be submitted separately.

DATE: 19th February 2014

TABLE OF PROFESSIONALS

Sr. No.	Work Scope	Reviewed By	Designation	Approved By
1	Project Management, Economic Evaluation and FSR Compilation	Habil Ahmed Khan	Projects and Investment Expert	Hamid Mir
2	Financial Evaluation	Habil Ahmed Khan	Finance Advisor	Hamid Mir
4	Project Management	Mohsin Iqbal	Project Manager	Hamid Mir
5	Project Management and FSR Compilation	Mohsin Iqbal	Project Manager	Maj (Retd) Naseer
6	Socio-Economic Benefits, Ecological Impacts and Comprehensive Explanations	Zeeshan Ahmed	Project Section Head	MAJ (Retd.) Riaz Ul Hassan
7	Technical and Design Evaluation	Habil Ahmed Khan	Senior Design Engineer	Maj (Retd) Naseer
8	O&M Methodology, Working Management	Adnan Aurengzeb	Senior Elect. Engineer	MAJ (Retd.) Riaz Ul Hassan
9	Engineering Electrical Power Systems	Riaz Ahmed	Electronics Engineer	MAJ (Retd.) Riaz Ul Hassan
10	Engineering Electrical and Instrument Controls	Noman Naseer	Electronics Engineer	MAJ (Retd.) Riaz Ul Hassan
11	Solar Resource Assessment Monitoring and Recording	Sarosh Tahir	Electronics Engineer	Kashif Riaz
12	Health, Safety and Environment Procedures	Umer Yar	Electronics Engineer	Kashif Riaz
13	Fire-Fighting and Emergency Procedures for Project	Fasi Ul Islam	Electronics Engineer	Kashif Riaz
14	Engineering and Vendor Selection for Solar panels, Inverters and Equipment	Naveed Ahmed	Electronics Engineer	Kashif Riaz
15	Engineering Geology	Daniyal Haider	Electronics Engineer	Kashif Riaz
16	Engineering task force analysis	Adil Mustafa	Electronics Engineer	Kashif Riaz
17	Civil Works and Construction Management	Sajjad Akhtar Choudhary	Civil Engineer	Kashif Riaz
18	Simulation and Solar Resource Modeling	Abdullah Usman	Design Engineer	Kashif Riaz

PREPARED BY: **Mr. Habil Ahmed Khan**
Mr. Mohsin Iqbal

REVIEWED BY: **Project Director Maj(Retd) Raja Naseer Ahmed**

APPROVED BY: **CEO Mrs. Afshan Mir**

Revisions

[illegible]	[illegible]	DATE	VOL	SECTION	DESCRIPTION OF CHANGE

DISTRIBUTION

1. Alternative Energy Development Board (AEDB)
2. Panel of Experts Assembled by AEDB
3. Welt Konnect Pvt Ltd

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF MAPS

LIST OF TABLES

Table 6.5.1.1.1 : Comparisons of LCOE base and advanced cases

LIST OF GRAPHS (CHARTS)

LIST OF ABBREVIATIONS

AC	Alternate Current
AEDB	Alternative Energy Development Board
Approx.	Approximately
ASL	Associated Surveyors (Pvt)Ltd
BM	Build Margin
BOO	Build Own and Operate
BOR	Board of Revenue
Bwp	Bahawalpur
CAA	Civil Aviation Authority
CCGT	Combined Cycle Gas Turbine
CDA	Cholistan Development Authority
CDM	Clean Development Mechanism
CDMA	Code division multiple access
CERs	Certified Emission Reductions
CM	Combined Margin
CMA	Certified Management Accountant
CNG	Compressed natural Gas

CO2	Carbon dioxide
COD	Commercial Operational Date
CoP	Conference of the Parties
CPPA	Central Power Purchasing Agency
CPV	Concentrator photovoltaic
DC	Direct Current
Deg	Degree
DG	Diesel Generator
DGPs	Dual Global Positioning System
DISCOs	Distribution Companies
DNA	Designated National Authority
DOE	Designated Operational Entity
DSSC	Dye-Sensitized Solar Cells
EE	Energy Efficiency
EF_y	Baseline Emission Factor
EIA	Environmental Impact Analysis
EMC	Electromagnetic Compatibility
EMP	Environment Plan

EPA	Energy Purchase Agreement
EPC	Engineering Procurement Construction
EPIA	European Photovoltaic Industry Association
EU	European Union
FDI	Foreign Direct Investment
FSR	Feasibility Study Report
GDP	Gross Domestic Product
GENCOs	Generation Companies
GHG	Green Gas
GIS	Geographic Information System
GoP	Government of Pakistan
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GTZ/GIZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HCA	Host Country Approval
HFCs	Hydro Fluorocarbons
HOMER	Hybrid Optimization Model for Electric Renewables
HSE	Health Safety and Environment

HSHD	Hard Surface High Duty
Hz	Hertz
IA	Implementation Agreement
IDC	Interest During Construction
IEA	International Energy Agency
IEE	Initial Environmental Examination
IEEE	Institute of Electrical and Electronic Engineers
IFC	International Finance Cooperation
IPPs	Independent Power Producers
IRR	Internal Rate of Return
JEDI	Jobs and Economic Development Impact
JI	Joint Implementation
JRC	European Joint Research Centre
Km	Kilometer
KV	Kilovolt
KW	Kilowatt
LIBOR	London Interbank Offered Rate
LNG	Liquefied Natural Gas

LNG	Liquefied Natural Gas
LOI	Letter of Intent
LOS	Letter of Support
LPG	Liquefied Petroleum Gas
LUC	Local Control Unit
m^2	Meter Square
m^3/h	Meter cube per hour
MEPCO	Multan Electric Power Company
Mm	Millimeters
mmcft	Million Cubic Feet
MoU	Memorandum of Understanding
MTDF	Medium Term Development Framework
MVA	Million Volt-Ampere
MW	Megawatt
N_2O	Nitrous Oxide
NAPWD	Northern Area Public Works Department
NASA	National Aeronautics and Space Administration
NCS	National Conservation Strategy

NEC	National Energy Conservation
NEPRA	National Electricity Power Regulatory Authority
NEQs	National Environmental Quality Standards
NGOs	Non-Government Organizations
NOCs	No Objection Certificate
NOCT	Nominal Operating Cell Temperature
NREL	National Renewable Energy Laboratories
NTDC	National Transmission and Dispatch Company
O & M	Operation & Management
OECD	Organization for Economic Cooperation and Development
OEMs	Original Equipment Manufacturer
OHL	Overhead Lines
OLTC	On-Load Tap Changer
OM	Operating Margin
OPV	Organic photovoltaic
OSHA	Occupational Safety and Health Administration
PAEC	Pakistan Atomic Energy Commission
PAEC	Pakistan Atomic Energy Commission

PCM	**Pulse Code Modulation**
PCRET	**Pakistan Council of Renewable Energy and technology**
PDD	**Project Design Document**
PEPA	**Pakistan Environment Protection Act**
PINs	**Project Idea Note**
PLC	**Programmable Logic Control**
PMD	**Pakistan Meteorological Department**
POE	**Panel of Experts**
PPDB	**Punjab Power Development Board**
PPIB	**Private Power Infrastructure Board**
PV	**Photo Voltaic**
PVC	**Poly Vinyl Carbonate**
QC	**Quality Control**
R & D	**Research and Development**
RE	**Renewable Energy**
RE2	**Renewable Resources (Pvt) Ltd**
RFP	**Request for Proposal**
RFQ	**Request for Quotation**

RMP	Risk Management of Project
ROC	Return on Capital
ROE	Return on Equity
RQD	Rock Quality Designation
SECP	Security Exchange of Pakistan
SHYDO	Sarhad Hydro Development Organization
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
SRA	Solar Resource Assessment
SRO	Statutory Regulatory Order
TGP	Three Gorges Project
TOE	Tons Oil Equivalent
Tsf	Tones/square foot
TTG	Trans Tech Group
TTP	Trans Tech Pakistan
UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptible Power Supply
USA	United States of America

WAPDA	**Water & Power Development Authority**
WK	**Welt Konnect (Pvt) Ltd**
WMO	**World Metrological Organization**

ACKNOWLEDGMENTS

We would like to express our gratitude to the support and cooperation extended by the Government of Punjab and the Federal Government of Pakistan in the development activities of the project.

We are also thankful to the dedicated team of the Punjab Power Development Board (PPDB) and the Alternative Energy Development Board (AEDB) for the generous support throughout all stages of project development.

We hope for and look forward to the continued cooperation of all relevant Government Organizations, Bodies and officials for further advancement in implementing the Project and pioneering the way for Solar Photo Voltaic in Pakistan.

DISCLAIMERS

This document is intended for use by the Stake Holders and relevant Government Authorities for understanding and effective decision making regarding this Project.

The Company and the sponsors are and will not be responsible for any decision made by the intended or unintended users for any other purpose except in relation to this project.

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Further, this is not intended to be a business or operational plan for the project.

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DOCUMENT INFORMATION

Purpose and Scope:

The purpose of this report is to provide information required for the relevant agencies to make informed decision regarding the implementation and execution of this project.

This document presents the technical, financial and commercial viability of this project within Pakistan's economic and regulatory framework.

STRUCTURE OF THE DOCUMENT:

The Feasibility Study has been divided into 2 main parts/volumes followed by supporting Volumes 3 to 6 composed of essential studies:

- Volume 1: is composed of the Executive Summary, Introduction and Overview of the Project along with the relevant regulatory framework and policies. Where as
- Volume 2: contains the Technical and Financial Studies: including Engineering Drawings and Plant 3D layout.
- Volume 3: is composed of the Geo-Technical Study Topographic Survey.
- Volume 4: is the Geo-Technical Investigation Report.
- Volume 5: is a compiled Environmental Study.
- Volume 6: is the Grid Interconnection Study being developed by the National Transmission Dispatch Company (NTDC) and to be submitted separately.

Each Volume is further sub-divided into chapters for ease of reviewing and understanding the project. Information in the document is supplemented by Annexures attached at the end of each volume.

EXECUTIVE SUMMARY OF THE PROJECT

The Government of Pakistan has developed a Renewable Energy Policy to encourage the private sector investments towards development of renewable energy solutions in the country. The Alternative Energy Development Board (AEDB) has been established within the Government to facilitate the implementation of such renewable energy projects.

Whereas Safe Solar Power (Pvt.) Ltd. ("Safe Solar Power" or the "Project Sponsor") has been established with the purpose of setting up a 10 MW Solar Power Plant as an IPP under the Government of Pakistan Renewable Energy Policy. Safe Solar Power is incorporated under the laws of Pakistan under the Companies Ordinance, with its head office in Islamabad.

Safe Solar intends to enter into an Engineering, Procurement and Construction ("EPC") agreement for the construction and installation of the equipment on a turnkey basis. The Project also intends to enter into Operations and Maintenance ("O&M") agreement to manage the Project on a day to day basis.

Safe Solar Power intends to enter into a 25-year Power Purchase Agreement ("PPA") with National Transmission & Dispatch Company Limited ("NDTC"). The PPA is expected to be signed under the Alternative Energy Development Board's Renewable Energy Policy of 2006 extended in 2012. Tariff for generation based incentive is expected to be negotiated with National Electric Power Regulatory Authority ("NEPRA"), as an upfront tariff.

Whereas Welt Konnect (Pvt) Ltd (a subsidiary of the Transtech Group) is a Power Projects Developing company working in Pakistan, working as a consultant on this project. Its niche in the Energy Sector lies in the provision of Renewable Energy Engineering solutions particularly for Wind & Solar Power Projects as Independent Power Producers (IPP's) under the Clean Development Mechanism of the UNFCCC. These integrated solutions and systems are designed, simulated and tested by its team of experts and engineers' using the most advanced software's and tools the industry has to offer at this time. WK believes in doing top quality engineering works and takes immense pride in being one of the few companies in Pakistan to have achieved this level of competence in the ever growing and critical field of Renewable Energy.

Whereas the Project Site is located near the Cholistan Desert, District Bhawalnagar, with nearest city of Bahawalpur and will have an installed capacity of 10MWp

Photovoltaic Panels and will function as an Independent Power Producer (IPP) under the rules and regulations of Pakistan.

The project pre-feasibility study was completed by end of 2013. Subsequently after submission of the Pre-Qualification Documents, to the Alternative Energy Development Board (AEDB) along with the Project Proposal, the required Bank Guarantees of 5'000.USD (five thousand) and the requisite fees, the sponsor successfully obtained an LOI (Letter of Intent) from the Board.

Teams were then immediately deployed to initiate work on the feasibility analysis of the project, and competent teams of Engineers & Specialists were deployed for conducting the various requisite studies.

The Project Sponsor is now submitting the final Feasibility Study along with this Volume 1, for approval by the Panel of Experts (POE) of AEDB. After sanctioning of which competent companies in the field of Solar Photovoltaic's will be selected through a Short Listing Criteria based on Experience, Financial And Technical Competencies of such firms in development & construction of Power Projects and Project Management, which shall be advertised in the News Papers & other relevant media. Consequently the Request for Proposal (RFP) shall be circulated and shared amongst the qualifying companies for finalization of the Engineering Procurement & Construction (EPC) Contract after which a petition for Generation License and a petition for Feed In Tariff would simultaneously be filed with the National Electric Power Regulatory Authority (NEPRA) as allowed under their policy, before issuance of the LOS (Letter Of support) by AEDB. This is intended to save time and cut through avoidable red tape in the development of Independent Power Producers in Pakistan.

The Sponsor has also completed substantial work on the financial modeling for the project. The Sponsor believes that keeping in view the recent improvement and trend in the viability of the technology, possibility of fast track implementation by virtue of the recently announced Feed In Tariff regime by NEPRA and current energy crises, this project is of paramount importance for Pakistan and will prove to be a pioneer in the Solar PV industry, paving the way for future progress in this ever growing field and at the same time provide a viable profitable investment opportunity to all stake holders of the country.

2 Introduction

Safe Solar Power (Pvt.) Ltd. ("Safe Solar Power" or the "Project Sponsor") has been established with the purpose of setting up a 10 MW Solar Power Plant as an IPP under the Government of Pakistan Renewable Energy Policy. Safe Solar Power is incorporated under the laws of Pakistan under the Companies Ordinance, with its head office in Islamabad.

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Safe Solar has the vision of being the one of the best clean energy groups of Pakistan specializing in solar power development, project management and operations; proactively developing Solar Power and other forms of renewable energy; steadily expanding and exploring avenues of overseas business.

Whereas the Trans Tech Group of Companies is a multipurpose engineering concern and actively engaged in various Civil Engineering, Railway, Telecommunication and Renewable Energy Projects in Pakistan since 1991. TTP is committed to professional excellence and is playing its due role in the national progress and development of Pakistan.

Trans Tech Group incorporates technical, ecological and economical optimization in its solutions and ensures an efficient and effective implementation of its projects. The man power resource pool of TTP consists of managers, engineers, planners, computer professionals, economists, support staff and skilled technicians.

The Group has been working in Pakistan for the past 25 years and has targeted a number of projects including but not limited to the Infrastructure Sector: namely Construction of Roads, Bridges and Motorways, and The Power Sector; including

Hydro Projects, Coal Power Projects, and Wind Energy Projects, and is currently working with its valuable foreign partners in implementing large scale projects.

Whereas Welt Konnect Pvt. Ltd ("WK" or the "consultant") a subsidiary of the Transtech Group is a duly established company under the laws of Pakistan specializing in Power Project Development. Its niche in the Alternative Energy sector lies in the provision of Renewable Energy Engineering particularly Wind & Solar Projects as Independent Power Producers (IPP's), various commercial applications & CDM projects. These integrated systems are designed, simulated and tested by its team of experts and engineers' using the most advanced software's and tools the industry has to offer at this time. WK believes in doing top quality engineering works and takes immense pride in being one of the few companies in Pakistan to have achieved this level of competence in this ever growing field of Renewable Energy.

After due diligence the Joint Venture awarded WK Consultants the task to provide technical consultancy Services for conducting the Feasibility Study Report (FSR) in accordance with the requirements of the Letter of Intent (LOI) issued by Alternative Energy Development Board (AEDB) under the 2006-2009 Alternative Power Policy coupled with an energy yield assessment for the PV Plant of 10MW, located in the region of Cholistan Desert in the province of Punjab Pakistan. This report describes the results of the Feasibility Study performed for the 10MW PV Plant on the site (Latitude N 029 09.872; Longitude E 072 41.789). The study also investigated solar power technology options that were appropriate for a large scale solar power facility in Cholistan Desert, Punjab and the economic viability of such a solar power facility

The plant consists of a rammed fixed mounted system with an installed module capacity of **10053 kWp** using Mono-crystalline Q-Cells module QC-C05 and 56 SMA Sunny Central inverters SMA SC 800 CP with a total AC capacity of 49,280 kVA.

The Project Layout has been designed to utilize 6 of "1.6 MW Inverter" combined units of two SMA 800 CP Series Inverters (Actual power output at test conditions is 1.76 MW for each unit) which are further connected to 6 SMA Low to Medium range voltage transformers at approximately 360V AC, one for each 1.6 MW unit respectively giving an output between 11 to 20KV range, leading finally to the switch gear or transformer from medium to high voltage range for connection to the Grid

Station at 132KV . Each unit of 1.6 MW will consist of 7480 panels, 2 inverters and 1 transformer.

A string concept is being used with 22 modules connected to a string, and 17 strings connected on a Bus leading to the SMA Inverters connection in parallel with a total of 10 such connections. The total number of PV modules used in this arrangement would be 694 units per 1.6 MW with a total of approximately 6 such units for the complete 10 MW setup.

The FSR also includes an introduction to the Country's Power Sector followed by an Analysis of the legal framework for ease of understanding the procedures and development steps to be taken ahead.

2.1 Purpose of Study

The scope of services stipulated for the FSR includes the following:

- Due Diligence of existing works and steps already taken by the sponsor.
- Analysis of Legal Framework and current scenario of the Power Sector of the country.
- International Market Analysis and case studies.
- Project Analysis
- Information about the site, Collection and Review of solar irradiation and climatic data of the site and comment on the adequacy and reliability of the data and make any corrections necessary;
- Evaluation of the site with respect to operations;
- Review the overall shading situation (horizon) and the detailed shading analysis of the nearby situated objects as well as the internal shading between the PV modules in function of fix mounted PV elements;
- Generation of climate relevant datasets from the installed solar resource measurement tower with NRG Symphonie Plus3 Data Logger and GSM iPack at site; along with the most advanced relevant programs including National Renewable Energy Laboratory's (NREL) of the USA's Department of Energy (DOE) Software Hybrid Optimization Model for Electric Renewables (HOMER), Maui Solar Corporation of California's Software Solar Studio Design Pro; International Climate Generator, Sun-Plot 3-D, ModuLab, etc. This data on irradiation, wind and temperature, is compared to other sources and long-term statistical data available from National Aeronautics and Space Administration (NASA) Meteorological Department, assessment and explanation of the differences;
- Simulation of the yearly energy production of the PV plant using up to date simulation software such as the National Renewable Energy Laboratory's (NREL) of the USA's Department of Energy (DOE) Software Hybrid Optimization Model for Electric Renewables (HOMER), PV SYST, VIPER, Maui Solar Corporation of California Software, Solar Studio Design Pro including; Solar PV Pro-G Version 6.0, International Climate Generator, Sun-Plot 3-D, ModuLab, PV Module Wizard, Sandia IV Tracer, (irradiation, wind and temperature) considering irradiation,

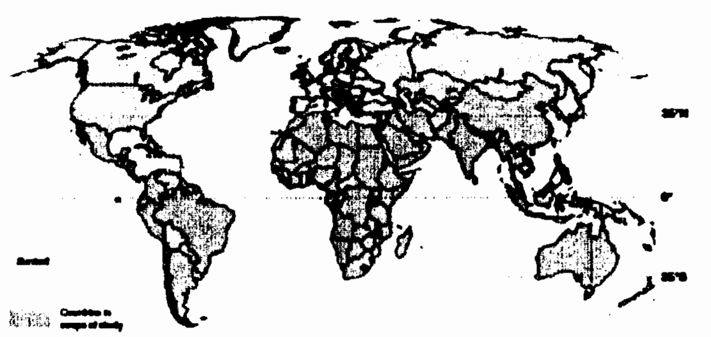
climatic conditions, shading situation, inverter failures, used PV technology and inverter type, external cabling and grid connection losses.

- Determination of expected losses, performance ratio (PR) and long-term performance taking into account module degradation;
- Uncertainty analysis of the simulation and the PV plant energy production assessment;
- Probability analysis of variances above the determined uncertainties concerning the amount of energy produced;
- If necessary, suggestions for improvement of the layout in order to improve the yield, the accuracy or mitigate the risks;
- Statement on the durability of the main equipment (modules, inverters and mounting structure)
- Description of technical equipment and Plant layout studies.
- Economic & Financial Analysis in concurrence with the prevailing industry regulations, standards and the National Electric Power Regulatory Authorities (NEPRA) policy regarding tariff determination
- Efficient Operation & maintenance studies with efficient Project management throughout
- Ecological lifecycle calculations & Ecological footprint, Environment Studies including IEE and EIA
- Socio-economic effects
- Geo-Technical Studies including Topographic Survey and Soil Testing
- Complete Clean Development Mechanism activities including development of PIN's, PDD's, Prior Consideration Form, and Evalutation Matrix

2.2 Background of Study

In view of the accelerated development of new markets for large scale solar power generation around the World and specifically in the so called "Sun-Belt" countries, of which Pakistan happens to be a very prominent member with very high irradiation levels; the JV aims at the identification and development of such large scale Solar PV Power Projects through collaboration with the concerned relevant boards and bodies through a structured approach and vision.

The "sunbelt" region is described as the region between 35N to 35S, encompassing 148 countries globally including Pakistan, as can be seen in Figure 2.2.1:



	Sunbelt countries in scope	All countries in Sunbelt	World
# countries (2008)	66	148	201
Population (2008)	5.0 billion	5.3 billion	6.7 billion
GDP (2008)	15.7 trillion	16.4 trillion	60.0 trillion
Electricity consumption (2007)	6,800 TWh	7,000 TWh	17,900 TWh

Source: World Bank, IMF, A.T. Kearney analysis

Figure 2.2.1: Sun Belt Countries Analysis

With Photovoltaic (PV) development booming globally the time seems just right for investment in the sector. More than 7,000 MW was added to the global generation base in 2009 alone; expanding the cumulated installed base well over 22 GW. Since then, there have been years of vigorous growth of the world-wide PV market, even during times of financial and economic crisis. Revisiting 2011 and now the early part of 2012 we see further growth and emphasis on the sector in emerging markets by Governments and the Private Sector alike. The volume of new grid-connected PV capacities world-wide rose from 16.6 GW in 2010 to 27.7 GW in 2011. Almost 21 GW of this growth can be accounted in Europe.

This somewhat paradoxically shows that the growth so far has mainly been driven by countries outside the world's Sunbelt; whereas by taking the initiative and focusing on the Sunbelt Countries, the growth of PV could be exponentially accelerated by tapping in to this huge natural resource. This phenomenon of unbalanced growth is further explained by the figure below:

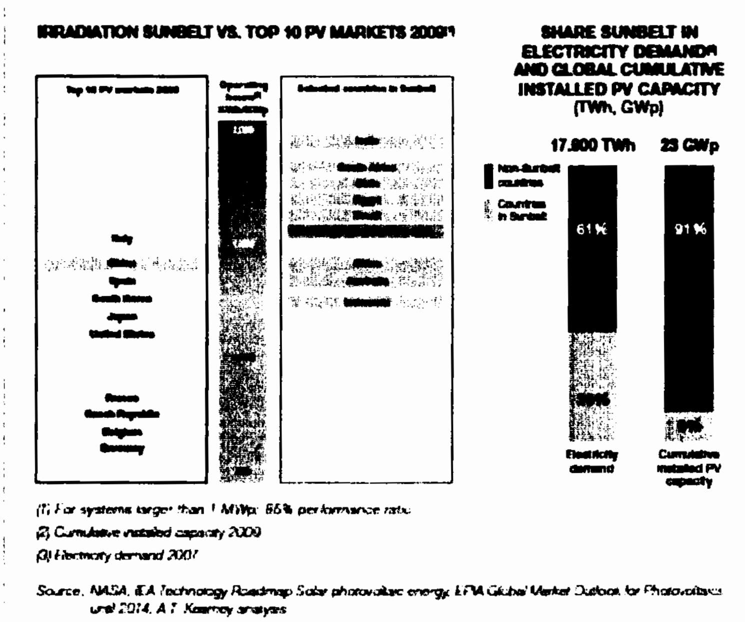


Figure 2.2.2: Comparison of Solar Irradiation, Share in Electricity Demand and Cumulative installed PV Capacity

It can clearly been seen that out of the top 10 PV markets of the world most are not as favorable in terms of PV potential but still have shown tremendous growth even through an era where skepticism over the affordability of the Solar Resource was high and financial crises had plagued several major global economies. It is further shown in Figure 2.2.2 that out of the total worldwide electricity demand of 17'900 TWh, 39% lies in the Sunbelt region whereas Cumulative Installed PV Capacity of the Sunbelt region is only 9% compared to 91% in non-Sunbelt countries. This shows the colossal latent opportunity for growth and investments in the PV sector in these areas.

Investing and tapping this huge naturally abundant resource would bring enormous benefits to the Sunbelt countries as summarized in Figure 2.2.3. The electricity grid may be decentralized, line losses reduced, and generation may be where it is needed rather than where it is available as is the case with other technologies and resources. PV can further contribute significantly to cover the dynamically increasing electricity demand of these growing economies in the shortest possible time, by harnessing low-carbon, free energy solar resource therefore decreasing dependencies on (imported) fossil fuels (one of the major reasons for trade deficits of most of these economies), reducing pressures on water use and improving the carbon balance.

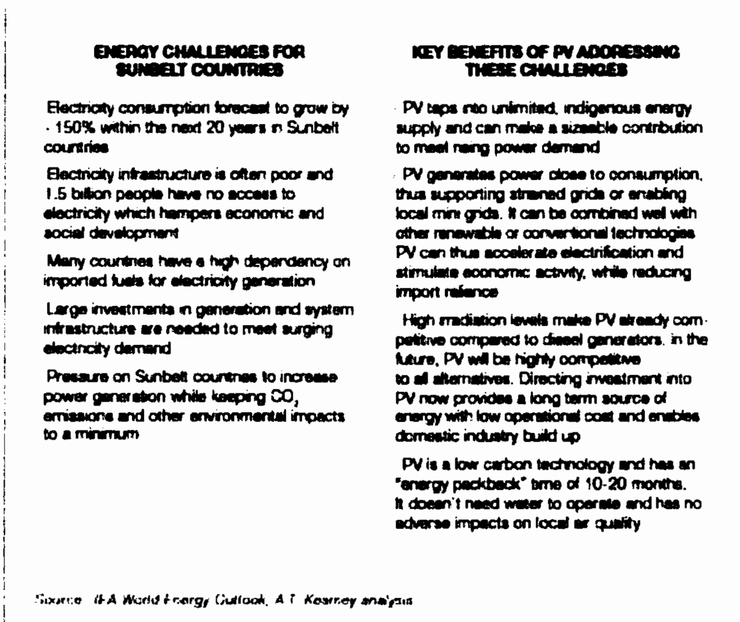
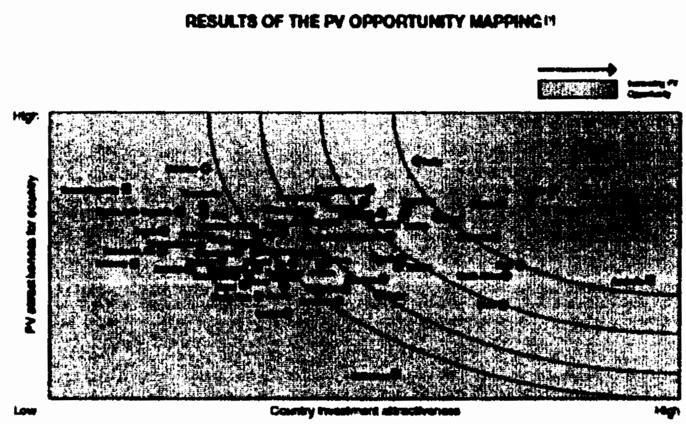


Figure 2.2.3: Benefits of PV for Sunbelt Countries

Amongst the Sunbelt countries we see Pakistan as a member with one of the highest PV Resource Potential with high average irradiation levels of almost 5.8 KWh/m^2 across the country but rather low installed capacity so far for a number of reasons effecting the region in the recent past; which include socio-political, financial and technical reasons coupled with the humanitarian disasters ensuing the country every couple of years.

However the opportunity for progress is immense, courtesy of the correct & appropriate environment which has now been developed through Government Support and Policy Emphasis on renewable energy, in face of the acute power shortage of almost 5000 to 6000 MW annually. The capacity for understanding the sector has also been on a constant rise which has further contributed to the sectors growth in Pakistan. Figure 2.2.4 shows how the country has been positioned in the past amongst other Sunbelt members.

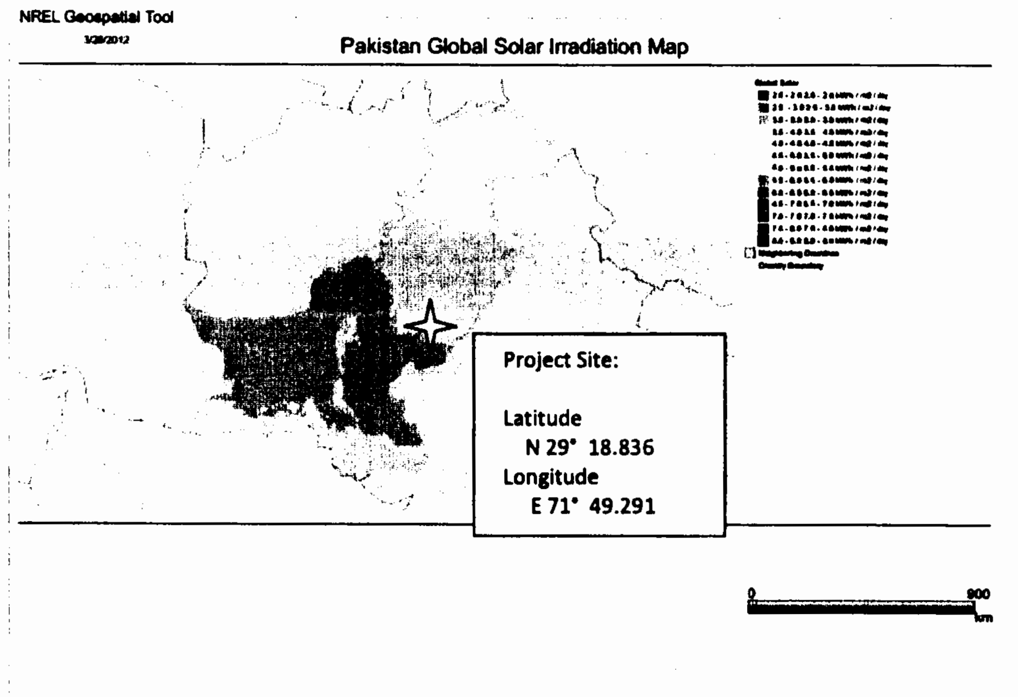


[1] Following countries are not shown on the mapping due to poor availability of data
Chad, Côte d'Ivoire, Congo Dem Rep, Cuba, Iraq, Madagascar, Mali, Myanmar, Somalia, Sudan, Uganda

Source: NASA, IEA Technology Roadmap, EPIA Global Market Outlook for Photovoltaics until 2014, A.T. Kearney analysis

Figure 2.2.4: PV Opportunity Attractiveness for Sunbelt Countries

Located on the western stretch of the South Asian Continent, Islamic Republic of Pakistan is largely under the influence of tropical desert climate with high global irradiation levels. Solar energy has excellent potential in most areas of Pakistan that receive high levels of solar radiation throughout the year. Every day, the country receives an average of about 19 Mega Joules per square meter of solar energy



Map 2.2.1: Pakistan Global Solar Irradiation Map

Pakistan covers 796,095 square kilometers of land between latitudes 24° and 36°north and longitudes 61° and 76° east. At present, it faces serious energy problems: majority of its electricity generation comes from hydropower, which becomes less productive during the driest, hottest months of the year and cannot keep pace with the sharp rise in energy demand.

The relative shortage of conventional energy resources in Pakistan, when coupled with the hiking energy prices worldwide, leads to a tension in the power supply of the country, it has become a top agenda of Pakistan government to find alternative energies, including solar power.

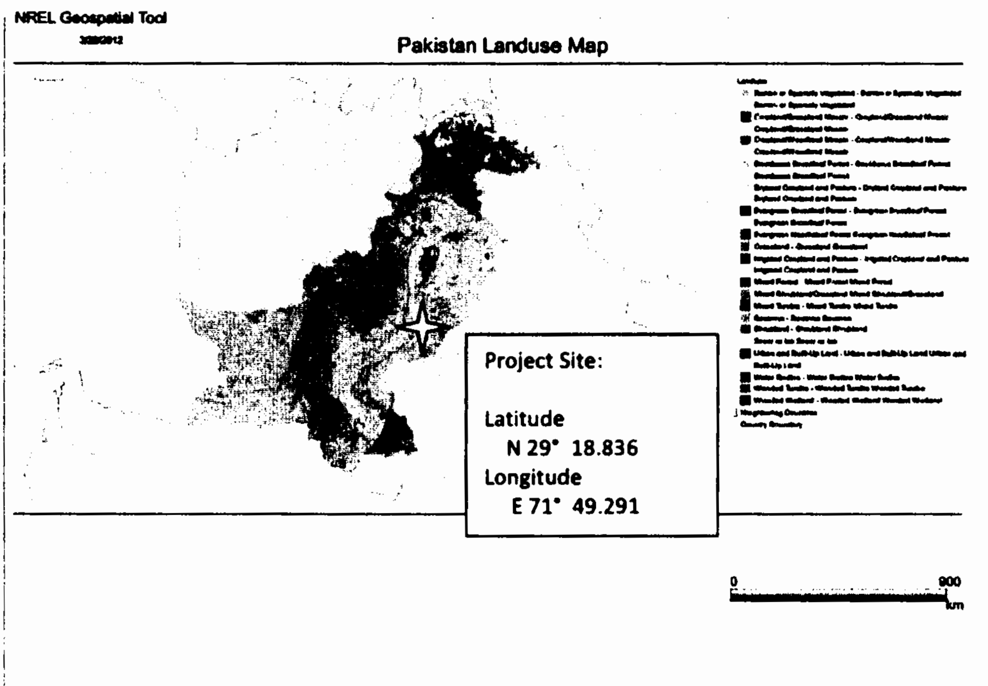
Also, about 70 per cent of the population lives in some 50,000 villages dispersed around the country. Many of these villages are far from the main transmission lines of the national grid and, because of their relatively small populations; it is usually not economically viable to connect these villages to the grid, however decentralized or networks could be developed on Solar Energy to power these areas, which provides an opportunity for micro-grid applications as well.

Government of Pakistan has formulated a policy to standardize and encourage the participation of private sector in the development and application of renewable energies. A Federal Government organization called Alternative Energy

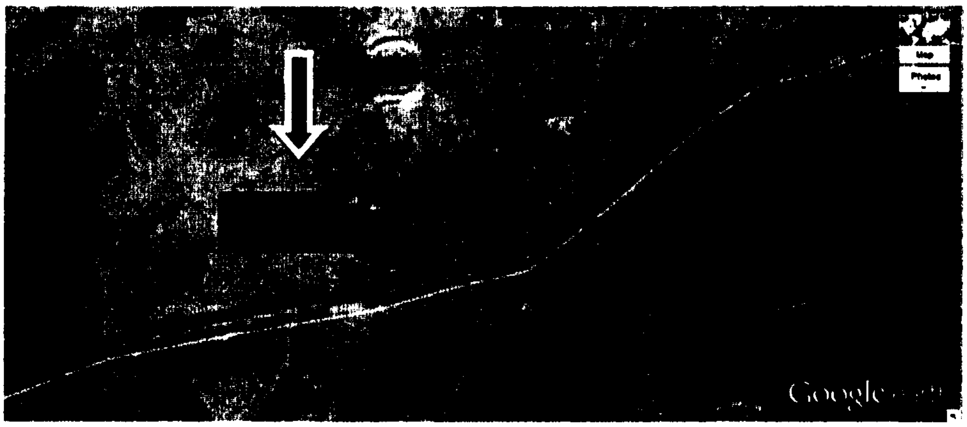
Development Board (AEDB) and respective Provincial Power Boards including the competent and highly esteemed Punjab Power Development Board (PPDB) have been established to facilitate the implementation of renewable energy projects. PPDB has been given a mandate, requisite resources and target to facilitate development of a number of Solar PV Power projects in Cholistan Desert, Bahawalpur District, Punjab Province.

Since the 18th Amendment to the Constitution of Pakistan, and the Powers vested to Provinces under article 157 Point 2(a) to 2(d), the Provincial bodies such as PPDB are now working actively and aggressively to ensure fast track development of Power Projects in their particular domains.

The site is located about 10 km from Bahawalpur, the nearest urban center. The locality enjoys a flat terrain, scarce plant cover, rich solar radiation, and availability of large area suitable for project expansion, accessibility and proximity to medium voltage transmission network, thus rendering itself an appropriate location for large Solar PV power stations.



Map 2.2.2: Project Site Coordinates



Map 2.2.3: Project Site Cholistan District, Punjab

The Project Sponsor has been following closely the Solar Power sector of Pakistan since 2005, and now registered as a member of AEDB in 2014 and obtained a preliminary qualification for solar power development. And consequently began development of the 10 MW Solar PV project in Cholistan Desert.

To stimulate this development, the government has passed a number of Fiscal Incentives for the Promotion of Renewable Energy which provides tax and customs duties exemptions for projects based on renewable energies.

The 10 MW Solar PV Power project benefits include avoided fossil fuel costs and emissions reductions from the displaced conventional power generation, and the economic analysis based on the guaranteed 17% Internal Rate of Return demonstrates that the project is beneficial to the Investors and project developers. The levelized cost of Energy comes out to be about 17.9 USD cents per KWh.

PV Mono Crystalline Cells have been selected as the preferred technology as the prices of various cell types have been converging and the use of slightly cheaper thin film technologies such as amorphous Silicon (a-Si) or Cadmium Telluride with a-Si would be requiring about 80% more land and at lower efficiency and hence off setting whatever cost benefit which was to be gained in the past.

2.3 Project overview

The Project Site is located near the Cholistan Desert, District Bhawalnagar, with nearest city of Bahawalpur; which is one of the oldest cities of the region with a very rich historical heritage. The direct distance between the Project Site and Main Bahawalpur City is about 75km. Detailed information on the Cholistan Desert and Bahawalpur City can be found in **Annexure 4:** General Site information, however relevant and concise information is provided below.

Cholistan Desert sprawls thirty kilometers from Bahawalpur, Punjab, Pakistan and covers an area of 26,300 km^2. It adjoins the Thar Desert extending over to Sindh and into India.

The word Cholistan is derived from the Turkish word Chol, which means Desert. Cholistan thus means Land of the Desert. The people of Cholistan lead a semi-nomadic life, moving from one place to another in search of water and fodder for their animals. The dry bed of the Hakra River runs through the area, along which many settlements of the Indus Valley Civilization have been found.

The Desert also has an Annual Jeep Rally, known as Cholistan Desert Jeep Rally. It is the biggest motor sports event in Pakistan

Bahawalpur located in Punjab, is the twelfth largest city in Pakistan. The city was once the capital of the former princely state of Bahawalpur. The city was home to various Nawabs (rulers) and counted as part of the Rajputana states (now Rajasthan, India). The city is known for its famous palaces such as the Noor Mahal, Sadiq Ghar Palace, and Darbar Mahal, as well as the ancient fort of Derawar in the Cholistan Desert bordering India. The city is located near the historical and ancient cities of Uch and Harappa, which were once a stronghold of the Delhi Sultanate and Indus Valley Civilization. The city is home to one of the few natural safari parks in Pakistan, Lal Suhanra National Park.

In 2007, the city's population was recorded to have risen to 798,509 from 403,408 in 1998. Punjabi and Saraiki are the major languages of local people, while Urdu is well understood and English is the official languages used in various educational and government institutions. Bahawalpur is located south of the Sutlej River and lies in the Cholistan region near the Thar Desert. It is situated 90 km from Multan, 420 km from Lahore, and 270 km from Faisalabad.

The main crops for which Bahawalpur is recognized are cotton, sugarcane, wheat, sunflower seeds, rape/mustard seed and rice. Bahawalpur mangoes, citrus, dates and guavas are some of the fruits exported out of the country. Vegetables include onions, tomatoes, cauliflower, potatoes and carrots. Being an expanding industrial city, the government has revolutionized and liberalized various markets, allowing the caustic soda, cotton ginning and pressing, flour mills, fruit juices, general engineering, iron and steel re-rolling mills, looms, oil mills, poultry feed, sugar, textile spinning, textile weaving, vegetable ghee and cooking oil industries to flourish.

Geography and climate: The city, which lies just south of the Sutlej River, is the site of the Adamwahan Empress Bridge, the only railway bridge over the Sutlej in Pakistan. It is situated 90 km from Multan, 420 km from Lahore, 122 km from Burewala, 90 km from Vehari, 270 km from Faisalabad and about 700 km from the national capital, Islamabad. The west region of the city is called the Sindh. It is a fertile alluvial tract in the Sutlej River valley that is irrigated by floodwaters, planted with groves of date palm trees, and thickly populated forests. The chief crops are wheat, gram, cotton, sugarcane, and dates. Mango Sheep and cattle are raised for export of wool and hides. East of Bahawalpur is the Pat, or Bar, a tract of land considerably higher than the adjoining valley. It is chiefly desert irrigated by the Sutlej inundation canals and yields crops of wheat, cotton, and sugarcane. Farther east, the Cholistan, is a barren desert tract, bounded on the north and west by the Hakra depression with mound ruins of old settlements along its high banks; it is still inhabited by nomads.

The climate is mainly hot and dry. In the summer the temperature reaches the high forties (Celsius) during the day and the nights are slightly cooler. Since the city is located in a desert environment there is little rainfall. Weather conditions reach extremes in both summer and winter. The average temperature in summer is 33 °C (91 °F) and 18 °C (64 °F) in winter. The average rainfall is 20 to 25 mm annually. (Kindly note all readings mentioned above are averages)

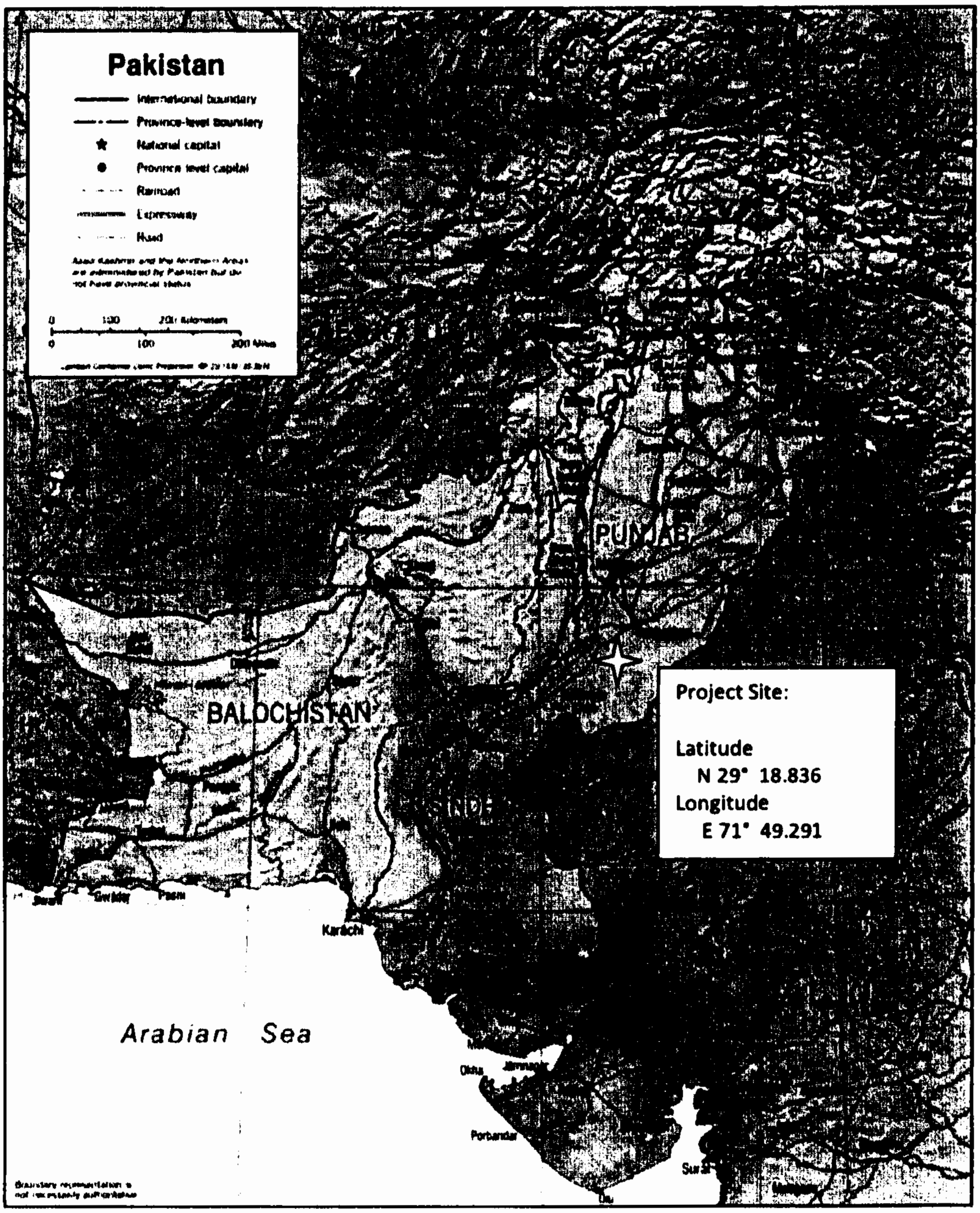
Demographics: Bahawalpur is one of the largest districts of Pakistan covering an area of 24,830 km^2. It has peculiar demographic, topographic and geographical characteristics. The district is situated almost in the center of the country at an elevation of 152 meters from the sea levels. The population of Bahawalpur district increased from 1.453 million in 1981 to 2.411 million in 1998, showing a growth rate of 3.88% per year and population density has increased from 59 in 1981 to 97 in 1998. The majority of Bahawalpur's residents speak Punjabi and Saraiki, while Urdu, and English are common languages used in various educational and government institutions

Transport: Bahawalpur is well connected with various cities in Pakistan. The city has its own airport built by the Dubai Civil Aviation Department and the CAA. Bahawalpur Airport links the city with various Pakistani cities such as Dera Ghazi Khan, Islamabad, Karachi and Lahore with the national flag carrier, Pakistan

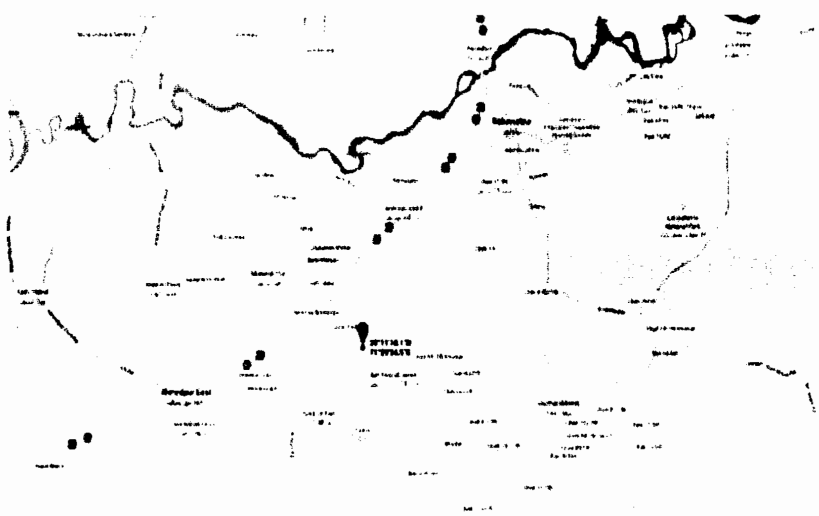
International Airlines. The airline has launched international flights to Dubai, and plans to introduce more international destinations. There are daily trains and bus services from Multan, Lahore, Sukkur and Karachi to Bahawalpur, taxicabs and rickshaws are plentiful in the city. Cars are also available for hire in the city.

The distance between Project Site and the border between Pakistan and India is between 100 to 150Km. The Project covers an area of **50 Acres which Is equivalent to 0.2134282112 Square Kilometers.** The latitudes and longitudes are provided in a table below. The altitude is 150m above sea level. The monsoon from the Indian Ocean, which is stable in its direction and high in its quality, brings rich wind energy resource to the Site.

The installed capacity of the Project is planned to be 10 MW. The geographical location of the project is shown in Map 2.3.1



Map 2.3.1: Regional Map showing Project Site in District Bhawalnagar, Cholistan Desert, Punjab



Map 2.3.2: Satellite Map of Project Site

WK 50 MW Project Coordinates

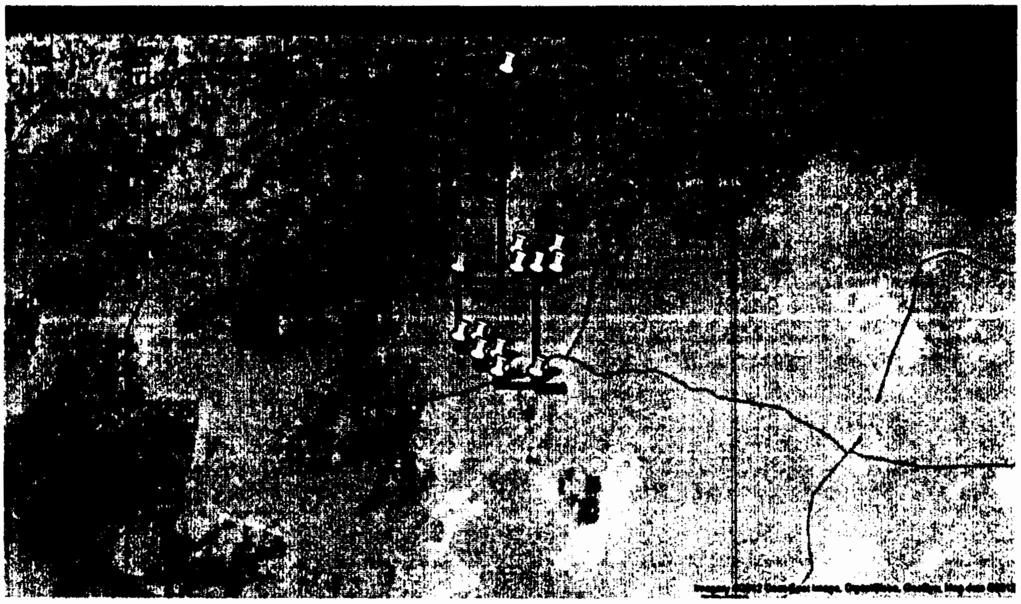
Node	Longitude (East)	Latitude (North)
1	E 71° 49.291	N 29° 18.836

Table 2.3.1: Geographical Coordinates of Project Site

The electric grid selected for connection with the PV power plant is the Marot Grid Station due to a number of factors. Connection to this grid station is most feasible as per initial surveys and research. The grid station has the required capacity (and is going up-gradation) for receiving and distributing maximum load from the PV Power station. Operators at grid station have also demonstrated their confidence in being able to forecast required information.

The grid station falls under the Multan Electric Power Company's (MEPCO) authority with which an initial round of meetings has already been conducted. The geographical details of the grid station are mentioned below:

Latitude:	N 29° 11' 18.0954
Longitude	E 71° 29' 34.4754
Distance (from site):	10 Km



Map 2.3.3: Satellite Map of Project Site showing Grid Station

The Project shall have an installed capacity of approximately 10.05 MW. There shall be a substation of 132KV, which shall dispatch electricity to MEPCO Grid through their station at Bahawalpur, which is to the North of the Site which would be between 3.2 to 4.5 Km's from the Power Station depending on where the switch gear is finally positioned on the project site.

The Project Site is connected to Bahawalpur through good quality metal road capable of handling high loads and Bahawalpur is connected to all major cities of the country via network of Roads and Highways, providing a good facility for transportation of equipment.

2.3.1 Project Size

The Project will install 41,888 Solar PV Modules of 240 Wp each, totaling 10.05 MWp approx., covering an area of almost 150 Meters square (37.5 acres).

2.3.2 Project Status and Calendar

The project has successfully achieved a number of milestones as outlined in the Executive Summary and Background of the Study provided above, and now the Comprehensive Feasibility Study Report is being submitted from here onwards for approval of feasibility and all its parts from the concerned stakeholders / Panel of

Experts of the Alternative Energy Development Board (AEDB). In parallel, the Project shall also pursue and continue work on availing the recently announced Feed In Tariff and signing of EPA/ IA.

All factors have been taken into account during the preparation of this Feasibility Study including the Project Site Location, natural resources, environment and construction of this Solar Power farm along with the local government's plans for social and economic development as well as requirements for the exploitation and use of Solar Power by the Federal and Provincial Governments of Pakistan.

2.3.3 Geological Conditions

The site selected lies in Cholistan desert and has been selected due to favorable conditions for a Solar PV Power plant in regards to the available infrastructure, microclimate effects, risks of natural hazards, geographical advantages, presence of distribution network for power and Geological conditions. The site map and coordinates of the site have been shown in **Figure 2.3.3.1** and **Figure 2.3.3.2** respectively.

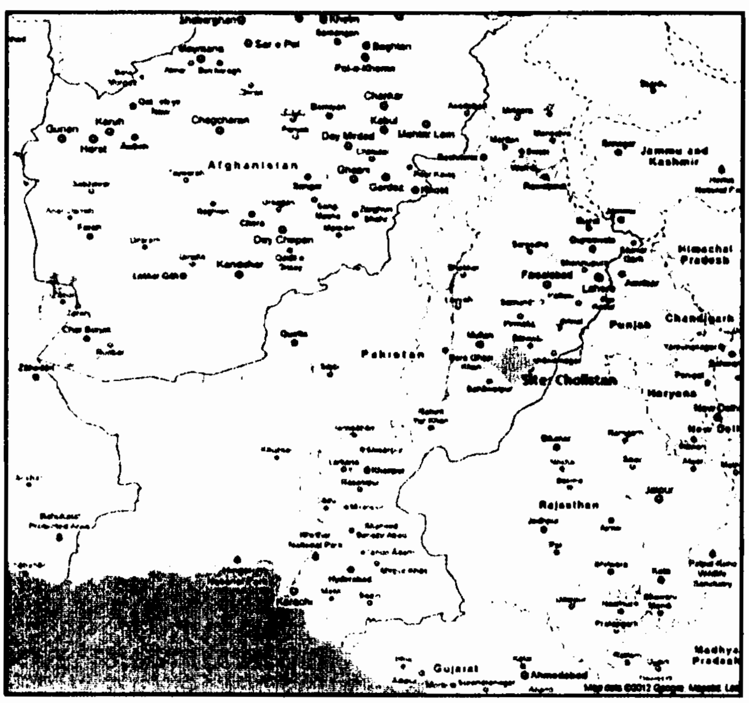


Figure 2.3.3.1: WK Project Site Overview

The Site encompasses an area of 50 Acres approximately 10 km from Bahawalpur (the nearest urban city). The location enjoys a flat terrain with sand dunes in the peripheral, scarce plant cover, rich solar irradiation, availability of water, nearby Government Guest houses and immediate access to the power grid at about 4km, thus rendering itself an appropriate location for the setup of a large solar power station

The subsurface stratum at the site consists of sandy silty clay and similar results were found to the maximum explored depth of 5m (16.4ft). Geological (Solid Earth) characteristics of the site are also affected by the microclimate factors of the area. Cholistan and nearby area are characterized by low and sporadic rain. Therefore aridity is the most striking feature of the Cholistan desert with wet and dry years occurring in clusters. Cholistan is one of the hottest regions of Pakistan.

Cholistan has very low propensity towards natural disasters or similar risks. Till date the nearest area to Cholistan which has faced the effects of a flood is Bahawalpur and only once in our history. Cholistan and nearby areas for a significant radius are not prone to earth quakes (as per past records). Similar studies support the selection of the site as a safe geographical location for operations of a solar power project. **Figure 2.3.3.3** and **Figure 2.3.3.4** show hazard maps of Pakistan.

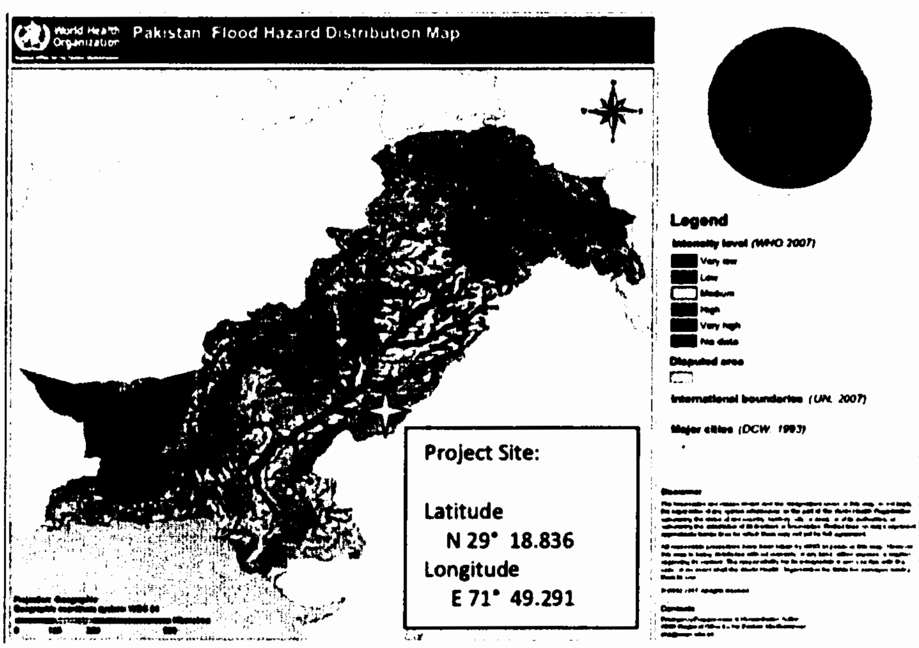


Figure 2.3.3.3: Shows the Flood hazard map of Pakistan

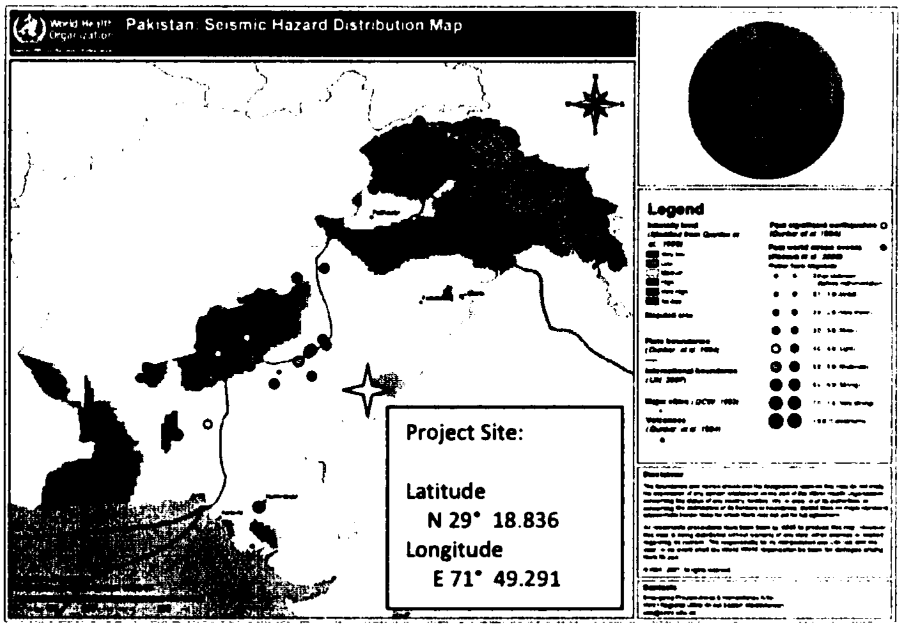


Figure 2.3.3.4: Shows the Natural Hazard map of Pakistan

The site is facilitated with a very favorable level of water table, less tan 20m below ground level. The project team would drill bores to gain access to this water table and its supply. Simultaneously for initial work scope, there are existing wells within approachable distance which are being used by local habitants for their livestock.

The land acquired by the Joint Venture consists primarily of flat ground and sand dunes. Construction of the solar farm will be focused on the flat areas. Scant vegetation (shrubs and bushes) is found in these areas causing no troubles regarding shading.

2.3.4 Solar Resource Assessment

The SRA equipment installed at site has been manufactured by NRG, Vermont with Data Logger Model # 4941 (**Fig. 10.3.5** NRG Data Logger Installed and Connected). The Solar Resource Assessment System; NRG Systems SymphoniePLUS3™ data logger, iPackGPS communications modules (GSM, CDMA, and Satellite), SDR software, meteorological tower components, and reliable sensors from NRG Systems is designed for the professional solar PV developer looking for quick and repeatable deployment, easy and autonomous off grid operation, and bankable data. The system is comprised of proven products including the NRG Systems

SymphoniePLUS3™ data logger, iPackGPS communications modules (GSM, CDMA, and Satellite), SDR software, meteorological tower components, and reliable sensors. NRG Systems resource assessment equipment is currently used on all continents and across 145 countries.

The complete region of Pakistan falls in the "sunbelt" region of the globe. The rise in interest of international PV industry in the region is due to its geographical location on the whole and the natural advantages as compared to other regions. As per NREL solar resource maps (**Fig 10.1.1** Solar resource map for Pakistan), average solar irradiation in Pakistan varies from 3.5 – 7 kWh/m2 per day while Germany witnesses a variation of 2.5 – 3.2 kWh/m2.

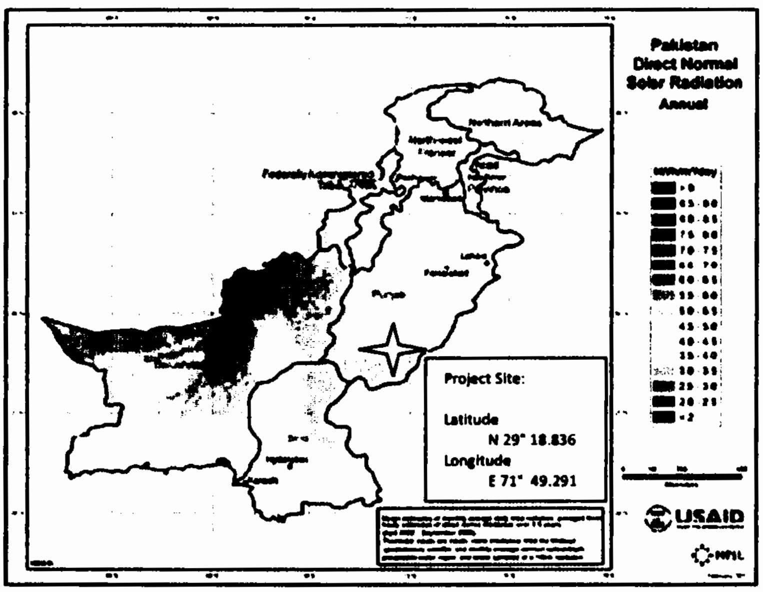


Figure 2.3.4.1: Solar Radiation Map of Pakistan

As can be clearly seen from Fig 2.3.4.1, the greatest amount of solar radiation after parts of Balochistan is in the southern part of Punjab. The daily radiation levels at the project site vary between 4.6 – 7.00 kWh/m^2/day and average at 5.53 kWh/m^2/day.

2.3.5 Solar Power Plant Equipment and Energy Yield Estimate

PV Modules

The modules used in the Feasibility Study have been selected after stringent analysis of technologies in the market. The product to be used is SW 240 Mono which is a 240 W solar panel manufactured by Solar World. The technology used in these panels is Mono-Crystalline silicone. It has the following specifications:

	STC*	NOTC**
P_{max}	240Wp	175.4 Wp
V_{mpp}	30.6 V	27.9 V
I_{mpp}	7.87 A	6.30 A

Table 2.3.5.1: Specifications of PV Modules

* Test conditions according to UL1703
** Performance at 800 W/m^2, NOCT (Nominal Operating Cell Temperature)

The total number of modules used is 209,440 units creating nominal power of 10.05 MW.

Inverters

The basic function of inverters is to convert DC electricity generated by the PV array into AC electricity. The inverter selected is the SC 800-CP model manufactured at SMA Solar Technology. The power rating of these inverters is at 800W at 50 °C and 880W at 25 °C. The specification of the inverter is as follows:

	Input (DC)	Output (AC)
P_{max}	898 kW	898 kW
Voltage Range @ 50 °C	583 V – 820 V (620V Rated)	324 V – 396 V (360V Rated)
I_{max}	1400 A	1411 A

Table 2.3.5.2: Specifications of Inverter

The modules are to be connected to the inverters in a sub-array concept. A string consists of 22 panels. 17 of these strings constitute a single connection. 10 such connections are connected to a single inverter. Therefore the total number of strings connected to an inverter is 170. The total number of inverters utilized is 12 units. The inverters are planted in close vicinity of the PV array

Transformers

A medium voltage transformer is used to step-up the voltage from 360V to 11 kV. The transformer used is the TSC 1000SC model also manufactured by SMA Solar Technology. The specifications are as follows:

	Medium-Voltage	Low-Voltage
P_{rated}	1760 kVA	
Voltage Range @ 50 °C	10 kV – 33 kV (20 kV Rated)	360 V
I_{max}	46.2 A	2 x 1283 A

Table 2.3.5.3: Specifications of Transformer

2 inverters could be connected to a single transformer. A total of 6 such transformers would be planted in close vicinity to the inverters. The transformers used in this layout are supplied by the manufacturers of the inverters thus allowing for optimum performance.

The output lines carry medium voltage electricity to specially constructed switchgear which steps up the voltage from 11 kV to 132 kV and feeds the electricity to the gridline. It has an input range from 10 kV to 33kV. The specifications are as follows:

Model:	SFZ9-60000/11/132 STEP UP TRANSFORMER
Input Voltage:	11 kV
Output Voltage:	132 kV
Capacity:	12000 kVA

Computer generated simulations of the layout showed that the annual system production is 15,830 MWh/yr at an average of 43.4 MWh/day.

All the equipment complies with international standards set by the IEC. The equipment also comes with certificates that guarantee performance at temperature extremes varying from -10 °C to 50 °C and under sand dust conditions.

2.3.6 Design of Electrical Engineering

The Project has an Installed capacity of 10.05 MW, with 41,888 solar modules installed. The module to be used for power generation is the "SW240 Mono Model" which is a 240 W solar panel manufactured by Solar World, using Mono-crystalline silicon. The output lines carry medium voltage electricity to specially constructed switchgear which steps up the voltage from 11 kV to 132 kV and feeds the electricity to the gridline.

Electrical designing of the plant has been done in view of recommendations and best practices of running Solar Power PV plants in the world. To prevent the design and installation issues discussed in research reports, system engineers have ensured that all components such as over current devices, fuses, and disconnect switches are dc rated. Metallic enclosures, junction boxes, disconnect switches, and equipment used in the entire solar power system, which could be accidentally energized are required to be grounded. NEC Articles 690, 250, and 720 describe specific grounding requirements. Equipment grounding conductors similar to regular wires are required to provide 25 percent extra ground current-carrying capacity and are sized by multiplying the calculated ground current value by 125 percent. The conductors must also be oversized for voltage drops as defined in NEC Article 250.122(B).

The modules are to be connected to the inverters in a sub-array concept. A string consists of 22 panels. 17 of these strings constitute a single connection. 10 such connections are connected to a single inverter. Therefore the total number of strings connected to an Inverter is 170. The total number of inverters utilized is 12 units. The inverters are planted in close vicinity of the PV array.

A medium voltage transformer is used to step-up the voltage from 360V to 11 kV. 2 inverters could be connected to a single transformer. A total of 6 such transformers would be planted in close vicinity to the inverters. The transformers used in this layout are supplied by the manufacturers of the inverters thus allowing for optimum performance. The output lines carry medium voltage electricity to specially constructed switchgear which steps up the voltage from 11 kV to 132 kV and feeds the electricity to the gridline. Computer generated simulations of the layout showed that the annual system production is 15,830 MWh/yr at an average of 43.4 MWh/day.

2.3.7 Design of Civil Works

Prior to any construction activity, the site must be cleared of all debris and surface vegetation if any. The leveling and grading can be carried out by normal earth moving machine. It is recommended that immediately after excavation for construction of foundation or other substructures, the excavation bottoms and slopes are cleared of all debris, proof rolled and covered by a 5 cm thick blinding concrete layer. The onsite material is generally classified as SANDY SILTY CLAY (CL-ML) group of Unified Soil Classification System. Select fill material should consist only of inorganic material and shall have 5-20% passing the No. 200 sieve. Fill material should pass 100% the 50 mm sieve. Besides, that portion of material passing sieve No. 40 should not have liquid limit more than 35 and plasticity index of not more than 12. Atterberg limits are not required for select fill material with less than 15% passing sieve No. 200. Select fill material shall have a carbonate content of less than 25% by weight.

The main construction activities of the Project are the foundations of the 132kV substation and the mountings for the PV modules. Detailed topographic analyses of the project site were conducted after which a structural design of the mountings was developed. Details of these designs have been provided in **Section 12.** The units have been designed to ensure easy site installations.

The inverters and medium voltage transformers provided by SMA are housed in compact and weatherproof enclosures ready for immediate outdoor set-up in close vicinity to the PV arrays.

In order to be safe, the load carrying strata must be competent to sustain the imposed loading without undergoing shear failure, and at the same time settlements of the foundations must not exceed the tolerable limits. Therefore, the load carrying characteristics of the strata must be evaluated keeping in view these two considerations. As per the information provided by the consultant, a foundation for solar panel is to be constructed at the site. Based on the type of structure, envisaged loading, type of subsurface strata and engineering analysis carried out, shallow foundation could be adopted for the intended structure. For the intended structure we recommend adopting isolated/strip footings with an allowable bearing pressure of 150 kN/m^2 (1.50tsf). Depth of foundations have been taken as 1.0m (3.28ft) below the existing investigated level which was already excavated up to 5ft from existing ground level.

2.3.8 Fire Fighting Management

In general, small-size solar power system wiring projects, such as residential installations commonly undertaken by licensed electricians and contractors who are not trained in life safety installation procedures; do not represent a major concern.

However, large installations where solar power produced by photovoltaic arrays generates several hundred volts of dc power require exceptional design and installation measures.

A complete SOP for the firefighting management will be prepared duping the Procurement and construction phases, in light of the guidelines given by OEMs and the structuring of the Power Plant. The decision is based on a brief introduction to "Fire Fighting Management in Solar Power Systems, by The Fire Protection Research Foundation"

Certain basic safety precautions should be taken into account by all fire fighters on the fire ground. Determining the presence of a PV system is the key to preventing fire ground injuries. The following six points of safe operation are offered for fire fighters:

- Daytime = Danger;
- Nighttime = No Hazard
- Inform the IC that a PV system is present
- Securing the main electrical does not shut down the PV modules
- At night apparatus-mounted scene lighting does not produce enough light to generate an electrical hazard in the PV system
- Cover all PV modules with 100 percent light-blocking materials to stop electrical generation
- Do not break, remove, or walk on PV modules, and stay away from modules, components, and conduit

A photovoltaic array will always generate electricity when the sun shines. These units do not turn "off" like conventional electrical equipment. Fire fighters on the fire ground should always treat all wiring and components as energized. Breaking or compromising a photovoltaic module is extremely dangerous and could immediately release all the electrical energy in the system.

Without light, photovoltaic panels do not generate electricity, and thus nighttime operations provide an inherent level of safety. Emergency scene lighting during a nighttime fire ground operation, such as from a mobile lighting plant unit, are not bright enough for the photovoltaic system to generate a dangerous level of electricity. Light from a full moon, which is reflected light, also will not energize the photovoltaic cells. However, lightning is bright enough to create a temporary surge of electrical current.

In summary, there are several fundamental points of consideration for fire fighters and incident commanders when handling any building fire equipped with a solar power system:

- Identify the existence of a solar power system
- locate rooftop panels
- clarify electrical disconnects
- obtain system information
- Identify the type of solar power system
- Solar Thermal System
- Photovoltaic System
- Isolate and shutdown as much of the system as possible
- Lock-out and tag-out all electrical disconnects
- Isolate the photovoltaic system at the inverter using reliable methods
- Work around all solar power system components

2.3.9 Construction Management

Installation and construction of Solar PV Power Stations require many specific considerations:

- Orientation and setting of the modules to take full advantage of sun as generators of energy
- Selection, delivery and handling of fragile, state-of-the-art components
- Expertise and qualifications of system installers such as roofers, electricians and glaziers.

Prior to and during construction activities, all contractors will be required to follow three main principles:

- Conduct systematic site inspections and prepare site plans with clients
- Project managers should be skilled at specifying, receiving and safely installing valuable materials
- Ensure that all personnel engaged in construction and installation are well qualified and trained

Civil works team is required to follow certain site specific guidelines. To avoid possible attack of deleterious salts on cement, we recommend the use of Type-I cement in underground structures including foundations. To minimize corrosion potential the concrete mix should be designed using a water cement ratio not greater than 0.45. Admixtures may be required to provide workability. Concrete shall be densified using vibrators and a cover of 75mm should be provided over all reinforcing steel embedded in foundations concrete. A layer of bitumen coating should be applied to the exterior of all the foundation and other concrete coming in contact with soil.

For construction activities of the project, during the planning phase primary focus is kept on the laws and legislations of land use set by the Provincial Government of Punjab, meaning the Land acquisition Act 1984, Soil Reclamation Act 1964 and The Punjab Development of Damaged Areas Act 1952; so that all activities are carried out in a manner which do not hinder the decommissioning procedures of the project or repairing the damaged areas.

Main soil types of Cholistan desert are sand dunes (44%), sandy soils (37%), loamy soils (2%) and saline-sodic clayey soils (17%). The 10 MW Cholistan Solar PV Power project is exempted from all requirements of IEE and EIA as it falls under schedule II classified by the Pakistan Environmental Protection Agency regulations 2000, S.R.O 339(1)/2001. However both studies were conducted and submitted to EPA Punjab which after its due diligence has issued a No Objection Certificate (NOC) to the Project. The site will be restored to the original landscape in the later phase of construction.

2.3.10 O & M Management

After the completion of its construction, the Project shall be jointly managed with the 132 kV Substation. A joint management organization will be established with the principle of requiring "few on-duty staff". After the electrical equipment and machinery have entered their stable operation mode; the solar farm and substation shall be managed with "no on-call staff and few on-guard staff'.

OEMs for Solar panels are responsible for providing the generic maintenance plans for solar panels which include cleaning. The maintenance manuals would be prepared for the utility plant. The joint management between Safe Solar (Pvt) ltd and EPC Contractor will be required to further determine the suitable cleaning requirements for the panel. This would be done by sharing complete site information (dust, dirt, pollen and/or pollution in the site environment; the frequency of rain or snow) with the OEMs for Solar panel, and ask them for site specific cleaning plans and details for the solar panels.

Operation and maintenance team members and their qualification requirements will be dependent on the requirements presented by OEMs for equipment and components, requirements identified by EPC Contractors and the Project Sponsor. Team structure would be dependent on the nature of approach taken towards the responsibility of O&M.

The Project Sponsor & the EPC Contractor will jointly draft procedure and decision protocols regarding the presence of skilled engineers and technicians on site to operate the plan or control through utility from remote location. The systems of Patrol Inspection, operation guardianship, maintenance and overhaul will be established for the daily maintenance of production equipment, instruments and apparatus. These SOPs would be in-line with all requirements of International Standards of Safety, Management, Quality and Human resource management.

2.3.11 Environmental Management

A separate environment study has been carried out. Please refer to Volume 5. There are no significant hazards. The minor adjustments required during construction phase have been addressed and mitigation plan provided. There are no settlements within 05-08 Km of the Project Site, which further supports the Project in this location. As mentioned above, the 10 MW Cholistan Solar PV Power project is exempted from all requirements of IEE and EIA as it falls under the schedule II classified by Pakistan Environmental Protection Agency regulations 2000, S.R.O 339(1)/2001. However both studies were conducted and submitted to EPA Punjab which after its due diligence has issued a No Objection Certificate (NOC) to the Project.

2.3.12 Health and Safety

During the construction and operation of the Project, the guideline of "safety first, (accident) prevention foremost" will be practiced. Comprehensive management and supervision will be applied to all staff members and the whole operation process, in order to ensure safe operation of the equipment and personal safety of workers.

HSE personnel will be required to draft emergency shutdown procedures for the plant in collaboration with the maintenance and project department during the detailed design phase of the Project. These would include all procedures in case of fire, lightning, flood, other natural disasters, etc. The procedures would be based on the guidelines from OSHA Standards (29 CFR 1910). Further standards and guidelines will be reviewed and adopted based on the recommendations of different stake holders.

A safety and health supervision department will be established on the site, which is to be in charge of the education, training and management of safety and health related issues after the project is put into operation. There will be safety personnel in the production section, and a part-time worker for the routine safety and health work.

The systems of patrol inspection, operation guardianship, maintenance and over-haul will be established for the daily maintenance of production equipment, instruments and apparatus. The safety and health supervision department will provide appropriate inspection equipment, as well as necessary public education service for production safety.

A comprehensive safety system will be established during the preparation phase, and carefully implemented during the construction process. The systems of work sheet, operation sheet shift relief, patrol inspection, operation guardianship, maintenance and over-haul will be strictly implemented, The Safety Regulation of the wind farm will also be seriously observed to preclude accidents such as fall, fire, or electric shock.

2.3.13 CDM Aspect

Thorough work has been done to develop the Project under the Clean Development Mechanism of the UNFCCC. The Project is a power generation project with renewable resource and zero emission. When put into operation, the project can provide power supply to the southern Pakistan power grid, which currently is mainly relying on fossil fuel. Therefore, it can help to reduce the greenhouse gas emission from coal or oil-fired power generation. It can deliver good environmental and social benefits. It is also consistent with the spirit of the Kyoto Protocol and qualifies for the application of CDM projects', NEPRA is allowing almost the same return on equity (RoE) to the thermal and the renewable energy projects. The Sponsors of the Project require CERs to bring the RoE at a level where they can invest in renewable energy projects in Pakistan in future as well. If the project is approved and registered as a CDM project, CERs can provide slightly extra financial resource for the project it encouraging project sponsors and lenders. Besides providing minutely more favorable conditions for the project financing, it will improve competitiveness of the project, and reduce investment risk during the project implementation process.

1	Location of the Solar Farm		
1.1	Elevation	m	135
1.2	Longitude (East)		071 49.291
1.3	Latitude (North)		029 18.836
2	Solar resource		
2.1	Annual Average Horizontal Radiation	kWh/m2/day	5.53
3	Major Equipment		
3.1	PV Modules		
(1)	Quantity	Ea	41,888
(2)	Technology		Mono Silicone
(3)	No. of cells	Ea/panel	60
(4)	Impp	A	30.6
(5)	Vmpp	V	7.87
(6)	Rated Power	Wp	240
3.2	Inverters		
(1)	Quantity	Ea	12
(2)	Pmax	Wp	880
(3)	Input Voltage	V	673
(4)	Input Imax	A	1338
(5)	Output Voltage	V	363
(6)	Output Imax	A	1400
3.3	Medium Transformers		
(1)	Quantity	Ea	6
(2)	Pmax	Wp	1760
(3)	Input Voltage	V	363
(4)	Input Imax	A	2 X 1400
(5)	Output Voltage	kV	20
(6)	Output Imax	A	46.2
3.4	High Voltage Transformer		
(1)	Quantity	Ea	1
(2)	Capacity	kVA	12000
(3)	Input Voltage	kV	11
(4)	Output Voltage	kV	132
(5)	Frequency	Hz	50
(6)	Phase	Ea	3
4	Civil Engineering		

4.1	PV Module Mountings	Simple truss structures for immediate installation at site	
4.2	Foundation for High Voltage Substation		
5	Construction		
5.1	Construction Period	month	9
6	Production Analysis		
	Annual Benchmark Energy Yield	GWh/yr	15.83
7	Budgetary Estimates		
7.1	EPC Cost	Min US $	16.927,083
7.2	Total Project Cost	Min US $	19.006,875
7.3	O&M Cost for Year 01 – 02	Min US $	1.05
7.4	O&M Cost for Year 03 – 05	Min US $	1.05
7.5	O&M Cost for Year 06 – 20	Min US $	1.05
8	Referenced Levelized Tariff		-
8.1	Levelized Tariff (Excluding withholding Tax)	US Cents / KWh	-
8.2	Levelized Tariff (Including withholding Tax)	US Cents / KWh	17.9

Figure 2.3.13.1: Project Technical and Financial Summary

2.4 Rational for Solar power

Pakistan's major electricity sources are thermal and hydro generation, meeting approximately 70% and 28% (respectively) of the country's annual electricity demand. The primary thermal generation fuels employed are furnace oil and gas. While both are produced domestically, demand already outstrips supply by a considerable amount. Oil import is a significant burden on the national exchequer and the increasing import bill continues to exert further pressure on the foreign exchange reserves.

Import of gas could be seen as a viable option to overcome the depleting domestic reserves but gas import has significant issues, mainly the need for substantial capital investment in infrastructure, security difficulties and physical terrain concerns. Moreover, it would increase Pakistan's reliance on imported fuels with associated foreign exchange effects. This must be considered in the context of rising fuel costs for gas and oil-based fuels as a result of uncertainty over future supply.

Alternatives to further fuel imports for electricity generation are the use of domestic coal, co-generation from hydro-electric or other renewable sources, such as Solar Power. These options will assist in reducing Pakistan's reliance on imported oil, and consequent vulnerability to changes on global oil prices which will in turn have a positive effect on the current trade deficit and inflating import bill. As with gas, securing future supplies of coal and hydro-electric power would rely on significant spending on infrastructure. Pakistan has domestic reserves of coal. However, coal currently makes up a very small proportion of total generation, largely the result of most of the reserves being located in one area, the Thar Desert. Exploiting the reserves would require huge and costly upfront investment in local infrastructure (including provision of water supplies), development of mines, housing and related infrastructure, and investment in transmission lines before power plant development could commence. Hydroelectric power already supplies almost 30% of electricity, and numerous sites for future investment exist but due to their locations, this would also require significant investment in transmission to meet the expected power needs. Moreover, there are varying political stands on hydro-electric power options.

Looking at how the country's future electricity needs might be met in a way that supports the environmental objectives of the Government of Pakistan, Solar Generation has the potential of being a strong contributor. The development of Solar Power generation projects could reduce dependence on fuels for thermal power generation, increase diversity in Pakistan's electricity generation mix, and reduce greenhouse gas (GHG) emissions avoiding thermal power generation. Also the per kWh tariff for Solar Power projects are now comparatively less than that of furnace oil tariff; particularly the rental power projects.

In addition Solar PV Power Projects have the benefit of supplying electricity in a decentralized manner to areas "where it is required", as the resource is not constrained by geographic locations', Solar Power can be generated in almost all parts of the country which enjoy high Irradiation levels of almost 5.8Kwh/m2 on average.

2.5 Country overview

Pakistan is located on the western stretch of South Asian Subcontinent with Arabian Sea in the south, China in the north, India on the east, Afghanistan and Iran on the west It covers an area of 796,000 km^2 and has a coastal line of 980km. Almost 3/5th of Pakistan's total area is mountains and hills, deserts spreading along the southern coastal areas, and plateau pastures and fertile agricultural land stretching north. The Indus River, which originates from China, traverses 2300km from north to south into the Arabian Sea.

Pakistan has a tropical climate. It is hot and dry in most of its areas, with relatively high average annual temperature. The southern coastal areas have an average yearly temperature of 26°C. Most areas show temperatures higher than 40°C around noon in June and July. Some parts of Sindh and Baluchistan even have temperatures higher than 50°C. The yearly precipitation in Pakistan is less than 250 mm; with 1/4th of Pakistan having annual rainfall less than 120 mm. Pakistan is under great influence of monsoon from Indian Ocean, which brings both precious rain and abundant wind energy resources.

2.6 Industry overview

2.6.1 INTRODUCTION

The series of years of vigorous growth of the world-wide PV market, even during times of financial and economic crisis, has continued in 2011. The volume of new grid-connected PV capacities world-wide rose from 16.6 GW in 2010 to 27.7 GW in 2011. Almost 21 GW of this growth can be accounted in Europe.

2.6.2 MARKET REPORT 2011

The global PV market in 2011: 27.7 GW of new plants connected to the grid

Globally, PV systems connected to the grid rose from 16.6 GW in 2010 to 27.7 GW in 2011. The number of markets reaching more than 1 GW of additional capacity during 2011 rose from 3 to 6. In 2010 the top 3 markets were Germany, Italy and the Czech Republic; in 2011 Italy leads the ranks and Germany, China, the USA, France and Japan follow, each with over 1 GW of new capacity.

The European share in the global PV arena still remains predominant with more than 75% of all new capacity in 2011. The 2 biggest markets, Italy and Germany, account for nearly 60% of global market growth during last year.

Increasing the PV momentum by adding additional markets of important growth can be considered the single most important achievement on the continued growth track of world-wide PV development. And yet, many of the cited markets, in particular China, the USA and Japan, but also Australia and India, have addressed only a very small part of their enormous potential; several countries from large sunbelt regions like Africa, the Middle East, Asia and South America are on the brink of starting their development.

Total installed PV capacity world-wide reached over 67.4 GW at the end of 2011. PV is now, after hydro and wind power, the third most important renewable energy in terms of globally installed capacity. The growth rate of PV during 2011 reached almost 70%, an outstanding level among all renewable technologies. The total energy output of the world's PV capacity run over a calendar year is equal to some 80 billion kWh. This energy volume is sufficient to cover the annual power supply needs of over 20 million households in the world.

In Europe, over 50 GW of PV systems were installed at the end of 2011. With growing contributions from Southern European countries, the average load factor of this capacity is increasing and will produce some 60 billion kWh on an annual basis, enough energy to supply over 15 million European households.

2011 also highlighted a peculiar feature of fast growing markets: the final numbers on grid connected capacities are communicated in several markets only around March. On the back of very strong growth contributions during the last quarter of the previous year, they then need to be revised upwards. In addition, specific regulation in Italy and France created strong installation growth in 2010; however the grid connection was to be counted only in 2011. Although this effect is not new, it reached between 3 and 5 GW of installations made in 2010 with grid connection taking place in 2011.

The following table 2.6.2.1 shows the top 15 markets world-wide, both in terms of newly connected capacity during 2011 and cumulative installed capacity at the end of the year. European countries are marked in orange.

	Country	2011 Newly connected capacity (MW)	2011 Cumulative Installed capacity (MW)
1	Italy	9,000	12,500
2	Germany	7,500	24,700
3	China	2,000	2,900
4	USA	1,600	4,200
5	France	1,500	2,500
6	Japan	1,100	4,700
7	Australia	700	1,200
8	United Kingdom	700	750
9	Belgium	550	1,500
10	Spain	400	4,200
11	Greece	350	550
	Slovakia	350	500
13	Canada	300	500
	India	300	450
15	Ukraine	140	140
	Rest of the World	1,160	6,060
	Total	**27,650**	**67,350**

Table 2.6.2.1: Top 15 Markets

The market share of the world's top 10 markets is highlighted in Chart 2.6.2.1. These top 10 markets make up over 90% of the entire PV growth world-wide.

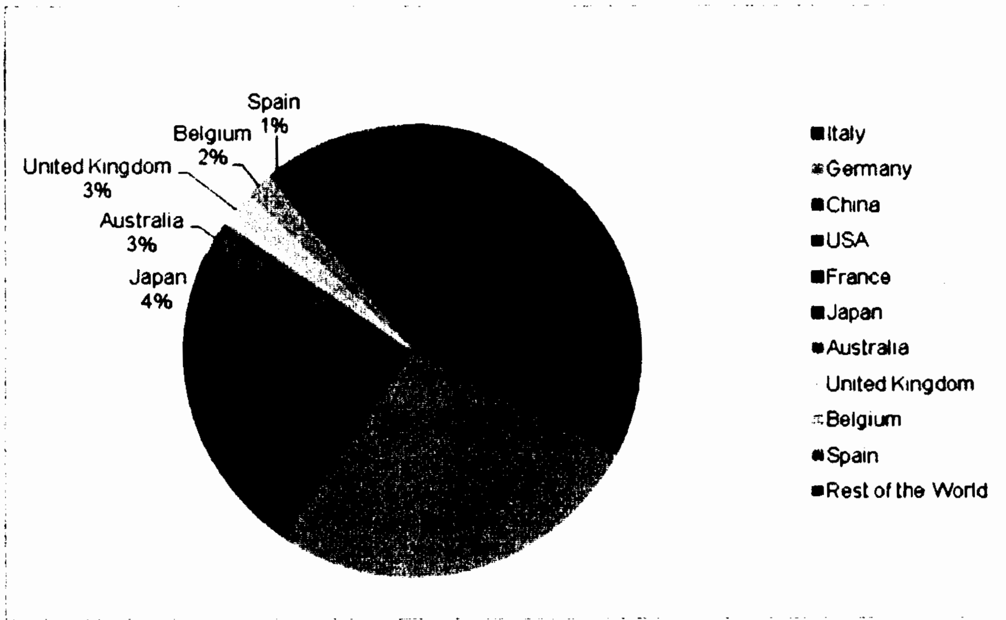


Chart 2.6.2.1: Top 10 markets

Figure 2.6.2.1 reveals the evolution of global cumulative PV capacity since the year 2000 and also indicates the market growth contributions from Europe (orange) and from all other markets (yellow).

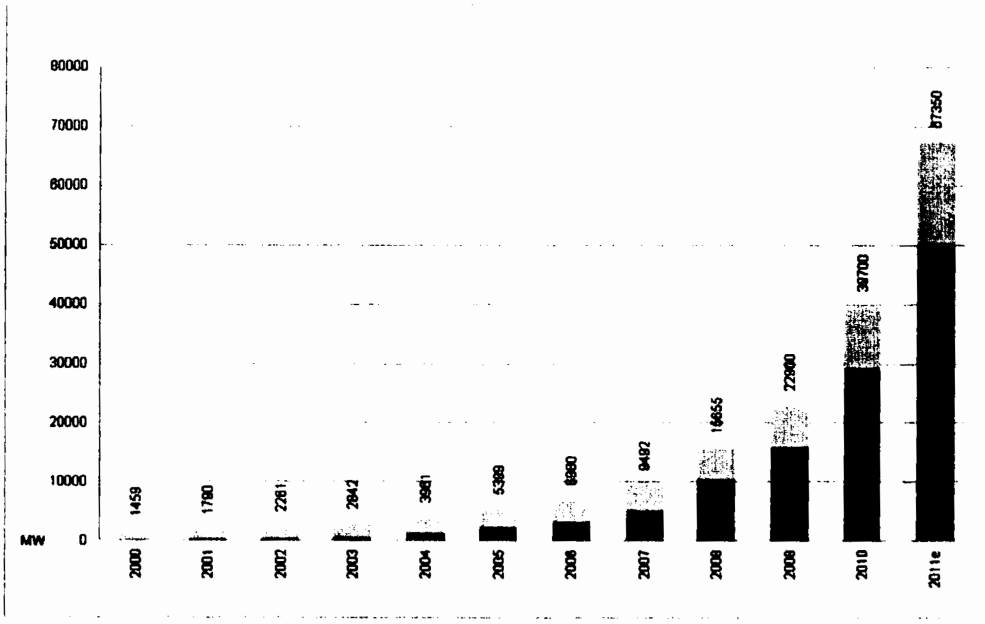


Figure 2.6.2.1: Evolution of Global PV Capacity

European markets: GW markets" and an all-time record for Italy

With almost 21 GW of grid connected PV installations in 2011 Europe has increased its cumulative capacity base by over 50%. This impressive figure is mainly driven by 3 markets: Italy, Germany and France.

Italy became for the first time the top PV market with 9 GW of newly connected systems in 2011 (compared to 2.3 GW in 2010). A substantial portion of these new connections were part of a rush of installations that took place at the end of 2010. The reason for this unusual concentration was the adoption of a decree allowing for systems installed by the end of 2010 but connected by mid-2011 to benefit from the more advantageous 2010 Feed-in Tariffs (FiT). This decree, known under the umbrella name "Salva Alcoa", allowed 3.5 GW of installations to benefit from these exceptional conditions.

At the beginning of 2011, Italy's 3rd *Conto Energia* registered 1.5 GW of newly connected systems. The 4th *Conto Energia* entered into force at the beginning of June 2011, and despite its stricter conditions and reduced FiT, it allowed for the connection of almost 4 GW in only 7 months.

As for **Germany**, a very strong last quarter propelled total 2011 market growth to 7.5 GW. 2011 started slowly with harsh weather conditions and small capacity additions due to lower FiT. From March, installations started to rise and reached up to some 600 MW in the months of June and July. Unlike the previous year there was no reduction of the FiT in July.

France saw 1.5 GW of new systems connected last year, mainly a result of installations done in 2010. Only less than 10% of this capacity was installed during 2011. The new legal framework allows systems of up to 100 kW only to benefit from a remunerative FiT level, whilst larger projects had to wait until the summer to apply for several types of call-for-tender schemes. The new support framework aims to limit the annual market size to 500 MW.

The extremely long grid connection process in France can take up to 18 months. The important FiT cuts and long grid connection lead times explain why new installations were at a poor level during 2011, whilst grid connections reached a record high of 1.5 GW in 2011.

The **UK** also delivered a surprising development during 2011, reaching unprecedented growth of some 700 MW. In April 2010 a new FiT scheme was introduced and immediately followed by enthusiastic market development. The reaction was so positive that after only a few months several stakeholders sought to curtail this rapid growth. This was confirmed in January 2011 with the introduction of a "fast track review" which led to a strong reduction of all FiT for PV systems over 50 kW. This led to a rush of projects seeking grid connection before the deadline. The awaited FiT cut was followed by another intervention announced at the end of October 2011 affecting smaller PV systems, leading to another massive rally for grid connection in 2011.

Other key markets in Europe were **Belgium** (550 MW), **Spain** (400 MW), **Slovakia** (350 MW) and **Greece** (350 MW). In Belgium the Flemish market boomed again in 2011 despite reduced support schemes while the Walloon market reached 100 MW, highly concentrated in the residential sector. Spain has not made particular progress since the halt of the market at the end of 2008. Slovakia drastically reduced its support to PV in mid-July, stopping the market after a rapid growth in the first 2 quarters of the year. Finally, the Greek market progressed in particular in the residential segment where some 60 MW were connected last year.

The **Czech Republic**, after 2 hectic years that saw PV installations reach 2 GW has disappeared from the PV map; with less than 10 MW of new PV installations as a result of strong opposition from major stakeholders.

Some other EU countries are progressing with yet limited capacities, with Austria reaching 100 MW and Bulgaria some 80 MW during 2011.

PV markets outside Europe: China ahead, several markets growing importantly

Outside Europe, **China** will probably rank first in 2011, with at least 2 GW of new PV systems installed and connected. The market was pushed thanks to the deployment of FiT at provincial level. Rapid growth was also seen in the **USA**, with at least 1.6 GW of newly connected systems. This is nearly double the 2010 market figures.
Behind those 2 leaders, **Japan** is expected to have connected over 1 GW of PV systems in 2011 benefiting from the revised FiT scheme. In Asia-Pacific, the performance of **Australia** was impressive, with some 700 MW of new installations in 2011. **India** installed over 300 MW during last year.

Sizeable contributions came also from 3 other markets in different parts of the world: 300 MW from **Canada**, 140 MW from **Ukraine** (2 large plants) and 130 MW from **Israel**. In 2010, 80% of global PV system connections were counted in Europe; in 2011, Europe's share declined to 75%.

2.6.3 MARKET SUSTAINABILITY: AN INDUSTRY AT THE CROSSROADS

2011 saw prices going down rapidly due to increased economies of scale, production efficiency and – in particular – a strong supply overhang compared to demand.

The PV industry is at a crossroads. Whilst European markets have always outpaced home production, this will presumably no longer be the case in the years to come. At the same time, massive capacity build-up concentrated in Asia has not yet led to a sustainable growth momentum in local markets and is far from being in tune with its enormous production power.

There may be at least 3 hints with regard to the future direction of the PV industry. Firstly, large producer countries will need to activate their home markets, placing a larger share of their production locally. Secondly, with enormous potentials still untapped in almost all continents, new markets will have to be opened up to drive PV development in the coming decade just as Europe accounted for it during the last decade. Finally, the principles of open markets and fair competition should be recalled and will certainly require more attention in the future.

EPIA will follow these guidelines and lobby for an ever-growing share of PV power to be fed and integrated into our energy systems. Prompt release of reliable market data is an elementary tool to better respond to all challenges our industry will face in the months and years to come.

Summary table	**2010**		**2011**	
	EU	World	EU	World
Newly connected PV systems (GW)	13,3	16,6	20,9	27,7
Year on Year growth	N/A	N/A	57%	67%
EU share in the World	80%		75%	
Cumulative installed capacity (GW)	29,4	39,7	50,3	67,4
Year on Year growth	N/A	N/A	71%	70%
EU share in the World	74%		75%	
% electricity demand	1,15%	0,25%	2%	0,5%

2.7 Project team

2.7.1 The Project Company

A special purpose Limited Liability Company (LLC) Safe Power (pvt) ltd (The Main Sponsor) has been incorporated in accordance with the laws and policies of Pakistan for development, construction and operation of the Project as an Independent Power Producer (IPP).

2.7.2 Welt Konnect (Pvt) Ltd

www.weltkonnect.com

Welt Konnect (Pvt) Ltd (a subsidiary of the Transtech Group) is a Power Project Developer working in Pakistan. Its niche in the Alternative Energy sector lies in the provision of Renewable Energy Engineering particularly Wind & Solar Projects as Independent Power Producers (IPP's), various commercial applications & CDM projects. These integrated systems are designed, simulated and tested by its team of experts and engineers' using the most advanced software's and tools the industry has to offer at this time. WK believes in doing top quality engineering works and takes immense pride in being one of the few companies in Pakistan to have achieved this level of competence in this ever growing field of Renewable Energy.

Welt Konnect is a technical enterprise, under the Transtech group of companies. Welt Konnect has carried out the solar resource assessment and energy yield estimates in different solar software for this Project.

Solar energy is renewable and green power resource. There is great solar power potential in Pakistan. With the New Energy Development Department, Welt Konnect is willing to cooperate with parties which want to develop wind power and contribute our share in developing wind power.

WK is the overall Project Consultant and coordinated all the project development activities. The scope of work for WK in Project includes the feasibility study, coordination with all project development teams, tariff petition and energy purchase agreement.

WK provides consultancy services in the fields of Renewable Energy (RE), Energy Efficiency (EE) and Environment. WK provides high quality energy engineering and management consulting services to enable rapid deployment of efficient, cost-effective, reliable, and environment-friendly renewable energy systems. Our customized technical solutions and services are dedicated to investment firms, energy groups, industries, financing institutions and public authorities involved in the development and/or acquisition of renewable and thermal power plants.

These services are backed with in-depth grip on technical, financial and administrative aspects at every stage that enables us to employ best practices in project development. This ultimately leads to implementation in accordance with the most efficient planning, which is a vital element in power projects in order to save unnecessary and huge overheads during execution.

The WK team also has the expertise to deal with the legal aspects of power projects including Generation License, Tariff Application & justification, Energy Purchase Agreement and Implementation Agreement. The professional team of WK is well acquainted with the policies, regulations, methodologies and standards of the complete power projects cycle.

2.7.3 AJK Surveyors (www.ajk.net.pk)

AJK Enterprises was established on 27th May, 2004 as a leading company of Professionals having rich experience in providing expert services such as civil works construction, reconnaissance visit to sites for on-the-site appraisal of site conditions, preparation of the most economical subsoil investigation programs, laboratory testing, evaluation of field data and laboratory test results including static and dynamic soil/design parameters.

AJK Enterprises can undertake the entire construction scope of a project. They have an effective management that can deliver projects as per contract requirements.

They are adept at handling heavy civil works for infrastructure projects. This expertise extends from earthworks to high-quality finishes. The civil team has a proven track record in completing 'fast track' projects consisting of infrastructure development. AJK Enterprises provides geotechnical services that require technical interpretation of the geotechnical investigations. AJK Enterprises has professional staff specific for the geotechnical investigation and interpretation works. AJK Enterprises has a team of surveyors who are experienced and professional in their field. With proper team work their surveyors can go for challenging tasks related to surveying and topographical mapping. They have state of the art equipment and tools to do the job to the satisfaction of the client. In the recent years they have completed a number of projects related to topographical surveys.

2.7.7 Solar World

http://www.solarworld-usa.com

The Solar Modules used in the analysis of the Project are of Solar World.

With about 3,300 employees, the **SolarWorld** group is one of the world's largest solar energy businesses – and the largest U.S. solar manufacturer for more than 35 years. In its innovation, performance and environmental track record, the company is an industry leader. SolarWorld's family of companies dedicates itself exclusively to the business of solar energy. Plus, it combines all stages of the photovoltaic value chain, from the raw material silicon to turn-key solar power plants, so that it can uphold high quality and environmental standards at every stage.

SolarWorld operates factories in the United States and Germany as well as sales offices in all of the world's solar markets. The SolarWorld group offers products ranging from crystalline silicon ingots, wafers, cells and panels for grid-tied and off-grid power generation. The main building blocks are high-performance mono-crystalline and polycrystalline SolarWorld Sun module™ solar panels and custom-designed Sunkits® solar systems.

Sunkits solar systems enable installation firms to offer reliable, cost-effective systems, featuring tailor-designed rooftop solar arrays and everything installers need to complete a system, delivered directly to end consumers.

2.7.8 SMA

http://www.sma-america.com

The inverters and medium voltage transformers used in the modeling of the Project are of SMA.

SMA Solar Technology AG is the worldwide market leader for solar inverters, a leading supplier of transformers and chokes, and a provider of innovative energy supply solutions for mass transit and main-line rail transportation.

The inverter is technologically the most important component in any solar power system: it converts the direct current generated in photovoltaic cells into alternating current suitable for the grid. In addition, it is an intelligent system manager, responsible for yield monitoring and grid management. SMA Solar inverters are characterized by a particularly high efficiency of up to 99 %, which allows for increased electricity production. The multi award-winning product range covers solar inverters for roof systems, major solar projects and off-grid systems, enabling

SMA to provide a technically optimized inverter solution for all size categories and system types. Its range of services is complemented by a worldwide service network. SMA's business model is driven by technological progress. The highly flexible manufacturing plants for solar inverters in Germany and North America have a capacity of approximately 11.5 GW a year. The SMA Group also operates a manufacturing plant for electromagnetic core components in Poland. Due to its flexible and scalable production, SMA is in a position to quickly respond to customer demands and promptly implement product innovations. This allows the Company to easily keep pace with the dynamic market trends of the photovoltaic industry and at the same time absorb short-term fluctuations in demand for solar inverters.

SMA Solar Technology AG is headquartered in Niestetal, near Kassel, and is represented in 19 countries on four continents. The Group employs a staff of over 5,300 worldwide, plus a number of temporary employees which varies on a seasonal basis. In recent years, SMA has received numerous awards for its excellence as an employer and in 2011 reached first place in the federal "Great Place to Work" competition.

Since June 27, 2008, the Company has been listed in the Prime Standard of the Frankfurt Stock Exchange (S92), and since September 22, 2008, the Company's shares have been listed in the TecDAX. In 2010, SMA generated sales of 1.9 billion euros.

3. COUNTRY PROFILE

3.1 General Overview

Area: 796,096 km^2
Population 165,000,000 (Approx.)

Located in South Asia, Pakistan, officially the Islamic Republic of Pakistan (Urdu: Islami Jumhuriyah Pakistan), shares an Eastern border with India (2,912km), a North-Eastern border with the People's Republic of China (523krn), a South Western border with Iran (909km) and a Western and Northern edge with Afghanistan (2,530km). The Arabian Sea is Pakistan's southern boundary with 1,064 km of coastline.

The name 'Pakistan' means 'Land of the Pure' in Sindhi, Urdu and Persian. It was coined in 1933 by Choudhary Rahmat Ali, who published it in the pamphlet "Now or Never". The name was coined from the names of five territories that were proposed as constituents of a separate country for the Muslims of British India. Officially, the nation was founded as the "Dominion of Pakistan" in 1947, and was renamed as the Islamic Republic of Pakistan in 1956.

The country has a total area of 796,940 km' and is nearly four times the size of the United Kingdom. From Gwadar Bay in south-eastern comer, the country extends more than 1,800 km to the Khunjerab Pass on China's border

The Indus Valley civilization, one of the oldest in the world and dating back at least 5,000 years, spread over much of what is presently Pakistan. In February 2008, Pakistan held parliamentary elections and in September 2008, after the resignation of former President MUSHARRAF, elected Asif Ali ZARDARI to the presidency.

Agriculture accounts for more than one-fifth of output and two-fifths of employment. Textiles account for most of Pakistan's export earnings, and Pakistan's failure to expand a viable export base for other manufactures has left the country vulnerable to shifts in world demand.

Over the past few years, low growth and high inflation, led by a spurt in food prices, have increased the amount of poverty - the UN Human Development Report estimated poverty in 2011 at almost 50% of the population. The government agreed to an International Monetary Fund Standby Arrangement in November 2008 in response to a balance of payments crisis.

Although the economy has stabilized since the crisis, it has failed to recover. Foreign investment has not returned, due to investor concerns related to governance, energy, security, and a slow-down in the global economy. Remittances from overseas workers, averaging about $1 billion a month since March 2011, remain a bright spot for Pakistan.

Located in South Asia, Pakistan, officially the Islamic Republic of Pakistan (Urdu: Islami Jumhuriyah Pakistan), shares an Eastern border with India (2,912km), a North-Eastern border with the People's Republic of China (523krn), a South Western border with Iran (909km) and a Western and Northern edge with Afghanistan (2,530km). The Arabian Sea is Pakistan's southern boundary with 1,064 km of coastline.

4. PAKISTAN ENERGY MARKET

It is hard to believe that only seven years back, in 2004, Pakistan had 30% surplus in generating capacity compared with demand. There were discussions at that time of exporting even the surplus to India. And now in August 2011, power shortage has reached 7,000 Megawatt (MW), about 40% of the demand, which has resulted in 10 hours of load shedding in urban areas and much more in rural areas. According to the prevailing circumstances, the situation is going to worsen in future.

Up till 2003-04 the countrywide power demand growth was only 3%-4% per year, but rose to 10% in 2007-08 following a high economic growth. The 2005 Medium-Term Development Plan targeted an installed capacity of 27,420 MW by June 2010. However the actual capacity in June 2010 was only 20,651 MW, with a shortfall of 6,769 MW (25%). About 4,670 MW of capacity was added to the system between 2000 and 2010 of which only 1,619 MW was from hydro, including Ghazi Barotha which with installed capacity of 1,450 MW was commissioned in 2004.

The first thing that comes to mind when faced with energy shortage is the installed capacity of the generating facilities being less than the demand. True, but in addition, we must keep in mind that all capacity may not be available at all times because some units may be out of service due to scheduled maintenance, breakdown, or in case of hydroelectric power, the water level in reservoir may be less and/or the water to be released through the power units is less.

Total Installed capacity in 2009 was about 19,786 MW; net available varies from 14,500 MW in winter to 17,500 MW in summer. Hydropower units lose about 40% of their generating capacity in winter due to lower water levels in the reservoirs and lower availability of water for release through turbines. In 2008-09, total energy generation was 91,616 gigawatt-hours (GWh). The current capacity mix is: *hydel 31.7%, thermal 66.3%, and alternate energy and nuclear 2.0%.*Actual generation during 2008-09 from different sources was: Oil 34.9%, Gas 32.7%, hydel 30.6%, coal 0.1%, and nuclear 1.7%.

Energy Generation by Resource (%)

	Pakistan	India	China	USA	World
Oil	34.9	4.1	0.7	1.3	5.5
Gas	32.7	9.9	0.9	20.9	21.2
Hydel	30.6	13.7	16.9	6.5	16.2
Coal	0.1	68.6	79.1	48.8	40.8
Nuclear	1.7	1.8	2.0	19.2	13.5
Others	0.0	1.9	0.4	3.4	2.8

Table 4.1: Energy Generation by Resource

Pakistan has a very high potential of other renewable resource like solar and wind but their invest costs are high. Potential from wind is estimated at 40,000 MW. Potential of solar energy is also very high with solar radiation of 2 MWh per square meter and 3,000 hours of sunshine per year which is among the highest in the world.

Pakistan's energy requirements are net through Oil, Gas, Hydro Power and Nuclear Power. While Hydro and nuclear are used only for electricity generation with reference to energy. Oil and Gas are used to supply other areas also. Although Pakistan has one of the largest coal reserves in the world, they remain under-utilized and their share in energy supply is insignificant at the moment,

Production of crude oil per day has decreased to 65,845 barrels during July-March 2008-09 from 69,954 barrels per day during the same period last year, showing a decline of 1.2 percent. The overall production of crude oil has decreased to 13.5 million barrels during July-March 2005-06 from 18.1 million barrels during the corresponding period last year, showing a decline of 1.1 percent. On an average, the transport sector consumes 49.794 of the petroleum products, followed by power sector (32.3%), industry (11.8%), household (2.5%), other government (2.3%), and agriculture (1.496) during last 10 years i.e. 1995-96 to 2004-05.

The average production of natural gas per day stood at 4,002million cubic feet during July-March, 2008-09, as compared to 3,973 million cubic feet over the same period last year, showing an increase of 4.5 %. The overall production of gas has increased to 1,460,679 million cubic feet during July-March 2008-09 as compared to 1,454,194 million cubic feet daily in the same period last year, showing an increase of 4.5 percent. On average, the power sector consumes 36.6 percent of gas, followed by fertilizer (22.5 %), industrial sector (18.8 %), household (18.4 %), commercial sector (2.8 %) and cement (1.3 %) during last 10 years i.e. 1995- 96 to 2004-05. Total installed capacity of electricity (WAPDA, KESC, KANUPP AND IPPs) stood at 19,786 MW during July-March 2008-09, compared to 19,420 MW during July-March 2007-08. Total installed capacity of WAPDA stood at 11,363 MW during July-March 2008-09 of which, hydel accounts for 56.9 percent or 6,463 MW, thermal accounts for 43.1 percent or 4,930 MW.

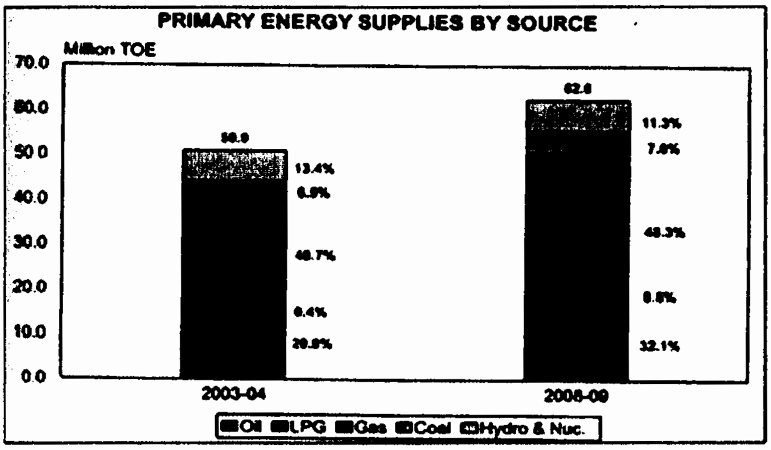


Figure 4.1: Primary energy Design

5. PAKISTAN ELECTRICITY MARKET

5.1 Electricity Suppliers

The electricity suppliers in Pakistan are given below:

- Water and Power Development Authority with 11,399 MW installed Capacity is the largest utility company in Pakistan and provides services to the entire country except Karachi.

- Karachi Electric Supply Company (KESC, http://ww.kesc.com.pk) with installed capacity of 1,955 MW supplies Karachi with electricity.

- Pakistan Atomic Energy Commission (PAEC, http://www.paec.gov.pk) has installed capacity of 462 MW from Chashma 1. Chashma 2 is expected to be operational in 2011 with 300 MWe net capacities.

- IPPs (Independent Power Producers) have an installed capacity of 7,678 MW (http://www.ppib.gov.pk).

WAPDA and PAEC are government entities, while KESC and IPPs operate in private sector.

Primary energy supplies by suppliers is shown in Figure 5.1.1

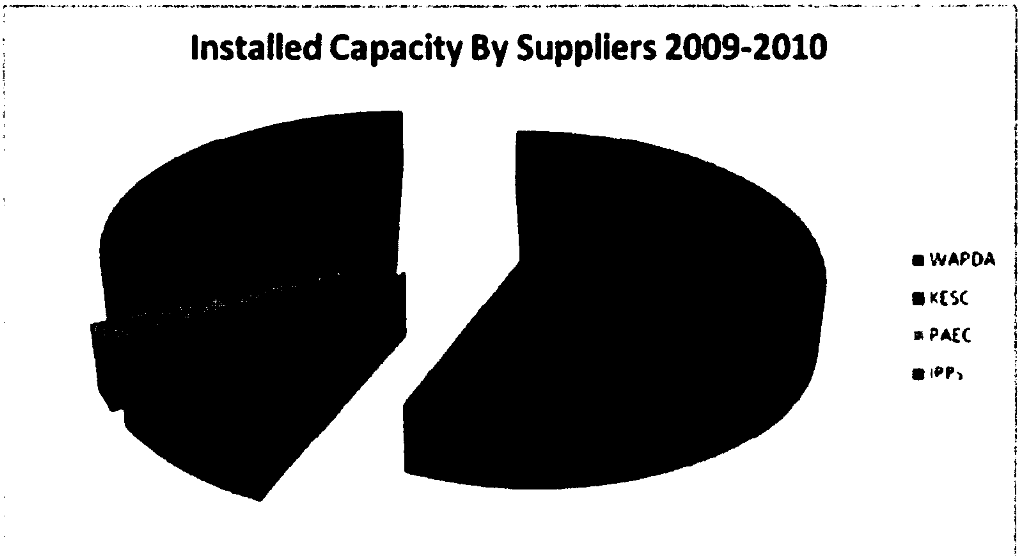


Figure 5.1.1: Primary energy supplies by suppliers

5.2 Electricity Generation Sources

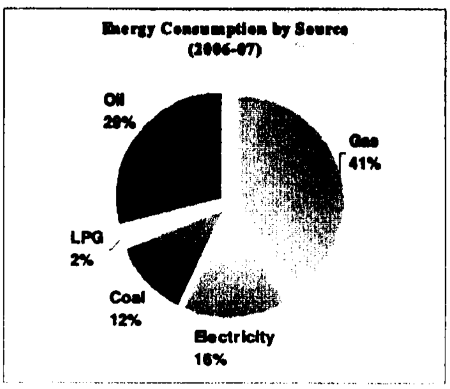
Major sources of electricity generation are:

- Thermal (both Gas and Oil)
- Hydra Power
- Nuclear Power

Following statistics give a better picture of the changes in energy generation sources:

Energy Type	Potential	Source
Crude Oil	**339 million barrels recoverable reserves.**	Pak Eco Survey 2007-08
Natural Gas	**31,266 trillion cubic feet recoverable reserves.**	Pak Eco Survey 2007-08
Coal	**185 billion tones recoverable reserves.**	Pak Eco Survey 2007-08
Hydro Energy	**46,000 MW identified potential**	Govt. of Pakistan 2005
Nuclear power	**Nuclear power of capacity 425 MWe**	World Nuclear Association 2008

Table 5.2.1: Energy generation statistics



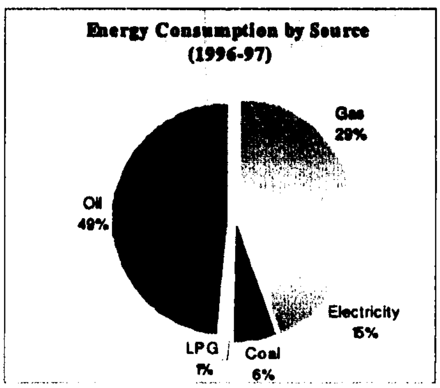


Chart 5.2.1: Comparison of Energy Consumptions

In terms of renewable sources, there are a few personal / off grid installation of wind and solar power. The on grid projects are all in the development phase except one project of 53 MW, which has inaugurated its first 5 MW capacity.

5.3 Power Crises

The country's power demand is 12,000 MW, out of which only 7,500 MW is being generated, reflecting a shortfall of 4,500 MW. More than 10 power generation plants out of 14, lying under Water and Power Development Authority (WAPDA) through Hydel resource of Tarbela Dam, have been shut down because of lesser water availability in the reservoirs.

Installed power generation capacity of the country is recorded up to 21,000 MW, while the demand of electricity in the country has reduced up to 12,000 MW in the sub-zero winter season. The power generation capacity of the second largest water reservoir, Mangla Dam, has reduced up to 75 percent from the installed capacity of 1,000 MW to approximately 250 MW, having the same reason of reduction in hydel resource.

Another major reason for reduction in power generation capacity, particularly by independent power producers (IPPs), which contribute the major chunk of electricity power to the national grid, is non-payment to fuel supplying companies. On the other hand, gas distribution companies Sui Northern Gas Pipelines Ltd and Sui Southern Gas Company are also reluctant to supply natural gas for power generation companies due to severe shortage in the country of up to 1.4 billion cubic feet (BCF). Another negligence of energy managers contributes the power shortfall of 300 MW to the national grid because of shutting down the Chashma Nuclear Power Complex 1 due to some technical faults.

Increase in electricity demand is directly linked to the growth of the country's economy. Keeping in view the sustained growth in all sectors of the economy in the coming years, it is expected that future demand for electricity will rise to more than 25,000 MW in near future. Supply of electricity as compared to demand has been stagnant for last decade or so with very little additions. The typical capacity factor of thermal IPPs is 60% and that of hydro power is 80%. Once transmission and distribution losses of 22% and auxiliary consumption of 4% are added, the situation starts to look further bleak.

Main drivers for the growth are industrial and domestic users. The demand for electricity from the industrial sector, given current growth trends, is going to rise substantially over the new five years. There has also been a rapid increase in the number of electricity consumers in recent years. This is due primarily to rapid urbanization and also the extension of the national grid to include an increased number of rural areas. In fact, village electrification has been a central part of the government's agenda.

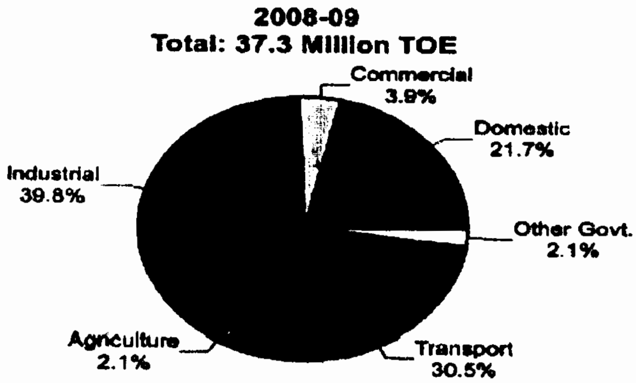


Chart 5.2.2: Energy consumption by Sector

Increase in electricity demand is directly linked to the growth of the country's economy. Keeping in view the sustained growth in all sectors of the economy in the coming years, It is expected that future demand for electricity will rise to more than 20,000 MW in near future. Supply of electricity as compared to demand has been stagnant for last decade or so with very little additions.

The typical capacity factor of thermal IPPs is 60% and that of hydro power is 80%. Once transmission and distribution losses of 22% and auxiliary consumption of 4% are added, the situation starts to look further bleak.

Source	Installed Capacity	Share	Installed Capacity	Share	%
	2008-2009	[%]	2009-2010	[%]	Change
WAPDA	11,454	57.9	11,399	56.5	-0.5
Hydel	6,555	57.2*	6,555	57.5*	0.0
Thermal	4,899	42.8*	4,844	42.5*	-1.1
IPPs	5,954	30.1	6,374	31.6	7.1
Nuclear	462	2.3	462	2.3	0.0
KESC	1,910	9.7	1,955	9.7	2.4
Total / Net	19,780	100	20,190	100	2.1

Table 5.2.2: Total Installed Capacity

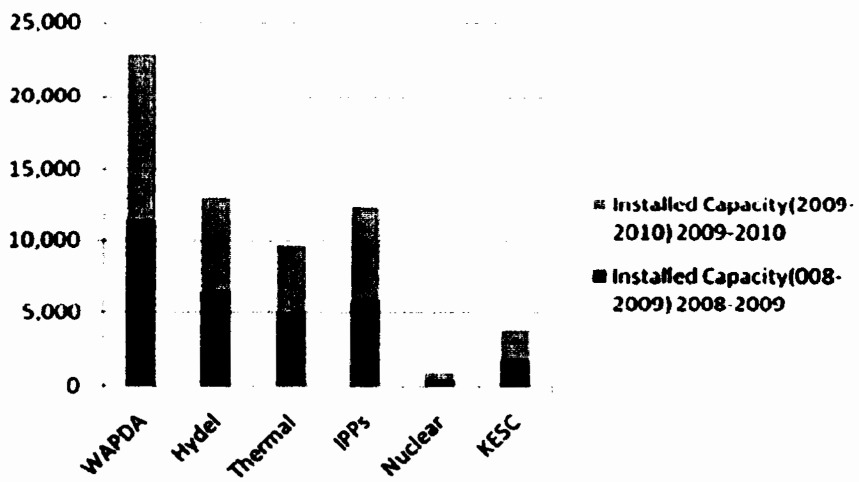


Chart 5.2.3: Total installed Generation Capacity

Main drivers for the growth are industrial and domestic users. The demand for electricity from the industrial sector, given current growth trends, is going to rise substantially over the new five years. There has also been a rapid increase in the number of electricity consumers in recent years. This is due primarily to rapid urbanization and also the extension of the national grid to include an increased number of rural areas. In fact, village electrification has been a central part of the government's agenda.

Electricity demand and supply analysis is shown in Chart 5.2.4

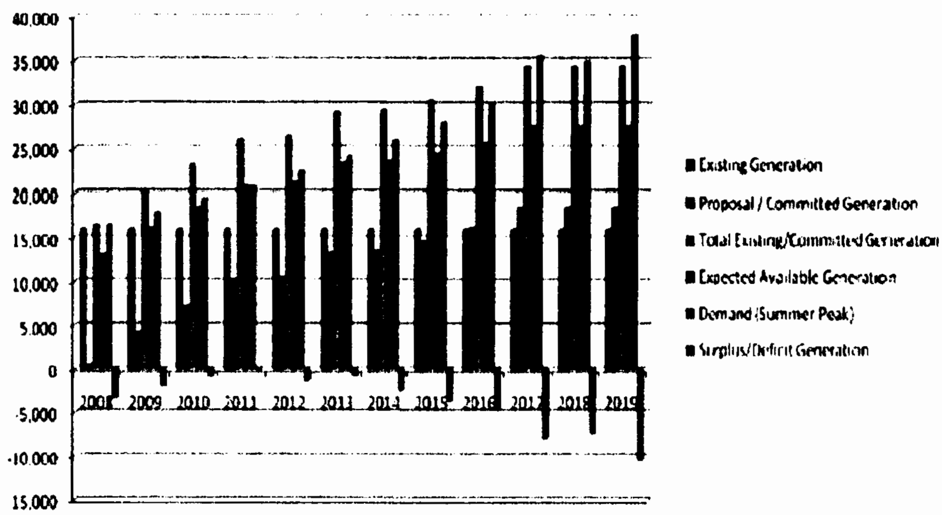


Chart 5.2.4: Electricity Demand Analysis

Generation	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing	15,903	15,903	15,903	15,903	15,903	15,903	15,903	15,903	15,903	15,903	15,903	15,903	15,903
Proposed / Committed	530	4,235	7,226	10,315	10,556	13,307	13,520	14,607	16,134	18,448	18,448	18,448	18,448
Total	16,484	20,138	23,129	26,018	26,459	29,210	29,423	30,510	32,037	34,351	34,351	34,351	34,351
Expected Available	13,146	16,110	18,503	20,814	21,167	23,368	23,538	24,408	25,630	27,481	27,481	27,481	27,481
Demand (Summer Peak)	16,484	17,868	19,352	20,874	22,460	24,126	25,919	28,029	30,223	35,504	34,918	37,907	41,132
Surplus / Deficit	-3,338	-1,758	-849	-60	-1,293	-758	-2,381	-3,621	-4,593	-8,023	-7,437	-10,426	-13,651

Table 5.2.3: Electricity Demand analysis

5.4 Government of Pakistan Energy Security Action Plan

Energy is the lifeline of economic development but unfortunately Pakistan lacks integrated National Energy Security Plan for the 21st century. While preparing the MTDF 2005-10 for the energy sector, a long term view has been taken in the context of energy security requirement for the next 25 years.

5.4.1 Objectives of Energy Sector

Pakistan's energy requirement is increasing rapidly every year. The primary energy consumption in Pakistan grew by almost 80% in the past 15 years from 34 million tons oil equivalent (TOE) in 1994-95 to 61 million TOE in 2009-10. The country's energy supply currently comes primarily from indigenous natural gas which is 45% of the energy mix and oil imports at 35% of the energy mix, with the balance from hydel at 12%, coal at 6% and nuclear at 2% of the mix respectively.

Supply of indigenous natural gas has provided major support for Pakistan's economic growth over the past several decades and has enabled the construction of an extensive gas transmission and distribution grid in the country. Conventional gas reserves in the country are however expected to decline over the next few years and Pakistan needs to develop enhanced capability for exploration and production of offshore and unconventional gas reserves (tight gas, shale gas) and to arrange for significant gas imports via pipelines and as liquefied natural gas (LNG).

Additionally Pakistan must move forward with development of its large-scale coal reserves in the Thar coal-fields to ensure security of long-term energy supply. Steady growth in renewable energy sources such as hydel, nuclear, solar and wind must also remain part of the energy mix in the country.

Meanwhile urgent reforms in the power sector are required to grow power generation capacity and enhance transformation efficiency. The current "circular debt" is also a major issue for the energy sector and has become a significant barrier for energy development in Pakistan.

International financial resources and technical expertise will be required for development of the diverse energy segments in Pakistan and this will provide attractive opportunities for investments by global energy and finance organizations. The 2011 Energy Conference aimed to bring together key local and international stakeholders, including the government on one platform for an informed discussion on energy issues in Pakistan and to agree the way forward.

5.4.2 Strategy

The strategic directions for development of the energy sector and sustainable supply of energy at competitive price to all sectors of the economy include:

- Supply to be based on an optimum energy mix;
- Maximum utilization of the indigenous resources to meet the increasing energy demand with a major emphasis on increasing the coal share in the total energy mix by developing indigenous coal reserves, and setting up integrated coal mining, power generation, petro-chemical plants and coal gasification; development of hydro for power generation; increasing local oil and gas production by enhancing drilling activities particularly in off-shore areas; replacement of imported oil with imported gas; and promotion of accelerated nuclear and renewable/alternate energy sources (wind, solar) in overall energy mix;
- Enhancing participation in the sector, including manufacturing of plants and equipment by strengthening regulatory frameworks and related institutions
- Development of infrastructure, and
- Development of human resources with emphasis on technical skills and expertise.

The strategy also includes extension of LPG supply to the domestic sector, encouragement of CNG utilization in the transport sector and import of LNG to meet short-term gas requirements, if feasible. Incentives would also be provided for mechanized development of coal gasification technology.

5.4.3 Targets

The energy demand over the next five years is expected to grow at a rate of 7.4 percent per annum. To meet future requirements with indigenous resources, domestic exploration, if feasible, would be intensified. Simultaneously, the energy supply options would be diversified, with import of gas and LNG. In power generation a total of 23 hydro projects are planned to be initiated during the MTDF period, out of which 14 hydro projects will be completed, so that hydro-thermal mix is shifted towards hydro generation. Worldwide, pumped storage is utilized to generate about 70,000 MW through hydropower.

Similarly, 900 MW capacities would be increased through coal-based projects. Recognizing the importance of exploitation of renewable energy, projects totaling 890 MW are also envisaged for implementation during 2005-10.

The country's energy mix and demand projections by fuel for the short, medium and long term are outlined in Table 5.4.3.1, Chart 5.4.3.1 and Chart 5.4.3.2 below:

	Current		Short term		Medium Term				Long Term	
	2004		2010		2015		2020		2025	2030
Total MTOE	50.8		79.39		120.18		177.35		255.37	361.31
Oil	15.20	30%	20.69	26%	32.51	27%	45.47	25.7%	66.84	18.5%
Natural Gas	25.45	50%	38.99	49%	52.98	44%	77.85	44%	162.58	45%
Coal	3.30	6.5%	7.16	9%	14.45	12%	24.77	14.0%	68.65	19%
Hydro	6.43	12.7%	11.03	13.9%	16.40	13.6%	21.44	12.1%	38.93	10.8%
Renewable	0.00	0%	0.84	1.1%	1.60	1.3%	3.00	1.7%	9.20	2.5%
Nuclear	0.42	0.8%	0.69	0.9%	2.23	1.9%	4.81	2.7%	15.11	4.2%

Table 5.4.3.1: Country's Energy Mix

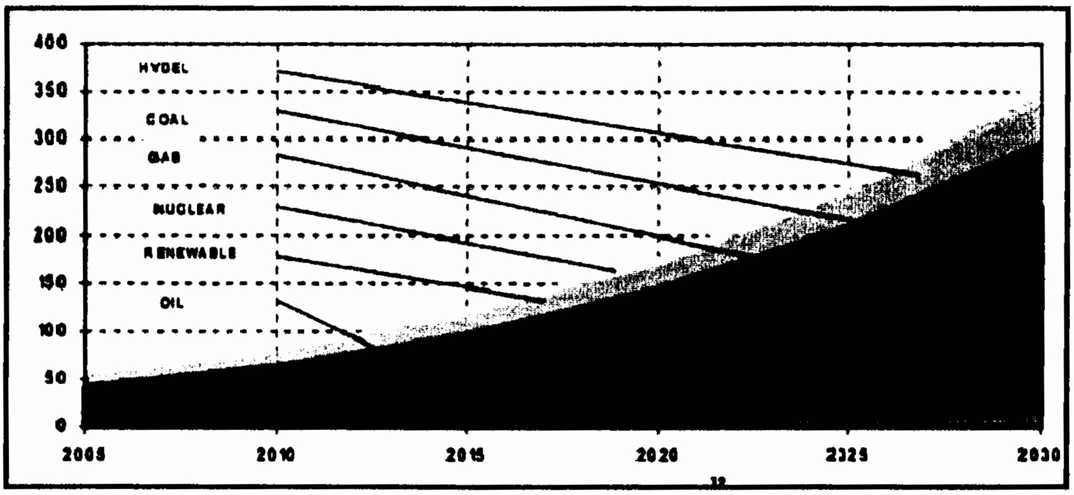


Chart 5.4.3.1: Demand Projections

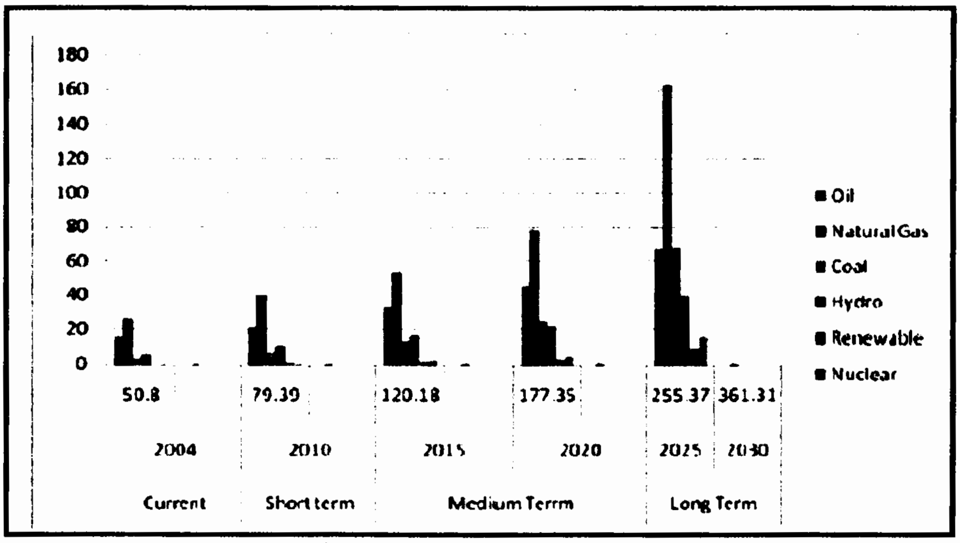


Chart 5.4.3.2: Demand Projections

The energy demand over the next five years is expected to grow at a rate of 7.4 percent per annum. To meet future requirements with indigenous resources, domestic exploration, if feasible, would be intensified. Simultaneously, the energy supply options would be diversified, with import of gas and LNG. In power generation a total of 23 hydro projects are planned to be initiated during the MTDF period, out of which 14 hydro projects will be completed, so that hydro-thermal mix is shifted towards hydro generation. Worldwide, pumped storage is utilized to generate about 70,000 MW hydro power.

Similarly, 900 MW capacity would be increased through coal-based projects. Recognizing the importance of exploitation of renewable energy, projects totaling 890 MW were also envisaged for implementation during 2005-10.

5.4.4 Objectives of Power Sector

The objectives for the development of the power sector include:

- To provide sufficient capacity for power generation at the least cost, and to avoid capacity shortfalls;
- To encourage and ensure exploitation of indigenous resources, which include renewable energy resources, human resources, participation of local engineering and manufacturing capabilities;
- To ensure that all stakeholders are looked after in the process, i.e. a win-win situation for all;
- To be attuned to safeguarding the environment.

5.4.5 Policy Provisions

The policy for power sector envisages:

- Utilization of indigenous resources for power generation and tilting the hydrothermal generation mix towards hydel by implementing maximum possible hydro based power projects;
- Maximizing generation through indigenous coal to increase its share to at least 18 percent (20,000 MW) by 2030;
- Increasing emphasis on nuclear power resources to increase generation from current 400 MW to 8800 MW by 2030. PAEC would enhance indigenization capability to maximize local content to reduce capital cost. Capacity of units would be increased from 300 MW to 600 MW and thereafter to 1000 MW;
- Facilitating captive power for old and new industries capacity available in sugar mills during off crushing season to be made available on national grid;
- Enhancing participation of private sector in power generation, transmission and distribution;

- Exploring the possibility for linking and developing the regional power grid for efficient and reliable use of power with emphasis on import of power from Tajikistan and Kyrgyzstan on 765 kV transmission line through silk mute;
- Strengthening regulatory bodies and making them truly autonomous, effective, transparent and credible;
- Promoting local engineering industry for power sector; encouraging the utilization of renewable energy (such as solar, wind, and biomass) especially for remote areas.

Total power demand and power generation plan are presented in Tables 5.4.5.1, Table 5.4.5.2 and Chart 5.4.5.1;

Year	Domestic	Commercial	Agriculture	Industrial	Others	Total(MW)
2005-06	7199	1216	1763	5891	1035	15,500
2006-07	7585	1251	1820	6481	1086	16,600
2007-08	8127	1312	1893	7252	1159	17,900
2008-09	8783	1354	1979	8181	1243	19,600
2009-10	9531	1408	2079	9267	1341	21,500

Table 5.4.5.1: Power demand

Year	Nuclear	Hydro	Coal	Renewable	Oil	Gas	Total	Cumulative
2005	400	6460	160	180	6400	5940	19540	NA
2010	0	1260	900	700	160	4860	7880	27420
2015	900	7570	3000	800	300	7550	20120	47540
2020	1500	4700	4200	1470	300	125620	24730	72270
2025	2000	5600	5400	2700	300	22490	38490	110760
2030	4000	7070	6250	3850	300	30360	51830	162590

Table 5.4.5.2: Power Generation Plan

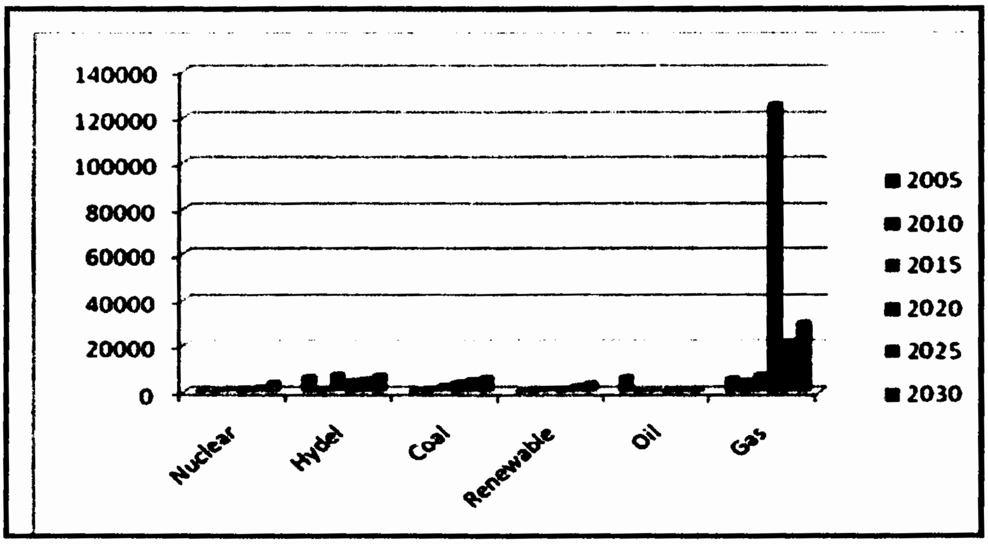


Chart 5.4.5.1: Power generation Plan

5.5 Transmission Network In Pakistan

After restructuring of WAPDA, transmission and distribution of electricity was delegated to NTDC. All high voltage lines and grid stations are now under control of the NTDC, which is also responsible for purchase of electricity from the generation companies as Central Power Purchasing Agent (CPPA). Distribution companies have the option to purchase electricity directly from the generation companies within their boundaries and distribute through medium voltage lines.

National Transmission & Dispatch Company (NTDC) Limited was incorporated on 6th November, 1998 and commenced commercial operation on 24th December, 1998. It was organized to take over all the properties, rights and assets obligations and liabilities of 220 KV and 500KV Grid Stations and Transmission Lines/Network owned by Pakistan Water and Power Development Authority (WAPDA). NTDC operates and maintains twelve 500 KV and twenty nine 220 KV Grid Stations, 5077 km of 500 KV transmission line and 7359 km of 220 KV transmission line in Pakistan.

NTDC was granted Transmission License No.TL/01//2002 on 31st December 2002 by National Electric Power Regularity Authority (NEPRA) to engage in the exclusive transmission business for a term of thirty (30) years, pursuant to Section 17 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

The transmission system of WAPDA and KESC are interconnected through 220kV double circuit transmission lines. Transmission of electricity takes place at voltages of 500kV, 220kV, 132kV, 66kV and 33kV and distribution at 11kV. WAPDA suffers a power loss of more than 20% of the total electricity generated mainly due to the inefficiency of the transmission and distribution system. These losses are incurred due to power theft, corruption, and a number of other problems. Most of WAPDAs transmission lines are made of steel instead of copper, resulting in higher losses during transmission

5.6 Why to Invest in the Power Sector of Pakistan

Reasons for investing in Pakistan are best described with 5 components of any economy. These 5 aspects are:

5.6.1: Geo-strategic Location

Located in the heart of Asia, Pakistan is the gateway to the energy rich Central Asian States, the financially liquid Gulf States and the economically advanced Far Eastern tigers. This strategic advantage alone makes Pakistan a marketplace teeming with possibilities.

5.6.2: Trained Workforce

A large part of the workforce is proficient in English, hardworking and intelligent. Pakistan possesses a large pool of trained and experienced engineers, bankers, lawyers and other professionals with many having substantial international experience.

5.6.3: Economic Outlook

Pakistan is one of the fastest growing economies of the world having touched a GDP growth rate of 8.4% in 2005. Today Pakistan has over 170 million consumers with an ever growing middle class. Foreign Direct investment has risen sharply from an average of $300 million in the 1990s to over $3.7 billion in 2008-09. Fiscal deficit has declined from an average 7% of GDP in the 1990s to around 3% in recent years. And FOREX reserves have increased from $3.22 billion in 2000-01 to $11.6 billion in June 2009.

5.6.4: Investment Policies

Current investment policies have been tailor made to suit investor needs. Pakistan's policy trends have been consistent, with liberalization, de-regulation, privatization, and facilitation being its foremost cornerstones.

5.6.5: Financial Markets

The capital markets are being modernized, and reforms have resulted in development of improved infrastructure in the stock exchanges of the country. The Securities and Exchange Commission of Pakistan has improved the regulatory environment of the stock exchanges, corporate bond market and the leasing sector. Whilst the Federal Board of Revenue has facilitated structural reform in tax and tariffs and the State Bank of Pakistan has invigorated the banking sector into high returns on investment.

6. SOLAR ENERGY INDUSTRY

6.1 Solar Energy Background

Status of solar power today

At the end of 2009 the world was running 23 GW of photovoltaic (PV) electricity, the equivalent of 15 coal-fired power plants. At the end of 2010, this number should reach more than 35 GW. We have known for decades that just a portion of the energy hitting the Earth's surface from the Sun every day could power all our cities several times over. Solar can and must be a part of the solution to combat climate change, helping us shift towards a green economy. It is also a potentially prosperous industry sector in its own right. Some industry indicators show just how far photovoltaic energy has already come.

- The cost to produce solar power has dropped by around 22% each time world-wide production capacity has doubled reaching an average generation cost of 15c€/KWh in EU.
- Average efficiencies of solar modules have improved a couple percentage points per year. The most efficient crystalline silicon modules go to 19.5% in 2010 with a target of 23% efficiency by 2020, which will lower prices further. That increase in efficiencies is seen in all PV technologies.
- Solar power booms in countries where the boundary conditions are right.
- Over 1,000 companies are involved in the manufacturing of the established crystalline silicon technology and already more than 30 produce Thin Film technologies.
- The energy pay time back the electricity it took to create them in one to three years. The most cutting-edge technologies have reduced this to six months depending on the geographies and solar irradiation, while the average life of modules is more than 25 years.

Imagining a future with a fair share of Sun

The European Photovoltaic Industry Association (EPIA) and Greenpeace commissioned updated modeling into how much solar power the world could reasonably see in the world by 2030. The model shows that with a Paradigm Shift scenario towards solar power, where real technical and commercial capacity is backed-up by strong political will, photovoltaic could provide:

- 688 GW by 2020 and 1,845 GW by 2030.
- Up to 12% of electricity demand in European countries by 2020 and in many Sunbelt countries (including China and India) by 2030. Around 9% of the world's electricity needs in 2030. Under an Accelerated scenario, which follows the expansion pattern of the industry to date and includes moderate political support, Photovoltaic's could provide:
- 345 GW by 2020 and 1,081 GW by 2030
- Around 4% of the world's electricity needs in 2020.

What are the benefits?

The benefits of a Paradigm Shift towards solar electricity as described in this model include:

- Provide clean and sustainable electricity to the world.
- Regional development, by creation of local jobs. New employment levels in the sector – as many as 1.62 million jobs as early as 2015, rising to 3.62 million in 2020 and 4.64 million in 2030.
- Clean electricity that contributes to international targets to cut emissions and mitigate climate change.
- Avoiding up to 4,047 million tons of CO2 equivalent every year by 2050. The cumulative total of avoided CO2 emissions from 2020 to 2050 would be 65 billion tons.

Solar photovoltaic technology has proven in recent years that, with the appropriate regulatory framework in place, it can be a major contributor to reaching the EU's target of 20% renewable energy sources (RES) by 2020. Technology improvements and economies of scale have spurred steady cost reduction, which will continue in coming years as the PV industry progresses toward competitiveness with conventional energy sources.

But already today, PV electricity is cheaper than many people think. In the coming years the technology will become even more cost-effective and competitive — and qualify therefore as a vital part of Europe's energy future. Under the right policy and initiative, PV competitiveness with grid electricity can be achieved instantly.

Decreasing prices and PV's generation cost

Over the last 20 years, PV has already shown impressive price reductions, with the price of PV modules decreasing by over 20% every time the cumulative sold volume of PV modules has doubled. System prices have declined accordingly; during the last 5 years a price decrease of 50% has been achieved in Europe. System prices are expected to decrease in the 10 coming years by 36-51% depending on the segment.

Importantly, there is a huge potential for further generation cost decline: around 50% until 2020. The cost of PV electricity generation in Europe could decrease from a range of 0.16-0.35 €/kWh in 2010 to a range of 0.08-0.18 €/kWh in 2020 depending on system size and irradiance level.

6.1.1 Basics of Solar Energy

Solar energy is quite simply the energy produced directly by the sun and collected elsewhere, normally the Earth. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. The process creates heat and electromagnetic radiation. The heat remains in the sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) streams out into space in all directions. Only a very small fraction of the total radiation produced reaches the Earth. The radiation that does reach the Earth is the indirect source of nearly every type of energy used today. The International Energy Agency projected that solar power could provide "a third of the global final energy demand after 2060, while CO2 emissions would be reduced to very low levels.

PV technology exploits the most abundant source of free power from the Sun and has the potential to meet almost all of mankind's energy needs. Unlike other sources of energy, PV has a negligible environmental footprint, can be deployed almost anywhere and utilizes existing technologies and manufacturing processes, making it cheap and efficient to implement.

Photovoltaic systems contain cells that convert sunlight into electricity. Inside each cell there are layers of a semi-conducting material. Light falling on the cell creates an electric field across the layers, causing electricity to flow. The intensity of the light determines the amount of electrical power each cell generates. A photovoltaic system does not need bright sunlight in order to operate. It can also generate electricity on cloudy and rainy days from reflected sunlight.

At the end of 2009 the world was running 23 GW of photovoltaic (PV) electricity, the equivalent of 15 coal-fired power plants. At the end of 2010, this number reached more than 35 GW. We have known for decades that just a portion of the energy hitting the Earth's surface from the Sun every day could power all our cities several times over. Solar can and must be a part of the solution to combat climate change, helping us shift towards a green economy. It is also a potentially prosperous industry sector in its own right.

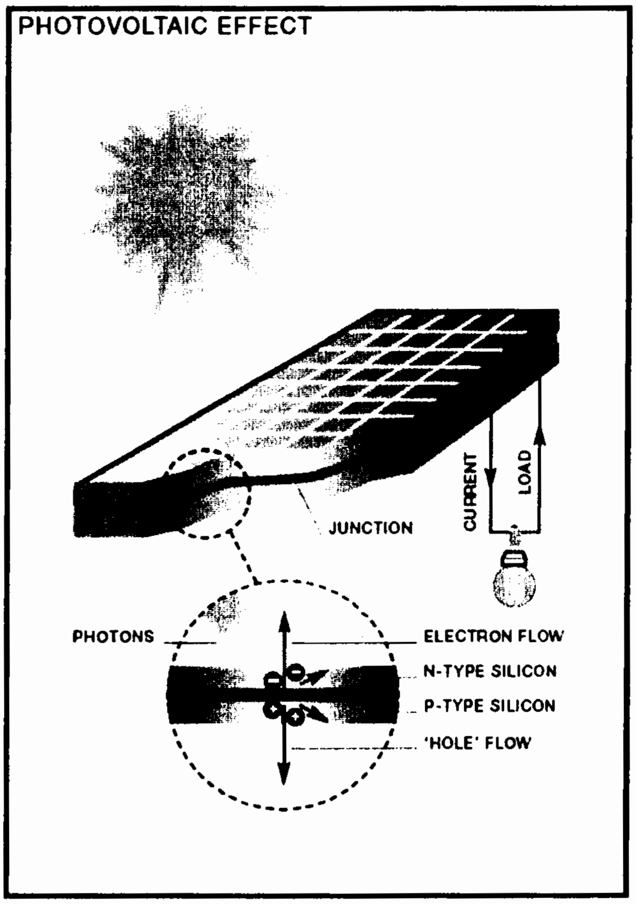


Figure 6.1.1.1: Photovoltaic Effect

6.1.2 Financial upsides to solar energy

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6.1.3 Future prospects with Solar Energy (EPIA Reports)

The **European Photovoltaic Industry Association (EPIA)** and **Greenpeace** commissioned updated modeling into how much solar power the world could reasonably see in the world by 2030. The model shows that with a Paradigm Shift scenario towards solar power, where real technical and commercial capacity is backed-up by strong political will, photovoltaic could provide:

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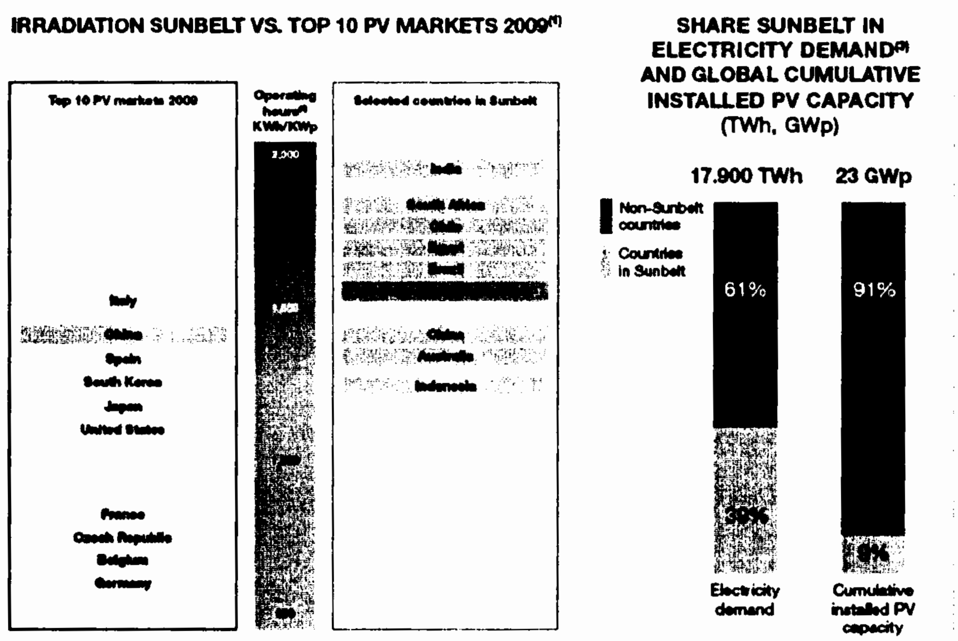
- Regional development, by creation of local jobs.
- Clean electricity that contributes to international targets to cut emissions and mitigate climate change
- Avoiding up to 4,047 million tons of CO2 equivalent every year by 2050. The cumulative total of avoided CO2 emissions from 2020 to 2050 would be 65 billion tons



(1) For systems larger than 1 MWp; 85% performance ratio

(2) Cumulative installed capacity 2009

(3) Electricity demand 2007

Source: NASA, IEA Technology Roadmap Solar photovoltaic energy, EPIA Global Market Outlook for Photovoltaics until 2014, A.T. Kearney analysis

Chart 6.1.3.1: Sun Belt vs. Top 10 Markets

6.1.4 Corporate Social Roles of Solar Power

PV technology exploits the most abundant source of free power from the Sun and has the potential to meet almost all of mankind's energy needs. Unlike other sources of energy, PV has a negligible environmental footprint, can be deployed almost anywhere and utilizes existing technologies and manufacturing processes, making it cheap and efficient to implement.

6.1.4.1 Environmental footprint of PV

The energy it takes to make a solar power system is usually recouped by the energy costs saved over one to three years. Some new generation technologies can even recover the cost of the energy used to produce them within six months, depending on their location. PV systems have a typical life of at least 25 years, ensuring that each panel generates many times more energy than it costs to produce.

6.1.4.2 Improves grid efficiency

PV systems can be placed at the center of an energy generation network or used in a decentralized way. Small PV generators can be spread throughout the network, connecting directly into the grid. In areas that are too remote or expensive to connect to the grid, PV systems can be connected to batteries.

6.1.4.3 Making cities greener

PV can seamlessly integrate into the densest urban environments. City buildings running lights, air-conditioning and equipment are responsible for large amounts of greenhouse gas emissions, if the power supply is not renewable. Solar power will have to become an integral and fundamental part of tomorrow's positive energy buildings.

6.1.4.4 No limits

There are no substantial limits to the massive deployment of PV. Material and industrial capability are plentiful and the industry has demonstrated an ability to increase production very quickly to meet growing demands. This has been demonstrated in countries such as Germany and Japan which have implemented proactive PV policies.

6.2 HISTORY OF SOLAR POWER

6.2.1 Solar Energy and Generations of Photovoltaic

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar energy technologies include solar heating, solar photovoltaic, solar thermal electricity and solar architecture, which make considerable contributions to solving some of the most urgent problems the world now faces.

The term "photovoltaic" comes from the Greek Word meaning "light", and the name of the Italian physicist Volta, after whom the volt (and consequently voltage) are named. It means literally of light and electricity.

The photovoltaic effect was first recognized in 1839 by French physicist Alexandre-Edmond Becquerel. However, it was not until 1883 that the first solar cell was built, by Charles Fritts, who coated the semiconductor selenium with an extremely thin layer of gold to form the junctions. The device was only around 1% efficient. Russell Ohl patented the modern solar cell in 1946. Sven Ason Berglund had a prior patent concerning methods of increasing the capacity of photosensitive cells.

The modern age of solar power technology arrived in 1954 when Bell Laboratories, experimenting with semiconductors, accidentally found that silicon doped with certain impurities was very sensitive to light.

This resulted in the production of the first practical solar cells with a sunlight energy conversion efficiency of around 6 percent. This milestone created interest in producing and launching a geostationary communications satellite by providing a viable power supply. Russia launched the first artificial satellite in 1957, and the United States' first artificial satellite was launched in 1958. Russian Sputnik 3, launched on 15 May 1958, was the first satellite to use solar arrays. This was a crucial development which diverted funding from several governments into research for improved solar cells.

Solar Cells are classified into three generations which indicates the order of which each became important. At present there is concurrent research into all three generations while the first generation technologies are most highly represented in commercial production.

- **First Generation**

  First Generation technologies involve high energy and labor inputs which prevent any significant progress in reducing production costs. Single junction silicon devices are approaching the theoretical limiting efficiency of 33% and achieve cost parity with fossil fuel energy generation after a payback period of 5-7 years.

- **Second Generation (Thin Film)**

  Second generation materials have been developed to address energy requirements and production costs of solar cells. Second generation technologies are expected to gain in market share. The most successful second generation materials have been cadmium telluride (CdTe), copper indium gallium selenide, amorphous silicon and micro-morphous silicon.

- **Third Generation**

  Third generation technologies aim to enhance poor electrical performance of second generation (thin-film technologies) while maintaining very low production costs. Current research is targeting conversion efficiencies of 30-60% while retaining low cost materials and manufacturing techniques.

6.2.2 Development in Generations of Solar Power

6.2.2.1 Crystalline silicon technology

Crystalline silicon cells are made from thin slices (wafers) cut from a single crystal or a block of silicon. The type of crystalline cell produced depends on how the wafers are made. The main types of crystalline cells are:

- Mono crystalline (mc-Si):
- Polycrystalline or multi crystalline (pc-Si)
- Ribbon and sheet-defined film growth (ribbon/sheet c-Si)

The single crystal method provides higher efficiency, and therefore higher power generation. Crystalline silicon is the most common and mature technology representing about 80% of the market today. Cells turn between 14 and 22% of the sunlight that reaches them into electricity. For c-Si modules, efficiency ranges between 12 and 19%.

Advances and alternatives in cell manufacturing methods are producing cells with higher levels of efficiency. Some of the most promising emerging technologies include:

- **Buried contacts:**

  Instead of placing the fingers and bus bars on the front of the cell, they are buried in a laser cut groove inside the solar cell. The change makes the cell surface area larger, enabling it to absorb more sunlight.

- **Back contact cells:**

  The front contact of the cell is moved to the back. The cell's surface area is increased and shadowing losses are reduced. This technology currently provides the highest commercial cell efficiency available on the market.

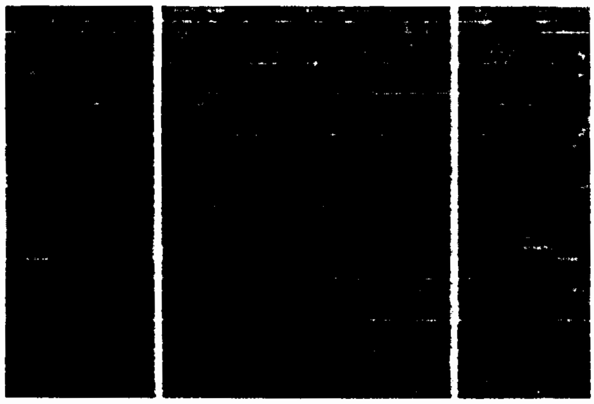
- **Pluto™:**

  Developed by Suntech, Pluto™ features a unique texturing process that improves sunlight absorption, even in low and indirect light.

- **HIT™ (Hetero-junction with Intrinsic Thin Layer):**

  Developed by Sanyo Electrics, the HIT™ cell consists of a thin, single-crystal wafer sandwiched between ultra-thin amorphous silicon (a-Si) layers. Using both amorphous and single crystal silicon improves efficiency.

CRYSTALLINE SILICON CELLS



Polycrystalline silicon PV cell.

Monocrystalline solar cell.

Figure 6.2.2.1.1: Crystalline Cells

6.2.2.2 Thin Films

Thin Film modules are constructed by depositing extremely thin layers of photosensitive material on to a low-cost backing such as glass, stainless steel or plastic. Once the deposited material is attached to the backing, it is laser-cut into multiple thin cells. Thin Film modules are normally enclosed between two layers of glass and are frameless. If the photosensitive material has been deposited on a thin plastic film, the module is flexible. This creates opportunities to integrate solar power generation into the fabric of a building or end-consumer applications.

Four types of Thin Film modules are commercially available:

- Amorphous silicon (a-Si)
- Multi-junction thin silicon film (a-Si/μc-Si)
- Cadmium telluride (CdTe)
- *Copper, indium, gallium, (di)selenide/ (di)sulphide (CIGS) and copper, indium, (di)selenide/(di)sulphide (CIS)*

Typical module power ranges from 60 to 350 W depending on the substrate size and efficiency. There is no common industry agreement on optimal module size for Thin-Film technologies. As a result they vary from 0.6 to 1.0 m^2 for CIGS and CdTe, to 1.4 to 5.7 m^2 for silicon-based Thin Films. Very large modules are of great interest to the building sector as they offer efficiencies in terms of handling and price.

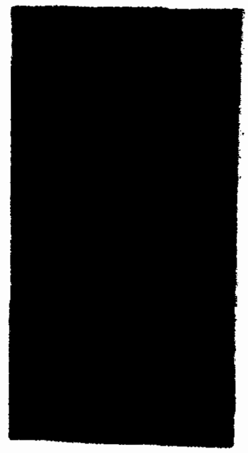
6.2.2.3 Concentrator photovoltaic

Concentrator photovoltaic (CPV) utilize lenses to focus sunlight on to solar cells. The cells are made from very small amounts of highly efficient, but expensive, semi-conducting PV material. The aim is to collect as much sunlight as possible. CPV cells can be based on silicon or III-V compounds (generally gallium arsenide or GaA). CPV systems use only direct irradiation. They are most efficient in very sunny areas which have high amounts of direct irradiation.

The concentrating intensity ranges from a factor of 2 to 100 suns (low concentration) up to 1000 suns (high concentration). Commercial module efficiencies of 20 to 25% have been obtained for silicon based cells. Efficiencies of 25 to 30% have been achieved with GaAs, although cell efficiencies well above 40% have been achieved in the laboratory.

The modules have precise and accurate sets of lenses which need to be permanently oriented towards the Sun. This is achieved through the use of a double-axis tracking system. Low concentration PV can be also used with one single-axis tracking system and a less complex set of lenses.

THIN FILM MODULE



Thin Film CdTe Module

Figure 6.2.2.2.1: Thin Film Module

6.2.2.4 Third generation photovoltaic

After more than 20 years of research and development, third generation solar devices are beginning to emerge in the marketplace. Many of the new technologies are very promising. One exciting development is organic PV cells. These include both fully organic PV (OPV) solar cells and the hybrid dye-sensitized solar cells (DSSC). For both technologies, manufacturing costs is constantly decreasing and is expected to reach 0.50€/W by 2020. This is enabled by the use of the R2R manufacturing process and standard printing technologies. The major challenges for this sector are the low device efficiency and their instability in the long-term.

Third generation PV products have a significant competitive advantage in consumer applications because of the substrate flexibility and ability to perform in dim or variable lighting conditions. Possible application areas include low-power consumer electronics (such as mobile phone rechargers, lighting applications and self-powered displays), outdoor recreational applications, and BIPV.

6.2.2.5 Historical and future evolution

Crystalline silicon technologies have dominated the market for the last 30 years. Amorphous silicon (a- Si) has been the technology most used for consumer applications (e.g. calculators, solar watches) due to its lower manufacturing cost while c-Si technologies have been used mainly in both stand-alone and on-grid systems.

Within the c-Si technologies, mono- and multi-crystalline cells are produced in fairly equal proportion. However, multi-crystalline cells are gaining market share. Ribbon c-Si represents less than 5% of the market. While a-Si has been the preferred clear Thin-Film technology used over the past three decades, its market share has decreased significantly compared to more advanced and competitive technologies. For example, CdTe has grown from a 2% market share in 2005 to 13% in 2010. Technologies such as Concentrator PV (CPV), organics and dye-sensitized solar cells are beginning to enter the market. They are expected to achieve significant market share in the next few years, capturing around 5% of the market by 2020.

6.2.3 Supply potential of Solar Energy

There is more than enough solar irradiation available to satisfy the world's energy demands. On average, each square meter of land on Earth is exposed to enough sunlight to generate 1,700 kWh of energy every year using currently available technology. The total solar energy that reaches the Earth's surface could meet existing global energy needs 10,000 times over.

A large amount of statistical data on solar energy availability is collected globally. For example, the US National Solar Radiation database has 30 years of solar irradiation and meteorological data from 237 sites in the USA. The European Joint Research Centre (JRC) also collects and publishes European solar irradiation data from 566 sites1. Where there is more Sun, more power can be generated. The sub-tropical areas of the world offer some of the best locations for solar power generation.

While only a certain part of solar irradiation can be used to generate electricity, this 'efficiency loss' does not actually waste a finite resource, as it does when burning fossil fuels for power. Efficiency losses do, however, impact on the cost of the PV systems. International Energy Agency (IEA) calculations show that if 4% of the world's very dry desert areas were used for PV installations, the world's total primary energy demand could be met.

There is already enormous untapped potential. Vast areas such as roofs, building surfaces, fallow land and desert could be used to support solar power generation. For example, 40% of the European Union's total electricity demand in 2020 could be met if all suitable roofs and facades were covered with solar panels.

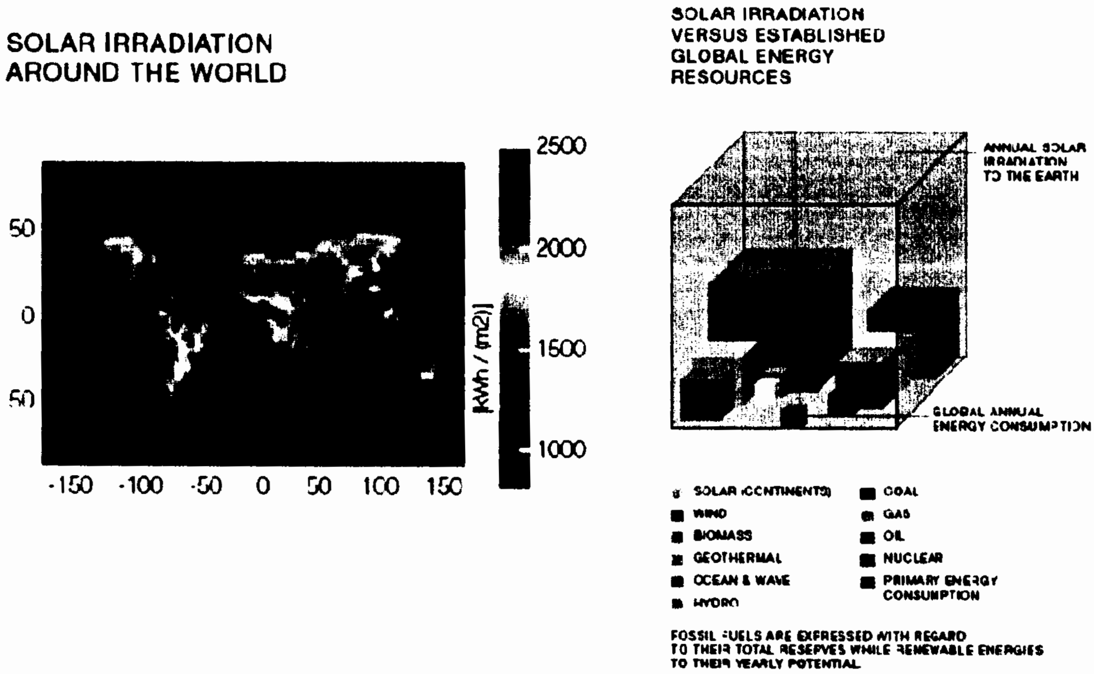


Chart 6.2.3.1: Global Irradiation

6.3.1 PV System Configuration

The key parts of a solar energy generation system are:

- Photovoltaic modules to collect sunlight
- An inverter to transform direct current (DC) to alternate current (AC)
- A set of batteries for stand-alone PV systems
- Support structures to orient the PV modules toward the Sun.

The system components, excluding the PV modules, are referred to as the balance of system (BOS) components.

6.3.1.1 PV cells and modules

The solar cell is the basic unit of a PV system. PV cells are generally made either from crystalline silicon, sliced from ingots or castings, from grown ribbons or from alternative semiconductor materials deposited in thin layers on a low-cost backing (Thin Film).

Modules can be connected to each other in series (known as an array) to increase the total voltage produced by the system. The arrays are connected in parallel to increase the system current. The power generated by PV modules varies from a few watts (typically 20 to 60 Wp) up to 300 to 350 Wp depending on module size and the technology used. Low wattage modules are typically used for stand-alone applications where power demand is generally low. Modules can be sized according to the site where they will be placed and installed quickly. They are robust, reliable and weatherproof. Module producers usually guarantee a power output of 80% of the Wp, even after 20 to 25 years of use. Module lifetime is typically considered of 25 years, although it can easily reach over 30 years.

6.3.1.2 Inverters

Inverters convert the DC power generated by a PV module to AC power. This makes the system compatible with the electricity distribution network and most common electrical appliances. An inverter is essential for grid-connected PV systems. Inverters are offered in a wide range of power classes ranging from a few hundred watts (normally for stand-alone systems), to several kW (the most frequently used range) and even up to 2,000 kW central inverters for large-scale systems.

6.3.1.3 Batteries and charge controllers

Stand-alone PV systems require a battery to store energy for future use. Lead acid batteries are typically used. New high-quality batteries, designed specifically for solar applications and with a life of up to 15 years, are now available. The actual lifetime of a battery depends on how it is managed. Batteries are connected to the PV array via a charge controller. The charge controller protects the battery from overcharging or discharging. It can also provide information about the state of the system or enable metering and payment for the electricity used.

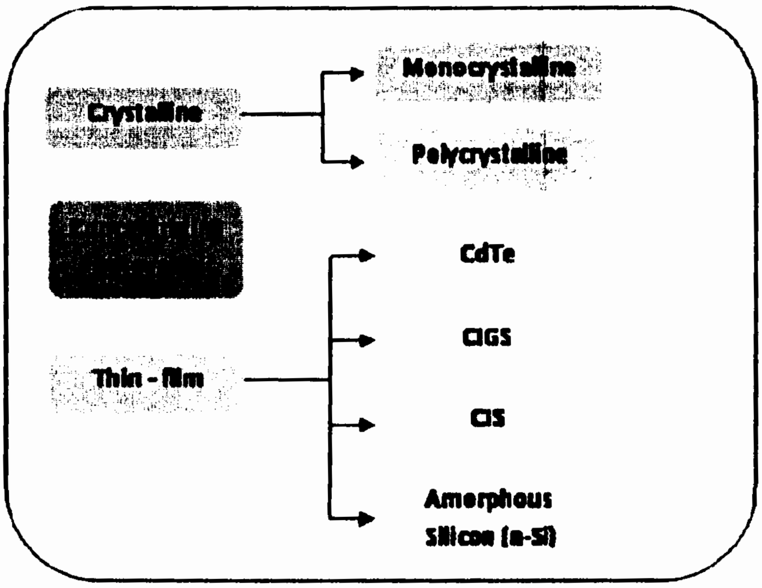
6.3.2 Categories of Solar Modules

- **Mono-crystalline silicon (mono-silicon or single silicon)**

  Right now, these are the most efficient type of solar panels. In other words, when sunlight hits these puppies, more of it turns into electricity than the other types below. As a result of their high silicon content, they're also more expensive, but you need fewer of them. That's why they're ideal for roofs. You can tell if you have a mono-crystalline solar panel by its square cells.

- **Polycrystalline silicon (multi-crystalline, multi-silicon, ribbon)**

"Poly" panels have lower silicon levels than "mono" panels. In general, that makes them less expensive to produce, but they're also slightly less efficient. The good news is that their overall construction design can often make up for the efficiency loss, so they're also good for roofs. You can tell poly-silicon panels by their groovy mélange of silicon woven through thin rectangular conduit wires.



- **Thin film (amorphous silicon, cadmium telluride, copper indium gallium (di)selenide)**

Everyone talks about "thin film" because they're really inexpensive to make and they don't mind the heat, which is all cool. Except right now, they're very inefficient, which means you'll see them in big solar farm projects with a lot of land, but not on your roof.

- **BIPV (building integrated photovoltaic)**

BIPV's can look like real roofing tiles (solar shingles are an example). That's nice, but good looks do cost a lot more. Second, they're way less efficient than conventional PV, which means you need a sunny spacious roof to make a dent in your electric bill. Finally, they may not last as long as regular panels. Right now, 1bog doesn't contract for BIPV systems.

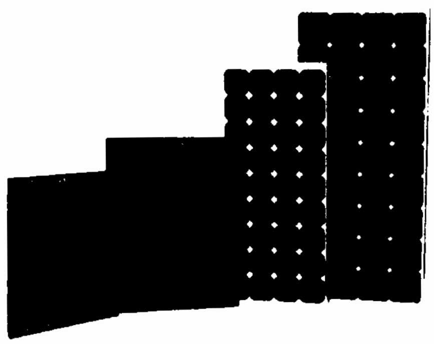


Figure 6.3.2.1: Photovoltaics

6.4 Solar Energy Applications Market

6.4.1 OFF Grid Applications

For isolated properties where there is no grid connection, solar PV panels can be used independently using batteries backup to provide additional supply when there is not enough daylight to generate electricity or when more energy is needed than the system is generating. Aside from providing power for homes solar photovoltaic is suitable for other off-grid applications.

Solar powered lighting for outbuildings / barns / sheds

Systems can be sized to run small off-grid applications, especially useful for rural locations such as farms.

Solar powered electric fencing / security systems / electric gates

Similar to above, these systems can be sized to each application off grid with batteries.

Solar powered pumps

One of the most practical and best paybacks there is. Solar powered pumps are ideal for irrigation or water sources in remote locations off grid.

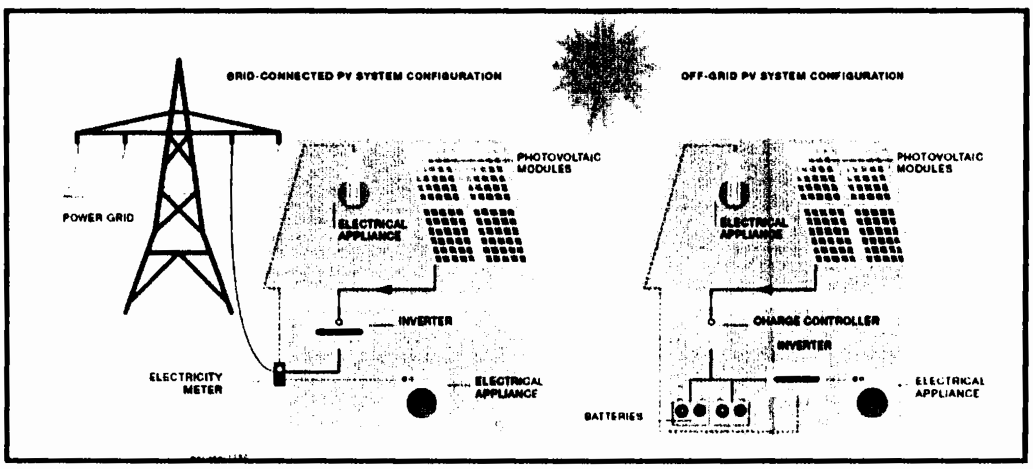


Figure 6.4.1.1: On-Grid and Off-Grid Applications

6.4.2 ON Grid Applications

Solar market for on-grid system comprises of residential, commercial, and utility applications.

Residential

Residential deployments are typically small (<5 KW) roof-mounted installations to supplement power usage to residential dwellings. Presently, residential deployments are the second highest in volume only after the commercial segment. Due to limited roof area, module efficiency is very important for residential deployments in order to achieve meaningful electricity generation. Although the residential market is currently dominated by silicon solar panels, thin-film is making inroads into the residential market.

Commercial

Commercial installations are medium to large (several KW to a MW) deployments to supplement electricity requirements of commercial sector customers including enterprise and public sector. As a result, both thin-film and silicon solar technologies are being deployed in the commercial segment. Other criteria important for commercial segment deployments include material safety, flexible form factor (avoiding penetrating mounts), and ease of installation that lowers the total system cost. The commercial segment is presently the largest segment within the solar market.

Utility

The utility segment comprises very large installations deployed as solar farms (1MW and higher) to complement electricity requirements of large power companies and utilities. Since the deployment areas are not a constraint, the efficiency requirements are typically low to medium. The utility segment is the third largest and fastest growing segment of the PV market. This segment is currently dominated by several thin-film technologies due to lower efficiency requirements and lower cost advantages combined with in-house expertise to develop, install and operate utility scale projects.

6.5 SOLAR FARM DEVELOPMENT

6.5.1 Financial Considerations during Solar Farm Development

6.5.1.1 Financial Concerns of development

The most important aspect for any project development initiative is the cost involved and the returns expected in form of ROE or IRR on investments. The generation cost refers to the price of a single unit of electricity – normally expressed as one kilowatt hour (kWh). The concept of Levelized Cost of Electricity (LCOE) allows to calculate the real cost of PV electricity and to compare this with the cost of other sources of electricity.

This method is preferred as it covers all investment and operational costs over the system lifetime, including the fuels consumed and replacement of equipment. Using LCOE makes it possible to compare a PV installation with any kind of power plant. For each system the LCOE calculation takes into account:

- The lifetime of the plant
- Investment costs
- Operational and maintenance costs
- The discount factor (WACC)
- The location of the plant, which for PV is essential to consider the difference in solar exposure

The starting base for the calculation is the total installed PV system cost. The cost of a PV system is split into the following elements:

- PV modules
- Inverter (enables connection of the system to the electricity grid)
- Structural components (for mounting and connecting the modules)
- The cost of installation (including the following costs: project development, administrative requirements, grid connection, planning, engineering and project management, construction and margins of the installers)

The module price reflects around 45-60% of the total installed system price, depending on the segment and the technology. Therefore, it is still the most important cost driver.

	LCOE Base Case (€cts/kWh)			LCOE Advanced Case (€cts/kWh)		
Country	2010	2020	2030	2010	2020	2030
Nigeria	0.152	0.089	0.063	0.141	0.066	0.045
Pakistan	0.145	0.085	0.060	0.135	0.063	0.043
Peru	0.153	0.090	0.063	0.142	0.066	0.045
Philippines	0.182	0.107	0.076	0.169	0.079	0.054
Qatar	0.155	0.091	0.064	0.144	0.067	0.046
Saudi Arabia	0.142	0.084	0.059	0.132	0.062	0.042
Senegal	0.134	0.079	0.056	0.124	0.058	0.040
Somalia	0.150	0.088	0.062	0.139	0.065	0.044
South Africa	0.139	0.082	0.058	0.129	0.060	0.041
Sri Lanka	0.150	0.088	0.062	0.139	0.065	0.044
Sudan	0.129	0.076	0.053	0.120	0.056	0.038
Syrian Arab Rep.	0.158	0.093	0.065	0.147	0.069	0.047
Tanzania	0.161	0.094	0.067	0.149	0.070	0.047
Thailand	0.160	0.094	0.066	0.149	0.070	0.047
Tunisia	0.174	0.102	0.072	0.162	0.076	0.051
Turkey	0.175	0.103	0.073	0.163	0.076	0.052
Uganda	0.164	0.096	0.068	0.152	0.071	0.048
UAE	0.144	0.085	0.060	0.134	0.063	0.043
Venezuela, RB	0.149	0.087	0.062	0.138	0.065	0.044
Vietnam	0.164	0.096	0.068	0.152	0.071	0.048
Yemen, Rep.	0.126	0.074	0.052	0.117	0.055	0.037
Zambia	0.141	0.083	0.058	0.131	0.061	0.042

Source: A.T. Kearney analysis

Table 6.5.1.1.1: Comparisons of LCOE base and advanced cases

When calculating the generation cost, the total system lifecycle cost has to be considered, including all costs made over the entire lifecycle of the PV system. Therefore, some additional cost drivers need to be taken into account:

- Price for operation and maintenance services
- Cost of one inverter replacement for each inverter
- Land cost (for large-scale ground-mounted systems only)
- Cost of take-back and recycling the PV system at the end of the lifetime

The generation cost assessed in the report reflects the technical generation cost, a theoretical value which might differ from the generation cost that can be achieved in the actual market. In practice, the capital cost is usually paid up-front. The remainder of the total cost is paid over the lifetime of the system. On the revenue side, every kWh produced corresponds to a flow of income over the entire lifetime of the system. As such, all costs and revenues that are not paid up-front have to be discounted in order to come up with a present value.

The discount factor used is differentiated across the market segments and the countries. A country-specific risk has been taken into account based on the differences in long-term government bond yields between the five countries assessed. Moreover, a differentiation has been made between private PV owners (residential systems) and business investors (all other market segments). It should be clearly noted that the cost of capital mentioned do not reflect the full cost of financing PV systems.

Future prospects of the Solar Industry

Multiple models have been developed for the accelerated growth of the solar industry from 2010 onwards to 2015 or 2020. Some underlying common assumptions while developing these models are as follows:

- **PV modules**

  An initial learning factor of 20% is assumed. For every doubling of the cumulative volume sold, the price will decrease by 20%. Whereas for Thin Film PV modules the learning rate is assumed to remain 20% until 2020, this rate could decrease towards 15% for Crystalline Silicon modules in 2020.

- **Inverters:**

  A learning factor of 20% is assumed for small-scale inverters (used in residential systems) and of 10% for large centralized inverters (used in all other market segments). The learning factors are based on the realized price reductions in the PV industry since the 1980s-1990s.

- **Structural components**

  The evolution of the cost of some components, such as cables and mounting structures, depends on the evolution of raw material prices, scale and learning effects. However, a significant part of their costs are influenced by PV module efficiency: the higher the efficiency, the fewer structural components are required.

- **Installation cost**

  The parameters that have been taken into account are similar to the ones that determine the evolution in the price of the structural components. The increase in labor cost is taken into account as well.

- **Cost per kWh for Solar PV Systems**

  To calculate the cost per kWh of electricity produced, the total energy output of the PV system has to be determined. This includes several parameters (as per costing methods developed by EPIA):

- **Solar Irradiance**

- **Performance ratio**

  During the day, a PV system does not produce at 100% of its capacity due to for example shading of the modules. The general standard is to assume about 75% for residential systems and 80% for larger systems.

- **Lifetime**

  To calculate generation cost, based on continuous technology developments, a gradual increase of the technical guaranteed lifetime of the PV modules, starting at 25 years and increasing to 35 years in 2020, is assumed.

- **PV module degradation**

  This affects the performance of the PV system over its lifetime. The assumption is based on the generally accepted guaranteed performance of the PV modules – namely 80% of the initial performance after 25 years.

6.5.2 Non-Financial Solar Farm Development guidelines

A solar farm is a large area of land with multiple ground mounted solar arrays. The solar panels convert the sun's energy into electricity that can be sold directly to the utility grid or to a neighboring facility. Developing a solar farm is complex and requires a company with the knowledge and resources available to make the project a reality. Photovoltaic solar farms use hundreds or thousands of panels covered with photovoltaic cells to convert the sun's light directly into electricity. They generate more power when daylight lasts longer - during summer months and in the south.

Solar farms that use PV technology may install stationary or rotating panels in rows. The more panels, the more space is needed - and the more electricity is generated. A PV solar farm can range from a few acres to hundreds of acres in size. Soil composition, water access, and proximity to power lines and substations all play a part in the selection of a site. Zoning issues affect the location of solar farms.

Landowners' legal rights to contract for long terms can influence site selection between private and federally owned land.

High quality resource assessments are the base for successful deployment of renewable energy sources. Their availability will lower the investors' uncertainty and risk about the availability of solar radiation. Investors would then be able to calculate lower surcharges and make their investment cheaper or optimize their systems better on the available resource and increase their revenues. Policymakers designing market introduction policies can better assess the level of necessary support in the beginning of market introduction. With this they can optimize the support schemes by fine-tuning the necessary amount of financial support, or by adding support for more systems and therefore speeding up the market introduction of these technologies.

To get an installation built, most solar farms rely on a combination of loans and grants from both public and private sources. National programs run by government lenders foreign bodies are one source of financing. Private investors and public/private partnerships are typical sources of funds. Other options that may be part of the financing deal include leasing land from a user of the solar power generated by the farm. Rebates and tax credits can help defray the costs of solar farm installation. Feed-in tariffs and solar renewable energy certificates can help make the operation of a solar farm profitable.

7. CARBON CREDITS

7.1 Emission Reduction Mechanisms

The Kyoto Protocol to the United Nations Framework Convention on Climate Change will strengthen the international response to climate change. Adopted by consensus at the third session of the Conference of the Parties (COP) in December 1997, it contains legally binding emissions targets for (industrialized) countries. By arresting and reversing the upward trend in greenhouse gas emissions that started in these countries 150 years ago, the Protocol promises to move the international community one step closer to achieving the Convention's ultimate objective of preventing dangerous anthropogenic [man-made) interference with the climate system.

The developed countries are to reduce their collective emissions of six key greenhouse gases by at least 5%. This group target will be achieved through cuts of 8% by Switzerland, most Central and East European states, and the European Union (the EU will meet its group target by distributing different rates among its member states); 7% by the US; and 6% by Canada, Hungary, Japan, and Poland. Russia, New Zealand, and Ukraine are to stabilize their emissions, while Norway may increase emissions by up to 1%, Australia by up to 8%, and Iceland 10%. The six gases are to be combined in a "basket", with reductions in individual gases translated into "CO2 equivalents" that are then added up to produce a single figure.

Each country's emissions target must be achieved by the period 2008 - 2012. It will be calculated as an average over the five years. 'Demonstrable progress" must be made by 2005. Cuts in the three most important gases carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) will be measured against a base year of 1990 (with exceptions for some countries with economies in transition). Cuts in three long-lived industrial gases — hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and Sulphur hexafluoride (SF6) - can be measured against either a 1990 or 1995 baseline. A major group of industrial gases, chlorofluorocarbons, or CFCs, are dealt with under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer.

Actual emission reductions will be much larger than 5%. Compared to emissions levels projected for the year 2000, the richest industrialized countries (OECD members) will need to reduce their collective output by about 10%. This is because many of these countries will not succeed in meeting their earlier non-binding aim of returning emissions to 1990 levels by the year 2000, and their emissions have in fact risen since 1990. While the countries with economies in transition have experienced falling emissions since 1990, this trend is now reversing. Therefore, for the developed countries as a whole, the 5% Protocol target represents an actual cut of around 20% when compared to the emissions levels that are projected for 2010 if no emissions-control measures are adopted.

The Kyoto Protocol provides that nations can redeem a part of their climate protection commitments by implementing projects aimed at reducing emissions in other countries. These projects are primarily to be carried out by the private sector.

These investment projects can financially benefit from generating additional emissions reductions as compared to a business as usual case.

7.1.1 Emissions Trading

There are three methods in Kyoto Protocol which permits the acquisition of emissions credits by means of project-based investment abroad. Kyoto includes "flexible mechanisms" which allow Annex 1 (who have accepted GHG emission reduction obligations) economies to meet their GHG targets by purchasing GHG emission reductions from elsewhere. These can be bought either from financial exchanges (such as the new EU Emissions Trading Scheme) or from projects which reduce emissions in non-Annex 1 economies under the Clean Development Mechanism (CDM), or in other Annex-1 countries under the JI.

7.1.2 Clean Development Mechanism (CDM)

Emissions Trading, also called Carbon Trading, involves trading carbon emission credits within nations. Allowances are created, thereby making emissions a commodity that can be traded between industries etc. The Kyoto Protocol says that it is ok to trade in emissions, but that it should not be the major means to achieve one's commitments. Some European countries and corporations have started implementing such programs to get a head start and to see how well it will work.

7.1.3 Joint Implementation (JI)

Clean Development Mechanism (CDM) allows richer countries to offset their CO2 emission against the emissions prevented when technology that cuts down on greenhouse gas emissions is deployed in poor countries.

7.2 Role Of CDM In The Project

The Project is a power generation project with renewable resource and zero emission. When put into operation, the project can provide power supply to the northern Pakistan power grid, which currently is mainly relying on fossil fuel. Therefore, it can help to reduce the greenhouse gas emission from coal or oil-fired power generation. It can deliver good environmental and social benefits. It is also consistent with the spirit of the Kyoto Protocol and qualified for the application of CDM projects. If the project is approved and registered as a CDM project, CERs can provide extra financial resource for the project. It will provide favorable conditions for the project financing, improve competitiveness of the project, and reduce investment risk during the project implementation process.

The Cholistan Solar PV Project is a 10 MW solar PV installation project, planned to be implemented in phases of 5 MW each. The project will be a pure solar PV grid connected installation. The project would become operational and start generating CERs directly after the completion of the first phase of the project, with work on the other phases continuing. The project is expected to help alleviate the huge energy deficit in Pakistan. It will be the first Solar PV project of its magnitude in Pakistan and will be a large source of clean energy. The project is expected to be using Poly Crystalline silicon solar cells.

The area of this project will be about 37.5 Acres and annual amount of electricity going to the grid will be about 16,000 MWh approx. As a result over 8,000 tons of CO_2 emissions will be abated per year. Cholistan Solar Farm is a 10 MW electricity generation plant designed to produce electricity by solar energy in Cholistan Desert in the province of Punjab, Pakistan. It employs solar photovoltaic (PV) technology that converts solar energy directly into electricity, while emitting zero greenhouse gases (GHG) into the atmosphere. The project is planned to be implemented in phases of 5 MW each and would become operational and start generating CERs right after the completion of the first phase of the project, with work on the other phases continuing. The generated electricity will be supplied to the national grid.

The project conforms to the government policy that promotes development of renewable energy technology and contributes to lowering dependence on electricity generation by fossil fuels which is over 66% of total generation in Pakistan. It is expected to help alleviate the huge energy deficit in Pakistan. It is the first Solar PV project of its size in Pakistan and will be a good source of clean energy.

8. REGULATORY REGIME

Power sector Pakistan has a ministry overlooking the electricity business in the country and a regulatory authority which independent of the ministry to control the business practices in the market. There are a number of stakeholders involved in the cycle:

- Ministry of Water and Power
- National Electricity Regulatory Authority (NEPRA)
- Water and Power Development Authority and its subsidiaries
- Karachi Electric Supply Corporation Limited (KESC)
- Independent Power Producers
- Private Power Infrastructure Board
- Alternative Energy Development Board (AEDB)

8.1 Ministry Of Water And Power

The federal Ministry of Water and Power is the GoP's executive arm for all issues relating to electricity generation, transmission and distribution, pricing, regulation, and consumption. It exercises these functions through its various line agencies as well as relevant autonomous bodies. It also serves to coordinate and plan the nation's power sector, formulate policy and specific incentives, and liaise with provincial governments on all related issues.

8.2 Water And Power Development Authority (WAPDA)

WAPDA was created in 1958 as a Semi-Autonomous Body for the purpose of coordinating, and giving a unified direction, to the development of schemes in the Water and Power Sectors. These were previously being dealt with by the respective Electricity and Irrigation Departments of the Provinces.

In 1992, the Government approved WAPDA's Strategic Plan for the Privatization of the Pakistan Power Sector. This Plan sought to meet three critical goals:

- Enhance capital formation,
- Improve efficiency and rationalize prices
- Gradually move towards full competition by providing the greatest possible role for the private sector through privatization.

This major decision was taken to improve the viability of Pakistan's electric power sector which was characterized by extensive government involvement in management, political interference, and a tariff plagued by cross-subsidies. A critical element of the Strategic Plan was the creation of a Regulatory Authority to oversee the restructuring process and to regulate monopolistic services.

The existence of an independent and objective regulatory entity reduces the risk to investors in the market. Accordingly, an autonomous regulatory agency is essential for the short and long-term stability of the sector.

The introduction of this regulatory regime reflects the desire of the Government to improve the efficiency and availability of electric power services by protecting the interest of the investor, the operator, and the consumers. It also shows the intention to increase competition and to deregulate power sector activities where there is competition.

In this regard several regulatory bodies were formed, namely:

- National Electric Power Regulatory Authority (NEPRA)
- Private Power Infrastructure Board (PPIB)
- Provincial Power Development Boards/Cells

Further, as part of the country's new electricity market restructuring and liberalization program, in the year 2000 WAPDA was subject to a vertical disintegration process. As a result the power wing of WAPDA, comprising of generation, transmission and the distribution of electricity has been restructured into fourteen (14) public limited companies. These fourteen (14) Corporate Entities are:

- Four (4) Thermal Power Generation Companies (GENCOs)
- One (1) National Transmission &Power Dispatch Company (NTDC)
- Nine (9) Distribution Companies (DISCOs)

8.3 National Electric Power Regulatory Authority (NEPRA)

NEPRA has been created to introduce transparent and judicious economic regulation, based on sound commercial principles, in the electric power sector of Pakistan. NEPRA regulates the electric power sector to promote a competitive structure for the industry and to ensure the coordinated, reliable and adequate supply of electric power in the future. By law, NEPRA is mandated to ensure that the interests of the investor and the customer are protected through judicious decisions based on transparent commercial principles.

8.4 National Transmission and Dispatch Company (NTDC)

National Transmission & Dispatch Company (NTDC) Limited was incorporated on 35 August 1998 and commenced commercial operation on 1st March 1999. It was organized to take over all the properties, rights and assets obligations and liabilities of 220kV and 500kV Grid Stations and Transmission Lines/Network owned by Pakistan Water and Power Development Authority (WAPDA).The NTDC operates and maintains nine 500kV Grid Stations, 4,160km of 500kV transmission line and 4,000km of 220kV transmission line in Pakistan.

NTDC was granted Transmission License No.TL/01//2002 on 31st December 2002 by National Electric Power Regularity Authority (NEPRA) to engage in the exclusive transmission business for a term of thirty (30) years, pursuant to Section 17 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

Under the regime set out in the License, the NTDC is entrusted to act as:

- Central Power Purchasing Agency
- System Operator
- Transmission Network Operator
- Contract Registrar and Power Exchange Administrator

8.5 Private Power Infrastructure Board (PPIB)

PPIB was created in 1994 to act as One-Window organization to facilitate the implementation of projects under various private power policies announced by the GoP from time to time. Its main task is to negotiate the Implementation Agreements (IAs) and provide support in negotiation Fuel Supply Agreements (FSAs) and Power Purchase Agreements (PPAs). PPIB also provides guarantees to private investors for the performance of Government entities (WAPDA. KESC, etc.) on behalf of the GoP; and monitors the performance of IPPs, WAPDA/NTDC, KESC, fuel suppliers and other government agencies under various contracts. To its credit, the PPIB has successfully implemented Private Sector Power Projects in Pakistan with a cumulative capacity of 5,577 MW,

8.6 Alternative Energy Development Board

Pakistan, like other developing countries of the region, is facing a serious challenge of energy deficit. Renewable Energy (RE) resources can play an important role in bridging this deficit. More importantly, RE can also play an important role in rural electrification. Realizing the importance of RE, the Government of Pakistan created the Alternative Energy Development Board (AEDB) in May 2003 to act as the central national body on the subject of Renewable Energy. The main objective of this Organization is to facilitate, promote and encourage development of Renewable Energy in Pakistan with a mission to introduce Alternative/Renewable Energy at an accelerated rate to achieve 10 percent share of RE in the energy mix of the country,

The current initiative is directed towards creating a market-based environment that is conducive to private sector investment and participation. The AEDB provides a one window point of operations for investors in the alternate energy sector. They perform all of the functions of the PPIB for alternate energy projects below 50 MW. This is done in order to reduce the timeframe required for the completion of these projects, which are deemed essential to meet Pakistan's short term and long-term energy requirements. Due to this, alternate energy projects to not go through the PPIB.

Another of the mandates of the AEDB is to form international associations in an effort to transfer foreign technology and expertise to Pakistan. It is their objective to reduce the cost of alternate energy by transfer wing as much of the manufacturing process to Pakistan as possible

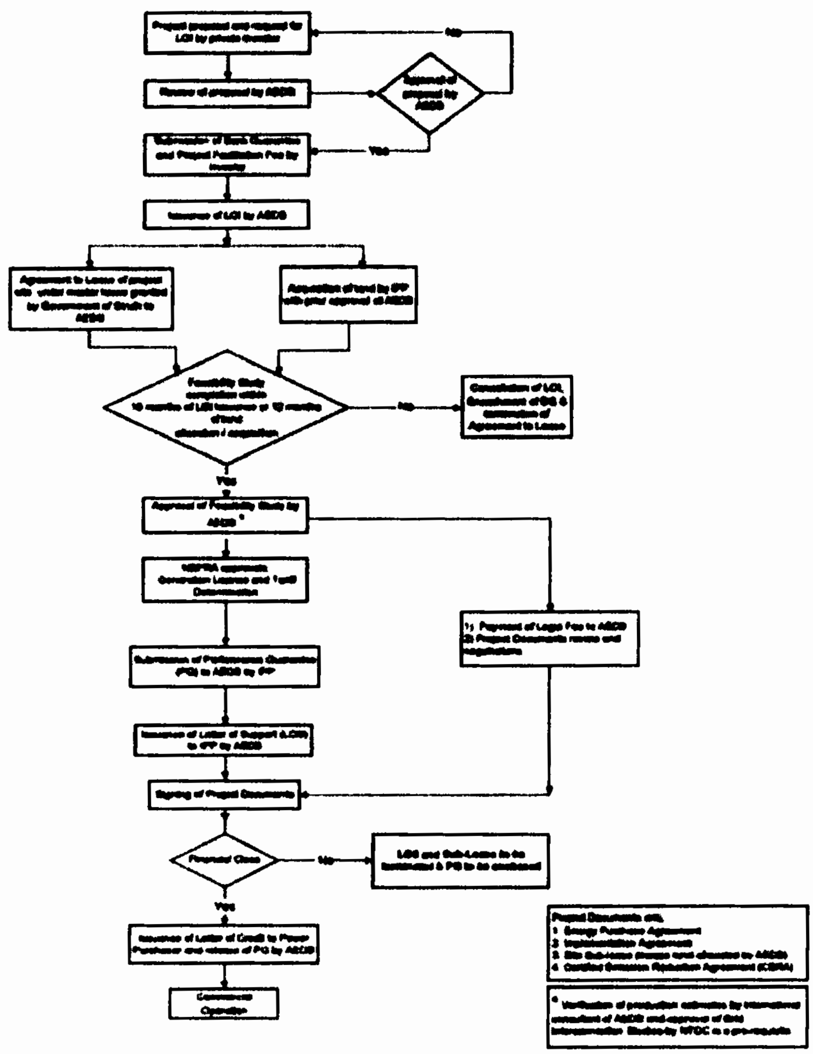
8.7 Provincial Power Cells

Power and irrigation departments exist in each of the four provinces and in AJK, whose prime function is to manage water resources for agriculture and small power generation units of less than 50 MW. Each of these departments has a Chief Engineer, Power Cell, who heads the department's technical management capacity with respect to provincial power projects.

The AEDB also moved towards establishing Alternative Energy Cells with the Sindh and Baluchistan governments by designating official government focal points to serve as liaison officers with the AEDB on RE issues. In northern Pakistan the Sarhad Hydro Development Organization (SHYDO) and the Northern Areas Public Works Department (NAPWD) have been engaged in the development of mini and microhydel schemes.

9. Licensing / Permitting / Security

9.1 Solar Power Project Flow Chart



9.2 Letter Of Intent (LOI)

First step is to get the sponsors registered with AEDB/PPDB or the concerned Board and obtain the Letter of Intent (LOI) from the Government. This letter entitles the sponsors to start working on the power project at official level and get support from the concerned Board and other government departments in the preparation of feasibility study and acquisition of land for the project.

9.3 Acquisition Of Land

PPDB/AEDB have acquired land from Government of Punjab for allocation to Solar Power Projects in the District of Bahawalpur/Bahawalnagar, Cholistan Desert in the province of Punjab. This land is being sub-divided and sub-let for various projects to the sponsors. There are two lease agreements i.e. one between Government of Punjab and PPDB/AEDB for large portions of the land acquired by them and the second between PPDB/AEDB and the project company for the portion required for individual projects.

However, PPDB/AEDB does not take the responsibility to ensure the acquisition of land. The investors have alternate option to buy private land and charge to the project capital cost.

9.4 Company Registration

In order to avail special incentives offered for the power projects such as exemption from income tax and import duties, a special purpose company ("the Project Company') has to be incorporated with only business authorized being electricity generation and sale. This company can be a private limited company or if the sponsors wish to have the company listed on stock exchanged, a public limited company.

9.5 Generation License

Rights to produce and sell electricity in Pakistan are granted by NEPRA through 'Generation License'. Project Company has to make an application to NEPRA for Generation License which authorizes a company to produce and sell electricity in the country.

9.6 Tariff Determination

Once generation license is granted to the Project Company, a separate application is required to be made for approval of the tariff at which the Company will sell electricity to the Power Purchaser. The Power Purchaser can be National Transmission and Distribution Company (NTDC) or one of the Distribution Companies (DISCO's) which in this project is Multan Electric Power Company (MEPCO).

9.7 Building Permissions

All required permissions and NOCs from all relevant authorities are being obtained by the PPDB/AEDB collectively for all power projects in the area.

9.8 Letter Of Support (LOS)

Once the tariff has been approved, the Project Company is required to move for arrangement of financing. PPDB/AEDB will issue a Letter of Support for the Project Company giving government guarantees until EPA and IA are fully effective to ensure sponsors and lender of the full government support. A bank guarantee is required to be submitted before issuance of LOS.

9.9 Energy Purchase Agreement (EPA)

Agreement between the Power Purchaser and the Project Company is called Energy Purchase Agreement (EPA). This agreement lists terms and conditions for the sale and purchase of electricity between the two companies. In a draft of EPA between WAPDA (the respective DISCO or NTDC) and Seller, the Purchaser and the Seller agree on the following:

- Seller plans to develop and implement a Solar PV Power Generating Plant with a nameplate capacity of 10 MW to be located at the site in Cholistan, on a build, own and operate ("BOO") basis.
- Seller wishes to sell and deliver, and the Power Purchaser wishes to purchase and receive the net energy output
- Simultaneously Seller is entering into an Implementation Agreement with the Government of Pakistan (the 'GoP)

9.10 Implementation Agreement (IA)

The Implementation Agreement (IA) provides security to the sponsors and lenders against the performance of the power purchases through guarantees from Government of Pakistan.

VOLUME 1 – ANNEXURE

ANNEXURE 1

LOI ISSUED BY AEDB

ANNEXURE 2

BANK GUARANTEE OF USD 5,000 SUBMITTED

ANNEXURE 3

ALLOCATION LETTER ISSUED BY PPDB TO THE PROJECT SPONSOR

ANNEXURE 4

GENERAL SITE INFORMATION

ANNEXURE 1

LOI ISSUED BY AEDB

Government of Pakistan
ALTERNATIVE ENERGY DEVELOPMENT BOARD
2nd Floor, OPF Building,
Shahrahe Jamhoriat, Sector G-5/2
Islamabad.
Tel: 051 9222360 Fax: 051 9222364

AEDB

B/3/2/SPV/SSP/28 January 13, 2014

Ms. Afshan Hamid Mir
Chief Executive Officer
M/s Safe Solar Power (Pvt.) Ltd.
28, Street 24, Sector F-8/2
Islamabad.

Subject: LETTER OF INTENT FOR 10 MW SOLAR PV POWER GENERATION PROJECT

Reference: Your Proposal dated December 27, 2013.

In terms of the Policy for Development of Renewable Energy for Power Generation 2006 ("Policy"), the Alternative Energy Development Board ("AEDB") hereby confirms its interest in your proposal for establishing an approximately 10 MW solar PV power generation project in Bahawalpur, Punjab province. The Sponsor(s) is responsible for arranging the land for the project. AEDB may facilitate the Sponsor(s) in arranging the land for the project; however, AEDB has no obligation to provide land to the Sponsor(s) for the project. AEDB acknowledges receipt of the bank guarantee Cheque No. 90541109 dated January 07, 2014 in the sum of US Dollar (US $ 5000/-).

2. The Sponsor(s) is required to complete the feasibility study and achieve the milestones listed at the Annex to this LOI ("LOI Milestones") for the subject project, at no risk and at no cost to, and without any obligation on the part of the AEDB, the Government of Pakistan, any Provincial Government or their respective agencies, within a period of Eighteen (18) months from the date of issuance of this Letter of Intent ("LOI").

3. The Sponsor(s) is required to carry out and complete the feasibility study at internationally acceptable standards and in accordance with the terms and conditions stipulated in the Policy and this LOI. The feasibility study must include, inter alia, Solar PV Plant equipment siting details, detailed power production estimates based on solar irradiance data of project site, soil tests reports, technical details pertaining to solar PV panels and other allied equipment to be used in the Solar PV Plant, grid tied solar PV project, electrical studies (including but not limited to short-circuit study, power quality study, load flow study and stability study), environmental study, project costing, financing plan, carbon credits, financing terms tariff calculations and assumptions for financial calculations including economic/financial analysis. The Sponsor is also advised to liaise with the power purchaser while determining the site, project layout, sub-station design and layout the transmission line, interconnection arrangements, and other related matters.

Page 1 of 4

4. The validity of this LOI is not more than 18 months from the date of its issue, where after it will automatically lapse immediately (unless extended pursuant to clauses 5 or 6), being the 13th July, 2015 (the "Expiry Date"). Issuance of this LOI or the lapsing of its validity, or your conducting a feasibility study there under, cannot form the basis of any claim for compensation or damages by the Sponsor(s) or the project company or any party claiming through or under them against the Government of Pakistan, the Provincial Government, AEDB or any of their agencies, employees or consultants on any grounds whatsoever, during or after the expiry of the validity of the LOI.

5. The Sponsor(s) is therefore required to complete the feasibility study and achieve the LOI Milestones for the subject project within the validity of this LOI. The Sponsor(s) is also required to submit quarterly progress reports. Provided the Sponsor(s) meets the LOI Milestones on the stated dates, the Expiry Date of this LOI shall be extended on a day-for-day basis for the number of days of delay by which the approval or review by the relevant public sector entity listed in the LOI Milestones is delayed beyond the corresponding period stated in the LOI Milestones. In case there is a delay in completion of the feasibility study within the validity of this LOI for reasons not attributable to a public sector entity, a one-time extension may be granted up to a maximum period of one hundred eighty (180) days if AEDB is satisfied that the feasibility study is being conducted in a satisfactory manner and is likely to be completed shortly, and provided the Sponsor(s) enhance the amount of the bank guarantee to twice its original amount and extend its validity for a period six (6) months beyond the extended Expiry Date. Furthermore, if the said feasibility study is technically approved by the Panel of Experts and later the tariff awarded by NEPRA is not agreed by the Sponsor(s) (such decision to be made within thirty (30) days of the award of the tariff, and in any event within the validity of the LOI), the bank guarantee less 10% deduction for administrative and ancillary charges, would be returned to the Sponsor(s).

6. The Sponsor(s) shall apply to NEPRA for award of tariff within the period of validity of this LOI. Upon tariff being given, the Sponsor(s) shall forthwith submit a new Performance Guarantee in the sum of US Dollars (USD 25000/-) and obtain the Letter of Support ("LOS") from AEDB within the validity period of this LOI, provided, if the award of the tariff is delayed beyond the initial validity of the LOI, the Sponsor(s) shall extend the bank guarantee for a further period of six (6) months and the Expiry Date shall be extended *ipso facto* for a further period of six (6) months, and the Sponsor(s) shall obtain the LOS and submit the Performance Guarantee within the extended period afore-said. For the avoidance of doubt, the afore-said extension process may be repeated if the tariff is not announced (including on any review petition filed by the Sponsor(s), such review (if any) to be filed within the period prescribed in the NEPRA (Tariff Procedures and Standards) Rules) up to fifteen (15) days before the then prevailing Expiry Date.

7. In case the Sponsor(s) fails to meet the LOI Milestones or perform any other obligations set forth in the Policy and this LOI, including the extension of the date of expiry of bank guarantee as provided herein, AEDB will terminate this LOI and encash the bank guarantee.

8 (A) Pending the nomination of the Main Sponsor per sub-clause (B), the M/s Safe Solar Power (SSP) is liable for all obligations and liabilities of and on behalf of all other shareholders/ Sponsor(s) (without relieving the other

shareholders/Sponsor(s) of their obligations and liabilities under this LOI). Accordingly, M/s Safe Solar Power (SSP). shall not transfer or assign its shareholding (or other participatory interest, if the project company is not formed by the date of issue of the LOI) in the project or the project company without the prior written approval of AEDB, which approval may be declined by AEDB in its discretion if the proposed transferee's financial and other relevant credentials are found unsatisfactory.

(B) The Sponsor(s) is advised to nominate the Main Sponsor *(being the individual or group holding at least 20% equity or participatory interest in the IPP project)* no later than the Expiry Date of the LOI. In default of nomination as aforesaid, the M/s Safe Solar Power (SSP) will be deemed the Main Sponsor for all intents and purposes. The Main Sponsor, together with other initial project shareholders/Sponsor(s) (which shall, subject in each case to sub-clause (A) above, be firmly settled and announced to AEDB by the Expiry Date of the LOI), must hold 51% of the project equity for a period up to the project's Commercial Operations Date (COD).

(C) Any actual or purported transfer or assignment of the shares or other participatory interests by the Sponsor(s) / shareholders in contravention of the foregoing restrictions without prior written consent of the AEDB shall render this LOI void and the bank guarantee will be enchased in such case by AEDB.

9. This LOI is not assignable and non-transferable. This LOI shall be void upon any actual or purported assignment or transfer hereof without the prior written consent of AEDB.

10. This LOI is issued subject to the grant of a generation license and award of tariff by the National Electric Power Regulatory Authority ("NEPRA") to the subject project under the provisions of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (the "NEPRA Act"). While AEDB shall extend its offices to support applications by the subject project before NEPRA under the current or any amended policy framework, by granting this LOI, AEDB does not make any representation or warranty on behalf of itself or the Government of Pakistan that the subject project will be granted a generation license or a tariff acceptable to the subject project or at all.

11. This LOI is issued in duplicate on the date hereof, and it shall come into effect when one copy is received by AEDB after being duly countersigned by you. Nevertheless, this LOI shall lapse if the countersigned copy is not received at AEDB within 15 days of its issuance.

13/01/2014

(Afshan Hamid Mir)
(Chief Executive Officer)
M/s Safe Solar Power Pvt. Ltd. (SSP)

(Asjad Imtiaz Ali)
(Chief Executive Officer)
AEDB

Annex-I

Milestones for the Letter of Intent (LOI)

Sr. No.	Milestones	Time Frame (in Months)
1.	Issuance of Letter of Intent (LOI)	T0
2.	Submission of complete Feasibility Study to AEDB, comprising of; (i) Technical study including resource assessment, plant & equipment details, layout and energy production analysis. (ii) Grid Interconnection Study (approved by NTDC) (iii) EIA / IEE study (approved by provincial Environmental Protection Agency)	No later than ten (10) months after issuance of LOI
3.	Vetting and approval of Feasibility Study by AEDB (*including verification of production estimates through third party consultant, if required, cost of which shall be borne by the Sponsor(s)*)	Within two (2) months after submission to AEDB. (*provided any requisite modifications are timely made by the Sponsor(s) and the modified feasibility study is resubmitted within 15 days of a letter by AEDB requiring the modifications*)
4.	Tariff and Generation from NEPRA	Within four (4) months of approval of Feasibility Study by AEDB
5.	Acceptance of Tariff by IPP	Within fifteen (30) days of determination of tariff by NEPRA
6.	Posting of Performance Guarantee for Issuance of Letter of Support (LOS)	Within fifteen (15) day of acceptance of Tariff by IPP
7	Issuance of Letter of Support (LOS) by AEDB	Within fifteen (15) days of posting of Performance Guarantee (PG)

ANNEXURE 2

BANK GUARANTEE OF USD 5,000

SUBMITTED

CASH SECURITY GUARANTEE

To The Alternative Energy Development Board (AEDB)
2nd Floor OPF Building
G-5/2, Islamabad
Pakistan

Date of the Cash Security Guarantee	07.01.2014 (Seven January two thousand fourteen
Amount of the Cash Security Guarantee	US $ 5000 (five thousand Only) (hereinafter referred to as the "Secured Sum").
Date of issuance.	07.01.2014 (Seven January two thousand fourteen)
Validity up to	[twenty four (24) months from the date of issue of Cash Security Guarantee]

THIS CASH SECURITY GUARANTEE Instrument is executed at AEDB on this 7th day of January 2014 BY:

the Safe Solar Power (Pvt) Ltd. hereinafter referred to as the "Obligor", which expression shall mean and include [its/their] successors, executors administrators, permitted assigns, legal representatives, whether jointly or severally).

1

In favour of the Alternative Energy Development Board ("AEDB") (hereinafter referred to as the "Beneficiary", which expression shall mean and include its successors, administrators and legal representatives, whether jointly or severally;

WHEREAS:

Upon the request and proposal of the Sponsor(s) to set up an electricity generation facility utilizing solar as the renewable energy resource in Pakistan, the Beneficiary has approved the issuance of a Letter of Intent (the "LOI") to the Safe Solar Power (Pvt) Ltd. subject to submission of this Cash Security Guarantee

In terms of the Policy, and in consideration thereof the Obligor is required to post a bank guarantee to secure its obligations under the LOI but has instead

offered cash deposit in equivalent sum by way of security which is acceptable to the Beneficiary;

The Obligor hereby furnishes this irrevocable, unconditional and without recourse, Cash Security Guarantee (hereinafter referred to as the "Cash Security Guarantee") in favour of the Beneficiary in order to secure the performance of the Sponsors'/Project Company's/Obligor's obligations under the LOI, being the conduct and completion of a feasibility study ("Feasibility Study") and submission of Performance Guarantee for acquiring Letter of Support (LOS) in accordance with the requirements stipulated in the LOI (hereinafter referred to as the "Secured Obligations")

NOW THEREFORE, this Cash Security Guarantee witnesseth as under

In the event that the Safe Solar Power (Pvt) Ltd. defaults in, delays, or fails to perform the Secured Obligations, of which event the Beneficiary shall be the sole arbiter, the Beneficiary may appropriate for its benefit and use the entire sum of or any part of the Secured Sum by written notice to the Obligor stating that the [Project Company Sponsor Obligor] has defaulted in, or delayed, or failed to perform the Secured Obligations under and in accordance with the terms of the LOI.

The decision of the Beneficiary as to the Sponsor(s)' / Project Company's/Obligor's default, delay, or failure in performing the Secured Obligations shall be final and binding on the Obligor, which shall not be questioned by the Obligor in any manner whatsoever.

This Cash Security Guarantee shall remain in full force and be effective for a period up to 06/01/2016 (six January two thousand sixteen).

The Beneficiary may, if and when and in such manner as the Beneficiary in it sole discretion deems appropriate, grant time or other indulgence to, or accept or make any composition or arrangement with the Sponsor(s) and or the Project Company and such acts shall not in any way whatsoever discharge the Obligor from its obligations under this Cash Security Guarantee.

The Obligor's obligations as set out in this Cash Security Guarantee shall be continuing obligations and shall not be modified or impaired upon the happening from time to time, without the Obligor's assent or otherwise, of any act or omission, or any circumstances or events which would otherwise discharge impact or otherwise affect any of Obligor's obligations [illegible] contained in the Cash Security Guarantee and the LOI

7 No delay or failure to exercise any right or remedy under the Cash Security Guarantee by the Beneficiary shall constitute a waiver of such right or remedy. No single or partial exercise of any right or remedy shall preclude any other or further exercise thereof or of any other right or remedy. No waiver by the Beneficiary shall be valid unless made in writing.

8 No set-off, counter claim, reduction or diminution of any obligation that the Obligor has or may have against the Beneficiary shall be available to it against the Beneficiary in connection with any of its obligations to the Beneficiary under this Cash Security Guarantee.

9 The Obligor hereby declares and confirms that under its constitution and applicable laws and regulations, it has the necessary power and authority and has obtained all necessary authorizations, approvals and consents thereunder to enter into, execute, deliver and perform the obligations it has undertaken under the Cash Security Guarantee, which obligations are valid and legally binding on and enforceable against the Obligor under the Laws of Pakistan, and that the signatory(ies) to this Cash Security Guarantee are the Obligor's duly authorized officers.

10 The Obligor agrees and acknowledges that this Cash Security Guarantee is given in lieu of the bank guarantee stipulated under the Renewable Energy Policy 2006 at the Obligor's request and the Obligor hereby waives all defences, claims and counter-claims against the Beneficiary for any encashment or appropriation of the Secured Sum or for any demands for renewals or extension

1

or enhancements of the Cash Security Guarantee which the Obligor would be required to comply with if a bank guarantee was furnished by or on behalf of the Obligor. Further, the Obligor hereby agrees that:

the Obligor is not entitled to and shall not demand any profit, interest, mark-up or other return of any form whatsoever accruing on the Secured Sum;
the risk of any adverse exchange rate variations between the currency of Secured Sum and Pakistan Rupees shall be carried by the Beneficiary; and
the Secured Sum (if not appropriated) will be returned in Pakistan Rupees should the laws of Pakistan prohibit the Beneficiary from returning foreign currency to the Obligor.

11 This Cash Security Guarantee is governed by the laws of Pakistan.
12 Capitalised terms not otherwise defined herein shall bear the meaning ascribed to them in the LOI.

For and on behalf of the Obligor

Name: Afshan Hamid Mir [illegible]
Designation: CEO

Witness 1	Witness 2
Name: Muhammad Yousaf	Name: Raja Rehan Mehdi
CNIC: [illegible]	CNIC: [illegible]
Address: new abadi tramri chowk p.o. Farlar distt. Islamabad	Address: [illegible] SB tehsil [illegible] Distt Sargodha

ANNEXURE 3

ALLOCATION LETTER ISSUED BY PPDB TO THE PROJECT SPONSOR

NO.S.O(C)(ED) 4-5/2014
GOVERNMENT OF THE PUNJAB
ENERGY DEPARTMENT
Dated Lahore the 7th February, 2014

To

The Managing Director
Cholistan Development Authority
District Bahawalpur

SUBJECT: - **ALLOCATION /EARMARKING OF LAND FOR 10 MW SOLAR PROJECT IN QA SOLAR PARK, BAHAWALPUR**

I am directed to refer to this department's letter of even No. dated 29.01.2014 on the above noted subject.

2. It is informed that M/s. Safe Solar Power (Pvt.) Ltd. holder of LOI from AEDB to develop 10-MW Solar PV Power Project in Cholistan, Bahawalpur. The said Company is hereby allowed to conduct the feasibility study as per following coordinates (Copy of marked map is attached):

(Sqr No. 4, 8 &12 of Block No. 371) & (Sqr No. 1, 5 & 9 of Block No. 372)

3 Further, these coordinates are allocated provisionally subject to the finalization of master plan of QASP and may be reallocated on the finalization of master plan.

SECTION OFFICER (Conservation)

C.C.

1. The Director (Solar), Alternative Energy Development Board (AEDB), Government of Pakistan, Ministry of Water and Power, Islamabad.
2. M/s Safe Solar Power (Pvt.) Limited, 28-Street 24 F-8/2 Islamabad.
3. The Managing Director, Punjab Power Development Board, Energy Department.
4. PS to Additional Chief Secretary (Energy), Energy Department.

ANNEXURE 4

GENERAL SITE INFORMATION

History Of Bahawalpur

It was an independent state until the creation of Pakistan 1947. The town of Bwp was built in about 1780 on an old site. It was Nawab Bahawal khan I (1746 to 1749) who laid the foundation of Baghdad-ul-jadidin 1748 and made it as his capital. His ruling period was nearly 3 years and was entombed in the graveyard of Malook Shah. Historical record shows that before the Sikh rule in Punjab the area of Bwp was much greater. Apart from the entire Dera Ghazi khan district. some parts of Sukkur, Multan, Sahiwal and Muzzafargarh districts were also included in it.

During its heydays Bwp was patronizing all notable Islamic institutions of the subcontinent including Aligarh Muslim University and Dar-ul-Ulms at nadva and deoband. The contribution of the State was not confined to the field of learning alone. During the decline of Mughal rule the state also served as abulwark against the inroads of Sikhs and Rajputs. It was Bwp which became an abode of peace for muslins.

The area that is now Cholistan was snatched along with its desert strongholds from Rajputs by the Abbasids rulers of the State. Had this not been done the history of the subcontinent would have been different. The present main Railway line connecting Karachi and Peshawar passed through this sensitive area called Bahawalpur. Bwp also did not allow Sikhs to cross the Sutlej river. On the birth of Pakistan the Princely State was the first state to join it and worked as an independent state till 1970. After that Bwp was included as a division in the province of Punjab.

Baghdad to Bahawalpur is the life story of people who have for the past many centuries have been serving Islam and the Islamic values in the subcontinent. Credit goes to our team for highlighting the achievements of these people. The web also contains some rare pictures which have important bearing on the history and culture of lower Punjab Pakistan.

Various documents given in the web site (www.mybahawalpur.com) brought to you by (Team Bwp) are of great value. Especially the letters of M.A Jinnah, Allama Iqbal, Sir Agha khan, Maulana Shibli Naumani, Khawaja Ghulam Farid and others.

The Ruling Family

Bahawalpur state belongs to the ruling family of the Abbaside clan and has directly descended from Hazrat-i-Abbas, the uncle of Holy Prophet (May Peace Of Allah Be Upon Him). Amir of Bwp, Lt. General, His Highness, Alhaj Sir Sadiq Mohammad Khan V, was the sixtieth in descent from Hazrat-i-Abbas Alamdar.

In 655 A.H. the Abbaside Caliphate at Baghdad was dismembered as result of the invasion of Baghdad by Halaku Khan who ruthlessly ravaged the sanctity of the holy city and mercilessly butchered all the members of the ruling family except one Abbaside prince who could escape the terrible fate only because he was out of the capital at the time of great massacre. He was prince Abdul Qasim Ahmed who fled to Egypt accompanied by about ten of his faithful nobles. At that time the ruler of Egypt was Malik Zahir Rukun-ud-Din who welcomed the fugitive prince and settled him down respectably in Cairo.

In an attempt to re-conquer Baghdad in 660 A. H. Prince Abdul Qasim suffered a heavy defeat and was lost in the war. Few of those who returned alive form the battlefield included one Abbaside prince Abul Abbas Al-Hakim, who was direct descendant of the twenty fifth Abbaside Caliph, Al-Mansor-al-fazlal Abbasi and was later installed as the second Abbaside caliph in Egypt. He was followed by fourteen more Abbaside princes and thus the Khilafat continued for another 255 years when, in 945 A. H., the last Caliph of this dynasty, Al-Mutawakkil, died and the Caliphate was diverted to Benu Usman.

Destiny and History of Bahawalpur Pakistan Starts Here

The exodus of the Abbaside nobles of Egypt to India had already started in about 725 A. H., in the reign of Mohammad Tughlak-ben-Ghias-ud-din. In 767 A. H. (1366 A. D.) Amir Sultan Ahmed II Abbasi fifth in direct descent from Abdul Qasim Ahmed (The First Abbaside Caliph Installed in Egypt) migrated to India with his family members and a few hundred followers and entered into Sindh through Balochistan.

His entry was challenged by the then ruler of Sindh, Rae Shoring, who threatened war, but yielded to the Amir. In course of time the Amir's family gradually moved northward, loosing much of the Sindh territory, but finally settled down at Derawar and in the vicinity of the present city of Bahawalpur.

The rulers first owed allegiance to Afghanistan but on the fall of the Durrani empire which was followed by the expulsion of Shah Shuja from Kabul they assumed independence. The rulers of the State faithfully implemented the terms of the treaty signed in 1838 between the East India Company and Nawab Bahawal Khan III.

New Look Of The City

Aside past it is now a much more developed city of Pakistan. It has become a Mega city in terms of Real Estate, Parks, Markets and Institutions. All kinds of facilities are away just by a phone call.

Bahawalpur has a well maintained zoo which attracts the visitors to the City. Take a look at the new pictures of the City.

Newly designed home views. Bazaars look distinctive, embroidered cloths, slippers and the delicate locally made filigree pottery. Developed roads, environment and green belts make the city glorious.

Coordinates:	29°23′44″N 71°41′1″E
Country	Pakistan
Region	Punjab
District	Bahawalpur District
Tehsil	Bahawalpur Tehsil
Union councils	36
City Area	2,372 km^2 (916 sq. mi)
Elevation	461 m (1,512 ft.)
Population (2011)	
• **City**	855,509
• **Density**	838/km^2 (2,170/sq. mi)
• **Urban**	545,103
Time zone	PST (UTC+5)
• **Summer (DST)**	PDT (UTC+6)
Area code(s)	062
Website	www.bahawalpur.gov.pk/

Bahawalpur (Urdu, Urdu: بہاولپور), located in Punjab, is the twelfth largest city in Pakistan. The city was once the capital of the former princely state of Bahawalpur. The city was home to various Nawabs (rulers) and counted as part of the Rajputana states (now Rajasthan, India). The city is known for its famous palaces such as the Noor Mahal, Sadiq Ghar Palace, and Darbar Mahal, as well as the ancient fort of Derawar in the Cholistan Desert bordering India. The city is located near the historical and ancient cities of Uch and Harappa, which were once a stronghold of the Delhi Sultanate and Indus Valley Civilization. The city is home to one of the few natural safari parks in Pakistan, Lal Suhanra National Park.

In 2007, the city's population was recorded to have risen to 798,509 from 403,408 in 1998. Punjabi and Saraiki are the major languages of local people, while Urdu is well understood and English is the official languages used in various educational and government institutions. Bahawalpur is located south of the Sutlej River and lies in the Cholistan region near the Thar Desert. It is situated 90 km from Multan, 420 km from Lahore, and 270 km from Faisalabad.

The main crops for which Bahawalpur is recognized are cotton, sugarcane, wheat, sunflower seeds, rape/mustard seed and rice. Bahawalpur mangoes, citrus, dates and guavas are some of the fruits exported out of the country. Vegetables include onions, tomatoes, cauliflower, potatoes and carrots. Being an expanding industrial city, the government has revolutionized and give liberty to various markets, allowing the caustic soda, cotton ginning and pressing, flour mills, fruit juices, general engineering, iron and steel re-rolling mills, looms, oil mills, poultry feed, sugar, textile spinning, textile weaving, vegetable ghee and cooking oil industries to flourish.

Demographics

Bahawalpur is one of the largest districts of Pakistan covering an area of 24,830 km^2. It has peculiar demographic, topographic and geographical characteristics. The district is situated almost in the center of the country at an elevation of 152 meters from the sea levels. The population of Bahawalpur district increased from 1.453 million in 1981 to 2.411 million in 1998, showing a growth rate of 3.88% per year and population density has increased from 59 in 1981 to 97 in 1998. The majority of Bahawalpur's residents speak Punjabi and Saraiki, while Urdu, and English are common languages used in various educational and government institutions

Flora and fauna

The most commonly seen animals in the city include the hog deer, ravine deer, black buck and blue bull. Fox, jackals, hares, wild boars, porcupines, mongoose, arks, owls and hawks are also found in large numbers.

The Bahawalpur Zoo is located in Bahawalpur. Spread over an area of several acres inside the city, it contains a variety of animal species, including Asiatic lions, Bengal tigers, hyenas, leopards, and peacocks. The zoo has a collection of 130 animals and 700 birds from tropical regions, particularly those found in the Cholistan region. The zoo occasionally breeds and supplies animals to other zoos in the country. It also has an aquarium and zoological museum with stuffed rare birds and animals.

Located 35 kilometres east of the city is the Lal Suhanra National Park, housing large animals including lions and rhinoceros.

Economy

Irrigation from canals such as this provides the city with fertile soil for crop production.

Bahawalpur lies at the junction of trade routes from the east, south-east, and south. It is a center for trade in wheat, cotton, millet, and rice grown in the surrounding region. Dates and mangoes are also grown here. Canals supply water for irrigation. The principal industries are cotton ginning, rice and flour milling, and the hand weaving of textiles.

Soap making and cotton ginning are important enterprises; cotton, silk, embroidery, carpets, and extraordinarily delicate pottery are produced. Factories producing cottonseed oil and cottonseed cake were built in the 1970s. It is an important marketing center for the surrounding areas and is located on the crossroads between Peshawar, Lahore, Quetta and Karachi. Bahawalpur is also known for its distinctively embroidered slippers and shoes and filigree pottery.

Bahawalpur has only one railway bridge, the Adamwahan (Empress) Bridge, over the Sutlej River, and also has rail links with Peshawar, the capital of North-West Frontier Province and Karachi, the capital of Sindh (which is 899 km from Bahawalpur), making it an important rail center. The surrounding area is mostly agricultural, which allows agricultural exports to many parts of the world. There is also a large market town for mangoes, dates, wheat, sugarcane, and cotton that brings in continuous demand all year round. It has soap making and cotton spinning factories, as well as enterprises producing silk and cotton textiles, carpets, and pottery. Bahawalpur has sugar mills that provide some of the export market out of the country.

Punjab is Pakistan's most fertile province, rich in both agriculture and ancient history. It is also one of the more stable of the country's regions. The prosperous and hospitable town of Bahawalpur is a gentle introduction to the area, which makes the city an ideal tourist destination. From here one can journey into Cholistan - a sandy wasteland dotted with nomadic communities and windswept forts - or the Lal Suhanra National Park, an important wildlife reserve. Further north is Harappa, which is an important site of the Indus Valley Civilization. Bahawalpur is the most southerly town in the Punjab. There are daily flights from Islamabad about 555 km (344 mi) away. Most of the major destinations in the Punjab can be reached by car, bus, coach, and train. According to PSMA (Pakistan Sugar Mills Association about 22% of Sugar is produced in Bahawalpur division (including Bhawalnagar and Rahimyarkhan

Culture

The Cholistan Jeep Rally is held in the city every year in the Cholistan desert

Derawar Fort is on the outskirts of the city in the Cholistan Desert

The city of Bahawalpur has a rich heritage and is an important hot spot for historians as well as archeologists. Bahawalpur is known for its cotton, silk, embroidery, carpets, and extraordinarily delicate pottery. The Punjab Small Industries Corporation (PSIC) has established a Craft Development Center for Cholistan area, outside Farid Gate, Bahawalpur from where handicrafts manufactured in Cholistan can be purchased. Some of the souvenirs produced in the city include:

- Flassi - 4 ft. by 7 ft., made of camel hair and cotton yarn; it is used for wall hanging, as a decoration piece and a carpet.
- Gindi or Rilli - Made of small pieces of many colors of cotton cloth and needlework; they can be used as wall hangings, bed covers, carpets and blankets.
- Changaries - Like big plaques, these are made of palm leaves in different bright colors with beautiful patterns and geometric designs. These are used for keeping the 'chapattis' and also as a wall decoration.
- Khalti - Like a purse embroidered on top with multicolored threads.

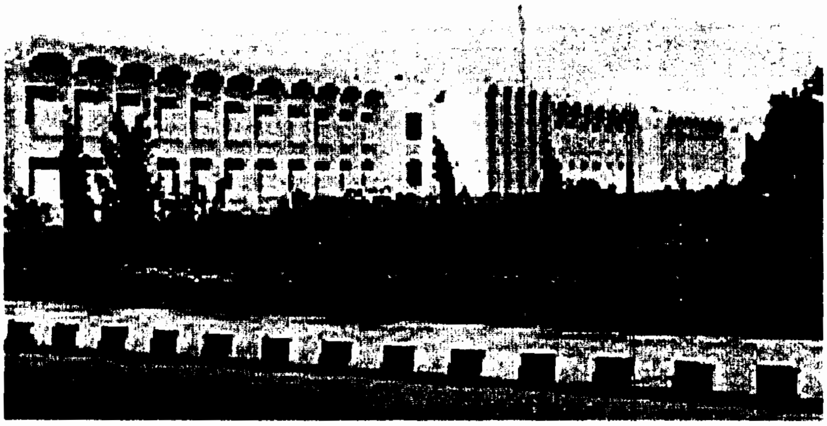
Artwork - An attractive type of embroidery done on dupatta, kurta and chaddar, etc. The main shopping centers of Bahawalpur are Shahi Bazaar, Machli Bazaar, Farid Gate and the Mall. The commercial area in Satellite Town is a newly developed center that is gaining popularity. A few shopping malls, including Bobby Plaza, Takbeer Shopping Mall, Time, and Prince, cater for all kinds of needs. Shopping is a major attraction in the city; the city is bustling with traders and craftsmen selling all sorts of artwork for travelers and tourists.

Noor Mahal lit at night after being newly renovated

East of Bahawalpur is the Cholistan Desert, which covers an area of about 15,000 km^2 and extends into the Thar Desert of India. The region was once watered by the Hakra River, known as the Saravati in Vedic times. At one time there were 400 forts in the area and archaeological finds around the Derawar Fort, the only place with a perennial waterhole, indicate that it was contemporaneous with the Indus Valley Civilization. The main tribes are the Chachar, Mehr, Lar, Paryar, Channar, Chandani and Bohar. The forts here were built at 29 km intervals, which probably served as guard posts for the camel caravan routes. There were three rows of these forts. The first line of forts began from Phulra and ended in Lera, the second from Rukhanpur to Islamgarh, and the third from Bilcaner to Kapoo. Built with double walls of gypsum blocks and mud, they are all in ruins now. Some of them date back to 1000 BC, and were destroyed and rebuilt many times.

The city also has several mausoleums of prominent leaders who fought and defended the region over several thousands of years. Some of the most prolific include the tombs of Channen Peer Tomb Yazman and Mausoleums of Haugha Sahib. There is also an old fort of Munde Shahid, 50 km from Bahawalpur and Marot Fort, which are considered to be antiquities. A place outside the Marot Fort is known as 'Baithak Maula Ali'. The tomb of Naugaza is located in the Munde Sharif Fort.

Education



Quaid-e-Azam Medical College, Bahawalpur designed by A. R. Hye

The city boasts a number of reputable educational establishments, most notably The Islamia University of Bahawalpur, Quaid-e-Azam Medical College, and Sadiq Public School, which is one of the largest boarding schools in Pakistan. Other top schools include Beacon house School Bahawalpur, The City School (Pakistan), Bloomfield Hall Schools, Askari Kids College, Umm al Qura school, Progressive Schooling System, Dar e arqam School, Jinnah Public School, Rangers Public School and College, The Climber Public School, Army Public School, Salsaal Public School, and Dominican Convent School. Notable universities and colleges include: Government Sadiq Egertin College (Post Graduate College),Punjab College Bahawalpur, Arrshhouse College, Government Degree College, Government Sadiq Degree College for Girls, The Islamia University of Bahawalpur, Government College of Technology, Government Sadiq College of Commerce, Government Polytechnic Institute, Government Polytechnic Institute For Women, Government Technical Training Institute, Government Technical High School Bahawalpur, Allama Iqbal College of Commerce and Government Para Medical School.

Transport

Bahawalpur is well connected with various cities in Pakistan. The city has its own airport built by the Dubai Civil Aviation Department and the CAA. Bahawalpur Airport links the city with various Pakistani cities such as Dera Ghazi Khan, Islamabad, Karachi and Lahore with the national flag carrier, Pakistan International Airlines. The airline has launched international flights to Dubai, and plans to introduce more international destinations. There is daily train and bus services from Multan, Lahore, Sukkur and Karachi to Bahawalpur, taxicabs and rickshaws are plentiful in the city. Cars are also available for hire in the city.

Cholistan Desert

Cholistan Desert (Urdu: چولستان صحرائے, also locally known as *Rohi*) sprawls thirty kilometers from Bahawalpur, Punjab, Pakistan and covers an area of 26,300 km^2. It adjoins the Thar Desert extending over to Sindh and into India.

The word Cholistan is derived from the Turkish word Chol, which means Desert. Cholistan thus means Land of the Desert. The people of Cholistan lead a semi-nomadic life, moving from one place to another in search of water and fodder for their animals. The dry bed of the Hakra River runs through the area, along which many settlements of the Indus Valley Civilization have been found.

The Desert also has an Annual Jeep Rally, known as Cholistan Desert Jeep Rally. It is the biggest motor sports event in Pakistan Culture and traditions

Local Dialect

The language of Cholistan also reflects a number of features of its historical and geographical background. The Saraiki language is an Indo-Aryan language of the Lahnda languages group, and is spoken in Cholistan as well as in a large part of central Pakistan. Though once a considered a dialect of Punjabi, it is considered a separate language now. One of the chief authors in the Saraiki language is Khwaja Ghulam Farid, a polyglot Sufi poet, who helped develop Saraiki's poetics. The Saraiki community diffused when Saraiki-speaking Hindus migrated to the neighboring Indian states of Bikaner and Jaisalmer during Partition and were replaced by Urdu-speaking Muslim refugees from India. However, since the majority of Urdu-speakers settled in the cities and few settled in rural Cholistan, the countryside maintains a strong Saraiki community.

Arts and crafts

In a harsh and barren land where rainfall is very sparse and unreliable, Cholistanis rely mainly on their livestock of sheep, goats, and camel. However in cold nights of winter they huddle indoor and engage themselves in various arts and crafts such as textiles, weaving, leatherwork, and pottery.

Local crafts

As mentioned above, the Indus Valley has always been occupied by the wandering nomadic tribes, who are fond of isolated areas; as such areas allow them to lead life free of foreign intrusion, enabling them to establish their own individual and unique cultures. Cholistan till the era of Mughal rule had also been isolated from outside influence. During the rule of Mughal Emperor Akbar, it became a proper productive unit. The entire area was ruled by a host of kings who securely guarded their frontiers. The rulers were the great patrons of art, and the various crafts underwent a simultaneous and parallel development, influencing each other. Mesons, stone carvers, artisans, artists, and designers started rebuilding the old cities and new sites, and with that flourished new courts, paintings, weaving, and pottery. The fields of architecture, sculpture, terra cotta, and pottery developed greatly in this phase.

Livestock

The backbone of Cholistan economy is cattle breeding. It has the major importance for satisfying the area's major needs for cottage industry as well as milk meat and fat. Because of the nomadic way of life the main wealth of the people are their cattle that are bred for sale, milked or shorn for their wool. Moreover, isolated as they were, they had to depend upon themselves for all their needs like food, clothing, and all the items of daily use. So all their crafts initially stemmed from necessity but later on they started exporting their goods to the other places as well. The estimated number of livestock in the desert areas is 1.6 million.

Cotton and wool products

Cholistan produces very superior type of carpet wool as compared to that produced in other parts of Pakistan. From this wool they knit beautiful carpets, rugs and other woolen items. This includes blankets, which is also a local necessity for the desert is not just a land of dust and heat, but winter nights here are very cold, usually below freezing points. Khes and pattu are also manufactured with wool or cotton. Khes is a form of blanket with a field of black white and pattu has a white ground base. Cholistanis now sell the wool for it brings maximum profit.

Textiles

It may be mentioned that cotton textiles have always been a hallmark of craft of Indus valley civilization. Various kinds of khaddar-cloth are made for local consumption, and fine khaddar bedclothes and coarse lungies are woven here. A beautiful cloth called Sufi is also woven of silk and cotton, or with cotton wrap and silk wool. Gargas are made with numerous patterns and color, having complicated embroidery, mirror, and patchwork. Ajrak is another specialty of Cholistan. It is a special and delicate printing technique on both sides of the cloth in indigo blue and red patterns covering the base cloth. Cotton turbans and shawls are also made here. Chunri is another form of dopattas, having innumerable colors and patterns like dots, squares, and circles on it.

Camel products

Camels are highly valued by the desert dwellers. Camels are not only useful for transportation and loading purposes, but its skin and wool are also quite worthwhile. Camel wool is spun and woven into beautiful woolen blankets known as falsies and into stylish and durable rugs. The camel's leather is also utilized in making kuppies, goblets, and expensive lampshades.

Leatherwork

Leatherwork is another important local cottage industry due to the large number of livestock here. Other than the products mentioned above, Khusa (shoes) is a specialty of this area. Cholistani khusas are very famous for the quality of workmanship, variety, and richness of designs especially when stitched and embroidered with golden or brightly colored threads.

Jewelry

The Cholistanis are fond of jewelry, especially gold jewelry. The chief ornaments made and worn by them are *Nath* (nose gay), *Katmala* (necklace) *Kangan* (bracelet), and *Pazeb* (anklets). Gold and silver bangles are also a product of Cholistan. The locals similarly work in enamel, producing enamel buttons, earrings, bangles, and rings.

Love for colors

The great desert though considered to be colorless and drab, is not wholly devoid of color. Its green portion plays the role of "color belt" especially after rains when vegetation growth is at its peak. Adding to that the locals always wear brightly colored clothes mostly consisting of brilliant reds, blazing oranges shocking pinks, and startling yellows and greens. Even the cloth trappings of their bullocks and camels are richly colored and highly textured.

Terra Cotta

The Indus Civilization was the earliest center of ceramics, and thus the pottery of Cholistan has a long history. Local soil is very fine, thus most suitable for making pottery. The fineness of the earth can be observed on the Kacha houses which are actually plastered with mud but look like white cemented. The chief Cholistani ceramic articles are their surahies, piyalas, and glasses, remarkable for their lightness and fine finishing.

In the early times only the art of pottery and terracotta developed, but from the seventh century onwards, a large number of temples and images were also built on account of the intensified religious passions and the accumulation of wealth in cities. The building activity reached to such an extent that some cities actually became city temples. In fact the area particularly came to be known for its forts, villas, palaces, havelis, gateways, fortifications, and city walls

2014

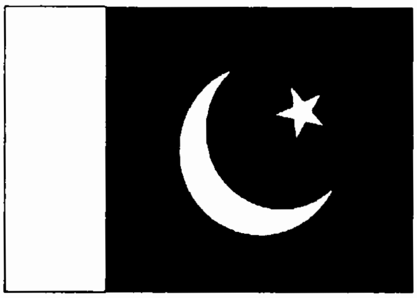
10 MW Solar PV Power Project in Quaid E Azam Solar Park Feasibility Study Report

Volume 2

Main Report – Part 2

WK WELT KONNECT

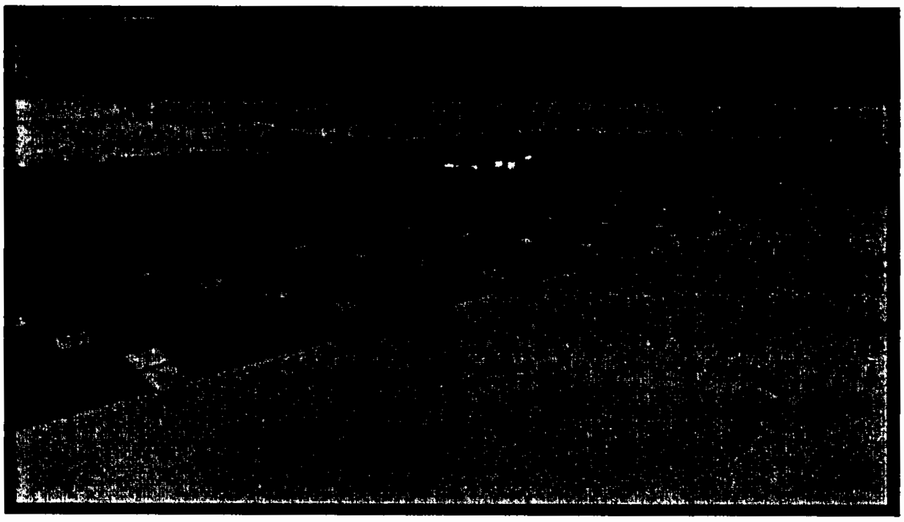
By



Feasibility Study Report

10 MW Solar PV Power Project in Quaid E Azam Solar Park

February, 2014



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Main Report - Part 2

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WELT KONNECT (PVT) LTD

WELT KONNECT

Driving You Into The Future

APPROVAL SHEET

TITLE : Feasibility Report
10 MW Solar Power Project in Quaid E Azam Solar Park, Cholistan

DOCUMENT NUMBER : 01-0786-02

CLASSIFICATION : **Un-Classified**

SYNOPSIS

This document is a feasibility study report of 10 MW Solar PV Power Project and is divided into 7 Volumes for ease of review and approvals.

Volume 1: Main Report Part 1: of this report contains detailed information regarding the geographic features of Pakistan, along with the insight to Pakistan's Energy and Electricity market. After discussing the solar energy industry and carbon credit details for information purposes, the volume focuses on mentioning the regulatory regime of the country that is applicable to the project and all legal requirements. The volume also summarizes the salient features of the project.

Volume 2: Main Report Part 2: of the report focuses entirely on the specific details of the project. It provides information on the selected site, the description of the technical equipment and the layout of plant. The report further includes the basis for calculations and designing, by giving details of the grid connections available and yield of power. Prior to conclusion, the report also gives details of the policies and procedures for O&M, Project Management, and tariff calculation. The report concludes with details of the ecological and socio-economic benefits of the project.

Volume 3: Geo-Technical Study Topographic Survey: of the Project Site, with detailed analysis.

Volume 4: Geo-Technical Investigation Report: for the Project Site, including Soil Testing

Volume 5: Environmental Study: contains the Initial Environmental Examination Report (IEE), the Environmental Impact Assessment Report (EIA), and the No Objection Certificate (NOC) for the project issued by the Environmental Protection Agency (EPA) of Punjab.

Volume 6: Grid Interconnection Study being developed by National Transmission Dispatch Company (NTDC) and to be submitted separately.

DATE: 19^{th} February 2014

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9	Engineering Electrical Power Systems	Riaz Ahmed	Electronics Engineer	MAJ (Retd.) Riaz Ul Hassan
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APPROVED BY: CEO Ms. Afshan Mir

Revisions

S #	REV. #	DATE	VOL #	SECTION	DESCRIPTION OF CHANGE

DISTRIBUTION

1. Alternative Energy Development Board (AEDB)
2. Panel of Experts Assembled by AEDB
3. Welt Konnect Pvt Ltd

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

LIST OF ABBREVIATIONS

AC	Alternate Current
AEDB	Alternative Energy Development Board
Approx.	Approximately
ASL	Associated Surveyors (Pvt)Ltd
BM	Build Margin
BOO	Build Own and Operate
BOR	Board of Revenue
Bwp	Bahawalpur
CAA	Civil Aviation Authority
CCGT	Combined Cycle Gas Turbine
CDA	Cholistan Development Authority
CDM	Clean Development Mechanism
CDMA	Code division multiple access
CERs	Certified Emission Reductions
CM	Combined Margin
CMA	Certified Management Accountant
CNG	Compressed natural Gas

CO2	Carbon dioxide
COD	Commercial Operational Date
CoP	Conference of the Parties
CPPA	Central Power Purchasing Agency
CPV	Concentrator photovoltaic
DC	Direct Current
deg	Degree
DG	Diesel Generator
DGPs	Dual Global Positioning System
DISCOs	Distribution Companies
DNA	Designated National Authority
DOE	Designated Operational Entity
DSSC	Dye-Sensitized Solar Cells
EE	Energy Efficiency
EF_y	Baseline Emission Factor
EIA	Environmental Impact Analysis
EMC	Electromagnetic Compatibility
EMP	Environment Plan

EPA	Energy Purchase Agreement
EPC	Engineering Procurement Construction
EPIA	European Photovoltaic Industry Association
EU	European Union
FDI	Foreign Direct Investment
FSR	Feasibility Study Report
GDP	Gross Domestic Product
GENCOs	Generation Companies
GHG	Green Gas
GIS	Geographic Information System
GoP	Government of Pakistan
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GTZ/GIZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HCA	Host Country Approval
HFCs	Hydro Fluorocarbons
HOMER	Hybrid Optimization Model for Electric Renewables
HSE	Health Safety and Environment

HSHD	Hard Surface High Duty
Hz	Hertz
IA	Implementation Agreement
IDC	Interest During Construction
IEA	International Energy Agency
IEE	Initial Environmental Examination
IEEE	Institute of Electrical and Electronic Engineers
IFC	International Finance Cooperation
IPPs	Independent Power Producers
IRR	Internal Rate of Return
JEDI	Jobs and Economic Development Impact
JI	Joint Implementation
JRC	European Joint Research Centre
Km	Kilometer
KV	Kilovolt
KW	Kilowatt
LIBOR	London Interbank Offered Rate
LNG	Liquefied Natural Gas

LNG	Liquefied Natural Gas
LOI	Letter of Intent
LOS	Letter of Support
LPG	Liquefied Petroleum Gas
LUC	Local Control Unit
m^2	Meter Square
m^3/h	Meter cube per hour
MEPCO	Multan Electric Power Company
mm	Millimeters
mmcft	Million Cubic Feet
MoU	Memorandum of Understanding
MTDF	Medium Term Development Framework
MVA	Million Volt-Ampere
MW	Megawatt
N_2O	Nitrous Oxide
NAPWD	Northern Area Public Works Department
NASA	National Aeronautics and Space Administration
NCS	National Conservation Strategy

NEC	**National Energy Conservation**
NEPRA	**National Electricity Power Regulatory Authority**
NEQs	**National Environmental Quality Standards**
NGOs	**Non-Government Organizations**
NOCs	**No Objection Certificate**
NOCT	**Nominal Operating Cell Temperature**
NREL	**National Renewable Energy Laboratories**
NTDC	**National Transmission and Dispatch Company**
O & M	**Operation & Management**
OECD	**Organization for Economic Cooperation and Development**
OEMs	**Original Equipment Manufacturer**
OHL	**Overhead Lines**
OLTC	**On-Load Tap Changer**
OM	**Operating Margin**
OPV	**Organic photovoltaic**
OSHA	**Occupational Safety and Health Administration**
PAEC	**Pakistan Atomic Energy Commission**
PAEC	**Pakistan Atomic Energy Commission**

PCM	Pulse Code Modulation
PCRET	Pakistan Council of Renewable Energy and technology
PDD	Project Design Document
PEPA	Pakistan Environment Protection Act
PINs	Project Idea Note
PLC	Programmable Logic Control
PMD	Pakistan Meteorological Department
POE	Panel of Experts
PPDB	Punjab Power Development Board
PPIB	Private Power Infrastructure Board
PV	Photo Voltaic
PVC	Poly Vinyl Carbonate
QC	Quality Control
R & D	Research and Development
RE	Renewable Energy
RE2	Renewable Resources (Pvt) Ltd
RFP	Request for Proposal
RFQ	Request for Quotation

RMP	Risk Management of Project
ROC	Return on Capital
ROE	Return on Equity
RQD	Rock Quality Designation
SECP	Security Exchange of Pakistan
SHYDO	Sarhad Hydro Development Organization
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
SRA	Solar Resource Assessment
SRO	Statutory Regulatory Order
TGP	Three Gorges Project
TOE	Tons Oil Equivalent
tsf	Tones/square foot
TTG	Trans Tech Group
TTP	Trans Tech Pakistan
UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptible Power Supply
USA	United States of America

WAPDA	**Water & Power Development Authority**
WK	**Welt Konnect (Pvt) Ltd**
WMO	**World Metrological Organization**

ACKNOWLEDGMENTS

We would like to express our gratitude to the support and cooperation extended by the Government of Punjab and the Federal Government of Pakistan in the development activities of the project.

We are also thankful to the dedicated team of the Punjab Power Development Board (PPDB) and the Alternative Energy Development Board (AEDB) for the generous support throughout all stages of project development.

We hope for and look forward to the continued cooperation of all relevant Government Organizations, Bodies and officials for further advancement in implementing the Project and pioneering the way for Solar Photo Voltaic in Pakistan.

DISCLAIMERS

This document is intended for use by the Stake Holders and relevant Government Authorities for understanding and effective decision making regarding this Project.

The Company and the sponsors are and will not be responsible for any decision made by the intended or unintended users for any other purpose except in relation to this project.

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Further, this is not intended to be a business or operational plan for the project.

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DOCUMENT INFORMATION

Purpose and Scope:

The purpose of this report is to provide information required for the relevant agencies to make informed decision regarding the implementation and execution of this project.

This document presents the technical, financial and commercial viability of this project within Pakistan's economic and regulatory framework.

STRUCTURE OF THE DOCUMENT:

The Feasibility Study has been divided into 2 main parts/volumes followed by supporting Volumes 3 to 6 composed of essential studies:

- Volume 1: is composed of the Executive Summary, Introduction and Overview of the Project along with the relevant regulatory framework and policies. Where as
- Volume 2: contains the Technical and Financial Studies: including Engineering Drawings and Plant 3D layout.
- Volume 3: is composed of the Geo-Technical Study Topographic Survey.
- Volume 4: is the Geo-Technical Investigation Report.
- Volume 5: is a compiled Environmental Study.
- Volume 6: is the Grid Interconnection Study being developed by the National Transmission Dispatch Company (NTDC) and to be submitted separately.

Each Volume is further sub-divided into chapters for ease of reviewing and understanding the project. Information in the document is supplemented by Annexures attached at the end of each volume.

EXECUTIVE SUMMARY OF THE PROJECT

The Government of Pakistan has developed a Renewable Energy Policy to encourage the private sector investments towards development of renewable energy solutions in the country. The Alternative Energy Development Board (AEDB) has been established within the Government to facilitate the implementation of such renewable energy projects.

Whereas Safe Solar Power (Pvt.) Ltd. ("Safe Solar Power" or the "Project Sponsor") has been established with the purpose of setting up a 10 MW Solar Power Plant as an IPP under the Government of Pakistan Renewable Energy Policy. Safe Solar Power is incorporated under the laws of Pakistan under the Companies Ordinance, with its head office in Islamabad.

Safe Solar intends to enter into an Engineering, Procurement and Construction ("EPC") agreement for the construction and installation of the equipment on a turnkey basis. The Project also intends to enter into Operations and Maintenance ("O&M") agreement to manage the Project on a day to day basis.

Safe Solar Power intends to enter into a 25-year Power Purchase Agreement ("PPA") with National Transmission & Dispatch Company Limited ("NDTC"). The PPA is expected to be signed under the Alternative Energy Development Board's Renewable Energy Policy of 2006 extended in 2012. Tariff for generation based incentive is expected to be negotiated with National Electric Power Regulatory Authority ("NEPRA"), as an upfront tariff.

Whereas Welt Konnect (Pvt) Ltd (a subsidiary of the Transtech Group) is a Power Projects Developing company working in Pakistan, working as a consultant on this project. Its niche in the Energy Sector lies in the provision of Renewable Energy Engineering solutions particularly for Wind & Solar Power Projects as Independent Power Producers (IPP's) under the Clean Development Mechanism of the UNFCCC. These integrated solutions and systems are designed, simulated and tested by its team of experts and engineers' using the most advanced software's and tools the industry has to offer at this time. WK believes in doing top quality engineering works and takes immense pride in being one of the few companies in Pakistan to have achieved this level of competence in the ever growing and critical field of Renewable Energy.

Whereas the Project Site is located near the Cholistan Desert, District Bhawalnagar, with nearest city of Bahawalpur and will have an installed capacity of 10MWp

Photovoltaic Panels and will function as an Independent Power Producer (IPP) under the rules and regulations of Pakistan.

The project pre-feasibility study was completed by end of 2013. Subsequently after submission of the Pre-Qualification Documents, to the Alternative Energy Development Board (AEDB) along with the Project Proposal, the required Bank Guarantees of 5'000.USD (five thousand) and the requisite fees, the sponsor successfully obtained an LOI (Letter of Intent) from the Board.

Teams were then immediately deployed to initiate work on the feasibility analysis of the project, and competent teams of Engineers & Specialists were deployed for conducting the various requisite studies.

The Project Sponsor is now submitting the final Feasibility Study along with this Volume 1, for approval by the Panel of Experts (POE) of AEDB. After sanctioning of which competent companies in the field of Solar Photovoltaic's will be selected through a Short Listing Criteria based on Experience, Financial And Technical Competencies of such firms in development & construction of Power Projects and Project Management, which shall be advertised in the News Papers & other relevant media. Consequently the Request for Proposal (RFP) shall be circulated and shared amongst the qualifying companies for finalization of the Engineering Procurement & Construction (EPC) Contract after which a petition for Generation License and a petition for Feed In Tariff would simultaneously be filed with the National Electric Power Regulatory Authority (NEPRA) as allowed under their policy, before issuance of the LOS (Letter Of support) by AEDB. This is intended to save time and cut through avoidable red tape in the development of Independent Power Producers in Pakistan.

The Sponsor has also completed substantial work on the financial modeling for the project. The Sponsor believes that keeping in view the recent improvement and trend in the viability of the technology, possibility of fast track implementation by virtue of the recently announced Feed In Tariff regime by NEPRA and current energy crises, this project is of paramount importance for Pakistan and will prove to be a pioneer in the Solar PV industry, paving the way for future progress in this ever growing field and at the same time provide a viable profitable investment opportunity to all stake holders of the country.

1. SITE INFORMATION

1.1 Geographic location, coordinates

The complete region of Pakistan falls in the "sunbelt" region of the globe. The rise in interest of international PV industry in the region is due to its geographical location on the whole and the natural advantages as compared to other regions. As per NREL solar resource maps provided below in Fig 10.1.1 solar resource map for Pakistan, the average solar irradiation in Pakistan varies from 3.5 – 7 kWh/m^2 per day while Germany witnesses a variation of 2.5 – 3.2 kWh/m^2. These results reinforce the confidence of the members and stake holders of the solar Industry as a whole and Project Developers along with Project Sponsors towards the feasibility and Profitability of such ventures in the Solar Resource rich country of Pakistan. Using these statistics and information at hand as a guide, all site selections were done to target the maximum availability of solar irradiation.

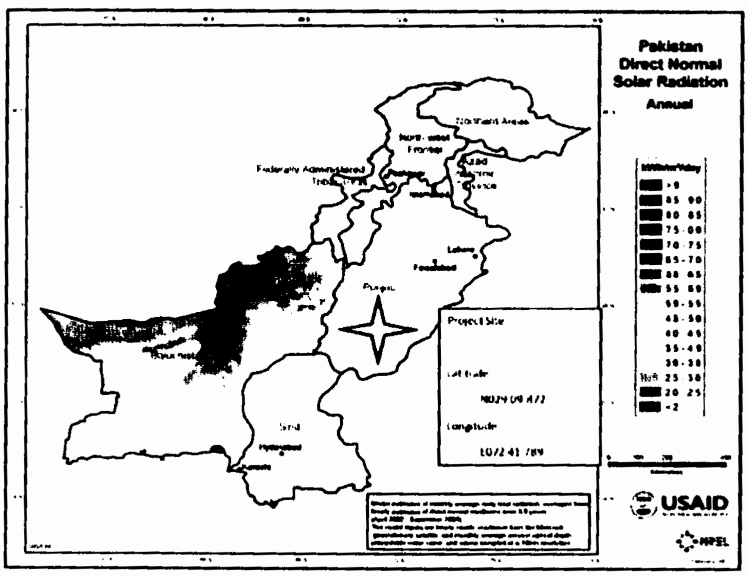


Figure 1.1.1: Pakistan Solar Irradiation Map

With the joint efforts of the Punjab Government, 4 suitable sites were short listed and identified in Cholistan, towards Southern Punjab with presence of the required minimum infrastructure, high irradiation levels and solar potential. Comprehensive due diligence was carried out by experts and representatives from all stakeholders of the project, which was followed by a review and selection procedure.

The site selected encompasses an area of 50 Acres which is approximately 10 km from Bahawalpur (the nearest urban city).

Project Site location is present in Figure **1.1.2**.

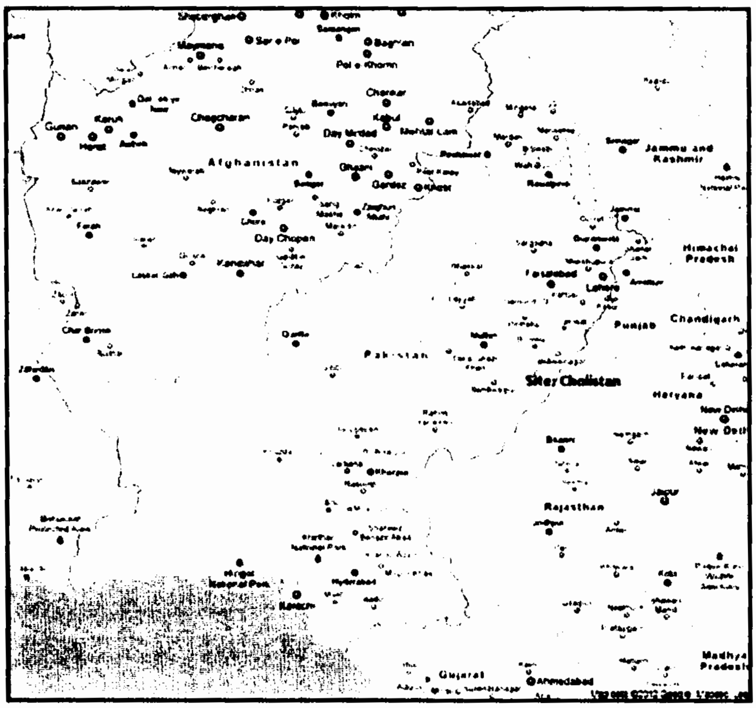


Figure 1.1.2: Project Site Overview

[redacted]

Node	Longitude (East)	Latitude (North)
1	E 71° 49.291	N 29° 18.836

The location enjoys a flat terrain with sand dunes in the peripheral, scarce plant cover, rich solar irradiation, availability of water, nearby Government Guest houses and immediate access to the power grid at about 4km, thus rendering itself an appropriate location for the setup of a large solar power station

1.2 Data Collection – NREL Meteorological Stations And NRG Solar Resource Assessment Data Logger and Software

As a generally accepted best practice, real time data collection and ability to forecast uniquely for every selected site is considered to make the study more bankable and further serve the purpose of Project Developers, Sponsors and other stake holders; as reliable short-term and day-ahead forecasting will increase penetrations of grid-tied PV systems.

Currently there are no operational solar resource forecasts being implemented for solar power project sites in Pakistan, although several approaches for implementing forecasting procedures have been explored. In Europe the development of reliable 1- to 3-day-ahead forecasts is underway by several institutions, and some operational forecasts are being used in a limited basis. **Figure 1.2.1** shows the meteorological stations map prepared by NREL showing the available 12 stations in Pakistan, whose data was used in preparation of the NREL Irradiation Map for Pakistan and other studies.

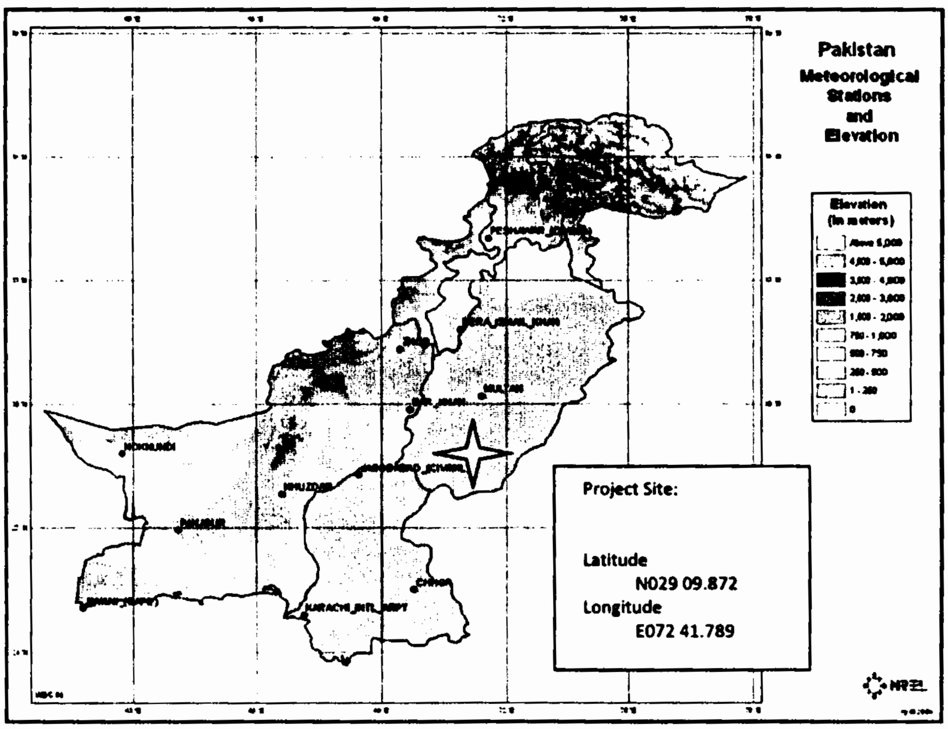


Figure 1.2.1: Pakistan Meteorological Stations and Elevation

Synthetic Data was also collected from renown resources such as NASA Meteorological Data Resource Center (provided in Annex 10), which was used in further simulations for calculations of the Yield Potential.

In compliance with Best Industry Practices Data was also procured from Meteonorm, one of Europe's most reliable Meteorological Forecasting and Data recording company, and is provided further in detail in section 1.17.

The need for assessing the Project Site with Specialized Solar Resource Measurement Equipment was identified along with various other site evaluation studies which were to be undertaken.

This step was taken for the reason that although currently there does exist some reasonable data of large and medium spatial scale of the solar resource in the region of Pakistan, the resolution of the information in many ways is inadequate for distributed PV analyses. For example, high-quality ground measurement stations that can provide adequate time series information (15-minutes or less) are very limited in number, and many locations around the area are not represented by any ground measurements at all.

The assessment of current information and its comparison to secondary sources also shows that there is no reliable operational short-term solar resource forecasting (1 to 3 days ahead) available to system operators and utilities (at the moment in time) for better understanding of dispatching and load following predictions of distributed PV systems.

Therefore as a solution and to counter such problems the Solar Resource Assessment equipment manufactured by NRG Systems USA was installed on site, Vermont with Data Logger Model # 4941 (**Fig. 10.2.2** NRG Symphonie Plus3 Data Logger Installed and Connected).

The Solar Resource Assessment System from NRG Systems is specifically designed for professional use having the following benefits:

- Quick and repeatable deployment
- Easy and autonomous off grid operation and
- Provision of bankable data.

The system is comprised of proven products including the NRG Systems Symphonie*PLUS*3™ data logger, iPackGPS communications modules (GSM, CDMA, and Satellite), SDR software, meteorological tower components, and reliable sensors. NRG Systems resource assessment equipment is currently being used on all continents and across 145 countries and has a proven track record of delivering, one of the reasons for which it was chosen by the technical teams.

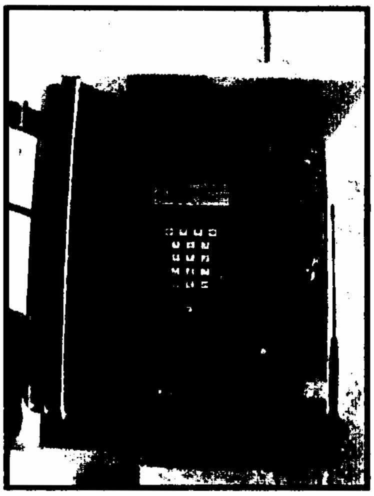


Figure 1.2.2: NRG Symphonie Plu3 Data Logger Installed and Connected prior to erection of equipment

The instrument was initially run and tested by the competent Engineers at office followed by on field testing and commissioning, which was conducted & performed using the appropriate methods and instructions provided by NRG and in accordance with Industry Best Practices, before installation was completed.

These instructions and the accompanying formats, check lists and analysis sheets are provided **in Annexure 1:** *Data Sheets for office and field testing of Data Logger.*

A complete set of readings and observations up to date from the instrument have been recorded and tabulated in **Annexure 2:** *Data Readings from NRG Solar Resource Assessment software and Data Logger.*

Data sheets (including visuals) of each individual component of the instrument are available in **Annexure 3:** *Data Sheets for sensors & Instrument on NRG Solar Assessment Instrument and Data Logger.*

The complete installed setup at the project site comprises the following sensors listed in Table 1.2.1. The resulting data is transmitted via Telenor GSM Networks and recorded & analyzed by Engineers at the project office:

CHANNEL / COMPONENT	*SENSOR INFORMATION*	*UNITS*
Data Logger	*Model # 4941; Serial # 369*	-
Site Information	*Site # 786; Site Elevation 145*	-
Channel 4	*LI-COR Pyro*	W/sqm
Channel 5	*Nova Lynx Rain*	Mm
Channel 6	*LI-COR Pyro*	W/sqm
Channel 8	*NRG 200P Vane*	Deg
Channel 9	*NRG 110S Temp*	C

Table 1.2.1: Channels, Sensor Information and Measurement Units of NRG Instrument at Site

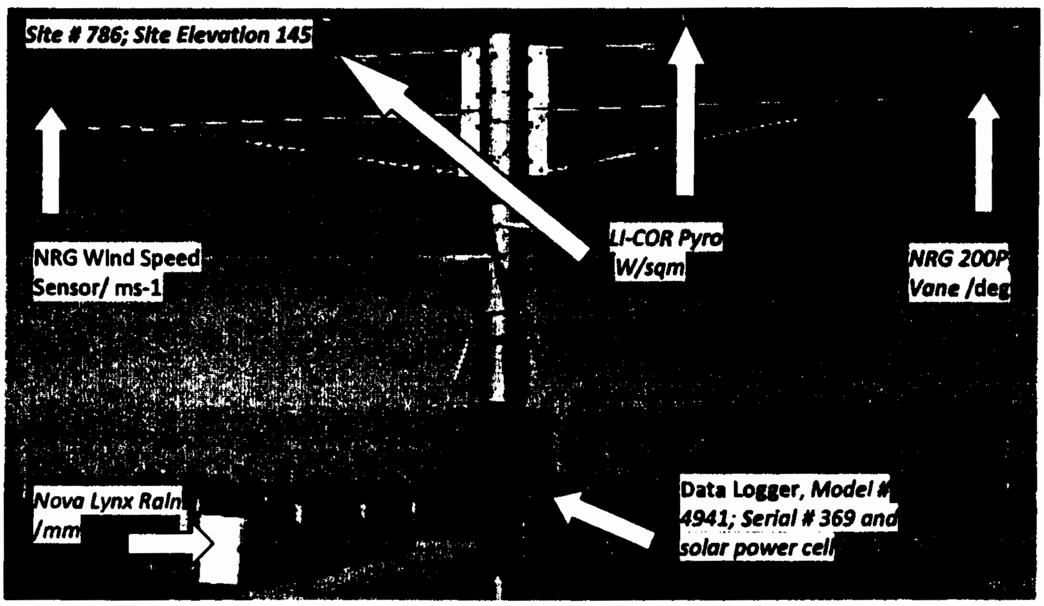


Figure 1.2.3: SRA from NRG Installed and Commissioned on site with all sensors installed

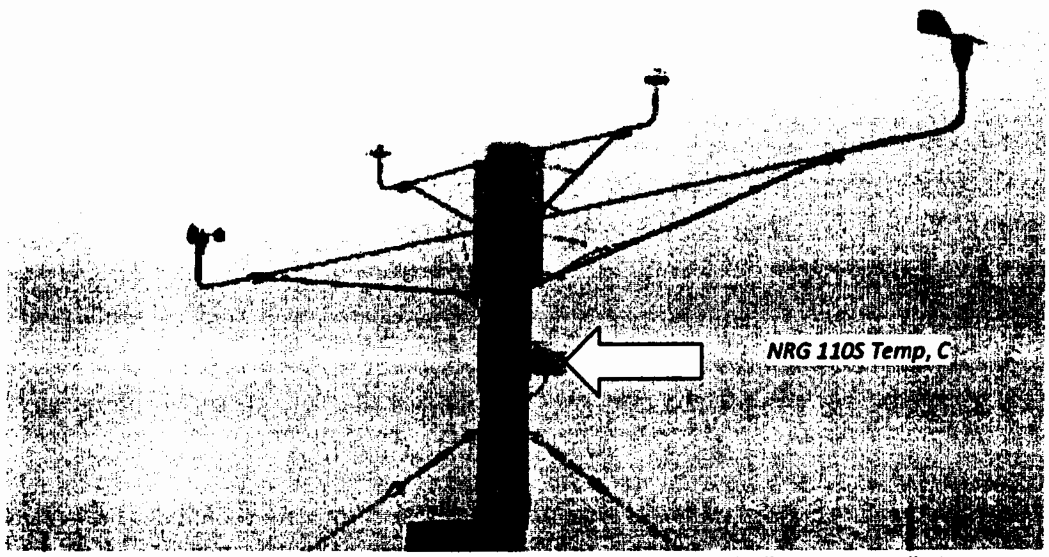


Figure 1.2.4: SRA from NRG Installed and Commissioned on site with all sensors installed

Below you will find **Figure 1.2.5** which represents the data collected for Wind direction (deg) using wind vane installed with NRG Data Logger at the site. The graph shows wind direction being consistent in two directions, with minor deflections on a few days.

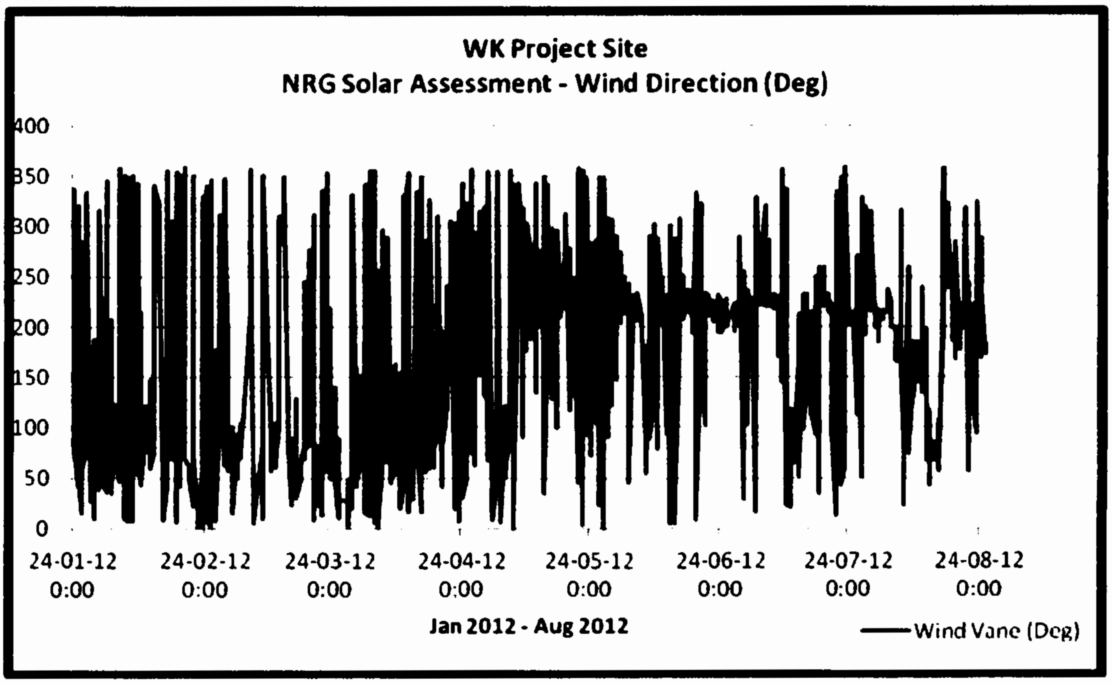


Figure 1.2.5: Primary data collected for Wind direction (deg) using NRG 200P wind vane

In **figure 1.2.6** provided below you will find the data collected for Direct Solar Radiation (W/sqm) using two Li-COR Pyranometers installed with the NRG Symphonies Plu3 Data Logger at the site. The graph shows the intensity of the Solar Radiation (is a measure of solar irradiance over of period of time - typically over the period of a single day) to be consistent throughout the season of Jan – Mar. The graph displays unique data measured at site with maximum accuracy that has been used in all calculations. Similarly correlating this data and further recordings will help us develop forecasts for the operations of the project.

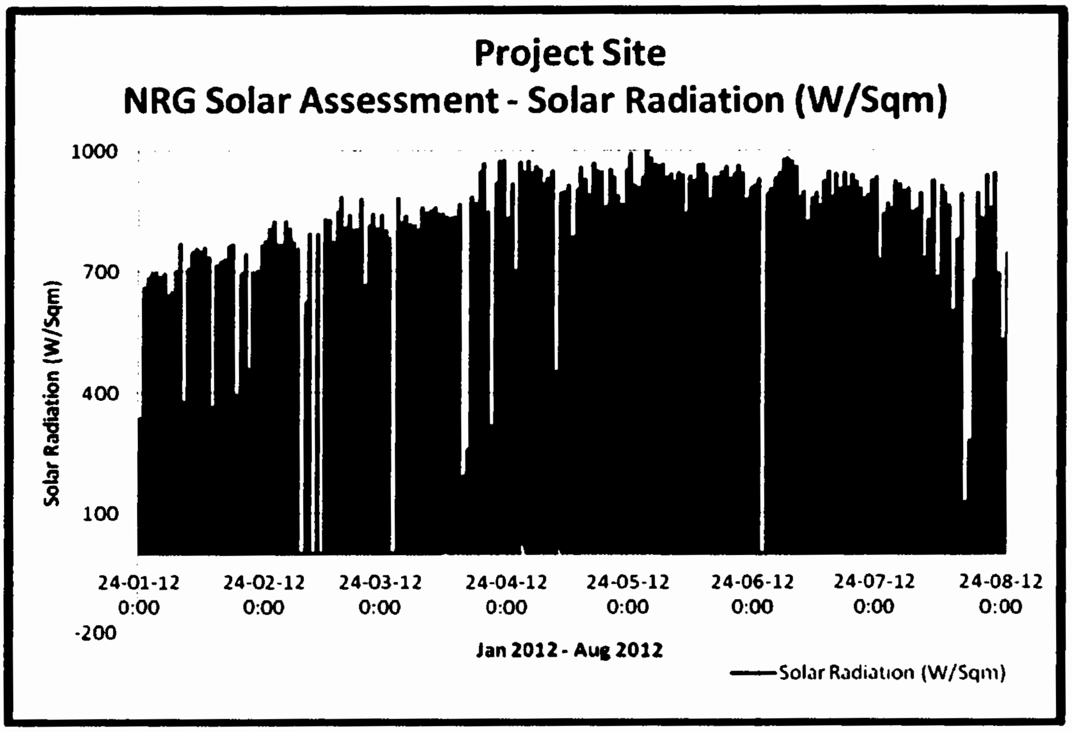


Figure 1.2.6: Primary data collected for **Average** Solar Radiation (W/Sqm) using Li-COR Pyros

In **Figure 1.2.7** provided below you will find the data collected for Temperature (^{0}C) using NRG 110s Sensor attached to the Solar Resource Assessment Equipment. The graph shows the temperature to follow a consistent flow throughout the season of Jan – Mar. The graph displays unique data measured at site with maximum accuracy that has been used in all calculations and signifies the continuous efficiency that will be obtained from the PV panels installed at the project site.

Similarly correlating this data and further recordings will help us develop forecasts for the operations of the project.

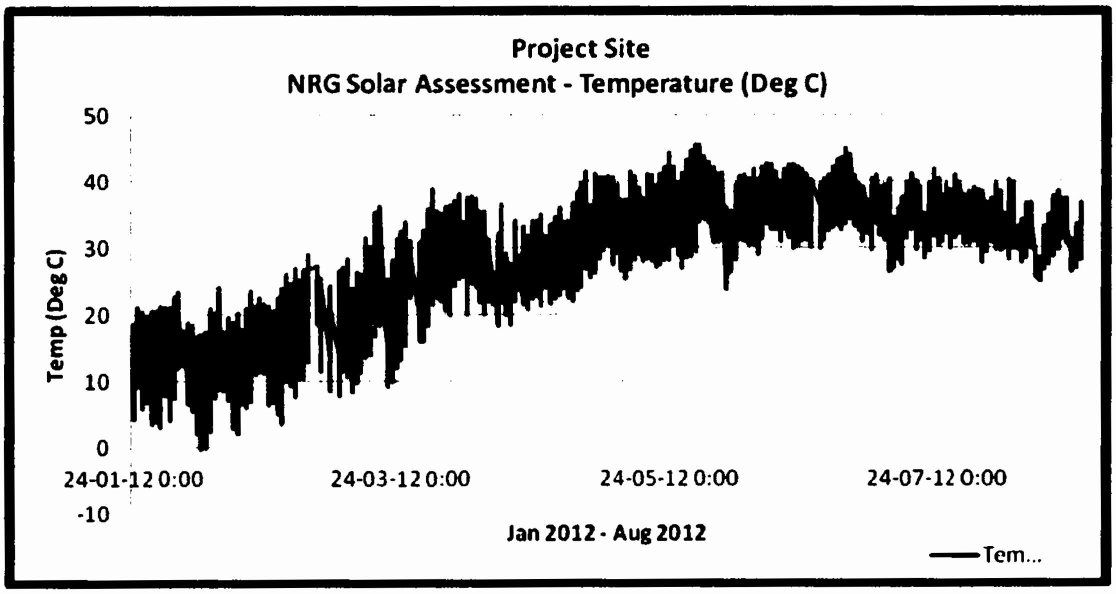


Figure 1.2.7: Primary data collected for Temperature (°C) using NRG 110s sensor

It is worth mentioning here that since the installation of the SRA on Site the readings recorded are on zero as it has not rained since then and from the past meteorological data it is evident that it might not throughout the year.

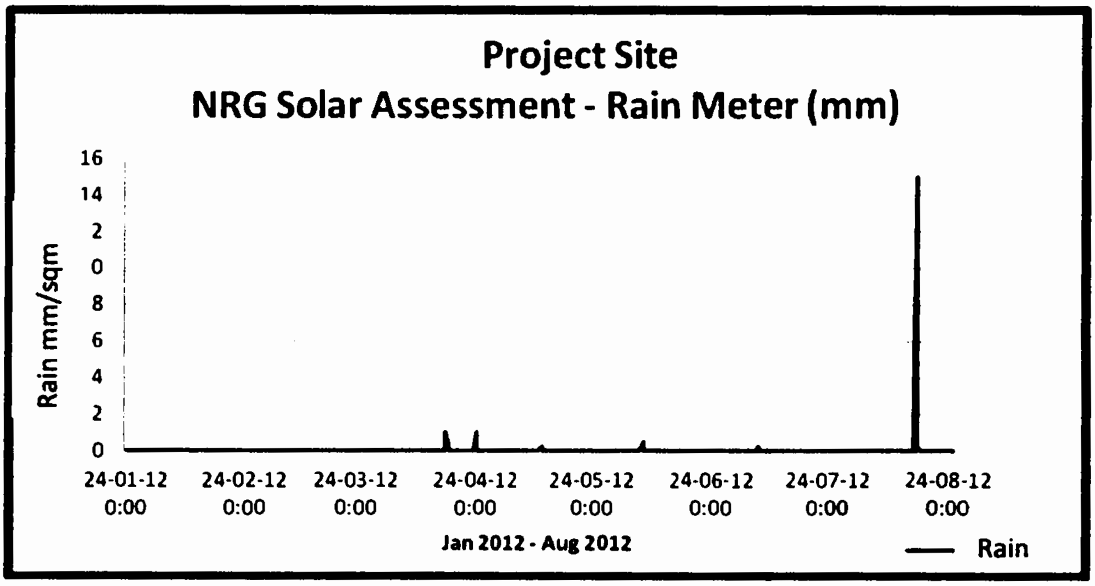


Figure 1.2.8: Primary data collected for Rain (mm) using NRG Rain Gauge sensor

As can be seen from the collected data from the Rain Gauge Sensor, there is minimal or almost no rainfall on the Project Site, making it an ideal location for Solar Pv Installations.

Deviation From Synthetic Data:

The data recorded so far compared with the Synthetic Data shows a deviation of less than 1%, which makes the synthetic data acquired highly reliable and bankable for purposes of the feasibility study.

This aspect is further explored in detail in section 1.17 of this Volume.

The Solar Resource Assessment using the synthetic data and the simulation softwares hence renders itself a reliable measure for the Power Output Analysis for the purposes of the Feasibility Study.

1.3 Meteorological Data of Site

As discussed in forecasting of variations, the accuracy of long-term assessment is of crucial importance in the frame of any solar power project yield assessment or assessment of operational data.

Experiences show that the expected long term energy output can vary, for the same PV plant and measurement data base, in a range of up to +/- 9% depending on the selected long-term meteorological station and the used correlation procedure. This data is of greater importance in the initial feasibility studies for Solar PV projects of this scale in this region. The quality of the correlation procedures and the results demonstrate that uncertainties connected to the choice of the long-term station are significantly higher than the uncertainties connected to the correlation procedures, unless a detailed stability analysis is carried out.

NREL has gathered data using 12 stations located in different areas of Pakistan. This data has been displayed in form of seasonal maps as shown in **Figures 1.3.1 (Fall), 1.3.2 (spring), 1.3.3 (summer) and 1.3.4 (Winter).**

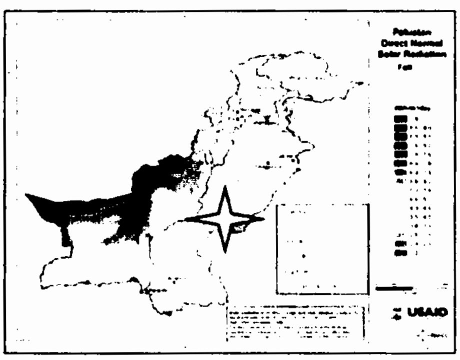


Figure 1.3.1: Fall Season Map

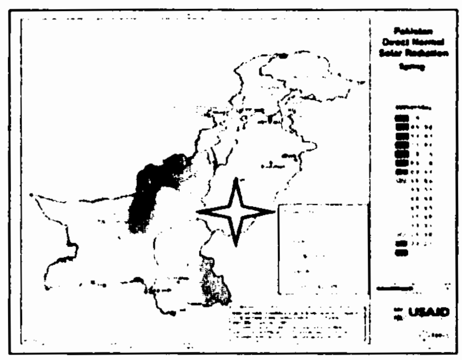


Figure 1.3.2: Spring Season Map

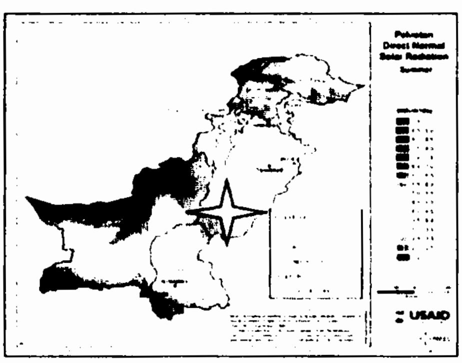


Figure 1.3.3: Summer Season Map

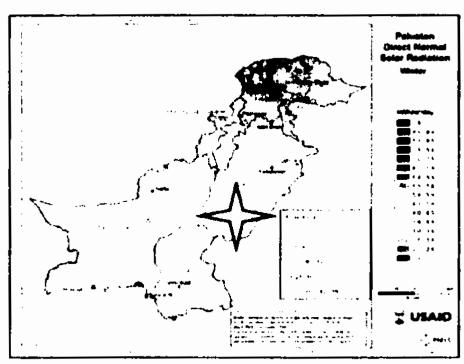


Figure 1.3.4: Winter Season Map

Correlation procedure implies that we should find a reliable long-term data source (at least 10 years, whenever possible, like NASA Satellite resource as applied in this study) usable as a long-term reference, with a high availability, representative to the site conditions and without inconsistency or any trend over the long-term period. Correlation method is applied between the site and the reference data and determines the relationship between both measurements during the common period and to allow the reconstruction of long-term site data by application of this relationship on the long-term reference data.

The results determined from correlation methods have to be considered as site-specific and cannot be applied as default uncertainty values of the regarded correlation methods. However, they represent a validation of the use of the monthly mean values approach and highlight what the energy yield prediction error due to the correlation methods is.

To draw a conclusion, the detailed stability analysis of any meteorological station selected for the long-term correlation of site data is strictly required and represents the cornerstone of the long-term correlation procedure.

For the project site Annual readings have been recorded over 22 years for the site **(See Annexure 10: Meteorological Data from NASA Satellite).**

The average annual precipitation at the project site is estimated to be 1.03 mm/day. The maximum annual temperature during summers can rise up to 30.6 ^{0}C while the minimum annual temperature reaches 24.5 ^{0}C. The average annual temperature of the site as per recordings is 19.0 ^{0}C and annual average wind speeds 4.45 m/s for all types of terrain.

The meteorological conditions of the site have been summarized in **Table 1.3.1**.

[illegible]	Average Temperature		[illegible]	[illegible]
Months	Min	Max		Mean
Jan	6.95	19.9	45.3	0.30
Feb	9.19	22.9	38.2	0.61
Mar	15.1	29.3	29.3	0.66
Apr	20.8	34.2	27.4	0.52
May	25.3	37.9	30.3	0.54
Jun	28.2	38.2	43.4	1.22
Jul	28.0	35.1	61.8	3.63
Aug	26.9	33.4	67.7	2.95
Sep	24.8	33.8	55.4	1.22
Oct	19.3	32.6	33.5	0.40
Nov	13.8	27.8	31.6	0.09
Dec	8.99	22.2	39.1	0.23

Table 1.3.1: Project Site Meteorological Details

Sunplot in 3D

The following results were obtained from analysis using Sunplot 3D of PV-Design Pro-G Solar v 6.0. Parameters used were the latitude, longitude and standard meridian for Cholistan, Pakistan (29.1, 287.6 and 285 respectively). The results show the sun's position at noon with several key parameters which are essential for effective and successful layout design and orientation of the Solar Panels, namely:

- **Solar Altitude:** The angle between the horizontal and the line to the sun.
- **Solar Azimuth:** The angular displacement from south of the projection of beam radiation on the horizontal plane; east of south negative, west of south positive (-90=E,+90=W,S=0,N=+/-180).

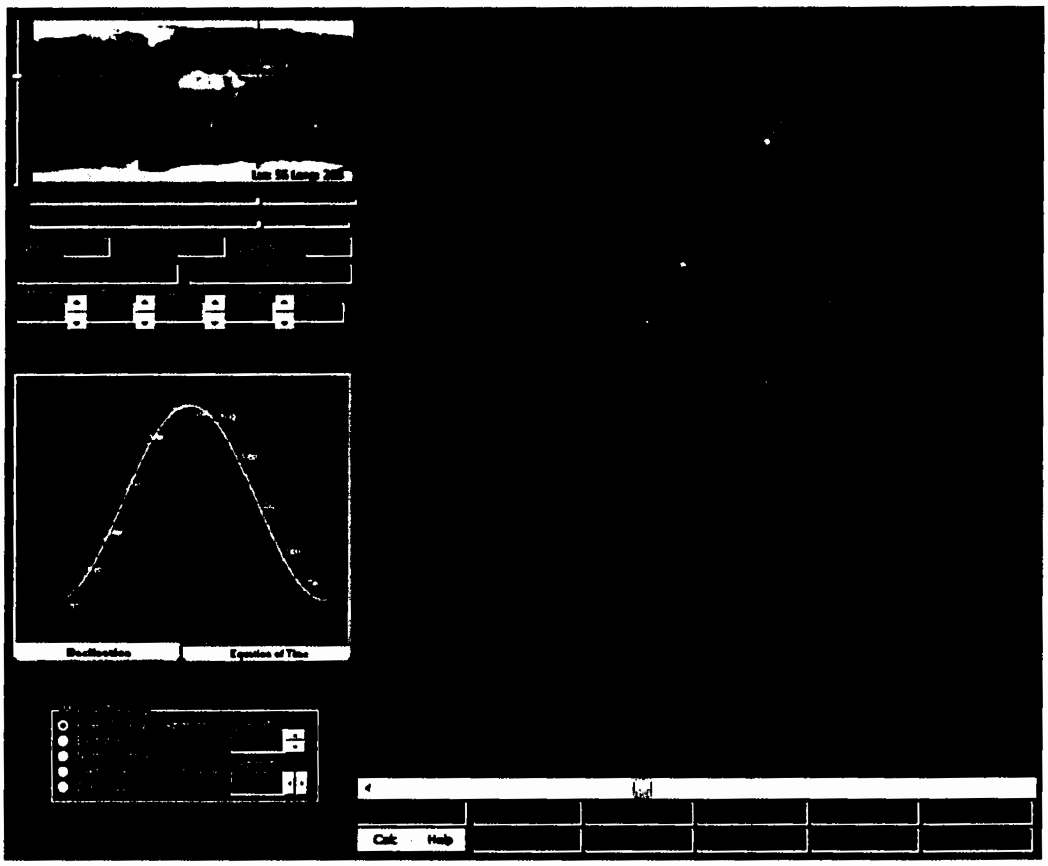


Figure 1.3.5: Project Site Meteorological Details Using Sunplot 3D for January

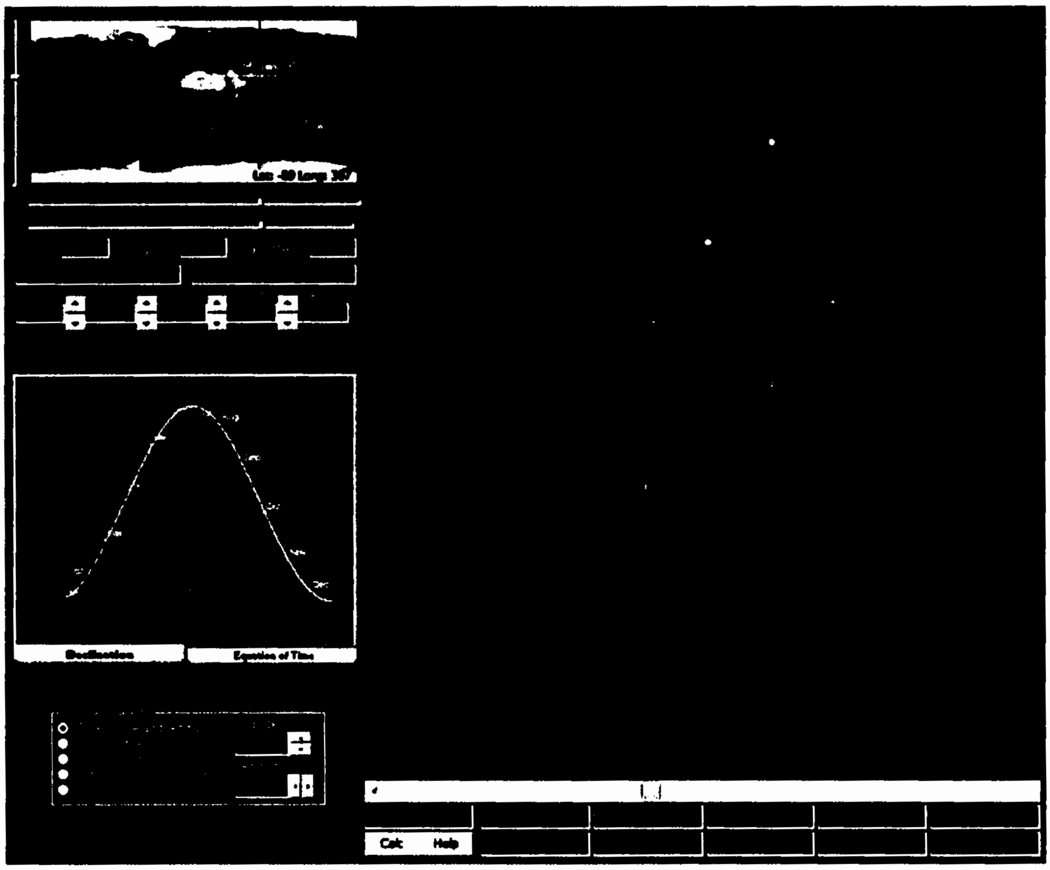


Figure 1.3.6: Project Site Meteorological Details Using Sunplot 3D for February

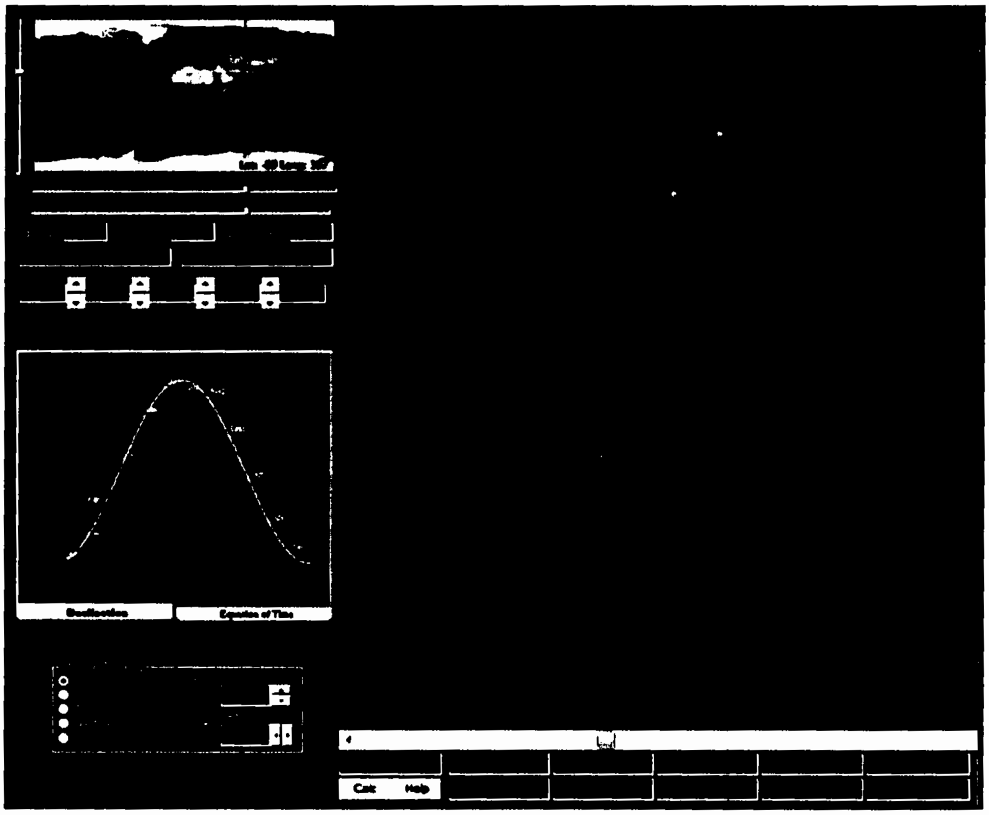


Figure 1.3.7: Project Site Meteorological Details Using Sunplot 3D for March

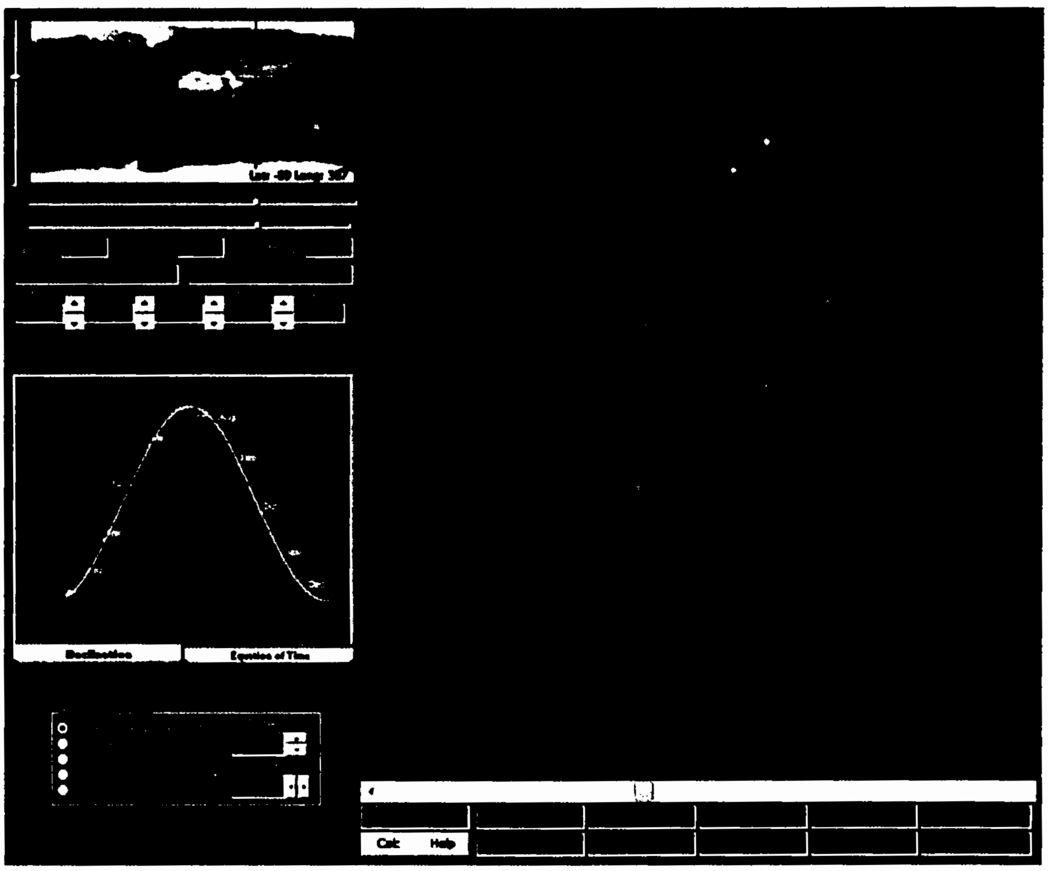


Figure 1.3.8: Project Site Meteorological Details Using Sunplot 3D for April

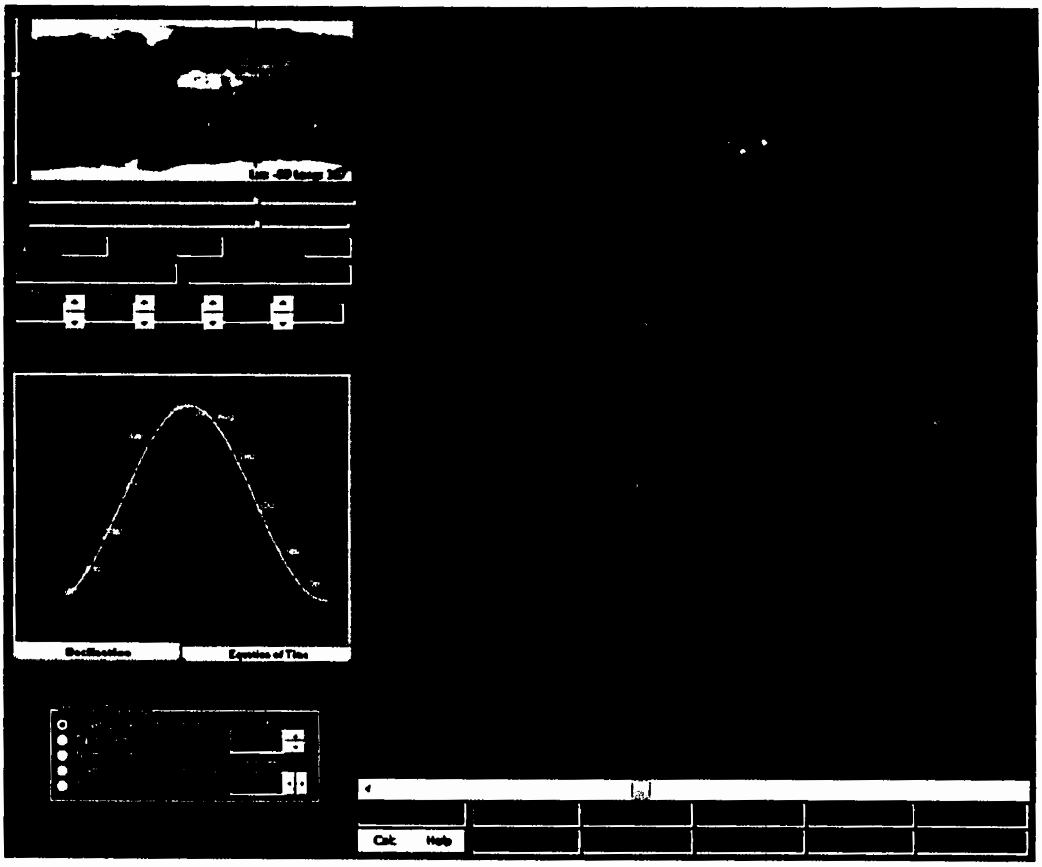


Figure 1.3.9: Project Site Meteorological Details Using Sunplot 3D for May

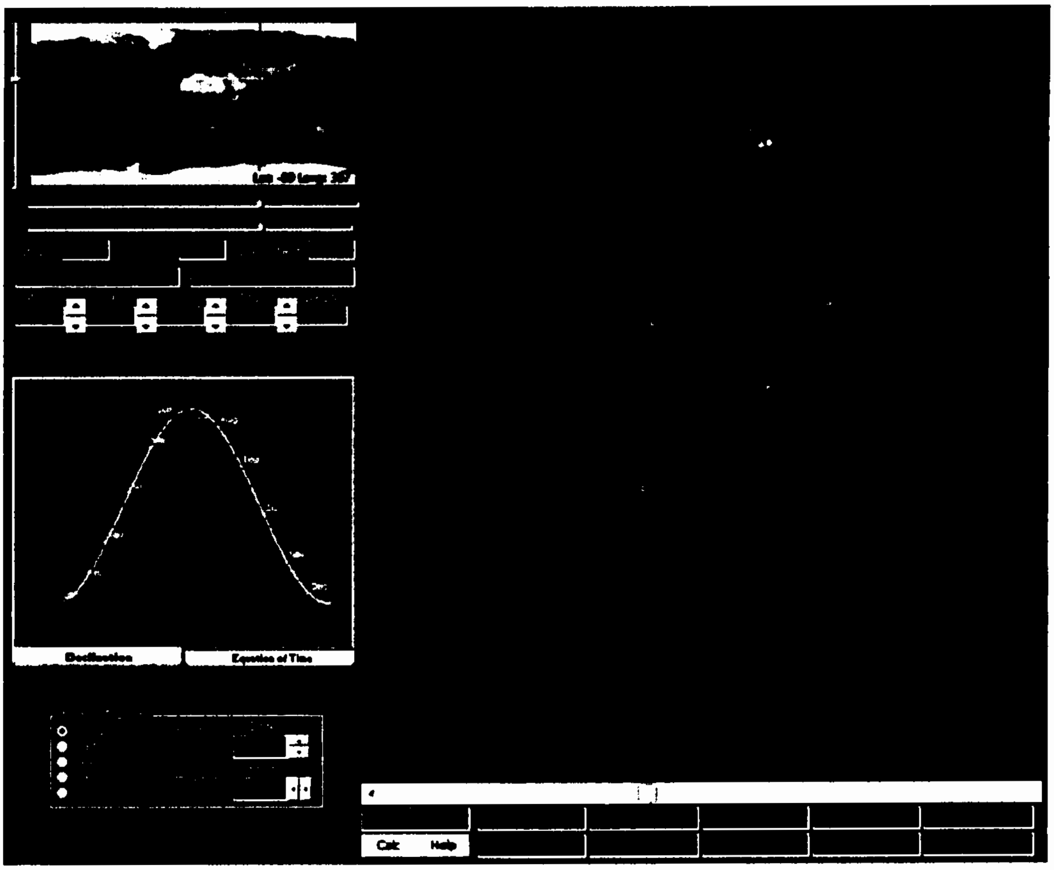


Figure 1.3.10: Project Site Meteorological Details Using Sunplot 3D for June

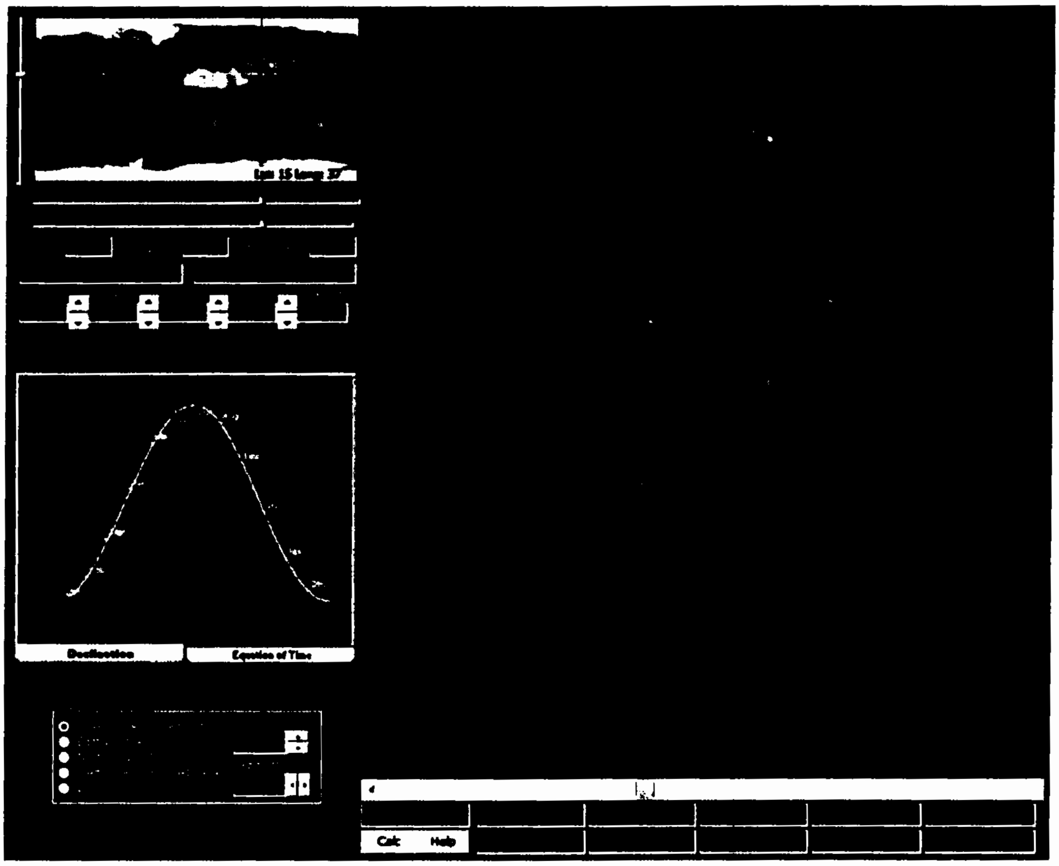


Figure 1.3.11: Project Site Meteorological Details Using Sunplot 3D for July

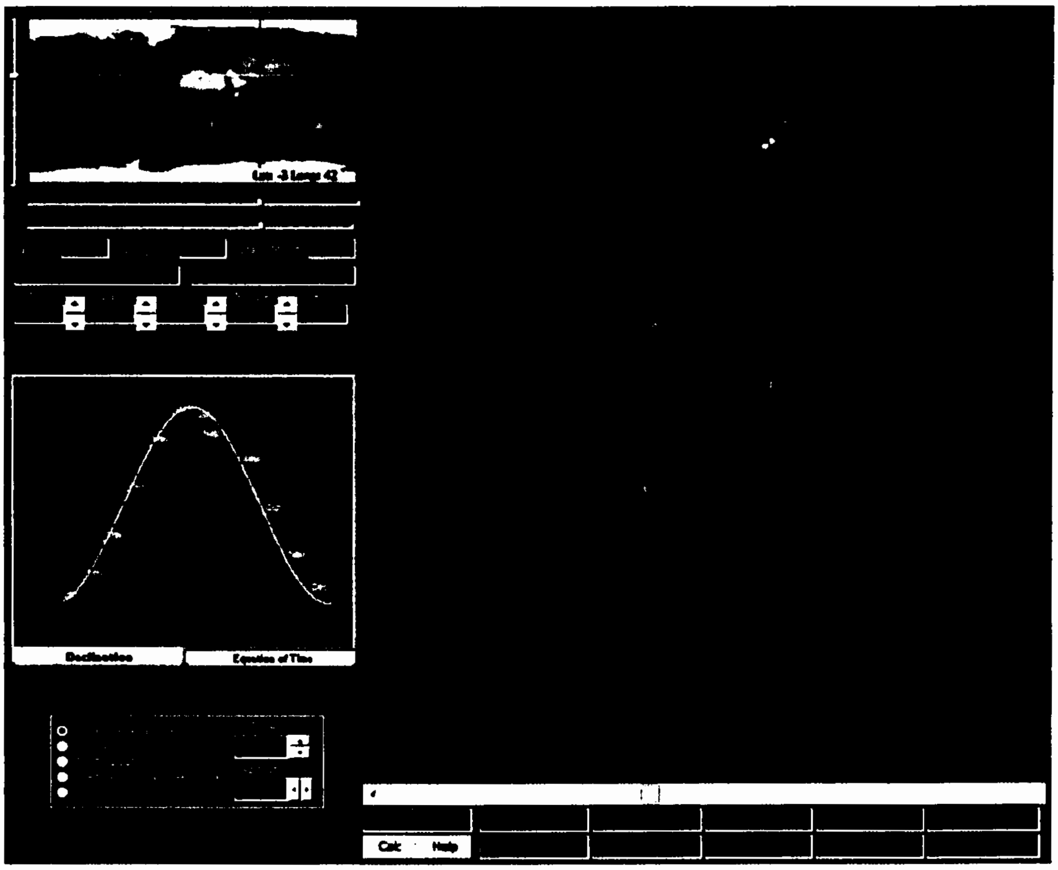


Figure 1.3.12: Project Site Meteorological Details Using Sunplot 3D for August

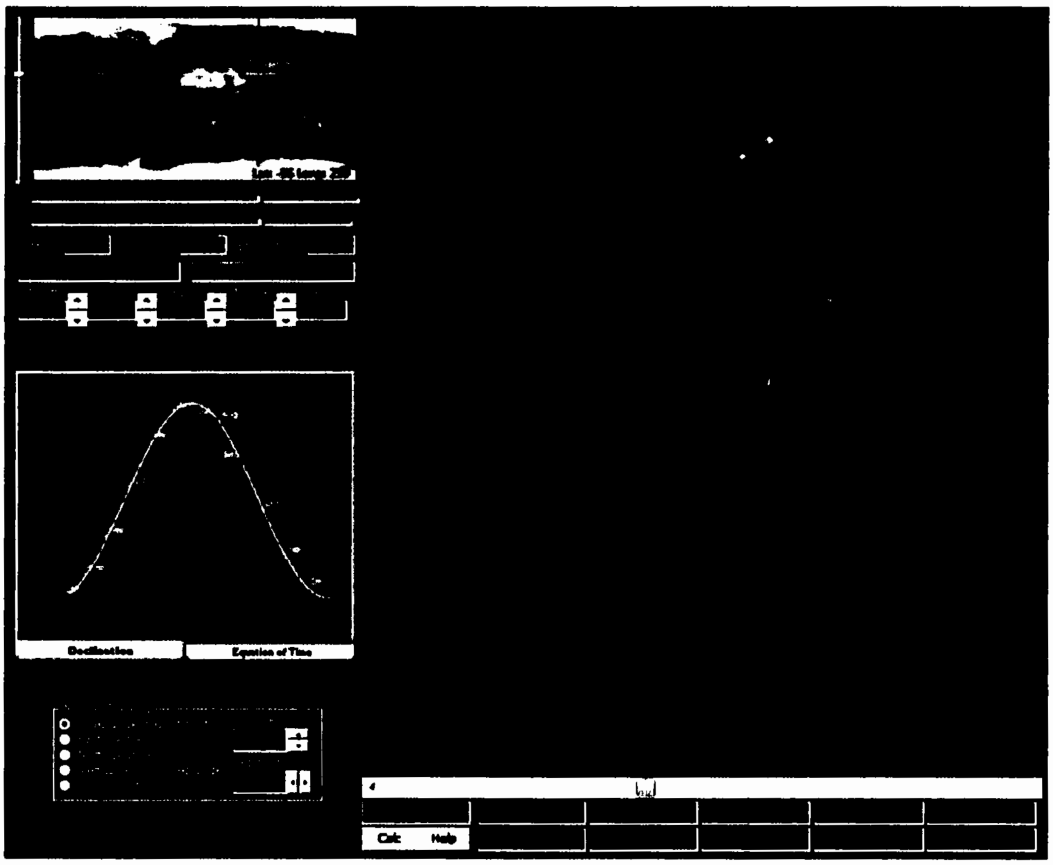


Figure 1.3.13: Project Site Meteorological Details Using Sunplot 3D for September

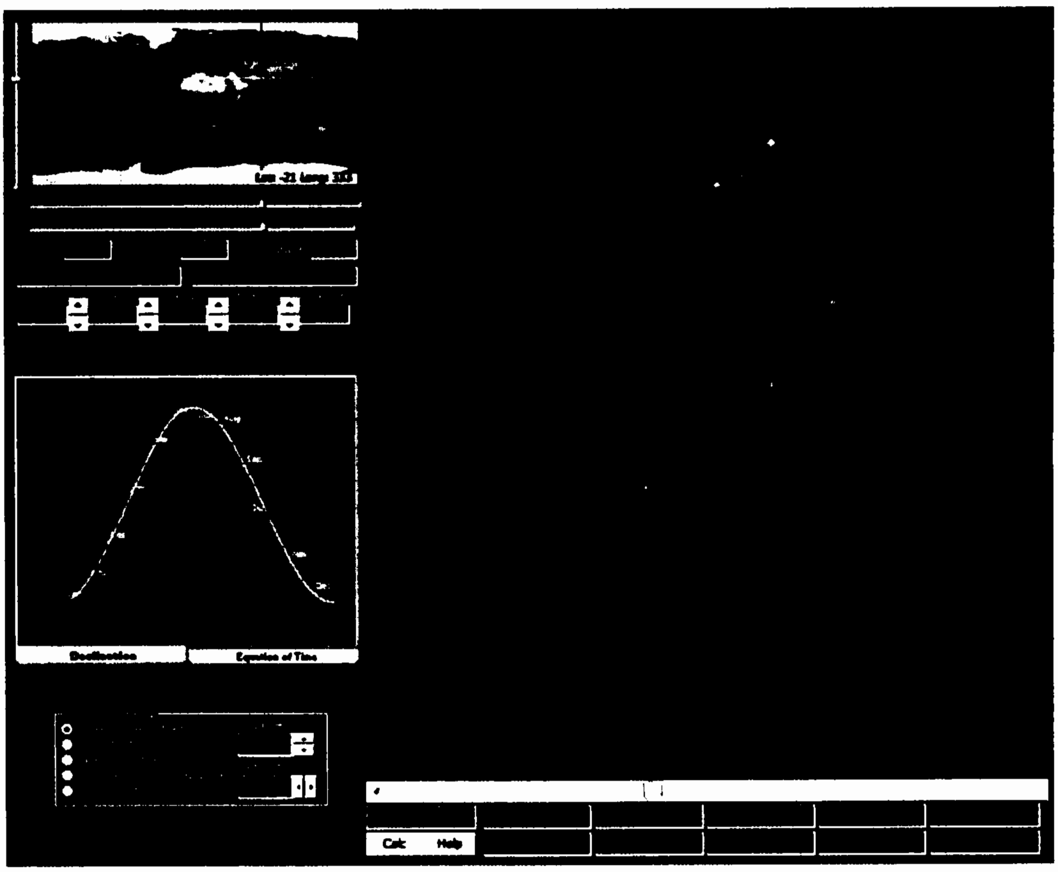


Figure 1.3.14: Project Site Meteorological Details Using Sunplot 3D for October

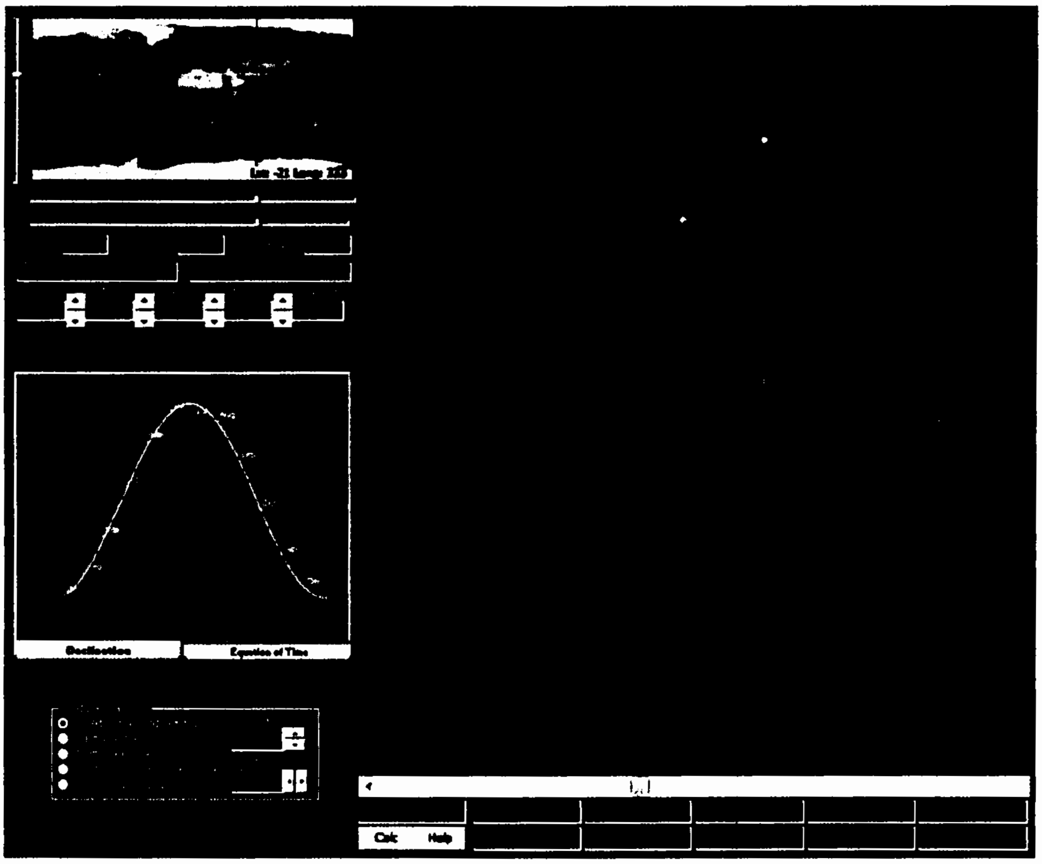


Figure 1.3.15: Project Site Meteorological Details Using Sunplot 3D for November

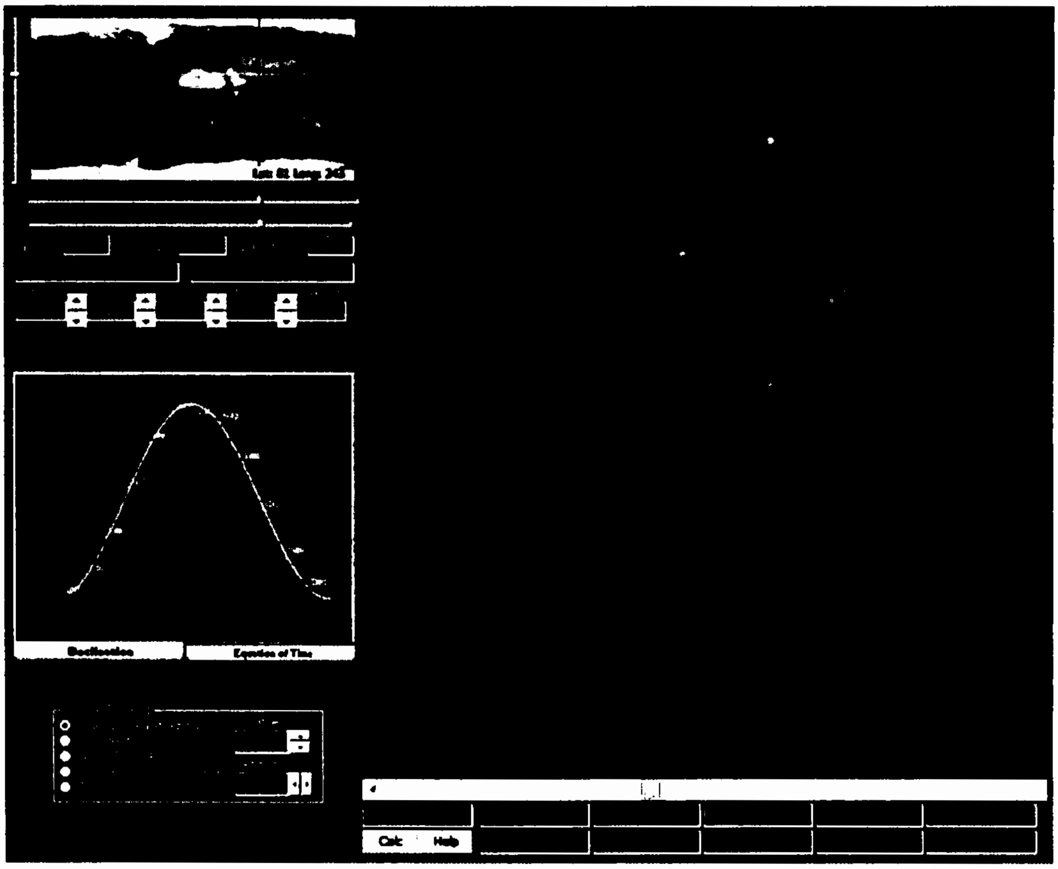


Figure 1.3.16: Project Site Meteorological Details Using Sunplot 3D for December

1.4 Microclimate effects

The Pakistan Meteorological Department is both a scientific and a service department, and functions under the Ministry of Defense. It is responsible for providing meteorological service throughout Pakistan to wide variety of interest and for numerous public activities and projects which require weather information.

In its services to aviation the department's responsibility goes to some extent beyond national boundaries in fulfillment of accepted international agreements and obligations which include, among other things, the collection and rebroadcast of meteorological data.

Apart from meteorology, the department is also concerned with Agro meteorology, Hydrology, Astronomy and Astrophysics (including solar physics), Seismology, Geomagnetism, Atmospheric Electricity and studies of the Ionosphere and Cosmic Rays. Pakistan Meteorological Department shoulders the responsibility to investigate the factors responsible for global warming, climate change its impact assessment and adaptation strategies in various sectors of human activities.

Major functions entrusted to the Pakistan Meteorological Department (PMD) are to provide information on meteorological and geophysical matters with the objective of traffic safety in air, on land and sea, mitigation of disasters due to weather and geophysical phenomena, agriculture development based on climatic potential of the country, prediction and modification of weather forecast.

Despite their prime functions, PMD provides all microclimate data required for current and future feasibilities as well as developing correlations between metrological data, microclimate effects and other factors.

Following tables and figures provide the latest microclimate trends all over Pakistan. Following these visuals, a brief summary on the microclimate effects of Cholistan and specifically the project site has been given.

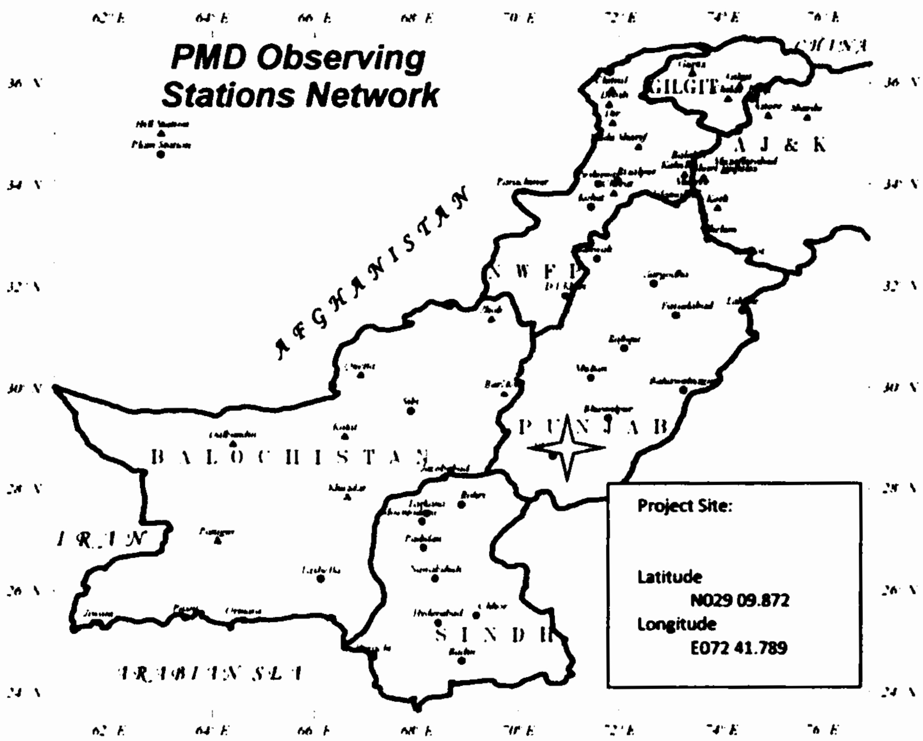


Figure 1.4.1: Meteorological Stations of PMD

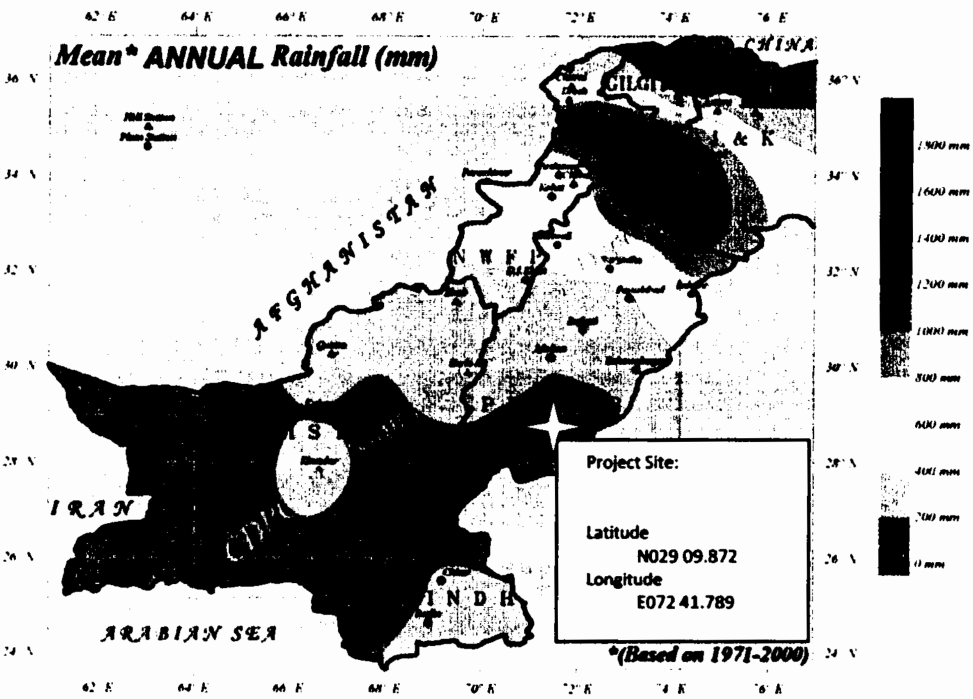


Figure 1.4.2: Mean Annual Rainfall (mm)

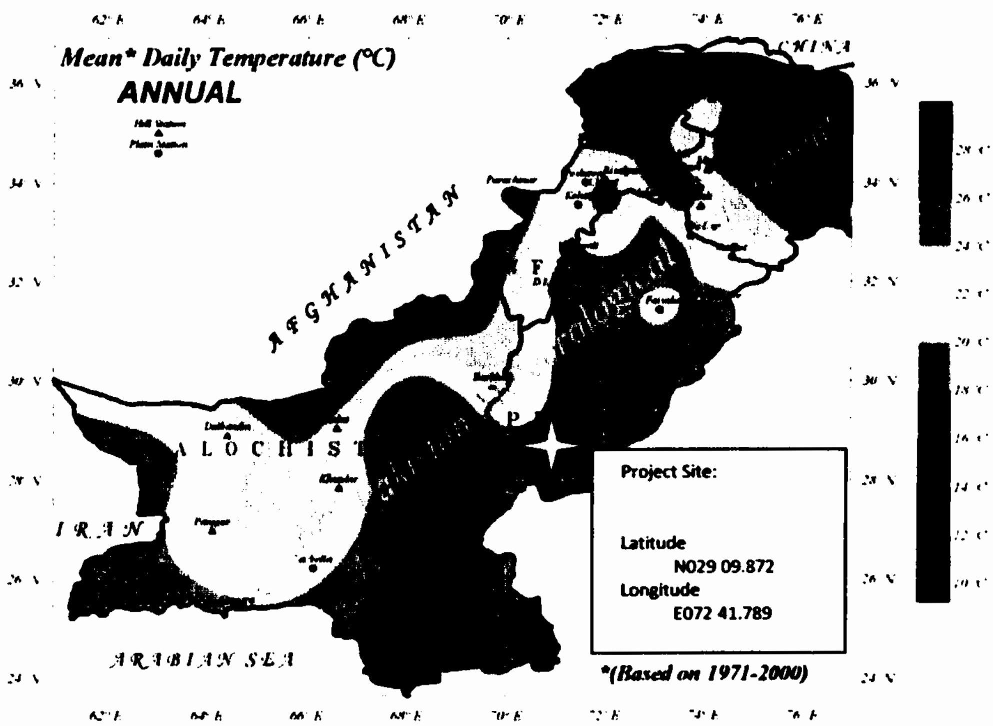


Figure 1.4.3: Mean Daily Temperature (°C)

Microclimate effects of Cholistan and nearby area are characterized by low and rare sporadic rain. The mean annual rainfall varies from less than 100 mm in the west to 200 mm in the east and as per collected Synthetic Data, installed SRA equipment on site and information gathered from Locals, it rains only 1 to 3 times in years.

Rain usually falls during monsoon (July through September), winter and spring (January through March). Aridity is the most striking feature of the Cholistan desert with wet and dry years occurring in clusters. Cholistan is one of the hottest regions of Pakistan. Temperatures are high in summer and mild in winter. The mean summer temperature (May, June) is 34 °C with the highest reaching above 51 °C. Further details are available in **Annexure 10.**

Below you will find a **recap of data collected from the Solar Resource Assessment unit at the site; Figure 1.2.5** which represents the data collected for Wind direction (deg) using wind vane installed with NRG Data Logger at the site; **Figure 1.2.6** provided below you will find the data collected for Direct Solar Radiation (W/sqm) using two Li-COR Pyranometers installed with the NRG Symphonies Plu3 Data Logger at the site; **Figure 1.2.7** provided below you will find the data collected for Temperature (^{0}C) using NRG 110s Sensor attached to the Solar Resource Assessment Equipment.

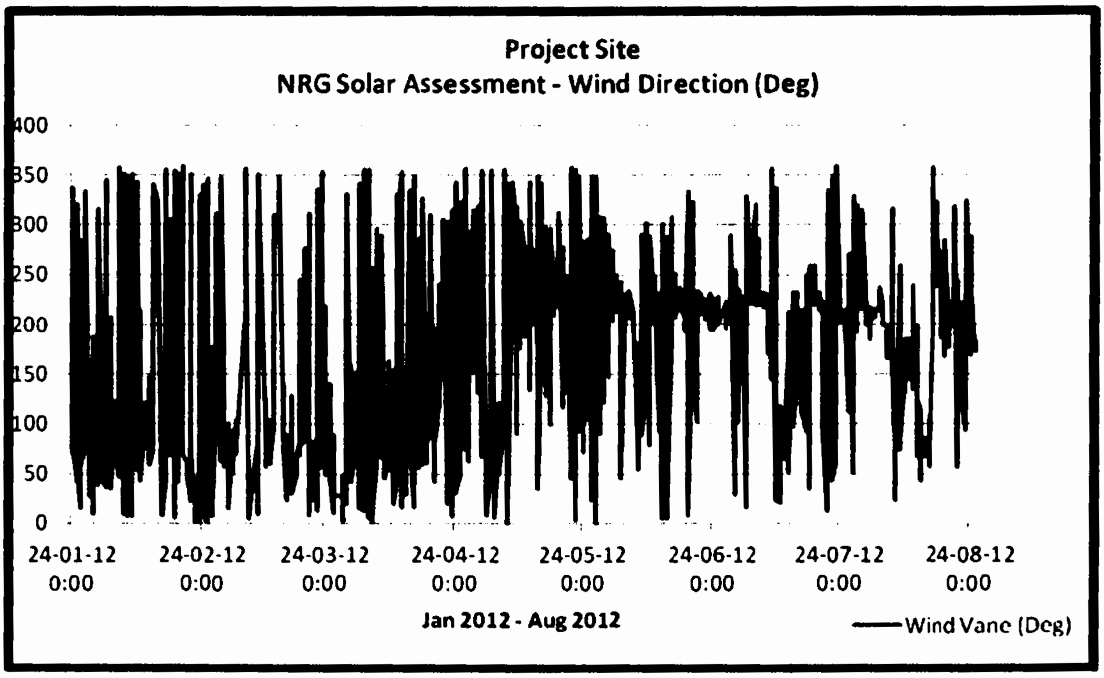


Figure 1.4.4: Primary data collected for Wind direction (deg) using NRG 200P wind vane

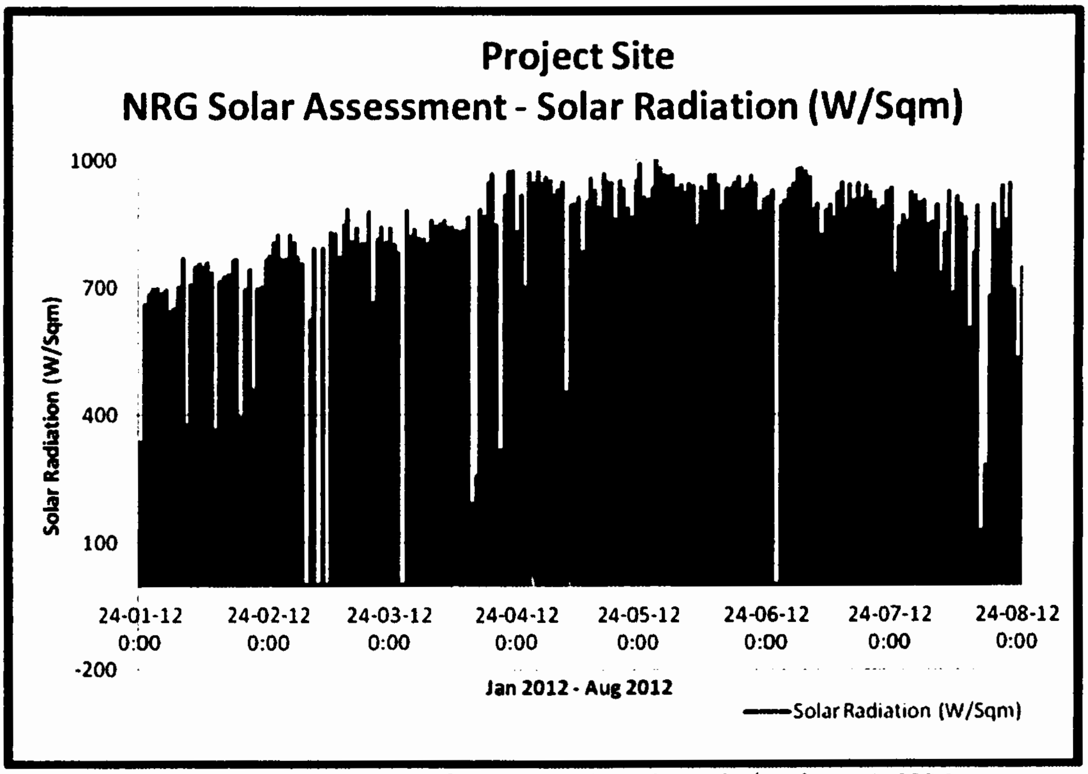


Figure 1.4.5: Primary data collected for **Average** Solar Radiation (W/Sqm) using Li-COR Pyros

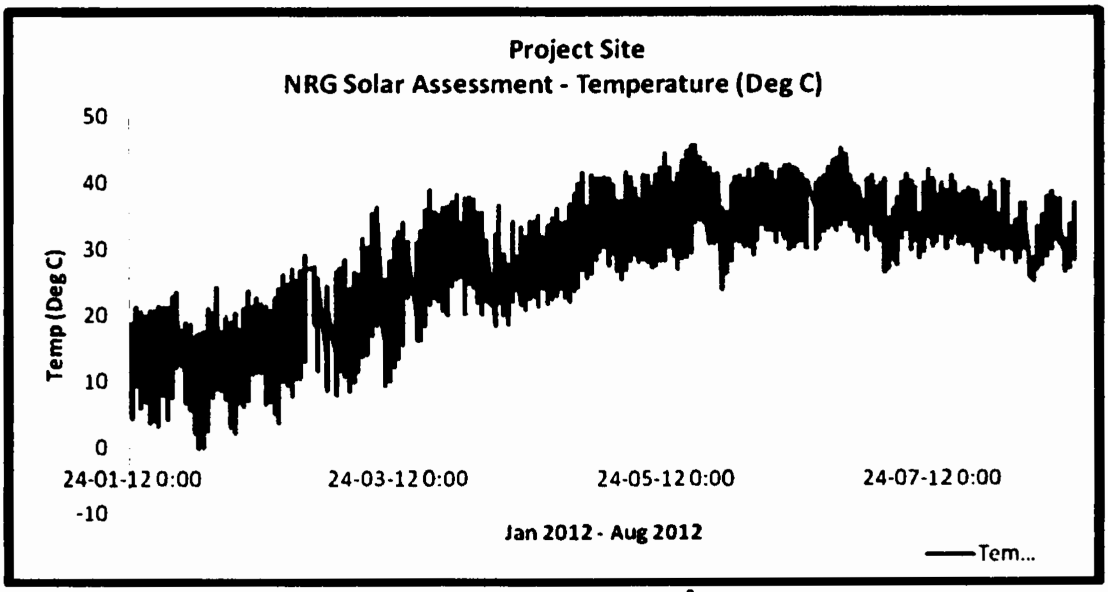


Figure 1.4.6: Primary data collected for Temperature ($^{\circ}C$) using NRG 110s sensor

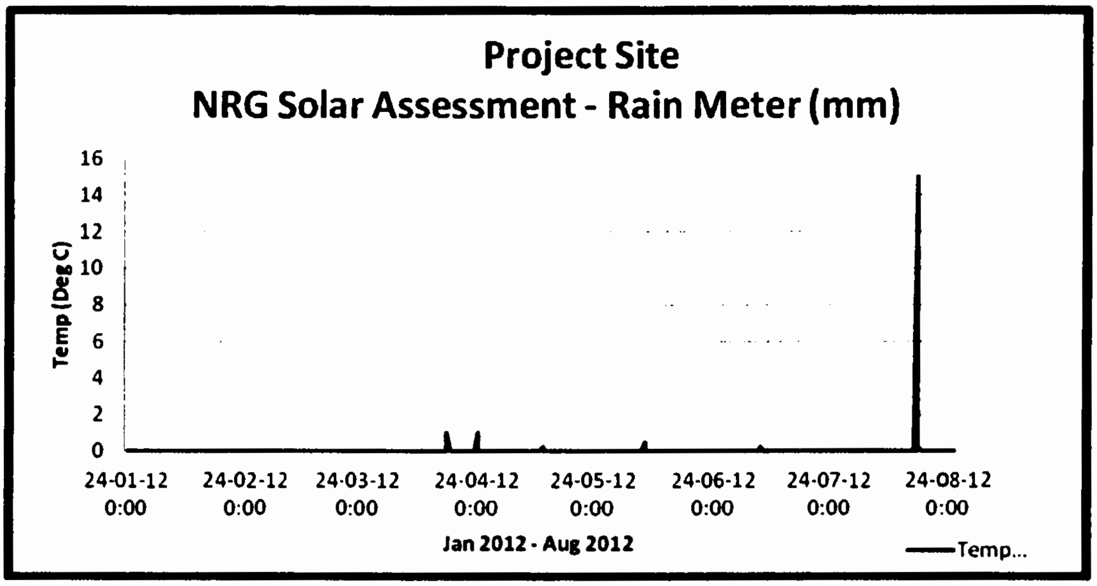


Figure 1.4.6: Primary data collected for Rain (mm) using NRG Rain Gauge sensor

1.5 Shading on Site

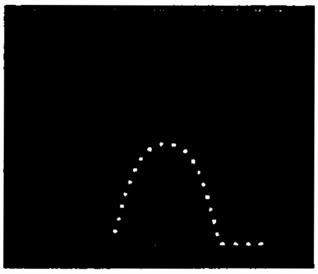
The land acquired by the Joint Venture consists primarily of flat ground and scarce sand dunes at the peripheral of the site. Construction of the solar farm will be focused on the flat areas.

Scant vegetation (shrubs and bushes) is found in these areas causing no troubles regarding shading. The panels would be mounted on racks, facing due south, at an angle of 29 degrees above horizontal to maximize the system for annual energy production.

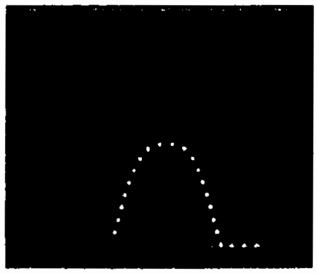
The mounting racks would be aligned in rows along an east-west axis across the entire area defined for the project. Depending on the height of the panels off the ground, it is estimated that approximately 4 feet of spacing between rows would be required to prevent shading from one row of modules onto the other. Due to the location of the site in smaller Cholistan, the project site is not vulnerable to pro-longed or intensive shading affects due to topographical rises or high rising tree line. **Table 1.5.1** is a graphical representation of the shading factors at the project site using Maui Solar.

Table 1.5.1: PROJECT SITE SHADING ANALYSIS – Model Using Maui Solar (1 Of 5)

Bottom Axis: ***Solar Azimuth in degrees*** Left Axis: ***Solar Altitude in degrees***



Week 1



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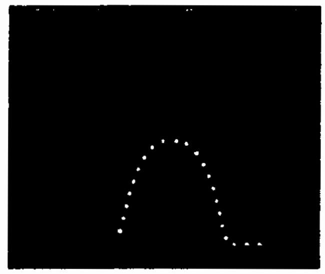

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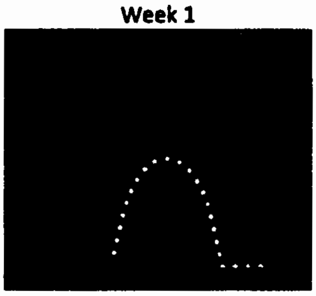

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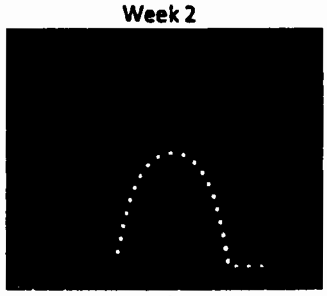

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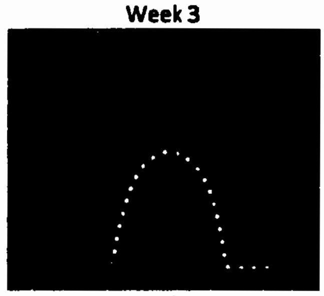

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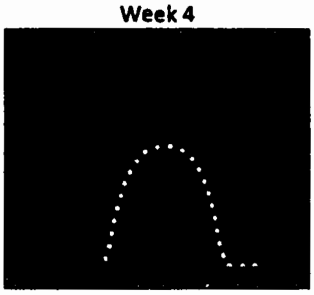

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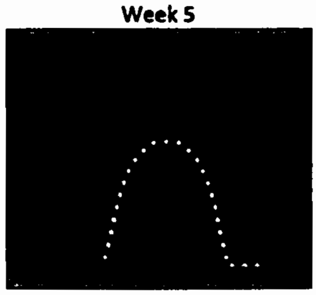

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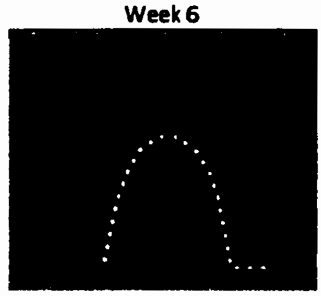

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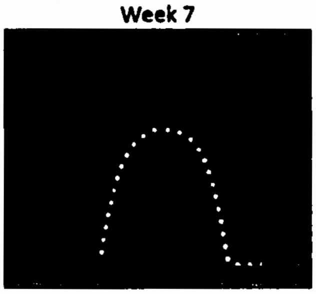

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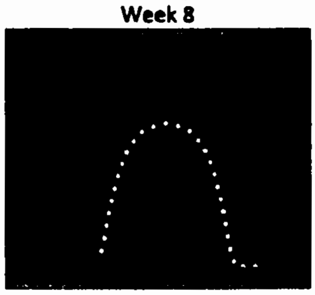

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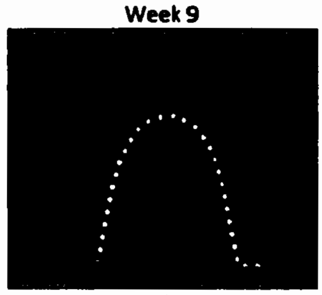
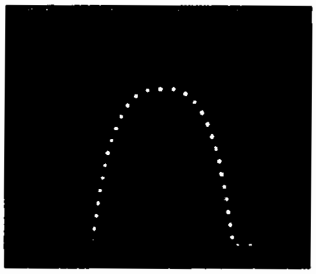


Week 12

Table 1.5.1: PROJECT SITE SHADING ANALYSIS – Model Using Maui Solar (2 Of 5)

Bottom Axis: ***Solar Azimuth in degrees*** Left Axis: ***Solar Altitude in degrees***



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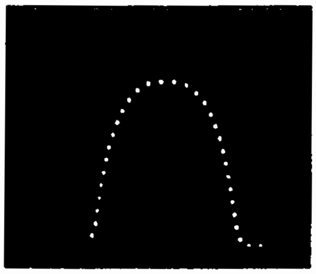

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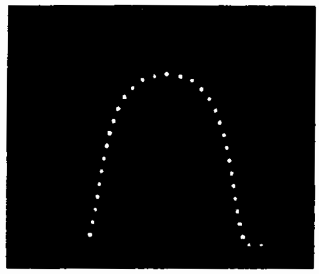

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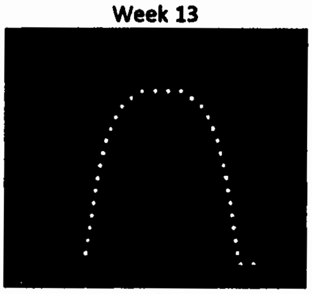

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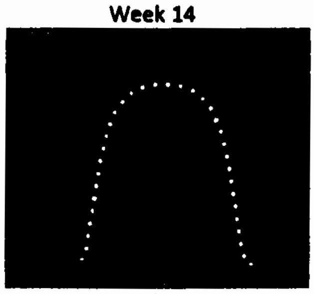

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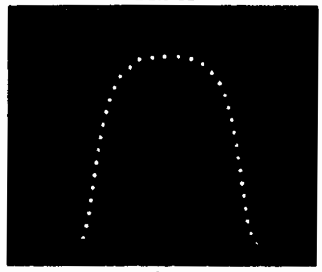

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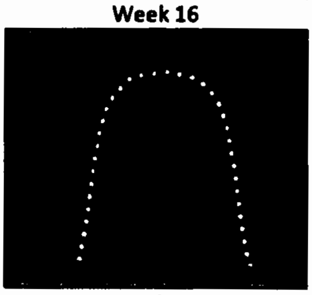

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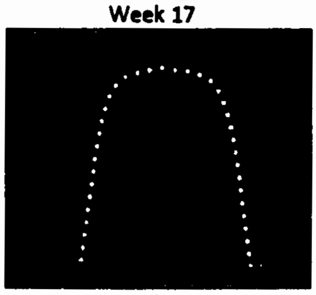

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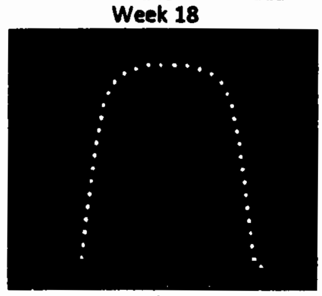

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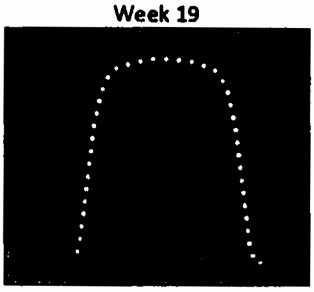

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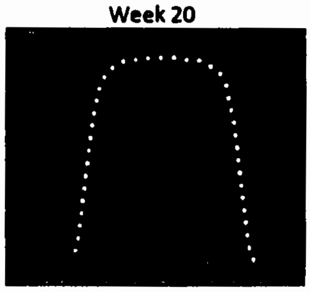

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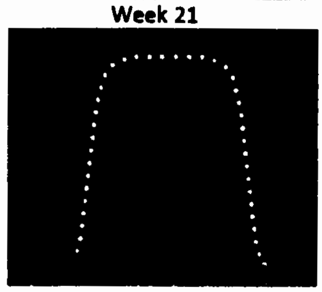

Week 24

Table 1.5.1: PROJECT SITE SHADING ANALYSIS – Model Using Maui Solar (3 Of 5)

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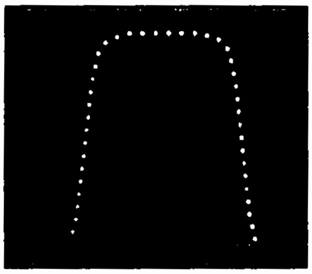
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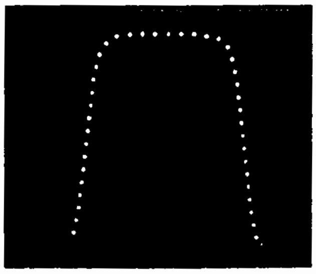
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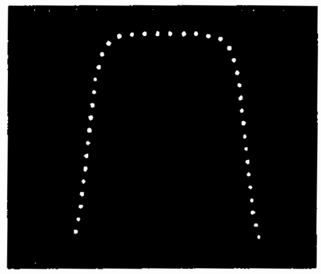
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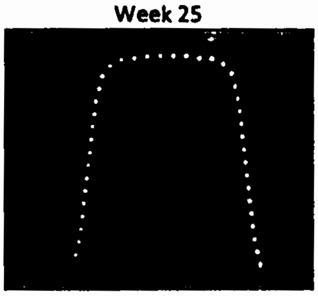
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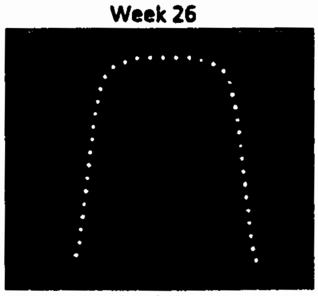
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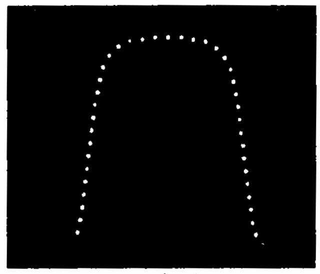
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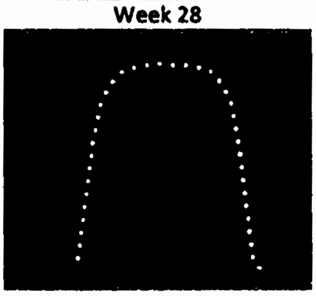
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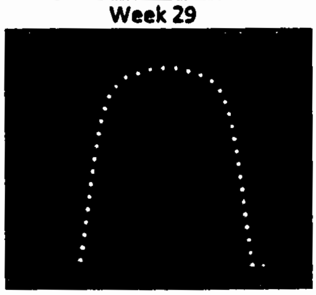
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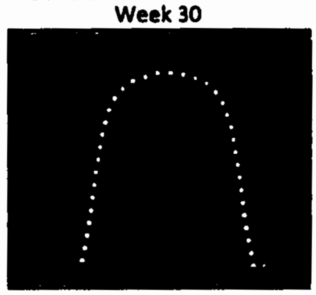
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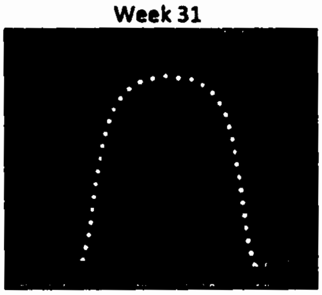
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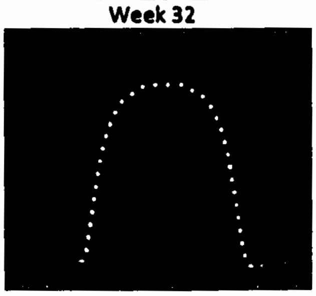
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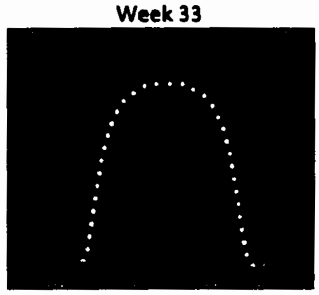
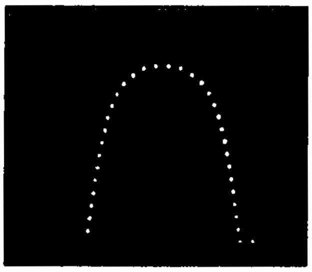

Week 36

Table 1.5.1: PROJECT SITE SHADING ANALYSIS – Model Using Maui Solar (4 Of 5)

Bottom Axis: ***Solar Azimuth in degrees*** Left Axis: ***Solar Altitude in degrees***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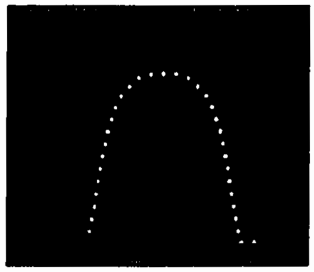
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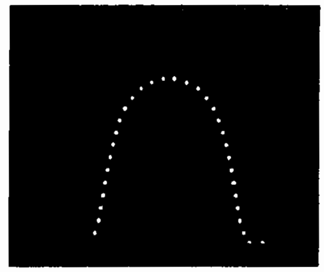
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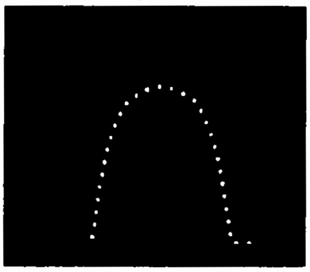
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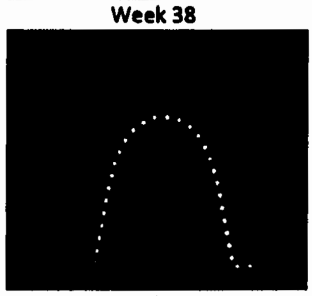
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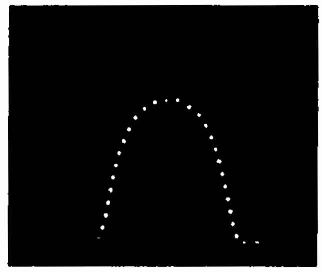
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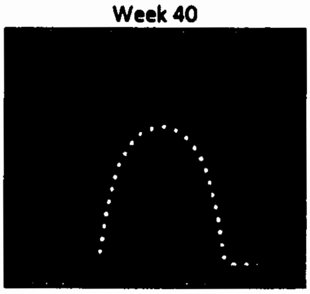
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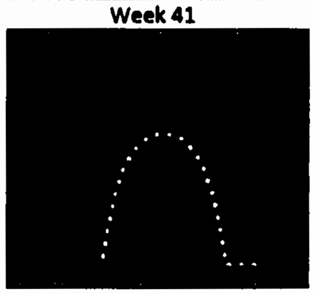
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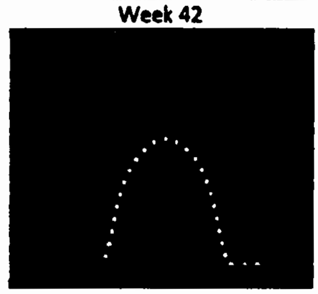
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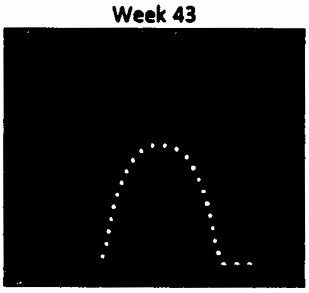
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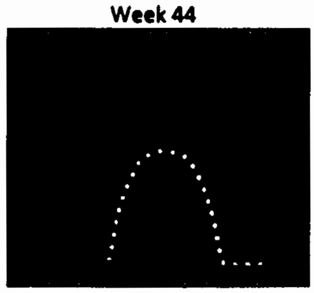
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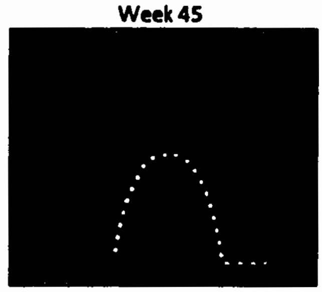
Week 48

Table 1.5.1: PROJECT SITE SHADING ANALYSIS – Model Using Maui Solar (5 Of 5)

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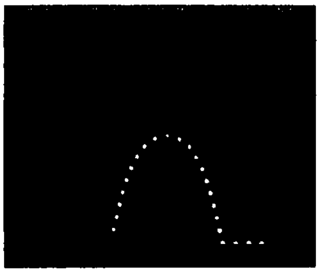

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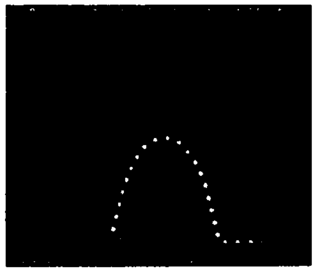
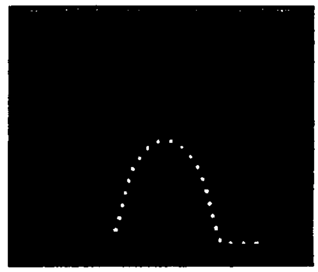
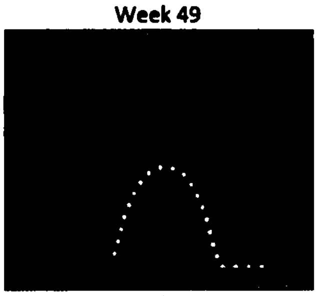


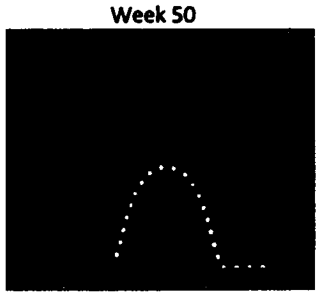
Week 50



Week 51



Week 52



Week 53

Please note Internal shading effects as in those arising from Solar PV Panel Installations have been addressed in the Plant Layout Section.

1.6 Site specific risks

Cholistan has very low propensity towards natural disasters or similar risks. Till date the nearest area to Cholistan which has faced the effects of a flood is Bahawalpur and that too only once in history.

Cholistan and nearby areas for a significant radius are not prone to earth quakes (as per past records).

Pakistan has faced only one tropical cyclone since 1947 and that was in Nov 1970 in East Pakistan. Much of the sand-storms in the desert are witnesses in the desert near to western Balochistan (considerably away from site). Similar studies support the selection of the site as a safe geographical location for operations of a solar power project. **Figure 1.6.1** and **Figure 1.6.2** show hazard maps of Pakistan.

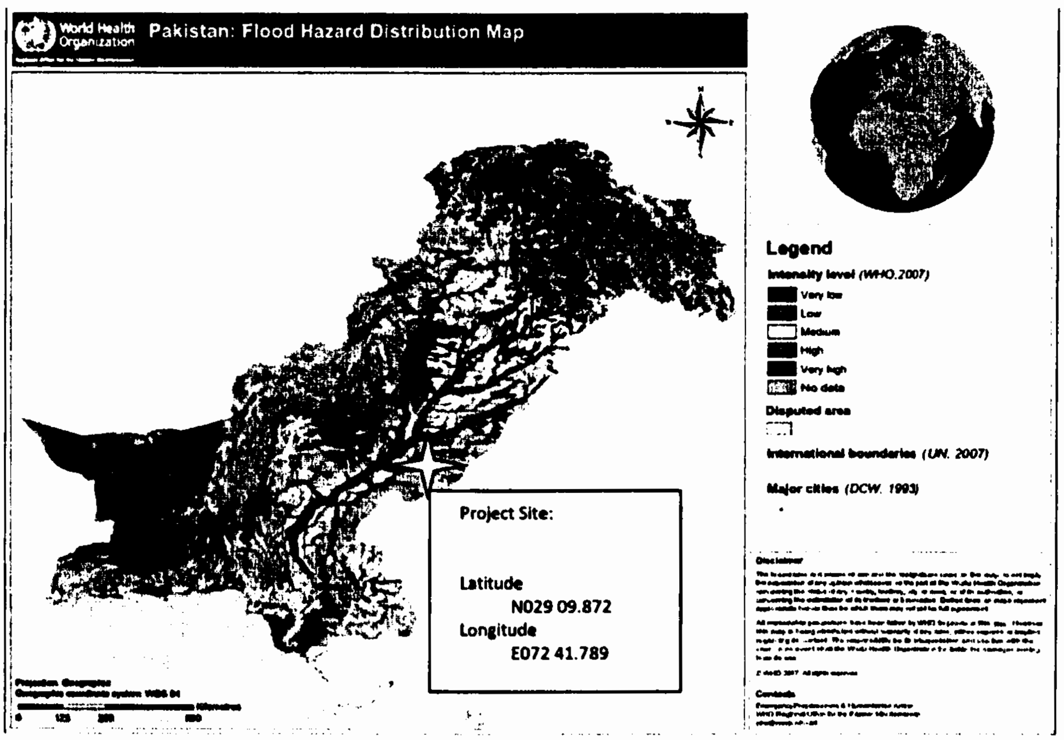


Figure 1.6.1: Flood hazard map of Pakistan

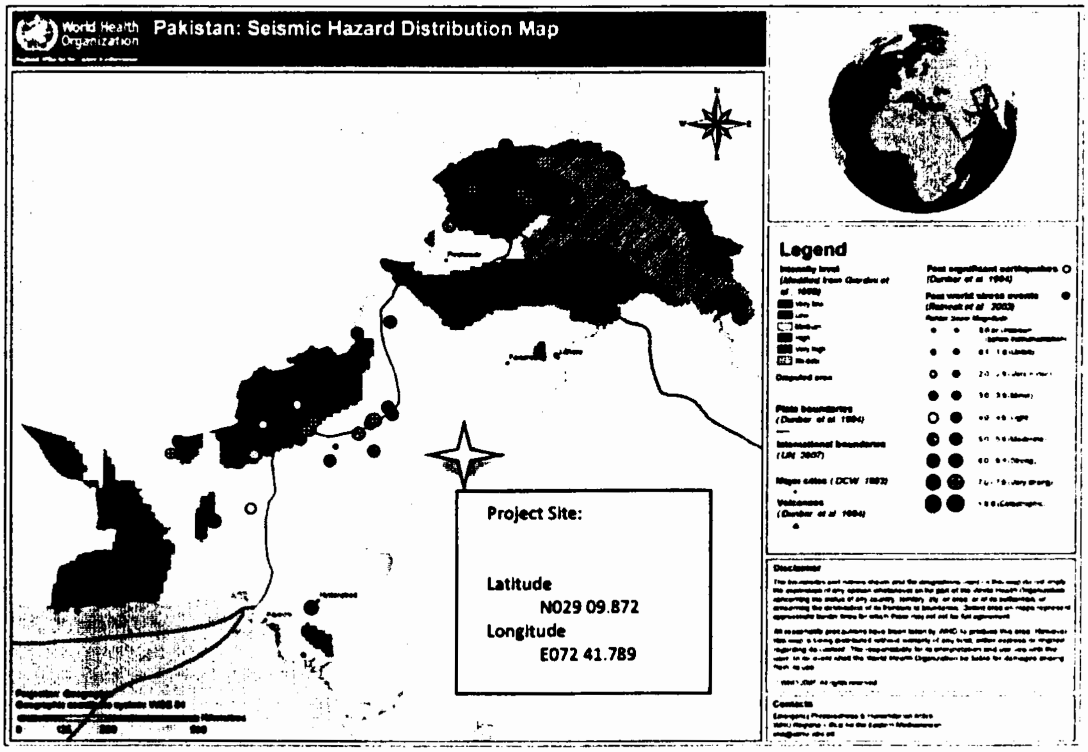


Figure 1.6.2: Natural Hazard map of Pakistan

1.7 Protection from Sand Storms:

The Project is strategically positioned between the Farm Lands being irrigated by manmade canals taken out from the Indus River passing through Punjab on its way to Sindh which cover it on 3 sides and on the other hand the Marot Fort with its high elevation.

The Farm Lands, near the Project Site covering it from the South, North and West, whereas on the East we have the Marot Fort at an elevation built on top of a hill protecting the sides from any sand storms.

1.8 Topographic and related studies (Site Visit Data)

Proficient Teams were deployed along with competent teams of Engineers & Specialists for conducting the Geo-Technical Studies, which were successfully completed and compiled in Volume 3 and Volume 4 of the Feasibility Study.

The Volumes/reports present details of the geotechnical investigations carried out, provide evaluation of the subsurface conditions encountered at the investigated locations, and recommendations for the foundations of the proposed building. The recommendations given in this report are based on field and laboratory test results, and on the state-of-the-art knowledge in geotechnical engineering, design and construction. Please refer to the above mentioned volumes for detail.

1.9 Environmental Issues (protected area, ground water protection, former land usage, etc.)

The requirements laid down by the Government of Pakistan and the Provincial Government of Punjab on different aspects of environment have been reviewed in detail. Apart from the primary requirements of IEE, EIA and NEQS there are multiple legislations and laws that need to be considered for any power generation projects in Pakistan. For renewable energy projects, these laws and legislations belong to 14 various sectors.

Solar projects are out of the scope of noise sector, as opposed to those of wind power projects.

Renewable Energy Projects do not have relevance to the sectors or concerns of Toxic or hazardous substances, Air Quality, Marine and Fisheries (except for any wind power projects undertaken which is off-shore), mineral Development and Public health and safety.

PV Power and Biogas projects do need to consider all laws set by sectors of livestock and solid wastes.

Important issues with the Solar PV Project and other similar projects in the region have to pay serious attention to the selection site for power generation to cater to the environmental standards as set by sectors like forest conservation, Parks and Wildlife conservation, cultural environment, Environmental protection, Land use and water quality and resources.

Considering the size of this project, primary focus was kept on the laws and legislations of land use set by the Provincial Government of Punjab, meaning the Land acquisition Act 1984, Soil Reclamation Act 1964 and The Punjab Development of Damaged Areas Act 1952. Damaged areas have been defined as any area that is declared damaged by the government through notification.

The Project Site is not used for agriculture farming due to very arid climate and undulating topography. Neither is livestock grazing an option due to the limiting weather conditions of the Land There is scarcity of drinking water both for humans and scarce livestock. As a result livestock production is less than its potential.

Groundwater is never the less available less than 20 meters below the surface however in some locations it is too saline to drink. The main method of keeping animals in areas further away from this hyper-arid region isa free availability of forage and monsoon rains which leave water stored in the pools dug in past by their owners.

Main soil types of Cholistan desert are sand dunes (44%), sandy soils (37%), loamy soils (2%) and saline-sodic clayey soils (17%).

The 10 MW Cholistan Solar PV Power project is exempted from all requirements of IEE and EIA as it falls under the schedule II classified by Pakistan Environmental Protection Agency regulations 2000, S.R.O 339(1)/2001. However please note as provided in Volume 5 Environmental Booklet, on request of the Ministry of Climate Change CDM Cell, the IEE and EIA were conducted and submission made to EPA Punjab which issued the NOC to the Project on 9/13/2012.

1.10 Environment Impact studies

The most important feature of solar PV systems is that there are no emissions of carbon dioxide - the main gas responsible for global climate change - during their operation. Although indirect emissions of CO2 occur at other stages of the lifecycle, these are significantly lower than the avoided emissions. PV does not involve any other polluting emissions or the type of environmental safety concerns associated with conventional generation technologies. There is no pollution in the form of exhaust fumes or noise.

Decommissioning a system is unproblematic. Although there are no CO2 emissions during operation, a small amount does result from the production stage. PV only emits 21.65 grams CO2/kWh, however, depending on the PV technology. The average emissions for thermal power, on the other hand, are 900g CO2/kWh. By substituting PV for thermal power, a saving of 835879 g/kWh is achieved.

The benefit to be obtained from carbon dioxide reductions in a country's energy mix is dependent on which other generation method, or energy use, solar power is replacing. Where off-grid systems replace diesel generators, they will achieve CO2 savings of about 1 kg per kilowatt-hour. Due to their tremendous inefficiency, the replacement of a kerosene lamp will lead to even larger savings, of up to 350 kg per year from a single 40 Wp module, equal to 25kg CO2/kWh. For consumer applications and remote industrial markets, on the other hand, it is very difficult to identify exact CO2 savings per kilowatt-hour.

Recycling of PV modules is possible and raw materials can be reused. As a result, the energy input associated with PV will be further reduced. If governments adopt a wider use of PV in their national energy generation, solar power can therefore make a substantial contribution towards international commitments to reduce emissions of greenhouse gases and their contribution to climate change. Natural gas is the most environmentally sound of the fossil fuels, because it produces roughly half as much carbon dioxide as coal, and less of other polluting gases. Nuclear power produces very little CO2, but has other major safety, security, proliferation and pollution problems associated with its operation and waste products.

Exemption from EIA or IEE

In addition virtue of the appropriate research, concrete reasons and paperwork, Please be informed that the matter of IEE and EIA reports for the 10MW Solar PV Power Project, was taken up with the Federal Government Ministry of Water and Power, with respect to the Exemption of the said Solar Power Project from either of

EIA And IEE Studies, under the Pakistan Environmental Protection Act, 1997 (which primarily deals with the creation of EPA's and their ambit of functioning with general guidelines) and the PAKISTAN ENVIRONMENTAL PROTECTION AGENCY (REVIEW OF IEE AND EIA) REGULATIONS, 2000 (the only document dealing in detail with IEE and EIA Studies.), ***As a result of which we a conditional No Object Certificate (NOC)dated 10/13/2011 by the Ministry fo Water and Power Enercon, has already been issued and is provided below in figure 1.10.3.***

You will find below a more detailed explanation to the above synopsis.

As can be seen in the language of article 12 of the Pakistan Environmental Protection Act, 1997, provided below and its relevant portion quoted here:

> "No proponent of a project shall commence construction or operation unless he has filed with the Government Agency designated by Federal Environmental Protection Agency or Provincial Environmental Protection Agencies, ***as the case may be***, or, ***where the project is likely to cause an adverse environmental effects an environmental impact assessment, and has obtained from the Government Agency approval in respect thereof***."

the proponent is Not required to do the IEE or EIA if that is not required as the case may be and/or the project does not have an adverse effect on the Environment. We are very well aware that Solar Power Project particularly Photovoltaic's has no such effect.

Now coming to the PAKISTAN ENVIRONMENTAL PROTECTION AGENCY (REVIEW OF IEE AND EIA) REGULATIONS, 2000 whose relevant sections 3. **Projects requiring an IEE**, 4 . **Projects requiring an EIA** and 5 **Projects not requiring an IEE or EIA**, are provided below. It can clearly be seen that We neither fall in Schedule 1 or Schedule II of the Regulations Governing the functioning of the EPA's with respect to the IEE and EIA reports.

3. Projects requiring an IEE
A proponent of a project falling in any category listed in Schedule I shall file an IEE with the Federal Agency, and the provisions of section 12 shall apply to such project.

4. Projects requiring an EIA
A proponent of a project falling in any category listed in Schedule II shall file an EIA with the Federal Agency, and the provisions of section 12 shall apply to such project.

5. Projects not requiring an IEE or EIA

(1) A proponent of a project not falling in any category listed in Schedules I and II shall not be required to file an IEE or EIA:
Provided that the proponent shall file –
(a) an EIA, if the project is likely to cause an adverse environmental effect;
(b) for projects not listed in Schedules I and II in respect of which the Federal Agency has issued guidelines for construction and operation, an application for approval accompanied by an undertaking and an affidavit that the aforesaid guidelines shall be fully complied with.

(2) Notwithstanding anything contained in sub-regulation (1), the Federal Agency may direct the proponent of a project, whether or not listed in Schedule I or II, to file an IEE or EIA, for reasons to be recorded in such direction: Provided that no such direction shall be issued without the recommendation in writing of the Environmental Assessment Advisory Committee constituted under Regulation 23.

(3) The provisions of section 12 shall apply to a project in respect of which an IEE or EIA is filed under sub-regulation (1) or (2)."

12. Initial environmental examination and environmental impact assessment.—(1) No proponent of a project shall commence construction or operation unless he has filed with the Government Agency designated by Federal Environmental Protection Agency or Provincial Environmental Protection Agencies, as the case may be, or, where the project is likely to cause an adverse environmental effects an environmental impact assessment, and has obtained from the Government Agency approval in respect thereof.

(2) The Government Agency shall subject to standards fixed by the Federal Environmental Protection Agency—

(a) review the initial environmental examination and accord its approval, or require submission of an environmental impact assessment by the proponent; or
(b) review the environmental impact assessment and accord its approval subject to such conditions as it may deem fit to impose, require that the environmental impact assessment be re-submitted after such modifications as may be stipulated or reject the project as being contrary to environmental objectives.

(3) Every review of an environmental impact assessment shall be carried out with public participation and no information will be disclosed during the course of such public participation which relates to—

(i) trade, manufacturing or business activities, processes or techniques of a proprietary nature, or financial, commercial, scientific or technical matters which the

proponent has requested should remain confidential, unless for reasons to be recorded in writing, the Director General of the Federal Agency is of the opinion that the request for confidentiality is not well- founded or the public interest in the disclosure outweighs the possible prejudice to the competitive position of the project or its proponent; or
(ii) international relations, national security or maintenance of law and order, except with the consent of the Federal Government; or
(iii) matters covered by legal professional privilege.

(4) The Government Agency shall communicate its approval or otherwise within a period of four months from the date the initial environmental examination or environmental impact assessment is filed complete in all respects in accordance with the prescribed procedure, failing which the initial environmental examination or, as the case may be, the environmental impact assessment shall be deemed to have been approved, to the extent to which it does not contravene the provisions of this Act and the rules and regulations.

(5) Subject to sub-section (4) the appropriate Government may in a particular case extend the aforementioned period of four months if the nature of the project so warrants.

(6) The provisions of sub-sections (1), (2), (3), (4) and (5) shall apply to such categories of projects and in such manner as may be prescribed.

(7) The Government Agency shall maintain separate registers for initial environmental examination and environmental impact assessment projects, which shall contain brief particulars of each project and a summary of decisions taken thereon, and which shall be open to inspection by the public at all reasonable hours and the disclosure of information in such registers shall be subject to the restrictions specified in sub-section (3)."

Hence the project is exempt from the IEE and EIA studies and an NOC in this regard has already been issued.

Initial Environment Examination (IEE) and Environmental Impact Assessment (EIA)

However please be informed that on advise of the Clean Development Mechanism Cell Ministry of Climate Change, both the IEE and EIA studies were conducted and the relevant No Object Certificate obtained by the Environmental Protection Agency (EPA) of Punjab on 9/13/2012, provided below in figure 1.10.1 and figure 1.10.2. Please refer to Volume 5 **Environmental Studies Booklet** for further detail and both the IEE and EIA and related documents.

1.11 Evaluation of the soil/ground conditions

The complete report on Geo-Technical Conditions of the project site are present in The Geo Technical Study - Volume 4 of the Feasibility Study Report; containing detailed information on the subsurface conditions encountered at the investigated locations, and recommendations for the foundations of the proposed building. The recommendations given in this report are based on field and laboratory test results, and on the state-of-the-art knowledge in geotechnical engineering, design and construction

The scope of work under this contract for geotechnical investigation consisted of the following major tasks.

1. Drilling and sampling of ten (10) boreholes down to a maximum depth of 5m (16.4ft)

2. Performance of Standard Penetration Tests (SPTs) at specified depth intervals to test and sample the subsurface soil.

3. Performing laboratory tests to determine pertinent index and engineering properties of the strata encountered at the site.

4. Analyze the field and laboratory data and submit an engineering report giving recommendations for the foundation design and construction.

1.12 Road Conditions to site

Comprehensive due diligence was carried out by experts and representatives from all stakeholders of the project, which was followed by a review and selection procedure. The site selected encompasses an area of 50 Acres which is approximately 10 km from Bahawalpur (the nearest urban city).

Hard Surface Hard Duty (HSHD) roads have been constructed from Bahawalpur to the site. The load bearing capacity of the roads are good enough to bear the loads of transportation vehicles and transported material. This allows easy access for transport of material from Bahawalpur Airport and equipment being transported by road from sea ports. The terrain is flat with minimum settlement and heavy and long vehicles can move easily. These are for long lengths multi-lane single-carriage roads. Similar types of road also form a network around the site making access to nearby locations and power grid station (Marot) convenient for regular travel to and from the site.

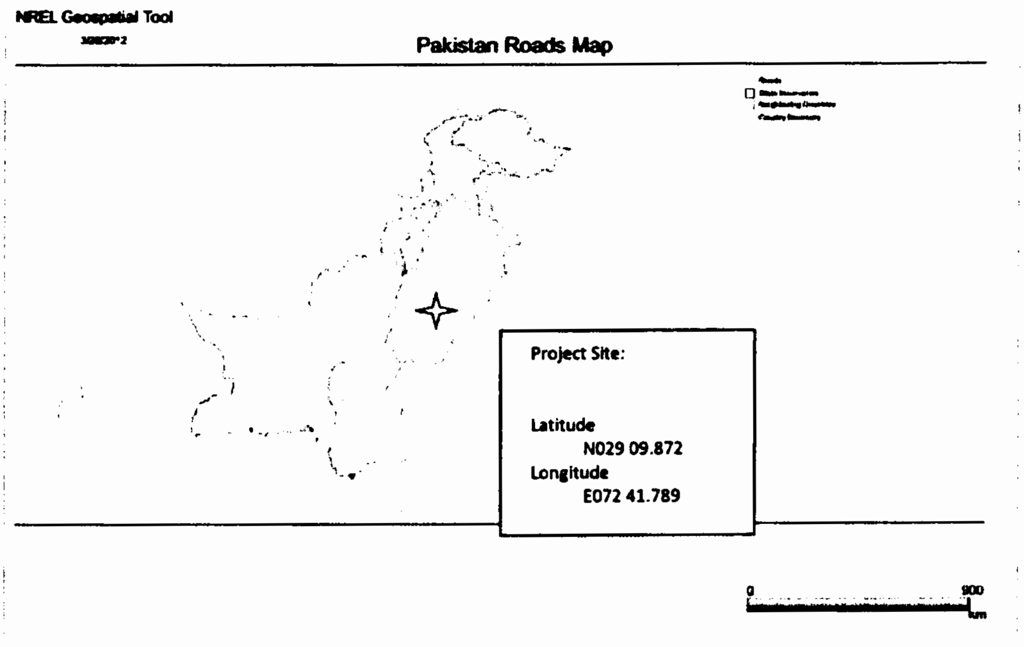


Figure 1.12.1: Road Maps of Pakistan

1.13 Water Conditions at Site

The site is facilitated with a very favorable level of water table, less than 20m below ground level. The project team would drill bores to gain access to this water table and its supply. Simultaneously for initial work scope, there are existing wells within approachable distance which are being used by local habitants for their livestock.

1.14 Grid Station

General Overview of Grid Evaluation and Selection:

The decision of selecting an electric grid for connection with the plant is dependent on the variability and uncertainty, which are inherent characteristics of power systems.

Loads, power lines, and generator availability and performance all have a degree of variability and uncertainty. Regulations, standards, and procedures have evolved over the past century to manage variability and uncertainty to maintain reliable operation while keeping costs down. There are many different ways to manage variability and uncertainty.

The standards, however, do not dictate *how* to meet many of the performance requirements. Planners look years into the future to project needs for generation and transmission capacity, estimate cost effective expansion of supply options, and assess flexibility needs. Flexibility of the generation fleet is characterized in terms of parameters such as minimum start-up and shut-down times, minimum stable generation, and ramp rates. Closer in, planners will schedule units for maintenance or to be available to meet expected loads. These units are committed to generate electricity for a system in the hours to days unit commitment time scale. In the 10-min to hours' time scale system operators will change the output of committed units to follow the changes in load throughout the day. More capacity than is needed at any particular time is committed to ensure that errors in forecasts or unexpected events can be accommodated without compromising reliability. In the tens of minutes time scale, system operators schedule adequate regulation reserves to track minute-by-minute changes in the balance between generation and load.

Managing variability and uncertainty is easier and less expensive when transmission lines are used to aggregate several diverse sources of variability and uncertainty. The daily load shape that system operators use to plan for the real-time operation of the grid is dramatically smoother than the daily profile of an individual residential customer, due to the diversity of load usage among customers.

Important lessons from the above discussion help us decide the location of the site, selection of electrical grid and grid station for connection and to conduct our load calculations to accuracy. These factors are summarized below as per directives and pattern of NREL:

1. **Clouds can cause significant ramps in solar insolation and PV plant output**
2. **Clouds are diverse**
3. **Smoothing occurs within PV plants**
4. **Diversity occurs between separate PV plants**
5. **Multiple methods are available for PV forecasting**
6. **Grid events can impact the variability of PV**

The Pakistan Transmission Network:

Pakistan has a vast transmission and distribution system ranging from northern areas to farthest corners of Balochistan and Sindh. National transmission and Distribution Company (NTDC) is the main authority which manages all the transmission facilities and the National Grid with the help of 08 distribution companies, the DISCOs. Figure 1.14.1 provided below shows the various power stations and transmission lines passing across the country.

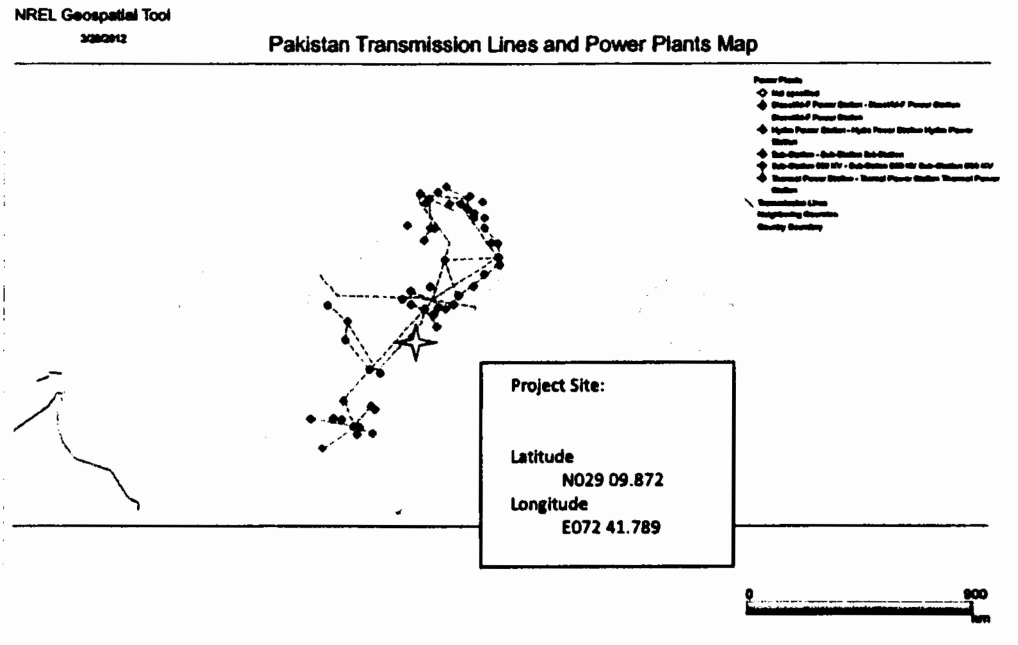


Figure 1.14.1: Transmission Lines and Power Plants of Pakistan

Selected Electric Grid Station:

The electric grid selected for connection with the PV power plant is the Marot grid station due to a number of factors. Connection to this grid station is most feasible as per initial surveys and research. The grid station has the required capacity (and is going up-gradation) for receiving and distributing maximum load from the PV Power station. Operators at grid station have also demonstrated their confidence in being able to forecast required information. In addition the Grid Station is at a displacement of approximately 3.5 KM from the Project Site and hence renders itself the most suitable for interconnection with the national grid.

The grid station falls under the Multan Electric Power Company's authority, with whom initial meetings have been done and full support has been ensured by the competent authorities for the Project.

The geographical details of the grid station are mentioned below:

Latitude:	N029 09.872
Longitude:	E072 41.789
Distance (from site):	4 to 4.5 Km

You will find below the pictures of the Marot Grid Station with its complete infrastructure, which were taken by our team of experts during their research visit and analysis of the site:

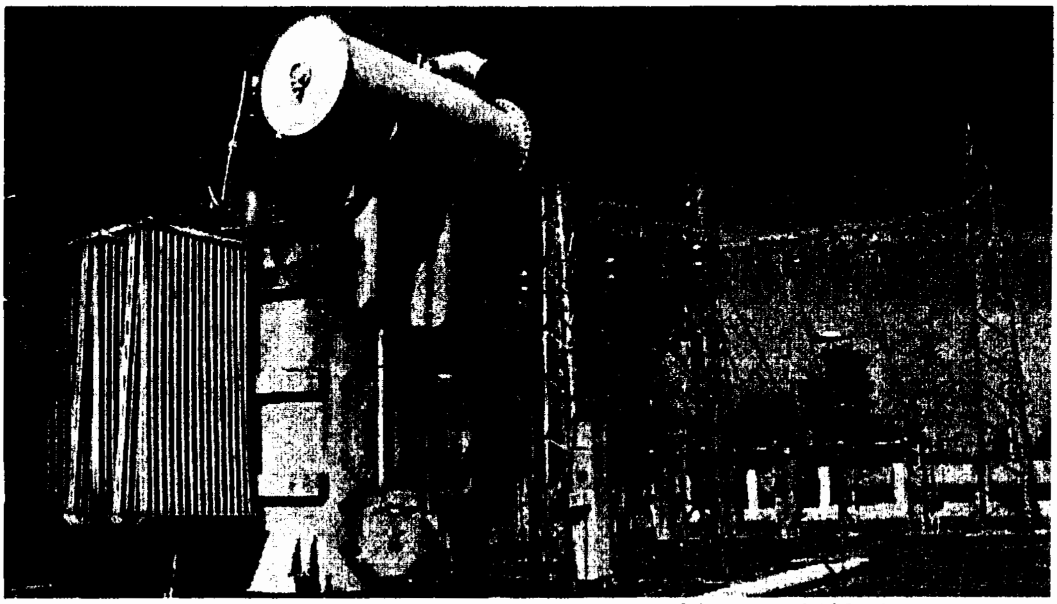


Figure 1.14.2: Incoming Transmission Lines at 132KV of the Marot Grid Station

Figure 1.14.3: Showing further progression along the transmission line into the Marot Grid Station

Figure 1.14.4: The outgoing Transmission Lines at 11KVA

1.15 Infrastructure Facilities in vicinity of Project Site

Cholistan primarily flourishes on the transport infrastructure that has been developed by the provincial government in recent times. This transport infrastructure, due to its well-maintained condition, provides residents, and visitors to Cholistan an ease of access to any basic facilities required. The primary link that Cholistan enjoys in terms of facilities and their availability is with Bahawalpur.

Bahawalpur is by every means well equipped with all facilities required to serve people. These facilities are available in Cholistan within a time gap of 45 minutes, which is the time it takes to reach Bahawalpur.

For emergency needs such as police personnel or doctors, Cholistan has established protocols and on road surveillance for its police department. Cholistan also has the benefit of being one of those locations, to which doctors and specialists from all over the country and abroad visit to provide free services to those suffering from different kinds of diseases or abnormalities.

Communications is another strong infrastructure in Cholistan. It performs to the extent that services of Mobilink such as wireless network and GPRS are easily accessible on any hand held device.

Other facilities such as waste management would be developed during the initial phases of the project since they are not a requirement of the current residents or habitants of Cholistan near the project site.

1.16 Social and Resettlement Studies

Different natures of projects are subject to different requirements. All projects in Pakistan should have to abide by the legislations and rules set by the Pakistan Environmental protection Agency as their first guideline. Any clarity required has to be sought by the appropriate office figures in the authority.

With almost no population in a 4 to 5 KM radius around the Project Site there is no requirement of any Resettlement Studies.

The project has a positive social impact, creating jobs and livelihood for people of Cholistan. It will bring a revolution in their lives through economic uplift. The Social Impact of the Project is covered in detail in later chapters of the FSR Volume 2.

All methods employed during the engineering, procurement and construction phase have not only been screened to develop opportunities in Pakistan but also to cater to important requirements such as providing a healthy environment to the community. This project will also play a crucial role in improving awareness on renewable energy and in turn on the right consumption pattern of power for consumers.

1.17 Analysis of Resource Potential at site

METEONORM Version 6.1.0.23

Standortname = meergarth

Geogr. Breite [°] = 29.150, Geogr. Länge [°] = 72.684, Höhe [m] = 145, Klimaregion = IV, 5

Strahlungsmodell = Standard (Stunde); Temperaturmodell = Standard (Stunde)

Modell für geneigte Flächen = Perez

Temperatur: Neue Periode = 1996-2005

Strahlung: Neue Periode = 1981-2000

Ta: Nur 2 Station(en) für Interpolation

Rh: Nur 2 Station(en) für Interpolation

SD: Nur 3 Station(en) für Interpolation

RD: Nur 4 Station(en) für Interpolation

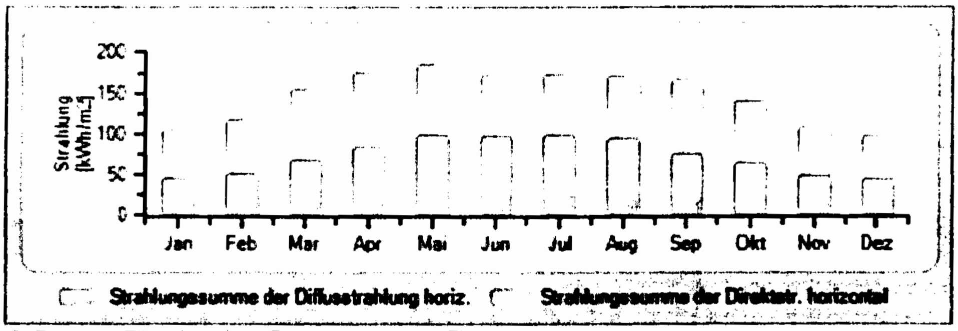
Nächste 3 Stationen: Gh: Multan (168 km), New Delhi (445 km), Lahore (311 km)

Nächste 3 Stationen: Ta: Bikaner (142 km), HISSAR (296 km)

Monat	H_Gh	H_Dh	H_Bn	Ta
	[kWh/m2]	[kWh/m2]	[kWh/m2]	[C]
Jan	105	46	117	14.9
Feb	119	52	116	19.0
Mar	155	68	136	25.3
Apr	176	84	130	30.8
Mai	186	99	116	34.9
Jun	173	98	100	34.9
Jul	175	99	99	33.2
Aug	173	95	103	32.2
Sep	167	76	134	31.6
Okt	141	65	122	27.9
Nov	109	49	116	22.0
Dez	98	45	111	16.8
Jahr	1776	876	1399	27.0

Legende:
H_Gh: Strahlungss. der Globalstrahlung horiz.
H_Dh: Strahlungssumme der Diffusstrahlung horiz.
H_Bn: Strahlungssumme der Direktnormalstrahlung
Ta: Lufttemperatur

METEONORM Version 6.1.0.23



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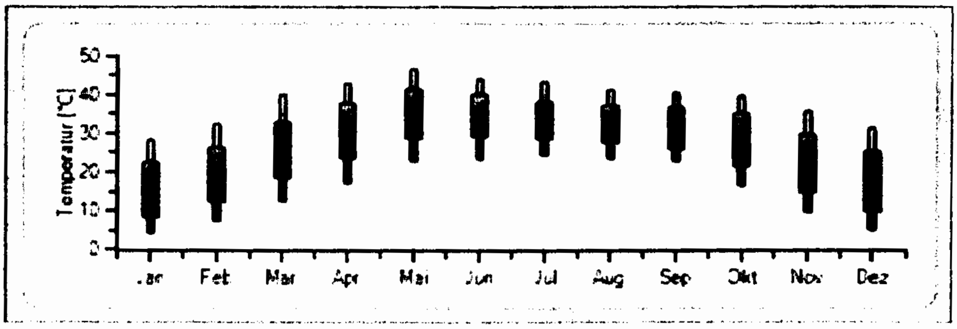

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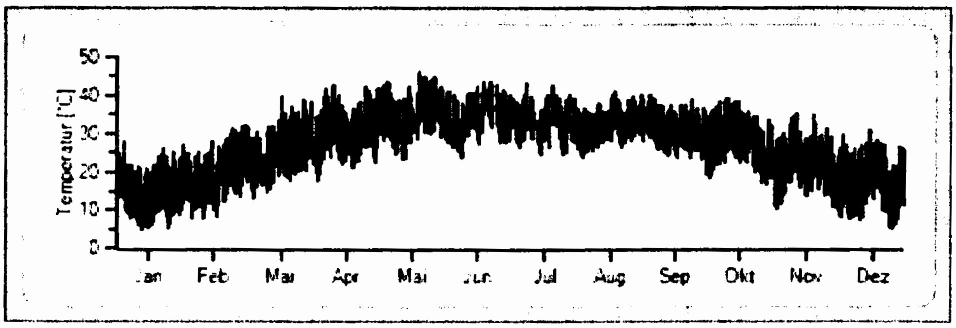

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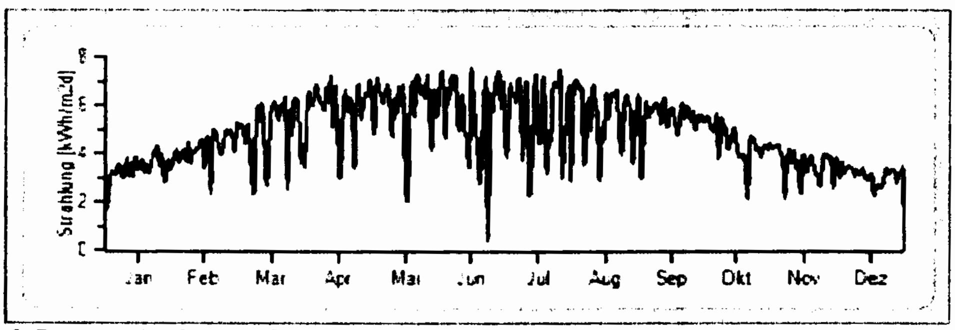

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PVSYST V5.20		24/09/12

Hourly meteorological data

Meteo data : **Cholistan, Synthetic Hourly data**
File Cholistan_SYN.MET of 15/03/12 16h46

Situation Latitude 29.2°N Longitude 72.4°E
Time defined as Legal Time Time zone UT+5 Altitude 135 m

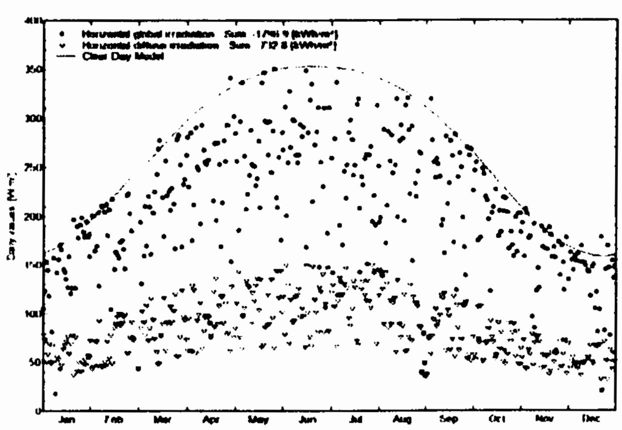
Source file characteristics Synthetic Data generation, Monthly renormalisation
Monthly Meteo Values Source NASA-SSE satellite data, 1983-1993, release 6

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	
Hor. global	3.51	4.11	4.97	5.73	6.19	6.36	5.72	5.47	5.15	4.61	3.83	3.26	4.91	kWh/m².day
Extraterrestrial	6.06	7.16	8.89	10.26	11.10	11.40	11.25	10.61	9.44	7.93	6.44	5.68	8.86	kWh/m².day
Clearness Index	0.577	0.574	0.559	0.557	0.557	0.558	0.508	0.515	0.546	0.582	0.594	0.574	0.554	
Amb. temper.	12.7	15.5	22.0	27.6	31.9	33.4	31.6	30.1	29.1	25.6	20.0	14.7	24.5	°C

Hourly meteo, monthly sums

Interval beginning	GlobHor kWh/m².mth	DiffHor kWh/m².mth	T Amb °C
January	108.8	42.04	12.70
February	119.2	48.02	15.50
March	154.1	63.40	22.00
April	171.9	68.42	27.60
May	191.9	80.87	31.90
June	190.8	77.48	33.40
July	177.3	87.04	31.60
August	169.6	73.30	30.10
September	154.5	60.76	29.10
October	142.9	52.04	25.60
November	114.9	41.21	20.00
December	101.1	38.76	14.70
Year	1796.9	732.82	24.57

Meteo for Cholistan, Synthetic data



Data acquired from NASA used in analysis of the system in PVSYST. The synthetic data obtained shows minimum deviation from the data obtained from METEONORM and the instruments at the site.

Month	Average Global Horizontal Radiation (Kwh/m^2.month)	
	METEONORM	NASA (Synthetic Data)
January	105	109
February	119	124
March	155	154
April	176	172
May	186	192
June	173	191
July	175	177
August	173	170
September	167	155
October	141	143
November	109	115
December	98	101
Average Deviation	Approx. 3%	

Table 1.17.1 Comparison between METEONORM and NASA Data

The Synthetic Data from both resources has been cross referenced and checked as in the above data, showing more or less the same Irradiation levels, and confirming their reliability.

MONTHLY COMPARISON OF Data from SRA and NASA Synthetic Data				
Month	**Monthly Average from SRA (W/Sqm/Day)**	**Monthly Average from SRA (kWh/Sqm/Day)**	**Monthly Average from NASA (kWh/Sqm/Day)**	**Deviation of SRA with NASA Data**
Jan-12	164.77	3.95448	3.51	+0.10
Feb-12	188.42	4.52208	4.26	+0.05
Mar-12	225.19	5.40456	4.97	+0.08
Apr-12	251.5	6.036	5.73	+0.05
May-12	298.18	7.15632	6.19	+0.13
Jun-12	299.01	7.17624	6.36	+0.11
Jul-12	280.53	6.73272	5.72	+0.15
Aug-12	234.39	5.62536	5.72	-0.01

Table 1.17.2 Comparison between Synthetic and Real Time Data

We find in the table above a further investigation to determine the Deviation of the Synthetic Data from the Real Time Data collected for Micro siting by the SRA Equipment installed on site the results of which further enhance the credibility of the yield analysis and FSR Report overall.

The overall positive average deviation of a factor of 0.08 which furthers the reliability of the Resource Potential Assessment of the Site and Yield Analysis performed in subsequent chapters based on this data.

2 DESCRIPTION OF TECHNICAL EQUIPMENT

Solar photovoltaic modules, called "photovoltaic" or "PV", are solid-state semiconductor devices with no moving parts that convert sunlight into direct-current electricity.

Today, annual global module production is over 100 MW, which roughly translates into a $1billion/year business. In addition to PV's ongoing use in space, its present day cost and performance also make it suitable for many grid-isolated applications in both developed and developing parts of the world, and the technology stands on the threshold of major energy-significant applications worldwide.

PV enjoys so many advantages that, as its comparatively high initial cost is brought down another order of magnitude, it is very easy to imagine its becoming nearly ubiquitous late in the 21 century. PV is likely to be employed on many scales in vastly differing environments, from microscopic cells integrated into and powering diamond-based optoelectronic devices in kilometers-deep wells to 100-MW or larger 'central station' generating plants covering square kilometers on the earth's surface and in space. The technical and economic driving forces favoring PV's use in these widely diverse applications will be equally diverse.

However, common among them will be PV's durability, high efficiency, low cost, and lack of moving parts, which combine to give an economic power source with minimum maintenance and unmatched reliability. In short, PV's simplicity, versatility, reliability, low environmental impact, and—ultimately—low cost, should help it to become an important source of economical premium-quality power within the next 50 years

All equipment used in the Feasibility Study Analysis including Simulation of the Power Project, has been selected keeping in view modules availability in the market and specifically quoted to the Joint Venture by reputable companies in the solar industry out of which some of the best were SMA Technologies Germany and Solar World keeping in view their experience, expertise and past record in the field with respect to the Project and its requirements.

2.1 Modules

The amount of electricity produced by PV systems depends primarily on the following factors:

Module types and efficiency
Module efficiency
System efficiency
Module reliability

2.1.1 Module Standards

The salient features and certifications of the Product include:

- IEC - 61215

  The test cetificate corresponding to IEC 61215 has gained acceptence in the past few years as the quality symbol for Silicone PV modules. Nowadays it is required for most national and international funding programs.

- IEC-61730

  The long term environmental tests of the EN IEC 61215 (resp. EN IEC 61646) do not cover the aspects of electrical safety adequately.

  Therefore, in the past, the TÜV developed test procedure for the qualification of PV modules as Safety Class II equipment (double or reinforced insulation) has gained worldwide reputation

- Plus-sorting
- Plus Sorting controlled by TUV Rheinland
- Qualified IEC 61212
- SGS Salt Water mist and Corrosive Gas Resistant
- Linear performance guarantee: 25 years
- Product guarantee: 10 years Service Certificate

- 3 Bypass Diodes for less losses through partial shading
- Over 30 years of Manufacturing Experience should be prefered

2.1.2 Module types

Two categories of PV cells are used in most of today's commercial PV modules: crystalline silicon and thin film. The crystalline silicon category, called first-generation PV, includes mono-crystalline and multi-crystalline PV cells, which are the most efficient of the mainstream PV technologies and accounted for about 84% of PV produced in 2008 (Bartlett et al. 2009). These cells produce electricity via crystalline silicon semiconductor material derived from highly refined poly-silicon feedstock. Mono-crystalline cells, made of single silicon crystals, are more efficient than multi-crystalline cells but are more expensive to manufacture.

The thin-film category, called second-generation PV, includes PV cells that produce electricity via extremely thin layers of semiconductor material made of amorphous silicon (a-Si), copper indium diselenide (CIS), copper indium gallium diselenide (CIGS), or cadmium telluride (CdTe). The efficiencies of all PV cell types have improved over the past several decades ranging from 20% to almost 28% for crystalline silicon cells and 12% to almost 20% for thin film.

For the usage of Modules in Large Scale Projects, long proven and established technology, mono-crystalline Photovoltaic has been recommended. At the moment the most available and so on the efficient Photovoltaic product is the mono-crystalline Technology. As per such large required numbers of Modules it is common to use a range of power classes to meet the delivery in a short time. The power output of Photovoltaic used in large scale projects is 240 – 245 Wp.

2.1.3 Module efficiency

The cells described in previously were manufactured in small quantities under ideal laboratory conditions and refined to attain the highest possible efficiencies. The efficiencies of mass produced cells are always lower than the efficiency of the best research cell. Further, the efficiency of PV modules is lower than the efficiency of the cells from which they are made. In 2008, the typical efficiency of crystalline silicon-based PV modules ranged from 13.5% for multi-crystalline modules to 17.5% for high-efficiency mono-crystalline modules (Mehta and Bradford 2009). For thin-film modules, typical efficiencies ranged from 6.5% for a-Si modules to about 10% for CIGS and CdTe modules.

2.1.4 Module reliability

Historic data suggest that reliability is a very important factor when considering the market adoption of a new technology, especially during the early growth stages of an industry. PV is currently experiencing unprecedented growth rates. To sustain these growth rates, it is imperative that manufacturers consider the implications of product reliability

Today's PV modules usually include a 25-year warranty. Standard warranties guarantee that output after 25 years will be at least 80% of rated output. This is in line with real world experience and predicted performance from damp-heat testing of modules

2.1.5 PV Module Price Trends

Photovoltaic modules have experienced significant improvements and cost reductions over the last few decades, and the market for PV modules has undergone unprecedented growth in recent years. Although PV module prices increased in the past several years, prices have been falling steadily over the past few decades and began falling again in 2008. Thin-film PV technologies are achieving manufacturing costs and selling prices significantly lower than for crystalline silicon modules.

Currently, 302 solar module prices are below $2.00 per watt (€1.52 per watt) or 31% of the total survey. In January, there were 313 price points below $2.00 per watt (€1.52 per watt), which was 28% of the survey.

The lowest retail price for a multi-crystalline silicon solar module is $1.08 per watt (€0.82 per watt) from a German retailer. The lowest retail price for a mono-crystalline silicon module is $1.20 per watt (€0.91 per watt), also from a German retailer. Brand, technical attributes, and certifications do matter. The lowest thin film module price is $0.81 per watt (€0.62 per watt) from a Germany-based retailer. As a general rule, it is typical to expect thin film modules to be at a price discount to crystalline silicon (like for module powers). This thin film price is for a 105 watt module.

Module Technology	Crystalline	Thin-Film
Generation	1st	2nd
Market Shares (2008)	84 %	16 %
Data Availability	Old Technology; Data is available for analysis	Relatively Newer Technology; Data is scant for reliability analysis
Efficiency	Mono crystalline: 17 % Poly crystalline: 13.5	9 %
Lowest Retail Price ($/watt)	High Mono Crystalline: 1.20 Poly Crystalline: 1.08	Low 0.81
Weight to Power Ratio	Small	Large
Module Size	Large range 65 – 240 W	Small Range 65 – 130 W

Figure 2.1.1: Comparison of Module Technologies

After consideration it has been decided to utilize mono crystalline modules, thereby compromising between cost and efficiency. Whereas thin-film modules are economically more suitable, it is a relatively new technology and therefore has a lower number of manufacturers and certifiers. On the other hand mono-crystalline modules are more efficient and have more certifications owing to its larger presence in the market.

2.2 Suitability of Solar Modules with SITE

The modules to be selected for the project should have in built features for extreme weather conditions to be suitable for the project site. The modules would be subject to conditions such as temperatures exceeding 50°C, wind speeds exceeding 5 m/s, and precipitation on panels in case of rare occasional occurrence of a sand-storm. Therefore, modules should consist of materials that have high tolerance to these conditions and more, meaning a high factor of safety and resilience. Additionally, the modules should allow for easy and fast maintenance along with cleaning operations.

2.3 Inverters / Transformers

There are two main types of inverters available on the market. Modified sine wave inverters were the earliest type of inverter introduced to the market. These inverters produce AC power, but do not achieve this perfectly. Many devices will not work properly when powered by a modified sine wave inverter.

Pure sine wave inverters, aka true sine wave inverters, produce a perfect replica of AC power. These inverters are more appropriate for grid-connected use.

Grid-tie inverters work much the same as any inverter but with one main difference. Grid-tie inverters must ensure that the power supplied will be in phase with the grid power. This allows renewable energy (wind, solar, etc.) generation plant owners to sell power to the utility.

Inverters work by taking the DC voltage from the source, such as solar panels or micro hydroelectric generators, and 'chopping' by turning it on and off at 60 Hz using a local oscillator and a power transistor. This 60 Hz chopped DC is then filtered to make it into a sine wave (removing the upper 3, 5, 7 harmonics that make up the square wave). Then the square wave is applied to a transformer to increase the voltage to 120 or 240 V.

SMA, founded in 1981, is now considered to be the world's largest supplier of Photovoltaic inverters, also producing monitoring systems. The company's inverter factory, considered to be the world's largest in 2009, was designed with the aim of CO2 neutrality. SMA has bases across the world including the USA and Australia. In 2009, the company claimed to have 38% of the global PV inverter market.

Specifications for SMA 800 CP Inverter are given in **Annexure 12:** Specifications for SMA 800 CP Inverter. However you will find below a description with salient features of the product below.

SMA Sunny Central 800CP

Self-commutated converter suitable for outdoor use with IP54- protected enclosure, connection area IP 23, innovative cooling concept OptiCool, standard DC input voltage range 1000V, system integrated DC main distribution with up to 9 inputs, power-operated DC switchdisconnector, AC contactor and AC circuit breaker, overvoltage protection for AC and DC side, comprehensive grid management functions (incl. LVRT). Connection for external power supply and designed for connection to an external transformer.

Product features:

- **Installation:** Suitability for outdoor installation and the prevailing ambient conditions according to IEC 60721-3-4 (4C2 regarding chemically active substances and 4S2 regarding mechanically active substances).

- **Enclosure :** Enclosure made of high-quality steel with protection degree of min IP54 according to IEC 60529

- **Temperature range:** Suitability for ambient temperatures from -20°C up to +50°C and delivery of full nominal power at +50°C . Operation up to 62 °C.

- **Overcapacity:** Overload capacity of 10% of nominal power at ambient temperature of 25°C

- **Ventilation:** Ventilation without filters and with minimum required maintenance. Fresh air consumption max. 3000m3/h.

- **Compact dimensions (HxBxT) and weight:** 228 x 256 x 95,6 cm,1800 kg

- **Grid management functions:** According to the requirements of BDEW medium voltage guideline for dynamic grid support

- **Efficiency:**
    - Euro-eta: 98,4%
    - THD total < 3% of nominal power
    - Power Factor: 0.9 leading ... 0,9 lagging
    - Energy consumption during operation: < 1500 W
    - Standby consumption: < 100 W

The Low DC to Medium Voltage transformation will take place using SMA 800 CP Inverters which will be taking input at 360V AC and the Transformers which shall be giving output at 11KV AC.

However to transmit power to the Grid Station a Switch Gear/Transformer shall be fabricated and installed to convert the 360V AC Medium Voltage to High 132KVA voltage for transmission to the Grid Station.

SFZ9-60000/11/132 STEP UP TRANSFORMER

MAIN TECHNICAL PARAMETER:

Input Voltage:	11KV(without input voltage regulator)
Output Voltage:	132KV
Voltage adjustment range:	±132KV×10% 8 step=8×1.25%
Capacity:	60000KVA
Phase:	3
Frequency:	50 Hz
Vector Group:	Ynd11(Input 11KV:Delta, Output132KV:Star)
Insulation Level:	IEC Standard(LI550AC230-LI325AC140/LI75AC35)
Impedance Voltage:	Ud=10.5%
Cooling:	ONAF
Noise Level:	70dB
Operating temperature:	+50°C/-10°C
Safety equipment:	temperature control protect equipment
Tape changer:	132KV automatic loaded voltage regulator

Environment Temperature (°C)	**-10**	**0**	**10**	**20**	**30**	**40**	**50**
Continuous load output ratio	**1.25**	**1.17**	**1.09**	**1.00**	**0.91**	**0.81**	**0.71**

The Plant integration shall also take place through the SMA OPC server software to and industrial SCADA system. Furthermore the inverters fulfill all grid management / smart grid functionalities:

- Power limitation peak shaving / grid safety management
- Frequency-dependent control of active power
- Grid support through reactive power
- Monitored dynamic grid support LVRT (Low Voltage Ride Through)

2.4 Balance of System

Bill of Quantities			
Part Name	Description	Quantity	Notes
Electrical Structure			
1	Solar Panels	41,888	SW 240 Mono
2	Inverter	12	SC 800 CP
3	Transformer	6	Transformer Compact Station 1600SC
4	Transformer	1	High Voltage Transformer
Mounting (22 Panels)			
1	Angle Beam L 60 x 60 x 6	15.37 m	
2	Cement R: 100 mm; D: 600 mm; V: 0.01886 m3	$2.0m^3$	
9400 Strings			
1	L 60 x 60 x 6 Angle Beam		349,800 m
2	Cement Cement Blocks		1290 m3
Wiring			
1	Grade 1	400m	String
2	Grade 2	250m	Bus
3	Grade 3		Inverter output
4	Grade 4		Transformer Out

3 PLANT LAYOUT

3.1 Layout of the Plant

After review of the equipment which would need to be utilized to ensure optimized performance and maximum yield generation, the Project Layout has been designed to utilize 6 of "1.6 MW Inverter" combined units of two SMA 800 CP Series Inverters (Actual power output at test conditions is 1.76 MW for each unit) which are further connected to 6 SMA Low to Medium range voltage transformers at approximately 360V AC, one for each 1.6 MW unit respectively giving an output between 11 to 20KV range, leading finally to the switch gear or transformer from medium to high voltage range for connection to the Grid Station at 132KV . Each unit of 1.6 MW will consist of 7480 panels, 2 inverters and 1 transformer.

A string concept is being used with 22 modules connected to a string, and 17 strings connected on a Bus leading to the SMA Inverters connection in parallel with a total of 10 such connections. The total number of PV modules used in this arrangement would be 3470 units per 1.6 MW with a total of approximately 6 such units for the complete 10 MW setup.

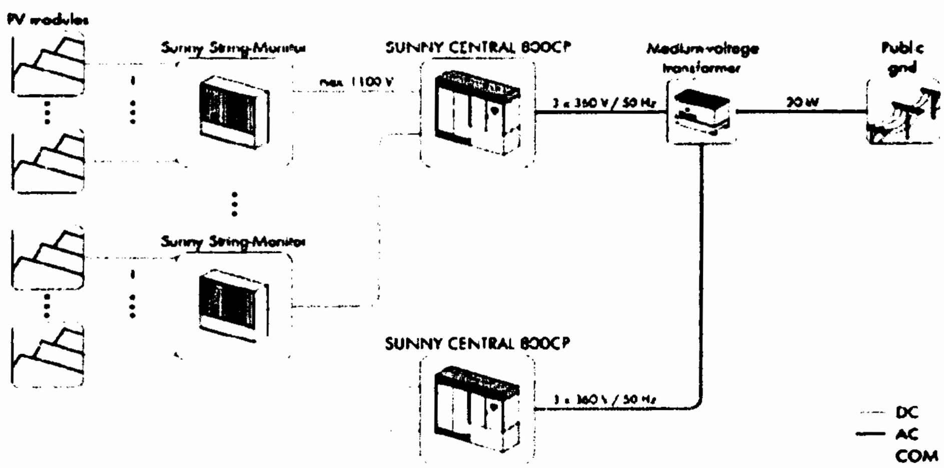


Figure 3.1.1: Block diagram of the power station layout

Summary of the Plant Layout

Location: Marot Fort Pakistan
Azimuth: 0°
Tilt: 29°

Modules:
- SW 240 mono
- 7480 Modules (240Wp in average) per 1.6MWp block
- 209,440 Modules for approximately 50,20 MWp DC

Inverter and Monitoring:
- 56 x SMA SC CP800
- 20 x SSM (combiner Box) per 1.6 MWp block

Miscellaneous:
- Transformer: 0.36/11 kV 1600 KVA x 28 Nos.
- 3.5 km away from the grid connection

Pos.	Quantity	Product	Option code
1	2	SC 800-CP-10	0010101ENDE2100
2	20	SSM	01B51
3	1	Communit-10	0030BB101EN
4	1	OPC-Server	0
5	1	Sensor	tempsensor-amb
6	1	Sensor	wind-sensor
7	1	Wall mounting bracket	wall-mount-bracket

Figure 3.1.2: Some of the System Components required in each 1 MW block

3.2 Details of the land acquired/Required

The Project Site is located near the Cholistan Desert, District Bhawalnagar, with nearest city of Bahawalpur and will have an installed capacity of 10MWp Photovoltaic Panels and will function as an Independent Power Producer (IPP) under the rules and regulations of Pakistan

With the help of the Punjab Government, initially 4 sites were short listed and identified in Cholistan, towards Southern Punjab with presence of the required minimum infrastructure, high irradiation levels and solar potential. After due scrutiny and deliberation by Experts over the sites; the 50 Acres strip of land located approximately 10 km from Bahawalpur, the nearest urban city, was selected and finalized. The location enjoys a flat terrain with innocuous sand dunes in the peripheral, scarce plant cover, rich solar irradiation, availability of water, nearby Government Guest houses and immediate access to the power grid at about 4km, thus rendering itself a technically and logistically feasible location for the setup of a large solar power station

The Joint Venture has been allotted/acquired 202,000 m2 (50 acres) of land in Cholistan region of Southern Punjab. A single string of 374 PV modules require approximately 170 meters x 9 meters where as a single inverter (3740 units of PV modules per inverter) requires 170 meters x 90 meters. The total requirement for construction of 41,888 units of PV modules including all logistical constructions and facilities, is approximately 150,000 m2 (37.5 acres) which is clearly within the value of the acquired land.

Refer to Volume 3 Topographic Survey, Volume 4 for Geo-Technical Studies and Volume 1 Annexure 7 for Site Survey report & further details.

3.3 Shading

External Shading:

Effects of external shading were simulated using PV-Solar G. The following results were obtained provided in the figures from Figure 3.3.1 to Figure 3.3.12.

Entries in the shading data grid will block varying proportions of beam radiation when the sun is at or below shading altitude angles entered at specific azimuths in the data grid. Beam radiation blockage is assumed to be at a 100 % due to sand dunes. However the large distance between sand dunes and virtually clear horizon show that there is a minimal amount of shading as is shown in the results.

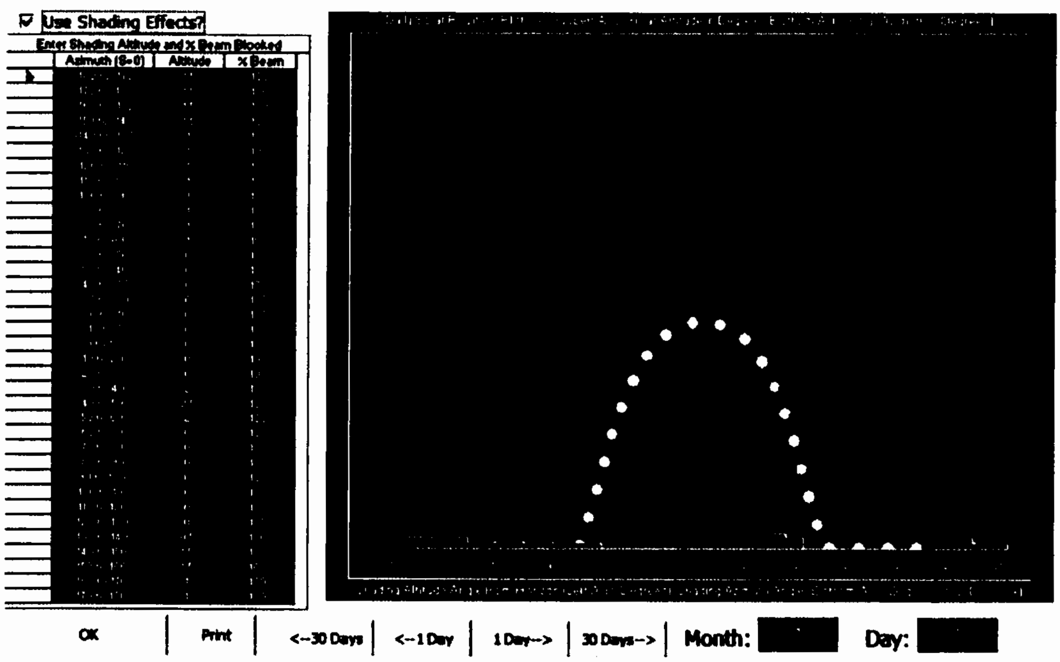


Figure 3.3.1: Showing the external shading effects in January

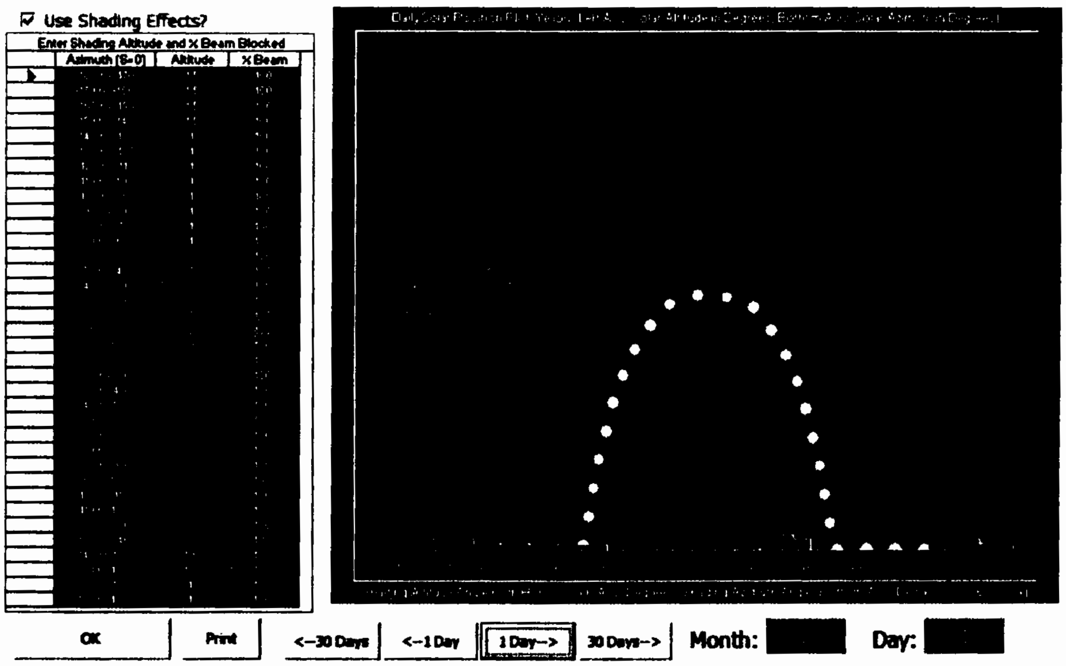


Figure 3.3.2: Showing the external shading effects in February

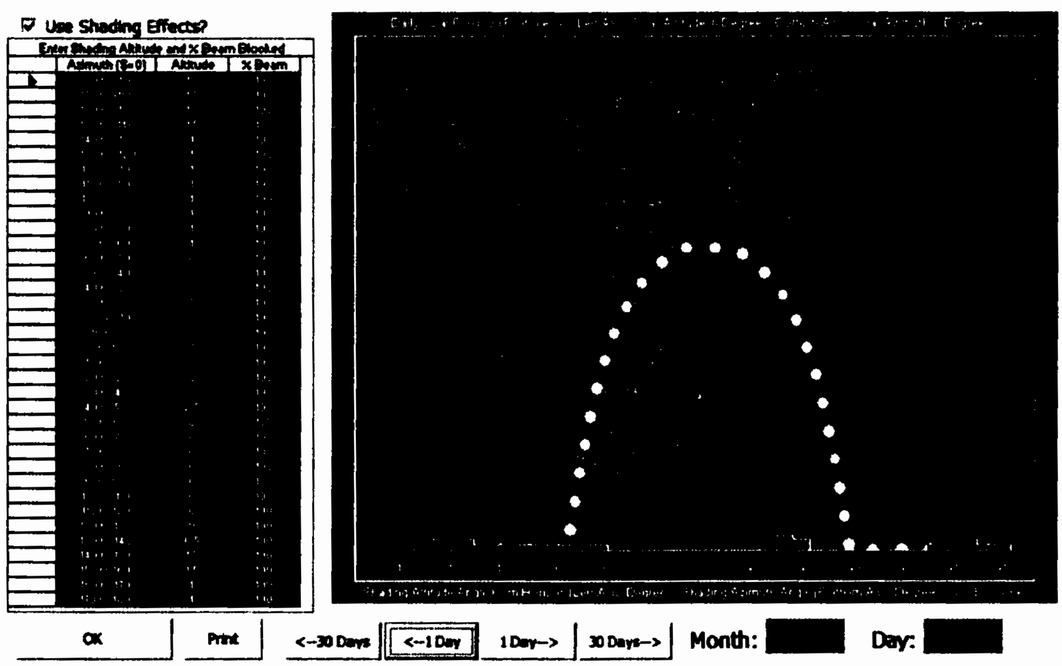


Figure 3.3.3: Showing the external shading effects in March

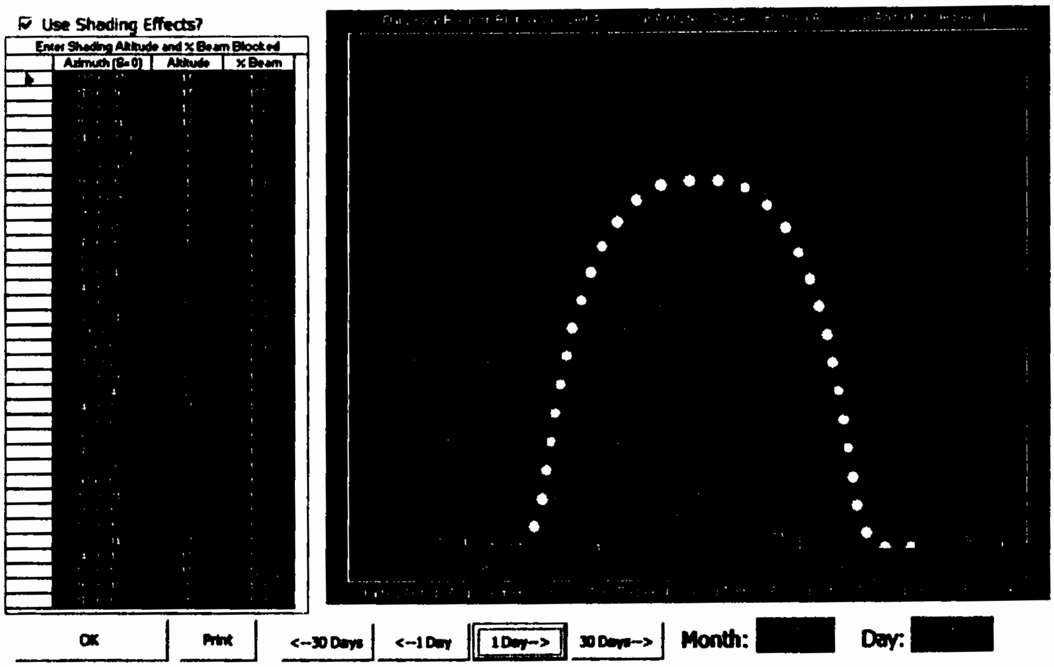


Figure 3.3.4: Showing the external shading effects in April

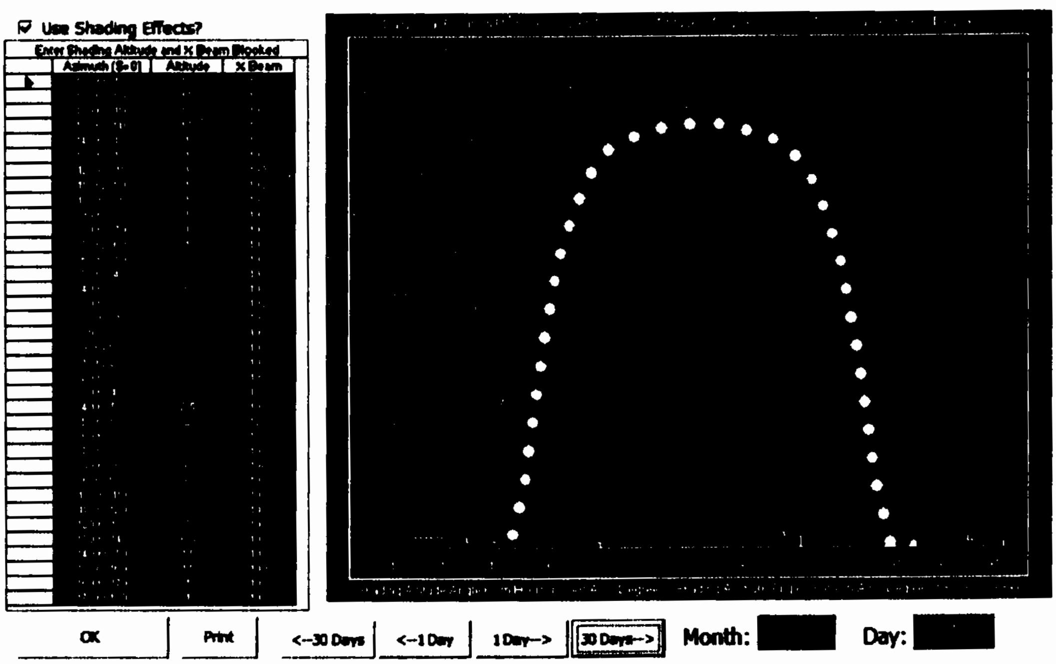


Figure 3.3.5: Showing the external shading effects in May

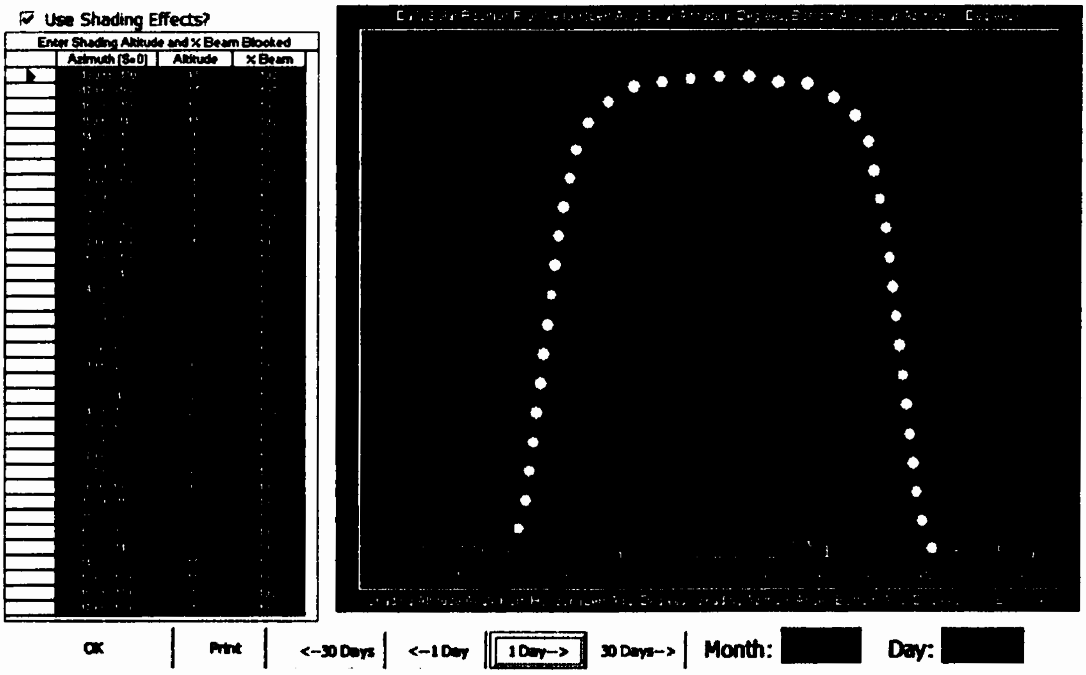


Figure 3.3.6: Showing the external shading effects in June

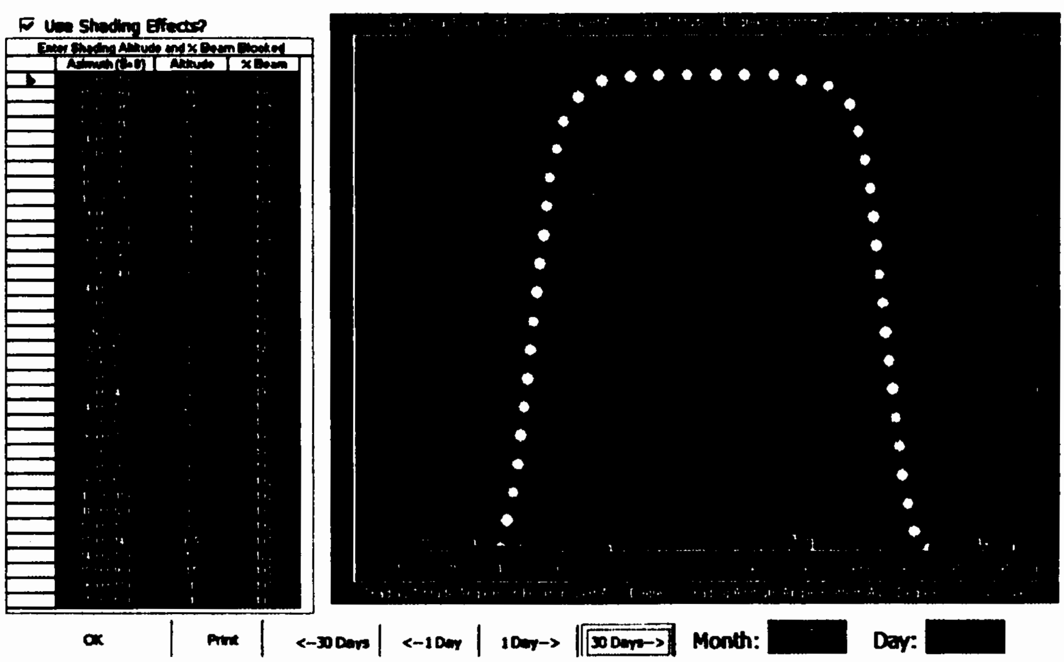


Figure 3.3.7: Showing the external shading effects in July

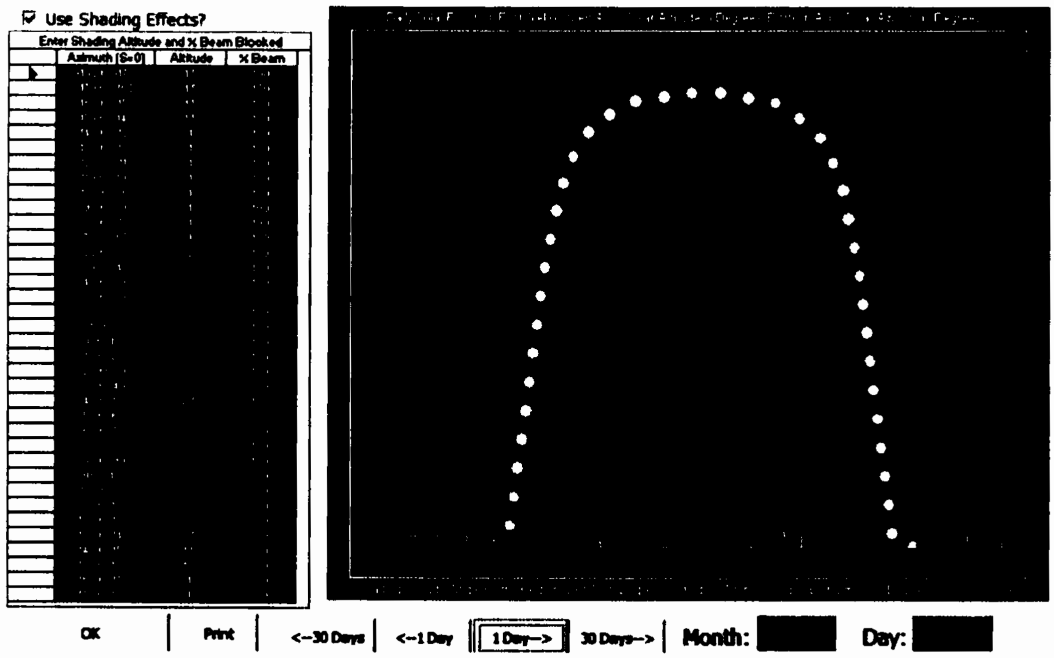


Figure 3.3.8: Showing the external shading effects in August

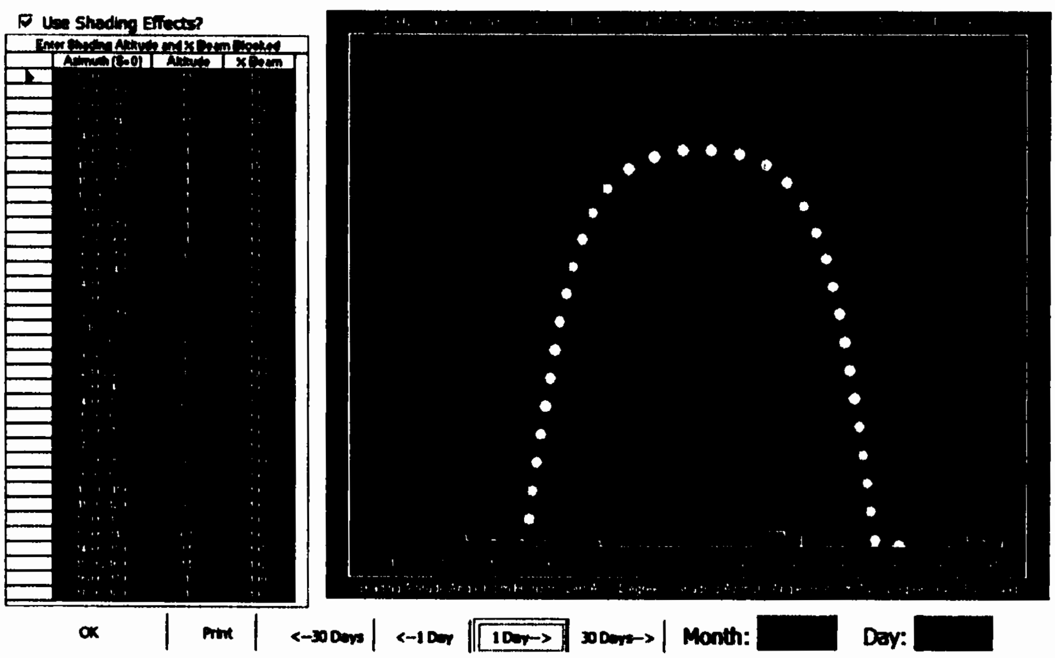


Figure 3.3.9: Showing the external shading effects in September

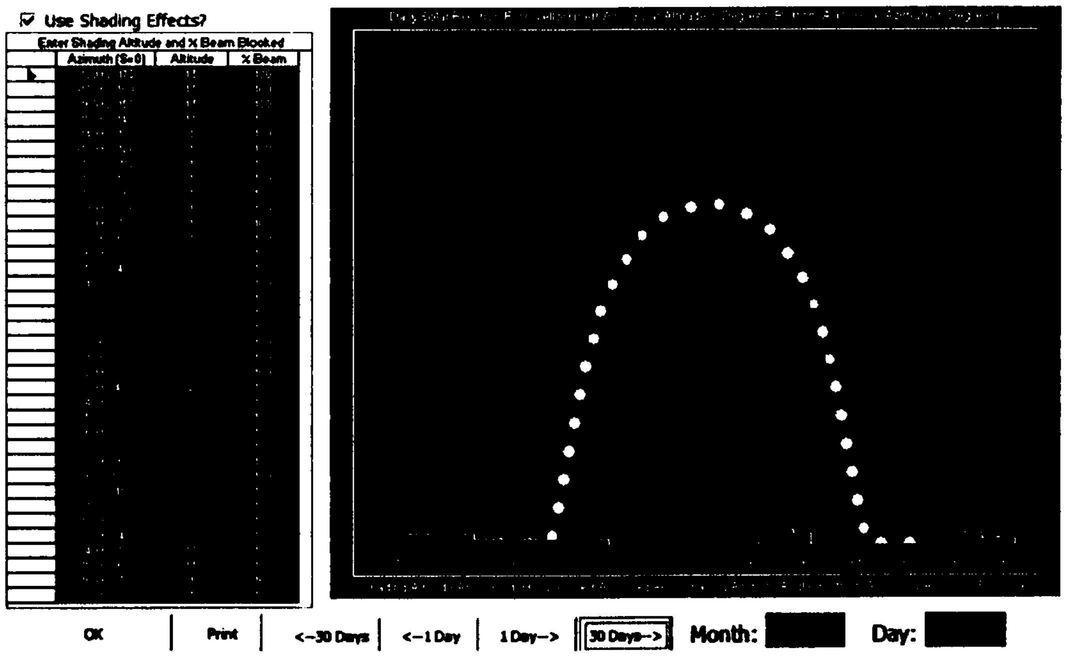


Figure 3.3.10: Showing the external shading effects in October

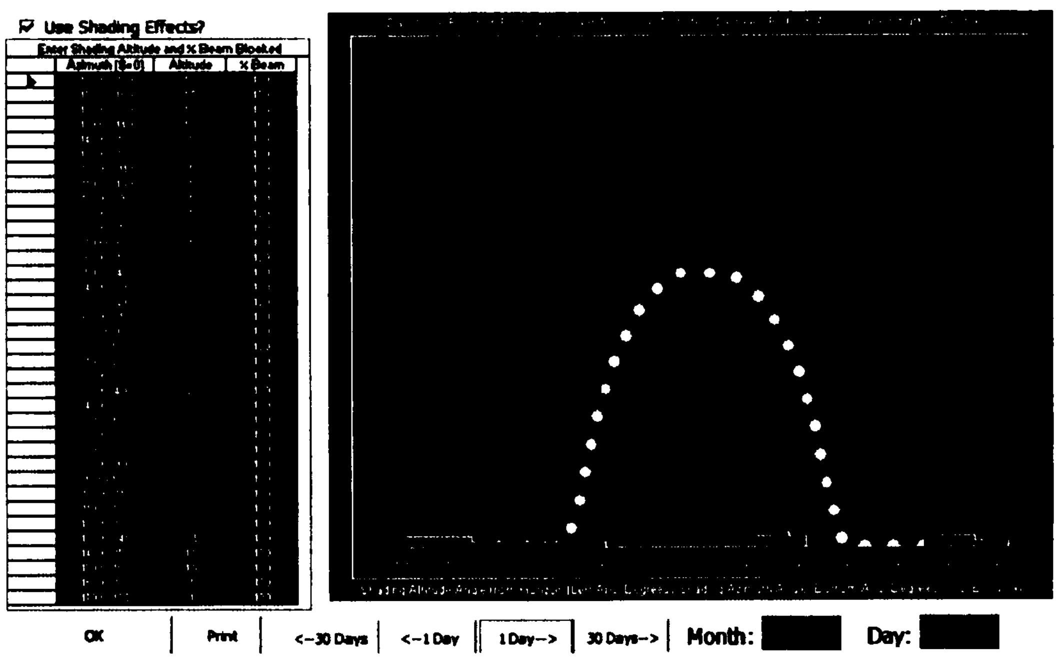


Figure 3.3.11: Showing the external shading effects in November

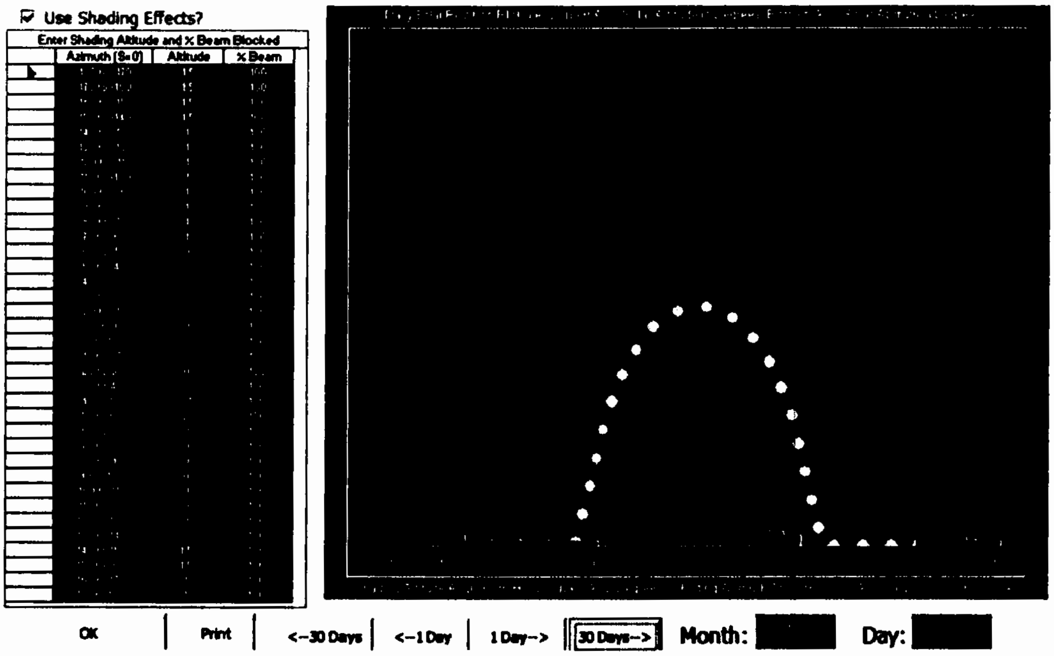


Figure 3.3.12: Showing the external shading effects in December

3.4 Tracking System and Mounting

There are three options that can be utilized when setting the tracking system of a photo-voltaic powered power plant namely single axis, dual axis or no tracking system.

Design optimization shows that for such a large number of panels, a tracking system would require a large initial investment as well as yearly maintenance for a relatively lower amount of increase in yield. Therefore the company has opted to utilize no tracking system

The modules would be clamped to a long term resistant mounting structure (details of which are provided in subsequent sections). The mountings will be made with considerations of stress analysis in weight and wind conditions.

High grades of mounting structures are made of Aluminum which is light, easy to install and long lasting in harsh weather and environmental. Options available in the market offer the advantage of easy installation on areas with different attitude levels without further needed landscaping work. These ground mounting system hold and align the solar modules and can be adapted to the individual ground conditions. The legs of the frame are fixed to the foundations. Horizontal and vertical rails hold and secure the modules in place. The frame also makes it possible to attach cable conduits, string monitors and inverters.

Figure 3.4.1: Ground Mounted Panels

The mounting system allows a range of ground pitch compensation and tilt angle adjustment using telescopic legs (ground pitch compensation of +/-10° in X/Z plane and +/-6° in Y/Z plane and 20° to 40 ° tilt angle adjustment).

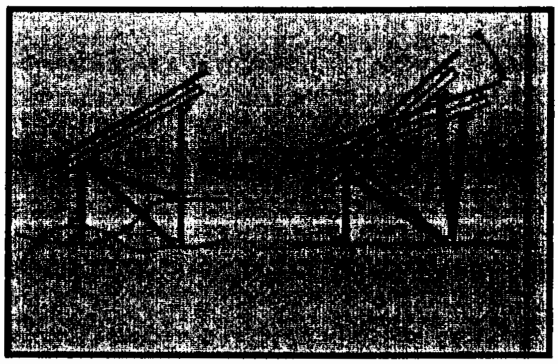


Figure 3.4.2: Adjustable Mountings for solar panels

3.5 Tilt and Azimuth as per Sensitivity Analysis

The most optimum direction of the Photovoltaic Modules is facing South 0°degree Azimuth and with an optimum tilt between 25° and 30 degree.

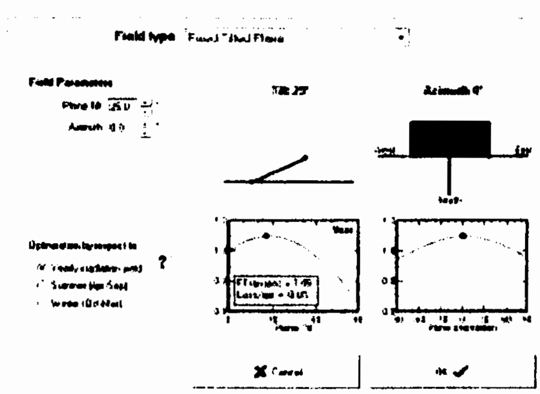


Figure 3.5.1 Yield - Tilt and azimuth

The following results were obtained from Maui Solar PV-Design Pro G. The results clearly show that maximum yield is obtained at 0° Azimuth and 30° tilt (marked in red).

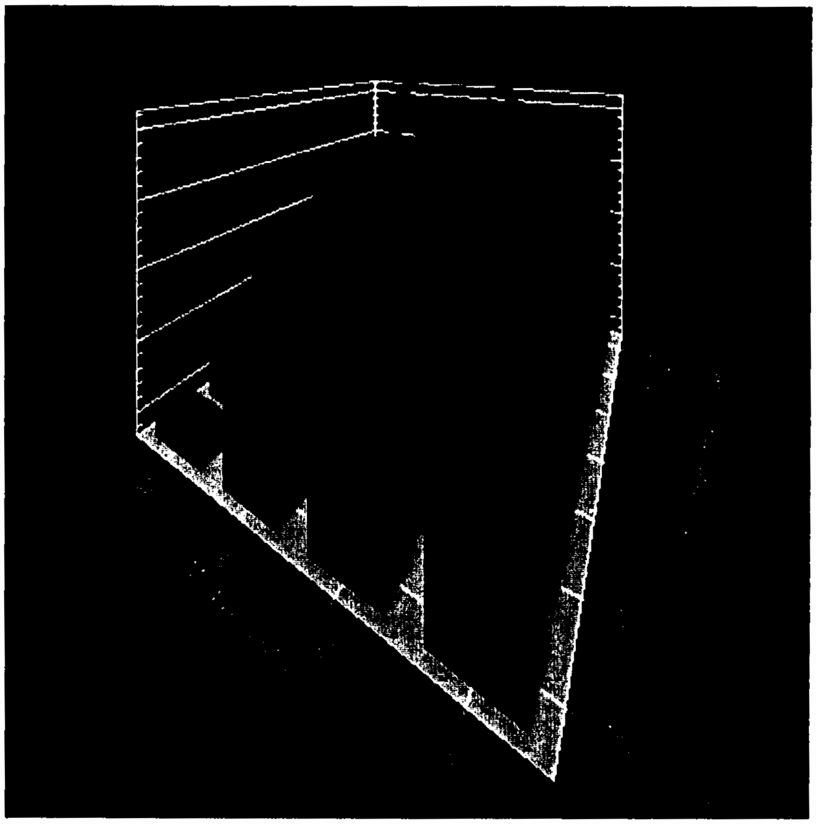


Figure 3.5.2: Showing the Module Slope and Azimuth generating the highest Yield.

3.6 Protection from Wind and Dust:

The Project is strategically positioned between the Farm Lands being irrigated by manmade canals taken out from the Indus River passing through Punjab on its way to Sindh which cover it on 3 sides and on the other hand the Marot Fort with its high elevation.

3.7 Modules Wiring, Subsystems Layout, Quality and Quantity of Inverters/ Transformers and their Layout

Array Concept Design Selection:

The following concepts can be utilized while designing the plant layout for large scale PV power plants. Figure 3.7.1 shows the array concept in which several strings are connected in parallel to a large central inverter. Several strings are connected in parallel to a single connection in the central inverter. The central inverter has the capacity to convert several KW of electricity. This is a cost effective method and allows easy installation. The efficiency of these inverters is also very high causing minimized array mismatch losses. Figure 3.7.2 depicts the string inverter concept in which long strings are connected to inverters of lower ratings. This concept is also utilized in large scale systems however the sub-array inverter concept has better reliability and is also more economically feasible. The design team has decided to move forward with the sub-array concept.

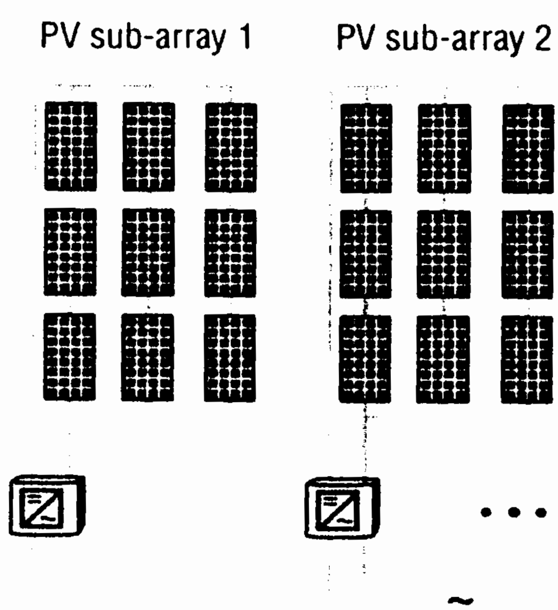


Figure 3.7.1: Sub Array System Design

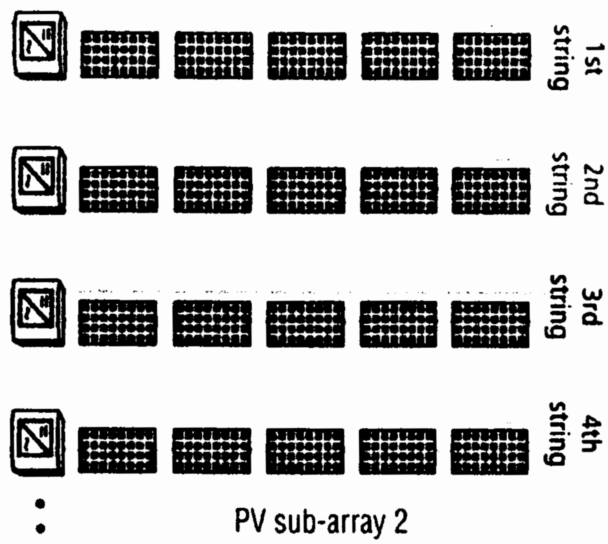


Figure 3.7.2: Sub Array System 2 String Design

Master Slave Concept:

Another concept utilized in large scale systems is the Master-Slave concept. It was originally used in places with low irradiance areas. Only a single primary inverter (master) is connected to string arrays while secondary inverters (slave) are connected at periods of high irradiance level. The master-slave concept utilized in the past has been rendered obsolete due to high efficiencies of central inverters and it is not required at the site due to high irradiance levels experienced at the desert

Block Diagram:

DC cables will carry current to the inverters. The voltage output from each string is 673 V and the current output is 7.87 A. 17 strings constitute to each connection. Each string in such connection is placed side by side. The voltage in each connection remains at 673 V while the current increases to 133.8 A / connection. 10 such connections are to be connected to an inverter. The voltage at this point remains at 673 V and the current rises to 1338 A. The power input to each inverter is 810 KW.

The design layout is as follows:

Figure 3 shows the circuit diagram of the plant. The layout consists of 6 groups of 7480 panels, 2 inverters and 1 medium voltage transformer (power output @ 1.6MW) connected to a High Voltage Transformer.

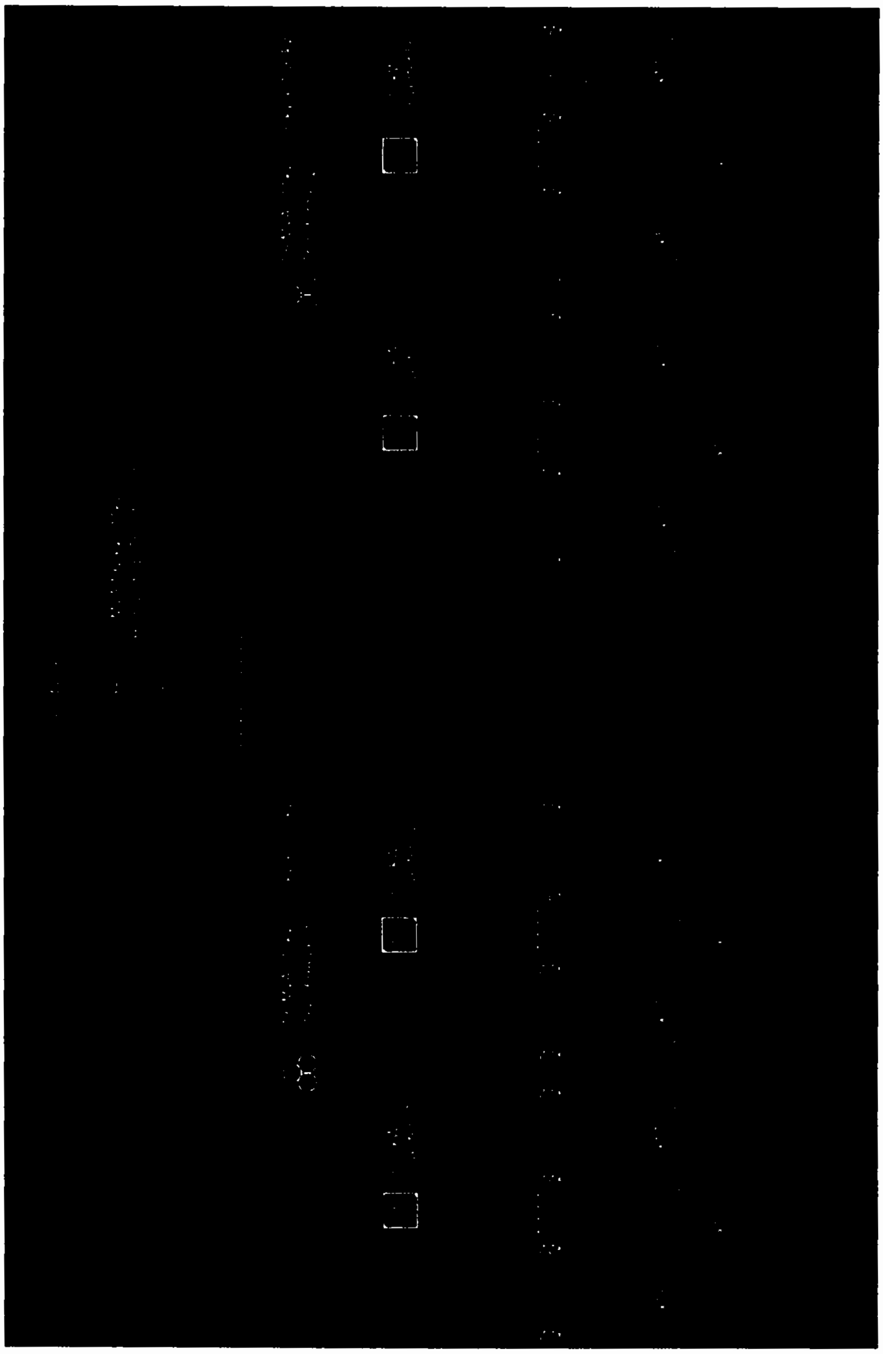


Figure 3.7.3: Block Diagram Showing the Plant Layout

Blocking diodes have been added to the main bus / connection at the end of each string to eliminate the possibility of backflow of current in case of damage / shading of some strings.

You will however find below a generic working explanation of Blocking and By-pass diodes for a better understanding of the Project Layout.

Blocking and Bypass Diodes:

A diode uses a semiconductor material, usually silicon, with two terminals attached. Its function in its simplest form is to allow electricity to pass in one direction but not the other. It can be used as either a:

Blocking Diodes

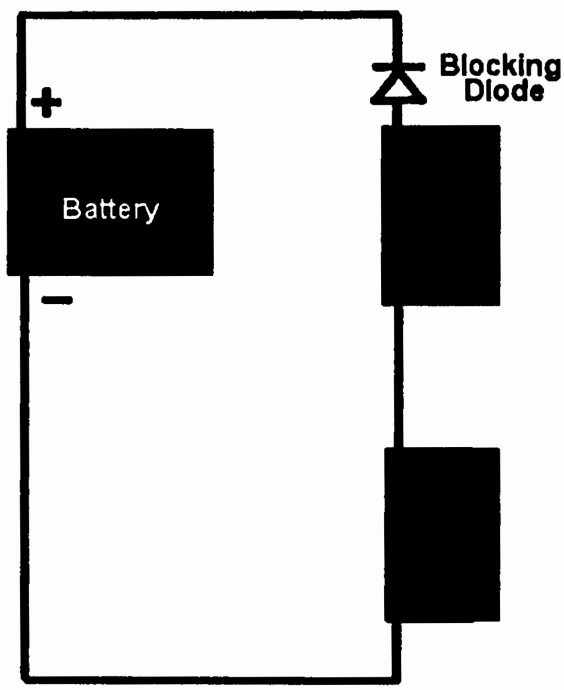


Figure 3.7.4: The conventional use of Blocking Diodes

The diagram shows a simple setup, **for information purpose,** with two panels charging a battery with a blocking diode in series with the two panels, which are also wired in series. When the sun shines, as long as the voltage produced by the two panels is greater than that of the battery, charging will take place. However, in the dark, when no voltage is being produced by the panels, the voltage of the battery would cause a current to flow in the opposite direction through the panels, discharging the battery, if it was not for the blocking diode in the circuit.

By-Pass Diodes

If a panel in the above mentioned diagram is not functioning properly it will have a high resistance, blocking the flow of power produced by the proper panel.

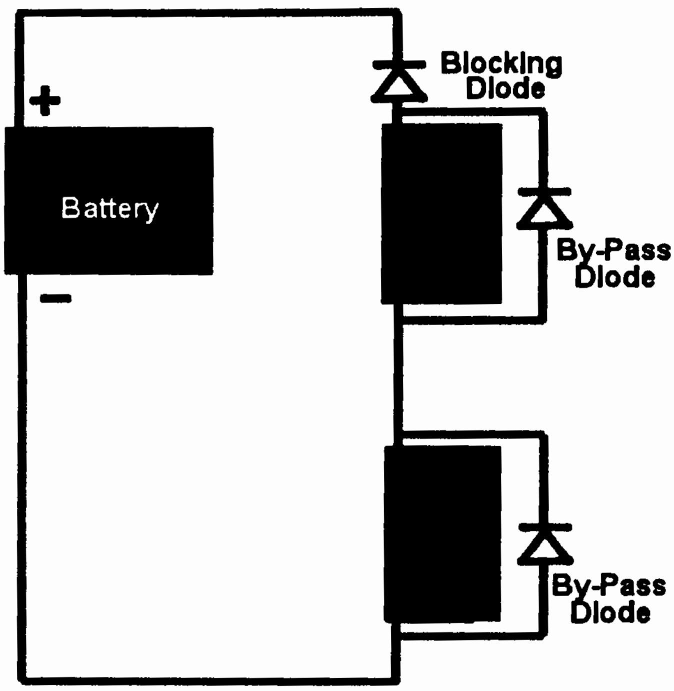


Figure 3.7.5: The conventional use of By Pass Diodes

This is where by-pass diodes come into play as shown in the diagram to the right. Now, if one panel is damaged, the current produced by the undamaged panel can flow through a by-pass diode to avoid the high resistance of the damaged panel.

A diode uses a semiconductor material, usually silicon, with two terminals attached. Its function in its simplest form is to allow electricity to pass in one direction but not the other. It can be used as a bypass diode. If one string becomes severely shaded, or if there is a short circuit in one of the modules, the blocking diode prevents the other strings from losing current backwards down the shaded or damaged string. The shaded or damaged string is "isolated" from the others, and more current is sent on to the load. In this configuration, the blocking diodes are sometimes called "isolation diodes".

3.8 Plant Monitoring

The Monitoring is essential for the operation of the Large Scale System and to allocate occurring problems within a short time. With the Monitoring solution from SMA for Large Scale Plants, it is possible to supervise the overall plant and alerting in case of a malfunction (string failure, Inverter failure, Grid failure) and to analyse the performance (using sensors or satellite data). Furthermore for Multi-MW plants it is possible to have a utility interaction (reactive/ active power regulation), as well to integrate the Monitoring in an industrial control system (SCADA).

The following figure shows a preliminary design of the plant monitoring system. A finalized design for the plant will be provided at the EPC stage of the project.

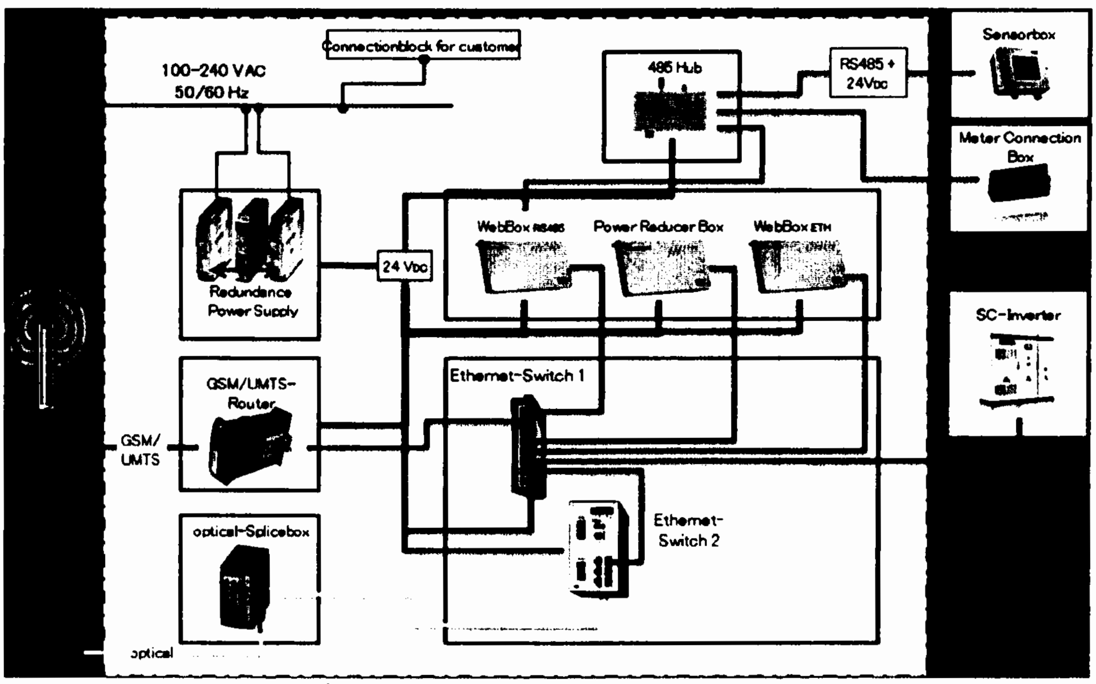


Figure 3.8.1: Monitoring Equipment Layout

3.9 Consideration of Grounding And Lightning Protection

The Equipment being used including the Solar Panel Structures and the Inverters shall be composed of grounding and lightning Protection. Some components such as the SMA Inverters and Transformers have built in Lightning protection instruments.

3.10 3D Design Plan with Engineering Drawings, Mounting Structures

Figure 3.9.1 shows the Shape of the simple beam that shall be used in the mounting structure of the Panels.

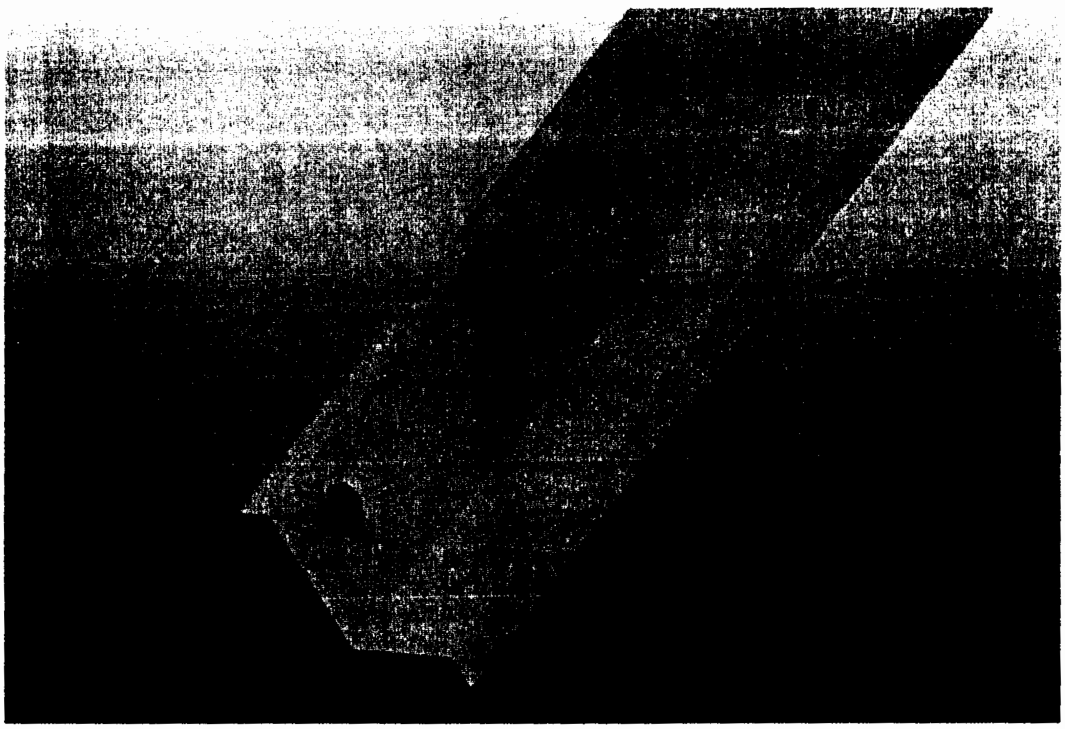


Figure 3.9.1: Angle Beam used for Trusses

L-shaped beams are readily available in the market thereby removing costs of extra manufacturing. The beams are also advantageous in their capability of handling high stresses with the least amount of material.

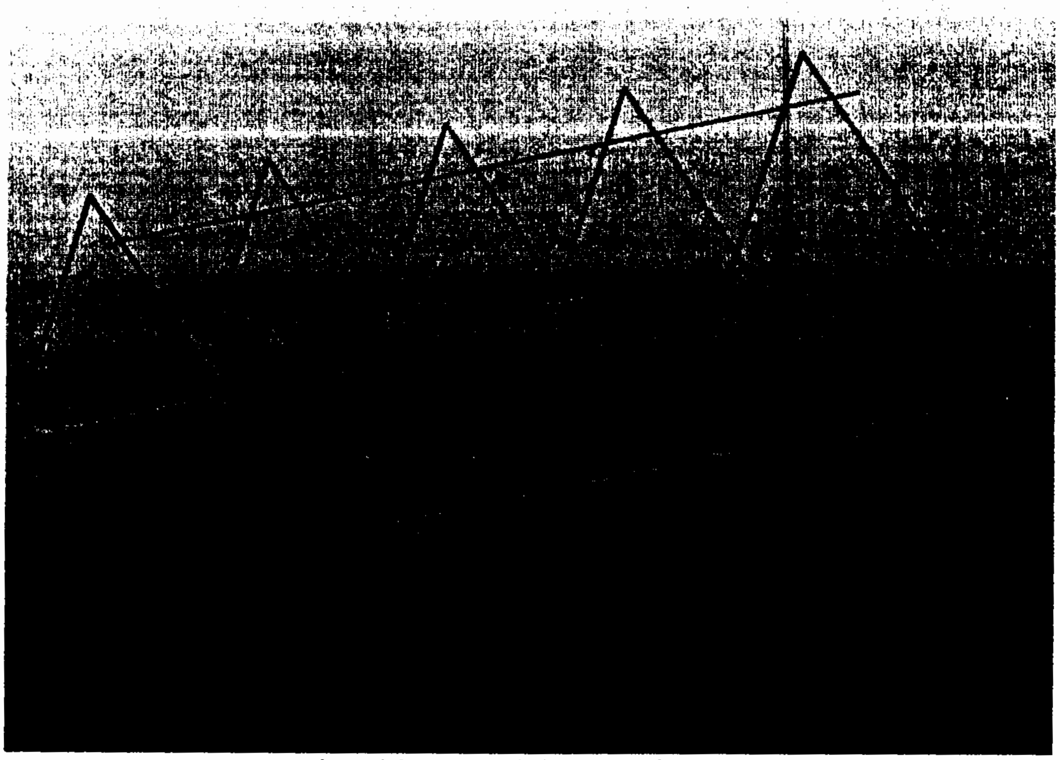


Figure 3.9.2: A compiled mounting for 22 PV modules

Three beams are used to construct a single truss. The lengths of the beams are:

- Perpendicular 1.7m
- Base 3.1 m
- Hypotenuse 5.2 m

The length of the rail and the girder is 11.8m and 12.0 m respectively. The purpose of the rail is to provide space for clamping successive panels. The girder will provide stability to the structure.

The structure will house 22 panels in arrays of [11x2].

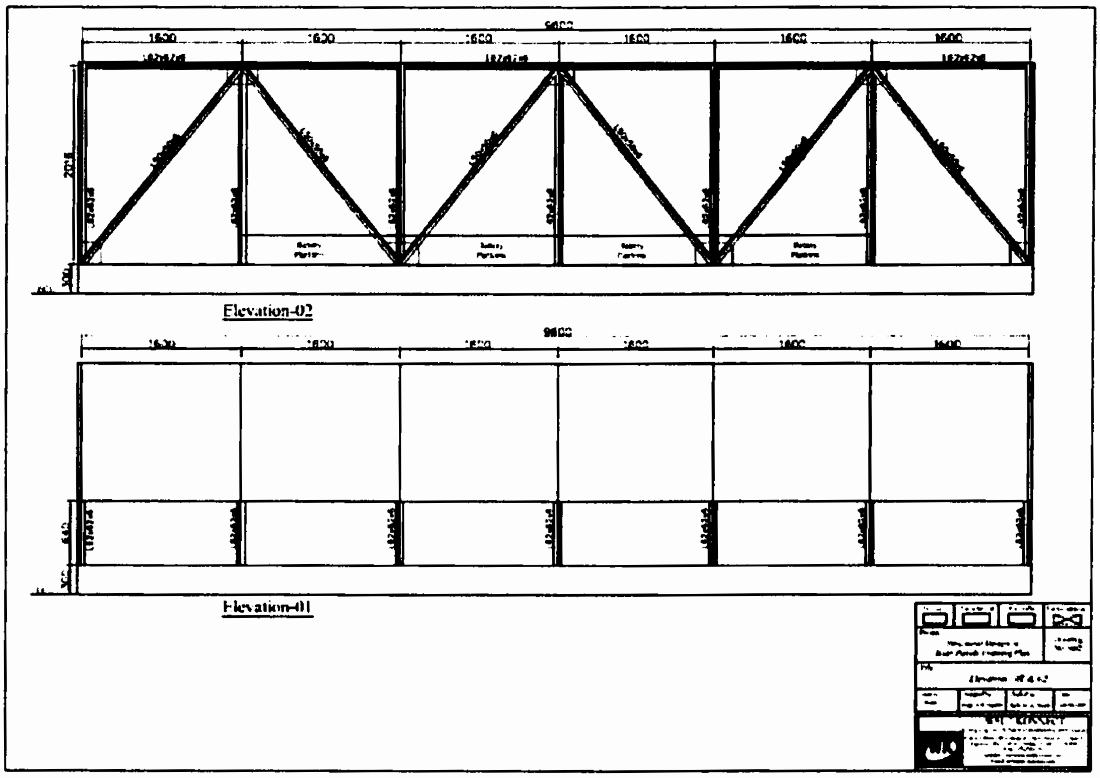


Figure 3.9.3: Back structures of the Hypothetical Mounting Structure for 22 PV modules

Figure 3.9.3 shows the rear view of the Mounting Structure that would be set up on site. Please note this layout has been designed keeping in view the best industry practices and precautions. However this structure is subject to change with further project development and shows a hypothetical situation.

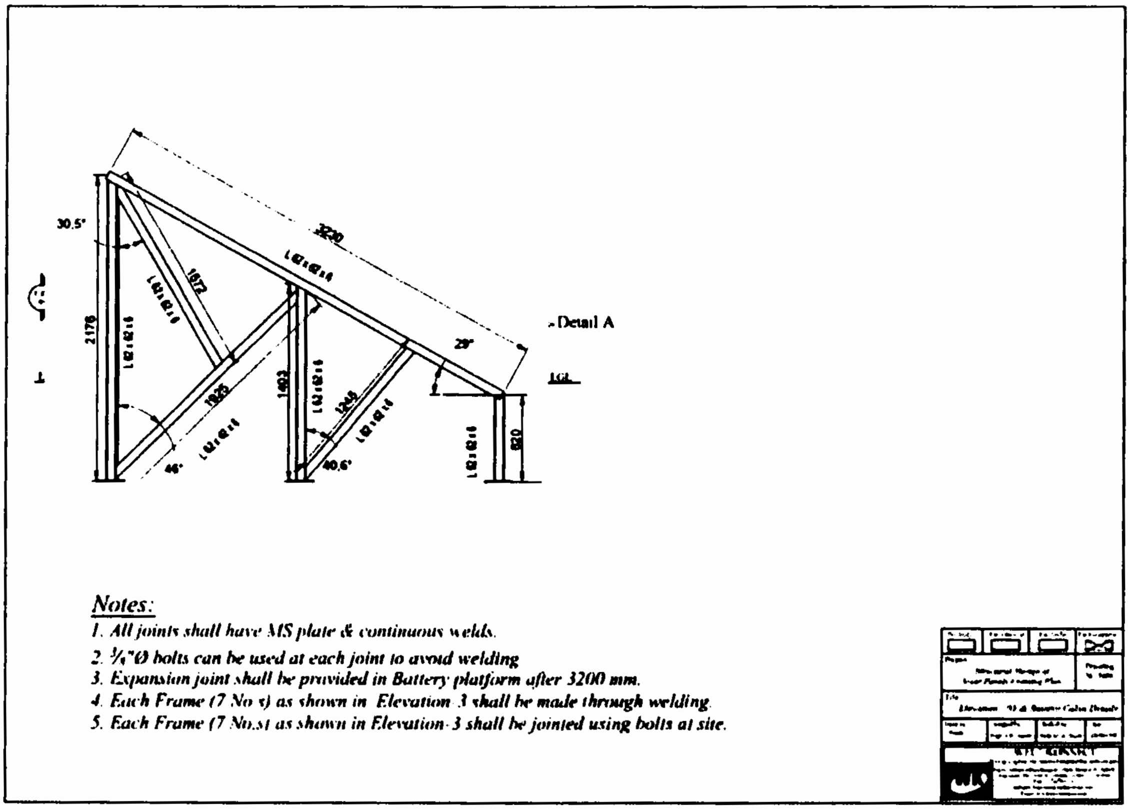


Figure 3.9.4: Side view of the Hypothetical Mounting Structure for a string of 22 PV modules

Figure 3.9.4 provides a side view of the Mounting Structure and is designed on the stress load of the Panels and wind speeds of up to 170km/h.

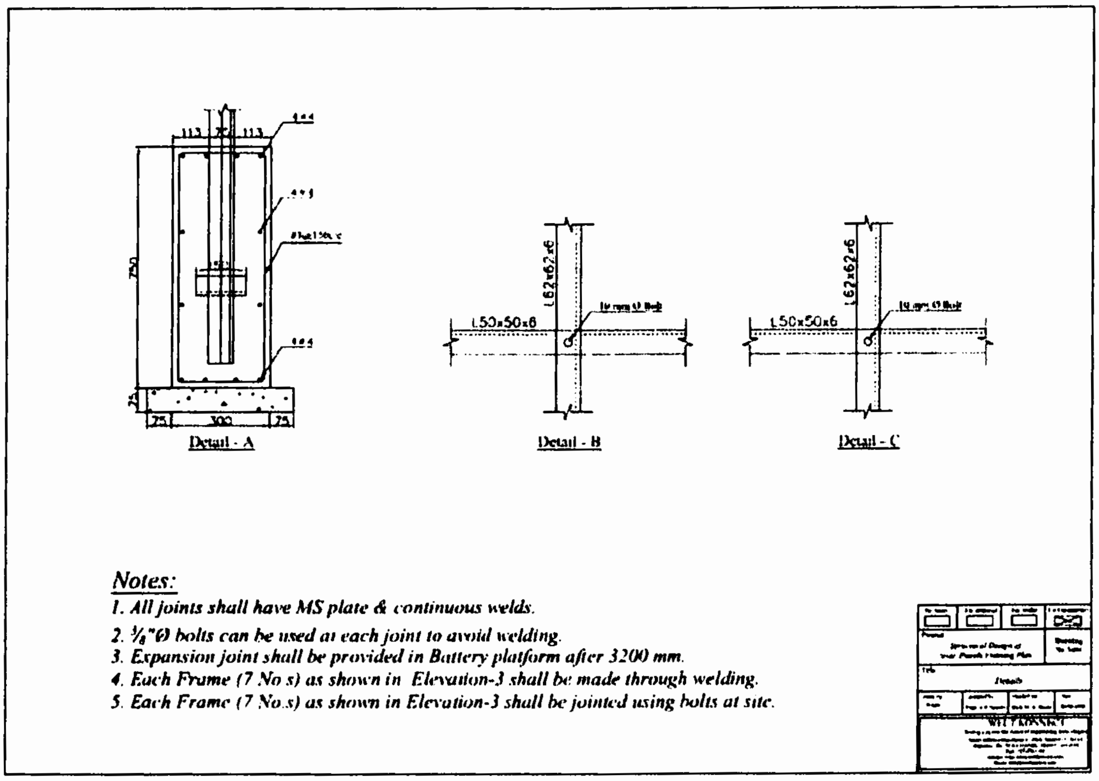


Figure 3.9.5: Details of Foundation in A, and Joints to be made in B and C respectively for the mounting structure for 22 PV modules

The foundations and joints designed shown in Figure 3.9.5 have been made keeping in view the stress analysis performed by the engineers and best industry practices to ensure durability under rugged environment and tough conditions.

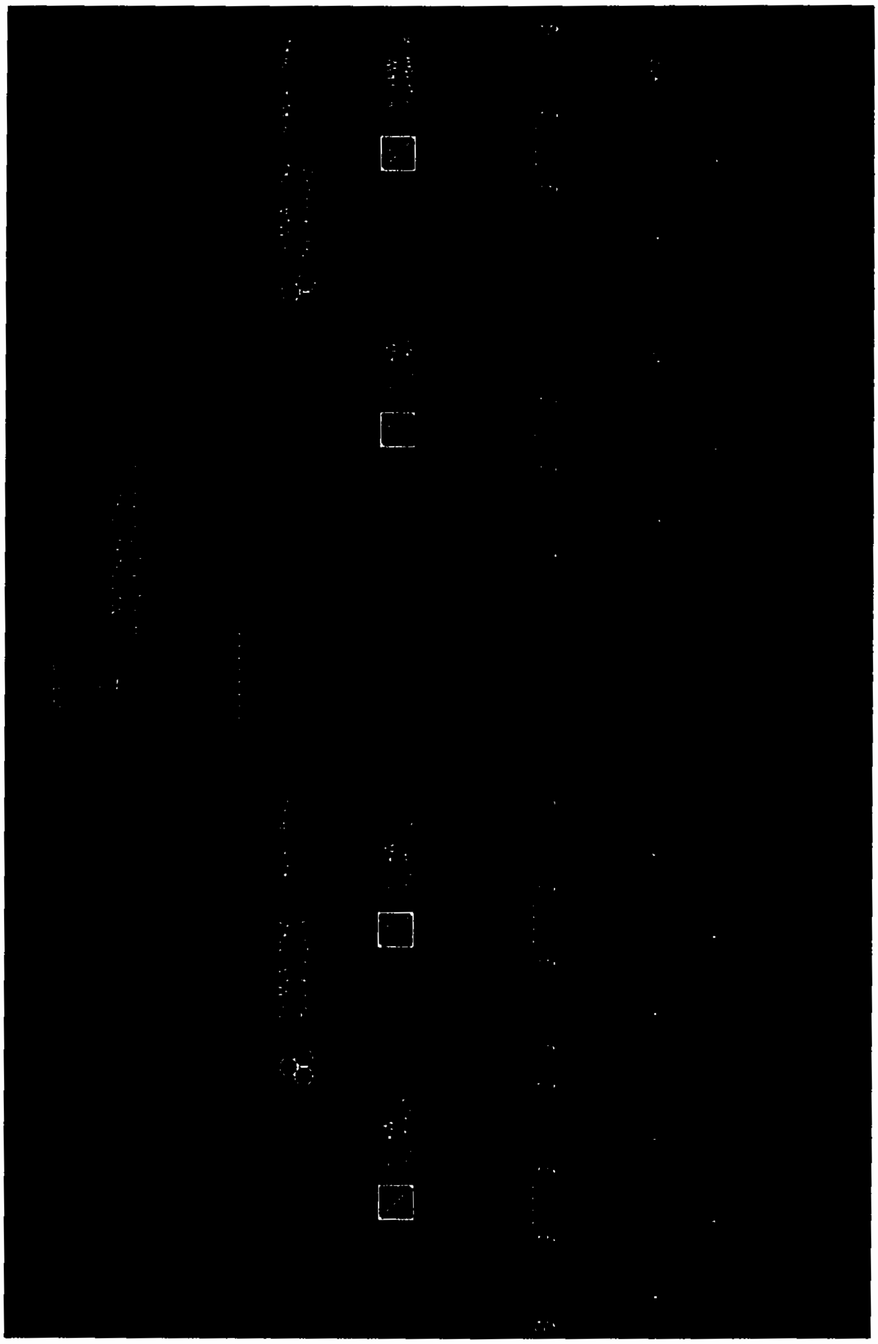


Figure 3.9.6 (a): Block Diagram Showing the Plant Layout

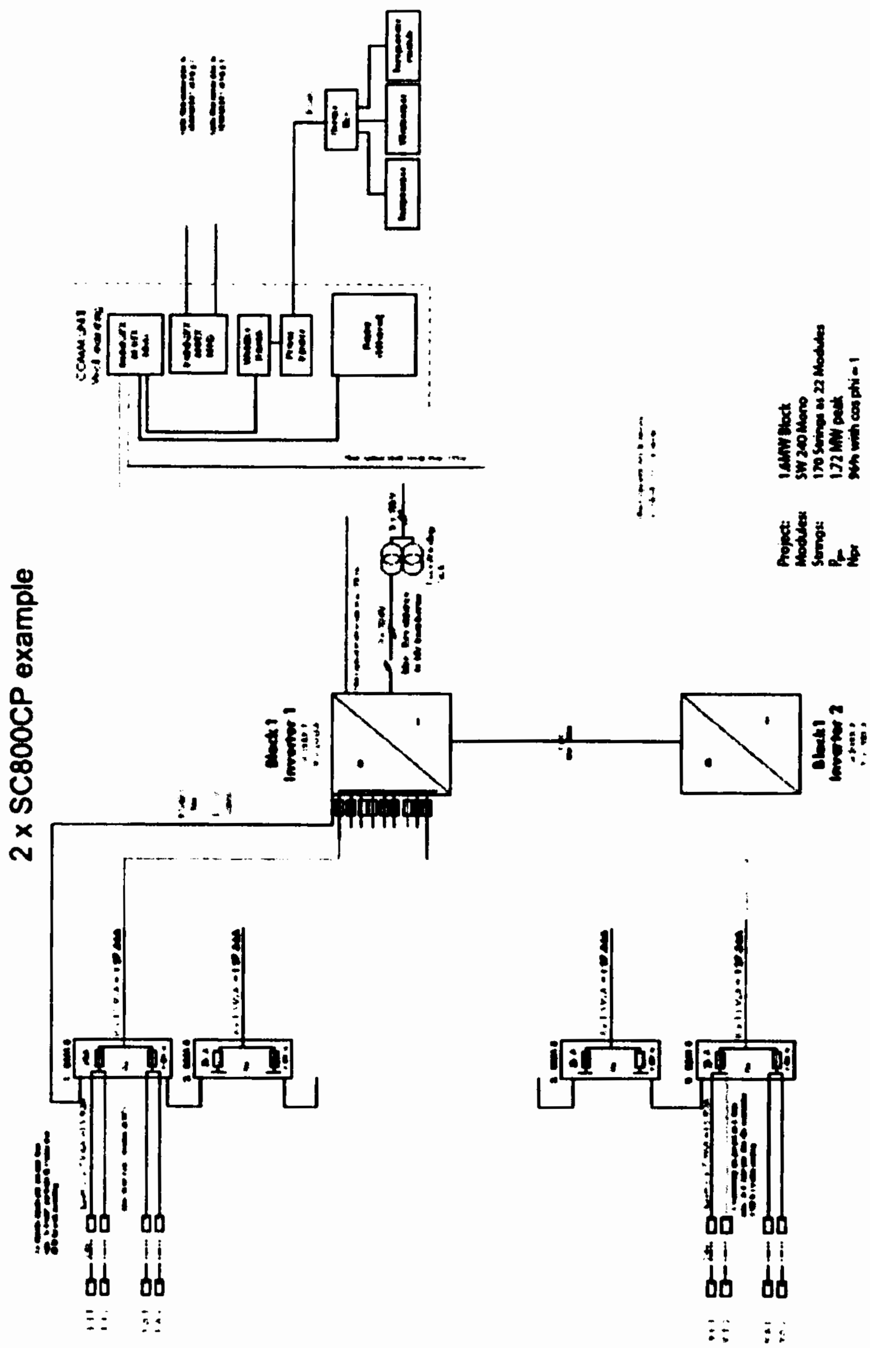


Figure 3.9.6 (b): Block Diagram Showing A single 1600 MW Block
(Consulted by Solar World)

From this point onwards you shall find detailed 3D design analysis and 3Drepresentation of the Power Plant to give you a better understanding of the layout and designed.

Please note the 3D analysis is focuses on the 1.6MW Block structure which is to be replicated throughout the power project implementation and development.

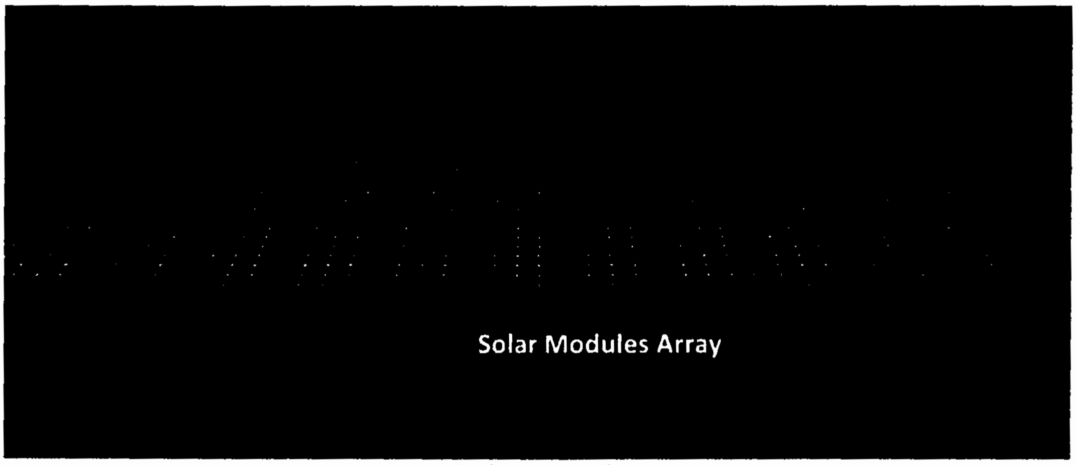


Figure 3.9.7: the front view of the mounting

Two factors were considered during the design phase of the arrays name the stress factors and ease of installation. The final design constitutes 22 modules in an [11x2] arrangement which would constitute a single string. The design has been made to handle the weight of the panels and wind and minor earthquake tremors.

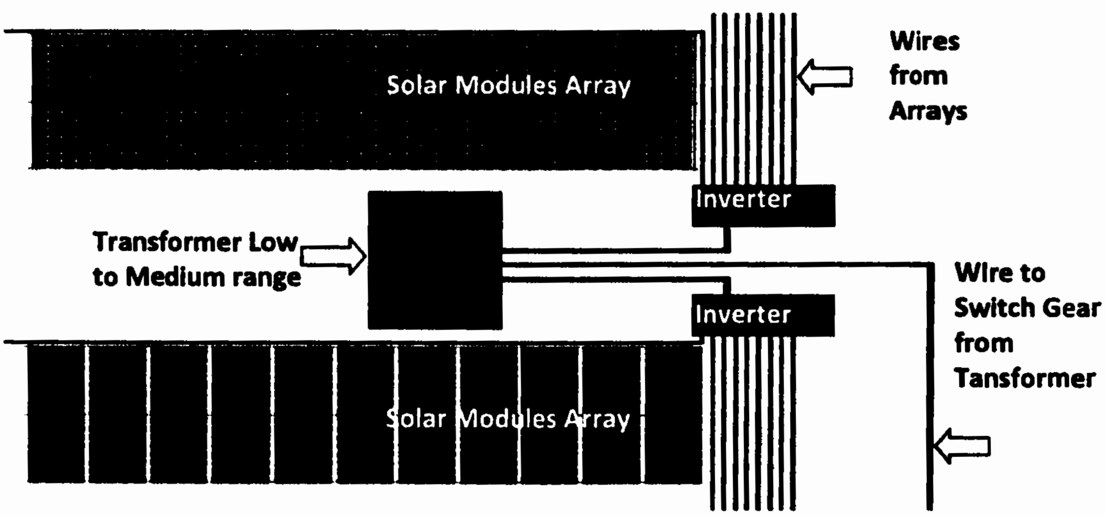
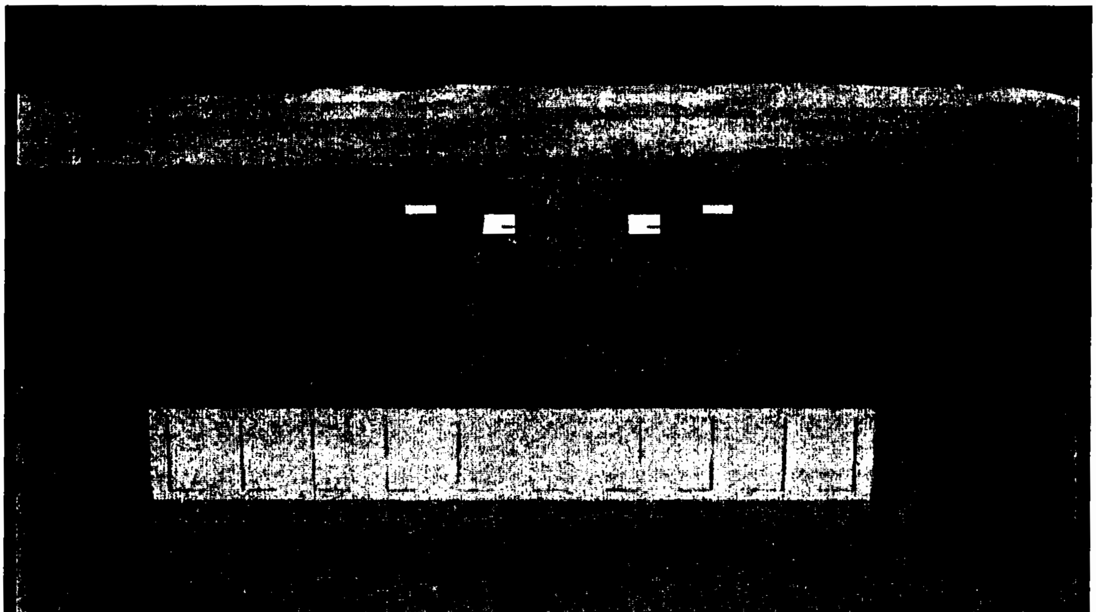


Figure 3.9.8: A view of the wiring with focus on the inverter and the transformer



Key

1. **PV Array**: The model consisted of 14960 modules (SW240 Mono) with a power output of 3.59 MWp
2. **Inverters**: Four SC 800 CP Inverters (SMA Solar Technology) are modeled. Rated output power is 3.52 MWp (3740 Modules / Inverter)
3. **Medium Voltage Transformer**: Two 1600-SC (SMA Solar Technology) Transformers are modeled. (7480 Modules / Transformer)
4. **Power Plant Controller**: Monitoring equipment and utilities will be kept in the same vicinity as the High Voltage Transformer
5. **High Voltage Transformer**: Customized transformer to feed high voltage in the grid

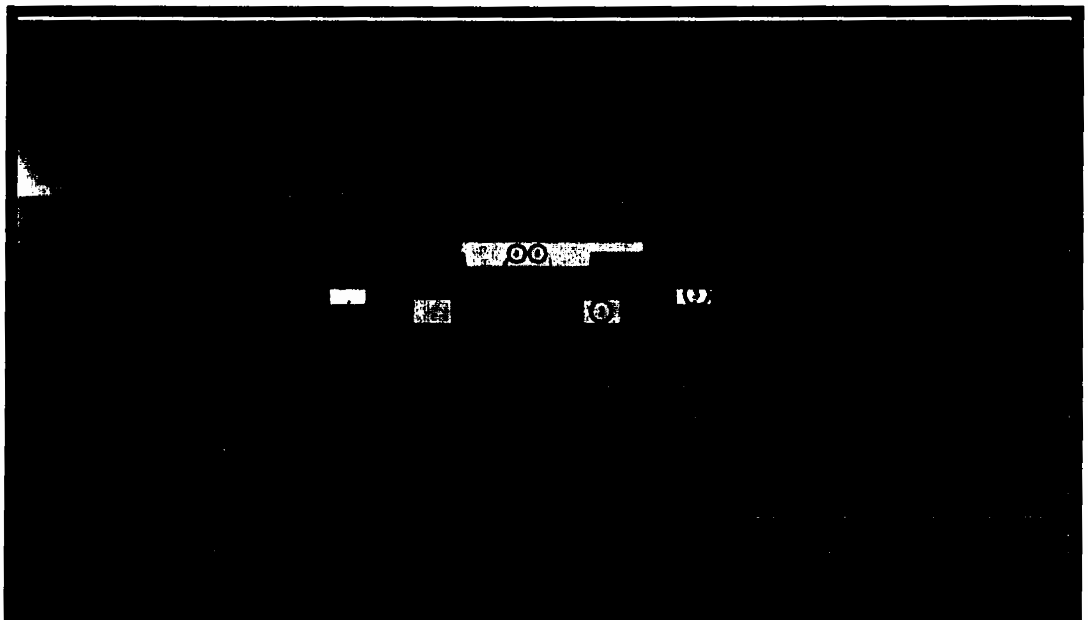
** Refer to **Annexure 18** SMA Solar Power Plant Solution that has been used as reference for model.

Blue Lines: DC Voltage at 640V (10 Connections represented)

Red Lines: AC Voltage at 360V

Green Lines: AC Voltage at 11 kV

Figure 3.9.9: 3D Front View of the 1.6MW Block of the Plant Layout showing the Major Components



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Red Lines: AC Voltage at 360V

Green Lines: AC Voltage at 11 kV

Figure 3.9.10: 3D Rear View of the 1.6 MW Block of the Plant Layout showing the Major Components

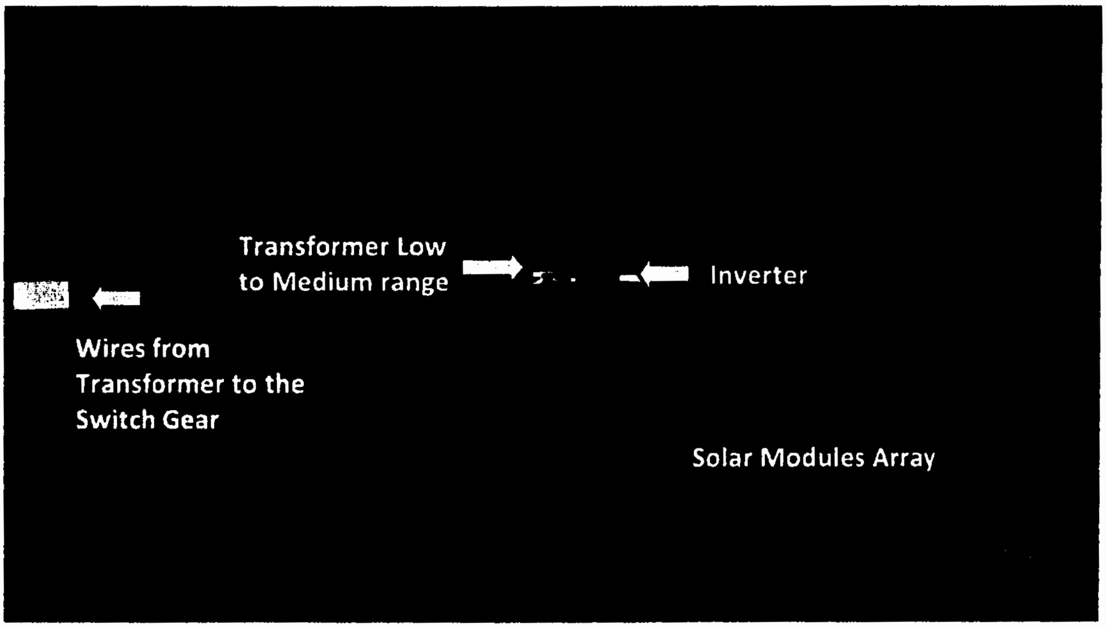


Figure 3.9.11: 3D View of two 1.6 MW Blocks of the Plant Layout showing the Major Components

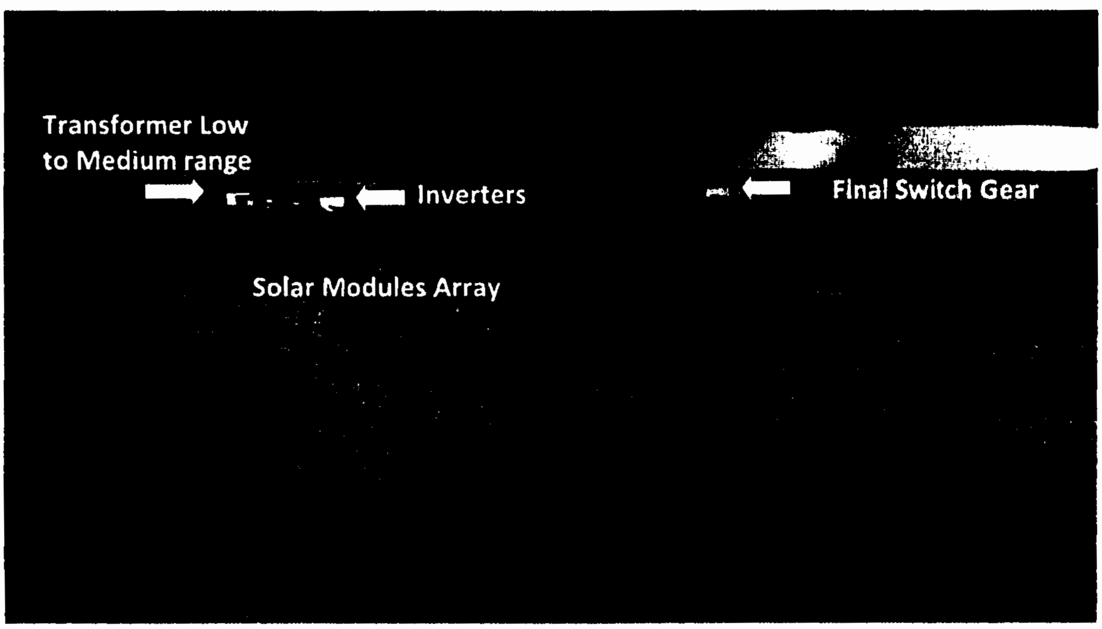


Figure 3.9.12: 3D View of two 1.6 MW Blocks of the Plant Layout showing the Major Components

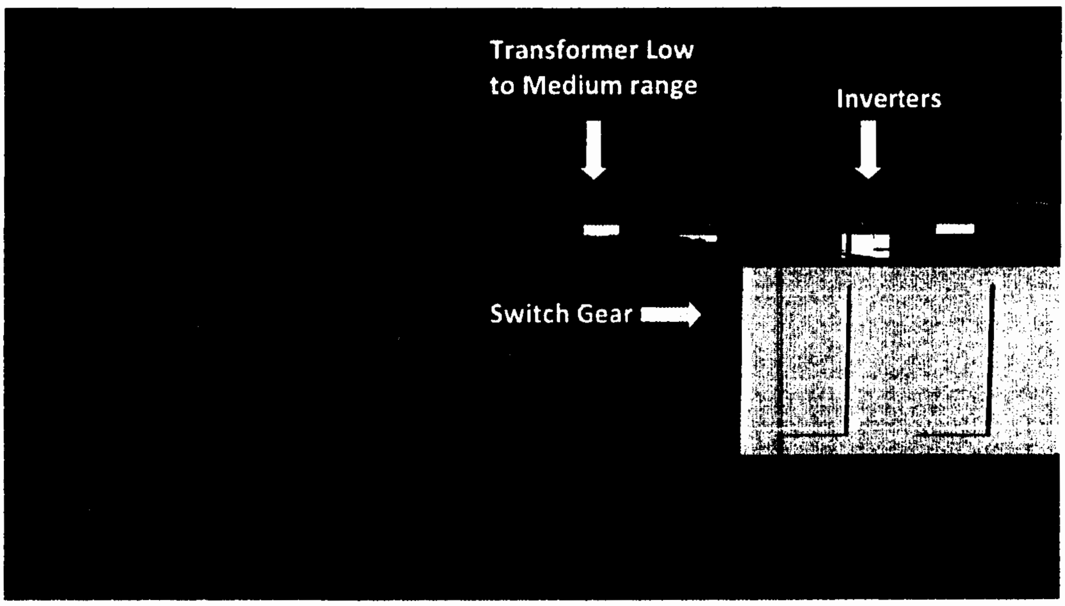
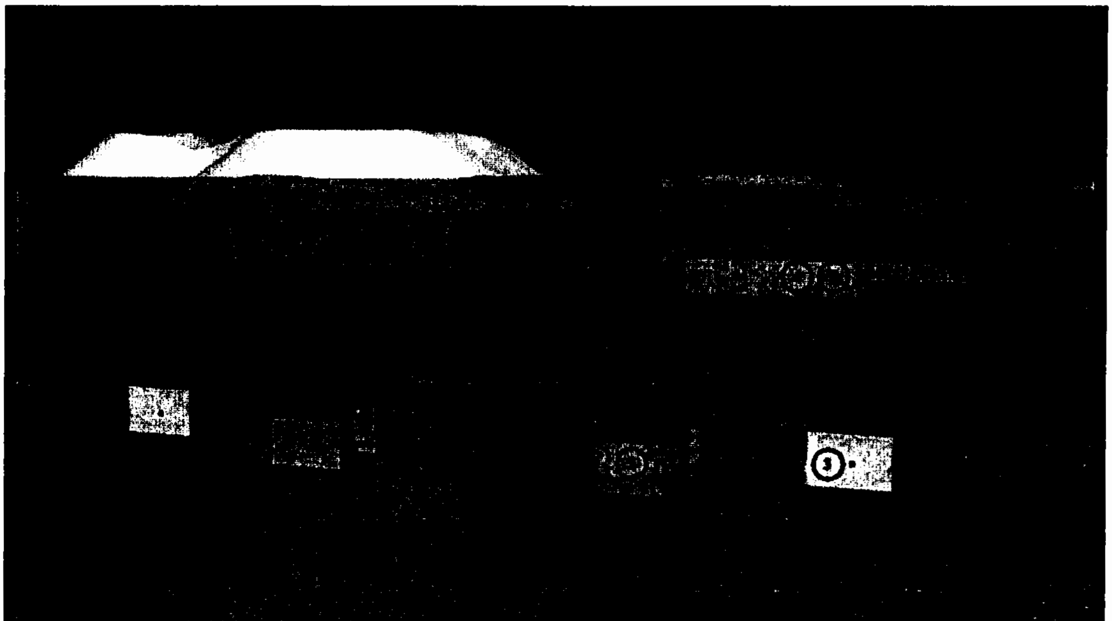


Figure 3.9.13: 3D View of two 1.6 MW Blocks of the Plant Layout showing the Major Components



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Blue Lines: DC Voltage at 640V (10 Connections represented)
Red Lines: AC Voltage at 360V
Green Lines: AC Voltage at 11 kV

Figure 3.9.14: 3D View of two 1.6 MW Blocks of the Plant Layout at an angle showing the Major Components

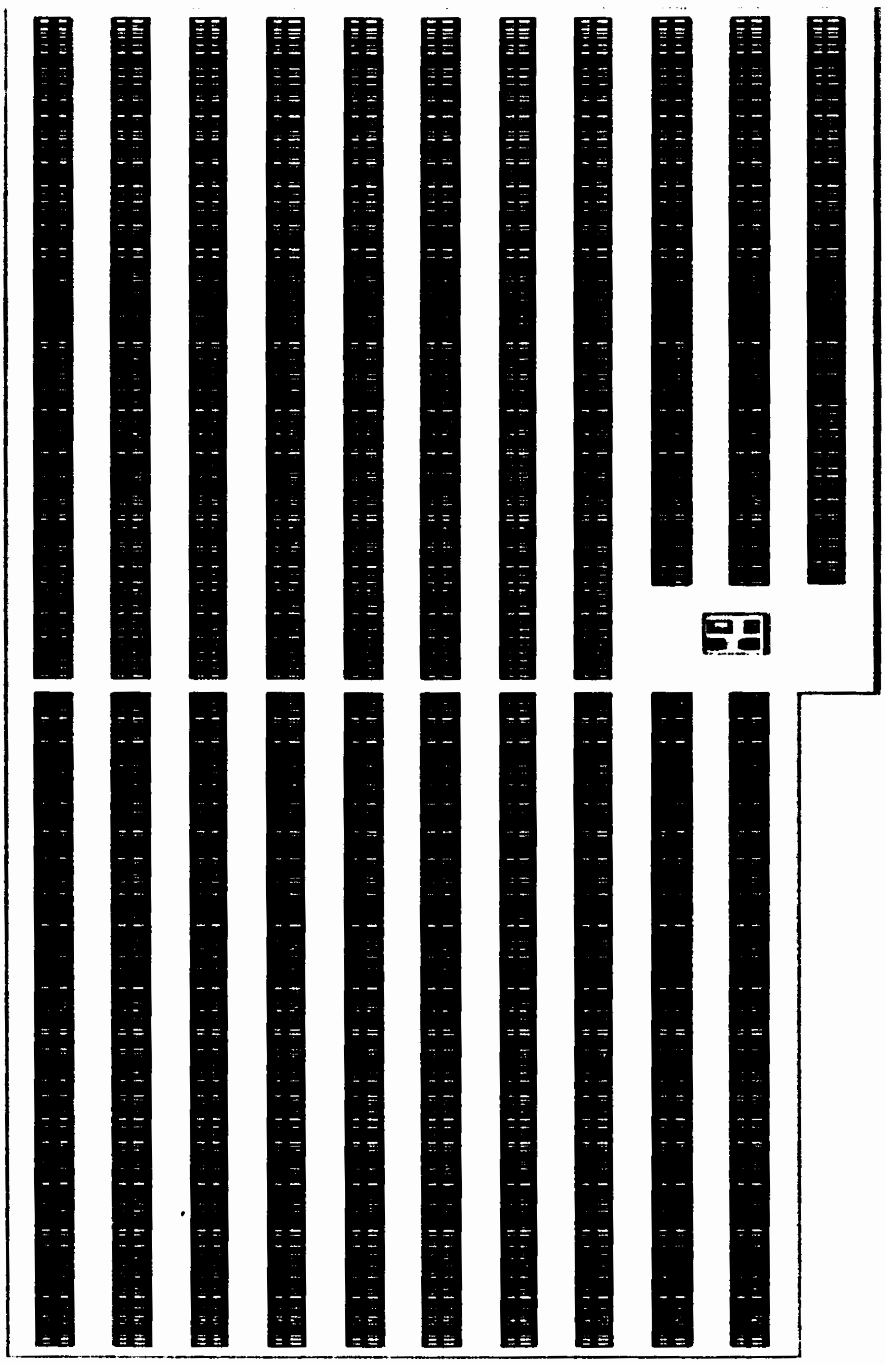


Figure 3.9.16: Plant Layout of 1.6 MW Block

4 GRID CONNECTION

Standards Are Being Developed and Validated In a Timely, Ongoing and Cohesive Manner. American National Standard IEEE1547 Published in 2003 has been developed by IEEE Standards Coordinating Committee 21 (IEEE SCC21). This committee is developing 1547 Series of Interconnection Standards and is also responsible for standards development in areas of Photovoltaic.

Standardization is enhancing systems integration of sound distributed energy resources with the grid that are contributing to modernizing our electric infrastructure. This standard has established a long-awaited technical foundation for the interconnection of distributed generation technologies with the electric grid. Its approval also ensured that major investments in technology development by the federal government and industry will result in real-world applications. It presents specific requirements related to the performance, operation, testing, safety, and maintenance of interconnections between distributed resources and other electric power systems.

The electric grid selected for connection with the PV power plant is the Marot grid station due to a number of factors. Connection to this grid station is most feasible as per initial surveys and research. The grid station has the required capacity (and is going up-gradation) for receiving and distributing maximum load from the PV Power station. Operators at grid station have also demonstrated their confidence in being able to forecast required information.

The grid station falls under the Multan Electric Power Company's authority. The geographical details of the grid station are mentioned below:

Latitude:	29° 13.38'
Longitude:	72° 25.7'
Distance (from site):	4 to 4.5 Km

PLEASE NOTE A SEPERATE GRID INTERCONNECTION STUDY IS BEING CONDUCTED BY THE GOVERNMENT AGENCY NTDC AND SHALL BE SUBMITTED AS VOLUME 7.

5 YIELD CALCULATION

5.1 Basis and Source of data on Radiation

The radiation database used for the software was obtained from NASA Meteorological Website http://eosweb.larc.nasa.gov/sse. This website provides meteorological data that has been accumulated for over 22 years. Synthetic hourly data can be generated by respective softwares. Details of the hourly climatic data can be found in **Annexure 10:** Meteorological Data from NASA Satellite.

5.2 Performance Ratio of different Specifications of modules at the site

The monthly Performance Ratio for simulations involving Poly Silicon, Mono Silicone and Thin Film PV modules is shown below:

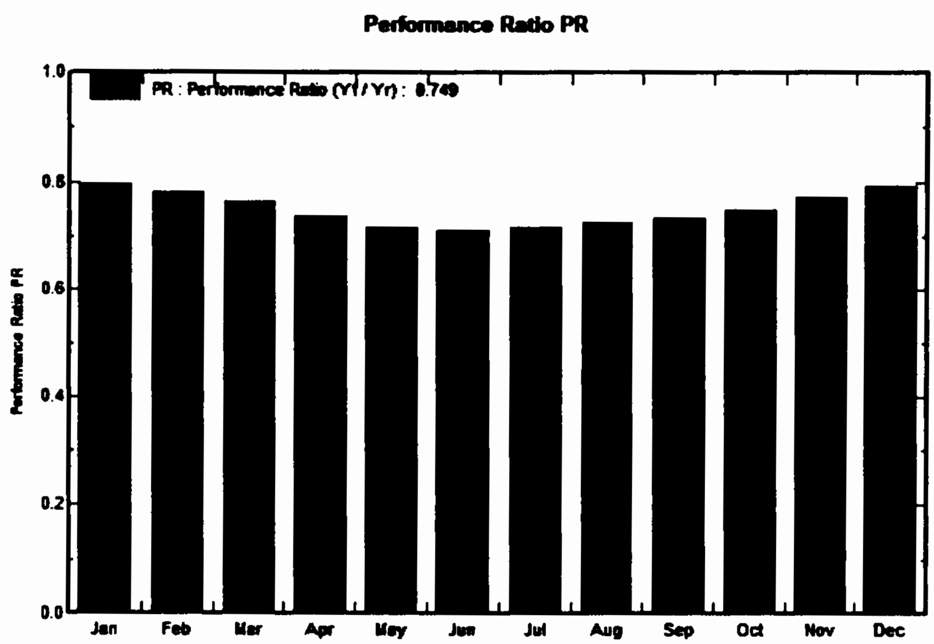


Figure 5.2.1: Poly Silicone PV modules

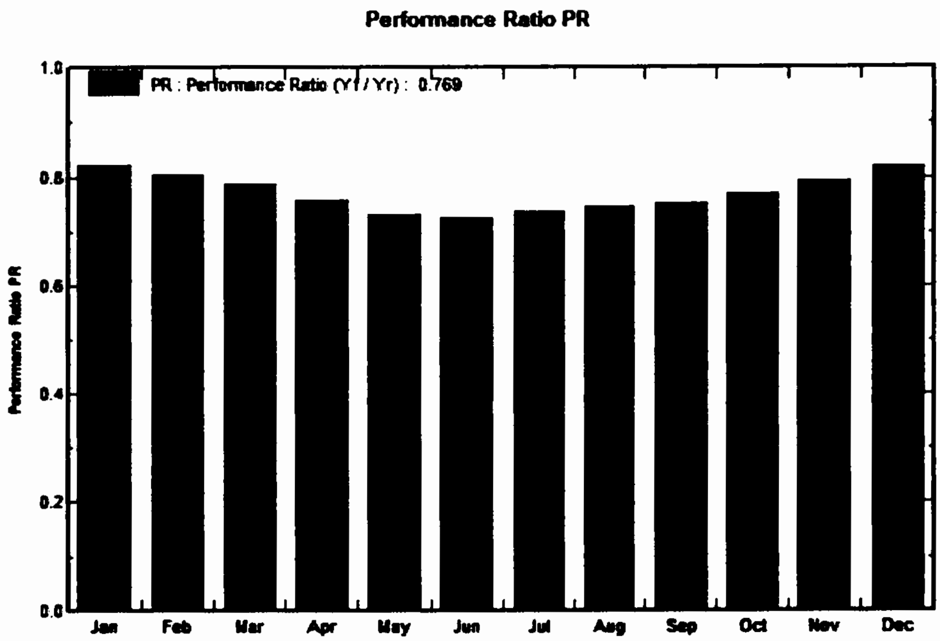


Figure 5.2.2: Mono Silicone PV modules

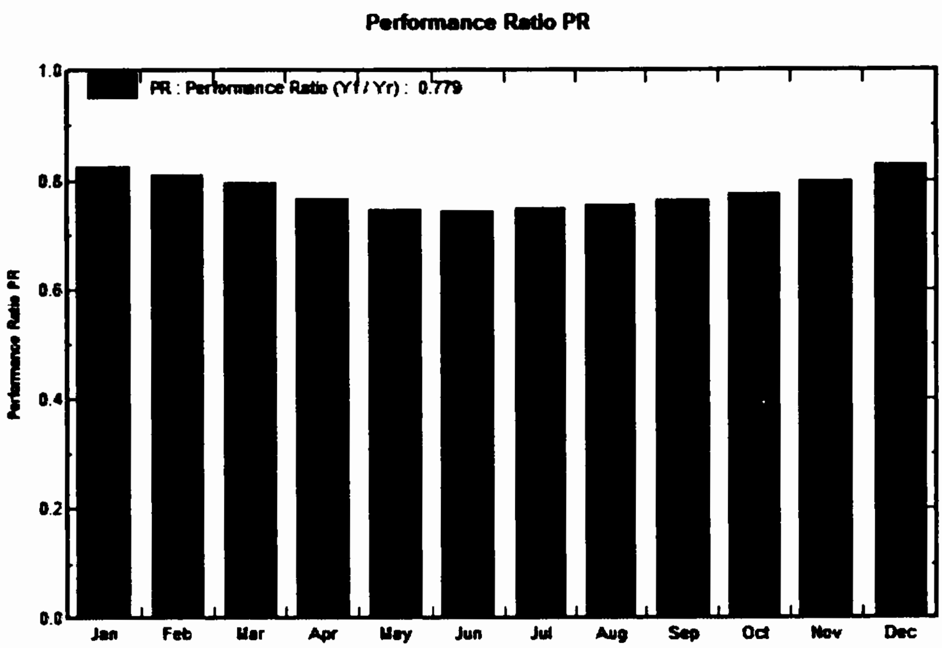


Figure 5.2.3: Thin Film PV modules

5.3 Power degradation of PV Modules

Power degradation of PV modules is the annual depreciation of the capacity of solar panel to produce electricity. This is usually spread over and calculated on average for the life time of the project which is typically 20 years.

This degradation has to be accounted while modeling the plant for forecasting future power generation and other purposes, in the financial analysis as this degradation causes noticeable reduction in revenue per annum at the same levelized tariff rates. This degradation has been accounted for in modeling of the scenarios and also in the financial calculations as in **section 6.**

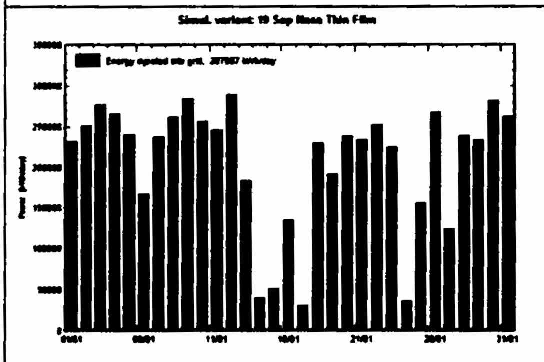
5.4 Developing Models – Softwares

A number of softwares, with varying degrees of accuracies, were used for the simulation of the Solar Park. The softwares provided sensitivity analysis of Tilt, Azimuth and the technology to be used. The results of this analysis will be provided in subsequent sections. This section is a brief introduction of the softwares used for generating the simulations. The inputs and general results for simulation of Solar 10 MW PV Power project have been tabulated in **Table 5.4.1:** Simulation Inputs for Solar 10 MW PV Power Project. Solar irradiation model that is generated has been presented in **Table 5.4.2**

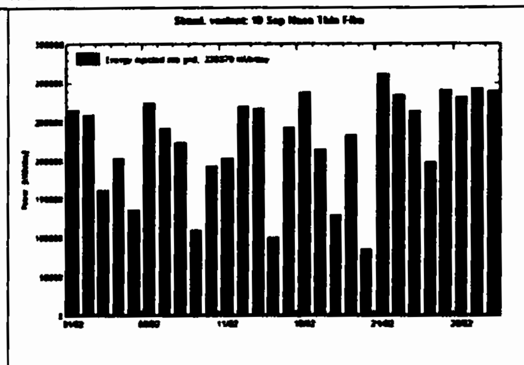
1. Location	Cholistan, Pakistan Latitude 29.1; Longitude 72.45	
2. System Type	Grid Connected	
3. Inverter array	Operating Voltage	450 – 820 V
	Unit Nominal Power	800 kW AC
	Number of inverters	12
	Total Power	10,020 kW AC
4.a. PV array	Technology	Poly Silicone
	Unit Power Nominal	240 Wp
	Number of modules per string	18
	Number of strings	2,320
	Total Number of Modules	41,760
	Module Area	75,373 m^2
	Nominal (STC)	10,022 kWp
	At operating Conditions	8,947 kWp
	I_{mpp}	15,468 A
	Energy Yield	14,761 ,445 kWh
4.b. PV array	Technology	Mono Silicone
	Unit Power Nominal	240 Wp
	Number of modules per string	22
	Number of strings	1,904
	Total Number of Modules	41,888
	Module Area	70,232 m^2
	Nominal (STC)	10,053 kWp
	At operating Conditions	8,996 kWp
	I_{mpp}	14,638 A
	Energy Yield	15,210,699 kWh
4.c. PV array	Technology	Thin-Film CIS
	Unit Power Nominal	228 Wp
	Number of modules per string	15
	Number of strings	2,940
	Total Number of Modules	44,100
	Module Area	112,058 m^2
	Nominal (STC)	10,055 kWp
	At operating Conditions	8,697 kWp
	I_{mpp}	16,319 A
	Energy Yield	15,399,929 kWh

Table 5.4.1: Simulation Inputs for Solar 10 MW PV Power Project

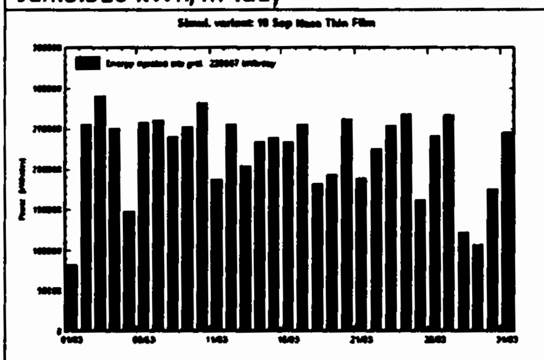
Solar Irradiation Model



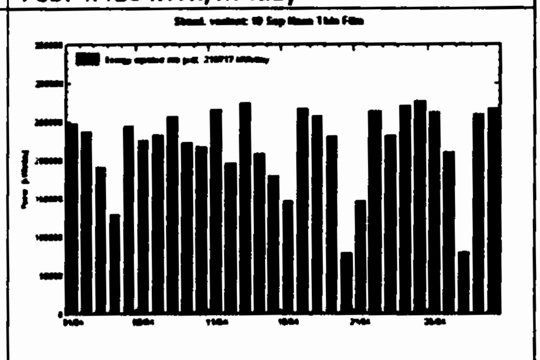
Jan:3.510 kWh/m².day



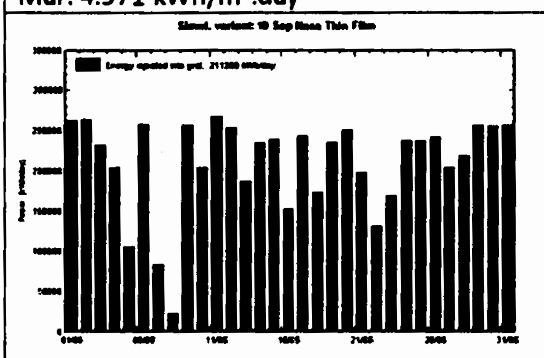
Feb: 4.410 kWh/m².day



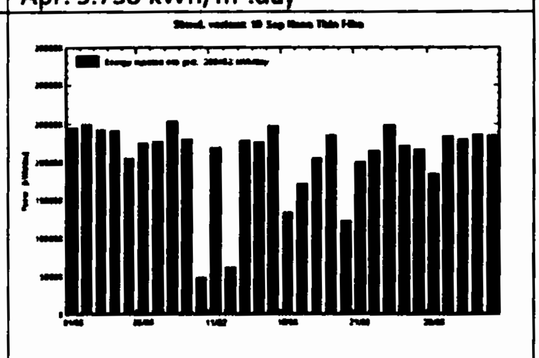
Mar: 4.971 kWh/m².day



Apr: 5.730 kWh/m².day



May: 6.191 kWh/m².day



Jun: 6.360 kWh/m².day

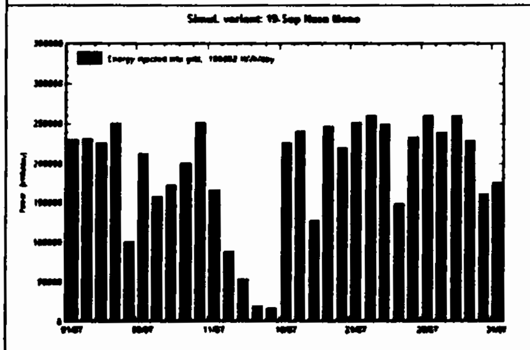
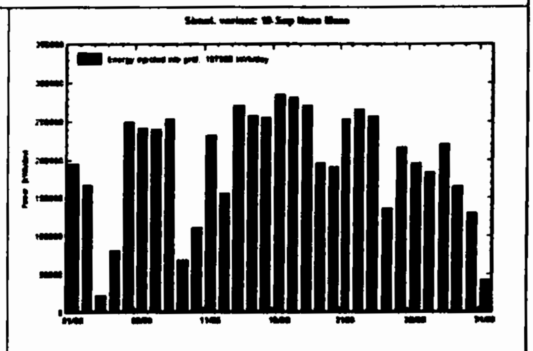
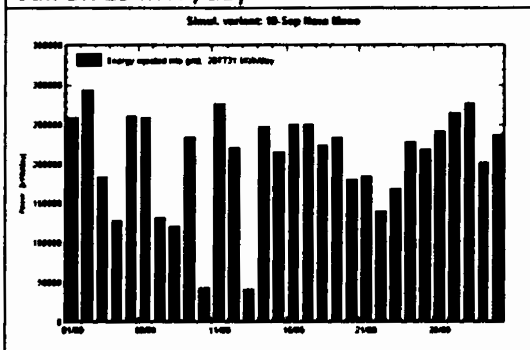
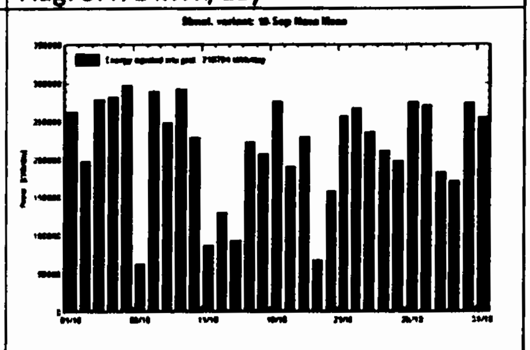
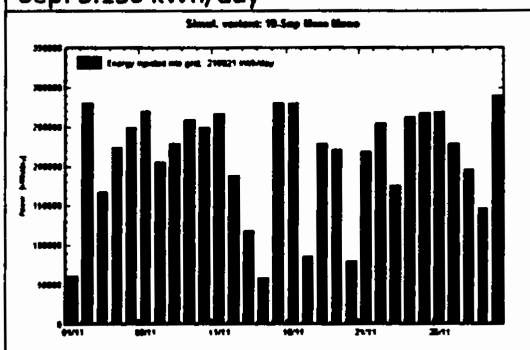
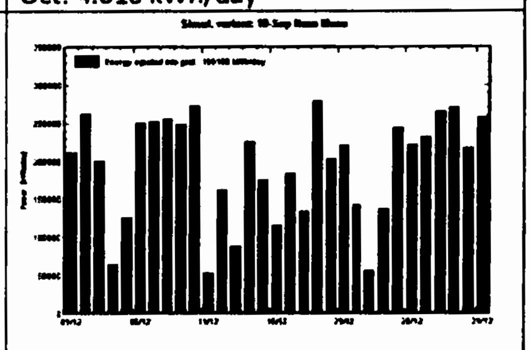
Solar Irradiation Model	
	
Jul: 5.719 kWh/day	Aug: 5.471 kWh/day
	
Sep: 5.150 kWh/day	Oct: 4.610 kWh/day
	
Nov: 3.830 kWh/day	Dec: 3.262 kWh/day

Table 5.4.2: Solar Irradiation Model

5.4.1 Homer

HOMER, the micro power optimization model, simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications. When a power system is designed, many decisions must be made about the configuration of the system: What components does it make sense to include in the system design? How many and what size of each component should you use? The large number of technology options and the variation in technology costs and availability of energy resources make these decisions difficult. HOMER's optimization and sensitivity analysis algorithms make it easier to evaluate the many possible system configurations. HOMER is a model that includes various power resources such as Hydro, Thermal, Wind, PV and can create model situations for on-grid and off-grid plants.

5.4.2 Maui Solar Design Studio PV-Design Pro v6.0

Maui Solar Design Studio PV-Design Pro v 6.0 is a suite of Windows 95, 98, NT, Win2000, and Vista compatible software designed to simulate photovoltaic energy system operation on an hourly basis for one year, based on a user selected climate and system design. Three versions of the PV-Design Pro program are included on the Solar Design Studio: "PV-Design Pro-S" for standalone systems with battery storage, "PV-Design Pro-G" for grid-connected systems with no battery storage, and "PV-Design Pro-P" for water pumping systems. The purpose of the programs are to aid in photovoltaic system design by providing accurate and in-depth information on likely system power output and load consumption, necessary backup power during the operation of the system, and the financial impacts of installing the proposed system.

5.4.3 PV SYST v 5.0

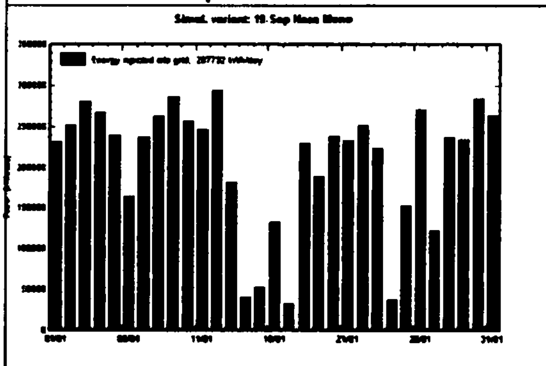
PVSYST V5.0 is a PC software package for the study, sizing and data analysis of complete PV systems. It deals with **grid-connected, stand-alone, pumping** and **DC-grid** (public transport) **PV systems**, and includes extensive meteorological and PV systems components **databases**, as well as general solar energy **tools**. This software is geared to the needs of architects, engineers, researchers.

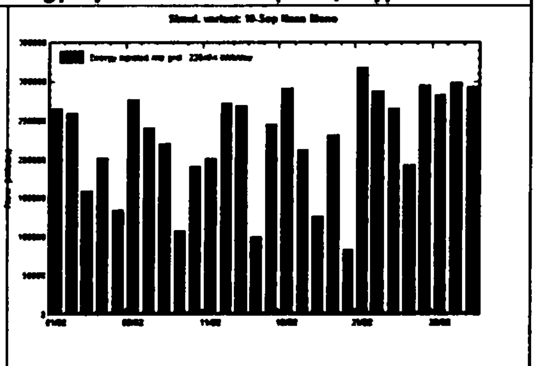
5.5 Modeling of Plant and Yield Calculation using the selected Modeling Software

Thin film modules produce the greatest amount of energy however their large size cause extra expenditures in terms of Construction and Transportation. Therefore it has been decided to utilize Mono-Silicone PV modules keeping in view the cost benefit analysis of each technology.

Details of Simulation results from Analyses of PV Modules can be found in **Table 5.5.1** Mono-Silicon PV Modules, **Table 5.5.2** Poly-Silicon PV Modules and **Table 5.5.3:** Thin Film Modules.

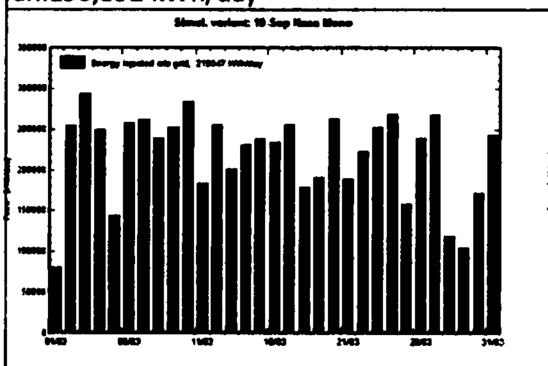
240 Wp Mono-Silicone PV Modules: Energy Injected Into Grid (KWh/day)

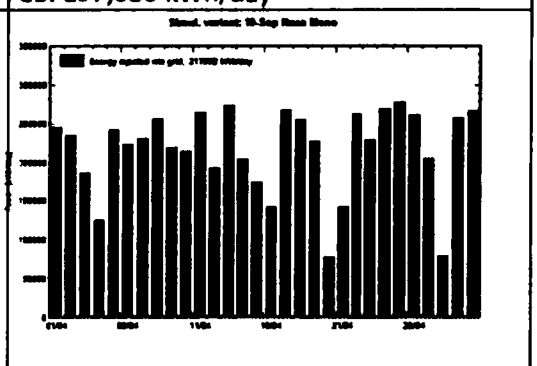




Jan:190,892 kWh/day

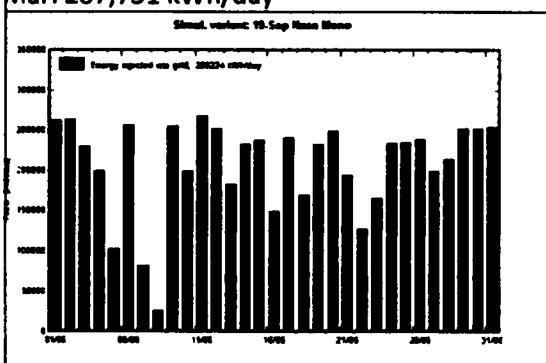
Feb: 197,080 kWh/day

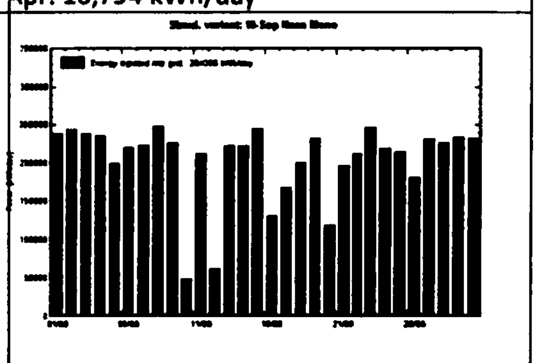




Mar: 207,731 kWh/day

Apr: 16,794 kWh/day

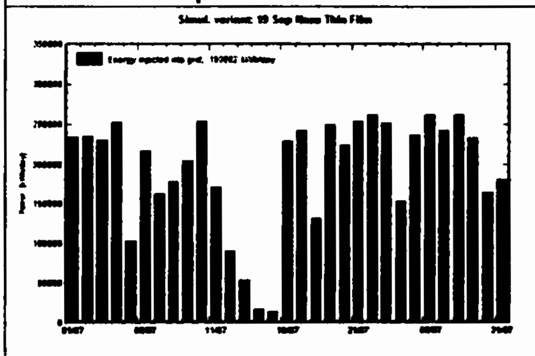




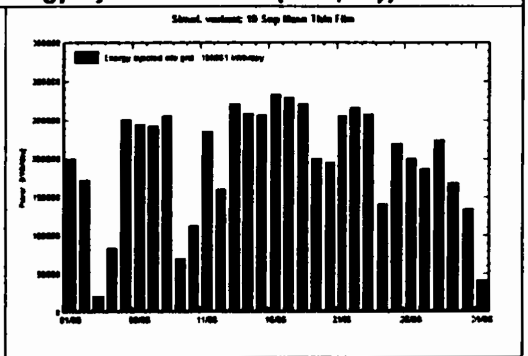
May: 210,921 kWh/day

Jun: 195,169 kWh/day

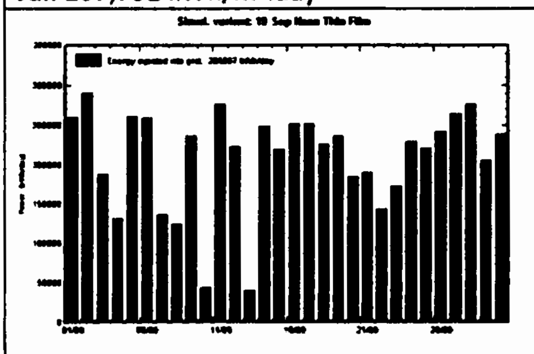
240 Wp Mono-Silicone PV Modules: Energy Injected Into Grid (KWh/day)



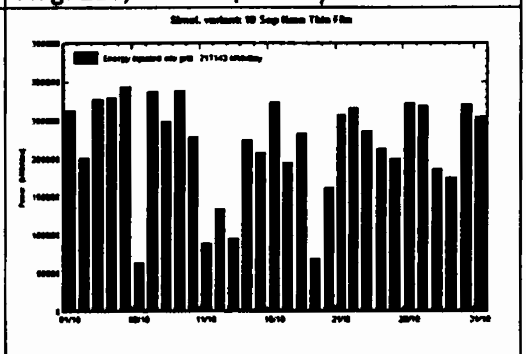
Jul: 207,732 kWh/m^2.day



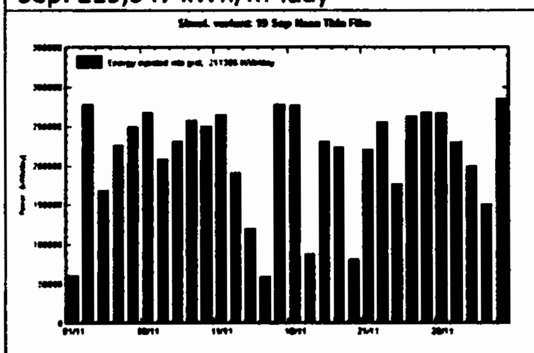
Aug: 226,464 kWh/m^2.day



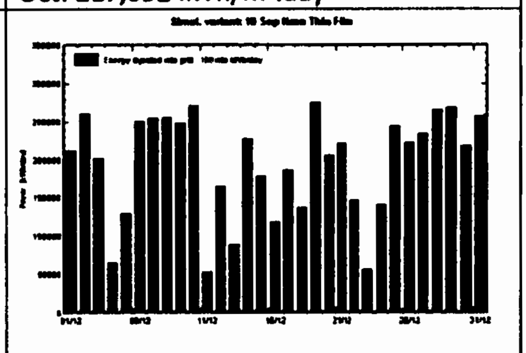
Sep: 219,347 kWh/m^2.day



Oct: 217,652 kWh/m^2.day



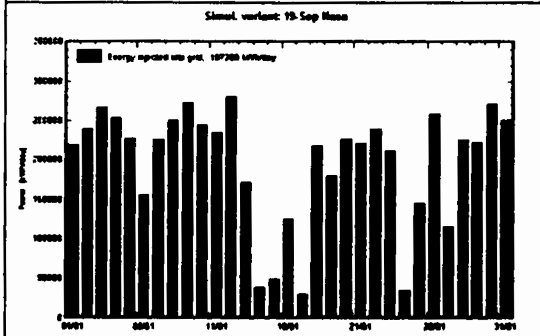
Nov: 208,224 kWh/m^2.day



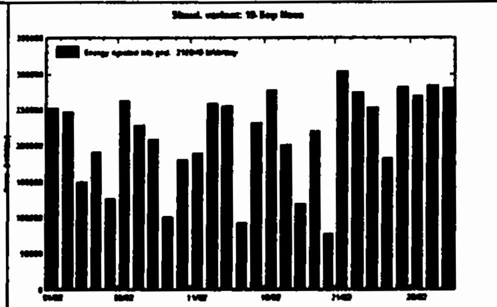
Dec: 204,368 kWh/m^2.day

Table 5.5.1: Energy yield using Mono-Silicon PV Modules

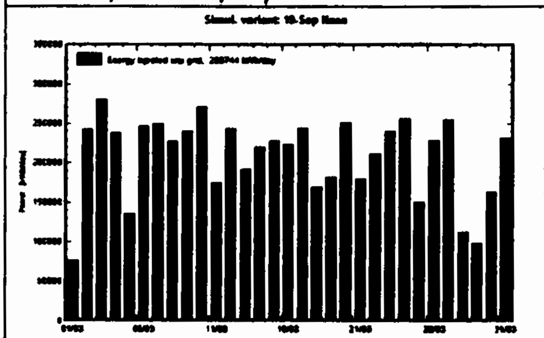
240 Wp Poly-Silicone PV Modules: Energy Injected Into Grid (KWh/day)



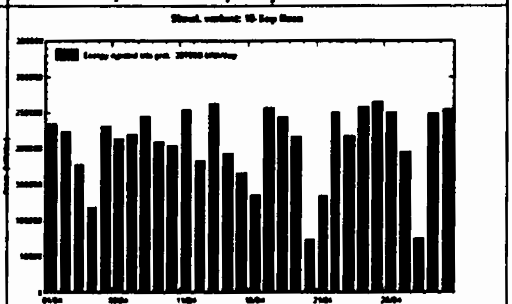
Jan:197,289 kWh/day



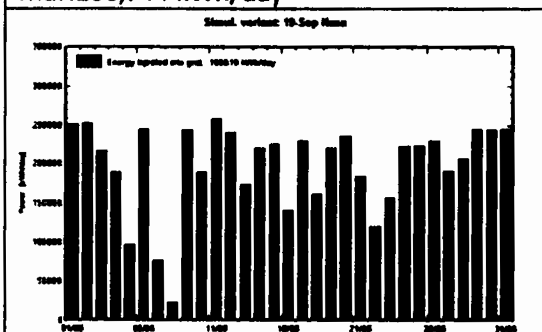
Feb:215,345 kWh/day



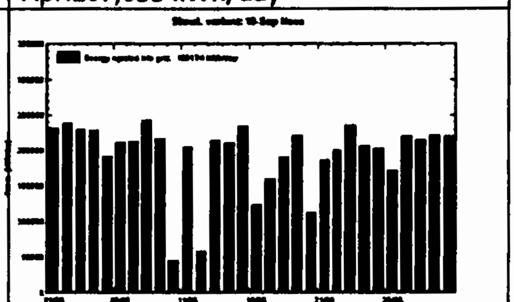
Mar:208,744 kWh/day



Apr:207,655 kWh/day



May: 199,519 kWh/day



Jun:196,174 kWh/day

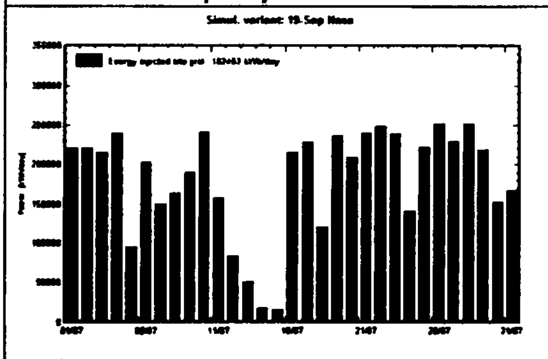
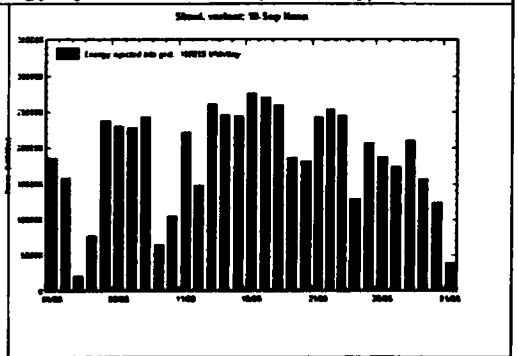
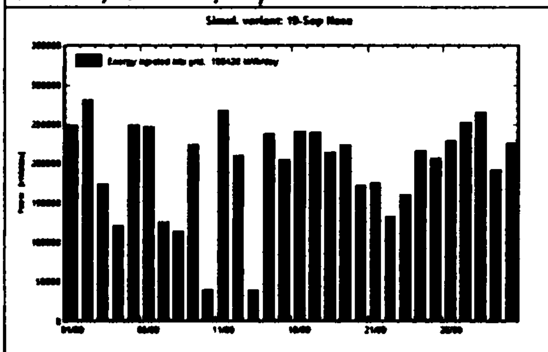
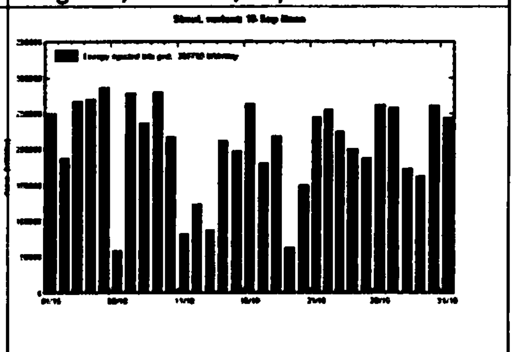
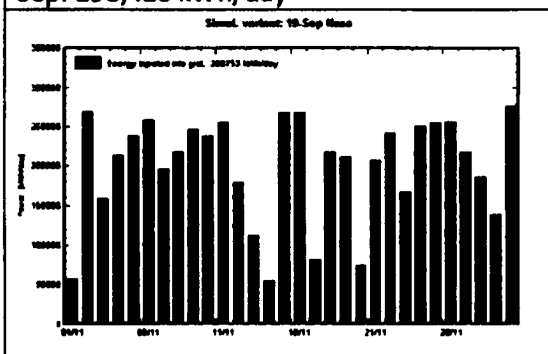
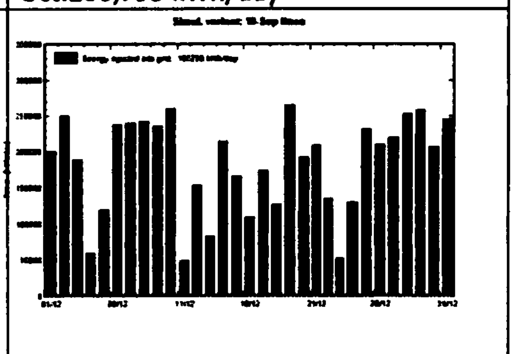
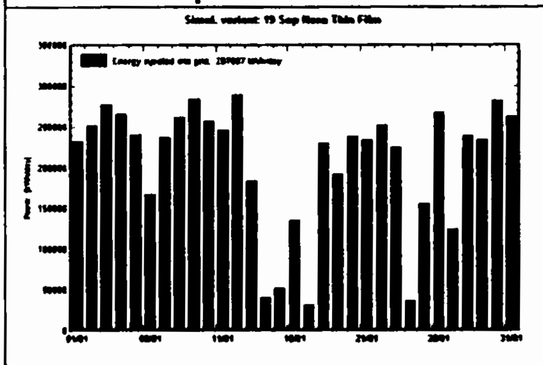
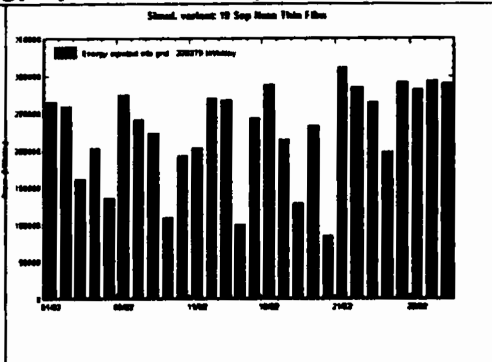
240 Wp Poly-Silicone PV Modules: Energy Injected Into Grid (KWh/day)	
	
Jul:182,453 kWh/day	Aug:188,205 kWh/day
	
Sep: 198,420 kWh/day	Oct:206,795 kWh/day
	
Nov: 200,753 kWh/day	Dec: 185,289 kWh/day

Table 5.5.2: Energy yield using Poly-Silicon PV Modules

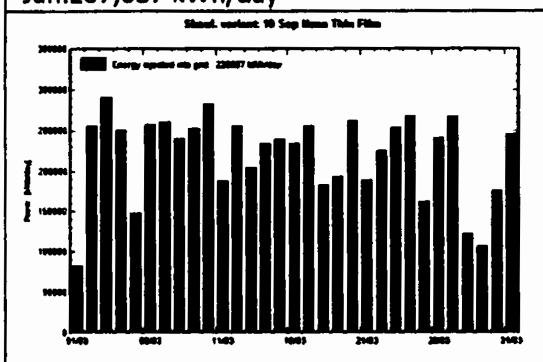
240 Wp Thin Film PV Modules: Energy Injected Into Grid (KWh/day)



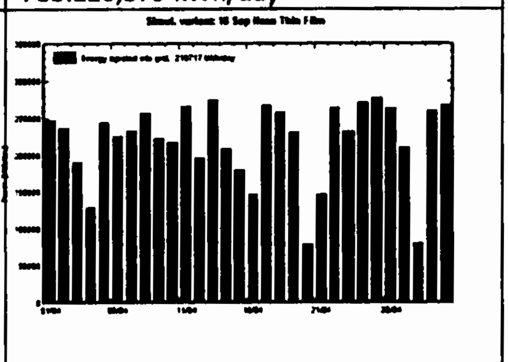
Jan:207,687 kWh/day



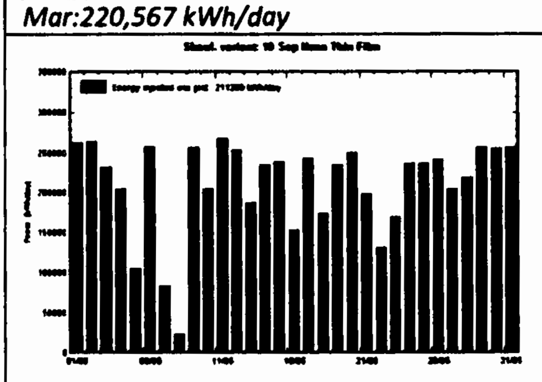
Feb:226,379 kWh/day



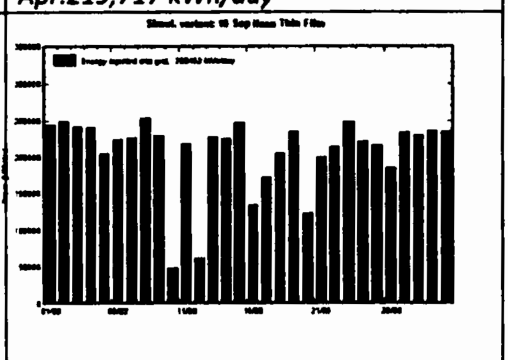
Mar:220,567 kWh/day



Apr:219,717 kWh/day

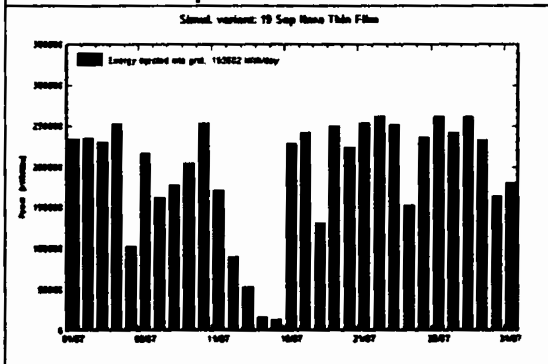


May: 211,369 kWh/day

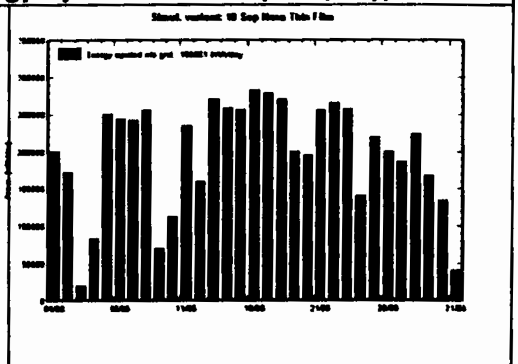


Jun:208,452 kWh/day

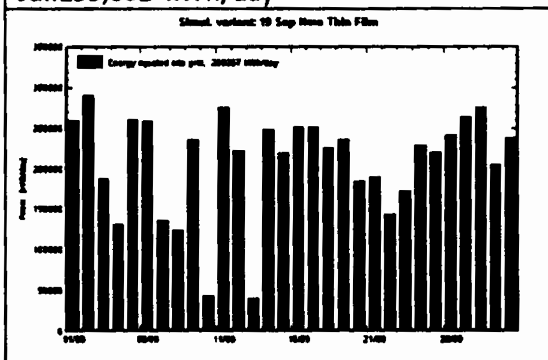
240 Wp Thin Film PV Modules: Energy Injected Into Grid (KWh/day)



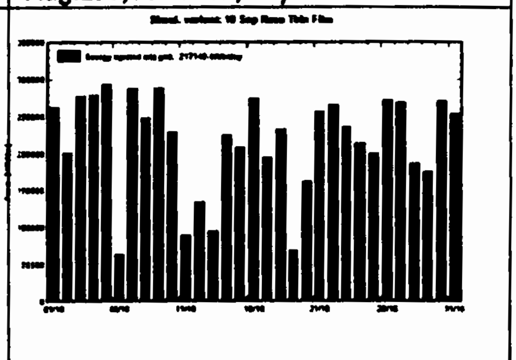
Jul:193,602 kWh/day



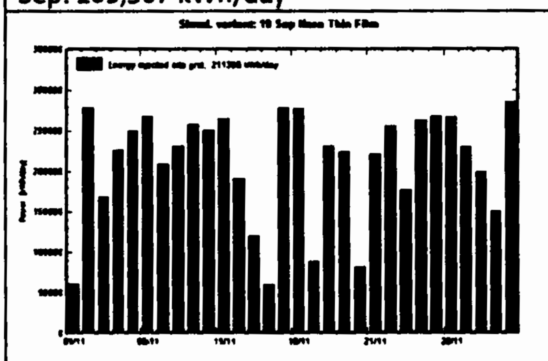
Aug:199,061 kWh/day



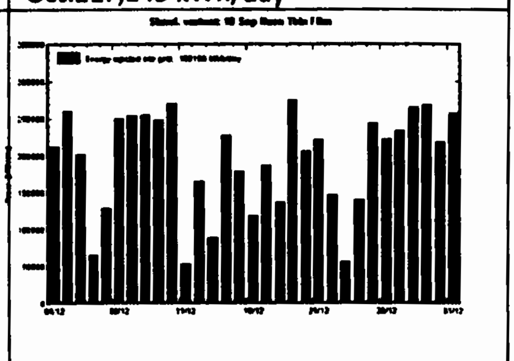
Sep: 209,367 kWh/day



Oct:217,143 kWh/day



Nov: 211,368 kWh/day



Dec: 196,186 kWh/day

Table 5.5.3: Energy yield using Thin Film PV Modules

5.6 Shading Model for the Site

The inherent site requirement for a solar PV project is a clear horizon with minimal vegetation and no building nearby. The 10MW PV Power Project site in Cholistan confirms to this requirement. The only possibility for shade is due to tall sand dunes which can be seen at a very large distance making them a non-issue, and a overheard telephone cable passing through the site for which a clearance area will be left.

Maui Solar Design Studio provides extensive parameters for partial and complete shading protocols. Details of hourly shading can be found in **Table 1.5.1:** Project Site Shading Analysis. The software also provides options for simulating the parameters in a no shading environment which provided an approximately equal yield. Therefore shading would not be a major obstacle at the selected site.

5.7 Final Energy Yield Estimation

The Final Energy Yield has been calculated using PV SYST v 5.55 Simulation Software which happens to be one of the most reliable and qualitative tool available in the Solar Industry Globally.

The salient features of the simulation analysis are provided below and state the annual production to be 15210 MWh/Year with a performance ratio of 80.0% (315 KWh/KWp/Year).

5.8 Uncertainty Analysis

An uncertainty analysis was carried out to assess the confidence of the estimated long term annual energy yield of the solar PV power plant and to evaluate whether the estimated quantity is within the interval defined by confidence limits. The study *first* identified the sources and values of uncertainties, and *second*, defined different probabilities of exceedance for the net energy output of the solar PV power plant. The exceedance probability is the likelihood of attaining or exceeding an energy production value. This is particularly important for project financing since decisions are made based on power plant guaranteed outputs.

Several uncertainties exist in the calculation of the PV plant's annual energy yield. Uncertainties and their deviation values taken into account in the analysis are based on our teams experience with previous PV projects as well as those used by other PV experts. These are uncertainties due to i) irradiance, ii) conversion to inclined surface, iii) soiling, iv) spectral uncertainty, v) albedo, vi) reflection, vii) deviation from module specifications, viii) inverter and transformer losses, ix) mismatch, x) ohmic losses, and xi) shading losses. The combined uncertainty was estimated to be ±3.52%.

From the predicted annual energy yield of the PV power plant and from the total uncertainty with respect to the input parameters, the probability of exceeding certain energy yields was estimated using statistical analysis.

The forecast average annual energy yield 15,210 MWh/Year with a performance ratio of 76.9% (315 KWh/KWp/Year) represents the mean yield (P50), having the highest rate of probability of all single results. P75 value represents the annual energy yield which is reached with a probability of 75% given the standard deviation and the mean annual yield.

In calculating various levels of Probability of Exceedance, the normal distribution (Gaussian distribution) and the cumulative distribution function was constructed based on the mean annual yield and standard deviation (***Figure 5.7.1***). ***Table 5.7.1*** provides probabilities of exceedance at 50%, 75% and 90% and their corresponding performance indicators.

Output		P50	P75	P90
Average annual yield	[kWh/a]	15.328.200	14.245.886	13.646.277
Overall YF	[kWh/kWp]	298	285	273
Overall PR	[%]	72.2%	68.9%	66.0%

Table 5.7.1: POE for the Average Annual and Specific Yield Avignonet (30 years)

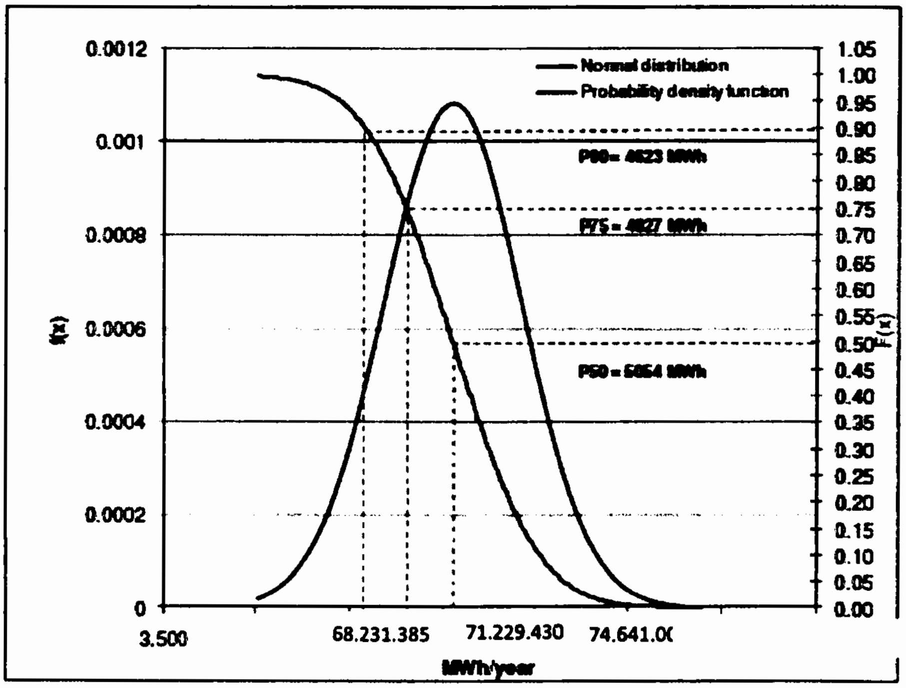


Figure 5.7.1: Annual Energy Yield and Probability of Exceedance

6 ECONOMIC CALCULATION – Upfront Tariff Determination (NEPRA)

Economic calculations in the following sections are based on the method of internal rate of return and compared with the levelized cost of energy. The important considerations for the 10 MW Solar PV Power project and others in the vicinity is the interest rate obtained for the project. The contributing factors in this region are the risk ratings of the countries in the financial market. The project has been analyzed on the basis of 17% internal rate of return as per requirements set by the authorities. The tariff determination is being presented as done and issued on 21st January 2014 by the tariff approving authority "National Electric Power Regulatory Authority (NEPRA)"

Registrar

National Electric Power Regulatory Authority

Islamic Republic of Pakistan

NEPRA Tower, Ataturk Avenue (East) G-5/1, Islamabad
Ph: +92-51-9206500, Fax: +92-51-2600026
Web: www.nepra.org.pk, E-mail: info@nepra.org.pk

No.NEPRA/UTS-01/777-779
January 21, 2014

Subject: **Determination of National Electric Power Regulatory Authority in the <u>Matter of Upfront Tariff for Solar Power Plants</u>**

Dear Sir,

Please find enclosed herewith the subject Determination of the Authority along with Annex-I, II, III & IV (45 pages).

2. The Determination is being intimated to the Federal Government for the purpose of notification of the approved tariff in the official gazette pursuant to Section 31(4) of the Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of 1997) and Rule 16(11) of the National Electric Power Regulatory Authority Tariff (Standards and Procedure) Rules, 1998.

3. Please note that only Order of the Authority at para 21 of the Determination relating to the reference tariff, adjustments, indexations and terms and conditions along with Annex-I, II, III & IV needs to be notified in the official Gazette.

Enclosure: <u>As above</u>

(Syed Safeer Hussain)

Secretary
Ministry of Water & Power
'A' Block, Pak Secretariat
Islamabad

CC:

1. Secretary, Cabinet Division, Cabinet Secretariat, Islamabad.
2. Secretary, Ministry of Finance, 'Q' Block, Pak Secretariat, Islamabad.

National Electric Power Regulatory Authority

(NEPRA)

****

Determination

In the matter of Upfront Generation Tariff for Solar PV Power Plants

January 21st, 2014

Commentators

1. Fauji Fertilizer Company Limited
2. Renewable Resources (Pvt) Limited
3. Roshan Power (Pvt) Limited
4. Precision Advocate
5. Mr. Akhtar Ali, Energy Consultant, Karachi
6. Zypher Power (Pvt) Limited

This determination is being given in accordance with the Regulation 3 of the Upfront Tariff (Approval & Procedure) Regulations, 2011 (vide S.R.O. 757(1)2011). An applicant can opt for the Upfront Generation Tariff for Solar PV Power Plant once notified in the Official gazette pursuant to section 31(4) of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (XL of 1997).

Authority

21/1/2014

(Habibullah Khilji)
Member

21/1/14

(Maj (R) Haroon Rashid)
Member

21.01.2014

(Khawaja Muhammad Naeem)
Vice Chairman

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
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AUTHORITY

21.01.14

of being installed. The amount of light-induced degradation has a substantial impact on the total electricity that a system can produce over its lifetime. There would be system degradation 0.5% - 0.7 % per annum of solar project.

b. There would be system availability of 98% of solar project.

c. There would be inflation in O&M cost per annum in solar project. NEPRA allowed the inflation in O&M cost in the wind power projects. We request NEPRA to keep the same in the solar upfront tariff.

7 Issues

Having considered the submissions of the stakeholders, following issues have emerged from the proceedings:

1) Solar Irradiation
2) Plant Capacity Factor
3) EPC Cost
4) Non-EPC and Project Development costs
5) Insurance Cost
6) Finance Fees & Charges
7) Interest During Construction
8) Operation & Maintenance Cost
9) Insurance Cost
10) Total Project Cost
11) Project Financing
12) Indexations

8 Solar Irradiation

8.1 Site selection and planning of PV power plants requires reliable solar resource data. Power production depends linearly on the plane of array irradiance, at least to a first approximation. The solar resource of a location is usually defined by the values of the global horizontal irradiation which includes both direct normal irradiation and diffuse horizontal irradiation. GHI is the total solar energy received on a unit area of horizontal surface. It includes energy from the sun that is received in a direct beam (direct irradiation) and from all directions of the sky when irradiation is scattered off the atmosphere (diffuse irradiation). The yearly sum of the GHI is of particular relevance for PV power plants, which are able to make use of both the diffuse and beam components of solar irradiance.

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8.2 Irradiation is measured in kWh/m2, and values are often given for a period of a day, a month or a year. A high long term average annual GHI is typically of most interest to PV project developers. Average monthly values are important when assessing the proportion of energy generated in each month. Long term annual average values of GHI and DNI can be obtained for a site by interpolating measurements taken from ground based sensors or indirectly from the analysis of satellite imagery. Ideally, historical values of daily or hourly irradiation with a special resolution of 10 km or less are required to generate regional solar atlases.

Satellite Derived Data

8.3 Satellite-derived data can offer a wide geographical coverage and can often be obtained retrospectively for historical periods in which no ground-based measurements were taken. This is especially useful for assessing long term averages. A combination of analytical, numerical and empirical methods can offer half-hourly data with a nominal spatial resolution down to 2.5 km, depending on the location and field of view of the satellite. One advantage of satellite resource assessment is that data is not susceptible to maintenance and calibration discontinuities. The same sensor is used to assess locations over a wide area. This can be particularly useful in comparing and ranking sites as bias errors are consistent. A comparison of the GHI values shows that statistics obtained from satellite readings correspond well with ground-measured data. But it is not so in the case of DNI values. Currently, it is not so clear if this dissonance is due to the satellite methodology or the poor maintenance of ground-based measurement stations, but is likely to be a combination of both.

8.4 Solar Irradiance is a measure of how much solar power you are getting at your location. This irradiance varies throughout the year depending on the seasons. It also varies throughout the day, depending on the position of the sun in the sky, and the weather. Solar insolation is a measure of solar irradiance over a period of time - typically over the period of a single day. This irradiance calculator takes data collated over a 22 year period to provide monthly average insolation figures. This information is then used to calculate the average daily power generation a photovoltaic system will produce in any given month.

Variability in Solar Irradiation

8.5 In terms of irradiation, the solar resource is inherently intermittent. In any given year, the total annual global irradiation on a horizontal plane varies from the long term average due to climatic fluctuations. This means that though the plant owner may not know the energy yield to expect in any given year, he can have a good idea of the expected yield averaged over the long term. To

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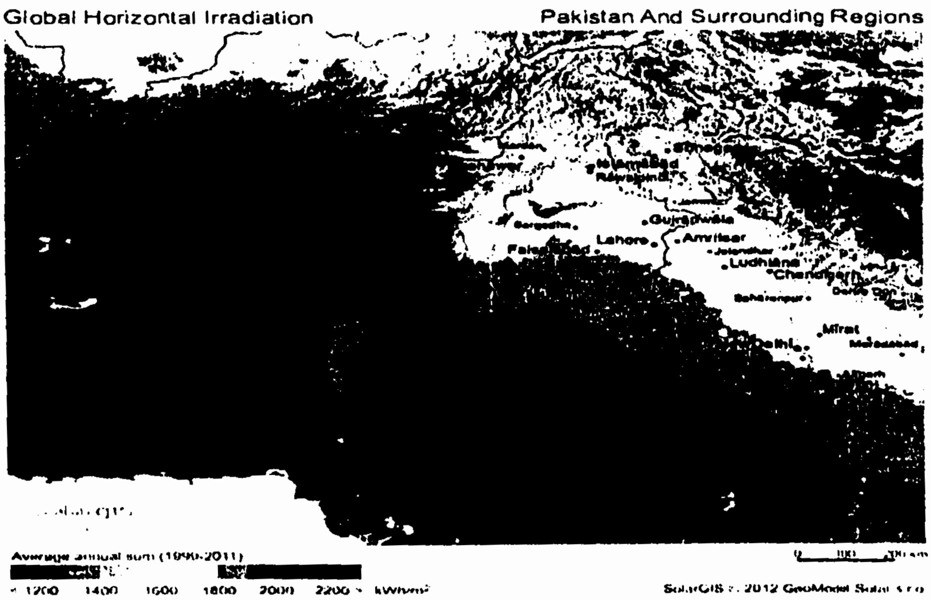
help lenders understand the risks and perform a sensitivity analysis, it is important to quantify the limits of the inter-annual variation. This can be achieved by assessing the long-term irradiation data (in the vicinity of the site) sourced from nearby MET stations or satellites. At least 10 years of data are usually required to give a reasonably confident assessment of the variation. Research papers show that for southern Europe (including Spain), the coefficient of variation (standard deviation divided by the mean) is below 4%.

Solar Irradiance in Pakistan

8.6 Pakistan receives high levels of irradiance across the board. However, there is a significant change of irradiance from North to South. The map below divides Pakistan into 4 main irradiance bands – yellow, pale orange, dark orange and ochre; the irradiation intensity increases with the depth of colour.



The highest levels of irradiance are found in Balochistan, Sindh and southern Punjab. Northern Punjab, ICT, FATA, KPK, Azad Kashmir receive lower irradiance.

Rationale for Proposing a Tiered Tariff Structure

8.7 A tiered tariff is a tool to balance competing interests of IPPs and the Government and general public. In this case, it is in the interest of the IPP to build his solar power plant in the area with the best natural resource profile to maximize his return. The government's interest is to receive energy generation

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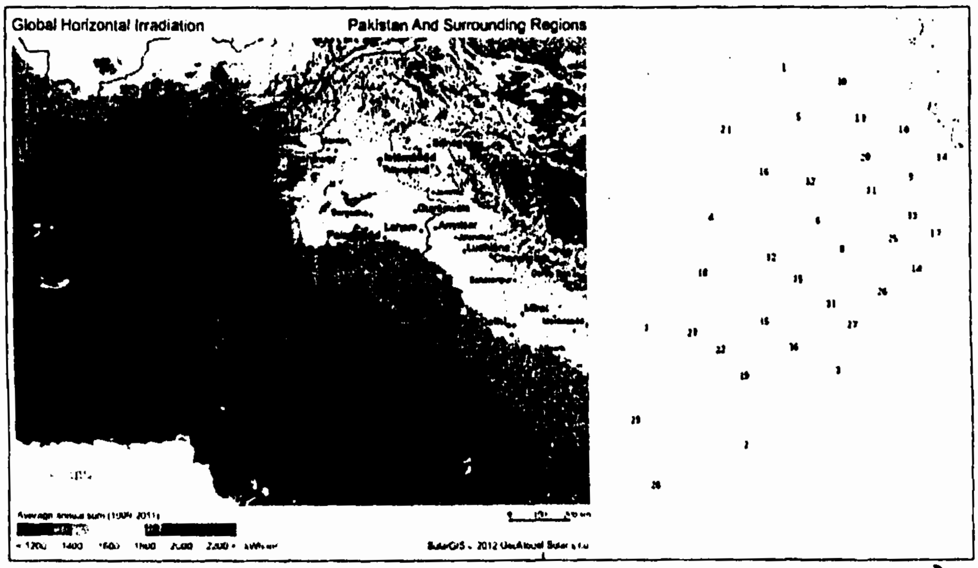
close to the load centers, thereby reducing the required investment in T&D infrastructure and minimizing transmission losses.

8.8 To provide a simple, robust and confident tier structure, the number of tiers should be kept in check. The Authority believes that, given the solar irradiance profile of Pakistan, the following two tiered structure is ideal:

South Region = high sun regions (dark orange and ochre bands on the insolation map)	**North Region = lower sun regions (yellow and light orange bands on the insolation map)**
• Balochistan • Sindh • Southern Punjab (including Cholistan)	• Northern Punjab • Federally Administered Tribal Areas • Kyber Pakhtunkhwa • Islamabad Capital Territory • Azad Kashmir • Gilgit-Baltistan

Punjab – Division into North and South

8.9 Given the irradiance profile of the country, there is a clear division of Punjab in lower irradiance and higher irradiance areas.



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Method of division	Main advantage	Main disadvantage	Verdict
Latitude/Longitude	Simplicity; rigidity	Disregards all real-world parameters	Least preferred option due to over-simplification
Natural contours	Usually undisputed and pre-dating present borders	Not always available	Not available; rivers run north to south
Administrative Regions	Easy to implement w.r.t. permits, approvals etc.	Possible mismatch with irradiance boundaries	Slight mismatch, but best fit for purpose

Administrative regions are the intuitive approach, since the determination, approval and enforcement of a tariff is, in essence, an administrative act. The boundaries of the administrative regions of Punjab do not match the solar irradiance boundary perfectly. However, the advantages of the administrative region method outweigh this discrepancy clearly. A list of administrative regions for inclusion in South Region is provided below. All other districts will be included in North Region.

South Region districts – southern Punjab

District	Map reference
Rahim Yar Khan	28
Rajanpur	29
Dera Ghazi Khan	7
Muzaffargarh	23
Multan	22
Lodhran	19
Vehari	36
Bahawalnager	2

9. Plant Capacity Factor

9.1 The capacity factor is a measure of operating efficiency which indicates the ability of a generating plant to deliver its full capacity. It is simply the generator's actual energy output for a given period divided by the theoretical energy output if the machine had operated at its full rated power output for the same period. It is indirectly an indicator of the reliability of supply.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA AUTHORITY

9.2 Capacity factor is a measure of how often an electric generator runs for a specific period of time. It compares how much electricity a generator actually produces with the maximum it could produce at continuous full power operation during the same period. For example, if a 1 MW generator produced 5,000 MWh over a year, its capacity factor would be 0.57 because 5,000 MWh equals 57% of the amount of electricity the generator could have produced if it operated the entire year (8,760 hours) at full capacity and produced 8,760 MWh of electricity. Generators with relatively low fuel costs are usually operated to supply base load power, and typically have average annual capacity factors of 80% or more. Generators with lower capacity factors may indicate they are in operation during peak demand periods and/or have high fuel costs, or their operation depends on the availability of the energy source, such as hydro, solar, and wind energy.

9.3 The capacity factor of a conventional nuclear or coal fired power plant is under management control and may be over 80%, whereas the capacity factor of a solar power plant will be much less than the conventional power plant and depends on the sun shine hours which vary from month to month. The Authority sought energy estimates based on Meteonorm data by AEDB duly verified by IfE Germany. Based on the verified energy estimates, the Authority has decided to adopt plant capacity factors of 16.78% for north region and 17.5% for south region of the rated out of the installed solar panels. In case the actual output exceeds the minimum output, the excess energy will be charged as per the table provided in the Terms & Conditions to this determination.

10. EPC Cost

10.1 The absolute cost and structure of PV modules varies by technology. Conventional c-Si PV modules are the most expensive PV technology, with the exception of CPV modules, but they also have the highest commercial efficiency. However, CIGS modules are approaching the efficiency levels of c-Si modules and are cheaper. Accurate data on global average PV module prices are difficult to obtain and in reality there is a wide range of prices, depending on the cost structure of the manufacturer, market features and module efficiency. Balance of system cost is one of the other major cost components. The BOS costs and installation comprise the remaining capital costs for a PV system. The BOS costs largely depend on the nature of the installation. The inverter is one of the key components of a PV system. It converts the DC electricity from the PV modules into AC electricity. Inverter sizes range from small textbook-sized devices for residential use to large container-sized

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

solutions for utility-scale systems. The size and numbers of inverters required depend on the installed PV capacity and system design options. Inverters are the primary power electronics components of a PV system and typically account for 5% of total installed system costs. Combiner box and miscellaneous electrical components include all remaining installation components, including combiner boxes, wires/conductors, conduits, data monitoring systems, and other miscellaneous hardware. Combiner boxes are the only PV system-specific product included in this category and they are sourced from dedicated manufacturers who supply pre-engineered systems. Other miscellaneous electrical hardware (e.g. wires, electrical conduits, overcurrent protection) are commodity products and can be sourced virtually anywhere. Site preparation and system installation are major components of the BOS and installation costs. System design, management and administrative costs include system design, legal, permitting, financing and project management costs. For residential and small-scale PV systems, these costs are typically included in the total PV installed prices quoted by companies. For large-scale installations these costs might be managed directly by the promoter or sub-contracted to a service provider. When PV system costs are quoted in literature, these costs are typically included in overhead costs and profit margins. These soft costs depend significantly on local conditions. In the United States (2010), they accounted for an average 37% of total system costs (GTM Research, 2011).

10.2 GIZ assumed an EPC cost of US$ 2.0384 million per MW of PV solar power plant. It is fact that solar PV prices have drastically came down over the years and are expected to go down further in the coming years. The EPC cost also depends on the scale of the project. In view of all these factors and current price trend, the Authority considers that US$ 1.693 million per MWp (offshore & onshore) for PV solar power plant is reasonable estimate and accordingly EPC cost of US$ 16.927083 million is approved for the 10 MWp solar PV power plant.

11. Non-EPC and Project Development Costs

11.1 Non EPC and project development costs generally include land and its development cost, administrative and staff accommodation building, project vehicles, standby generator, all kind of studies, regulatory fees, independent engineer fees, administrative expenses etc. etc. GIZ assumed non EPC and project development cost of US$ 210, 000 per MW. GIZ estimate is based on the global average values and number quote by local investors. After examining the information available and discussions with the prospective

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

investors, the Authority considers that US 1.32 million for non-EPC and project development cost for a 10 MWp solar PV power plant is reasonable and the same is being approved.

12 Insurance during Construction

12.1 GIZ assumed insurance cost @ 1.35% of the EPC cost (US$ 27,518/MW) as per NEPRA standards. GIZ ignored that NEPRA standard regarding insurance during construction was established for projects with constructions period of two years for entirely different technologies. For solar power plants, the construction period is approximately 8 months only and the nature of equipment is such that much less insurance cost is expected as compared to conventional power plants. Accordingly, the Authority assessed an amount of US$ 126,953 (0.75% of EPC cost) as insurance during construction for the 10 WMp solar power plant.

12.2 Cost of insurance during construction shall be adjusted at the time of COD on actual basis on production of documentary evidence subject to maximum of 0.75% of the EPC cost.

13 Financing Fees and Charges

13.1 GIZ assumed financing charges @ 3.5% of the debt amount. In line with the upfront coal tariff, the Authority approved 3.5% of the debt amount (US$ 480,985) as financing fees and charges which will be subject to adjustment at the time of COD on actual basis with maximum of 3.5% of the debt amount.

14 Interest during Construction (IDC)

14.1 On the basis of 8 months construction period, LIBOR of 0.31% and a premium of 450 basis points and debt equity ratio of 75:25, the Authority assessed IDC of US$ 150,105. The IDC will be reestablished at the time of COD with actual LIBOR, actual debt equity ratio and actual premium with maximum of 450 basis points. In case of KIBOR, the maximum allowed premium will be 350 basis points.

15. Operation & Maintenance Cost

15.1 The number of grid-connected solar photovoltaic (PV) systems is expected to increase dramatically over the coming decades. This increase in the number of PV units leads to an increased focus by utilities and other solar generating firms on achieving the highest level of performance and reliability from the solar asset. In addition to the typical focus of thinking about up -front costs of a solar plant, determining a plan and budget for operations and maintenance (O & M) is essential in assessing the business case for a PV facility.

15.2 Low maintenance cost is one of the principal drivers of the solar power energy. Unlike conventional electrical generation there are no rotating parts and no high pressure steam and water systems and therefore less equipment exposed to inherent wear and repair processes that typically require the generating unit to be off load, unavailable for costly investment maintenance. The maintenance requirements of a solar project typically are O&M on the electrical systems and cabling, connectors of modules, inverter equipment will typically require changeover of certain parts after 10 years. Solar modules have a typical lifetime of 25-30 years. Regular cleaning of modules and measuring equipment is important as is ground maintenance to ensure the solar panels do not become shaded by vegetation or land mass collection.

15.3 GIZ assumed O&M cost of US$ 35,879/MW on the basis of 1.5% of the project cost. On the basis of the feedback and input from the stakeholders and information received from the prospective investors, the Authority considers that 1.5% of the EPC cost is a reasonable estimate of the O&M cost for solar PV power plants and accordingly annual US$ 253,906 per annum has been assessed as O&M cost for the 10 MWp solar PV power plant.

16. Insurance during Operation

16.1 During the plant operation period of 25 years, GIZ assumed insurance cost @ 1.35% of the EPC cost (US$ 27,000/MW) for each year. The actual insurance cost of most of the thermal IPPs is less than 1% of their EPC cost. It is generally considered that due to entirely different nature of the plants, insurance cost of PV Solar plants are less than the conventional thermal power plants. Therefore, the Authority assessed US$ 169,271 (1% of the EPC cost) as insurance cost for the upfront solar tariff.

16.2 The annual operating insurance cost will be subject to adjustment on actual basis on production of authenticated documentary evidence subject to maximum of 1% of the EPC cost in Pak Rupees using the exchange rate prevailing on the 1st day of the insurance coverage period.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA AUTHORITY

17 Total Project Cost

17.1 On the basis of discussion in the preceding paragraphs, the summary of approved project cost for upfront solar tariff based on a 10MWp solar power plant on the rated capacity of the solar PV panels installed is provided hereunder:

Description	Approved (US$)
EPC Cost	16,927,083
Non EPC & Project Development Cost	1,320,000
Insurance during construction	126,953
CAPEX	**18,328,255**
Financing Fees & Charges	482,318
Interest During Construction	150,521
Total Project Cost	**19,006,875**

18. Project Financing & Cost of Capital

18.1 Based on the above project cost, following capital structure for the upfront solar tariff has been assumed:

Description	Million (US$)
Foreign Debt	14,255,157
Equity	4,751,719
Total Project Cost	19,006,875
Debt: Equity Ratio	75:25

18.2 Minimum equity for the project will be 20%. There will not be any maximum limit for financing of the project through equity. However, the equity exceeding 30% of the total project cost will be considered as debt.

18.3 The Authority has decided to allow 18% return on equity portion of the project financing. Cost of debt has been allowed on the basis of 0.31% LIBOR plus a premium of 450 basis points on foreign financing. In case of project financing through local debt, interest cost will be allowed on the basis of KIBOR plus a premium of 350 basis points. Savings, if any, in the premium will be shared by the power purchaser and the power producer in the ratio of 60:40 respectively.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

19. **Indexations**

19.1 The following indexation will apply on the reference components the determined tariff:

Component	Indexation
O&M-Local	Local CPI (General)
O&M-Foreign	PKR/US$, US CPI
Insurance	Actual with maximum of 1% of EPC cost
Return on Equity	PKR/US$
Principal Repayments (Foreign Loan)	PKR/US$ or the applicable currency
Interest Payments	LIBOR/KIBOR, PKR/US$

20. **Feedback from the Government of Punjab**

20.1 In the Energy Meeting held on 31st July 2013, it was informed by the Government of Punjab that it has reached an understanding with the investors for setting up of solar PV power plants in Punjab on tariffs in the range of US Cents 13/14 per kWh which were relatively lower than NEPRA's working. Government of Punjab was requested vide letter No. NEPRA/CM/11/13 dated 16-8-2013 to provide details of the above proposal to NEPRA for finalizing upfront tariff as early as possible. Follow up letters were also sent on 6th September and 30th September 2013. Government of Punjab was also requested vide letter No. NEPRA/TRF-UTS/13149-52 dated 27-11-2013 and letter No. NEPRA/TRF-100-UTS/13282-84 dated 29-11-2013 to provide requisite information otherwise the Authority will be constrained to announce the solar tariff on the basis of available information. However no information was provided by the Government of Punjab.

20.2 NEPRA vide letter No. NEPRA/R/132-135 dated 02-01-2014 sent the basis, assumptions, working and tariff to the Government of Punjab with a request to provide comments on the proposed upfront solar tariff within seven (7) days and non reply will be considered as if the Government of Punjab do not have any reservations on the proposed upfront solar tariff. Since no comments were received from the Government of Punjab, therefore, the Authority has decided to announce the upfront tariff for solar projects on the basis of available information.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA AUTHORITY

21. Order

I. The Authority hereby determines and approves the following upfront tariff and adjustments/indexations for solar power generation for delivery of electricity to the power purchaser based on a 10MWp solar power plant on the rated capacity of the solar PV panels installed:

Specified Reference Tariff

Description	North Region		South Region		Indexations
	Year 1-10	Year 11-25	Year 1-10	Year 11-25	
	Rs./kWh	Rs./kWh	Rs./kWh	Rs./kWh	
Fixed O&M	1.8137	1.8137	1.7391	1.7391	CPI , US CPI, US$/PKR
Insurance	1.2091	1.2091	1.1594	1.1594	Actual on annual basis
Debt Service – Foreign	12.8872	-	12.3570	-	US$/PKR & LIBOR
Return on Equity	6.1097	6.1097	5.8583	5.8583	US$ /PKR
Total	**22.0197**	**9.1325**	**21.1138**	**8.7568**	

Note:

i. The above tariff will be applicable for 25 years commencing from the date of the commercial operations.

ii. The reference Component wise tariff is attached at Annex-I for North and Annex II for South regions. Debt Servicing Schedules for north and south regions are attached at Annex-III and Annex-IV respectively.

II. One Time Adjustment at COD

i). The Authority has assessed Equipment, Procurement and Construction (EPC) cost US$ 16.927083 million. The reference exchange rate has been assumed as Rs. 105/US$. Since the exact timing of payment to EPC contractor is not known at this point of time, therefore, an adjustment for relevant foreign currency fluctuation for the portion of payment in the relevant foreign currency will be made. In this regard the sponsor will be required to provide all the necessary relevant details along with documentary evidence. The adjustment shall be made only for the currency fluctuation against the reference parity values.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA AUTHORITY

ii). Cost of insurance during construction shall be adjusted at the time of COD on actual basis on production of documentary evidence subject to maximum of 0.75% of the EPC cost.

iii) Financing fees shall be adjusted at the time of COD as per actual subject to maximum of 3.5% of the total financing.

III. **Adjustment in Insurance as per actual**

i) The actual insurance cost for the minimum cover required under contractual obligations with the Power Purchaser not exceeding 1% of the EPC cost will be treated as pass-through. Insurance component of reference tariff shall be adjusted annually as per actual upon production of authentic documentary evidence according to the following formula:

$$\text{Insurance (Adj)} = AIC / P_{(Ref)} * P_{(Act)}$$

Where;

AIC	=	Adjusted Insurance Component
$P_{(Ref)}$	=	Reference Premium Rs. 13.33 million.
$P_{(Act)}$	=	Actual Premium or 1% of the EPC cost in Pak Rupees on exchange rate prevailing on the 1st day of the insurance coverage period which ever is lower

IV. **Indexations:**

The following indexations shall be applicable to the reference tariff;

i) **Indexation of Return on Equity (ROE)**

After COD, ROE component of tariff will be quarterly indexed on account of variation in PKR/US$ parity according to the following formula:

$$ROE(Rev) = ROE(Ref) * ER(Rev) / ER(Ref)$$

Where;

ROE (Rev)	=	Revised ROE Component of Tariff
ROE (Ref)	=	ROE Component of Tariff established at the time of COD
ER (Rev)	=	The revised TT & OD selling rate of US dollar as notified by the National Bank of Pakistan

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

ER (Ref) = Reference Exchange Rate at the time of COD

ii) <u>Indexation applicable to O&M</u>

The O&M component of tariff will be adjusted on account of local Inflation (CPI) and foreign inflation (US CPI) and exchange rate quarterly on 1st July, 1st October, 1st January and 1st April based on the latest available information with respect to CPI notified by the Pakistan Bureau of Statistics (PBS), US CPI issued by US Bureau of Labor Statistics and revised TT & OD selling rate of US Dollar notified by the National Bank of Pakistan as per the following mechanism:

$L\ O\&M_{(REV)}$	=	70% of Rs. 1.8135/kW/Hour * $CPI_{(REV)}$ / $CPI_{(REF)}$
$F\ O\&M_{(REV)}$	=	30% of Rs. 1.8135/kW/Hour * $US\ CPI_{(REV)}$ / $US\ CPI_{(REF)}$ * $ER_{(REV)}/ER_{(REF)}$
Where:		
$L\ O\&M_{(REV)}$	=	the revised applicable O&M Local Component of tariff
$F\ O\&M_{(REV)}$	=	the revised applicable O&M Foreignl Component of tariff
$CPI_{(REV)}$	=	the revised Consumer Price Index (General) published by Pakistan Bureau of Statistics.
$CPI_{(REF)}$	=	the reference Consumer Price Index (General) of 191.21 of November 2013
$US\ CPI_{(REV)}$	=	the revised US CPI (All Urban Consumers) published by US Bureau of Labor Statistics
$US\ CPI_{(REF)}$	=	the reference US CPI (All Urban Consumers) of 233.069 of November 2013
$ER_{(REV)}$	=	the revised TT & OD selling rate of US dollar published by National Bank of Pakistan
$ER_{(REF)}$	=	the reference TT & OD selling rate of RS. 105/US dollar

iii) <u>Indexation for LIBOR Variation</u>

The interest part of fixed charge component will remain unchanged throughout the term except for the adjustment due to variations in interest rate as a result of variation in 3 months LIBOR according to the following formula;

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

ΔI = $P_{(REV)}$ * ($LIBOR_{(REV)}$ - 0.31%) /4

Where:

ΔI = the variation in interest charges applicable corresponding to variation in 3 months LIBOR. ΔI can be positive or negative depending upon whether $LIBOR_{(REV)}$ is > or < 0.31%. The interest payment obligation will be enhanced or reduced to the extent of ΔI for each quarter under adjustment applicable on quarterly basis.

$P_{(REV)}$ = The outstanding principal (as indicated in the attached debt service schedule to this order) on a quarterly basis on the relevant quarterly calculation date. Period 1 shall commence on the date on which the 1st installment is due after availing the grace period.

Terms and Conditions of Tariff:

The above tariff and terms and conditions, stipulated hereunder, shall be incorporated in the Energy Purchase Agreement between the Power Purchaser and the Power Producer, the draft standardized version of which along with the Implementation Agreements should be finalized by AEDB in consultation with the stakeholders within 45 days of the publication of this determination.

i. All plant and equipment shall be new and shall be designed, manufactured and tested in accordance with the latest IEC standards or other equivalent standards.

ii. The verification of the new machinery will be done by the independent engineer at the time of the commissioning of the plant duly verified by the power purchaser.

iii. The Energy Purchase Agreement should stipulate terms and conditions, regarding periodic physical inspection of the plant and equipment, ensuring that the power plant is properly maintained and continues to supply energy for the entire tariff control period of 25 years.

iv. Plant Capacity factors for north and south regions will be 16.78% and 17.5% respectively.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

v. In case the actual output exceeds the minimum output, the excess energy will be charged in accordance with the following mechanism:

Net Annual Plant Capacity Factors	% of the prevalent tariff
Above 16.78%/17.50% to 17.78%/18.50%	75%
Above 17.78%/18.50% to 18.78%/19.50%	50%
Above 18.78%/19.50% to 18.78%/20.50%	25%
Above 19.78%/20.50% to 18.78%/21.50%	20%
Above 20.78%/21.50%	10%

vi. The risk of lower solar irradiation will be on the power producer.

vii. The choice to opt for this tariff will only be available up to 6 months from the date of its determination by the Authority.

viii. The sponsors interested in availing Upfront tariff will submit unconditional formal application to NEPRA for approval by the Authority in accordance with the NEPRA Upfront Tariff (Approval and Procedure) Regulations 2011.

ix. The applicant will have to achieve financial close by March 31, 2015. The upfront tariff granted to the applicant will no longer remain applicable/valid, if financial close is not achieved by the applicant by March 31, 2015 or generation license is declined to the applicant.

x. The targeted maximum construction period after financial close is 8 months. No adjustment will be allowed in this tariff to account for financial impact of any delay in project construction. However, the failure of the applicant to complete construction within 8 months of financial close will not invalidate the tariff granted to it.

xi. The eligibility criteria for opting upfront solar tariff will be as under:

a. The projects holding Letter of Intent (LOI) from AEDB/provincial Government agencies.

b. The projects whose proposed plant & machinery is confirmed to be new as per undertaking/affidavit to be provided by the project sponsors along with their applications to the Authority for acceptance of upfront tariff.

c. The projects having completion of grid connectivity study and its approval by the power purchaser.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

d. The projects opting for upfront tariff will dispatch power at 11 kV system

xii. On the basis of IfE Germany validation of the energy estimates, the degradation not exceeding 0.7%/annum of initial power will be provided in the Energy Purchase Agreement.

xiii. Pre COD sale of electricity to the power purchaser, if any, shall be allowed subject to the terms and conditions of EPA, at the applicable tariff excluding principal repayment of debt component and interest component.

xiv. In the Upfront Tariff no adjustment for certified emission reductions has been accounted for. However, upon actual realization of carbon credits, the same shall be distributed between the power purchaser and the power producer in accordance with the Policy for Development of Renewable Energy for Power Generation 2006, as amended from time to time.

xv. This tariff will only be valid for approvals given for the first 50 MW. Projects under this tariff shall not exceed 10 MWp (minimum 1MWp) in terms of installed plant capacity except as provided in Para VI.

xvi. The decision to opt for upfront tariff once exercised will be irrevocable.

xvii. Debt part of the project financing has been assumed on foreign financing. However, the debt part of the project can also be financed through local financing or mix of local and foreign financing and the debt servicing component will be adjusted accordingly.

xviii. The adjustment/indexation of upfront tariff will be made on the basis of benchmarks assumed by the Authority for Upfront Tariff in accordance with the indexation mechanism stipulated hereinabove, and a single Upfront Tariff will be applicable for all solar PV projects coming under the Upfront Tariff regime. No project specific adjustments shall be taken into account.

xix. No provision for income tax, workers profit participation fund and workers welfare fund, any other tax, custom/excise duty or other duty, levy, charge, surcharge or other governmental impositions, payable on the generation, sales, exploration has been accounted for in the tariff. If the company is obligated to pay any tax the exact amount will be reimbursed by CPPA/DISCO on production of original receipts. However, withholding tax on dividend will not be pass through under the upfront solar tariff in line with the coal upfront tariff.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

xx. General assumptions, which are not covered in this determination and National Electric Power Regulatory Authority Upfront Tariff (Approval & Procedure) Regulations, 2011, may be dealt with as per the standard terms of the Energy Purchase Agreement.

VI. Existing Tariff Petitions

The Access Solar (Pvt) Limited is the only project company which has filed a tariff petition for determination of solar tariff for its 11.52 MWp proposed power plant at Pind Dadan Khan, Punjab. The petition has been admitted and is pending for the decision. If the upfront solar tariff specified above is acceptable to them, they will have the first right to opt for the upfront solar tariff as they fulfill the criteria for opting the upfront solar tariff.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA
AUTHORITY

Annex-I

Upfront Solar Tariff
Reference Tariff Table (North Region)

Year	O&M	Insurance	Return on Equity	Debt Servicing	Total Tariff	
	Rs./kWh	Rs./kWh	Rs./kWh	Rs./kWh	Rs./kWh	US¢/kWh
1	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
2	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
3	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
4	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
5	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
6	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
7	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
8	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
9	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
10	1.8137	1.2091	6.1097	12.8872	22.0197	20.9712
11	1.8137	1.2091	6.1097	-	9.1325	8.6976
12	1.8137	1.2091	6.1097	-	9.1325	8.6976
13	1.8137	1.2091	6.1097	-	9.1325	8.6976
14	1.8137	1.2091	6.1097	-	9.1325	8.6976
15	1.8137	1.2091	6.1097	-	9.1325	8.6976
16	1.8137	1.2091	6.1097	-	9.1325	8.6976
17	1.8137	1.2091	6.1097	-	9.1325	8.6976
18	1.8137	1.2091	6.1097	-	9.1325	8.6976
19	1.8137	1.2091	6.1097	-	9.1325	8.6976
20	1.8137	1.2091	6.1097	-	9.1325	8.6976
21	1.8137	1.2091	6.1097	-	9.1325	8.6976
22	1.8137	1.2091	6.1097	-	9.1325	8.6976
23	1.8137	1.2091	6.1097	-	9.1325	8.6976
24	1.8137	1.2091	6.1097	-	9.1325	8.6976
25	1.8137	1.2091	6.1097	-	9.1325	8.6976
Levelized	**1.8137**	**1.2091**	**6.1097**	**8.7238**	**17.8563**	**17.0060**

Installed Capacity (MWp)	10.000
Minimum Annual Energy (GWh)	14.699
CPI (General) November 2013	191.210
US CPI (All Urban Consumers) November 2013	233.069
Exchange Rate (Rs./US$)	105.000

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA AUTHORITY

Annex-II

Upfront Solar Tariff
Reference Tariff Table (South Region)

Year	O&M	Insurance	Return on Equity	Debt Servicing	Total Tariff	
	Rs./kWh	Rs./kWh	Rs./kWh	Rs./kWh	Rs. per kWh	¢ per kWh
1	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
2	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
3	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
4	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
5	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
6	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
7	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
8	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
9	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
10	1.7391	1.1594	5.8583	12.3570	21.1138	20.1083
11	1.7391	1.1594	5.8583	-	8.7568	8.3398
12	1.7391	1.1594	5.8583	-	8.7568	8.3398
13	1.7391	1.1594	5.8583	-	8.7568	8.3398
14	1.7391	1.1594	5.8583	-	8.7568	8.3398
15	1.7391	1.1594	5.8583	-	8.7568	8.3398
16	1.7391	1.1594	5.8583	-	8.7568	8.3398
17	1.7391	1.1594	5.8583	-	8.7568	8.3398
18	1.7391	1.1594	5.8583	-	8.7568	8.3398
19	1.7391	1.1594	5.8583	-	8.7568	8.3398
20	1.7391	1.1594	5.8583	-	8.7568	8.3398
21	1.7391	1.1594	5.8583	-	8.7568	8.3398
22	1.7391	1.1594	5.8583	-	8.7568	8.3398
23	1.7391	1.1594	5.8583	-	8.7568	8.3398
24	1.7391	1.1594	5.8583	-	8.7568	8.3398
25	1.7391	1.1594	5.8583	-	8.7568	8.3398
Levelized	**1.7391**	**1.1594**	**5.8583**	**8.3649**	**17.1216**	**16.3063**

Installed Capacity (MWp)	10.000
Minimum Annual Energy (GWh)	15.330
CPI (General) November 2013	191.210
US CPI (All Urban Consumers) November 2013	233.069
Exchange Rate (Rs./US$)	105.000

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
NEPRA AUTHORITY

Annex-III

Upfront Solar Tariff
Debt Servicing Schedule (North Region)

Period	Foreign Debt					Annual Principal Repayment Rs./kWh	Annual Interest Rs./kWh	Annual Debt Servicing Rs./kWh
	Principal USD	Repayment USD	Mark-up USD	Balance USD	Debt Service USD			
	14,255,157	279,612	171,418	13,975,544	451,031			
	13,975,544	282,975	168,056	13,692,569	451,031			
	13,692,569	286,378	164,653	13,406,192	451,031			
	13,406,192	289,821	161,209	13,116,371	451,031			
1	14,255,157	1,138,786	665,337	13,116,371	1,804,123	8.13	4.75	12.8872
	13,116,371	293,306	157,724	12,823,064	451,031			
	12,823,064	296,833	154,197	12,526,231	451,031			
	12,526,231	300,403	150,628	12,225,828	451,031			
	12,225,828	304,015	147,016	11,921,813	451,031			
2	13,116,371	1,194,557	609,565	11,921,813	1,804,123	8.53	4.35	12.8872
	11,921,813	307,671	143,360	11,614,143	451,031			
	11,614,143	311,371	139,660	11,302,772	451,031			
	11,302,772	315,115	135,916	10,987,657	451,031			
	10,987,657	318,904	132,127	10,668,753	451,031			
3	11,921,813	1,253,060	551,062	10,668,753	1,804,123	8.95	3.94	12.8872
	10,668,753	322,739	128,292	10,346,014	451,031			
	10,346,014	326,620	124,411	10,019,394	451,031			
	10,019,394	330,547	120,483	9,688,847	451,031			
	9,688,847	334,522	116,508	9,354,325	451,031			
4	10,668,753	1,314,428	489,694	9,354,325	1,804,123	9.39	3.50	12.8872
	9,354,325	338,545	112,486	9,015,780	451,031			
	9,015,780	342,616	108,415	8,673,164	451,031			
	8,673,164	346,736	104,295	8,326,428	451,031			
	8,326,428	350,905	100,125	7,975,523	451,031			
5	9,354,325	1,378,802	425,321	7,975,523	1,804,123	9.85	3.04	12.8872
	7,975,523	355,125	95,906	7,620,398	451,031			
	7,620,398	359,395	91,635	7,261,002	451,031			
	7,261,002	363,717	87,314	6,897,285	451,031			
	6,897,285	368,091	82,940	6,529,194	451,031			
6	7,975,523	1,446,328	357,794	6,529,194	1,804,123	10.33	2.56	12.8872
	6,529,194	372,517	78,514	6,156,677	451,031			
	6,156,677	376,997	74,034	5,779,681	451,031			
	5,779,681	381,530	69,501	5,398,151	451,031			
	5,398,151	386,118	64,913	5,012,033	451,031			
7	6,529,194	1,517,162	286,961	5,012,033	1,804,123	10.84	2.05	12.8872
	5,012,033	390,761	60,270	4,621,272	451,031			
	4,621,272	395,460	55,571	4,225,812	451,031			
	4,225,812	400,215	50,815	3,825,597	451,031			
	3,825,597	405,028	46,003	3,420,569	451,031			
8	5,012,033	1,591,464	212,659	3,420,569	1,804,123	11.37	1.52	12.8872
	3,420,569	409,898	41,132	3,010,671	451,031			
	3,010,671	414,827	36,203	2,595,843	451,031			
	2,595,843	419,816	31,215	2,176,028	451,031			
	2,176,028	424,864	26,167	1,751,164	451,031			
9	3,420,569	1,669,405	134,717	1,751,164	1,804,123	11.92	0.96	12.8872
	1,751,164	429,973	21,058	1,321,191	451,031			
	1,321,191	435,143	15,887	886,047	451,031			
	886,047	440,376	10,655	445,671	451,031			
	445,671	445,671	5,359	(0)	451,031			
10	1,751,164	1,751,164	52,959	(0)	1,804,123	12.51	0.38	12.8872

NEPRA AUTHORITY
NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

44

Annex-IV

Upfront Solar Tariff
Debt Servicing Schedule

Period	Foreign Debt					Annual Principal Repayment Rs./kWh	Annual Interest Rs./kWh	Annual Debt Servicing Rs./kWh
	Principal USD	Repayment USD	Mark-up USD	Balance USD	Debt Service USD			
	14,255,157	279,612	171,418	13,975,544	451,031			
	13,975,544	282,975	168,056	13,692,569	451,031			
	13,692,569	286,378	164,653	13,406,192	451,031			
	13,406,192	289,821	161,209	13,116,371	451,031			
1	14,255,157	1,138,786	665,337	13,116,371	1,804,123	7.80	4.56	12.3570
	13,116,371	293,306	157,724	12,823,064	451,031			
	12,823,064	296,833	154,197	12,526,231	451,031			
	12,526,231	300,403	150,628	12,225,828	451,031			
	12,225,828	304,015	147,016	11,921,813	451,031			
2	13,116,371	1,194,557	609,565	11,921,813	1,804,123	8.18	4.18	12.3570
	11,921,813	307,671	143,360	11,614,143	451,031			
	11,614,143	311,371	139,660	11,302,772	451,031			
	11,302,772	315,115	135,916	10,987,657	451,031			
	10,987,657	318,904	132,127	10,668,753	451,031			
3	11,921,813	1,253,060	551,062	10,668,753	1,804,123	8.58	3.77	12 3570
	10,668,753	322,739	128,292	10,346,014	451,031			
	10,346,014	326,620	124,411	10,019,394	451,031			
	10,019,394	330,547	120,483	9,688,847	451,031			
	9,688,847	334,522	116,508	9,354,325	451,031			
4	10,668,753	1,314,428	489,694	9,354,325	1,804,123	9.00	3.35	12.3570
	9,354,325	338,545	112,486	9,015,780	451,031			
	9,015,780	342,616	108,415	8,673,164	451,031			
	8,673,164	346,736	104,295	8,326,428	451,031			
	8,326,428	350,905	100,125	7,975,523	451,031			
5	9,354,325	1,378,802	425,321	7,975,523	1,804,123	9.44	2.91	12.3570
	7,975,523	355,125	95,906	7,620,398	451,031			
	7,620,398	359,395	91,635	7,261,002	451,031			
	7,261,002	363,717	87,314	6,897,285	451,031			
	6,897,285	368,091	82,940	6,529,194	451,031			
6	7,975,523	1,446,328	357,794	6,529,194	1,804,123	9.91	2.45	12 3570
	6,529,194	372,517	78,514	6,156,677	451,031			
	6,156,677	376,997	74,034	5,779,681	451,031			
	5,779,681	381,530	69,501	5,398,151	451,031			
	5,398,151	386,118	64,913	5,012,033	451,031			
7	6,529,194	1,517,162	286,961	5,012,033	1,804,123	10.39	1.97	12.3570
	5,012,033	390,761	60,270	4,621,272	451,031			
	4,621,272	395,460	55,571	4,225,812	451,031			
	4,225,812	400,215	50,815	3,825,597	451,031			
	3,825,597	405,028	46,003	3,420,569	451,031			
8	5,012,033	1,591,464	212,659	3,420,569	1,804,123	10.90	1.46	12.3570
	3,420,569	409,898	41,132	3,010,671	451,031			
	3,010,671	414,827	36,203	2,595,843	451,031			
	2,595,843	419,816	31,215	2,176,028	451,031			
	2,176,028	424,864	26,167	1,751,164	451,031			
9	3,420,569	1,669,405	134,717	1,751,164	1,804,123	11.43	0.92	12.3570
	1,751,164	429,973	21,058	1,321,191	451,031			
	1,321,191	435,143	15,887	886,047	451,031			
	886,047	440,376	10,655	445,671	451,031			
	445,671	445,671	5,359	(0)	451,031			
10	1,751,164	1,751,164	52,959	(0)	1,804,123	11.99	0.36	12.3570

7 OPERATION & MAINTENANCE

7.1 O&M Costing

PV O&M budgeting is an inherent compromise between the costs and subsequent value of maintaining asset availability and performance. Some O&M costs such as those associated with monitoring, can be reasonably defined and calculated based on equipment type, quantity, and desired level of monitoring capability.

However, other expenses, such as those associated with maintenance activities, are less predictable and can be influenced by: system size and location (e.g., water availability, weather conditions, travel distances), plant architecture and ease of site access (e.g., ground mount vs. roof mount, tracker vs. fixed plate), as well as the extent that meters and inverters are deployed at a site, among other factors. As a result, estimated and actual O&M expenses can markedly diverge.

Following are the expected operation and maintenance activities that would require efficient cost analysis of the activities mentioned in **Table 7.1.1:** Maintenance Activities:

Preventive Maintenance	Corrective maintenance	Corrective Based
1. Panel Cleaning 2. Vegetation Management 3. Wildlife Prevention 4. Water Drainage 5. Retro-Commissioning	1. On site monitoring / mitigation 2. Critical Reactive Repair 3. Non-critical Reactive repair 4. Warranty Enforcement	1. Active Monitoring 2. Warranty Enforcement 3. Equipment Replacement

Table 7.1.1: Maintenance Activities

The costs estimated for the 10MW Solar PV power project in Cholistan include the following:

(i) Cost of Outsource for O&M
(ii) Fixed Assets
(iii) Payroll and Allied Expenses
(iv) Operation cost of Backup Diesel Generator
(v) Vehicle Fuel and Maintenance
(vi) Technical Consultant Fee
(vii) Working Capital
(viii) Other Administrative Cost

7.2 Responsibility

After the completion of this 10MW Solar PV Project, a joint management organization will be established with the principle of requiring "few on-duty staff". After the electrical equipment and machinery have entered their stable operation mode, the PV plant shall be managed with "no on-call staff and few on-guard staff".

The PV Plant is divided into the production area and the utility area. The production area Includes facilities such as Solar PV panels, etc. The complex will have multiple functions of administration, living, and production. The offices of the building will consist of relay protection room (including the DC panel room), central control room, communication room, and general purpose offices. The control room, the room for distributing high and low voltage electricity, and power distribution will be arranged conveniently so as to reduce the total length of cable laying and save construction cost. The other section is for daily lives including dormitories, dining room, and kitchen.

7.3 On Site availability of Spares and technicians

Spare part list and advance procurement decisions will be the responsibility of EPC Contractor after review and approval from Welt Konnect project team. After the electrical equipment and machinery have entered their stable operation mode, the PV plant shall be managed with "no on-call staff and few on-guard staff".

7.4 Housekeeping of Facility

OEMs for Solar panels are responsible for providing the generic maintenance plans for solar panels which include cleaning. The EPC Contractor will be required to further determine the suitable cleaning requirements for the panel. This would be done by sharing complete site information (dust, dirt, pollen and/or pollution in the site environment; the frequency of rain or snow) with the OEMs for Solar panel, and ask them for site specific cleaning plans and details for the solar panels.

Innovative methods for different maintenance and operation aspects are being employed all over the globe. One such Example is placed below (**Figure 7.1**: Innovative methods of Panel Cleaning)

Figure 7.4.1: Innovative methods of Panel Cleaning

7.5 Operations & Maintenance Team

Operation and maintenance team members and their qualification requirements will be dependent on the requirements presented by OEMs for equipment and components, requirements identified by EPC Contractors. Team structure would be dependent on the nature of approach taken towards the responsibility of O&M. The team would follow the following basic hierarchy:

Asset Manager: The Asset Manager will have overall responsibility for performance of the Project and will be based at the office of the Welt Konnect.

O&M Site Manager: The O&M Site Manager will be responsible for daily management of on-site activities, including being the point of contact for community questions and managing the maintenance technicians.

Supervisors: Supervisors for departments like HSE will be put in charge for routine rounds and observations.

Technicians: Technicians will be located on-site and will perform routine maintenance on the modules, inverters, etc.

7.6 Concerns to be addressed in SOP of the plant

The concerns over PV Variability and uncertainty continue between utilities, PV system developers and owners, and regulators to characterize PV variability and develop effective measures to manage the variability and uncertainty. The initial lessons learned that have to be made as guidelines for all solar PV projects being undertaken in the region are:

Rapid ramps are important to characterize and understand for PV, but in the end system operators need to maintain a balance between the aggregate of all generators and loads. Understanding the characteristics of aggregate PV output over large areas and correlation to load are critical to understanding potential impacts of large quantities of PV.

PV variability can drive localized concerns, which typically manifest themselves as voltage or power quality problems. These issues are distinct from grid system level issues of balancing, and ought not to be confused. Management and remediation options for local power quality problems are generally different than options for maintaining a balance between load and supply at the system level.

The variability observed by a point insolation measurement will not directly correspond to the variability of a PV plant. A point measurement ignores sub-minute time scale smoothing that can occur within multi-kW plants and sub-ten minute smoothing that can occur within multi-MW plants. Extrapolation suggests that further smoothing is expected for short time-scale variability within PV plants that are hundreds of MW, but this needs to be confirmed with field data from large systems.

Diversity over longer time scales (10-min to hours) can occur over broad areas encompassed by a power system balancing area. Data indicates that the spatial separation between plants required for changes in output to be uncorrelated over time scales of 30-min is on the order of 50 km. The spatial separation required for output to be uncorrelated over time scales of 60-min is on the order of 150 km.

Multiple methods will be used for forecasting solar resources at differing time scales. Clouds are the primary influence in the solar forecast. Over short time scales, it is important to recognize that clouds (and their rate and direction of movement) are visible to satellites and ground-based sensors. Over longer time scales clouds can change shape and grow or dissipate, so numerical weather modeling methods may prove necessary. As with wind forecasting, solar forecasting will benefit from further development of weather models and datasets.

Photovoltaics fall under the broader category of variable generation. The experience with managing wind variability and uncertainty will benefit solar integration efforts. An important inference is that wherever it is *appropriate, unified approaches for managing variable generation will ease integration issues.*

The most important lesson, however, is that the dialogue regarding PV variability requires, above all else, additional time-synchronized data from multiple PV plants and insolation meters over spatial scales ranging from sq. km to greater than 10,000 square kilometers. The data will need to cover at least a year and should be synchronized with comparable load data in order to understand the net impact on the variability that must be managed by the system operators. Certain questions, particularly questions concerning power quality and regulation reserves, will require data with as high of a time resolution as multiple seconds

The EPC Contractor will jointly draft procedure and decision protocols regarding the presence of skilled engineers and technicians on site to operate the plan or control through utility from remote location. The systems of Patrol Inspection, operation guardianship, maintenance and overhaul will be established for the daily maintenance of production equipment, instruments and apparatus. These SOPs would be in-line with all requirements of International Standards of Safety, Management, Quality and Human resource management.

7.7 Emergency Procedures

During the construction and operation of the project, the guideline of "safety first, (accident) prevention foremost" will be practiced. Comprehensive management and supervision will be applied to all staff members and the whole operation process, in order to ensure safe operation of the equipment and personnel safety of the workers. The safety and health supervision department will provide appropriate inspection equipment, as well as necessary public education service for production safety.

HSE personnel will be required to draft emergency shutdown procedures for the plant in collaboration with the maintenance and project department during the detailed design phase of the Project. These would include all procedures in case of fire, lightning, flood, other natural disasters, etc. The procedures would be based on the guidelines from OSHA Standards (29 CFR 1910).

7.8 Safety and Security concerns

Responsibility for security concerns before the construction of the project will lie with the EPC Contractor. Post-construction the responsibility will lie with the joint management to develop a team and an SOP mentioning the number of personnel required for the security purpose of the facility.

8 PROJECT MANAGEMENT

8.1 Project Organogram

This feasibility study, after approval, will be followed by a further awarding of the EPC Contract to a general contractor. EPC Contractor for the project will be selected through a process of pre-bid qualifications, bidding and evaluation. The bidding process will be managed by the Punjab provincial government, and Project Sponsor.

This is a one phase project in which a Solar PV plant will be set up by Project Sponsor and the provincial government of Punjab with a capacity of 10MW in Cholistan desert, 4 km away from Marot grid station and covering an area of 50 Acres. This power will be connected to the grid through Marot Grid Station under the jurisdiction of MEPCO (Multan Electric Power Distribution Company).

The project focuses on high involvement of the local industry in the project in form of contractors, sub-contractors, manufacturers, vendors, transporters, logistics, etc. This process also involves the roles of government bodies like AEDB and others.

Following the approval of the feasibility study nominated people will be selected for the role of project managers on behalf of the Project Sponsor. On finalizing the EPC Contractor the Project manager and the EPC project management team will be identified, evaluated and selected by the Project Sponsor.

8.3 Approval of Project Timeline

Approval of Project timeline will be given by Project Sponsor, which would be on the basis of accuracy and practicality of the following components:

- Work Breakdown Structure (Should be carried out to the smallest of distinguishable activities)
- Activity list (Insight into activities involved should be visible)
- Man Power allocation and planning while developing time line
- Crash periods available on critical paths
- Buffers available (crashing) for delays in activities
- Accuracy of contingency time periods
- Contingency Costs
- Invoicing time lines

8.4 Involvement of Statutory Bodies, Regulators and Laws

Detailed interactions have been and will be undertaken by Project sponsors with the habitants of the areas near the project site and those who are initially going to be receiving power through Marot Grid Station. It will be necessary to meet the managements of all local authorities of infrastructure such as transportation, hospitals, police, fire department, etc. for smooth functioning of the project activities. All meetings and signing of agreements as per the requirements of the project will be planned in advance and notices of the same will be communicated to all stake holders prior to the target dates. Detailed meetings with MEPCO and regular progress updates with Punjab Government will continue as per schedule prepared by Welt Konnect Pvt. Ltd.

The project will be evaluated for all legal requirements during the feasibility phase. All parties will be held responsible for covering and addressing all legal issues pertaining to their activities and roles in the project. Some important aspects for consideration include the following:

- Power Purchase Agreements: Distributed Generation Projects
- Power Purchase Agreements: Utility-Scale Projects
- Solar Energy System Design, Engineering, Construction, and Installation Agreement
- Regulatory and Transmission-Related Issues
- Permitting and Land Use
- Financing a Solar Project

- Tax Issues
- Monetizing the "Green" in Green Power: Renewable
- Energy Certificates
- Tribal Laws and Land Issues
- Foreign Corrupt Practices Act
- Securities Regulation
- Resumes and Contacts

8.5 Transportation

Hard Surface Hard Duty (HSHD) roads have been constructed from Bahawalpur to the site. The load bearing capacity of the roads are good enough to bear the loads of transportation vehicles and transported material. This allows easy access for transport of material from Bahawalpur Airport and equipment being transported by road from sea ports. The terrain is flat with minimum settlement and heavy and long vehicles can move easily. These are for long lengths multi-lane single-carriage roads. Similar types of road also form a network around the site making access to nearby locations and power grid station (Marot) convenient for regular travel to and from the site.

8.6 Vendors

Procurement and fabrication of materials will depend on the approved vendor's list provided by EPC contractor and a detailed cost benefit analysis of components.

8.7 Risk Management

The risk management plan, documents the procedures that will be used to manage risk throughout the project. In addition to documenting the results of the risk identification, it also covers who will be responsible for managing various areas of risk, how risks will be tracked throughout the project, and how plans of action will be implemented.

Risk management plan is an assessment tool that may is used in the project oversight process. For the 10 MW Solar PV Power Project in Cholistan, the RMP includes at least the following information:

- Purpose and scope
- Risk management methodology
- Overview or summary of risk
- Risk identification
- Risk analysis
- Risk response planning
- Risk monitoring and controls

9 ECOLOGICAL LIFECYCLE CALCULATIONS, ECOLOGICAL FOOTPRINT

9.1 Calculation of Energy back period

Producing electricity with photovoltaic (PV) emits no pollution, produces no greenhouse gases, and uses no finite fossil fuel resources. The environmental benefits of PV are great. But just as we say that it takes money to make money, it also takes energy to save energy. The term "energy payback" captures this idea. How long does a PV system have to operate to recover the energy—and associated generation of pollution and CO2—that went into making the system, in the first place?

Thin-film PV modules use very little semiconductor material. The major energy costs for manufacturing are the substrate on which the thin films are deposited, the film-deposition process, and facility operation. Because PV technologies all have similar energy requirements, we'll use amorphous silicon as our representative technology.

9.2 Calculation of CO2 Emission

An average household uses 830 kWh of electricity per month. On average, producing 1,000 kWh of electricity with solar power reduces emissions by nearly 8 pounds of sulfur dioxide, 5 pounds of nitrogen oxides, and more than 1,400 pounds of carbon dioxide. During its projected 28 years of clean energy production, a rooftop system with a 2-year energy payback and meeting half of a household's electricity use would avoid conventional electrical-plant emissions of more than half a ton of sulfur dioxide, one-third a ton of nitrogen oxides, and 100 tons of carbon dioxide. PV is clearly a wise energy investment that affords impressive environmental benefits.

9.3 Recycling or Decommissioning of Project

Welt Konnect & CWE Investment Corporation will ensure that the entire Project Location is restored back to its pre-construction condition (successional vegetation land use or as may be appropriate at that time) and that the decommissioning is conducted in accordance with the applicable local (Bahawalpur and Cholistan bodies), provincial (Punjab Government) and federal requirements. In addition, potential effects and mitigation pertaining to significant natural features on and/or in proximity to the Project Location will documented. Overall, no significant adverse impacts to the environment are expected as a result of decommissioning the Project. **Figure 9.3.1** shows the flow chart of the decommissioning procedure.

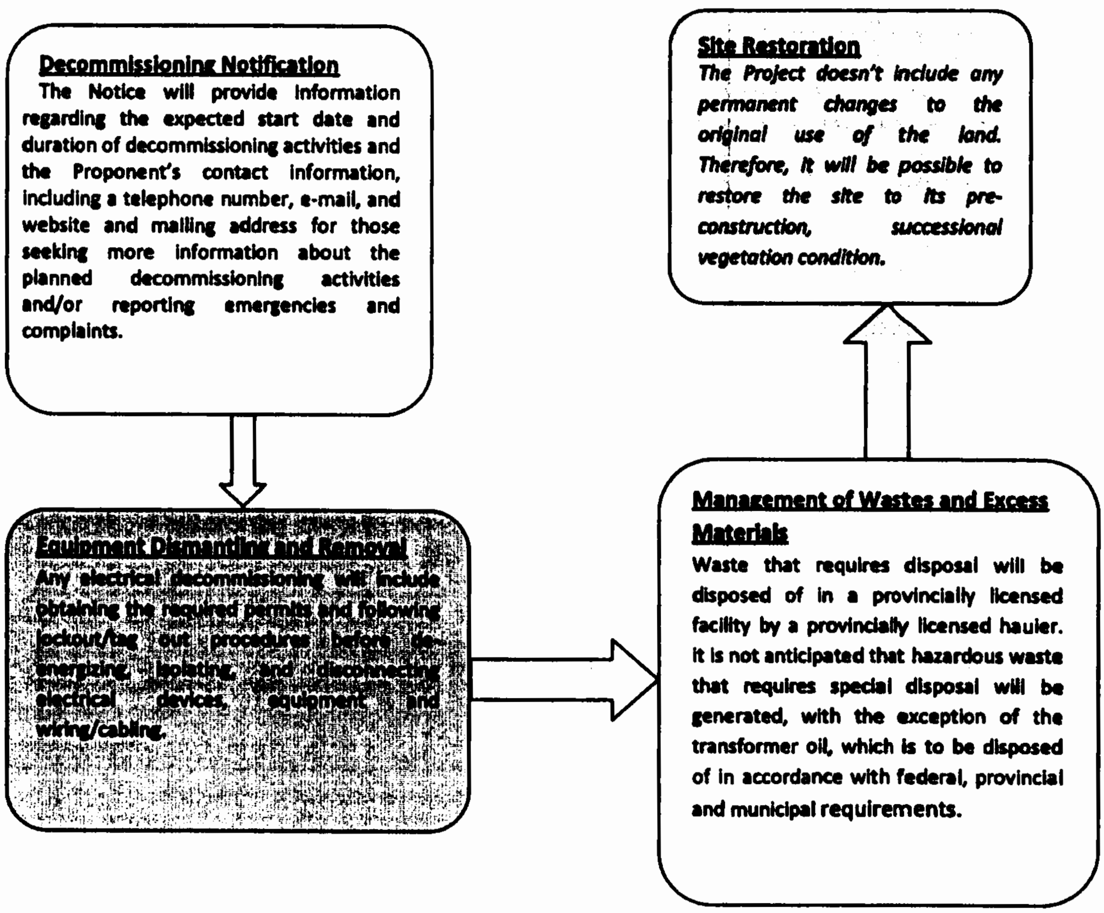


Figure 9.3.1: Decommissioning Procedure

9.4 Ecological Impact of Land Coverage

Like other renewable energy technologies, photovoltaic (PV) arrays contend with low power densities. Nevertheless, annual energy output can be impressive. As electricity costs increase PV technologies will take a more pronounced role in the energy market. The need to address and mitigate the negative environmental consequences of the business as usual approach to energy industry must be addressed. Project Sponsors will play their part in reducing the impact of ecological footprint left due to the manufacturing and transportation of the equipment by developing energy audit methodologies and have them implemented in the industries participating in this project.

10 SOCIO-ECONOMIC EFFECTS

For the purpose of this study the "JEDI - Jobs and Economic Development Impact" model of evaluating socio economic factors has been employed. The (JEDI) models are user-friendly tools that estimate the economic impacts of constructing and operating power generation and biofuel plants at the local level. Based on project-specific and default inputs (derived from industry norms), JEDI estimates the number of jobs and economic impacts to a local area (usually a state) that could reasonably be supported by a power generation project.

For example, JEDI estimates the number of in-state construction jobs from a new solar project. JEDI models are input-output models designed to provide reasonable estimates, not exact numbers. JEDI also provides estimates on land lease and property tax revenues, when appropriate.

Various ownership and financing structures can be incorporated by the user as well. Results obtained for the impact of this project on the local employment can be represented by empirical changes on employer payroll. This can be seen in **Figure 10.1:** *Empirical results of Using JEDI with Cost estimates on employer payroll.*

PV System Annual Operating and Maintenance Costs			
	Cost	Local Share	Locally (Y or N)
Labor			
Technicians	$136,667	100%	
Subtotal	$136,667		
Materials and Services			
Materials & Equipment	$113,333	100%	N
Services	$0	100%	
Subtotal	$113,333		
Sales Tax (Materials & Equipment Purchases)	$9,350	100%	
Average Annual Payment (Interest and Principal)	$1,508,000	0%	
Property Taxes	$0	100%	
Total	$1,767,350		
Other Parameters			
Financial Parameters			
Debt Financing			
Percentage financed	80%	0%	
Years financed (term)	10		
Interest rate	10%		
Tax Parameters			
Local Property Tax (percent of taxable value)	0%		
Assessed Value (percent of construction cost)	0%		
Taxable Value (percent of assessed value)	0%		
Taxable Value	$0		
Property Tax Exemption (percent of local taxes)	100%		
Local Property Taxes	$0	100%	
Local Sales Tax Rate	8.25%	100%	
Sales Tax Exemption (percent of local taxes)	0%		
Payroll Parameters	Wage per hour	Employer Payroll Overhead	
Construction and Installation Labor			
Construction Workers / Installers	$21.39	45.6%	
O&M Labor			
Technicians	$21.39	45.6%	

Figure 10.1: Empirical results of Using JEDI with Cost estimates on employer payroll

10.1 Direct Socio-Economic benefits:

The current recession being faced by the globe has shifted the attention towards major socio-economic disasters such as inflation, industries crashing, unemployment rise, and standards of living reducing dramatically. Pakistan and the nearby region has been a victim of these conditions prior to recessions and is expected to keep facing similar situations in the aftermath of recess.

Projects like these provide us with the two major solutions to problems which form the foundation of social and economic disasters; Employment and cheap power for comfort. Through projects of this scale and nature, direct benefits to the community and economy are that of:

- Immediate employment
- Cheap energy and comfort

Some indirect and important benefits are:

- A Creation of a local market and/or of a local industry for PV products and services,
- Security of energy supply
- Poverty alleviation, Creation of education facilities (need of skilled personnel)
- Recovery of vegetation due to improved irrigation / improved access to safe drinking water due to solar water purification

All methods employed during the engineering, procurement and construction phase have not only been screened to develop opportunities in Pakistan but also to cater to important requirements such as providing a healthy environment to the community. This project will also play a crucial role in improving awareness on renewable energy and in turn on the right consumption pattern of power for consumers.

The project holds complete compliance to every law and rule set down by the Government of Pakistan, Provincial government of Punjab, regulatory bodies for power, and regulatory bodies for Economics such as SECP and regulatory requirements of Environment.

At an early stage of PV power development it is not likely that PV modules or cells for large power plants will be produced in Pakistan, so the creation of local industry should not be overestimated in beginning of the development of a the national PV market.

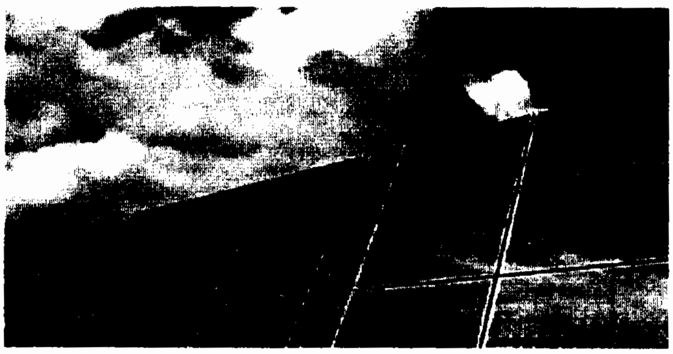
Report No. PPI-85.1-Draft/14

PPI

INTERCONNECTION STUDY

For

10 MW Solar Power Project by Safe Solar Private Limited at Quaid-e-Azam Solar Park



Draft Final Report
(28-02-2014)

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Executive Summary

- The study objective, approach and methodology have been described.
- The expected COD of the project is November 2014. In view of planned COD of Safe Solar Power Plant in November 2014, the above proposed interconnection scheme has been tested for steady state conditions through detailed load flow studies for the peak conditions of January 2015 for maximum thermal power dispatches in the grid during winter.
- The MEPCO system data as available with PPI for other studies have been used.
- The nearest substations of MEPCO are Lal-Sohanra 132 kV and Bahawalpur-New 220/132 kV Substation.
- The proposed MEPCO interconnection facilities for Quaid-e-Azam Solar Power Project would be as follows:

    - A 132 kV D/C transmission line approx. 4 km long on Rail conductor for looping In/Out of the proposed 132 kV Bahawalpur – Lal Sohanra S/C at Solar Power Plants at Quaid-e-Azam Solar

    - A 132 kV D/C transmission line approx. 4 km long on Rail conductor for looping In/Out of the proposed 132 kV Bahawalpur – Lal Sohanra S/C at Solar Power Plants at Quaid-e-Azam Solar
    - For evacuation of power within Quaid-e-Azam Solar a 132/11 kV collector station is proposed for each 50 MW block.
- The following scheme of interconnection of Solar Power Plant by Safe Solar to evacuate its maximum power of 10 MW is envisaged and studied in detail:
    - A direct 11 kV double circuit of 1-2 km length using Osprey conductor to be laid from 11 kV switchroom of Safe Solar to the 132/11 kV collector substation in the 50 MW block of Quaid-e-Azam Solar in which Safe Solar is located.
    - In this context two 11 kV panels need to be added in the 11 kV switchgear hall of the relevant 132/11 kV Collector Substation at Quaid-e-Azam Solar

- Detailed load flow studies have been carried out for the peak load conditions of January 2015 for the proposed scheme under normal and N-1 contingency conditions to meet the reliability criteria.
- Steady state analysis by load flow reveals that proposed scheme is adequate to evacuate the maximum power of 10MW of the plant under normal and contingency conditions.
- The short circuit analysis has been carried out to calculate maximum fault levels at the Safe Solar Power Plant at 11 kV, and the substations of 132 kV in its vicinity. We find that the fault currents for the proposed scheme are much less than the rated short circuit capacities of switchgear installed at these substations. There are no violations of exceeding the rating of the equipment due to contribution of fault current from the Safe Solar Solar Power Plant.

  The maximum short circuit level of 11 kV bus bar of Safe Solar Power Plant 11 kV is 9.31 kA and 9.15 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA is considered adequate with enough margin for future increase in fault levels due to future reinforcements in this area.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 11 kV bus bar of the Safe Solar power plant substation followed by the final trip of 11 kV circuits emanating from this substation, has been performed for fault clearing of 10 cycles (200 ms) as understood to be the maximum fault clearing time of 11 kV protection system. The system is found strong enough to stay stable and recovered with fast damping. The stability of system for far end faults of 3-phase occurring at Quaid-e-Azam Solar 132 kV bus bar has also been checked. The proposed scheme successfully passed the dynamic stability checks for near and far faults.
- The proposed scheme of interconnection has no technical constraints or problems, it fulfills all the criteria of reliability and stability under steady state load flow, contingency load flows, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.

Report Contents

Appendices

1. Introduction

1.1 Background

The site of proposed project is located in Quaid-e-Azam Solar Park in Punjab in the concession area of Multan Electric Power Company (MEPCO). The net output planned to be generated from the site is about 10 MW of electrical power which will start commercial operation by November 2015. The electricity generated from this project would be supplied to the MEPCO network through the network developed for evacuation of power from Quaid-e-Azam Solar Park.

1.2 Objectives

The overall objective of the Study is to evolve an interconnection scheme between Safe Solar Power Project and MEPCO network, for stable and reliable evacuation of 10 MW of electrical power generated from this plant, fulfilling N-1 reliability criteria. The specific objectives are:

1. To develop scheme of interconnections at 11 kV for which right of way (ROW) and space at the terminal substations would be available.
2. To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
3. To check if the contribution of fault current from this new plant increases the fault levels at the adjoining substations at 11kV and 132 kV voltage levels to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the substation at the Safe Solar Solar Power Plant.
4. To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping after 3-phase faults on the system.

1.3 Planning Criteria

The planning criteria as per Grid Code required to be fulfilled by the proposed interconnection is as follows:

Steady State:

Voltage	± 5 %, Normal Operating Condition
	± 10 %, Contingency Conditions
Frequency	50 Hz, Continuous, ± 1% variation steady state
	49.2 - 50.5 Hz, Short Time
Power Factor	0.80 Lagging; 0.9 Leading (for conventional synchronous generators but would not be applicable to solar PP)

Dynamic/Transient:

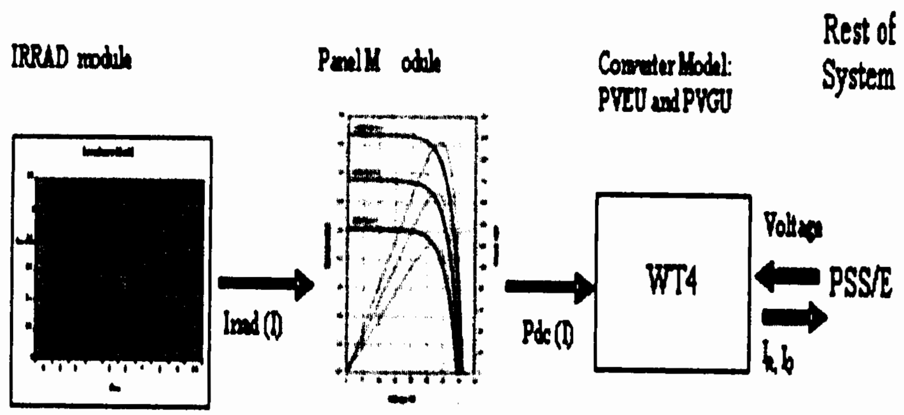
- The system should revert back to normal condition after dying out of transients without loosing synchronism with good damping. For 11 kV the total maximum fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 200 ms (10 cycles).
- For the systems of 132 kV and above the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 100 ms (5 cycles).

2. Assumptions of Data

The detailed electrical parameters would be designed at the EPC stage. However for the purposes of this study, following assumptions have been made:

2.1 Solar Power Plant data

The Solar Power plant has been modeled according to the following block diagram



The way this works is that the irradiance profile from the sun is used as an input to the panel module which then calculates the DC power at that value of the irradiance. This value is then input to the electrical model of the solar power plant (inverter module) which then goes on to calculate the AC power supplied by the solar power plant.

Due to the presence of the inverter module, from the point of view of the network, the solar power plant is considered a voltage source convertor.

Dynamic Data:

Converter time constant for IQcmd seconds = 0.02 s

Converter time constant for IQcmd seconds = 0.02 s

Voltage sensor for LVACR time constants = 0.02 s

Voltage sensor time constant = 1.1 s

2.2 Network data

The 132 kV and 11 kV networks available for interconnection to Safe Solar Power Plant are as shown in Sketches 1 and 2 in Appendix-A.

The MEPCO system data of National Grid have been assumed in the study as already available with PPI.

3. Study Approach and Methodology

3.1 Understanding of the Problem

The 10 MW Solar Power Plant by Safe Solar is going to be a Photovoltaic (PV) based solar project in Quaid-e-Azam Solar Park embedded in the 132 kV distribution network of MEPCO. It would run almost all the months of the year though with some variation in its output due to variation in the strength of light in winter and in rainy season.

The existing nearest MEPCO grid stations are Lal-Sohanra 132 kV and Bahawalpur-New 220/132 kV Substations. The addition of this source of power generation embedded in local distribution network of this area and shall provide relief to the transformers at Bahawalpur-New 220/132 kV and the sources feeding this area from further away. The 132 kV network of MEPCO in the electrical vicinity of Quaid-e-Azam Solar has significant load demand; therefore a portion of the power from Safe Solar Power Plant will be utilized in meeting this load demand on substations including Lal-Sohanra, Karorpca, Hasilpur and K.P. Tomi.

The adequacy of MEPCO network of 132 kV in and around the proposed site of Safe Solar Power Plant would be investigated in this study for absorbing and transmitting this power fulfilling the reliability criteria.

3.2 Approach to the problem

The consultant has applied the following approaches to the problem:

- A base case network model has been prepared for January 2015, which is the scenario for the maximum thermal power dispatches in the grid during winter after the November 2014 COD of 10 MW Solar PV Plant by Safe Solar Private Limited, comprising all 500kV, 220kV and 132 kV system, envisaging the load forecast, the generation additions and transmission expansions for that year particularly in MEPCO.
- The expected COD of the project is November 2014. In view of planned COD of Safe Solar Power Plant in November 2014, the above proposed interconnection scheme has been tested for steady state conditions through

detailed load flow studies for the peak conditions of January 2015 for maximum thermal power dispatches in the grid during winter.

- Performed technical system studies for peak load conditions to confirm technical feasibility of the interconnections. The scheme has been subjected to standard analysis like load flow and short circuit, and transient stability study to check the strength of the plant and the proposed interconnection scheme under disturbed conditions.
- Determine the relevant equipment for the proposed technically feasible scheme.
- Recommend the technically most feasible scheme of interconnection.

4. Development of Scheme of Interconnection

4.1 The Proposed Network for Quaid-e-Azam Solar Park

The proposed MEPCO interconnection facilities for Quaid-e-Azam Solar Power Project would be as follows:

- A 132 kV D/C transmission line approx. 4 km long on Rail conductor for looping In/Out of the proposed 132 kV Bahawalpur – Lal Sohanra S/C at Solar Power Plants at Quaid-e-Azam Solar
- A 132 kV D/C transmission line approx. 4 km long on Rail conductor for looping In/Out of the proposed 132 kV Bahawalpur – Lal Sohanra S/C at Solar Power Plants at Quaid-e-Azam Solar

The existing 132 kV network around these 132 kV grid station is shown in Sketch-1 in Appendix-A.

Within Quaid-e-Azam Solar Park 50 MW blocks have been proposed for Solar Power Plants. It is proposed that each 50 MW block would have its own 132 kV Collector Substation which will collect the power from the smaller solar power projects within the block and then transmit it towards the MEPCO network on 132 kV level.

Given the location of Safe Solar within Quaid-e-Azam solar power plant, the most feasible interconnection of Safe Solar Power Plant will be by a direct 11 kV double circuit on Osprey Conductor with the 132/11 kV Collector Substation developed for the 50 MW block in which Safe Solar is located.

There is strong 220 kV network in the vicinity connecting Bahawalpur-New 220/132 kV grid station Muzaffargarh 220 kV substation. A strong system helps in stable operation of a power plant.

4.2 The Scheme of Interconnection of Solar Power Plant

Keeping in view of the above mentioned network available in the vicinity of the site of Safe Solar Power Plant, the interconnection scheme has been developed as shown in Sketch-2 in Appendix A by laying down double circuit using Osprey conductor of about 1-2 km from 11 kV switchroom of Safe Solar-PP till the 132/11 kV Collector Substation developed for the 50 MW block in which Safe Solar is located. Even though one 11 kV circuit using Osprey conductor would be sufficient to evacuate power from Safe Solar Power Plant, an additional circuit has been added to fulfill N-1 contingency criteria. At the 132/11 kV collector substation two 132/11 kV 10/13 MVA Transformers would have to be place to step-up the incoming power from Safe Solar to the 132 kV level.

5. Detailed Load Flow Studies

5.1 Base Case 2015, Without Solar Power Plant

A base case has been developed for the peak load of January 2015, using the network data of MEPCO.

The results of load flow for this base case are plotted in Exhibit 0.0 of Appendix-B. The system plotted in this Exhibit shows 132 kV network in the vicinity of Quaid-e-Azam Solar including the substations of Lal-Sohanra, Bahwalpur-New, Hasilpur, Karorpca. During day time when the output of Quaid-e-Azam solar would be high the following line opening have been suggested and considered in the cases

- Hasilpur – Chistian 132 kV Single Circuit
- Hasilpur – Ludden 132 kV Single Circuit

The load flow results show that the power flows on all circuits are within their specified normal current carrying rating. The voltages are also within the permissible limits.

For N-1 contingency conditions we have performed the following cases

Exhibit-0.1	QAD-SOL-I to L.Sohanra 132kV Single Circuit Out
Exhibit-0.2	QAD-SOL-II to L.Sohanra 132kV Single Circuit Out
Exhibit-0.3	QAD-SOL-I to B.W.P-N 132kV Single Circuit Out
Exhibit-0.4	BPUR-Cantt to B.W.P-N 132kV Single Circuit Out

In both cases the power flows on all circuits remain within their ratings. Thus we find that there are no capacity constraints in terms of MW or MVA flow in the 132 kV network available in the vicinity of Safe Solar Power Plant for its connectivity under normal and contingency conditions prior to its connection.

5.2 Load Flow with Safe Solar Power Plant

We have considered the scenario of January 2015 so that we can judge the maximum impact of the project on the system during the winter season when the loading on the lines would be at its maximum under high thermal dispatch conditions.

The scheme of interconnection modeled in the load flow for Safe Solar Power Plant is by laying down double circuit using Osprey conductor of about 1-2 km from 11 kV switchroom of Safe Solar-PP till the 132/11 kV Collector Substation developed for the 50 MW block in which Safe Solar is located. At the 132/11 kV collector substation two 132/11 kV 10/13 MVA Transformers would have to be place to step-up the incoming power from Safe Solar to the 132 kV level. The results of load flow with Safe Solar Power Plant interconnected as per proposed scheme are shown in Exhibit 1.0 in Appendix-B. The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % off the nominal.

We find no capacity constraints on 11 kV or 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows;

Exhibit-1.1	Safe-Solar to Safe-1 11kV Single Circuit Out
Exhibit-1.2	QAD-SOL-1 132/11kV Single Transformer Out
Exhibit-1.3	QAD-SOL-I to L.Sohanra 132kV Single Circuit Out
Exhibit-1.4	QAD-SOL-II to L.Sohanra 132kV Single Circuit Out
Exhibit-1.5	QAD-SOL-I to B.W.P-N 132kV Single Circuit Out
Exhibit-1.6	BPUR-Cantt to B.W.P-N 132kV Single Circuit Out

In all the above contingency cases, we find that in the event of outage of any circuit, the intact circuits remain within the rated capacity.

Also the bus bar voltages are well within the rated limits in all the contingency events. Thus there are no constraints in this scheme in the contingency conditions mentioned above.

5.3 Conclusion of Load Flow Analysis

From the analysis discussed above, we conclude that the proposed interconnection scheme of laying a double circuit using Osprey conductor of about 1-2 km from 11 kV switchroom of Solar-PP till the 132/11 kV Collector Substation developed for the

50 MW block in which Safe Solar is located and using two 132/11 kV 10/13 MVA Transformers at the 132/11 kV collector substation for the block in which Safe Solar is located to step-up the incoming power from Safe Solar to the 132 kV level ensures its reliability and availability under all events of contingencies i.e. planned or forced outages, covered in this study.

6. Short Circuit Analysis

6.1 Methodology and Assumptions

The methodology of IEC 909 has been applied in all short circuit analysis in this report for which provision is available in the PSS/E software used for these studies. .

The maximum fault currents have been calculated with the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence
- Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition.

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the year 2015 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

6.2 Fault Current Calculations without Safe Solar Power Plant

In order to assess the short circuit strength of the network of 132 kV without the Solar Power Plant for the grid of MEPCO in the vicinity of the site of the Plant at Quaid-e-Azam Solar Park, fault currents have been calculated for balanced three-phase and unbalanced single-phase short circuit conditions. These levels will not only give us the idea of the fault levels without Safe Solar Power Plant and later on how much the contribution of fault current from the Solar Power Plant may add to the existing levels, but also we get a feel of the strength of the proposed node to connect this Power Plant depending on its relative short circuit strength.

The results are attached in Appendix – C.

The short circuit levels have been represented graphically on the bus bars of 132 kV which are shown in the Exhibit 2.0 attached in Appendix-C.

Both 3-phase and 1-phase fault currents are indicated in the Exhibit which are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault currents are shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-C for the 132 kV bus bars of our interest i.e. 132 kV circuits lying close to Quaid-e-Azam Solar. The tabular output is the detailed output showing the contribution to the fault current from the adjoining sources i.e. the lines and transformers connected to that bus. The phase currents, the sequence currents and the sequence impedances are shown in detail for each faulted bus bar.

The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 6.1. We see that the maximum fault currents do not exceed the short circuit ratings of the equipment at these 11 kV and 132 kV substations which normally are 20 kA, 25 kA.

Table - 6.1
Maximum Short Circuit Levels without Safe Solar PP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Qad-Sol-I 132kV	7.88	6.70
Qad-Sol-II 132kV	7.45	6.30
L.Sohanra 132kV	8.32	7.80
BhawalpurCantt 132kV	10.63	9.89
Bhawalpur-New 132kV	14.35	14.58
Karorpca 132kV	7.84	7.67
Bhawalpur 220kV	11.65	10.04

6.3 Fault Current Calculations with Safe Solar Power Plant interconnected

Fault currents have been calculated for the electrical interconnection of proposed scheme. Fault types applied are three phase and single-phase at 11 kV bus bars of Safe Solar Power Plant itself and other bus bars of the 132 kV substations in the electrical vicinity of Safe Solar. The graphic results are indicated in Exhibit 2.1.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV and 11 kV bus bars of the network in the electrical vicinity of Safe Solar Power Plant are placed in Appendix-C. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.2.

Comparison of Tables 6.1 and 6.2 shows slight increase in short circuit levels for three-phase and single – phase faults due to connection of Solar Power Plant on the 132 kV and 11 kV bus bars in its vicinity. We find that even after some increase, these fault levels are much below the rated short circuit values of the equipment installed on these substations. The maximum short circuit level of 11 kV bus bar of Safe Solar Power Plant 11 kV is 9.31 kA and 9.15 kA for 3-phase and 1-phase faults respectively. Therefore an industry standard switchgear of the short circuit rating of 25 kA should be installed at 11 kV switchyard of the Solar Power Plant leaving enough margin to accommodate fault current contribution from any future reinforcements taking place in that area.

Table-6.2
Maximum Short Circuit Levels with Safe Solar PP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Safe-Solar 11kV	9.31	9.15
Qad-I 132kV	11.30	11.07
Qad-Sol-I 132kV	7.90	6.72
Qad-Sol-II 132kV	7.47	6.32
L.Sohanra 132kV	8.34	7.82
BhawalpurCantt 132kV	10.64	9.90
Bhawalpur-New 132kV	14.37	14.60
Karorpca 132kV	7.85	7.69
Bhawalpur 220kV	11.66	10.04

6.4 Conclusion of Short Circuit Analysis

The short circuit analysis results show that for the proposed scheme of interconnection of Safe Solar Power Plant with the 132/11 kV Collector Station for the 50 MW block in which Safe Solar is located, we don't find any problem of violations of short circuit ratings of the already installed equipment on the 132 kV and 11 kV equipment of substations in the vicinity of the Solar Power Plant due to fault current contributions from this plant due to three-phase faults as well as single phase faults.

The maximum short circuit level of 11 kV bus bar of Safe Solar Solar Power Plant 11 kV is 9.31 kA and 9.15 kA for 3-phase and 1-phase faults respectively. Therefore an industry standard switchgear of the short circuit rating of 25 kA should be installed at 11 kV switchyard of Safe Solar Power Plant leaving enough margin to accommodate fault current contribution from any future reinforcements taking place in that area.

7. Transient Stability Analysis

7.1 Assumptions & Methodology

7.1.1 Stability Models

The assumptions about the generator and its parameters are the same as mentioned in Ch.2 of this report.

We have employed the generic stability models available in the PSS/E model library for dynamic modelling of the PV-Solar power generator, its electrical model and the panel as follows;

Generator	PVGU1
Electrical Model	PVEU1
Solar Panel Model	PANELU1

We have done studies with the inverter which has reactive support capability of ± 0.95 PF.

7.1.2 System Conditions

We have used the system conditions of January 2015 because this represents the scenario of maximum thermal power dispatches in the grid during winter and hence the maximum impact of Quaid-e-Azam Solar Power Plant can be judged.

The proposed scheme of a direct 11 kV double circuit of 1-2 km length using Osprey conductor to be laid from 11 kV switchroom of Safe Solar to the 132/11 kV collector substation in the 50 MW block of Quaid-e-Azam Solar in which Safe Solar is located, has been modeled in the stability analysis.

All the power plants of WAPDA /NTDC from Tarbela to HUBCO have been dynamically represented in the simulation model.

7.1.3 Presentation of Results

The plotted results of the simulations runs are placed in Appendix - D. Each simulation is run for its first one second for the steady state conditions of the system prior to fault or disturbance. This is to establish the pre fault/disturbance conditions of the network under study were smooth and steady. Post fault recovery has been monitored for nine seconds. Usually all the transients due to non-linearity die out within 2-3 seconds after disturbance is cleared in the system.

7.1.4 Worst Fault Cases

Three phase faults are considered as the worst disturbance in the system. We have considered 3-phase fault in the closest vicinity of the Solar Power Plant i.e. right at the 11 kV bus bar of the solar power plant substation, cleared in 10 cycles, as normal clearing time for 11 kV i.e. 200 ms, followed by permanent trip of 11 kV single circuit emanating from this substation.

7.2 Transient Stability Simulations' Results

7.2.1 Fault at 11 kV Near Safe Solar Power Plant

We applied three-phase fault on the Safe Solar Power Plant 11 kV bus bar, cleared fault in 10 cycles (200 ms) followed by trip of 11 kV circuit between the Safe Solar Power Plant and 132/11 kV collector substation of Quaid-e-Azam Solar in which Safe Solar is located. We monitored different quantities for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows;

Fig. 1.1 Bus Voltages

The bus voltages of 11 kV bus bars of Safe Solar-PP and 132 kV Bus Bars of QAD-Solar-I, QAD-Solar-II, Lal Sohanra, Bahwalpur-New and Bahawalpur Cantt are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Solar Power Plant

The pre-fault output of Safe Solar Power Plant was 10 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 1.4 Voltage Sensor for LVACR

The value for LVACR is restored to its pre-fault value after the fault clears.

Fig. 1.5 MW /MVAR Flow from Safe Solar Power Plant to QAD-I 11 kV

Followed by clearing of fault, the trip of 11 kV circuit between the power plant and QAD-I circuit caused the entire load of that circuit to flow through the intact 11 kV circuit between the Solar-PP and QAD-I. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 1.6 Rotor Angles

The rotor angles of the generators of Liberty Power 132 kV, Guddu 220 kV, Engro-P 220 kV, Fauji-MR 220 kV and Guddu-New 500 kV are plotted relative to machines at Guddu-New 500 kV. The results show that the rotor angles gets back after the first swing and damps down quickly. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.2 Fault at 132 kV QAD-Solar-I (Far-End Fault)

We applied three-phase fault on far-end 132 kV bus bar of QAD-Solar-I to study the impact of a disturbance in the grid on the performance of the plant. The fault is cleared in 5 cycles (100 ms) as standard clearing time for 132 kV systems, followed by trip of one 132/11 kV TF of QAD-Solar . We monitored different quantities for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows;

Fig. 1.1 Bus Voltages

The bus voltages of 11 kV bus bars of Safe Solar-PP and 132 kV Bus Bars of QAD-Solar-I, QAD-Solar-II, Lal Sohanra, Bahwalpur-New and Bahawalpur Cantt are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Solar Power Plant

The pre-fault output of Safe Solar Power Plant was 10 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 1.4 Voltage Sensor for LVACR

The value for LVACR is restored to its pre-fault value after the fault clears.

Fig. 1.5 MW /MVAR Flow on QAD-Solar 132/11 kV intact Transformer

Followed by clearing of fault, the trip of one QAD-Solar-I 132/11 kV Transformer causes the entire load of that circuit to flow through the intact 132/11 kV transformer.

We plotted the flows of MW and MVAR on this intact transformer and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 1.6 Rotor Angles

The rotor angles of the generators of Liberty Power 132 kV, Guddu 220 kV, Engro-P 220 kV, Fauji-MR 220 kV and Guddu-New 500 kV are plotted relative to machines at Guddu-New 500 kV. The results show that the rotor angles gets back after the first swing and damps down quickly. The system is strongly stable and very strong in damping the post fault oscillations.

7.3 Conclusion of Dynamic Stability Analysis

The results of dynamic stability show that the system is very strong and stable for the proposed scheme for the severest possible faults of 11 kV and 132 kV systems near to and far of the Solar Power Plant of Safe Solar. Therefore there is no problem of dynamic stability for interconnection of this Solar Power Plant; it fulfils all the criteria of transient stability. The reactive support from the inverter also helps the system stability.

8. Conclusions

- The nearest substations of MEPCO are Lal-Sohanra 132 kV and Bahawalpur-New 220/132 kV Substation.
- The proposed MEPCO interconnection facilities for Quaid-e-Azam Solar Power Project would be as follows:
  - A 132 kV D/C transmission line approx. 4 km long on Rail conductor for looping In/Out of the proposed 132 kV Bahawalpur – Lal Sohanra S/C at Solar Power Plants at Quaid-e-Azam Solar
  - A 132 kV D/C transmission line approx. 4 km long on Rail conductor for looping In/Out of the proposed 132 kV Bahawalpur – Lal Sohanra S/C at Solar Power Plants at Quaid-e-Azam Solar
  - For evacuation of power within Quaid-e-Azam Solar a 132/11 kV collector station is proposed for each 50 MW block.
- The following scheme of interconnection of Solar Power Plant by Safe Solar to evacuate its maximum power of 10 MW is envisaged and studied in detail:
  - A direct 11 kV double circuit of 1-2 km length using Osprey conductor to be laid from 11 kV switchroom of Safe Solar to the 132/11 kV collector substation in the 50 MW block of Quaid-e-Azam Solar in which Safe Solar is located.
  - In this context two 11 kV panels need to be added in the 11 kV switchgear hall of the relevant 132/11 kV Collector Substation at Quaid-e-Azam Solar
- Detailed load flow studies have been carried out for the peak load conditions of January 2015 for the proposed scheme under normal and N-1 contingency conditions to meet the reliability criteria.
- Steady state analysis by load flow reveals that proposed scheme is adequate to evacuate the maximum power of 10MW of the plant under normal and contingency conditions.
- The short circuit analysis has been carried out to calculate maximum fault levels at the Safe Solar Power Plant at 11 kV, and the substations of 132 kV in its vicinity. We find that the fault currents for the proposed scheme are much less

than the rated short circuit capacities of switchgear installed at these substations. There are no violations of exceeding the rating of the equipment due to contribution of fault current from the Safe Solar Solar Power Plant.

The maximum short circuit level of 11 kV bus bar of Safe Solar Power Plant 11 kV is 9.31 kA and 9.15 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA is considered adequate with enough margin for future increase in fault levels due to future reinforcements in this area.

- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 11 kV bus bar of the Safe Solar power plant substation followed by the final trip of 11 kV circuits emanating from this substation, has been performed for fault clearing of 10 cycles (200 ms) as understood to be the maximum fault clearing time of 11 kV protection system. The system is found strong enough to stay stable and recovered with fast damping. The stability of system for far end faults of 3-phase occurring at Quaid-e-Azam Solar 132 kV bus bar has also been checked. The proposed scheme successfully passed the dynamic stability checks for near and far faults.

  The proposed scheme of interconnection has no technical constraints or problems, it fulfills all the criteria of reliability and stability under steady state load flow, contingency load flows, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.