# BEFORE
# THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY (NEPRA)

## APPLICATION FOR A GENERATION LICENSE FOR SOLAR POWER GENERATION FACILITY

PURSUANT TO ENABLING PROVISIONS OF NEPRA ACT 1997 READ WITH ENABLING PROVISIONS OF RULES MADE THEREUNDER, LICENSING (APPLICATION & MODIFICATION PROCEDURE) REGULATIONS AND LICENSING (GENERATION) RULES 2000

ON BEHALF OF

**K1 SOLAR POWER LAHORE (PRIVATE) LIMITED**

FOR NEPRA'S GRANT OF GENERATION LICENSE FOR
K1 SOLAR POWER LAHORE (PRIVATE) LIMITED

FOR A POWER PROJECT OF 15 MWP (THE **PROJECT**)

AT

MANKERA, PROVINCE OF PUNJAB, PAKISTAN

**DATED:** April 10, 2019

**LEGAL & REGULATORY CONSULTANT**

**HAIDERMOTABNR & CO.**

KARACHI OFFICE
D-79, BLOCK 5, KDA SCHEME 5, CLIFTON
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TEL: +92-21-111520000
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**APPLICANT**

**K1 SOLAR POWER LAHORE (PRIVATE) LIMITED**
REGISTERED OFFICE
216 LANDMARK PLAZA,
JAIL ROAD GULBERG ,
LAHORE, PAKISTAN
TEL: 042-35740219
FAX: 042-32535946
EMAIL: info.pv@k1solar.com
adeel.ahmed@ibvogt.com

SOLAR POWER LAHORE

K1 Solar Power Lahore (Private) Ltd 2nd Floor • No.9 • Link Farid Kot Road •Lahore-54000 •Pakistan

Ref: SCA201
20/02/2019

K1 Solar Power Lahore (Private) Ltd
2nd Floor
No.9 • Link Farid Kot Road
Lahore-54000
Pakistan
Corporate Universal Identification No.
0103476
Directors:
Anton Milner
Carl von Braun

**THE REGISTRAR,**
National Electric Power Regulatory Authority,
NEPRA Tower, Ataturk Avenue (East),
G-5/1,
Islamabad,
Pakistan.

**SUBJECT:** **STATEMENTS OF AUTHORIZED REPRESENTATIVE, ON BEHALF OF K1 SOLAR POWER LAHORE (PRIVATE) LIMITED, IN RESPECT OF AN APPLICATION FOR A GENERATION LICENSE RELATING TO 15 MWP SOLAR POWER PROJECT LOCATED AT MOUZA RAKH CHABEEL, MANKERA, PUNJAB, PAKISTAN**

**I, CHARLES ANTON MILNER**, holding Passport No. 525622078 (**British**), being:

a) the DIRECTOR of **K1 SOLAR POWER LAHORE (PRIVATE) LIMITED** (a company duly established and existing under the laws of Pakistan with its registered office located at 2nd Floor, No. 9, Farid Jot Road, Lahore, Pakistan) (the **Applicant**); and

b) the duly authorized representative of the Applicant in terms of the authority and powers vested in and conferred on ME, ANTON MILNER, *vide* the duly passed resolution(s) of the board of directors (the **Board**) of the Applicant dated 14/02/2019.

hereby, pursuant to the applicable laws of Pakistan, including the '*Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997*' (the **NEPRA Act**) and the rules and regulations made thereunder (including regulation 10(2) of the '*National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations, 1999*' and the '*National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000*') (the **Applicable NEPRA Laws**) submit, on behalf of the Applicant, to the **NATIONAL ELECTRIC POWER REGULATORY AUTHORITY** (the **Authority**) an application (together with the documents attached thereto) (the **Generation License Application**) relating to 15 MWp solar power project located at Mankera, Punjab, Pakistan (the **Project**).

I, CHARLES ANTON MILNER, certify, on behalf of the Applicant, to the Authority that Generation License Application has been prepared and submitted in conformity with the Applicable NEPRA Laws and undertake, on behalf of the Applicant, to the Authority to abide by the terms and provisions of the same. In addition, I, CHARLES ANTON MILNER, confirm, on behalf of the Applicant, to the Authority that the information provided in the Generation License Application is true and correct to the best of MY, [CHARLES ANTON MILNER]'S, knowledge.

Further, I, CHARLES ANTON MILNER, on behalf of the Applicant, confirm to the Authority that the Generation License Application is being submitted with the required

SOLAR POWER LAHORE

generation license fee (as communicated by NEPRA) through a non-refundable bank draft/pay order in the amount of PKR 250,956/- (Pakistani Rupees Two Hundred Fifty Thousand, Nine Hundred and fifty six only) drawn in favor of the Authority.

Sincerely,
For and on behalf of:
K1 SOLAR POWER LAHORE (PRIVATE) LIMITED

.....
**CHARLES ANTON MILNER**
DIRECTOR & AUTHORIZED REPRESENTATIVE

# COPY OF EXTRACT OF RESOLUTION PASSED BY BOARD OF DIRECTORS OF K1 SOLAR POWER LAHORE (PRIVATE) LIMITED

**BOARD RESOLUTIONS**

**"It is hereby unanimously resolved that:**

(A) **K1 SOLAR POWER LAHORE (PRIVATE) LIMITED** (*a private company duly established and existing under the laws of Pakistan with its registered office located at* 2nd Floor, No. 9, Farid Jot Road, Lahore, Pakistan) (the **Company**), having obtained a Letter of Interest in favour of its sponsors for the development of a 15MWp solar power project to be located at Mankera, Punjab, Pakistan (the **Project**) from the Punjab Power Development Board, January 9, 2018; and having made steady progress in respect of the development of the Project;

**BE AND IS HEREBY AUTHORIZED** to prepare, finalize, deliver, file, apply and submit, pursuant to the applicable laws of Pakistan, including the '*Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997*' (the **NEPRA Act**) and the rules and regulations made thereunder (including regulation 10(2) of the '*National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations, 1999*' and the '*National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000*') (the **Applicable NEPRA Laws**), an application (together with all documents attached thereto) (the **Generation License Application**) before the **NATIONAL ELECTRIC POWER REGULATORY AUTHORITY** (the **Authority**) for the Authority's approval of the Generation License Application and to, *inter alia*, enter into and execute all required documents, make all filings, attend all hearings, provide all required information and pay all applicable fees, in each case, of any nature whatsoever.

(B) **FURTHER RESOLVED THAT,** in respect of the matters relating to the Generation License Application, **MR. CHARLES ANTON MILNER** (being the Director of the Company and having Passport No. 525622078) is **HEREBY** singly appointed as authorized representative of the Company and is **HEREBY** authorized and empowered for and on behalf of the Company, as the Company duly appointed **AUTHORIZED REPRESENTATIVE,** to address, perform, negotiate, decide, execute, implement and/or undertake all matters of any nature whatsoever in relation to the Generation License Application including, without limitation:

(i) review, execute, submit, and deliver the Generation License Application and any related documentation required by the Authority for its approval, including any contracts, documents, powers of attorney, affidavits, statements, letters, forms, applications, deeds, guarantees, undertakings, approvals, memorandum, amendments, letters, communications, notices, certificates, request statements and any other instruments of any nature whatsoever;

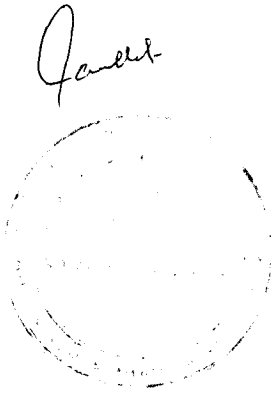
(ii) represent the Company in all negotiations, representations, presentations, hearings, conferences and/or meetings of any nature whatsoever with any entity (including, but in no manner limited to the Authority, any private parties, companies, partnerships, individuals, governmental and/or semi-governmental authorities and agencies, ministries, boards, departments, regulatory authorities and/or any other entity of any nature whatsoever);

(iii) sign, execute and deliver, for and on behalf of the Company, all necessary documentation (including any contracts, documents, powers of attorney,

affidavits, statements, letters, forms, applications, deeds, guarantees, undertakings, approvals, memorandum, amendments, letters, communications, notices, certificates, request statements and any other instruments of any nature whatsoever), pay the necessary fees, appear before any entity (including the Authority, any private parties, companies, partnerships, individuals, governmental and/or semi-governmental authorities and agencies, ministries, boards, departments, regulatory authorities and/or any other entity of any nature whatsoever), as required from time to time, and do all acts necessary for processing and approval of the Generation License Application, by the Authority;

(iv) further sub-delegate any or all of the aforementioned powers and authorities to one or more officers of the Company or any other person or persons, singly and/or jointly; and

(v) do all such acts, deeds and things as may be necessary for carrying out the purposes aforesaid and give full effect to the above resolutions.



## CERTIFICATION
## CERTIFIED TO BE TRUE COPY

**CERTIFIED**, that, the above resolutions were duly passed by the board of directors of **K1 SOLAR POWER LAHORE (PRIVATE) LIMITED** (*a private company duly established and existing under the laws of Pakistan with its registered office located at* 2nd Floor, No. 9, Farid Jot Road, Lahore, Pakistan) on 14/02/2019.

**FURTHER CERTIFIED**, that the afore-stated resolutions have not been rescinded and are in operation and in full force and effect as at the date hereof and that this is a true copy of the same.

.....
**COMPANY SECRETARY**

SOLAR POWER LAHORE

K1 Solar Power Lahore (Private) Ltd

K1 Solar Power Lahore (Private) Ltd

# AUTHORITY LETTER

**THIS AUTHORITY LETTER** is executed on this **22nd** day of **February**, 2019 in Berlin.

WHEREAS I, **MR. CHARLES ANTON MILNER** (being the director of the Company and having [Passport No. 525622078]), son of [Karl-Heinz Milner], resident of [Ernst-Ring-Strasse 4, 14129 Berlin] (the "**General Attorney**") am the duly constituted authorized representative of **K1 SOLAR POWER LAHORE (PRIVATE) LIMITED** (*a private company duly established and existing under the laws of Pakistan with its registered office located at 2nd Floor, No. 9, Farid Jot Road, Lahore, Pakistan*) (the "**Company**") *vide* the Company's board resolution(s) dated February 14, 2019 (the "**General Authorizations**");

AND WHEREAS, the Company having obtained a Letter of Interest in favour of its sponsors for the development of a 15 MWp solar power project to be located at Mankera, Punjab, Pakistan (the "**Project**") from the Punjab Power Development Board, dated January 09, 2018 and has made steady progress in respect of the development of the Project;

AND WHEREAS, in terms of paragraph B(iv) of each of the General Authorizations, the General Attorney is authorized to designate any person or persons all or any of the powers conferred upon the General Attorney under the General Authorizations as the General Attorney may deem fit;

AND WHEREAS, the General Attorney, in terms of paragraph B(iv) of each of the General Authorizations, appoints, nominates and authorizes:

(1) **MR. ADEEL AHMED**, son of [Ahmad Khan Dar], resident of 73 Saville Road Gatley, SK8 4BY having [Pakistani] passport number [AF7999853], to act singly; and
(2) **MR. MURAD CAN**, son of [Taner Can], resident of [Westfaelischestrasse 62, 10709 Berlin Germany], having [DEUTSCH] passport number [C3JJPL57Y], to act singly;

as its attorneys in its place and in its name (the "**Sub Attorneys**"), in respect of perusing development of the Project, and more particularly to:

i. review, execute, submit, and deliver the Generation License Application and Tariff Petition and any related documentation required by the National Electric Power Regulatory Authority, Pakistan (the "**Authority**") for its approval, including any contracts, documents, powers of attorney, affidavits, statements, letters, forms, applications, deeds, guarantees, undertakings, approvals, memorandum, amendments, letters,

communications, notices, certificates, request statements and any other instruments of any nature whatsoever;

ii. represent the Company in all negotiations, representations, presentations, hearings, conferences and/or meetings of any nature whatsoever with any entity (including, but in no manner limited to the Authority, any private parties, companies, partnerships, individuals, governmental and/or semi-governmental authorities and agencies, ministries, boards, departments, regulatory authorities and/or any other entity of any nature whatsoever);

iii. sign, execute and deliver, for and on behalf of the Company, all necessary documentation (including any contracts, documents, powers of attorney, affidavits, statements, letters, forms, applications, deeds, guarantees, undertakings, approvals, memorandum, amendments, letters, communications, notices, certificates, request statements and any other instruments of any nature whatsoever), pay the necessary fees, appear before any entity (including the Authority, any private parties, companies, partnerships, individuals, governmental and/or semi-governmental authorities and agencies, ministries, boards, departments, regulatory authorities and/or any other entity of any nature whatsoever), as required from time to time, and do all acts necessary for processing and approval of the Generation License Application and the Tariff Petition, by the Authority.

CERTIFIED TO BE TRUE COPY

COMPANY SECRETARY
K1 SOLAR POWER LAHORE
PRIVATE LIMITED

SOLAR POWER LAHORE

**AND I HEREBY** ratify and confirm all lawful acts done by the said Sub Attorneys pursuant to this Authority Letter.

**SIGNED AND** executed in the presence of the following witnesses on the day, month and year first above written.

**CHARLES ANTON MILNER**

**WITNESSES:**

1. .....

NAME: David Ludwig

ADDRESS: Schoeneweider Str. 18; 12055 Berlin

PASSPORT NO.: C3J7G01TC

2. .....

NAME: BIZHAN ZHANIAGAZI

ADDRESS: REUTERSTR. 46, 12047 BERLIN

PASSPORT NO: 566248689

3. .....

NAME:

ADDRESS:

PASSPORT NO.:

CERTIFIED TO BE TRUE COPY

COMPANY SECRETARY
K1 SOLAR POWER LAHORE
PRIVATE LIMITED

NAME:

ADDRESS:

PASSPORT NO.:

# 1. BACKGROUND TO GENERATION LICENSE APPLICATION

## 1.1 PROCESS OF ISSUANCE OF LETTER OF INTENT, LEADING TO GENERATION LICENSE APPLICATION

### 1.1.1 ISSUANCE OF "LETTER OF INTENT"

The sponsors of the project M/s. ib vogt GmbH (the **Main Sponsors**), M/s. Vogt Solar Limited and M/s. Milner Vermögensverwaltungs GmbH (collectively, **the Sponsors**) were issued a LETTER OF INTENT by the Punjab Power Development Board (the **PPDB**) on January 9, 2018 *vide* its letter No. PPDB/R.E/DRE/27/2018 (the **LOI**) to develop and establish a 15 MWp solar power project to be located at Mankera, Punjab (the **Project**) – Attached as **ANNEXURE A**. The Sponsors had also submitted a bank guarantee for an amount equal to US$ 15,000/- (United States Dollars Fifteen Thousand only) issued by *Askari Bank.*

### 1.1.2 ESTABLISHMENT OF SPECIAL PURPOSE VEHICLE

After issuance of the LOI, the sponsors of the Project incorporated a special purpose vehicle that is, K1 SOLAR POWER LAHORE (PRIVATE) LIMITED'S (*a company duly organized and existing under the laws of Pakistan, with its office located at 2nd Floor, No. 9, Farid Jot Road, Lahore, Pakistan*) (the **Project Company**). A copy of the Project Company's Certificate of Incorporation is attached hereto as **ANNEXURE B** for NEPRA's perusal.

### 1.1.3 CHANGE IN CONSORTIUM

In due course, one of the original sponsors of the Project, Green Energy UK Direct Limited was replaced by Milner Vermögensverwaltungs GmbH which change was duly approved by PPDB *vide* Letter No. PPDB/R.E/MRE/133/2019 attached as **ANNEXURE C.**

### 1.1.4 SUBMISSION OF INITIAL ENVIRONMENTAL EXAMINATION.

The Project Company hired consultants, AAA Environment Advisors, who completed the initial environmental examination for the Project (the **Initial Environmental Examination**) and the Project Company submitted the same to the Environmental Protection Agency, Punjab (the **EPA**) on September 9, 2018.

After careful review and analysis of the Initial Environmental Examination, the EPA accorded its approval for the Project through its decision (Ref: No. DD (EIA)/EPA/393(IEE)/2018/616/1808) dated June 4, 2018 (the **IEE Approval Decision**). A copy of the IEE Approval Decision is attached hereto at **ANNEXURE D** for NEPRA's perusal.

### 1.1.5 GRID INTERCONNECTION STUDIES

The Project Company engaged independent consultants, ARCO Energy Consultants, who have conducted the grid interconnection studies (the **Grid Interconnection Studies**). The Grid Interconnection Study approval was received from Faisalabad Supply Cooperation on March 20, 2019 and is attached herewith as **ANNEXURE E** for NEPRA's perusal.

1.1.6 SUBMISSION OF THE FEASIBILITY STUDY

Pursuant to the relevant provisions of the Punjab Power Generation Policy, 2006 (the **Punjab Power Policy 2006**) and the LOI, the Project Company, through the Main Sponsor, completed the detailed technical feasibility study for the Project, (including geo-technical investigation, topographic survey) and the Project Company submitted the same to PPDB for its approval on September 3, 2018 (the **Project Feasibility Study**). A copy of Project Feasibility Study is attached hereto as **ANNEXURE F** for NEPRA's perusal. A copy of the Panel of Expert's approval of the Project Feasibility Study is attached hereto as **ANNEXURE G**.

1.1.7 REQUEST FOR GRANT OF A GENERATION LICENSE

Based on the matter provided in Section 1.1.1 through 1.1.6 above, whereby the Project Companyhas undertaken and completed all activities required for procurement of approvals from various stakeholders it is submitted that the requirements of the regulatory process for applying to NEPRA for grant of a generation license for the Project Company are complete.

## 1.2 SUBMISSION

1.2.1 Under the Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of) 1997 (the **NEPRA Act**) and the National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, the National Electric Power Regulatory Authority (**NEPRA**) is responsible for and has the authority to, *inter alia*, grant licenses for the generation of electric power and other terms and conditions for the supply of electricity through generation.

1.2.2 **PURSUANT TO** the NEPRA Act, the National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations 1999, National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, **AND** in accordance with the Punjab Power Policy 2006: **K1 SOLAR POWER LAHORE (PRIVATE) LIMITED HEREBY SUBMITS,** for NEPRA's kind and gracious consideration, the application for the grant of a generation license along with supporting documents (the **Generation License Application**) for its 15 MWp power generation facility to be located at Mankera, Punjab, Pakistan.

1.2.3 Given the advance stage of the Project, NEPRA is kindly requested to process this Generation License request at the earliest, thereby enabling the Project Company to proceed further with the development process.

1.2.4 This Generation License Application is submitted in triplicate.

1.2.5 The generation license fee, payable by the Project Company, in respect of this Generation License Application is also enclosed in the form of a pay order for an amount of PKR 250,956/- (Pakistani Rupees Two Hundred Fifty Thousand, Nine Hundred and fifty-six only) drawn in favor of the Authority.

## 2. APPLICANT – K1 SOLAR POWER LAHORE (PRIVATE) LIMITED

2.1 The Project Company, being the applicant under this Generation License Application, is a private limited company incorporated under the laws of Pakistan and has been specifically established to undertake power generation business and activities in Pakistan.

2.2 The Project Company (following grant of a generation license and approval of the Project Company's reference generation tariff by NEPRA) proposes to design, engineer, construct, insure, commission, operate and maintain the Project constituting of a 15 MWp solar power generation facility (the **Facility**) to be located at Mankera, Province of Punjab, Pakistan (the **Site**).

2.3 The following supporting documents relating to the Project Company are attached herewith as follows:

| DOCUMENTS | ANNEXURE |
|---|---|
| Shareholding Pattern | ANNEXURE H |
| Memorandum and Articles of Association | ANNEXURE I |
| Certificate of Incorporation | ANNEXURE B |

# 3. FACILITY UTILIZATION

## 3.1 ELECTRICITY DEMAND

3.1.1 Pakistan is a developing economy having a constant growth in industrialization coupled with a constantly rising demand for electricity. The long standing gap between demand and supply of electrical power has resulted in excessive and frequent load shedding, resulting in determinant and loss to the economy and socio-economic development in the country.

3.1.2 The demand for electricity has continued to increase by out pacing the growth rate of the economy. In the past years, shortfall at times crosses 6000 MW and this is the time when urban areas have 8-12 hours of load shedding and small cities/ rural areas have 18 hours of load shedding. While it may be arguable that the demand and supply gap in electricity it is soon to be bridged, however the same does not account for the fact that a developing economy, coupled with growing consumption and demand could result in another cycle of shortfall in potential supply, which could be the major cause for stunned growth in the industrial sector in Pakistan. The industry, having its self-generation on gas, has a suspended supply of gas for 2-3 days a week during winters. Pakistan's major electricity sources at present are thermal and hydro generation, meeting approximately 97% of the country's annual electricity demand. The primary thermal generation fuels employed are furnace oil and gas. While both fuels are produced domestically, demand for them already outstrips supply by a considerable amount. Oil imports are already a significant burden on the national exchequer and the increasing import bill continues to exert further pressure on the foreign exchange reserves. Therefore, securing alternative fuels and the technical management should be strengthened to solve these problems and solar power, a cleaner source of energy can play a very important role in overcoming Pakistan's growing energy crisis.

3.1.3 In light of compliance by the Project Company of all requirements under the Punjab Power Policy 2006 for eligibility of an application for a generation license and following grant of a generation license and approval of Project Company's reference generation tariff, in each case, by NEPRA, the Project Company will finance, design, engineer, procure, construct, install, test, complete, commission, insure, operate and maintain the Project at Site.

3.1.4 The proposed Project will, following its completion, contribute towards relieving the shortage of electric power in the country and continuing to ensure that the supply of electricity continues to meet the growing demand.

3.1.5 Based on a thorough analysis of the national electricity generation structure and in light of technical parameters, it is anticipated that the Project shall operate as one of the most competitive independent power producers in Pakistan.

## 3.2 POWER OFF-TAKE

3.2.1 Following commercial operation date of the Project, the electricity generated will be sold to the Central Power Purchasing Agency (Guarantee) Limited), as an agent of the ex-Wapda distribution companies (the **Power Purchaser**) pursuant to an energy purchase agreement (the **EPA**), which in turn will distribute and modulate the electricity generated by the Project Company.

3.2.2 The EPA will be finalized and executed by and between the Project Company and the Power Purchaser following NEPRA's approval of the Project Company's twenty-five (25) years reference generation tariff, the grant of a generation license to the Project Company and the issuance by the Government of Pakistan of the Letter of Support.

# 4. THE SPONSORS

## 4.1 AN INTRODUCTION

4.1.1 The Main Sponsor, Vogt Solar Limited and Milner Vermögensverwaltungs GmbH intend to be a major player in developing projects in the energy sector with particular emphasis on development of renewable energy projects through investment in efficient and profitable projects.

4.1.2 The main sponsor of the Project shall be **M/S. IB VOGT GMBH**. Established in 2002, ib vogt GmbH focuses on developing and delivering high-quality large-scale turnkey PV plants worldwide. As a manufacturer-independent integrated developer with a strong worldwide network of local development partners the company provides high-quality turnkey PV plants, designed and engineered in Germany, to end investors internationally. IB VOGT employs over 150 experts in all areas of the solar power plant value chain. The family-owned company creates business in more than fifty-nine (59) countries, operating internationally from its headquarters in Berlin, Germany and offices in UK, USA, Australia, Panama, Poland, Spain, India and South East Asia, as well as several joint ventures across Africa. Company Profile – Attached as **ANNEXURE J.**

4.1.3 Vogt Solar Limited's activities cover project development, engineering, procurement and construction, operation and maintenance and ownership and asset management of its solar farm portfolio. The company focuses on solar farm solutions to maximize lifecycle performance.

4.1.4 Milner Vermögensverwaltungs GmbH is a limited company which holds solar farm assets and currently hold a portfolio of 30MW approx.

## 4.2 FINANCIAL HIGHLIGHTS

The Main Sponsor ibvogt GmbH turnover for year 2018 was > 200 Million Euros. A summary of each Sponsors' audited financial highlights for year 2017, 2016 & 2015 are attached herewith as **ANNEXURE K.**

## 4.3 COMMITMENT TO PROJECT

4.3.1 The Sponsors are committed to playing its part in the development of Pakistan's various sectors. Realizing the role of clean energy, the Sponsors endeavor to play a positive role in the development of renewable energy in Pakistan and through the Project, the Sponsors intends to promote technological development, construction, operation and maintenance of solar power plants.

4.3.2 The unmatched standards of corporate governance, efficiency, safety and operations established by the Sponsors in projects around the globe are now expected to be replicated in its solar power generation venture in Pakistan – thus raising the bar for all future solar power projects.

# 5. RESOURCES

## 5.1 SENIOR MANAGEMENT & PERSONNEL

5.1.1 Given the Sponsors' long standing engagement in the solar industry, the Project Company has access to and has engaged the highly qualified personnel for the development of the Project. The Project Company is presently under the process of appointing various personnel and details of the same will be provided upon finalization of the terms and conditions of their appointment.

5.1.2 In addition, the curriculum vitae of the following individuals currently engaged by the Project Company are attached herewith at **ANNEXURES L, M, N, AND O**:

| | NAME OF INDIVIDUALS | POSITION | ANNEXURE |
|---|---|---|---|
| **1.** | ANTON MILNER | DIRECTOR | **L** |
| **2.** | CARL VON BRAUN | DIRECTOR | **M** |
| **3.** | MURAD CAN | DIRECTOR EURASIA AND LATIN AMERICA | **N** |
| **4.** | ADEEL AHMED | MANAGER BUSINESS DEVELOPMENT | **O** |

## 5.3 LEGAL ADVISER

5.3.1 **HAIDERMOTABNR & CO.** has been selected by the Project Company to provide legal support on all legal aspects of the Project including Project documentation, regulation and financing matters. HaidermotaBNR & Co. has been actively involved in the power sector and projects and has advised various project companies / sponsors, lenders and the Government of Pakistan on various transactions and matters. It is ranked by Chamber & Partners as a "*Band 1*" firm in Pakistan for Projects, Banking & Finance and Corporate & Commercial.

## 5.4 FINANCIAL ADVISORS

5.4.1 **ERNST & YOUNG (FORD RHODES SIDAT HYDER) (E&Y)** has been selected by the Project Company to provide support on all financial aspects of the Project. E&Y has been actively involved in the power sector and infrastructure projects in Pakistan.

## 6. CAPITAL BUDGET

6.1 The estimated total Project cost (the **Total Project Cost**), expressed in United States Dollars, has been calculated after thorough analysis, evaluation and understanding of the dynamics that affect the development and operation of a solar power plant. The Total Project Cost comes to approximately Million US$ 14.58 /- (United States Dollars Fourteen Million Five Hundred Seventy-Five Thousand, Nine Hundred and Seventy-Nine).

6.2 The capital structure of the Project is proposed as follows:

| | USD |
|---|---|
| DEBT | 2,915,196 |
| EQUITY | 11,660,783 |
| TOTAL PROJECT COST | 14,575,979 |

# 7. FINANCIAL PLAN

7.1 The Total Project Cost of US$ 14,575,979/- (United States Dollars Fourteen Million Five Hundred Seventy-Five Thousand, Nine Hundred and Seventy-Nine only) is to be financed in a debt to equity ratio of 80-20.

## 7.1 DEBT

7.1.1 It is expected that the debt for the Project (the **Debt**) will be secured from a Bank/DFI which will provide foreign financing in United States Dollars to the Project Company.

## 7.2 EQUITY

7.2.1 Based on the Debt to Equity ratio of 80-20, the equity required to be injected by the Sponsors (the **Equity**), amounts to USD 2,915,196/- (United States Dollars Two Million Nine Hundred Fifteen Thousand, and One Hundred Ninety-Six only). The Sponsors will subscribe to the total amount of the Equity required for the Project from time to time.

7.2.2 The financial strength and net worth of the Sponsors is illustrated by the Audited Financial highlights attached at **ANNEXURE K.**

# 8. THE FACILITY

## 8.1 TECHNOLOGY

### 8.1.1 Technology Selection Criteria

The technology for the Project has been shortlisted/selected after detailed analyses of various power generation technologies available internationally for the purposes of power generation through solar. Various factors were considered in selection of equipment and technology which included:

(a) equipment to be of latest proven technology, megawatt class and high efficiency;

(b) safe transportation of equipment to the Site;

(c) maintainability of the equipment and availability of personnel;

(d) energy output with warranted power curve and performance warranty;

(e) grid compatibility with proposed energy yields and grid code requirements; and

(f) suitability of operation and maintenance concept for the size and location of projects with suitable availability of spare parts, consumables and main components.

### 8.1.2 The Selected Technology

The Project Company has selected the equipment for the Project:

| Sr. No. | Equipment | Brands |
|---|---|---|
| 1 | PV modules | Tier 1 (Hanwah Q-Cells, Jinko, Trina, Longi solar or similar) |
| 2 | Single Axis Tracker | Leading global supplier (Arctech, Soltec, Schletter) |
| 3 | Inverters | ABB, GE, Sungrow, HUAWEI |
| 4 | DC/AC brand | Faber or Huawei |
| 5 | Step – up transformers | Siemens, ABB, TBEA, QRE, Chint |
| 6 | Medium voltage switch gear and 132KV substation | Siemens, ABB, Chint |
| 7 | SCADA | Gatner, ABB, Schneider |

Additional Plant Technical Details

Plant Configuration:

1. Installed Capacity: 15 MWp
2. Capacity at Operating Conditions: 13.602 MWp ($50^0$C)
3. Auxiliary Consumption approx.: 120 KvA
4. Net output (MSC): 12.4 MW (AC)
5. Life of facility: 25 years

The Project will be set up using Monocrystalline bifacial PV modules, which will be installed in arrays, and their DC output will be converted in to AC through inverters. Thereafter, a group of arrays/inverters will be routed to step-up transformer(s)/switchgear(s) for connecting to the system as per the interconnection scheme.

Detailed plant configuration is provided in **ANNEXURE P, ANNEXURE Q Schedule Part I and Schedule Part II** and **ANNEXURE F** attached hereto.

## 8.2 THE PROJECT SITE

8.2.1 The Site of the Project is located near the village of Mankera, Punjab. The area has been extensively surveyed and due to its predominantly flat topography has been identified as having strong potential for the proposed solar project. The following other parameters have also been considered for the implementation of the Project at the proposed Site:

(a) Forecasted power output;
(b) Access to the proposed site (materials and equipment transport feasibility study);
(c) Suitability for the surrounding environment;
(d) Utility connections for electric, gas and water supply; and
(e) Grid Station connection a 66/11KV grid station is located approximately 4.5km from the Site.

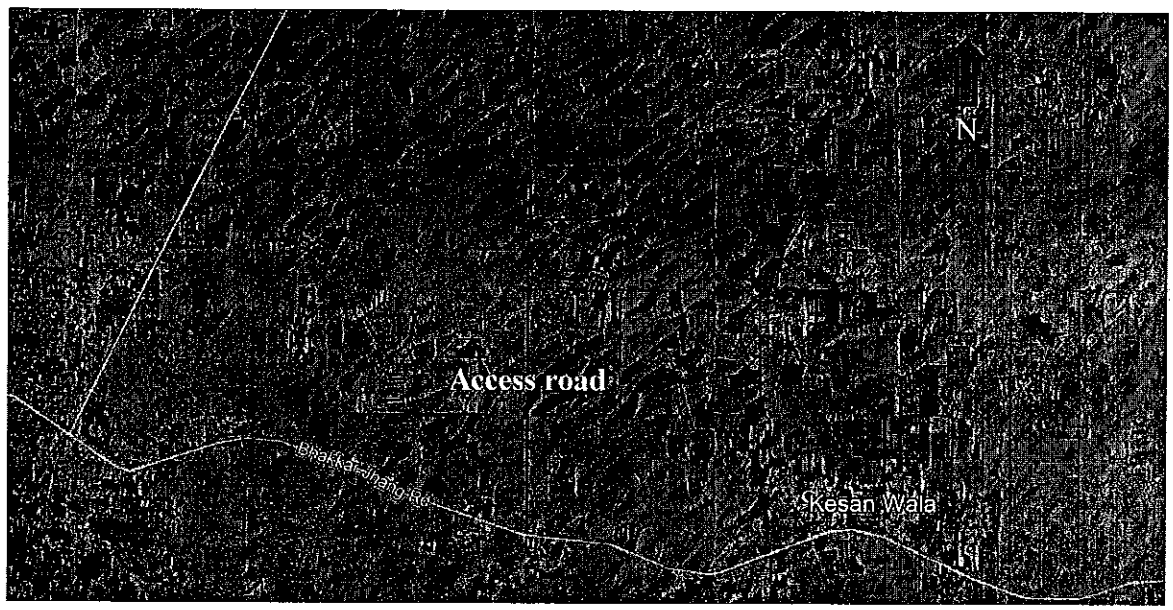
8.2.2 The Project Company has privately acquired the land for the development of the Project. The nearest settlement to the proposed Site is Mankera town (4 km north west). The Site is located at 538m above sea level. The size of the whole solar farm is about 62.4 acres.

8.2.3 The coordinates of the Site are as follows:

| Sr. No. | Entry | Details |
|---|---|---|
| 1 | Site Name | Mankera Solar Farm |

| | | |
|---|---|---|
| 2 | Site Coordinates | P1= 31°24'3.62"N, 71°28'42.77"E<br>P2= 31°24'15.96"N, 71°28'42.54"E<br>P3= 31°24'16.54"N, 71°29'8.41"E<br>P4= 31°24'4.38"N, 71°29'7.94"E |
| 3 | Altitude | 164 m (Highest recorded value)<br>162 m (Lowest recorded value) |
| 4 | Proposed AC and DC capacity | 12.5 MW AC ~ 15 MW DC |
| 5 | Global irradiation levels | 1784 KWh / $m^2$ (Solar GIS) |

**FIGURE 1: SITE OVERVIEW**



# 9. ENVIRONMENTAL AND SOCIAL SOUNDNESS

## 9.1 INVESTIGATION SUMMARY

9.1.1 The investigations at Site have shown that in general the realization of the Project is possible at the Site from an environmental point of view and no adverse impact on the existing flora and fauna at Site is expected. The Facility will not emit any solid, liquid and gaseous waste during the entire life of the Project and thus the power will be generated without polluting the environment of the surroundings.

9.1.2 A data collection survey that included geology, meteorology, hydrology, ambient air quality, water quality, soil characteristics, noise levels, shadow forecasting, flora and fauna, land use pattern, and socioeconomic conditions was undertaken based on available secondary information or data collected in the field. Primary data was collected to establish baseline conditions for the soil, water (surface and ground) quality, flora and fauna, and noise. Secondary data was collected for land, ecology, climate, and socioeconomic factors.

9.1.3 It was observed that the area is highly underdeveloped and there is no industrialization in the area and thus the baseline emissions are very low. The nearest settlements of human habitats are located 4-5 Km away from the Project Site. There is very sparse vegetation in the forms of herbs and shrubs, there being no reserved forest site or sanctuary located within the Project land area that needs to be demolished. The Site is located in remote areas with very little social and commercial activity and thus limiting the long term social impact.

9.1.4 Noise impacts will be around 52 DB(A) at 3m which are within the range as per National Environmental Quality Standards (NEQs) of Pakistan. But at distance of 100m from the noise impact will also be negligible. As the nearest dwelling/residential area from the site is almost at 3-4 km from the solar farm. Hence the noise impact due to operation of solar farm will be almost zero. The environmental disturbance normally associated with construction activities will be minimized through an Environment Management Plan (EMP), implementation of which will continue during Project operation and which includes monitoring arrangements.

9.1.5 There exist high potential of solar energy at the Site and the proposed Project will help in tapping this potential without impairing the environmental conditions of the area.

## 9.2 IEE REPORT APPROVAL FROM THE ENVIRONMENTAL PROTECTION AGENCY, PUNJAB

9.2.1 As already submitted in Section 1 (*Background to Generation License Application*) above, the Punjab EPA has already accorded its **approval** to the IEE Report for the Project through its decision dated September 9, 2018. A copy of the IEE Approval Decision is attached hereto at **ANNEXURE D.**

## 10. SAFETY

10.1 The Project will be implemented in accordance with internationally accepted health and safety standards and in-line with the acclaimed practices and procedures. The Sponsor's, entails introducing and establishing its unmatched safety standards and procedures in the business operations of the Project Company, so as to establish an enviable benchmark in the country's solar energy sector.

## 11. TRAINING AND DEVELOPMENT

11.1 Periodic environmental and HSE trainings will be given to employees working in the project area. The management of K1 Solar Power Lahore (Private) Limited understands the requirement of diligence and care in this respect and will develop strict SOPs for the health and safety of workers. Various sessions of in-house trainings will also be conducted in the Project.

## 12. PROJECT FEASIBILITY STUDY

12.1 The Project Company engaged leading technical consultants for elaborating the Project Feasibility Study and for supervising the solar measurements and preparing conceptual design of the Facility.

12.2 A copy of the Project Feasibility Study is attached hereto at **ANNEXURE F.**

## 13. IMPLEMENTATION SCHEDULE

13.1 The following table provides the key milestones and dates for the Project's development to date:

| MILESTONES ACHIEVED TO DATE | |
|---|---|
| **ACTIVITIES** | **COMPLETION DATE** |
| Issuance of Letter of Intent | January 9, 2018 |
| IEE approval by EPA | September 9, 2018 |
| Approval of Grid Interconnection Study | March 20, 2018 |
| Approval of the Project Feasibility Study | March 3, 2019 |

13.2 The following table provides the key upcoming milestones and dates for the Project's development:

| MILESTONES TO BE ACHIEVED | |
|---|---|
| **ACTIVITIES** | **COMPLETION DATE** |
| Grant of Generation License | Upon NEPRA's approval |
| Reference Tariff Determination | Upon NEPRA's determination |
| Submission of Performance Guarantee by Project Company for issuance of LOS | 15 days after Tariff determination by NEPRA |
| Issuance of LOS to Project Company by Government of Pakistan | 7 days after submission of Performance Guarantee |
| EPA Signing with CPPA(G) | Within the time period allowed under the LOS |
| IA Signing with Government of Pakistan | Within the time period allowed under the LOS |
| Project Financial Close & ordering of equipment | Within the time period allowed under the LOS |
| Commercial Operation Date | 6 months following Financial Close |
| Adjustment of reference tariff by NEPRA | Following Commercial Operations Date |

## 14. CONCLUSION

14.1 In light of the submissions, the relevant financial analysis and information contained in this Generation License Application, along with the Annexures attached hereto, this Generation License Application is submitted for NEPRA's kind consideration and grant of the Generation License to the Project Company.

Respectfully submitted for and on behalf of:
**K1 SOLAR POWER LAHORE (PRIVATE) LIMITED**

.....

**MR. ADEEL AHMED**
AUTHORIZED REPRESENTATIVE OF
K1 SOLAR POWER LAHORE (PRIVATE) LIMITED

No. PPDB/R.E/DRE/ 27 /2018
**PUNJAB POWER DEVELOPMENT BOARD**
**ENERGY DEPARTMENT**
1st Floor, Irrigation Secretariat,
Old Anarkali, Lahore
(Ph: 042-99 213877 Fax: 042-99213875)
**Dated: 09/01/2018**

**Consortium**
**M/s. ib vogt GmbH (Main Sponsor)**
**Address: Head office Helmboltzstraze 2-9, 10587 Berlin, Germany**

M/s vogt Solar Limited (Consortium member),
M/s Green Energy UK Direct Limited (Consortium member)

Subject: **LETTER OF INTEREST (LOI) FOR THE DEVELOPMENT OF 15 MW SOLAR POWER PROJECT IN PUNJJAB**

Reference: Your Statement of Qualification (SOQ) submitted for development of approximately 15 MW solar power project at Mouza Rakh Chabeel, District Lahore. Follow up meetings of the representative of M/s. ib vogt GmbH (the "Consortium") at Energy Department, Government of the Punjab and Punjab Power Development Board (PPDB), Meeting chaired by Chairman PPDB / ACS (Energy) on December 05, 2017. PPDB Board 48th meeting dated December 12, 2017. PPDB award of letter of LOI letter No. PPDB/1610/2017 dated December 15, 2017 and acknowledgment of your company vide letter no. LOI1612 dated December 16, 2017.Further through your letter no. LAHBG03 dated December 28, 2017 submission of Bank Guarantee No. LG No. AKBL06/17/071 CAD Ref No. CAD/G/6519 amounting USD fifteen thousand (15,000/-) issued by Askari Bank Limited having registered office at 7-A, Shahrah-e-Aiwan-e-Tijarat, Lahore which was received to this office on December 29, 2017 in replacement of earlier submitted Bank Guarantee L/GNo. : AKBL 06/16/037 dated August 04, 2016 along with its amendments.

2. Now, this letter of interest (hereinafter referred to as "LOI") is being issued on behalf of the Government of the Punjab, in terms of the provisions of Punjab Power Generation Policy 2006, revised 2009 (the "Policy"). The Government of Punjab hereby confirms its interest in your proposal for conducting feasibility study (hereinafter referred to as the "Feasibility Study") for establishing an approximately 15 MW private solar power project in Punjab subject to the following:-

a. Your Consortium is required to complete Project Feasibility Study for the subject Project, at no risk and cost to, and without any obligation on the part of, the Govt. of the Punjab and its agencies, within nine (09) months from the date of this LOI. There would be no adverse claim towards any of the Government of Punjab entities in case the project is declared non-feasible. You are further required to submit the monthly progress report of the Feasibility Study to PPDB failing which PPDB may proceed against your Company for cancellation of this LOI.

b. Your Consortium is required to carry out the Project Feasibility Study, complete and get approved, at internationally acceptable standards and in accordance with the terms and conditions stipulated in the Policy. The Feasibility Study must include an Initial Environment Examination (IEE) Study, detailed design of power house, load flow and stability studies, design of interconnection / transmission lines, details pertaining to infrastructure, project cost, financing and, financing terms, tariff calculations and assumptions of financial calculations including economic / financial analysis. You are advised to liaise with the power purchaser while determining your plant size and site, project layout, transmission line and interconnection arrangements, etc.

c. The Consortium will carry out the Feasibility Study according to the specific milestones appended herewith at **Annex–A**, and submit monthly progress reports showing progress against these milestones.

d. Your Consortium shall require to establish the Special Purpose Vehicle (SPV) company and shall maintain the shares in this company in accordance with Para 39 & 40 of Punjab Power Generation Policy 2006 (revised 2009) and submit a copy of Memorandum of Articles & Association as well the Form 29 duly attested by the Security Exchange Commission of Pakistan (SECP).

e. PPDB will appoint a Panel of Experts to monitor the conduct of the Feasibility Study and its progress, to verify attainment of the aforesaid milestones and to ensure implementation of the project consistent with national and provincial needs.

f. The Main Sponsor will be liable for all obligations and liabilities of and on behalf of other Sponsors. Further processing of the Feasibility Study is subject to Govt. of the Punjab acceptance in accordance with the Policy.

g. The validity of this LOI is nine (09) months from the date of its issuance, where after or before it, if found otherwise, violating the Policy will automatically lapse immediately. 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 Sponsors or the project company or any party claiming through them against the Government or Punjab / PPDB or any of its agencies, employees or consultants on any grounds whatsoever, during or after the expiration of its validity.

h. Your Consortium, therefore, required to complete the Feasibility Study for the Subject Project **within the validity of this LOI**. In case there is delay in completion of the Feasibility Study within the validity of this LOI, a one-time extension by the PPDB Committee referred in Section 2.2 Para 34 may be granted up to a maximum period of ninety (90) days, provided the Panel of Experts is satisfied that the Feasibility Study is being conducted in a satisfactory manner and is likely to be completed shortly. Furthermore, extension in validity of the LOI will only be provided upon submission of a bank guarantee in **double the original amount and valid beyond 180-days of the extended LOI period**.

i. **In case, if you fail to meet the relevant milestones and standards, PPDB will terminate this LOI and encash the Bank Guarantee.**

j. This LOI has been issued in duplicate on the date hereof, and it shall come into effect when one copy hereof is received by PPDB after having been duly countersigned by you. Nevertheless, this LOI shall lapse if the countersigned copy is not received at PPDB within thirty (30) days of its issuance.

**(SANIYA AWAIS)**
**MANAGING DIRECTOR**
**PUNJAB POWER DEVELOPMENT BOARD**

Accepted and agreed
for & on behalf of ib vogt GmbH.

Managing Director

Date: 26/1/2018

Encl: As stated above

C.C:

1. Secretary, Ministry of Energy (Power Division), Islamabad
2. Chairman, NEPRA, NEPRA Tower, Islamabad
3. Chairman WAPDA,WAPDA House Lahore
4. Chairman PPDB Board
5. Chairman, P&D/ACS (Energy), Govt. of the Punjab, Lahore
6. Secretary, Energy Department, Govt. of the Punjab, Lahore
7. Chief Executive Officer (concerned DISCO)
8. Chief Executive Officer Alternate Energy Development Board, Islamabad
9. Environment Protection Agency, Govt. of the Punjab, Qadafi Stadium, Lahore

**Annex-A**

**Consortium M/s. ib vogt GmbH (Main Sponsor)**
**Timelines for conduct of Feasibility Study of 15 MW Solar PV Power Project in Punjab**

| Sr. No. | Activities | Target Days | Target Date & Presentation to PPDB / POE |
|---|---|---|---|
| 1. | Issuance of LOI by PPDB | 09.01.2018 | |
| 2. | Return of the duly signed LOI & formation of SPV company registered with SECP | 9 months | |
| 3. | Procurement of Consultancy Service and Award of Contract | | |
| 4. | Mobilized Consultant | | |
| 5. | Data Collection | | |
| 6. | Geo-Technical investigation | | |
| 7. | Topographic Survey, Environment and related studies | | |
| 8. | Electrical & Grid Interconnection Study | | |
| 9. | IEE, Social and resettlement Studies | | |
| 10. | Selection of Final Layout and Sizing of Power Plant | | |
| 11. | Optimization of Selected Layout | | |
| 12. | Draft Feasibility Design | | |
| 13. | Financial Model Includes: Unit rate Analysis, Costing, Economic & Financial Analysis and Ultimate Tariff | | |
| 14. | Draft Feasibility Study report submission | | 03.09.2018 |
| 15. | Review comments and Presentation to POE | | 08.09.2018 |
| 16. | Incorporation of POE Comments & Final Review | | 13.09.2018 |
| 17. | Final Feasibility Report Submission and Approval of POE | | 18.09.2018 |

A024270

SECP

# SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

## COMPANY REGISTRATION OFFICE, LAHORE

## CERTIFICATE OF INCORPORATION

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

Corporate Universal Identification No. **0103476**

I hereby certify that **K1 SOLAR POWER LAHORE (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 **Lahore** this **Ninth** day of **November,** Two **Thousand** and **Sixteen**.

**Fee Rs.2,000/-**

**(SHAUKAT HAMEED)**
Joint Registrar

COMPANY REGISTRATION OFFICE LAHORE
SECP

No.ARL/ 890 / **DATED: 09-11-2016**

# THE COMPANIES ORDINANCE, 1984

## (Private Company Limited by Shares)

## ARTICLES OF ASSOCIATION

## OF

## K1 SOLAR POWER LAHORE (PRIVATE) LIMITED


### PRELIMINARY

1. The Regulations contained in Table 'A' in the First Schedule to the Companies Ordinance, 1984 shall not apply to the Company except to the extent and as hereinafter, expressly incorporated. In case of any conflict between the provisions referred to and the provisions herein contained and the incorporated Regulations of Table 'A', the provisions herein contained shall prevail.

Company to be governed by the Articles & Table 'A' not to apply.

### INTERPRETATION

2. In the interpretation of these Articles, words importing the singular shall include the plural, and vice versa and words importing the masculine gender shall include feminine gender and words importing persons shall also include corporate bodies.

The 'Articles' means these Articles as originally framed or as from time to time altered in accordance with law.

Articles

The 'Commission' means the Securities and Exchange Commission of Pakistan.

Commission

The 'Board' means Board of Directors for the time being of the company.

Board

The 'Chief Executive' means an individual who subject to the control and directions of the directors, is entrusted with the whole or substantially the whole, of the powers of management of the affairs of the company and includes a director or any other person occupying the position of a chief executive, by whatever name called, and whether under a contract of service or otherwise.

Chief Executive

incorporation of the company and thereafter once at least in every calendar year within a period of four months following the close of its financial year and not more than fif of its last preceding annual general meeting.

26. All general meetings of a company other than annual general meeting shall be called extraordinary general meetings. Extra Ordinary General Meeting

27. The directors may, whenever they think fit, call an extraordinary general meeting. Extraordinary general meeting shall also be called on such requisitions or in default, may be called by such requisitions, as is provided by Section 159. If at any time there are not within Pakistan sufficient directors capable of acting to form a quorum, any director of the company may call an extraordinary general meeting in the same manner as nearly as possible as that in which meetings may be called by the directors. Calling of an Extra Ordinary General Meeting

## NOTICE AND PROCEEDINGS OF GENERAL MEETINGS

28. 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, 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 regulations of the company, entitled to receive such notices from the company; but the accidental omission to give notice to, or the non-receipt of notice by, any member shall not invalidate the proceedings at any general meeting. In case of extraordinary meeting a shorter notice may be given with the consent of Registrar as provided in Section 159 and for passing a special resolution, meeting may be conveyed on a shorter notice with the consent of all the members as provided in Section 2 (1) (36). Notice

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

30. No business shall be transacted at any general meeting unless a quorum of members is present at that time when the meeting proceeds to business; save as herein otherwise provided, members having twenty five per cent of the voting power present in person or through proxy and two members personally present, shall be a quorum. Quorum

31. 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 Adjourned Mee

| | |
|---|---|
| The name of the Company is "K1 Solar Power Lahore (Private) Limited". | Company |
| The 'Directors' means the Directors for the time being of the company. | Directors |
| 'Dividend' includes bonus. | Dividend |
| 'Document' includes summon, notice, requisition, order, other legal process, voucher and register. | |
| 'Month' means the calendar month according to the English Calendar. | |
| The 'Office' means the Registered Office for the time being of the Company. | Office |
| The 'Ordinance' means the Companies Ordinance, 1984. | Ordinance |
| 'Proxy' includes Attorney duly constituted under a Power of Attorney. | Proxy |
| The 'Register' means the Register of Members to be kept in pursuance to Section 147 of the Ordinance. | Register |
| The 'Registrar' means the Registrar of Joint Stock Companies having jurisdiction on the Company. | Registrar |
| 'Redeemable Capital' includes finance obtained on the basis of Participation Terms Certificate (PTC), Musharika Certificate, Term Finance Certificate (TFC) or any other security or obligation not based on interest, other than an ordinary share of a company representing an instrument or a certificate of specified denomination, called the face value or nominal value evidencing investment of the holder in the capital of the company on terms and conditions of the agreement for the issue of such instrument or certificate or such other certificate or instrument as the Federal Government may, by notification in the official Gazette, specify for the purpose. | Redeemable Capital |
| 'Section' means Section of the Ordinance. | Section |
| The 'Seal' means the common seal of the Company. | Seal |
| 'Security' means any share, script, debenture, participation term certificate, modaraba certificate, musharika certificate, term finance certificate, bond, pre-organization certificate or such other instrument as the Federal Government may, by notification in the official Gazette, specify for the purpose. | Security |

'In Writing' and written include printing, lithography and other modes of representing or reproducing words in a visible form. Writing

Words and phrases used herein but not defined shall be assigned the same meaning as given to them in the Ordinance. Expressions

## BUSINESS

3. The business of the company shall include the several objects expressed in the various clauses of the Memorandum of Association or any of them.

4. The business of the Company may be commenced as soon as after the incorporation of the Company or as the Directors shall think fit, notwithstanding that a part of the capital has been subscribed.


## PRIVATE COMPANY

5. The Company is a private company within the meaning of Section 2 (1) Clause (28) and accordingly:

a) No invitation shall be issued to public to subscribe for any share or debenture of the Company.

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

c) The right to transfer shares in the Company is restricted in the manner and to the extent hereinafter provided.

6. The Capital of the Company is Rs.100,000/- (Rupees One Hundred Thousand only) divided into 10,000 (Ten Thousand) Ordinary shares of Rs.10/- each with power to increase or reduce the capital and to divide the share in the capital for the time being into several classes. Share Capital

7. The Shares shall be under the control of the Directors who may allot or otherwise dispose of the same or any of them to such persons, on such terms and conditions and at such times as the Directors think fit and with full power to give to any person the right to call for the allotment of any shares at a premium or at par or (subject to the provisions of the Ordinance) at a discount and for such time and for such consideration as the Directors think fit. However while issuing further shares, requirements of Section 86 shall be observed.

Allotment of shares under Director's Control

8. No share shall be offered for subscription except upon the term that the amount payable on application shall be the full amount of the nominal value of the share.

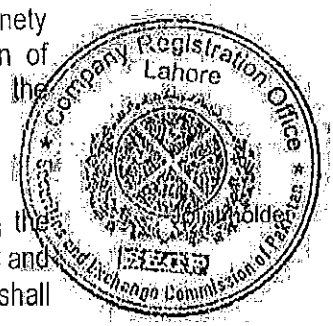
Offer for Subscription

9. The directors shall, as regards any allotment of shares, duly comply with such provisions of Section 73, as may be applicable thereto.

Return of Allotment

10. Every person whose name is entered as member in the register of members shall, without payment, be entitled to receive, within ninety days after allotment or within forty-five days of the application of registration of transfer, a certificate under the seal specifying the share or shares held by him and the amount paid up thereon.

Certificate




11. In respect of a share or shares held jointly by several persons, the company shall not be bound to issue more than one certificate and delivery of a certificate for a share to one of several joint holders shall be sufficient delivery to all.

12. As provided in Section 87, the Directors may issue ordinary shares or grant option to convert into ordinary shares, the outstanding balance of any loans, advances or credits or other non-interest bearing securities and obligations outstanding or having a terms of not less than three years in the manner provided in any contract with any schedule bank or a financial institution to the extent of twenty percent of such balance.

Issue of shares to banks and financial institutions

13. The Director may issue to banks or financial institution either severally, jointly or through a syndicate, Redeemable Capital in consideration of any funds, moneys, accommodations received or against promise, guarantee, undertaking or indemnity issued to or in favour or benefit of the company.

Issue of Redeemable Capital

Duplicate Certificate

14. If a share certificate is defaced, lost or destroyed, it may be renewed on payment of such fee, if any, not exceeding one rupee, and on such terms, if any, as to evidence and indemnity and payment of expenses incurred by the company in investigating title, as the directors think fit. Within forty-five days of application, directors shall issue certificate to the applicant.

## TRANSFER OF SHARES

Restriction on Shares

15. No transfer of any share shall be made or registered without previous sanction of the majority of Directors who may after assigning any reason decline to give any such sanction and shall so decline in the case of the transfer of shares, the registration of which will involve a contravention of Article 5.

Execution of Transfer

16 The instrument of transfer of any share in the company shall be executed both by the transferor and the transferee, and the transferor shall be deemed to remain holder of the share until the name of the transferee is entered in the register of members in respect thereof. No transfer shall be made to an infant or persons of unsound mind.

17. Shares in the company shall be transferred in any usual or common form which the directors shall approve.


## TRANSMISSION OF SHARES

Shares of Deceased

18. The executors, administrators, heirs or nominees, as the case may be, of a deceased sole holder of share shall be the only persons recognized by the company as having any title to the share, in the case of share registered in the name of two or more holders the survivors or survivor, or the executors or administrators of the deceased survivor, shall be the only persons recognized by the company as having any title to the share.

Nomination by Members

19. A member/shareholder may deposit with the company a nomination conferring on one or more persons the right to acquire the interest in the shares therein specified in the event of his death. Regulation of Section 80 will apply in case of all such nominations.

Entitlemen Shares

20. Any person becoming entitled to a share in consequence of the death or insolvency of a member shall, upon such evidence being produced as may from time to time be required by the directors, having the right, either to be registered as a member in respect of the share or, instead of being registered himself, to make such transfer of the share as the deceased or insolvent person could have made; but the directors shall in either case having the same right to decline or suspend registration as they would have had in the case of a transfer of the share by the deceased or insolvent person before death or insolvency.

Entitler of Divic

21. A person becoming entitled to a share by reason of the death or insolvency of the holder shall be entitled to the same dividends and other advantages to which he would be entitled if he was the registered holder of the share, except that he shall not, before being registered as member in respect of the share, be entitled in respect of it to exercise any right conferred by membership in relation to meetings of the company.

## ALTERATION OF CAPITAL

Increase in Sha Capital

22. The company may, from time to time by special resolution increase the share capital by such sum to be divided into shares of such amount, as the resolution shall prescribe. The new shares shall be subject to same provisions with reference to transfer, transmission and otherwise as the shares in the original share capital.


Consolidation D Sub-divisions a Cancellation of Shares

23. The company may by special resolution:

a) consolidate and divide its share capital into shares of larger amount than its existing shares;

b) sub-divide its existing shares or any of them into shares of smaller amount than is fixed by the memorandum of association, subject nevertheless, to the provisions of clause (d) of sub-section (1) of Section 92; and

c) cancel any shares which at the date of passing of the resolution have not been taken or agreed to be taken by any person.

Reduction of C

24. The company may by special resolution, reduce its share capital in any manner and with, and subject to any incident authorized and consent required by Sections 96 to106.

## GENERAL MEETINGS

Annual Genera Meeting

25. A general meeting to be called the annual general meeting shall be held as may be determined by the directors in accordance with the provisions of Section 158, within eighteen months from the date of

shall stand adjourned to the same day in the next week at the same time and place, and, if at the adjourned meeting a 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.

Chairman

32. The chairman of the board of directors, if any, shall preside as chairman at every general meeting of the company, but if there is 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.

Power to adjou general Meetin

33. The chairman may, with the consent of any meeting at which 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 a 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 or of the business to be transacted at an adjourned meeting.

Adoption of resolution

34. 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 result 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, been carried, or carried unanimously, or by a particular majority, or lost, and 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.

Demand for p

35. A poll may be demanded only in accordance with the provisions of Section 167.

Manner and ti of taking poll

36. If a poll is duly demanded, it shall be taken in accordance with manner laid down in Section 168 and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded. A poll demanded on the election of chairman or on a question of adjournment shall be taken at once.

Casting Vote

37. In the case of an inequality of votes, whether on a show of hands or on a poll, the chairman of the meeting at which the show of hands takes place, or at which the poll is demanded, shall have and exercise a second or casting vote.

## VOTES OF MEMBERS

Right to Vote

38. 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 shall apply. On a poll every members shall have voting rights as laid down in Section 160.

Vote of Joint holder

39. In case of joint-holders, the vote of the senior who tenders a vote, whether in person or by proxy, shall be accepted to the exclusion of the votes of the other joint-holder; and for this purpose seniority shall be determined by the order in which the names stand in the register of members.

Vote by Proxy and by Corporate Representative

40. On a poll votes may be given either personally or by proxy; Provided that no body corporate shall vote by proxy as long as a resolution of its directors in accordance with the provisions of Section 162 is in force.

Proxy to be in writing

41. The instrument appointing a proxy shall be in writing under the hand of the appoint or of his attorney duly authorized in writing. A proxy must be a member.

Deposit of instrument of Proxy

42. The instrument appointing a proxy and the power-of-attorney or other authority (if any) under which it is signed or a notarized 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.

Form of Proxy

43. An instrument appointing a proxy may be in any usual or common form as near thereto as may be which the directors shall approve.

## DIRECTORS

First Directors

44. The first directors of the Company shall be the following;

1. Carl Friedrich Edler Von Braun
2. Charles Anton Milner

Number of Directors

45. Subject to the provisions of the Ordinance, the Company may from time to time in general meeting increase or decrease the number of directors. However such number shall not in any case be less than two.

Nominated Directors

46. The company may have directors nominated by the company's creditors or other special interest by virtue of contractual arrangements..

Alternate Director

47. A Director who is about to leave or is absent from Pakistan may with the approval of the Directors appoint any person to be an Alternate Director during his absence from the country provided such absence shall not be less than for a period of three months and such appointment shall have effect and such appointee whilst he holds office as an Alternate Director, shall be entitled to notice of the meeting of the Directors, and to attend and vote thereat accordingly but shall ipso facto vacate office when his appointor returns to the country or vacates office as Director. If the company in General Meeting removes the appointee from office and any appointment and removal under the clause shall be affected by notice in writing under the hand of director making the same.

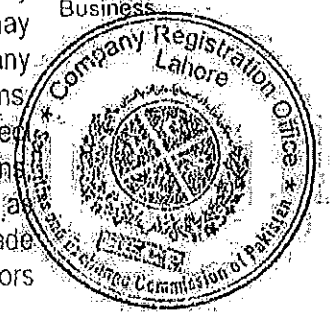
Remuneration of Director

48. The remuneration of director for performing extra services, including holding of the office of Chairman, and the remuneration to be paid to any director for attending the Meeting of the Directors or a committee of Directors shall from the time to time be determined by the Board of Directors in accordance with the law.

## POWERS AND DUTIES AND DIRECTORS

Management of Business

49. 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 power 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 regulation 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.




Power to appoint attorne

50. The Directors may from time to time by power of attorney under the Company's Seal, appoint any person or persons to be the attorney(s) of Company for such purposes and with such powers, authorities and discretions (not exceeding those vested in, or exercisable by the Directors under these presents) and for such period and subject to such conditions as the Directors may from time to time think fit. Any such attorney (s) may, if authorized by the Directors, delegate all or any of the powers vested in him/them.

Filing of Return

51. The directors shall duly comply with the provisions of the Ordinance or any statutory modification thereof for the time being in force, and in particular with the provisions in regard to the registration of the particulars of mortgages and

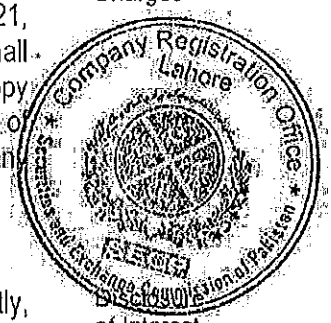
charges affecting the property of the company or created by it to the keeping of a register of the directors and to the sending to the registrar of an annual list of members, and a summary of particulars relating thereto and notice of any consolidation or increase of share capital, or sub-division of shares, and copies of special resolutions and a copy of the register of directors and notification of any changes therein.

Power to borrow

52. Subject to the provisions of Section 196, the Directors may from time to time at their discretion borrow such sum or sums as they may think fit for the purpose of the company including from any banks and financial institutions and secure the payment or repayment of such sum or sums in such manner and upon such terms and conditions as they think fit by mortgage or charge upon the whole or any part of the property, present and future or any such other way as the Directors may think expedient. The company may raise and secure payment of any sum by issue of Redeemable Capital. The Redeemable Capital may be issued at a discount, premium or otherwise with special privilege as to redemption, conversion into share with voting rights and their subsequent reconversion to Redeemable Capital.

Mortgages and Charges

53. The Directors shall cause a proper register to be kept in accordance with Section 135 of all mortgages and charges specifically affecting the property of the company and shall duly comply with the requirements of Sections 121, 122 and 129 in regard to registration of mortgages and charges and shall also duly comply with the requirements of Section 130 as to keeping a copy of every instrument creating any mortgage or charge and requirements of Section 132 as to giving intimation of the payment or satisfaction of any charge or mortgage created by the company.




Disclosure of Interest by Directors

54. Every director or his relative who is in any way, whether directly or indirectly, concerned or interested in any contract or arrangement entered into, or to be entered into, by or on behalf of the company shall disclose the nature of his concern or interest at a meeting of the directors, as required by Section 214.

Minutes to be made

55. 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.

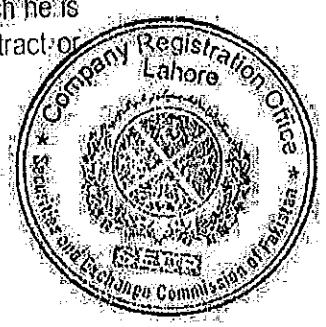
c) of all resolutions and proceedings at all meetings of the company and of the directors and committees of directors.

and every director present at any meeting of directors or committee of directors shall sign his name in a book to be kept for that purpose.

## DISQUALIFICATION OF DIRECTORS

Ineligibility

56. No person shall become director of the Company if he suffers from any of the disabilities or disqualifications mentioned in Section 187 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 has 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

Meetings of Directors

57. The directors may meet together for the dispatch of business, adjourn and otherwise regulate their meetings, as they think fit. The quorum for the meeting shall be fixed by the directors and unless so fixed shall be two. 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 casing vote. A director may, and the secretary on the requisition of director shall, at anytime summon a meeting of directors.

Delegation of Power to committees

58. The directors may delegate any of their powers not required to be exercised in their meeting to committees consisting of such member or members of their body as they think fit; any committee so formed shall, in the exercise of the powers so delegated, conform to any restrictions that may be imposed on them by the directors.

Chairman

59. The directors may elect a 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 fifteen 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.

Chairman of committee meetings

60. A committee may elect a chairman of its meetings; if no such chairman is elected, or if at any meeting the chairman is not present within fifteen minutes after the time appointed for holding the same or is unwilling to act as chairman, the members present may choose one of their number to be chairman of the meeting.

Proceedings of committee members

61. A committee may meet and adjourn as it thinks proper. Questions arising at any meeting shall be determined by a majority of votes of the members present. In case of an equality of votes, the chairman shall have and exercise a second or casting vote.

Validity of Director's Act

62. All acts done by any meeting of the directors or of a committee of directors or by any person acting as a director, shall, notwithstanding that it be afterwards discovered that there was some defect in the appointment of any such directors or persons acting as aforesaid, or that they or any of them were disqualified, be as valid as if every such person had been duly appointed and was qualified to be a director.

63. A resolution in writing signed by all the directors or affirmed by them through telex or telegram shall be as valid and effectual as if it had been passed at a meeting of directors duly convened and held.


## ELECTION AND REMOVAL OF DIRECTORS

Period of Office

64. The First Directors of the Company shall retire from their offices at the first Annual General Meeting of the Company, and directors shall be elected in their place in accordance with Section 178 for a term of three years, unless they resign earlier, become disqualified for being Directors or otherwise cease to hold office.

Election

65. The Directors shall comply with the provisions of Section 174 to 178, 180 and 184 relating to election of directors and matters ancillary thereto.

Eligibility

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

Casual Vacancy

67. 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.

Mode of Election

68. The number of directors determined by the Board shall be elected to hold office by the members in general meeting in the following manner:

a) A member shall have such number of votes as is equal to the product of the number of voting shares or securities held by

him and the number of Directors to be elected;

b) A member may give all his votes to a single candidate or divide them between more than one of the candidates in such manner as he may choose; and

c) The candidate who gets the highest number of votes shall be declared elected as director and then the candidate who gets the next highest number of votes shall be so declared and so on until the total number of directors to be elected has been so elected.

Removal

69. The Company may by resolution in general meeting remove a director appointed under Section 176 or Section 180 or elected in the manner provided for in Section 178.

Provided that a resolution for removing a director shall not be deemed to have been passed unless the number of votes cast in favour of such a resolution is not less than:


i) the minimum number of votes that were cast for the election of a director at the immediately preceding election of directors, if the resolution relates to removal of a director elected in the manner provided in sub-section (5) of Section 178; or

ii) the total number of votes for the time being computed in the manner laid down in sub-section (5) of Section 178 divided by the number of directors for the time being, if the resolution relates to removal of a director appointed under Section 176 or Section 180.

Vacation of Office

70. A director shall ipso facto cease to hold office if:

a) he becomes ineligible to be appointed a director on any one or more of the grounds enumerated in Section 187.

b) he absents himself from three consecutive meetings of the directors or from all the meetings of the directors for a continuous period of three months, whichever is the longer, without leave of absence from the directors;

c) he or any firm of which he is a partner or any private company of which he is director:

i) without the sanction of the company in general meeting accepts or holds any office of profit under

the company other than that of chief executive or legal or technical adviser or a banker; or

ii) accepts a loan or guarantee from the company in contravention of Section 195.

## CHIEF EXECUTIVE

First Appointment

71. The directors of the company as from a date not later than the fifteenth day after the date of its incorporation appoint any individual to be the chief executive of the company

Form of Office

72. The chief executive appointed as aforesaid shall, unless he earlier resigns or otherwise ceases to hold office, hold office upto the first annual general meeting of the company or, if a shorter period is fixed by the directors at the time of his appointment, for such period.

Subsequent Appointment and Term of Office

73. Within fourteen days from the date of election of directors under Section 178 or the office of the Chief Executive falling vacant, as the case may be, the directors of a company shall appoint any person, including an elected director, to be the chief executive, but such appointment shall not be for a period exceeding three years from the date of appointment.

Eligibility for reappointment

74. On the expiry of his term of office under Section 198 or 199, a chief executive shall be eligible for reappointment.

Continuation of office until Appointment of successor

75. The chief executive retiring under Section 198 or 199 shall continue to perform his functions until his successor is appointed unless non-appointment of his successor is due to any fault on his part or his office is expressly terminated.

Terms and Conditions

76. The terms and conditions of appointment of a chief executive shall be determined by the directors.

Deemed to be Director

77. The chief executive shall, if he is not already a director of the company, be deemed to be its director and be entitled to all the rights and privileges, and subject to all the liabilities, of that office.

Ineligibility

78. No person who is ineligible to become a director of a company under Section 187 shall be appointed or continue as the chief executive of the company.

Removal

79. The directors of a company by resolution passed by not less than three fourths of the total number of directors for the time being or the company by a special resolution may remove a chief executive before the expiration of his term of office notwithstanding anything contained in these articles or in any agreement between the company and such chief executive.

## SEAL

Common Seal

80. The company shall have a common seal and the director shall provide for the safe custody thereof. 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 authorised in that behalf by the directors and two directors or one director and the secretary of the company shall sign every instrument to which the common seal is affixed.

Official seal

81. The directors may provide for the use in any territory, district or place not situated in Pakistan of an official seal which shall be facsimile of the common seal of the Company with addition on its face of the name of every territory, district or place where it is to be used. The provisions of Section 213 shall apply to the use of such official seal.


## DIVIDENDS AND RESERVES

82. The company in general meeting may declare dividends but no dividend shall exceed the amount recommended by the directors.

Interim Dividend

83. The directors may from time to time pay to the members such interim dividends as appear to the directors to be justified by the profits of the company.

Dividend out of Profits only

84. No dividends shall be paid otherwise than out of profits of the year or any other undistributed profits.

No dividend out of Capital Profits

85. No dividend shall be declared or paid out of profits made from sale or disposal of any immovable property or assets of Capital nature comprised in the undertaking except after such profits are set off or adjusted against losses arising from the sale of any such immovable property or assets of Capital nature.

86. Subject to the rights persons (if any) entitled to shares with special rights as to dividends, all dividend shall be declared and paid according to the amounts paid on the shares, if and so long as nothing is paid upon any of the shares in the company, dividends may be declared and paid according to the amounts of the shares. Dividend in proportion to amount paid

87. Any general meeting declaring a dividend may resolve that such dividend be paid wholly or in part by the issue of paid up shares or debentures. Dividend in Specie

88. The directors may, before recommending any dividend, set aside out of the profits of the company such sums as they think proper as a reserve or reserves which shall, at the discretion of the directors be applicable for meeting contingencies, or for equalizing dividends, or for any other purpose to which the profits of the company may be properly applied, and pending such application may, at the like discretion, either be employed in the business of company or be invested in such investments (other than shares of the company) as the directors, may subject to the provisions of the Ordinance, from time to time, think fit. Transfer to Reserve

89. The directors may carry forward any profits which they may think prudent not to distribute, without setting them aside as a reserve. Retention of Profits

90. Any General Meeting may resolve that moneys, investments or other assets forming part of the Company standing to the credit of the Reserve Funds or in the hands of the Company and available for dividend or representing shares premium accounts be capitalized and distributed amongst such of the shareholders as would be entitled to receive the same if distributed by way of dividend and in the same proportions on the footing that they become entitled thereto as capital and that all or any part of such capitalized funds be applied on behalf of such shareholders in paying up in full any unissued shares of the Company which shall be distributed accordingly and that such distribution or payment shall be accepted by such shareholders in full satisfaction of their interest in the said capitalized sum. Capitalization of Reserves

91. If several persons are registered as joint-holders of any shares, any one of them may give effectual receipt for any dividend payable on the share. Dividend to joint-holders

92. The dividend shall be paid within thirty days of the declaration or otherwise in accordance with Section 251 of the Companies Ordinance, 1984. Time of payment

## BOOKS AND ACCOUNTS

93. The directors shall cause to be kept proper books of account as required under Section 230. — Books of account

94. 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. — Place where Books of account kept

95. The directors shall from time to time determine whether and to what extent and at what time and place and under what conditions or regulations the accounts and books or papers of the company or any of them shall be open to the inspection of members not being directors, and no member (not being a director) shall have any right of inspecting any account and book or papers of the company except as conferred by law or authorized by the directors or by the company in general meeting. — Inspection by members

96. The directors shall as required by Sections 233 and 236 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 sheet duly audited and reports as are referred to in those sections. — Annual accounts

97. A balance sheet, profit and loss account, income and expenditure account and other reports referred to in clause 96 above shall be made out in every year and laid before the company in the annual general meeting made up to date not more than four months before such meeting. The balance sheet and profit and loss account or income and expenditure account shall be accompanied by a report of the auditors of the company and the report of directors. — Presentation of Annual account before Annual General Meeting

98. Every account of the Company when audited and approved by a general meeting shall be conclusive except as regard any errors discovered therein within three months next after the approval thereof. Whenever any such error is discovered within that period, the account shall forthwith be corrected and thenceforth shall be conclusive. — When accounts settled

99. A copy of the balance sheet and profit and loss account or income and expenditure account and reports of directors and auditors shall, at least twenty one days preceding the meeting be sent to the persons entitled to receive notices of general meetings in the manner in which notices are to be given hereunder. — Copies to be sent to members

Compliance with Ordinance

100. The directors shall in all respects comply with the provisions of Sections 230 to 236.

## AUDIT

Audit

101. Auditors shall be appointed and their duties regulated in accordance with Sections 252 to 255.

## NOTICES

Mode of Service of Notice

102. 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 the giving of notices to him. 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 letter would be delivered in the ordinary course of post.

Notice by Newspaper

103. If a member has no registered address in Pakistan, and has not supplied to the company an address within Pakistan for the giving of notices to him, a notice addressed to him or to the shareholders generally and advertised in a newspaper circulating in the province of the registered office of the company shall be deemed to be duly given to him on the day on which the advertisement appears.

Company Registration Office Lahore Securities and Exchange Commission of Pakistan

Notice to joint-holders

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

Notice to person entitled to transmission

105. A notice may be given by the company to the person entitled to a share in consequence of the death or insolvency of a member by sending it through the post in a prepaid letter addressed to them by name, or by the title of representatives of the deceased or assignee of the insolvent or by any like description, at the address (if any) in Pakistan supplied for the purpose by the person claiming to be so entitled or (until such an address as been so supplied) by giving the notice in any manner in which the same might have been given if the death or insolvency had not occurred.

Notice of General meeting

106. Notice of every general meeting shall be given in some manner hereinbefore authorized to;

a) every member of the company except those members who, having no registered address within Pakistan, have not supplied to the company an address within Pakistan, for the giving of notice to them, and also to

b) every person entitled to a share in consequence of the death or insolvency of a member, who but for his death or insolvency would be entitled to receive notice of the meeting, and

c) to the auditors of the company for the time being.

## SECRECY

Secrecy

107. Every Director, Chief Executive, Secretary, Auditor, Trustee, Member of Committee, Officer, Servant, Agent, Accountant or other person employed in business of the Company shall, if so required by the directors before entering upon this duties, sign a declaration pledging himself to observe a strict secrecy respecting all transactions of the Company with its customers and the state of accounts with individuals and in matters relating thereto and shall by such declaration pledge himself not to reveal any of the matters which may come to his knowledge in the discharge of his duties except when required to do so by the directors or by any meeting or by a court of law or by the person to whom such matters relate and except so far as may be necessary in order to comply with any of the provisions in these presents.


Members' access to compan Premises

108. No member or other person (not being a director) shall be entitled to enter the property of the company or examine the company's premises or properties without the permission of a director, subject to Article 107, to require discovery of or any information respecting any detail of the Company's trading or any matter which is or may be in the nature of a trade secret, mystery of trade or secret process or of any matter whatsoever which may relate to the conduct of the business of the company and which in the opinion of the directors will be inexpedient in the interest of the members of the company, to communicate.

## WINDING UP

Division of assets in specie

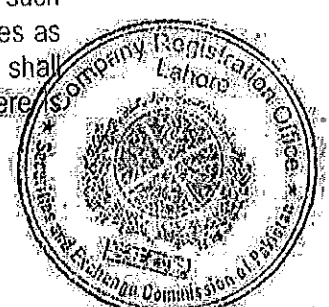
109. If the company is wound up, the liquidator may, with the sanction of a special resolution of the company and any other sanction required by the Ordinance, divide amongst the members, in specie or kind, the whole or any part of the assets of the company, whether they consist of property of the same kind or not.

Valuation by Liquidator

110. For the purpose aforesaid, the liquidator may set such value as he deems fair upon any property to be divided as aforesaid and may determine how such division shall be carried out as between the members or different classes of members.

Assets in Trust

111. The liquidator may, with like sanction, vest the whole or any part of such assets in trustees upon such trusts for the benefit of the contributories as the liquidators, with the like sanction, thinks fit but so that no member shall be compelled to accept any shares or other securities whereon there is any liability.




## INDEMNITY

Directors' and others' right to indemnify

112. Every officer or agent for the time being of the company may be indemnified out of the assets of the company against any liability incurred by him in defending any proceedings, whether civil or criminal, arising out of his dealings in relation to the affairs of the company, except those brought by the company against him, in which judgment is given in his favour or in which he is acquitted or in connection with any application under Section 488 in which relief is granted to him by the Court.

## ARBITRATION

Differences to be referred to mediator(s) and then arbitrator(s)

113. In the event that a dispute, claim or controversy arises between the company, its management and its shareholders, or between the shareholders inter-se, or the directors inter-se, all steps may be taken to settle the dispute and resolve the issue through mediation by an accredited mediator before taking recourse to formal dispute resolution such as arbitration or litigation. Any arbitration shall be held in London, United Kingdom.

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

| S. No. | Name and Surname (present & former) in full (in Block Letters) | NIC No. (in case of foreigner, Passport No.) | Father's/ Husband's Name in full | Nationality (ies) with any former Nationality | Occupation | Residential address in full | Number of shares taken by each subscriber | Signatures |
|---|---|---|---|---|---|---|---|---|
| 1 | K1 Energy (Lahore) Limited through its authorized representative Mr Carl Friedrich Edler Von Braun s/o Mr Franz Josef Von Braun | | | British | | 14, High Cross, Truro Cornwall TR1 2 AJ United Kingdom | 9,998 | |
| 2 | Carl Friedrich Edler Von Braun | C84PRLM13 | Franz Josef Von Braun | German | Businessman | Ferdinand-Lassalle-Strasse 15, 04109 Leipzig, Germany | 1 | |
| 3 | Charles Anton Milner | 525622078 | Karl Milner | British | Business-man | Pfalzburger Straße 60, 10717 Berlin, Germany | 1 | |
| | | | | | **Dated the 21st day of October, 2016** | **Total number of shares taken** | **10,000** | **(Ten Thousand)** |

**Witness to above signatures.**

**Signature**

**Full Name : MARLEN ZIMMERMANN**

**NIC Number : C3MX8VLR1**

**Father's Name: WOLFGANG ZIMMERMANN**

**Full Address : HEGELALLEE 12, 14467, POTSDAM, GERMANY**

***Occupation* : LEGAL ASSISTANT**

CERTIFIED TO BE TRUE COPY

27/4/2016

JOINT REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

# ENVIRONMENT PROTECTION DEPARTMENT

Government of the Punjab
National Hocky Stadium, Lahore.

NO. DD (EIA)/EPA/393(IEE)/2018/ 6/6/1808
Dated: 28 - 9 -2018

To,

Mr. Adeel Ahmed,
K1 Solar Power Lahore (PVT) limited,
2nd Floor Office No. 09 Link Farid,
Kot Road, Lahore.

Subject: **DECISION OF EPA PUNJAB REGARDING THE PROJECT "15 MW SOLAR POWER PLANT BY K1 SOLAR POWER LAHORE (PVT) LIMITED AT CHAK NO. 03 RAKH MANKERA, DISTRICT BHAKKAR."**

1. Description of Project: 15 MW Solar PV farm over an area of 62.4 acres.

2. Location of Project: Chak No. 03 Rakh Mankera, District Bhakkar

3. Date of filing: 04-06-2018

4. EPA Punjab has reviewed the Initial Environmental Examination Report (IEE) and considered Site Inspection Report received from Assistant Director Bhakkar vide letter No. 4316/AD/EPA/BK dated 13-07-2018. EPA Punjab has also considered the recommendations of **Committee of Experts** 18-08-2018 and other relevant record to take lawful decision.

5. **Environmental Protection Agency, Punjab accords Environmental Approval under Section 12 of PEPA, 1997 for Construction of your aforesaid project subject to the following conditions:**

i. The Proponent shall ensure compliance of Punjab Environmental Quality Standards (PEQS).
ii. Mitigation Measures suggested in the IEE report and Environmental Management Plan (EMP) shall be strictly adhered to minimize any negative impacts on soil, ground water, air and biological resources of the project area.
iii. Monitoring shall be carried out during the entire period of the project activities. Monitoring reports shall be submitted to EPA Field office in the district on quarterly basis.
iv. The Proponent shall take measures to conserve water resources by incorporating rain water harvesting and ensuring provision of ground water recharge galleries. Furthermore Proponent shall not pollute or over draw any surface water body in the vicinity of the project.
v. The Proponent shall ensure that strict and efficient health and safety measures are in place for protection of workers backed by a comprehensive emergency response system while working.
vi. The Proponent shall redress the objection / concerns of neighbours / stakeholder on priority basis (if any at any stage).
vii. The Proponent shall obtain No Objection Certificates/ clearance of all other concerned departments before commencement of work.
viii. The Proponent shall follow the SOPs regarding dengue larvae eradication and shall ensure removal of stagnant water on daily basis.
ix. The Proponent shall plant 3000 trees of indigenous species of 6-7 feet height in the district in consultation with Assistant Director of District **Bhakkar** within six months. The Proponent shall also take measures for protection and maintenance of these trees and maintain their proper record for verification by EPA.
x. Camping sites shall be located at suitable distance away from any settlement to avoid disturbance to the local people. These shall be constructed at a suitable distance from any permanent or seasonal water source. Septic tank shall not be located in the areas where high ground water table exists.
xi. The Proponent shall avoid the disturbance of the traffic flow during construction and operation phase.
xii. The Proponent shall provide compensation to the inhabitants in case of loss of agricultural land, crop, property, etc. in accordance with the rates that are agreed upon. All conflicting issues regarding compensation, etc. should be settled amicably before the start of the project activities.
xiii. The Proponent shall ensure proper cleanliness arrangements and shall dispose of solid waste in a proper scientific way.

xiv. The Proponent shall take necessary measures to safeguard social and economic conditions affecting the community life.

xv. The construction material shall be piled / stored in such a way that it shall not destroy the flora / environment of the locality.

xvi. The proponent shall dispose of wastewater after treatment.

xvii. waste shall be retained within the unit boundary / premises and shall be disposed of in an environmental friendly way at a suitable disposal facility

xviii. The proponent shall take effective measures for safe transportation of Photovoltaic Cell / Solar Panel.

xix. The proponent shall ensure that the functionality of design will remain same during construction phase.

xx. The Proponent shall not use ground water for washing of solar panels and shall use alternate methods in this regard

xxi. The proponent shall dispose of discarded solar panels and electronic waste in scientific manner.

6. The Proponent shall, before commencing construction of the project, acknowledge acceptance of the stipulated conditions by executing an Undertaking in the form prescribed in Schedule VII of Review of IEE/EIA Regulations 2000.

7. The Proponent shall be liable for correctness and validity of information supplied to this department directly or through the environmental consultant.

8. This approval is accorded only for the construction phase of the project. The Proponent shall apply for confirmation of compliance under Regulation 14 of IEE / EIA Regulation, 2000 by submitting Environmental Management Plan for operational phase along with compliance status report of the Environmental Approval of the construction phase of the project.

9. The Proponent shall be liable for compliance of Regulations 13, 14, 18 and 19 of IEE/EIA Regulations, 2000, regarding approval, confirmation of compliance, entry, inspections and monitoring.

10. EPA reserves the right to impose any other condition based on its monitoring.

11. Any change in the approved project shall be communicated to EPA, Punjab and shall be commenced after obtaining the approval.

12. This approval shall be treated as null and void if all or any of the conditions mentioned above, is/are not complied with and in case of any interim injunction by any court of law against said project.

13. This approval shall be valid (for commencement of construction) for a period of three years from the date of issue under Regulation 17 of IEE / EIA Regulations, 2000.

14. This approval can be withdrawn at anytime without any prior notice if deemed necessary in the public / national interest.

15. This decision is issued with approval of Director General, EPA, Punjab.

ASSISTANT DIRECTOR (EIA)

**NO. & DATE EVEN.**

A copy is forwarded to the Assistant Director Bhakkar vide letter No. 4316/AD/EPA/BK dated 13-07-2018 . He is requested to:

i. Obtain undertaking from the project Proponent mentioned at para 6 for the record of EPA Headquarter and Field Office.

ii. Ensure compliance of the conditions mentioned in the Environmental Approval and maintain the file / record of correspondence with the project Proponent properly.

ASSISTANT DIRECTOR (EIA)

# Faisalabad Electric Supply Company Limited

FESCO

Tel # 041-9220179
Fax # 041-9220511

OFFICE OF
THE CHIEF ENGINEER (P&D)
FESCO FAISALABAD
Dated 26 /03/2019

No. 2271-74/CE(P&D)

Mr. Adeel Ahmed,
Business Development Manager,
Ib vogt GmbH
K1 Solar Pvt Ltd,
216 Landmark Plaza, Jail Road, Gulberg Lahore

**Subject:** **ISSUANCE OF CONSENT FOR EVACUATION OF POWER BASED ON GIA REPORT FROM IBTVOGT 15MWp GROSS POWER SOLAR POWER PLANT AT JHANG BHAKKAR, FAISALABAD, PUNJAB**

**Ref:** **Your office letter no. 2809GI-S dated 28.09.18 and letter no. FE2003 dated 20.03.2019.**

With reference to above mentioned letter no. the revised final grid interconnection assessment (GIA) report of 15MWp Gross Power (net AC Power 12.5MW) Solar Power Plant was received. After review and vetting, it is stated that FESCO has no objection to evacuate Power from 15MWp Solar Power Project at Jhang Bhakkar, Faisalabad Punjab.

Furthermore, it is also mentioned that the current infrastructure of FESCO is reliable for this project.

Chief Engineer (P&D),
FESCO FAISALABAD

C.c to:

1. The Chief Executive Officer (CPPA-G), Ground Floor, ENERCON Building, G-5, Islamabad.
2. General Manager (Tech.) FESCO, Faisalabad
3. ARCO Energy Pakistan, Office No.515, Eden Tower, Main Boulevard, Gulberg, Lahore

ibvogt

# TECHNICAL FEASIBILITY STUDY

# MANKERA SOLAR PROJECT – PUNJAB - PAKISTAN

## FOR K1 SOLAR POWER LAHORE PRIVATE LTD.

FEBRUARY 18, 2018

# Contents

## Glossary / List of Abbreviations

| Acronym or keywords | Definition |
|---|---|
| **PPDB** | Punjab Power Development Board |
| **AC** | Alternating Current |
| **Corrected PV split from the combined feed-in** | Share of energy fed in that is coming from the PV side, after curtailment due to energy feed-in from wind turbines and correction for data gaps |
| **Capex** | Capital Expenditure |
| **CUF** | Capacity Utilization Factor - the ratio, given as percentage, of the actual AC output from a solar plant over the year to the maximum output that would be generated if operated continuously at maximum capacity |
| **DC** | Direct Current |
| **W.C.S.** | Worst Case Scenario |
| **EIA** | Environmental Impact Assessment |
| **EMP** | Environmental Management Plan |
| **EPC Contractor** | Engineering, Procurement and Construction Contractor - the entity that will be contracted to design, buy the necessary materials, and construct the Plant |
| **GHG** | Greenhouse Gases |
| **GHI** | Global Horizontal Irradiation - the amount of irradiation falling on a horizontal plane over a period. Usually measured in kWh of energy falling on a square meter over a set amount of time (hourly, daily , monthly or annually), e.g. kWh/m2/yr |
| **GII** | Global Inclined Irradiation - the amount of irradiation falling on an inclined or tilted plane over a period of time Effective GIi is the amount of irradiation that falls on a plane that tracks the sun such as those used in single axis tracking PV systems |
| **HV** | High Voltage |
| **IEE** | Initial Environmental Examination |
| **IFC** | International Finance Corporation |
| **ILO** | International Labor Organization |
| **IRR** | Internal Rate of Return - the rate that results in the Net Present Value equal to zero |
| **kV** | Kilo-Volts ( 1 kV = 1000 Volts) |
| **LCOE** | Levelised Cost of Electricity |
| **LID** | Light Induced Degradation |
| **LV** | Low Voltage |
| **MPPT** | Maximum Power Point Tracker |
| **MRA** | Maintenance Reserve Account |
| **MV** | Medium Voltage |

| | |
|---|---|
| **MVA** | Mega-Volt-Amps , a measure of the capacity of a power line or transformer to carry real and reactive power |
| **MWp** | The nameplate capacity of PV modules on a site measured in Mega-Watt peak. Also, expressed as kWp or Wp |
| **NPV** | Net Present Value - a financial formula to calculate the potential return from an investment |
| **O&M** | Operations and Maintenance |
| **Opex** | Operational Expenditure |
| **PEPA** | Punjab Environmental Protection Agency. |
| **P50** | A value which is based on uncertainties and probabilities, has a 50% chance of being exceeded. For example, the P50 yield number is the estimate for the yield produced and the probability of the actual yield being higher is 50% and lower is also 50% |
| **P90** | A value which, based on uncertainties and probabilities, has a 90% chance of being exceeded. For instance, the P90 yield number is the estimate for which the probability of the actual yield being higher is 90% and lower is 10% |
| **POC** | Point of Connection (to the electricity grid) |
| **PR** | Performance Ratio - a measure of how well the plant performs compared to an ideal case. This parameter given as a percentage indicates the ratio between the actual and theoretically possible energy outputs. If multiplied by the GIi, this ratio gives the P50 Specific Yield of a project |
| **PV** | Photovoltaic |
| **R.O.W** | Right of Way |
| **RE** | Renewable Energy |
| **SEP** | Stakeholder Engagement Plan |
| **SLD** | Single Line Diagram |
| **Specific yield** | A measure of the energy produced by the plant over a year divided by its nominal installed capacity which allows for comparison of the performance of different sized plants Usually measured in kWh/ yr. of energy produced per kWp of PV installed |
| **VSAT** | Very Small Aperture Terminal |

Issue and Revision Record

| Revision | Date | Originator | Checker | Approver | Status |
|---|---|---|---|---|---|
| A | 13/08/2018 | AA, MC, EN, HM,JM, CB, JJ, | MC, AA | MC | 1st Draft |
| B | 18/02/2019 | AA, MC, EN, HM,JM, CB, JJ, AB, AS, SR, DS, RK | MC, AA | MC | 2nd Draft |
| | | | | | |
| | | | | | |

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# 1. Project Overview and Back Ground

K1 Solar Power Lahore (Pvt.) Limited (KSPL) is a special purpose vehicle, set up to develop, build, own and operate a 12.5 MW AC ~ 15 MW DC Solar Power Plant in Mankera, Punjab. Thus contributing to the national development by providing self-sufficiency in power and reducing dependence on fossil fuels. K1 Solar Power Lahore (Pvt) Limited, is fully incorporated with Securities & Exchange Commission of Pakistan. SPV is owned by Consortium of three companies, ibvogt Gmbh, Vogt Solar and GEUK.

Established in 2002, ibvogt GmbH specializes in the development, design & engineering, financing, EPC, operation & maintenance and asset management of solar power plants. The company provides high-quality turnkey solar power plant solutions, designed and engineered in Germany, to end investors internationally. Vogt Solar is subsidy of ibvogt and has built over 400MW of solar farms in UK alone. vogt solar's activities cover project development, engineering, procurement and construction (EPC), operation and maintenance (O&M) and ownership and asset management of its solar farm portfolio. The company focuses on solar farm solutions to maximise lifecycle performance.

Whereas Green Energy UK Direct is a Manchester based developer, who develops solar projects for the end investors. The successfully developed solar projects portfolio of GEUK Direct ranges from 60MW – 100MW.

In 2015 ibvogt, Vogt Solar and GEUK Direct made a consortium and applied for three solar projects against a public tender, advertised by Govt. of Punjab Energy Department. A consortium agreement was signed between three companies and registered with Punjab Power Development Board (PPDB). As per Consortium Agreement ibvogt Gmbh was nominated as main sponsor of the project.

Consortium was than awarded with 15MW DC Moza Rakh Chabeel Site in Lahore in 2016 and was issued a pre-qualification letter in 2017. Due to unavailability of Public land for the project, Consortium received a delayed LOI approval letter for having a solar project anywhere in Punjab or on the public site against which Consortium has submitted its Statement of Qualification. Due to time constraint main sponsor ibvogt Gmbh and Consortium members decided to lock the private land for the project. Consortium immediately locked the private land and started the necessary feasibility study work as per milestones mentioned in the LOI.

The LOI is valid until October 2018, and it can be extended one time while submitting a double bank guarantee in favor of PPDB. The first feasibility study draft needs submission by 3rd of September 2018 as per timelines mentioned in LOI issued by Punjab Power Development Board.

Consortium through their main sponsor, ibvogt Gmbh started working on the Feasibility study. ib vogt recently conducted a Wind Solar hybrid feasibility study for Fauji Fertilizer Company in Pakistan and the study has been recently approved by AEDB Panel of Experts. The objective of Mankera Solar farm study is to assess the feasibility of the project and is structured as follow:

- Project Overview; complete understanding of the solar power project.
- Site appraisal geotechnical investigation.
- Planning policy statement;
- Desktop based Environmental and Social Impact Assessment (IEE attached as Annex – I)

- Design and Access Statement
- Capacity and Layout of solar PV power plant to optimize combined plant economics and minimize curtailment.
- Energy Yield Assessments of solar PV system on P50 basis.
- Economic analysis including total project cost estimations for the construction and operation of the plant along with various sensitivities.

## 1.1 Site and Works overview

Key details for the project are shown in Table 1 and the location of the proposed site is indicated in Fig 1

| S.No. | Entry | Details |
|---|---|---|
| 1 | Site Name | Mankera Solar Farm |
| 2 | Site Coordinates | P1= 31°24'3.62"N, 71°28'42.77"E<br>P2= 31°24'15.96"N, 71°28'42.54"E<br>P3= 31°24'16.54"N, 71°29'8.41"E<br>P4= 31°24'4.38"N, 71°29'7.94"E |
| 3 | Altitude | 164 m (Highest recorded value)<br>162 m (Lowest recorded value) |
| 4 | Proposed AC and DC capacity | 12.5 MW AC ~ 15 MW DC |
| 5 | Global irradiation levels | 1784 KWh / $m^2$ (Solar GIS) |

Table 1 showing the site coordinates, altitude, capacity and GHI value

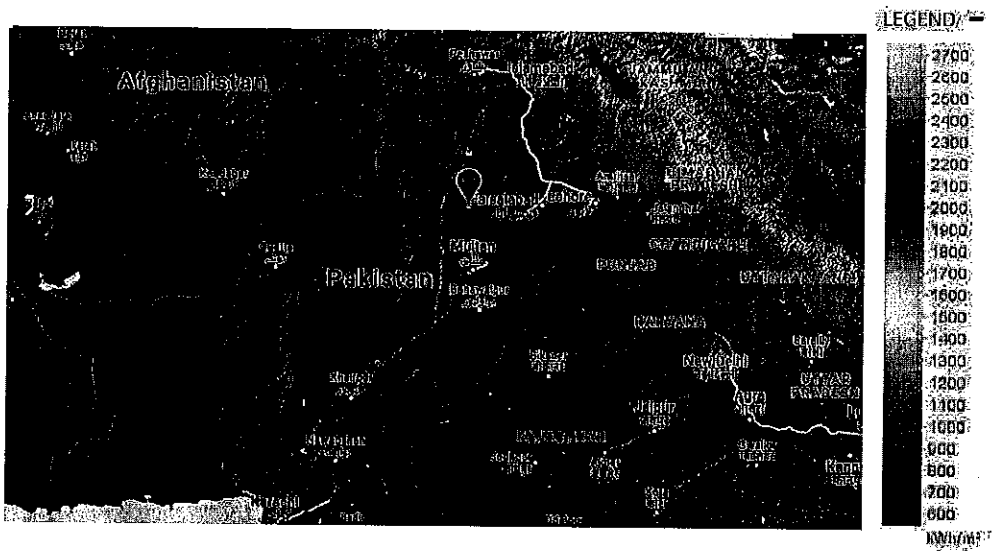



Figure 1 showing GHI value for the site

Global horizontal irradiation map for Pakistan can be seen in Figure 1 with the location of the proposed site. (ESMAP, Solar GIS).

The proposed layout is for a ground mounted single axis tracker system using Bankable Tier 1 monocrystalline modules and European central inverters. A drawing of the proposed layout is shown in Annexure A.

An indicative timeline for the Project is shown in Annexure B Contractors will be required to comply with a prearranged schedule of works and complete the construction and installation of equipment by the required deadline. We recommend that permits, equipment, infrastructure logistics and grid application be secured for the Project prior to commencement of works

## 1.2 Pakistan Power Market

Electricity is life line of any economy and most vital instrument of socioeconomic development of a country. Electricity is pivotal in running machinery in factories and industrial units, for lighting our cities and powering our vehicles. The challenge of ensuring electricity access for industries and providing increased access to the poor parts of the population is the key issue for any government.

There has been an enormous increase in the demand of energy because of industrial development and population growth, in comparison to enhancement in energy production. Supply of energy is, therefore, far less than the actual demand, resultantly crisis has emerged.

Pakistan's energy infrastructure is not well developed; rather it is underdeveloped and poorly managed. Currently the country is facing severe energy crisis. Moreover, rapid demand growth, transmission losses due to outdated infrastructure, power theft, and seasonal reductions in the availability of hydropower have worsened the situation. Consequently, the demand exceeds supply and hence load-shedding is a common phenomenon through power shutdown.

## 1.3 Electricity sector structure

Pakistan power sector constitutes of four major entities, Water and Power Development Authority (WAPDA), Karachi Electric Supply Corporation (KESC), Independent Power Producers (IPPs), Pakistan Atomic Energy Commission (PAEC).

Two vertically integrated public entities, i.e. WAPDA, which serves entire country except economical capital – Karachi and KESC that solely facilitates Karachi as well as its surroundings.

Under 1997 "The Regulation of Generation, Transmission and Distribution of Electric Power Act" National Electric Power Regulatory Authority (NEPRA) was formed; with a challenging charter to operate as an independent regulator and to devise a transparent, economically dynamic, competitive power sector in Pakistan. The National Electric Power Regulatory Authority ('NEPRA") is an independent regulator setup for the regulation of Pakistan' s power sector to balance the interests of consumers and power sector companies NEPRA develops the regulatory regime and future market design for the power sector. All generation transmission and distribution companies are now licensees of NEPRA and matters related to tariffs, licensing, safety, grid codes, consumer interest are regulated by NEPRA.

WPDA Power wing was further transformed into four sub tier entities GENCOs (Generation Companies), Eleven DISCOs (Distribution Companies), one NTDC (National

Transmission & Dispatch Company) and KESC (Karachi Electric Supply Corporation) later named K-Electric after privatization. Pakistan Atomic Energy Commission was than established for generation of electricity from Nuclear Power. Private Power infrastructure board was established to magnetize the investment from private sector through a one window operation. To explore the opportunities in the field of renewable energy Alternative Energy Development Board was

recently established with aim of generation of electricity through alternative resource. Provinces after the empowerment from Council of Common Interest can generate their own electricity and each province has their own power development boards including AJK.

Central Power Purchase Agency ("CPPA"), a public-sector agency. has recently become active for the centralized purchase of power from all existing and upcoming private and public sector power producers. All public-sector agencies/companies are administered/overseen by the Ministry of Water & Power, Govt of Pakistan.

## 1.4 Situational Analysis

The overall power generation capacity of Pakistan at the end of 2013-17 was 28,172 Mega Watt (MW) on the NTDC system and 2,709 MW on K-Electric. Against this installed capacity, the power generation was 120,692 GWh, which represents 44 per cent average capacity utilization. Seasonal variation in hydro power generation, de-rated capacity of the public-sector generating units and failure of timely supply of fuels to the IPPs are main causes of low-capacity utilization.

| S.NO | Peak demand during July 2017 (MW) | Generation during July 2017 (MW) | Surplus (MW) | Short fall due to 19.4% losses (MW) |
|---|---|---|---|---|
| 1 | 25717 | 30881 MW | 5164 | 826 |

Table 2 showing peak demand and generation during July 2017 (source: NTDC)

The situational analysis for year 2017 shows that Country has now surplus generation but still due to weak transmission system there are lot of line losses and Country still faces load shedding especially in rural areas where power Generation projects are not located closer to the existing grid. To improve the situation National Transmission and Dispatch Company is supporting the new renewable energy generation projects near the load centers and to the National Grid. So that line losses can be reduced. Proposed solar project is also located near to the and exiting grid and it's in 5km radius of the Mankera grid making it closer load center.

## 1.5 Current Statistics

Installed Capacity (MW)

| Installed Capacity (MW) | | | | | |
|---|---|---|---|---|---|
| **Description** | **2013** | **2014** | **2015** | **2016** | **2017** |
| **Hydel** | | | | | |
| Wapda Hydel | 6733 | 6902 | 6902 | 6902 | 6902 |
| IPPs Hydel | 195 | 195 | 213 | 213 | 213 |
| **Thermal** | | | | | |
| GENCOs with PEPCO | 4785 | 5458 | 5788 | 5788 | 5762 |
| KE Own | 2341 | 2422 | 1875 | 2295 | 2295 |
| **IPPs** | | | | | |
| IPPs connected with PEPCO | 8381 | 8793 | 8857 | 8842 | 12428 |
| IPPs connected with KE | 289 | 228 | 352 | 349 | 339 |
| **Nuclear** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| CHANUPP (PAEC) | 650 | 650 | 650 | 650 | 990 |
| KANUPP (PAEC) | 137 | 137 | 75 | 75 | 75 |
| **Renewable** | | | | | |
| Solar | 0 | 0 | 100 | 400 | 400 |
| Wind | 50 | 106 | 256 | 306 | 782 |
| Bagasse | 0 | 0 | 83 | 146 | 281 |
| Distributed Generation Capacity / Imports | | | | 413 | 413 |
| **Total PEPCO** | 20850 | 22104 | 22849 | 23247 | 28172 |
| **Total KE** | 2767 | 2787 | 2302 | 2719 | 2709 |
| **Total Installed Capacity** | 23617 | 24891 | 25151 | 25966 | 30881 |

Table 3 showing generation from different sources up till 2017 (source: NTDC)

## 1.6 Energy Mix

Most of the power generated from Pakistan is coming from two main sources Thermal and Hydro. The installed generation capacity by June 2017 and energy mix is as follows:

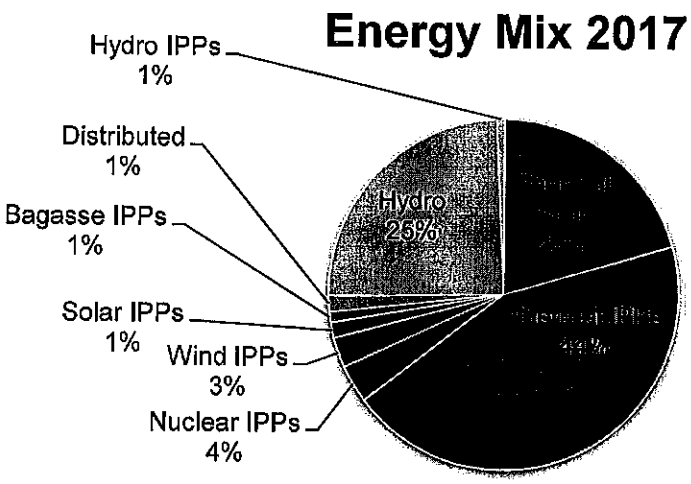



Figure 2 showing current energy mix of Pakistan (source: NTDC)

## 1.7 Pakistan Power Pakistan - Key Challenges

Pakistan's power sector is currently afflicted by several challenges.

### 1.7.1 Energy Mix

Due to poor energy mix, most of the country generation is coming from thermal fuel sources including furnace oil and high speed diesel, which results in expensive generation 12 USD cents / KWhr on average.

### 1.7.2 Transmission and Distribution infrastructure

High losses, in range of 19.4% is because weak transmission and distribution infrastructure. The inefficiencies and high cost of generation are resulting in high levels of subsidies and circular debt. This also include loses due to theft as well.

### 1.7.3 Electricity shortfall due to losses

Due to high energy losses, still country faces load shedding problem and taking transmission losses into account, still electricity shortfall of 826.914 MW.

### 1.7.4 Installed and Planned Power Projects up to 2018-2019

| Sr. No. | Names of projects Agency | Fuel | Location | Installed capacity (MW) |
|---|---|---|---|---|
| 1 | Quaid-e-Azam Solar Park PPDB (Phase-1) | Solar | Lal Sohnra (Cholistan), Punjab | 100 |
| 2 | FWEL-I AEDB | Wind | Jhampir/Gharo/Bhambore, Sindh | 150 |
| 3 | Nandipur (Remaining Unit-CC) GENCO | RFO | Gujranwala, Punjab | 425 |
| | **Total generation addition in 2014-15** | | | **675** |
| 4 | Sapphire Wind Power Plant AEDB | Wind | Jhampir/Gharo/Bhambore, Sindh | 50 |
| 5 | CHASNUPP-III PAEC | Nuclear | Chashma, KPK | 340 |
| 6 | Other Wind Power Plants AEDB | Wind | Jhampir/Gharo/Bhambore, Sindh | 330 |
| 7 | Quaid-e-Azam Solar Park PPDB (Phase-2) | Solar | Lal Sohnra (Cholistan), Punjab | 300 |
| | **Total generation addition in 2015-16** | | | **1,020** |
| 8 | Other Wind Power Plants AEDB | Wind | Jhampir/Gharo/Bhambore, Sindh | 1,120 |
| 9 | Neelum Jhelum Hydel WAPDA | Hydel | Nauseri/Muzaffarabad, AJK | 969 |
| 10 | CHASHNUPP-IV PAEC | Nucl | Chashma, KPK | 340 |
| 11 | Tarbela 4th Ext. Project WAPDA | Hydel | Tarbela, KPK | 1,410 |
| 12 | Patrind HPP PPIB | Hydel | Kunhar River, KPK/AJK | 147 |
| 13 | LNG Based Plants (Phase-I) PPIB | LNG | Bhikki and Baloki, Punjab | 2,400 |
| 14 | Quaid-e-Azam Solar Park PPDB (Phase-3) | Solar | Lal Sohnra (Cholistan), Punjab | 600 |
| | **Total generation addition in 2016-17** | | | **6,986** |

| | | | | |
|---|---|---|---|---|
| 15 | Keyal Khwar WAPDA | Hydel | Dasu District, KPK | 122 |
| 16 | Coal Plant at Sahiwal PPDB | Coal | Sahiwal, Punjab | 1,320 |
| 17 | Port Qasim Power Plant PPIB | Coal | Port Qasim Karachi, Sindh | 1,320 |
| 18 | Engro Thar Coal (unit-1) PPIB | Coal | Thar, Sindh | 330 |
| 19 | Nooriabad Gas Plant GoS | Gas | Nooriabad ,Sindh | 100 |
| 20 | Engro Thar Coal (unit-2) PPIB | Coal | Thar, Sindh | 330 |
| 21 | LNG Based Plants (Phase-II) PPIB | LNG | Haveli Bahadur Shah (Jhang), Punjab | 1,200 |
| 22 | Coal Plant at Salt Range PPDB | Coal | Salt Range, Punjab | 300 |
| 23 | Tarbela 5th Ext. Project WAPDA | Hydel | Tarbela, KPK | 1,400 |
| 24 | S S R L TCEB | Coal | Thar, Sindh | 1,320 |
| | **Total generation addition in 2017-18** | | | **7,742** |
| 25 | Golen Gol HPP WAPDA | Hydel | Chitral, KPK | 106 |
| 26 | HUB Power Company Ltd. PPIB | Coal | HUB, Baluchistan | 1,320 |
| 27 | Siddiqsons Limited TCEB | Coal | Port Qasim, Sindh | 350 |
| 28 | Lucky Electric Power Company Ltd. TCEB | Coal | Port Qasim, Sindh | 660 |
| 29 | Grange Holding PPIB | Coal | Arifwala, Punjab | 163 |
| 30 | Gulpur Poonch river PPIB | Hydel | Poonch River/Gulpur, AJK | 100 |
| | **Total generation addition in 2018-19** | | | **2,699** |
| | **Total addition during the Plan period** | | | **19,122** |

Table 4 showing installed and planned capacity up till 2018 - 2019 (source: NTDC).

# 2. Site Appraisal

Punjab Power Development Board (PPDB) awarded the LOI to Consortium for anywhere in Punjab. The consortium through its main sponsor / lead developer ibvogt Gmbh started looking for land and visited almost 16 – 20 sites in different areas of Punjab. The sites were assessed on the basis of the following factors:

1. Location
2. Access
3. Proximity to Grid
4. Terrain
5. Geo tech
6. Flood Risk
7. Shading
8. Irradiation levels
9. Land use
10. Landscape & Visual Impact
11. Availability of utilities (Gas, Water & Electricity)
12. Any National or local planning designation
13. Environmental Impact
14. Land Cost
15. Legal ownership any court litigation

After site surveys and desktop assessment Mankera site was selected as a feasible option from financial and technical perspective. Site was further appraised while going through following steps:

- Preliminary technical and financial assessment for pre-feasibility
- Pre-Feasibility technical and financial assessment
- Site visit

## 2.1 Preliminary technical and financial assessment

ibvogt as a lead developer carried out an in house technical and financial assessment for Mankera site. The project development cost component was assessed as per NEPRA guidelines. NEPRA only allows certain per MW development cost as a tariff component. It was made sure that due to cost of land the overall project development cost should not go beyond NEPRA threshold. All the numbers were put in the financial model and a suitable but competitive tariff was identified. Also our local Grid Consult Arco Energy performed a Desktop based assessment (DBA). The DBA showed that site is approx. 4.2 km away from the 66KV Mankera Grid station and grid connection is possible at 11KV. Grid Consultant also suggested that due to NEPRA Grid Interconnection guidelines for renewable energy project, only projects below 12.5 MW AC can be connected at 11KV. Hence the project AC Capacity was capped at 12.5 MW AC to meet the NEPRA guidelines.

### 2.1.1 Pre-Feasibility

A pre-feasibility technical and financial assessment was then carried out by Lead developer ibvogt to for in house strategic meeting and following outcomes were shared with Board.

**Summary**

- The Solar System appears to be extremely viable and economically attractive,
- The optimal system sizing is expected – depending on several factors (NEPRA Grid Interconnection guidelines, IRR or NPV maximization) to be 12.5 MW AC ~ 15 MW DC
- At a PPA with a tariff of $ 6,07 c/kWh an IRR for such system would be expected of ~ >15-16% (range) assuming "normal" costs in the region
- The optimal technology choice is likely to be "Manual Seasonal Tilt"
- There is strong potential to increase the IRR through (a) Total Cost and (b) Financial structuring
- As a further potential, installing short term battery storage to minimize short term fluctuation driven curtailments could be very beneficial and increase the overall project sizing – probably a "Phase 2".
- Information regarding the above is supplied below, together with technical team thoughts on the relevant planning assumptions
- It is recommended that a detailed Feasibility Study should be undertaken to deepen, verify and optimize potentials in the Project

## 2.2 Site Visit

After the submission of pre-feasibility work, a site visit was then carried out to gather the primary data from the site.

### 2.2.1 Site Location

The Solar Farm site is located in Mankera District Bakhar, Punjab. Most of district lies in the desolated plains of Thal Desert.

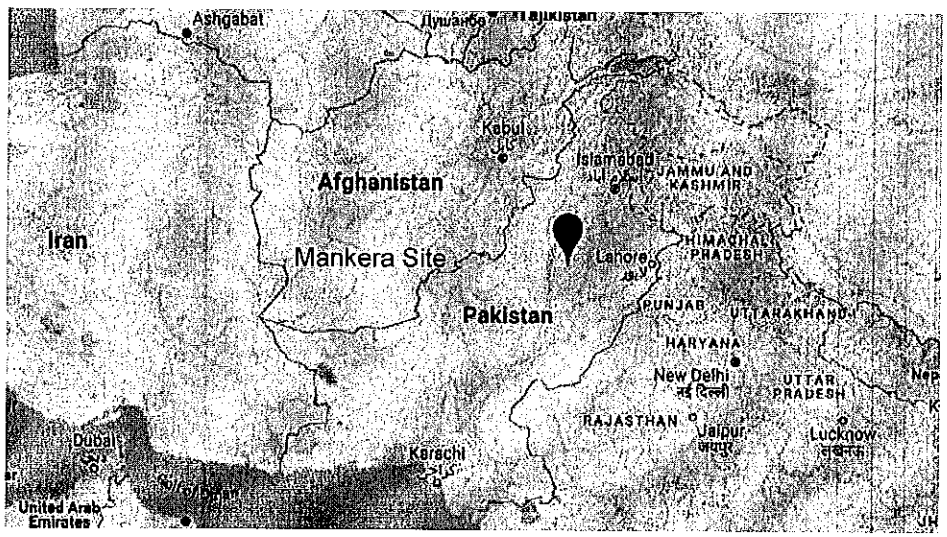



Fig 3 showing the location of Mankera Solar Farm site

## 2.2.2 Weather Data Meteonorm

Weather for the Mankera Solar farm site is collected from the two data set sources Meteonorm and Solar GIS. Both the data sets were analyzed and data with lower expected bias value was selected for the detailed technical analysis.

## 2.2.3 Average Temperature Data Mankera (Meteonorm)

The max average annual temperature recorded at the site is above 45 $^{0}$C for month of June. High temperatures, can affect the efficiency of solar cells. Hence solar panels with permitted module temperature between -40 $^{o}$C to +85 $^{o}$C will be used for the Mankera Solar farm site.

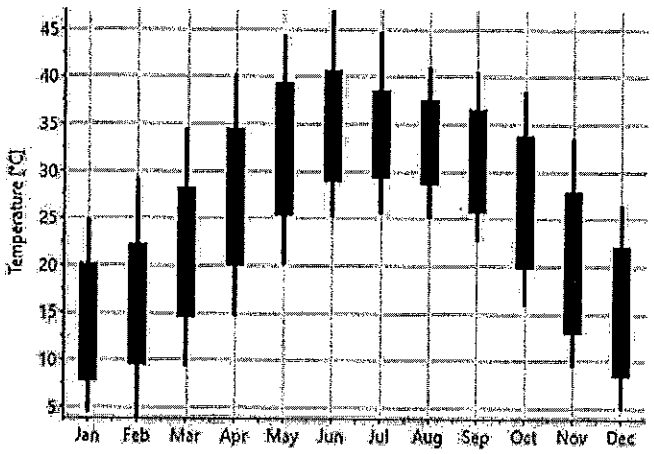



Fig 4 showing min, max and average temperatures at Mankera

## 2.2.4 Average Temperature Data Mankera (Meteonorm)

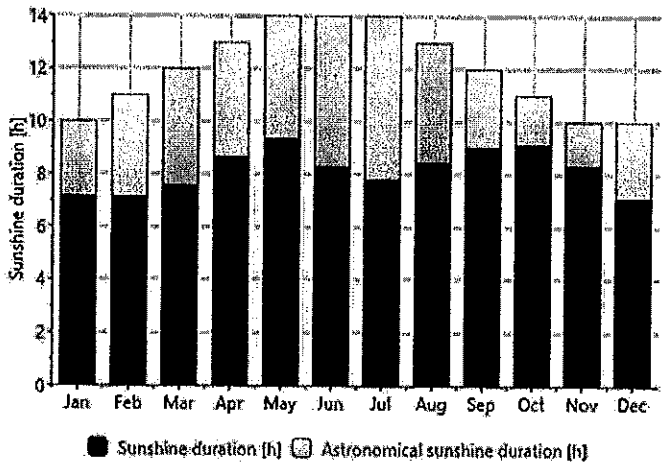



Fig 5 sowing sunshine hours at the Mankera site

## 2.2.5 Average Rainfall (Meteonorm)

Weather at Mankera site is usually dry and it only rains heavily during the wet season of Monson. The following precipitation graphs show the high values for precipitation and days from June to September.

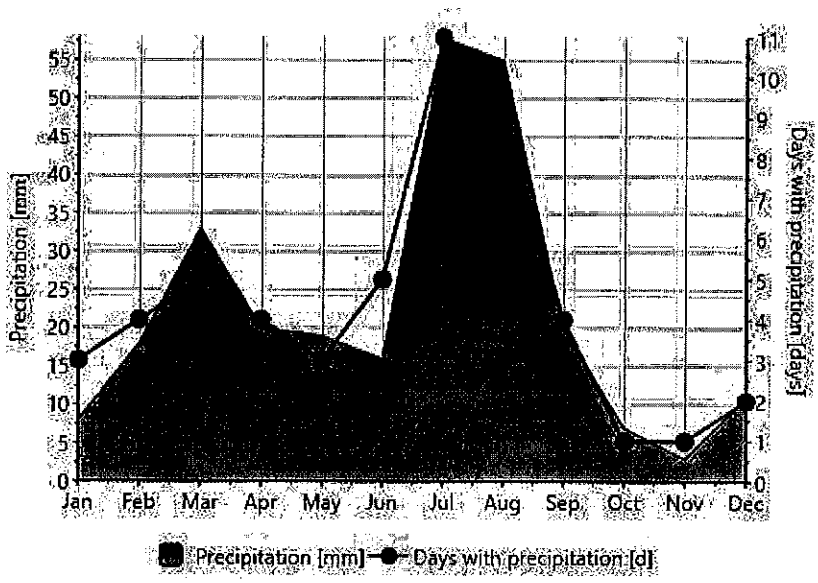



Fig 6 showing precipitation graph in Mankera

## 2.2.6 Solar irradiation (Meteonorm)

Mankera solar farm site is near to Northern areas of Pakistan and blessed with annual Global Horizontal Irradiation value of 1724 KWhr/$^2$m, making it suitable site for a solar farm development.

| | GH | DH | BN | TA | TD | FF |
|---|---|---|---|---|---|---|
| | KWH/$^2$M | KWH/$^2$M | KWH/$^2$M | $^O$C | $^O$C | M/S |
| JAN | 97 | 44 | 110 | 13.3 | 8.1 | 1.8 |
| FEB | 109 | 52 | 103 | 15.9 | 9.2 | 2.3 |
| MAR | 150 | 69 | 127 | 21 | 13.8 | 2.3 |
| APRIL | 172 | 86 | 122 | 27.4 | 16.5 | 2.3 |
| MAY | 191 | 96 | 129 | 32.2 | 18 | 2.3 |
| JUNE | 185 | 97 | 117 | 35.3 | 22.6 | 2.7 |
| JULY | 177 | 100 | 104 | 33.9 | 26.4 | 2.6 |
| AUG | 169 | 98 | 97 | 33 | 26.9 | 2.6 |
| SEPT | 154 | 82 | 108 | 31.4 | 24.7 | 2.2 |
| OCT | 131 | 67 | 104 | 26.4 | 19 | 1.8 |
| NOV | 99 | 49 | 100 | 20.1 | 14.6 | 1.8 |
| DEC | 91 | 40 | 112 | 14.5 | 10.1 | 1.8 |
| ANNUAL | 1724 | 880 | 1333 | 25.4 | 17.5 | 2.2 |

Table 5 showing irradiation levels at Mankera

Gh: Global horizontal radiation ("GHI")

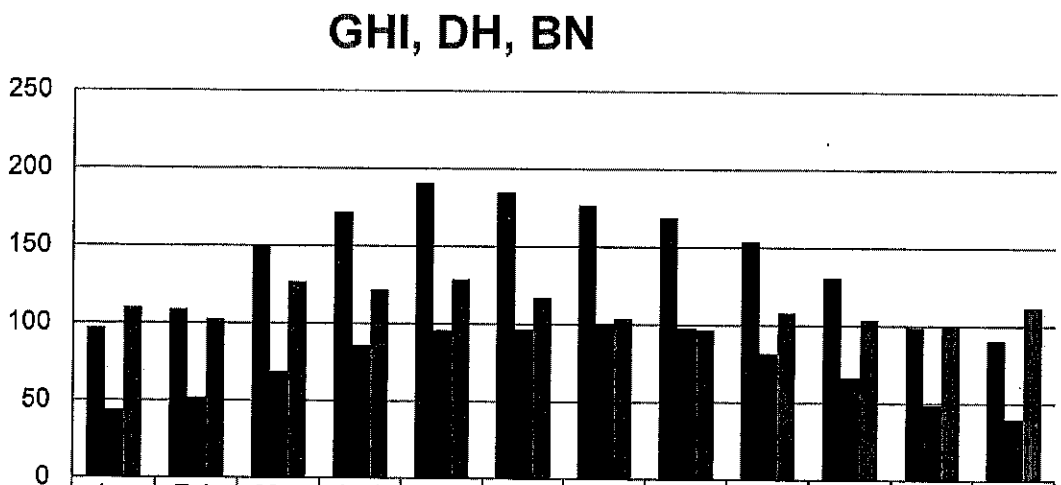
Dh: Diffuse radiation arising from the upper hemisphere reduced by the direct solar radiation from the sun's disk and its surroundings (6° aperture)

Bn: Direct normal radiation (DNI, beam) arising from a narrow solid angle of 6° centered around the sun's disk

Ta: Air temperature (2 m above ground)

Td: Dewpoint temperature

FF: Wind speed (FFE, FFN longitudinal and latitudinal part of the wind speed)




| | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gh KWh/m.sq | 97 | 109 | 150 | 172 | 191 | 185 | 177 | 169 | 154 | 131 | 99 | 91 |
| Dh KWh/m.sq | 44 | 52 | 69 | 86 | 96 | 97 | 100 | 98 | 82 | 67 | 49 | 40 |
| Bn KWh/m.sq | 110 | 103 | 127 | 122 | 129 | 117 | 104 | 97 | 108 | 104 | 100 | 112 |

Fig 7 showing GHI, DH and Bn irradiation levels at site

## 2.2.7 Solar irradiation (Solar GIS)

The weather data from Solar GIS was also analyzed, and yield assessment was carried on the basis on in house software interpolation and previous experience.

| MONTH | GHM (KWHR/M.SQ.) | DHD (KWHR/M.SQ.) | DHM (KWHR/M.SQ.) | T24 (DEGREE CELCIUS) |
|---|---|---|---|---|
| JAN | 93 | 1.58 | 49 | 11.7 |
| FEB | 108 | 1.86 | 52 | 15.1 |
| MAR | 162 | 2.41 | 75 | 21.2 |
| APRIL | 188 | 2.83 | 85 | 28.2 |

| | | | | |
|---|---|---|---|---|
| MAY | 210 | 3.3 | 102 | 34.1 |
| JUNE | 191 | 3.55 | 107 | 37.3 |
| JULY | 167 | 3.44 | 107 | 37.9 |
| AUG | 164 | 3.23 | 100 | 36.8 |
| SEPT | 161 | 2.79 | 84 | 32.7 |
| OCT | 143 | 2.29 | 71 | 25.1 |
| NOV | 102 | 1.75 | 53 | 18 |
| DEC | 95 | 1.49 | 46 | 13 |
| | 1784 | 2.55 | 931 | 26 |

Table 6 showing irradiation levels at Mankera Site

Long-term averages:

Ghm = Monthly sum (annual) of global horizontal irradiation (kWh/m2)

Dhd = Daily sum of diffuse horizontal irradiation (kWh/m2)

Dhm = Monthly sum (annual) of diffuse horizontal irradiation (kWh/m2)

## 2.2.8 Global Horizontal Irradiance (GHI) – Solar GIS

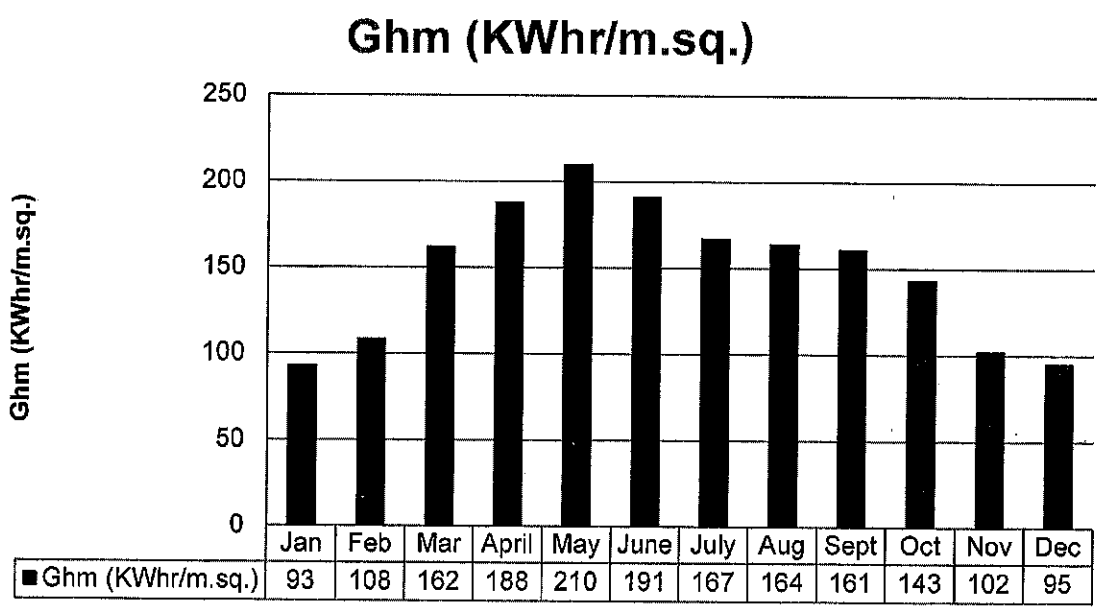



Fig 8 showing GHI levels at Mankera Site

### 2.2.9 Diffused Horizontal Irradiation (DHI) – Solar GIS

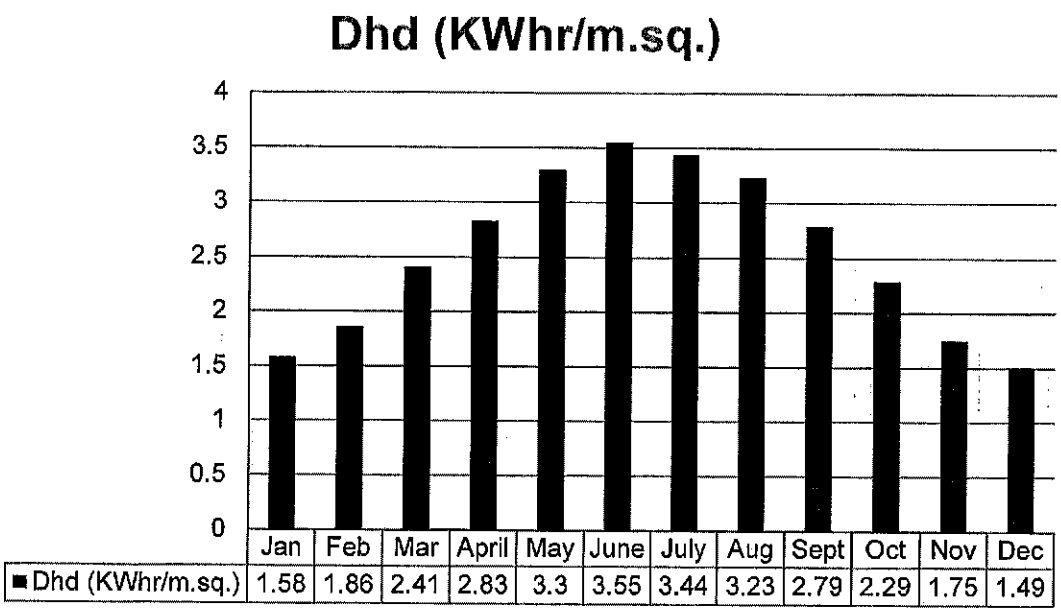



Fig 9 showing DHI levels at Mankera site

### 2.2.10 Average diurnal (24 hour) air temperature at 2 m) – Solar GIS

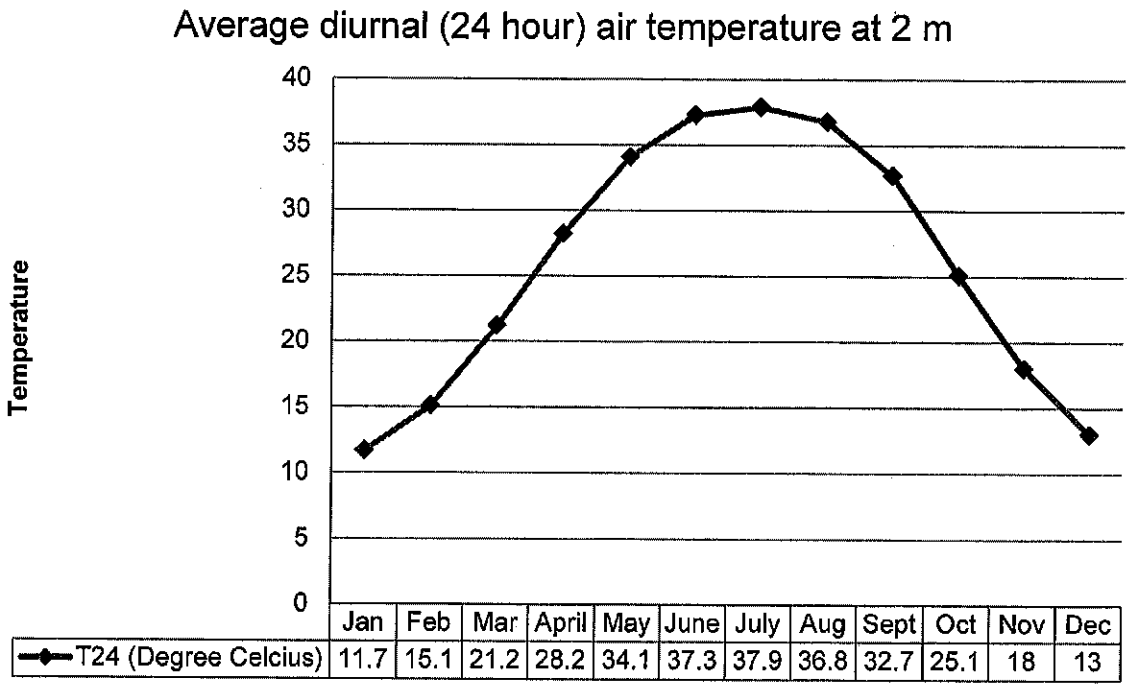



Fig 10 showing Average diurnal (24 hour) air temperature at 2 m

### 2.2.11 Site Access

Mankera solar farm site is located on Jhang Bakhar road. The site can be accessed through a 2.17km track, sandy in nature. The track will be converted into a small concrete road during the construction, which will be used later during the operation and maintenance stage.

### 2.2.12 Road types

Jhang Bakhar Road is the main artery and primary road through which site is accessed.

| S.No. | Road Type | Name |
|---|---|---|
| 1 | Primary | Jhang Bakhar Road |
| 2 | Secondary | Access Road |

Jhan Bakhar Road is a single carriage way road for two-way traffic. The road width is sufficient to cater the heavy traffic vehicles.

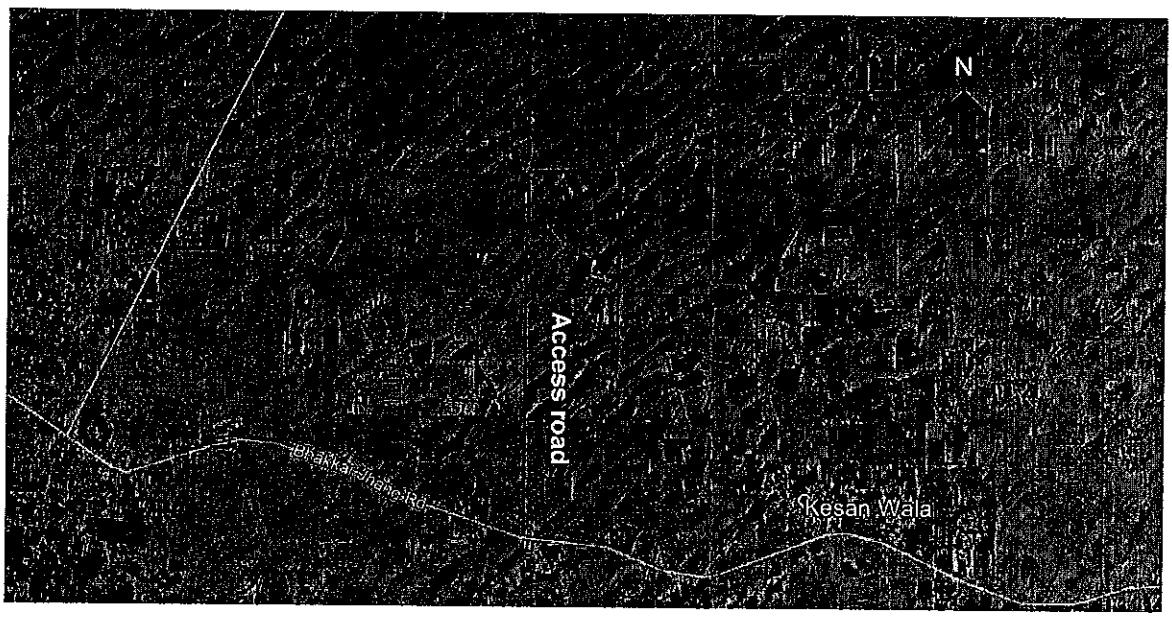



Fig 11 showing connectivity of the site through Bhakkar Jhang Rd.

### 2.2.13 Site boundary

During the Mankera Solar Farm site visit. The identification of the red line site boundary for solar project was already done by Punjab Property Centre. The first session comprised of the desktop assessment and second session comprised of:

1. Viewing solar farm site from a high surveillance point
2. Walking on the site

### 2.2.14 First Session

A desktop assessment (DSA) was carried out by ibvogt technical team and site was checked against all the National and local planning designations. The DSA showed that site does not lie in areas of outstanding natural beauty, green belt, National Park or located near to a site of special scientific interest. Also the site is not classified as prime agricultural land and only a low quality crop can be cultivated on the land. As the site is part of the Thal Desert, hence most of use surrounding solar farm is desolated or of low agricultural activity. Mankera solar farm is also located in rural area and the project will support the rural economy. An economic analysis was carried out for the land owner and its benefits were shared with landowner. Financial benefit of propose development will help landowner/farmer to hire additional resource to improve the quality of his another land holding nearby the solar farm. Overall cost of the land was negotiated with land owner and after few discussions; a final offer was then made.

### 2.2.15 Second Session:

The second session comprised of the site visit and started from signing of the land agreement with the land owner. During the visit whole of the site is viewed from a high surveillance point. From that point whole site was viewed and it was noticed that site is generally flat and comprises of one or two terraces. Also a small number of mature trees were found on the site.

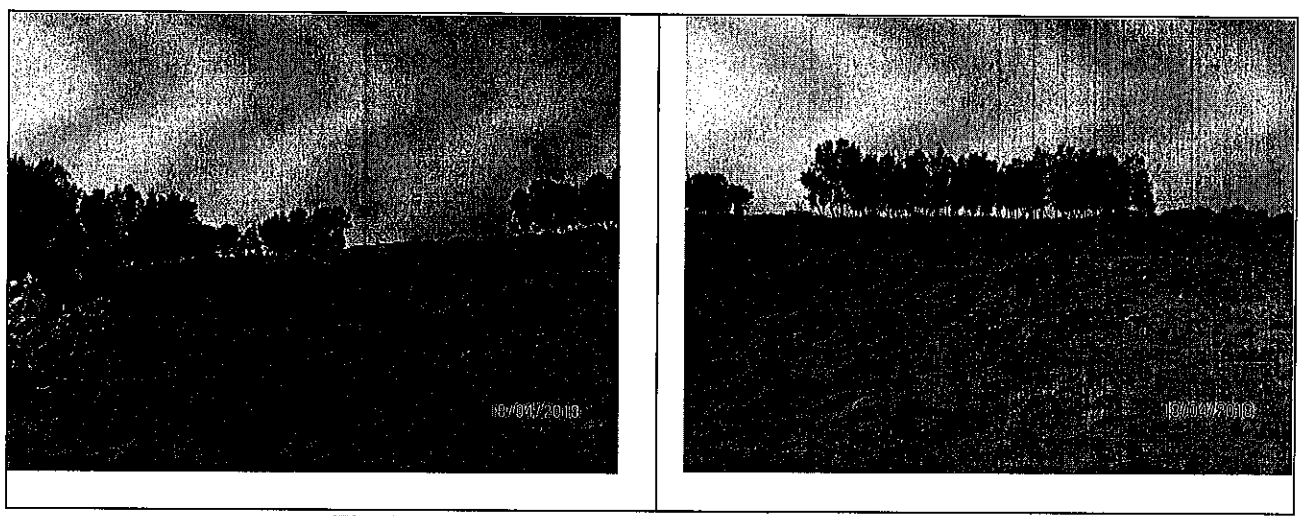


Fig 12 showing some mature trees on the site

A detailed reconnaissance survey was then carried out. Site usually has flat topography and small vegetation cover on the top. Topsoil shows that site is suitable for ramming of profiles but a detailed Geo Tech study would be required for detailed design of foundations.

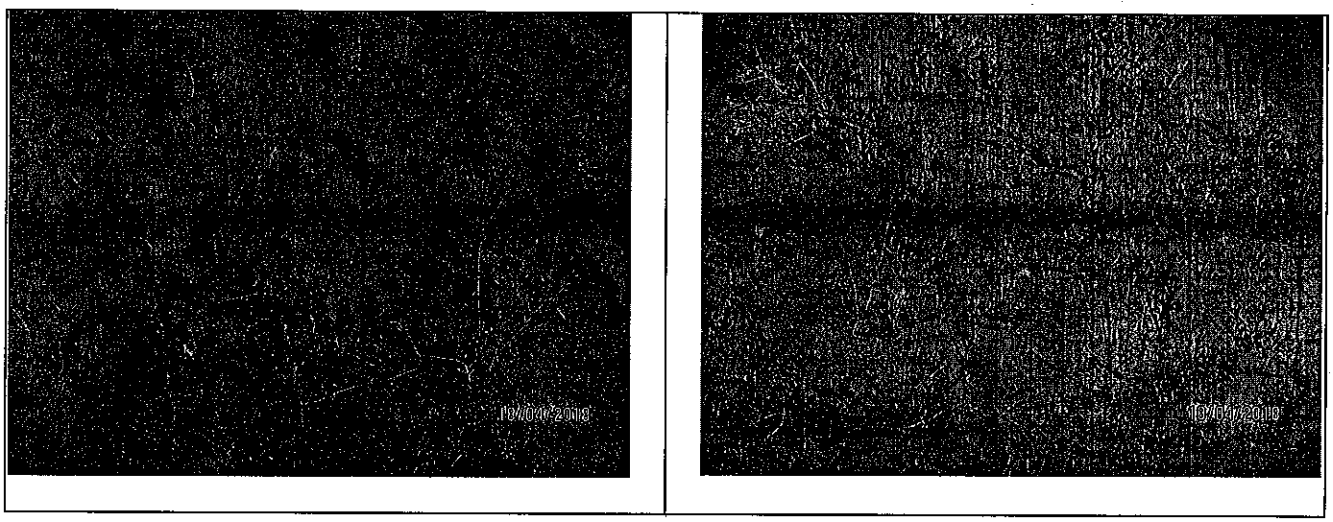


Fig 13 showing some mature trees on the site


Fig 14 showing the proposed redline boundary for detailed Geotech study

## 2.3 Surrounding Land use

The site itself has power generation use and surrounded by few residences, in 5km radius toward south east and south west direction of the site, most of the land is lying vacant or as desolated chunk.

A site is located at a higher elevation as compare to the residential areas; hence there will no issue of overlooking the site from houses. Similarly, due to this difference of elevation there will be no glint and glare impact from solar farm development.

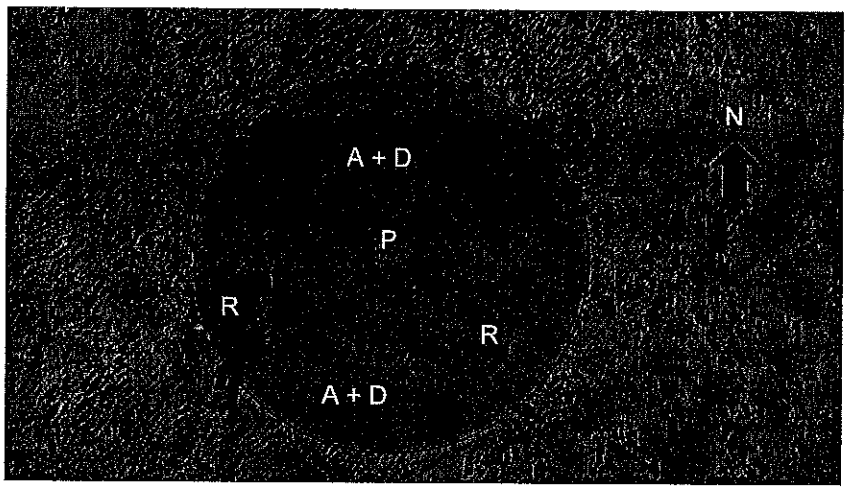



Figure 15 showing the major land uses around the site in 5KM radius

P = Proposed Power Generation use,
A + D = Agricultural + Desert
R = Residential use

## 2.4 Existing Land use

The site doesn't have any distinctive land use. Occasionally landowner cultivates the land with low quality crop, on some part of the land. Proposed solar farm site has a bit of sand cover, which make it unsuitable for any good quality crop.

## 2.5 Topography

The topography of the site is predominantly flat which makes it suitable for development of solar farm development. The site generally slopes from North to South and very gradual slope from west to east. A grade analysis has been carried out at points of highest level difference to check the gradient of the slope in redline boundary of the site for solar farm.

The topography of the site is predominantly flat which makes it suitable for development of solar farm. The site generally slopes from North to South and very gradual slope from west to east.


Figure 16 showing the section through site and gradual fall of terrain toward south, average slope 0.3%.

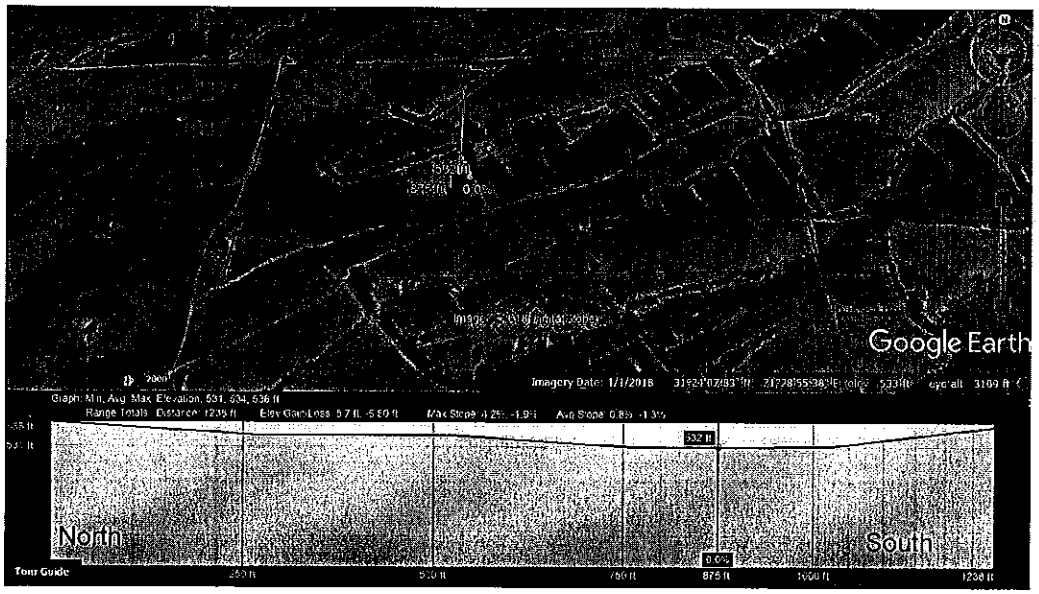



Figure 17 showing the section through the site and showing gradual fall of terrain towards south average slope 0.8%. Section shows a very small bit of reverse slope towards south.

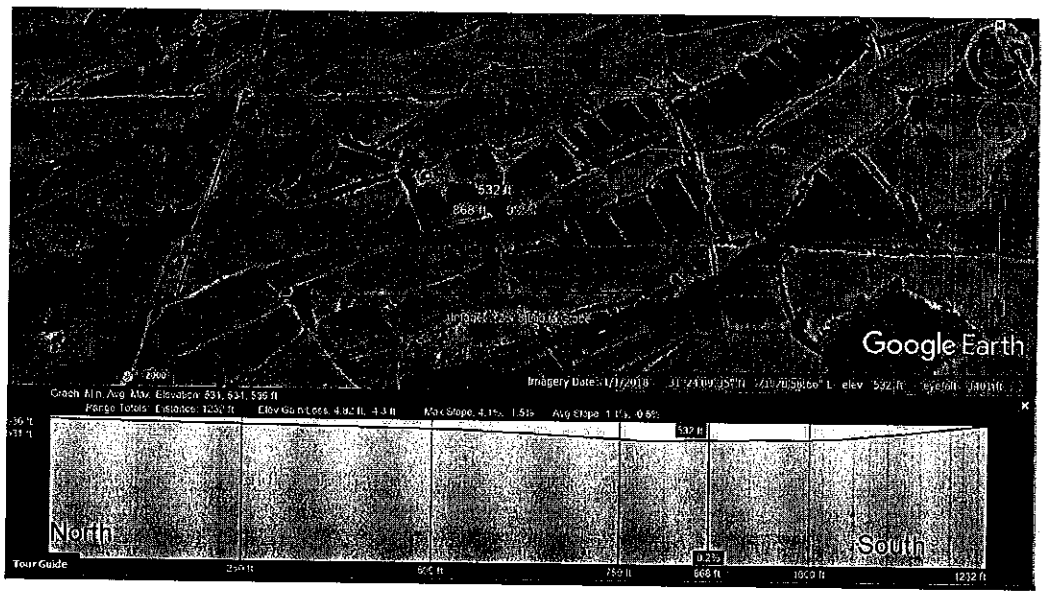



Figure 18 showing section through the site and drop in terrain from north to south – average slope 1.1% and showing a bit of reverse slope towards south

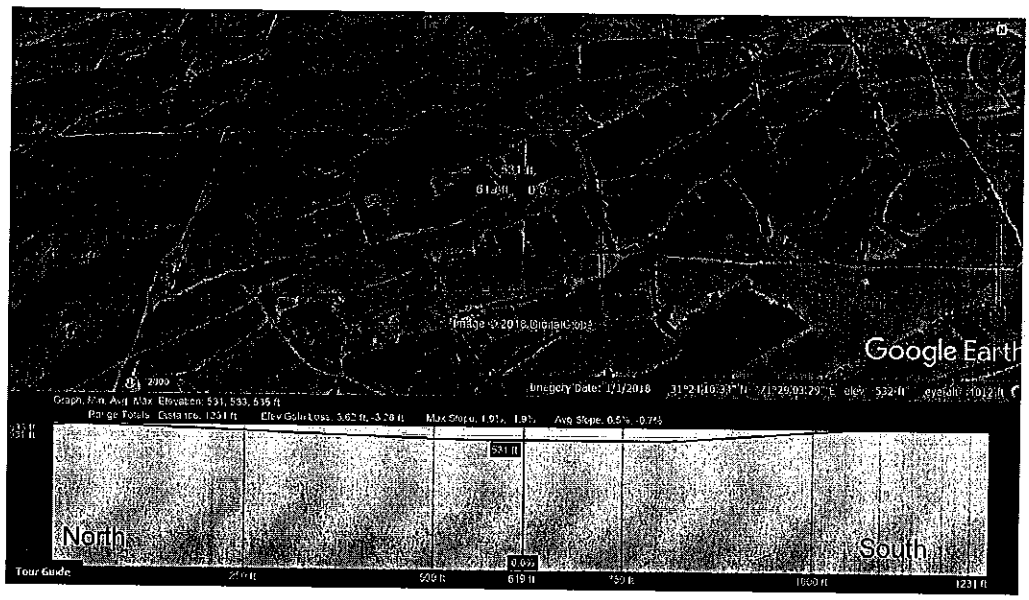



Figure 19 showing section through the site and drop in terrain from north to south – average slope 0.5% and showing a bit of reverse slope towards south

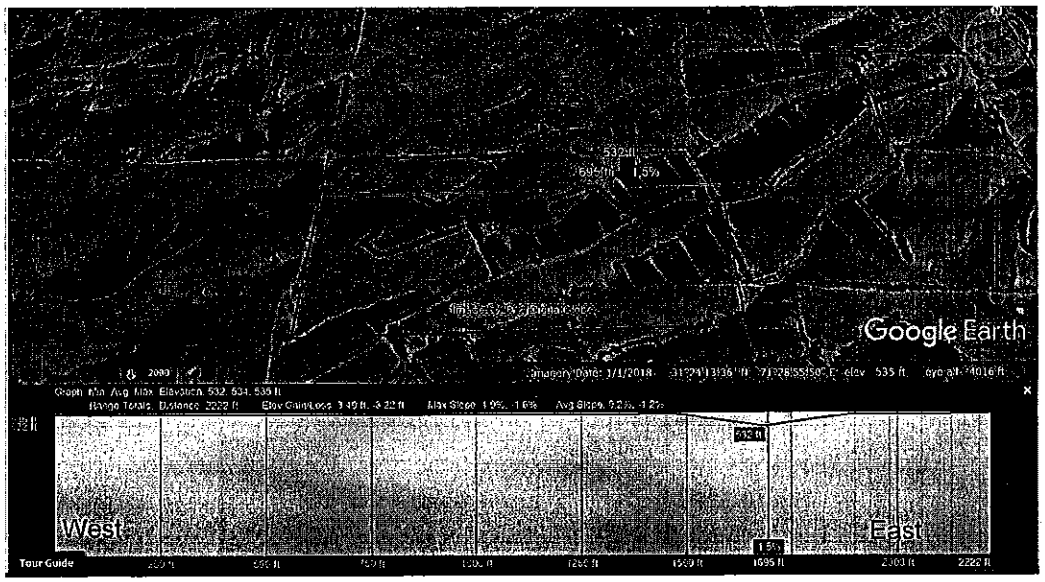



Figure 20 showing section through the site, predominantly flat and gradual drop in terrain from west to east – average slope 0.2%

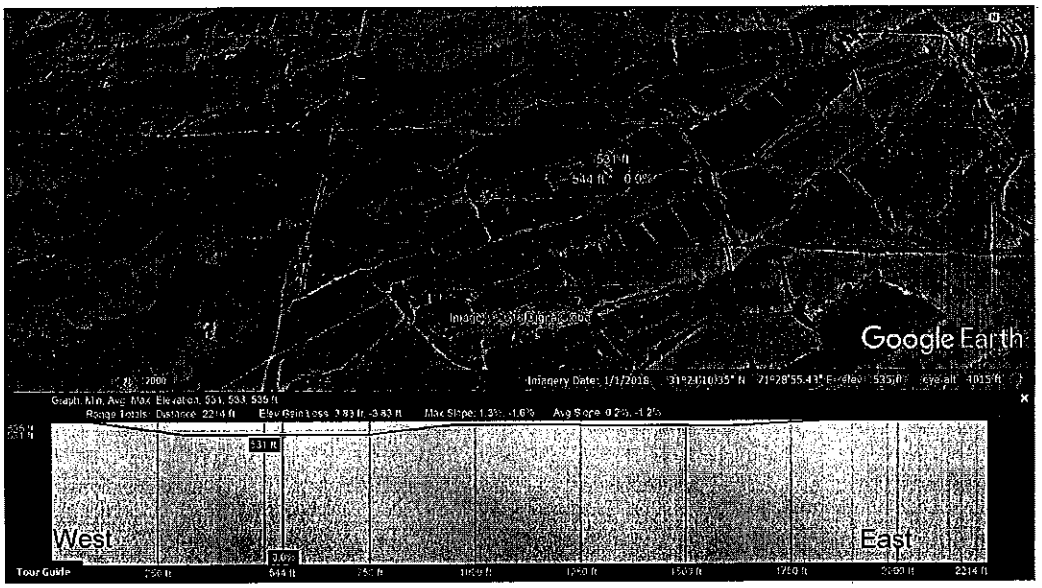



Figure 21 showing section through the site, very gradual undulation – average slope 0.2%

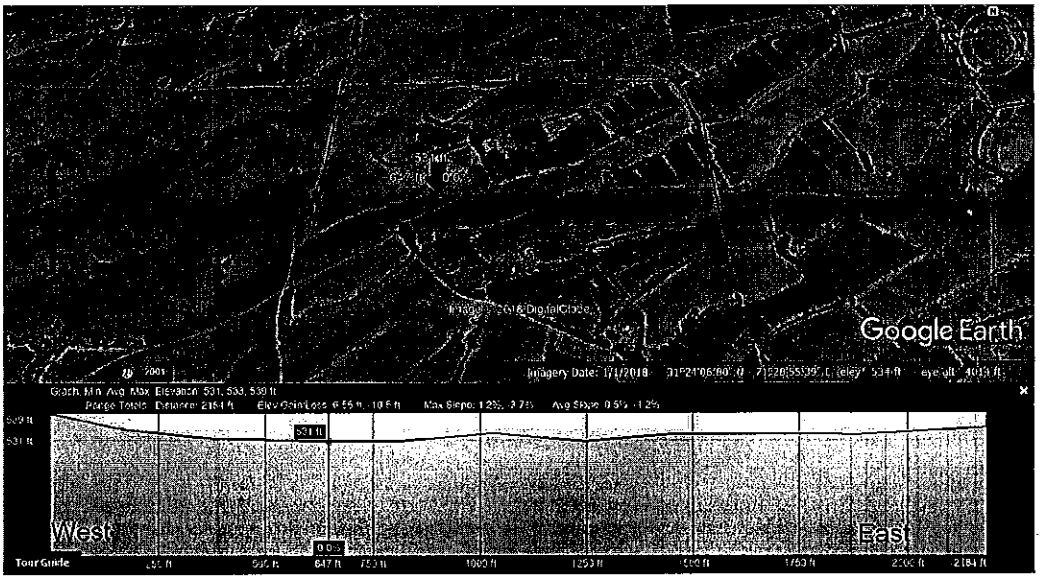



Figure 22 showing section through the site, very gradual undulation – average slope 0.5%

## 2.6 Flood risk

The site has its natural drainage pattern and quite few natural Nullahs / swale /rain water drains are passing through site. Incorporating the natural drainage pattern of the site into the design will reduce the risk of flooding on the site. Currently site is free from a flood risk and lies out the flood plain.

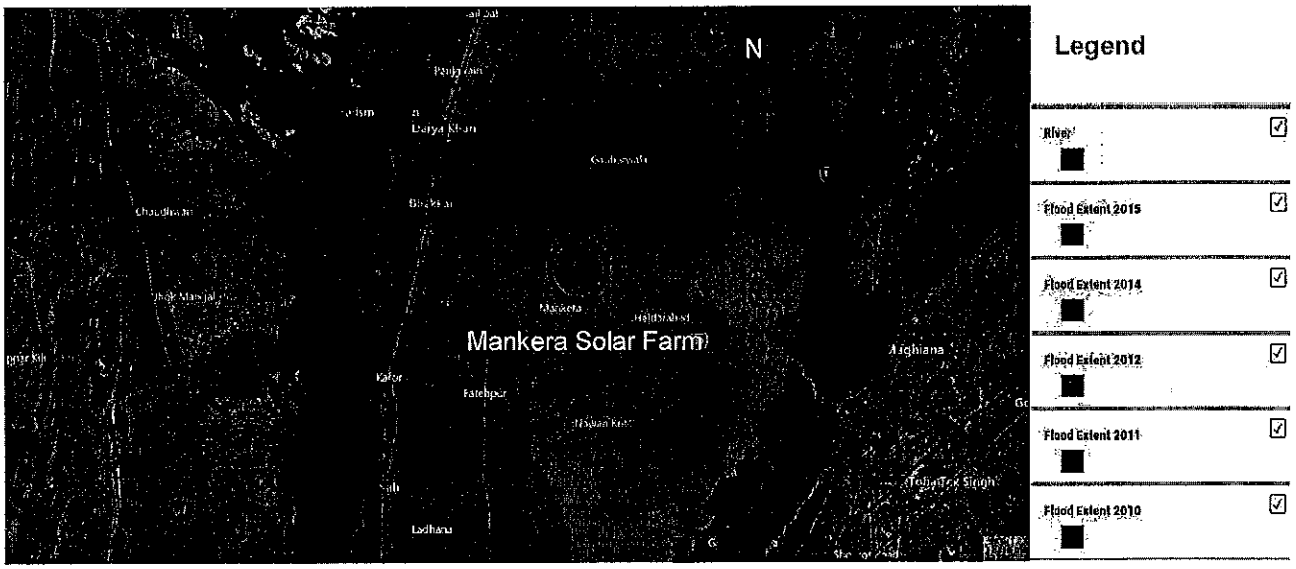



Fig 23 showing flood risk map for the Mankera and it lies outside the flood plains of Punjab

The National Disaster Management flook risk map shows that site is free from any risk of flooding and is located closer to the exisitng natural drains. A fresh water channel passes through the site which is used to water the crop / land. Small natural water channels already present on the site are best suited as drainage channels during the event of rain.

Due to undulation, there is a potential of onsite ponding and the phenomenon was noticed frequently during monsoon season. As the solar farm development, usually don't have any adverse impact on the surrounding, but sometimes the angle of solar panels can increase the velocity of surface water runoff and can cause flooding somewhere else. Hence a separate flood risk assessment may be carried out before construction.

Natural drainage pattern of the site shows that most of the time the surface water runoff will be moving towards south along the natural slopes of the site.

The flood extent of 2010-2015 also shows that site is free from any river flooding and located out the flood plains of Punjab.

## 2.7 Shading

Shading is one phenomenon which can affect the efficiency of the solar panel. Only 10% area of the panel in shade can result in 50% loss in the efficiency of the solar panel. The Mankera solar farm has some mature trees and one built room on the site. The room is built for the possession purpose by the land owner. Once the solar farm construction will start, room will be demolished. Both the heighted features will be taken care of during the design stage. Still to avoid the impact of the shading on to generation the solar panels with fitted by pass diode will be used for the installation.

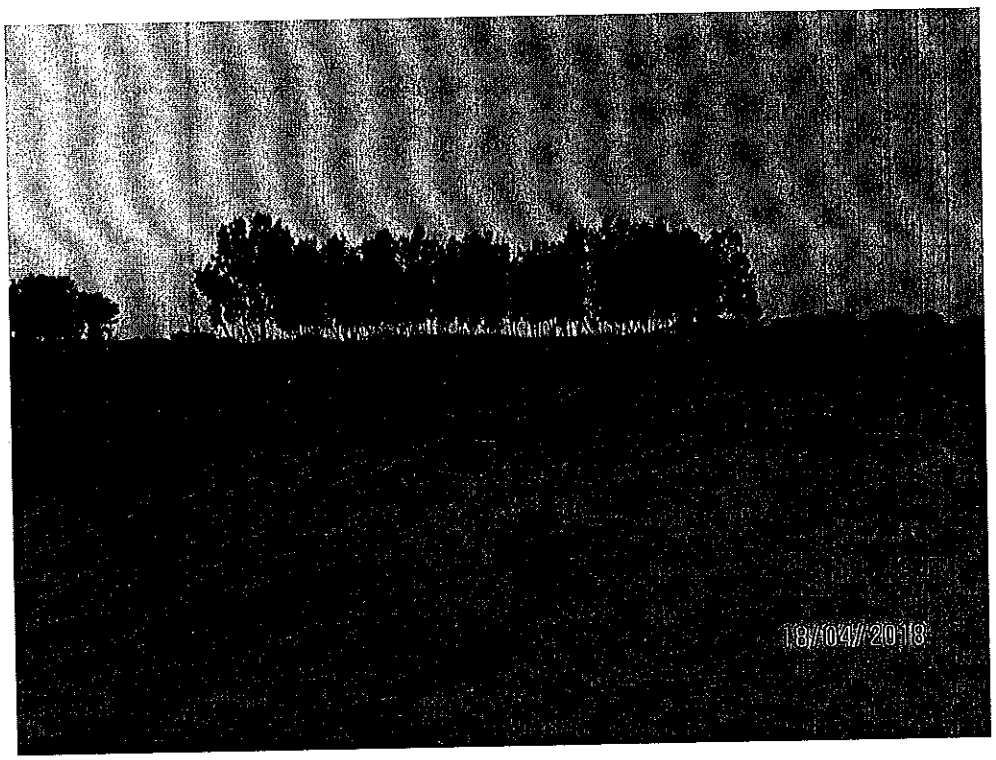



Figure 24 showing some trees on the site as heighted features.

The other form of shading that can affect the power generation is from solar panels themselves. For large scale, solar farms, solar panels are usually arranged in two in portrait or four in landscape at an optimum tilt angle, usually 15-25 degrees depends on the angle of sun. Usually height of the solar arrays ranges between 1.5 – 2.5 m. Single Axis trackers will be used hence the array will rotate 60 degrees to the horizontal plane either way (east or west) and tilt angle for solar array will vary from 0-60 degrees depending on sun angle.

Sufficient land is available for the solar farm generation. Hence the shading distance between the arrays will be maxed out, to avoid any form of shading from the solar arrays.

## 2.8 Existing features

Lot of small shrubs and bushes are present on the site. Single room settlement, Tube well, Trees 11KV Feeder are the main existing features on the site. No distinct flora and fauna have been noticed on the site.

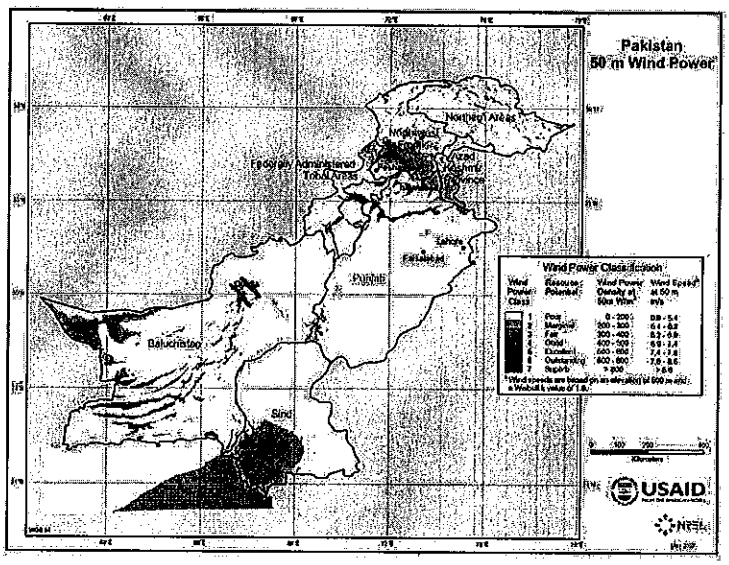
## 2.9 Utility connections

Electricity and gas are easily available on the site. Due to high water table, a fresh water tube well is already present on the site. Same water will be used for cleaning of panels during O&M stage of the project.

## 2.10 Wind Direction and Speed

The predominant wind direction is from North to South. The average wind speed is 3.5 m/s. The max wind speed recorded in the area is 5.3 m/s.

The North to South direction will only have a sideways impact on arrays. The tables will be facing east and west while tracking the sun. Hence the wind will not have significant pull out force, in case of any wind storm.




US AID Pakistan Wind Resource Map also shows that site is located in FESCO region and wind resource is very low / poor in the area where Mankera solar farm is located.

Figure 25 showing wind resource available in the area.

## 2.11 Legal status of site

The site has been purchased by the Project SPV K1 Solar Power Lahore Pvt Ltd and land agreement with land owner has already been signed. The land Title is clear from any court litigation. Initial legal due diligence has been carried out by project lawyers.


Figure 26 showing Mankera site ownership boundary

## 2.12 Way leave issues

The solar power plant will be connected to FESCO network through 11KV overhead line. The local DNO will take of the way leave.

## 2.13 Underground cables and pipeline

The desktop assessment shows that site don't have any underground cables or gas pipes. The local utility will be consulted before the start of the construction to make sure, that project civil work will not cause any harm to the existing infrastructure. Proposed solar farm site is privately owned, hence during the site visit land owner shared that there are no underground oil or gas pipes passing through the site. Only tube well pipe is present on the site, which has been demarcated during topographical survey.

## 2.14 Fiber optic cable

For monitoring purpose SCADA communication system will be installed in the control room. All the PV MW blocks will be connected with CR via underground fiber optic cable (F.O.C). No existing underground fiber cable encountered.

## 2.15 Environmental Impact Assessment

As per Punjab Environmental Protection Agency regulations, the solar farm sites below 50MW will not require any EIA and will only be liable to submit an Initial Environmental Examination report.

Initial desktop assessment shows that, there will be no impact on the flora & fauna of the area since there is no established grazing land, national parks, protected wild life zones or bird sanctuary present near the solar farm. The site has also been examined from Noise, Shadow and Visualization Impact Angle. The results show that there would be no adverse impact of Noise, Shadow and visualization on nearby dwellings. The land is also free from resettlement issues since it was hold previously by private landowners and now under use of K1 Solar PK Pvt. Ltd

The desktop based land use assessment also showed that there wasn't any prime use of the land and there isn't any special planning or environmental designation recorded on the site after 2008 till to date. As per Punjab EPA, IEE would be required for the project.

## 2.16 DNO connection

Solar farm site will be connected to 66/11 KV Mankera grid of FESCO located at 4.2 KM away from the site through an overhead 11KV line.

# 3. Planning Policy Statement

This chapter provides a brief outline of the planning policy information applicable to the project with emphasis on renewable energy policy and climate change. The current Government have attached substantial importance to the continued development of renewable energy sources and their renewable energy policy sets the context for the determination of planning applications. The policies outlined in this statement clearly indicate that considerable planning weight should be attributed to these policies.

The Renewable Energy Policy 2006 revised in 2009 provides the support for the development of RE projects in Pakistan.

## 3.1 International Policy

Climate change became a prominent issue in the 1980s and in response to this the United Nations adopted a resolution on the 'Protection of global climate for present and future generations of mankind'.

The United Nations Framework Convention on Climate Change (UNFCC 1992) and the Kyoto Protocol (1997) committed parties to individual, legally binding targets to limit or reduce their greenhouse gas emissions.

The Stern Review of 200611 warned that *"Delaying action, even by a decade or two, will take us into dangerous territory. We must not let this window of opportunity close".* The review highlights the importance of acting now to reduce carbon emissions. In the short term renewable energy is one of the main options for reducing carbon emissions.

The 4th Assessment Report of the IPCC (Intergovernmental Panel on Climate Change) raised the possibility of the Earth's temperature rising well above the ceiling quoted in earlier accounts and giving rise to severe consequences such as the collapse of the Greenland ice sheet and disruption of the Gulf Stream Ocean current.

A 'roadmap' towards a new climate deal in which developed and developing countries are legally bound to reduce their carbon emissions was the agreement born out of the United Nations Climate Change Conference 2011, Durban. The terms of the agreement are to be drawn up by 2015 and come into effect by 2020.

## 3.2 European Policy

The European Climate and Energy Package12 (2007) aims to further improve energy security and reduce carbon emissions. The package sets out the following climate and energy targets that are to be met by 2020:

- A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels;
- 20% of EU consumption to come from renewable resources;
- 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency".

These targets are known as the 20-20 targets. EU leaders have agreed to increase Europe's emissions reduction target to 30% if a global climate agreement can be achieved. To achieve the EU renewable energy, target each member state has agreed to an individual target.

## 3.3 Asia Pacific Renewable Energy Targets

Burgeoning energy demand, limited fossil fuel reserves, and global warming concerns have forced countries in the Asia-Pacific region to increase the share of renewable energy in their energy mix. The region has made significant investment in renewable energy projects in recent years, and this is expected to continue in future. Many countries have adopted policy instruments such as Feed-in Tariffs (FiTs), Renewable Portfolio Standards (RPS), soft loans and tax incentives to promote renewable energy. Most of the government measures that have been introduced have received a positive response and have played a vital role in the development of the renewable energy industry.

Investment in renewable energy projects increased following the introduction of the Kyoto Protocol in 1997. This protocol sets binding obligations for industrialized countries to reduce greenhouse gas emissions by 5% against 1990 levels by 2012 (the first commitment period) and by 18% against 1990 levels by 2020 (the second commitment period).

Australia, Japan and New Zealand have signed the Kyoto Protocol, thereby committing to the reduction of carbon emissions. India and China, as participants in the Copenhagen Accord in 2009, pledged to work towards respective binding carbon intensity reduction targets of 20–25% and 40–45% by 2020, in comparison with 2005 levels.

China is rapidly becoming a major player in the global renewable energy industry. In recent years, the country has developed its wind turbine and solar Photovoltaic (PV) manufacturing industries. The government has shown commitment to renewable energy through the introduction of a series of new laws and financial support measures.

India and Australia have also implemented several support measures for the development of renewable energy; the efficiency with which these measures are implemented will determine future growth in both countries. The new programs related to solar power development announced in India are expected to significantly increase the share of solar power in the renewable energy portfolio. The Japanese government has shown commitment to renewables through the introduction of a FiT for renewable energy. It also announced plans to entirely rebuild its energy policy following the Fukushima nuclear disaster in March 2011. The policy now recommends gradually reducing dependence upon nuclear power while enhancing the share of renewable energy and efficient fossil-fuel power generation.

Thailand, which has announced several measures to support the growth of its renewable industry, is aiming for renewable energy to account for a 25% of overall power within the next 10 years. Pakistan currently don't have any renewable energy targets but still Govt is encouraging the installation of Wind and Solar power plants and have got a policy frame work in place to support the RE projects in Pakistan.

## 3.4 National RE Policy 2006

Pakistan has a tremendous renewable energy potential. Ministry of Water and Power in 2006 published RE Policy which encourages the deployment of wind, solar, hydro and biomass projects. The policy provides the detailed process and guidelines for development of RE project in Pakistan. Salient feature of 2006 RE policy are as follow:

| |
|---|
| **i. It invites investment from the private sector for following categories of proposals: a. Independent power projects, or IPPs (for sale of power to the grid only) b. Captive cum grid spillover power projects. (i.e., for self-use and sale to utility) c. Captive power projects (i.e., for self or dedicated use) d. Isolated grid power projects (i.e., small, stand-alone)** |
| **ii. Except for Category (a) above, these projects will not require any LOI, LOS, or IA from the Government.** |
| **iii. Electricity purchase by NTDC/CPPA from qualifying renewable energy-based generation projects has been made mandatory.** |
| **iv. It permits an investor to generate electricity based on renewable resources at one location and receive an equivalent amount for own use elsewhere on the grid at the investor's own cost of generation plus transmission charges (wheeling).** |
| **v. It allows net metering and billing so that a producer can sell surplus electricity at one time and receive electricity from the grid at another time and settle accounts on net basis. This will directly benefit the economics of small scale, dispersed generation and optimize capacity utilization of installed systems.** |
| **vi. It delicenses and deregulates small scale power production through renewable resources (up to 5 MW for hydro and 1 MW for net metered sales) to reduce the transaction costs for such investments. This will be particularly beneficial for micro, mini and small hydro as well as solar-based electricity production.** |
| **vii. It lays down simplified and transparent principles of tariff determination.** |
| **viii. In insulates the investor from resource variability risk, which is allocated to the power purchaser.** |
| **ix. It facilitates projects to obtain carbon credits for avoided greenhouse gas emissions, helping improve financial returns and reducing per unit costs for the purchaser.** |

Table 7 showing salient features of RE Policy 2006

These guidelines are in line with the Government's open door policy for inviting private investment into the country." Projects with Govt. PPA are developed under same RE Policy.

**The brief of development process is as follows:**

| S.NO. | O&M | Typical Allowance (Days) |
|---|---|---|
| 1 | Submission of proposal on raw site by sponsors | - |
| 2 | Review of proposal and qualification of sponsors by AEDB/Provincial/AJK Agency | 30 |
| 3 | Posting of Bank Guarantee by sponsors | 15 |
| 4 | Issuance of Letter of Intent (LoI) by AEDB/Provincial/AJK Agency | 7 |
| 5 | Initial time allowed to carry out feasibility study and term of the LoI. | Based on schedule submitted by IPP, subject to maximum of 18 months |
| 6 | Tariff negotiations with power purchaser and approval of tariff by NEPRA (the time can be significantly reduced if up-front tariff is accepted by IPP) | 90 |
| 7 | Submission of Performance Guarantee by sponsors upon approval of tariff by NEPRA | 15 |
| 8 | Issuance of LoS by AEDB/Provincial/AJK Agency | 7 |
| 9 | Financial close | 365 |

Table 8 project development process as per policy 2006

**Note:**

LOI to proposed solar farm development was awarded by Punjab Power Development Board. Hence project will be developed under Punjab Power Generation Policy 2006 revised 2009. LOI copy attached here as Annexure J.

# 4. Desktop based Environmental and Social Impact Assessment

As per Environmental Protection Agency Regulation 2000, Energy project below 50MW will require an Initial Environmental Examination (IEE). As per regulation all the developments that require IEE or EIA are categorized into two types Schedule I and Schedule II developments. The energy project (hydro generation) above 50MW require an EIA and energy project (hydro generation) below 50MW will require an IEE. As per Schedule I development, an Initial Environmental Examination (IEE) will need to be carried out to demonstrate that the impact on the environment and local communities is acceptable and that the Project complies with national environmental laws and regulations. The proposed solar plant will require an IEE which shall be carried out by an environment expert and the IEE study approval shall become part of this Feasibility Study as Annexure I.

If the Project require at any stage, international financing than it will need to demonstrate compliance with the requirements of International Financing Institutions, such as Development Agencies and Banks. This is generally achieved by following the International Finance Corporation's (IFC) Performance Standards on Social and Environmental Sustainability, and Industry Sector Guidelines. The standards relate to various elements of social and environmental assessment and management, summarized as follows:

**Performance Standard 1· Assessment and Management of Environmental and Social Risks and Impacts**

**Performance Standard 2 Labor and Working Conditions**

**Performance Standard 3 Resource Efficiency and Pollution Prevention**

**Performance Standard 4 Community Health, Safety, and Security**

**Performance Standard 5 Land Acquisition and Involuntary Resettlement**

**Performance Standard 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources**

**Performance Standard 7 Indigenous Peoples**

**Performance Standard 8 Cultural Heritage**

The IFC Performance Standards are reinforced by the Equator Principles (EPs), a credit risk management framework for determining, assessing and managing environmental and social risk in Project Finance transactions. As Lenders for this type of project are generally Equator Principles Financial Institutions (EPFIs). It is likely that adherence to these Principles will be required.

A gap analysis between the IEE produced for the Project and compliance with the IFC Standards and EPs would identify additional issues that should be addressed to reduce risk to the project and to help safeguard the project against any environmental and social uncertainties. This analysis will produce an Environmental and Social Action Plan (ESAP). Listing actions are required to meet the various standards

These actions would form part of a Condition Precedent issued by the lender and can be addressed as financing proceeds. Thus, incorporating these standards is unlikely to result in delays to the project or prohibitive costs.

The principal impacts of a solar development are dictated by the specific nature of the site, and usually limited to the following key impacts and issues:

- landscape and visual impact
- Ecological impact
- Hydrological impact
- change in land use
- construction impacts
- employment opportunities

## 4.1 Environment

Solar farm development is temporary development in nature, and has minimal impact on surrounding. The solar panels are passive in nature and do not generate any harmful emissions. Almost 0.75m high from the front and 2.5m high from the back, make the vegetation grow well and sheep grazing is easily possible. Solar farm generates electricity by using the solar irradiations and don't require fossil fuel for most of its operation, which makes it zero carbon development. In addition, the production of electricity from a renewable source will make a significant contribution to reductions in Greenhouse Gases (GHG) emissions over the lifetime of the Project. The solar farm will have energy generating capacity of approximately 12.5 MW and will generate enough low carbon renewable electricity to meet the demands of more than 7812 homes a year.

Solar Project Generation in MWhr = 2026*12.5 = 25325

Combined Margin Emission Factor $_{grid, CM, y}$ = 0.6343 $tCO_{2e}$/MWh.

Carbon Emissions savings = Solar Project Generation X Combined Margin Emission Factor $_{grid, CM, y}$

= 25325 MWhr X 0.6343 $tCO_{2e}$ / MWh

= 16063.6475 $tCO_{2e}$

The principal environmental and social aspects identified as part of our early observations are outlined below for the proposed project site, with a brief statement regarding possible mitigations that have been identified at this early stage.

## 4.2 Ecological Impact

The proposed solar farm site is not a prime agricultural land and don't have any record of threatened flora and fauna. Not a single endangered tree species has been found over the site, only the Native bushes are present on distant locations.

The site has mainly rocky strata at and below the surface, which is not suitable for a quality green cover.

### 4.2.1 Flora

The flora of the area is governed by the type of soil and the amount of moisture available. As it is an open uninhabited area, so no particular flora is present. Only some bushes are present at the project site. The project site itself is a barren land but the natural vegetation around the site is comprised of few scattered perennial trees namely Eucalyptus and Kiker (Acacia arabica).

### 4.2.2 Fauna

The wildlife in the area has been affected by colonization of the area and many wild life species have either diminished or vanished. Most of the domestic fauna are in the vicinity of the Project Site. Terrestrial fauna of the area includes cats, jackals and dogs. Domestic animals like cow, buffalo, goats, sheep, donkey and horses are also found. The bird community, found in the area, includes variety of residential birds such as sparrows, crows, parrots etc. Small squirrels, rats and snakes are also found in the area.

## 4.3 Cultural Heritage

The site is in Mankera Punjab and mostly has desolated land use in the surrounding. The site doesn't have any other historic building in the surrounding. Hence site setting will not be affected by the development of solar farm and history of land use of the site shows that site is free from any kind archeological findings. The desktop assessment clearly demonstrates that the solar farm will not have any cultural or heritage impact.

## 4.4 Landscape and Visual

The site and surrounding area are characterized by an overall flat topography, with no elevated areas in the vicinity to give significant views of the development. The closest settlement to the proposed site is a residential area in south west direction of the Mankera power plant. The closest settlement near to the solar site is located almost 5km away from the site in south west direction. Being located closer to the site, the residential area is located at almost the same elevation and because of distance from solar plant, it is highly likely that residents will overlook the site. But as the only residence located near the site is in the south east direction, hence only side of the solar arrays will be visible, which will not cause any glint or glare impact. The landscape character of the area is not outstanding and has not been designated as area of outstanding natural beauty or national park. Hence development of solar farm will not deteriorate the surrounding environment and landscape. With proper landscaping plan, the existing character of the area can be strengthened.

## 4.5 Site Land Use

Prior to development of solar farm, the site was predominantly of infertile character with having any low quality agricultural activity. The development of solar farm will not result in the change of use, as site existing use is desolated land. Thus, there will be no loss of existing agricultural land or displacement of any users of the land. The installation of the solar power plant would provide income from a site which was previously unused and non-productive.

## 4.6 Hydrology and Water Use

The major surface water source in the area is Indus River, flows right side of the Bhakkar District. In addition to that there are few other surface water sources, which are used for irrigation purposes for agricultural lands in the area.

The major sources of the groundwater in the area are hand pumps, pressure pumps and tube wells. The main source of drinking water in the area is groundwater, which is pumped through hand pumps, pressure pumps and tube wells. The groundwater is also used for irrigation purposes. Currently site has an existing tube well facility which will be used for module cleaning. The ground water recharge will not be affected, as only 40% of the site area will be covered with solar panels and mounting structure will not cause any stoppage of water during any event of recharge.

## 4.7 Transport and Access

Main roads such as Jhang Bhakkar Road are in easy and close access of the proposed project site. Mankera solar farm site is located on Jhang Bakhar road. The site can be accessed through a 2.17km track, sandy in nature. The track will be converted into a small concrete road during the construction, which will be used later during the operation and maintenance stage.

Road types Primary = Jhang Bakhar Road
Secondary = Access track already present on the site

The current development of solar farm will only generate the traffic during the construction period which will last for six months' maximum. During the operation, the only small LTVs will be carrying out the maintenance jobs. After construction HTVs will visit the site in case of replacement of major part / equipment like inverter, which usually happens for once during whole project life.

## 4.8 Waste Management

To reduce the waste generated from the construction of the development there will be waste recycling and re-using initiatives in place. Two waste containers will be on site; one for the recycling of paper and cardboard, and the other for the recycling of wood. Several containers will be needed during the installation to store panels as they are constructed. Earthwork materials arising from the construction process will be stored and re-used on site. It should be noted these quantities will be minimal. This will avoid the need to import and export material. To minimize damage to soil structure all top and sub soil will be handled and stored carefully. It should be noted these quantities will be minimal. Site office waste will be collected in separate bins to allow for recycling. Recycling bins will allow for cans, bottle and paper. Paint spray cans, used for surveying, will be logged when issued so that it can be ensured all are disposed of properly.

Wastewater from the portable toilets and washing facilities will be discharged into sealed containment systems and disposed of by licensed contractors.

## 4.9 Social

The solar project should also place emphasis on Corporate Social Responsibility. Targets and commitments should be made with regards to issues such as local spend for both the construction and the operation phases, as well as commitment to a community trust, targeting further priority issues such as education or training projects.

The land on the proposed site is not currently occupied by any tenant farmers and, being located within the existing power plant security perimeter, is not in unofficial use by any of the local population. No physical or economic displacement will therefore result from the development.

## 4.10 Environmental and Social Management

### 4.10.1 Impact Assessment

Solar PV plants are not currently clearly classified in either Schedule I or Schedule II of the reviewed section 33 of the Pakistan Environmental Protection Act, 1997 (XXXIV of 1997). However, the development of the proposed Project is very unlikely to cause any negative effect on the surrounding environment and as the project size is less than 50M therefore it may be assumed that the Project falls within the Schedule I for which only the IEE is required as part of the planning and approval process.

The IEE provides a description of the environmental and social setting of the development, an assessment of potential impacts and recommendations for mitigation measures.

### 4.10.2 Environmental Management Plan

Although it is expected that the Project will be established using local financing, we recommend compliance with IFC Performance Standards which are considered industry best practice and demonstrate ongoing and responsive management of all potential social and environmental impacts throughout both construction and operational phases, in line with the principles already established at ibvogt other power plant. A key requirement in this regard is the provision of an Environmental Management Plan (EMP). The EMP for the solar project is set out in Section 6 of the IEE, describing mitigation and management measures for the development and allocating responsibilities for the measures proposed.

### 4.10.3 Stakeholder Engagement Plan

Stakeholder engagement is an essential element of a robust environmental and social assessment and is a key lender requirement, e.g. Principle 5 Stakeholder Engagement, of the Equator Principles, and IFC Good Practice Handbook for Stakeholder Engagement. The general stakeholder process is as follows:

- To identify people or communities that are or could be affected by the project, as well as other interested parties
- To ensure that such stakeholders are appropriately engaged on environmental and social issues that could potentially affect them through a process of information disclosure and meaningful consultation
- To maintain a constructive relationship with stakeholders on an ongoing basis through meaningful engagement during project implementation

# 5. Design and Access Statement

The Design and Access Statement will describe the various design elements of the proposed development in terms of use, amount, layout, scale, and appearance. It has demonstrated that the proposal has been designed in accordance with industry best practice and with the principle of good design in mind.

From the site visit it can be assumed that the soil is rammable although the presences of stones may hinder these works. A thorough geotechnical study has been carried out which shows that ramming of profiles is possible, which makes the site feasible for development of solar farms.

## 5.1 Introduction

This Design and Access Statement (DAS) has been prepared by ibvogt GmbH to assess the feasibility for the proposed solar farm with an installed capacity of 12.5 MW AC at the Mankera site in Punjab, Pakistan and forms an integral part of the feasibility study. The solar farm is intended to operate as Grid connected generation facility which will sell electricity to National Grid through an EPA. Specifically, ibvogt intends to develop a solar power plant located on the premises owned by the project SPV.

During the preparation of this DAS, ibvogt has leveraged decades of expertise in designing, constructing, operating and maintaining utility-scale solar power plants across the globe. Several key experts within the ibvogt team were involved in the design process to develop the best and most optimal outcome for Mankera Solar Farm.

This DAS encompasses the design factors, issues and decisions that should be considered for any solar farm, including the design layout, type and number of components, positioning, soil and material attributes, etc.

It should be noted that this DAS should be read in conjunction with both the accompanying Planning Policy Statement, which establishes the plans for the design of the application proposal, and the supporting environmental report, which considers any potential impacts on ecology, landscape and aesthetics, transport and flood risk, among others.

## 5.2 Site Location

The proposed site is comprised of approximately 25.25 hectares and The Solar Farm site is located in Mankera District Bakhar, Punjab. Most of district lies in the desolated plains of Thal Desert.

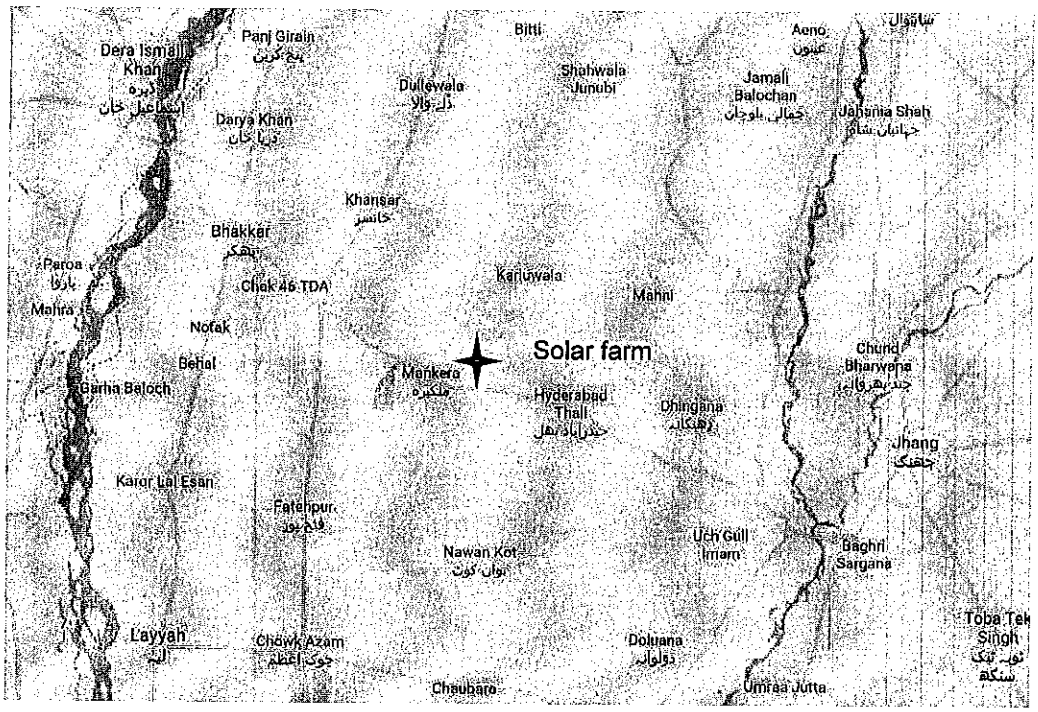



Fig 27 showing location of Mankera solar farm

## 5.3 Transport and Site Access

Specifically, the project site is located at Chak No 03, Rakh Mankera, District Bhakkar, Punjab. The site is located almost 4-5 km away from the main center of Mankera in north east direction.

Main roads such as Jhang Bhakkar Road are in easy and close access of the proposed project site. Mankera solar farm site is located on Jhang Bakhar road. The site can be accessed through a 2.17km track, sandy in nature.

The track will be converted into a small concrete road during the construction, which will be used later during the operation and maintenance stage.

Road types Primary = Jhang Bakhar Road

Secondary = Access track already present on the site

Mankera can be accessed from three directions. From Multan via Chowk Azam, from Jhang through Hyderabad Thal and from Dera Islmail khan through Bhakkar. All the three routes described above are continuously used by Heavy Traffic Vehicles (HTV's) making site suitable for access of construction vehicles during construction.

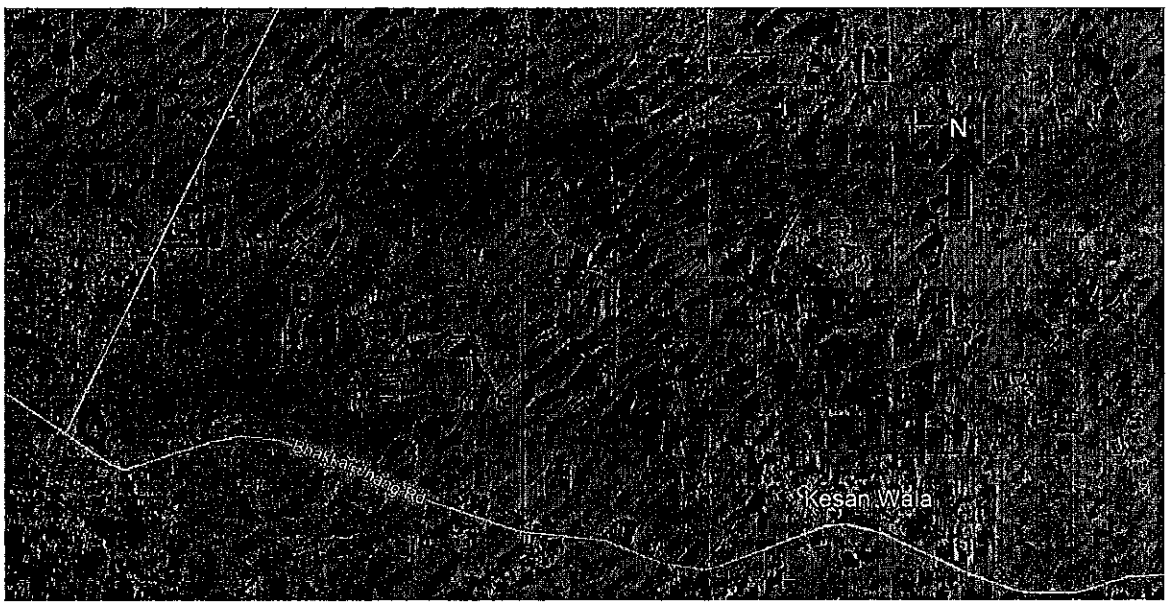



Fig 28 showing connectivity of the site through Jhang Bakhar road.


Fig 29 showing the existing track to access the site, and will be converted into TST (Triple Surface treatment) road during the construction.

## 5.4 Proposed Development and Design Principles

With every solar farm project development, ibvogt follows a proven methodology to render the best design solutions. Extensive experience has made these design approaches and processes more effective and efficient over the years. As Per the methodology, the development and design principles are based on:

- Physical opportunities and constraints the site provides;
- Material and labor needs of the development itself;
- Policy context relevant to the development of the site, and;
- Technical input and criteria from local consultants.

In addition, from its extensive track record, ibvogt is committed to established international standards and norms applicable in the industry, including IEC as well as local standards. For example, some notable IEC standards in the past have included "IEC 61557: Photovoltaic (PV) module safety qualification" and "IEC 62446: Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection."

The key considerations and constraints as well as opportunities are outlined below.

Key Considerations and Constraints

The design must consider:

- Any potential archeological assets, wildlife habitats, precious resources or minerals at the site. The input provided by Environmental Consultants confirms that the site is not home to any protected wildlife or trees and is not subject to minerals or mining rights, archaeology finding, any local or national designation as a national park or areas of any special scientific interest, nor any special ecological features.

- Physical characteristics of the site, such as the field boundary, slopes, etc. Following the site visit and GIS analysis, the topography of the land at the site seems to be relatively flat with minimal, gradual sloping, which are not enough to significantly affect the tilting and positioning of the modules.

- Shading form nearby Trees and heighted feature. Solar power plants are prone to higher risk of losses due to shading, which can be mitigated or completely avoided through careful planning and design. Following a thorough analysis and software simulation, the engineering team at ibvogt has determined an optimal placement of the racks at sufficient distances away from every tree to avoid shading effects.

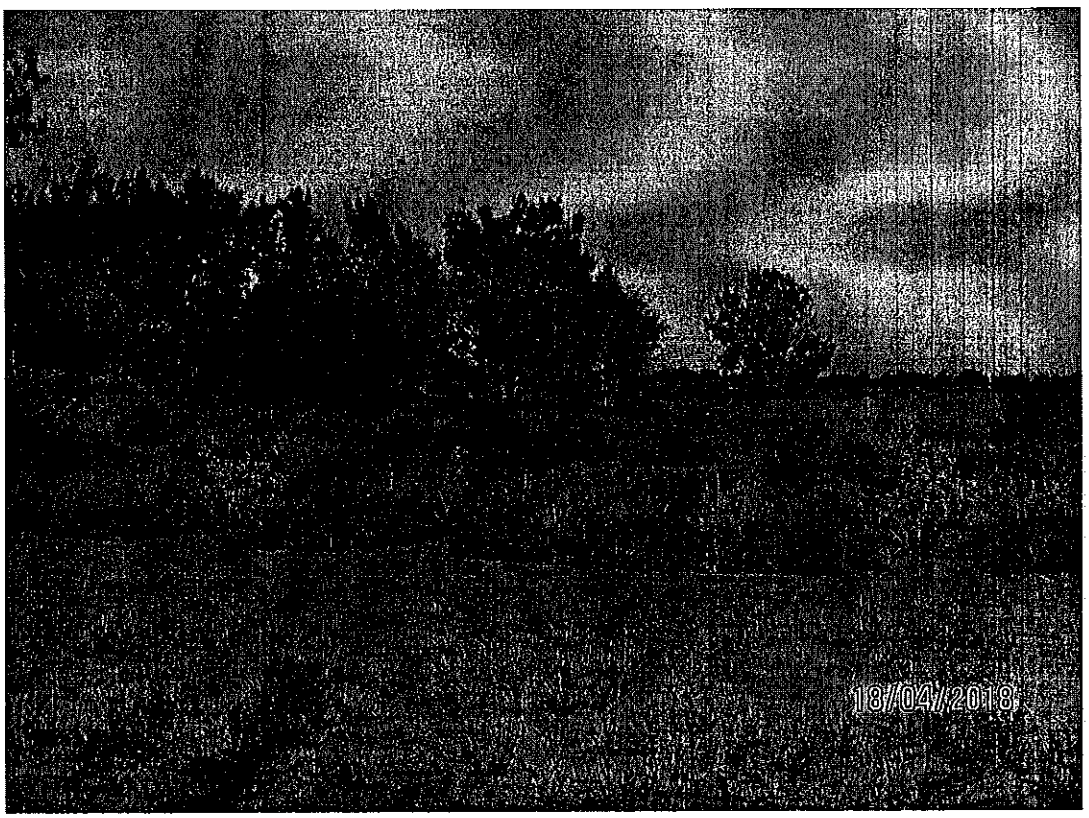



Figure 30 showing the trees that can cause shading along with small shrubs on the site which will be cleared of after initial grubbing of the site

- Module soiling and cleaning. Given the dusty and windy climate of the site, soiling and cleaning of the modules requires an in-depth analysis. From projects developed in the African deserts, ibvogt already has experience in soiling and cleaning marginal cost and benefit calculations, where the actual and monetary values of the yield reduction due to soiling and infrequent cleaning are compared to cost of cleaning the modules. Module cleaning, whether manual or using robots, also requires water, which is a scarce resource in the area. But Mankera solar farm site has an tube well on the site. Laboratory test of tube well water shows that it's a fresh drinking water and will also be used for cleaning of panels. The salinity of water is low which means there will be no salt deposits on the solar panels after cleaning.

- Ramming, drilling or blasting of the ground. The subject area is part of the Greater THALL Desert which is between rivers of Sindh and Jehlum and district Bhakkar forms a part of this desert. The land mass is generally composed of fine Dune SAND as per AASHTO soil classification it is A-3 type, or fine silty SAND with AASHTO classification of A-2-4. The LPT (Light Penetration Test) indicates that the soil compactness varies from medium dense to very dense. The top soil in some shows 1-2 blows for 100mm penetration, however at depth greater than 1.50m the average blows is 3-6 upto 3.0m beyond which it is generally 8 blows for 100mm penetration, which designate a very dense state. Majority of the LPT reached the maximum depth of 4.0m without reaching the refusal. The general depth of testing was 4.0 meters. The Geotech study result shows that ramming is possible

on the site as no hard strata encountered. A total of 91 DCPT Tests were conducted, details of the test summary is appended to this report Attached as Annex H.

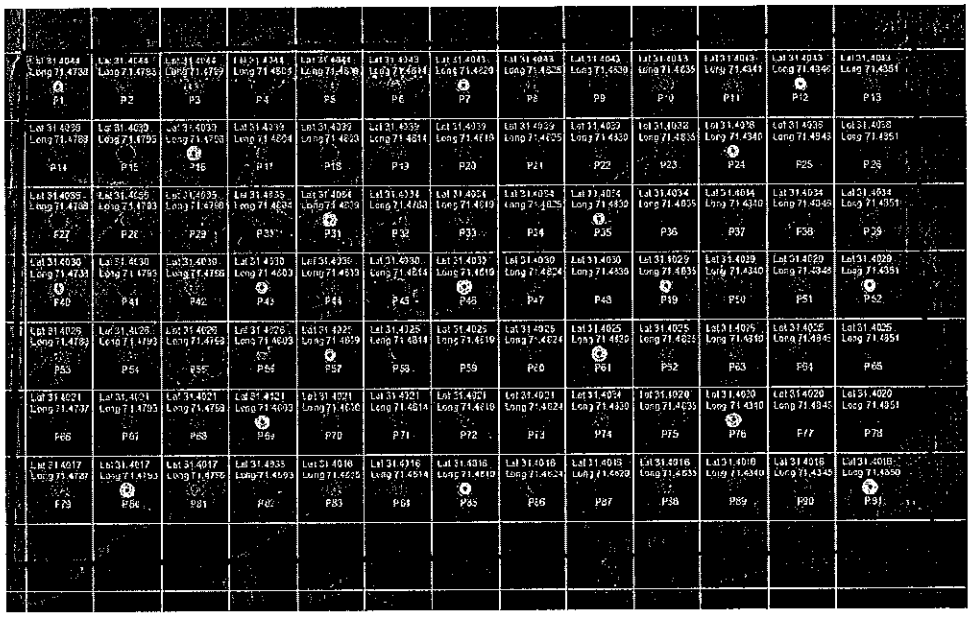


Figure 31 showing 50mX50m grid, yellow points for hand excavation samples, red points for slotted red tests and Light penetration test on all 91 points.

Chemical tests on soil samples indicate that soil does not exhibit an aggressive natureand no special cement or precaution will be required. Bhakkar is situated in Seismic Zone 2A as per Building Code of Pakistan (Seismic provinces -2007), with peak Horizontal Ground Acceleration of 0.08g to 0.16g. Ground water table was not encountered in any of the pits or DCPT however as per information from locals, the water table is around 20ft depth.

## 5.5 Opportunities

On a broader level, the solar farm at presents advantages and opportunities for positive impact, namely:

- Contribution to national renewable energy and climate change targets;
- The delivery of renewable energy at a local level;
- A positive contribution to the economic development and diversification of the area;
- Use of underutilized barren land;
- Sunlight intensity levels - the site is well located geographically for relatively high solar irradiation and flat terrain that is free of any buildings or mountain ranges that could cause shadowing;
- Relatively good road access from the east, west and south, as mentioned above;
- The site is not historically protected or environmentally sensitive, as described within the EIA Regulations;
- Area requirements - the site provides enough land to accommodate a 12.5 MW AC solar farm, and;
- The site is available for the entire lifetime of the proposed scheme (designed operational life span is 25 years).

## 5.6 Design Solution

As evidenced by the company's extensive portfolio of solar power plants, ibvogt's vast EPC and O&M track record serves as a robust indicator of the success and reliability of the design solutions and the comprehensive in-house expertise of the project development teams. This section elaborates on some of the design solutions mentioned previously and addresses important site requirements and local characteristics, specifically with respect to the proposed use of the site; amount, scale and appearance of components; site layout; location; materials requirements; and site access.

### 5.6.1 Proposed Use

As mentioned, the proposed development is for a ground-mounted solar farm. To ensure an optimally operating solar farm and maximize yield and earnings, ibvogt offers its EPC and O&M expertise to design, build and operate the solar farm as per proposed site layout. The solar farm will have energy generating capacity of approximately 12.5 MW AC and will generate enough low carbon renewable electricity to meet the demands of more than 7812 homes a year. The Carbon emissions saving calculations has been carried out and are as follows:

Solar Project Generation in MWhr = 2026*12.5 = 25325

Combined Margin Emission Factor $_{grid, CM, y}$ = 0.6343 $tCO_{2e}$/MWh.

Carbon Emissions savings = Solar Project Generation X Combined Margin Emission Factor $_{grid, CM, y}$

= 25325 MWhr X 0.6343 $tCO_{2e}$ / MWh

= 16063.6475 $tCO_{2e}$

The solar farm is proposed for a standard operational lifetime (approximately 25 years), after which the associated equipment can be removed from the site and the land would be restored to its original condition.

Amount, Scale and Appearance of Components

The attributes of key components are as follows:

- **Modules:** out of the top technologies (e.g. mono- and polycrystalline silicon and thin film) and brands, the most appropriate PV panel type must be selected to generate a combined AC capacity of 12.5 MW. An important point is availability, which can determine the success and speed of the project during construction. As an established leader in the industry, ibvogt has prominent relationships with top module manufacturers, facilitating the procurement process.

- **Module Dimensions:** The dimensions of the selected panel would be in the range of 1.99 m x 0.99m x 0.40m. As part of an optimal arrangement that minimizes near shading, the mounted height of the panels should be no higher than 3 m above ground level and, at the

lower end, at least 600 mm above ground level. The glass coated panels are coated to maximize daylight absorption, and thus minimize glare potential.

**Mounting Frames:**

The solar panels will be oriented towards east and west on metal mounting rack frames by using Sun tracking technology. Each rack is designed with 2 rows of 21 solar panels in portrait orientation. To capture maximum direct irradiation, the mounting frames will adjust its angle of between 0-60 degrees from the horizontal. Rest the solar array will be able move 60 degrees from horizontal either way, east or west. Posts and beams of the supporting structure are made from galvanized steel or aluminum. The design is based on a detailed structural calculation tool developed in-house by ibvogt.

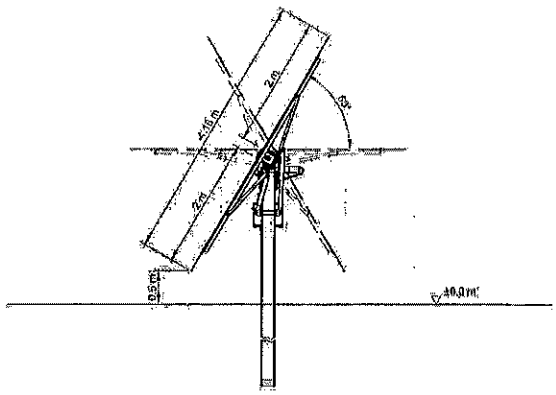
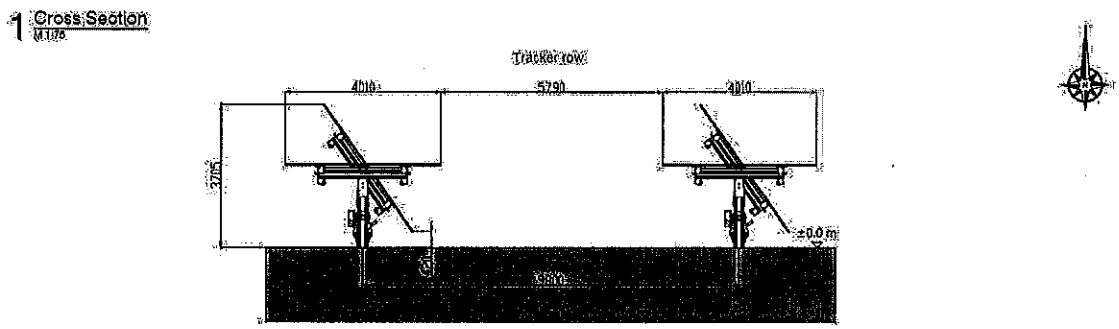


Figure 32 showing side elevation of mounting structure for Single Axis trackers

- **Module Tilt**: in past projects, ibvogt has conducted in-depth analyses on projects across the globe on the applicability of fixed tilt, seasonal tilt and tracking systems. Building upon this extensive track record, ibvogt has compared the financial and technical implications based on a preliminary analysis for each of the approaches for the solar farm site. Due to drop in the equipment prices and will higher yield output, Single – Axis tracker is the best solution for markets with low Feed in Tariff. The module Tilt usually varies between the 15-30 Degrees in different regions depending on angle of the sun. For Mankera development the tilt angle will be adjusted automatically between 0-60 degrees depending of sun angle.



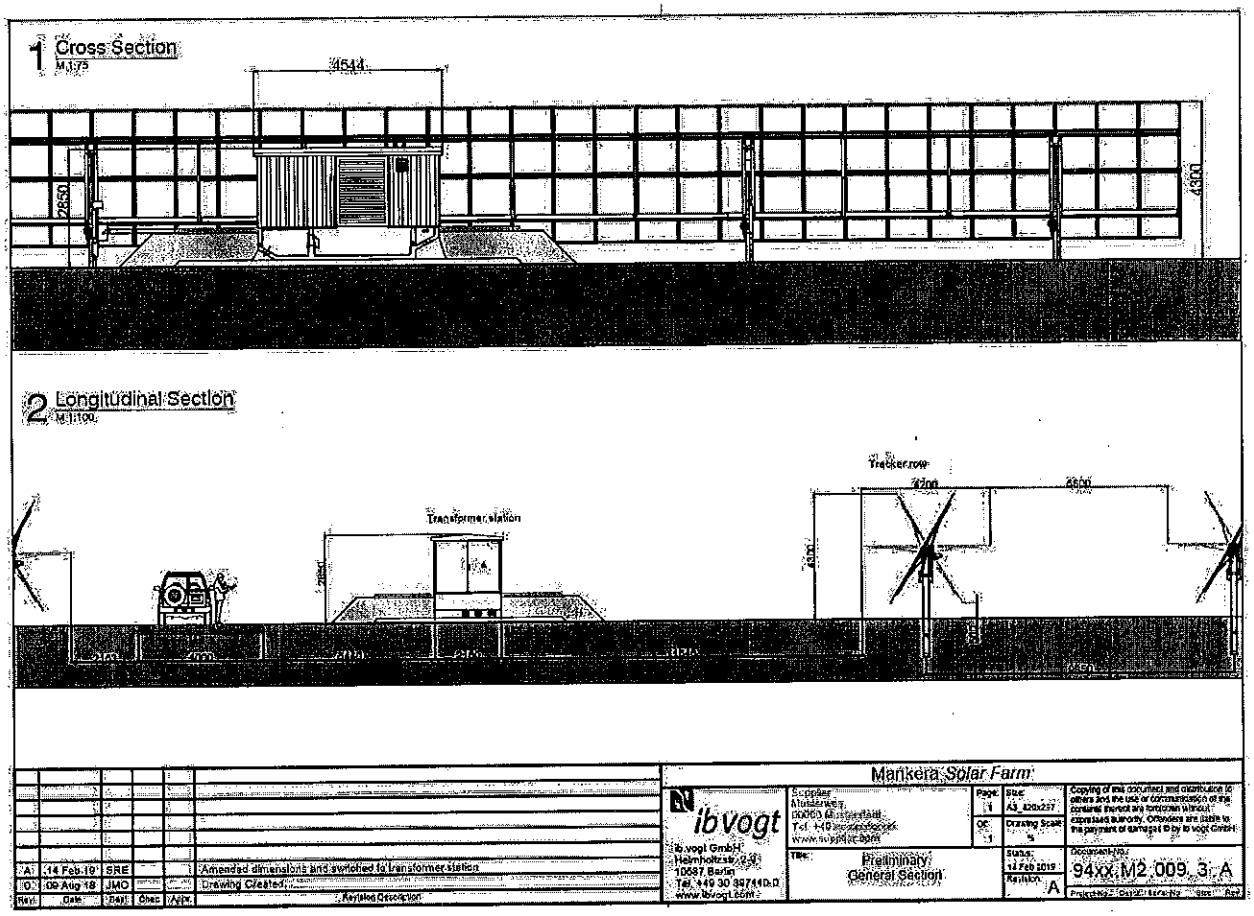



Figure 33 showing generic, side elevation of solar array and front elevation of solar array

Mounting Piles: as the main supporting structure for the modules, piles serve a very important role and must be fixed properly. Piles can be driven but, ramming depth should base on a more detailed analysis of the soil at the site. The mounting frame piles are typically driven approximately 1.5 m into the ground and, contrary to other developments, no concrete foundations are required. At the end of their operational life, when the site is decommissioned, the piles are simply removed from the ground, leaving negligible ground disturbance.

- **MV / Customer Substations (Inverter/Transformer)**: the solar panels generate DC (direct current) electricity and require an inverter to convert DC into AC (alternating current) for injection into the grid. The proposed solar farm will use string inverters like most standard solar farms and details can be found in the example datasheet provided in Annexure C.

  As per the Plant SLD, one collector group is having twenty-five string inverter of 105kVA capacity each that are connected to one transformer station of 0.8/0.230kV, 2750kVA capacity. The output voltage of each inverter is 0.8kV, following with 0.8/0.230kV Transformer. The total five collector groups formed are used to accumulate all available power from PV panels to 11kV bus bar.

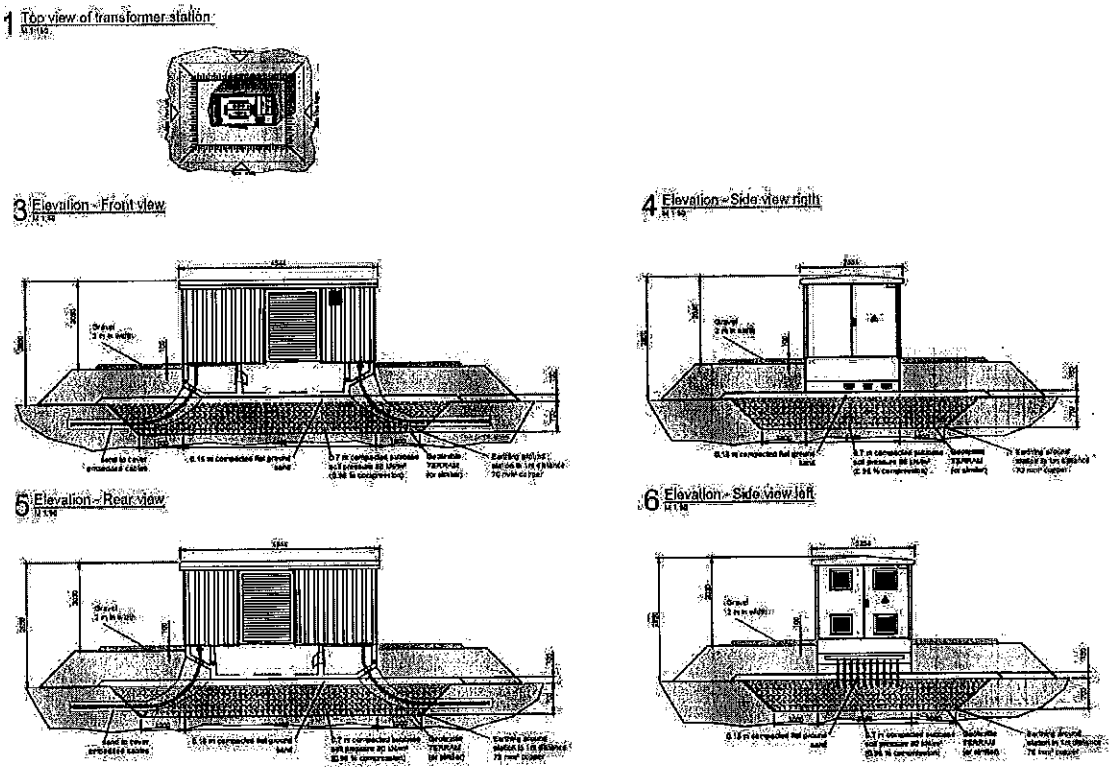
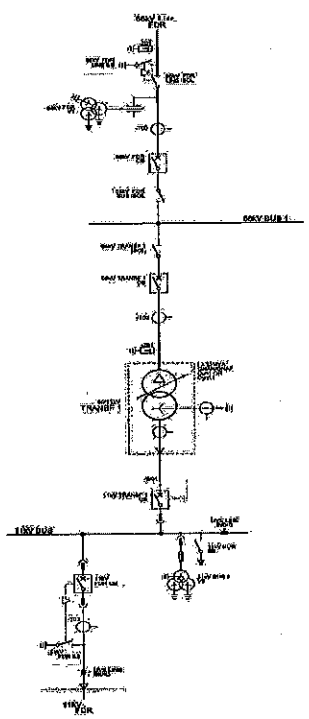



Figure 34 showing typical transformer station

- **Substation (DSO)**: a substation is required on every solar farm site as it is the point of connection from where the electricity flows into the grid network via the connection cable. The substation houses the switchgear which acts as a safety mechanism to protect the solar farm from any fault in the grid and vice versa. It automatically disconnects the electrical circuits if there is a fault in the system. Appropriate earthing and lightning protection systems will be developed during the engineering phase of the project.



Solar farm will be conencted to National Grid through a 11KV connection.

More details of Grid interconection has been discussed in Chapter 6 of the feasibility study.

Figure 35 showing SLD of 66/11KV grid station

- **Communications Pole:** a communications pole will be installed on site so that the solar farm can be remotely monitored by technical operations and maintenance staff. Additional provisions, such as a very small aperture terminal (VSAT) system, teleprotection and communication through a Digital Power Line Carrier (DPLC) system, can be included.

- **Spares Building**: a small storage/spares building will be installed to allow the safe storage of spare parts required from time to time as well as other maintenance equipment.

- **Perimeter Fence**: a perimeter fence must be installed to prevent wild or large animals from entering the site and damaging the panels and equipment. Additionally, it is required for security purposes to prevent vandalism and unauthorized access as well as for health and safety reasons to ensure no unauthorized personnel can access the onsite equipment.

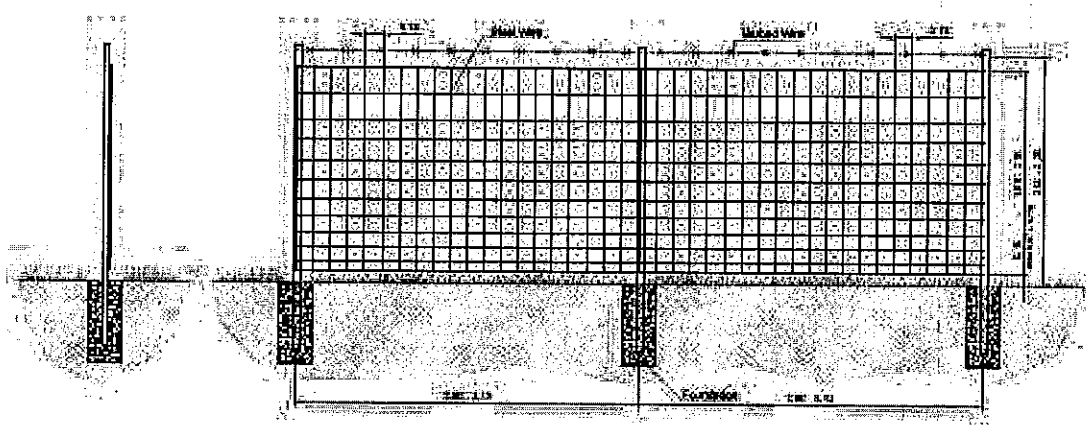


Figure 36 showing typical fence drawing

- **Security Cameras**: to monitor the site and prevent any unauthorized access motion sensor CCTV cameras will be installed along the site boundary. The CCIV cameras will be mounted on poles approximately 4 m in height. Additionally, although the cameras use infrared technology, lighting will be required according to WTG specifications.

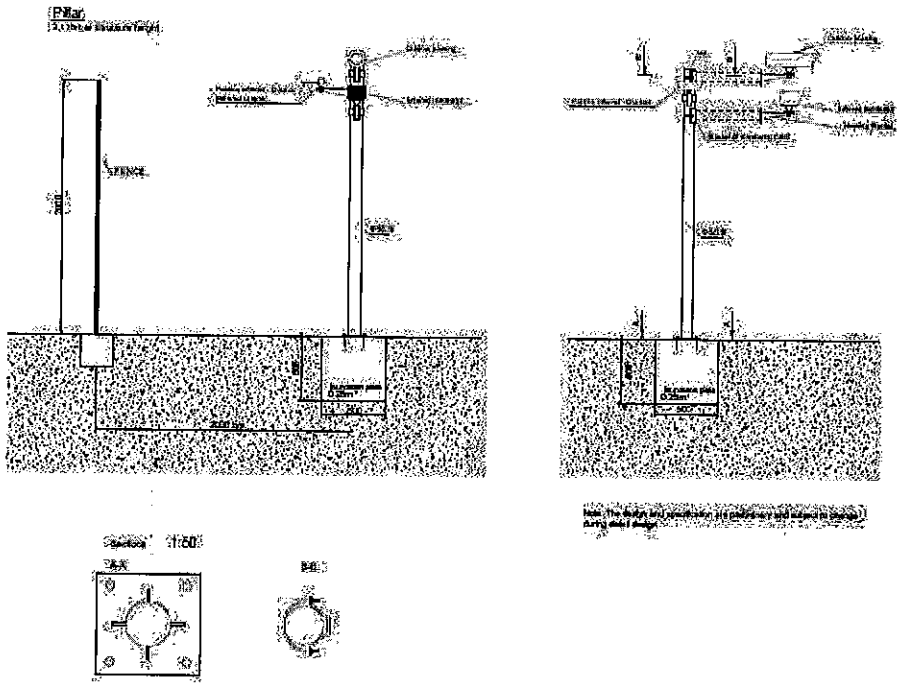


Figure 37 showing typical security camera drawing

- **Temporary Construction Compound**: a temporary construction compound or area is proposed towards the south-western end of the site. This will enable ease of access for construction staff and provide a suitable location for loading and unloading of construction materials. This area will be in temporary use whilst the solar farm is being constructed.

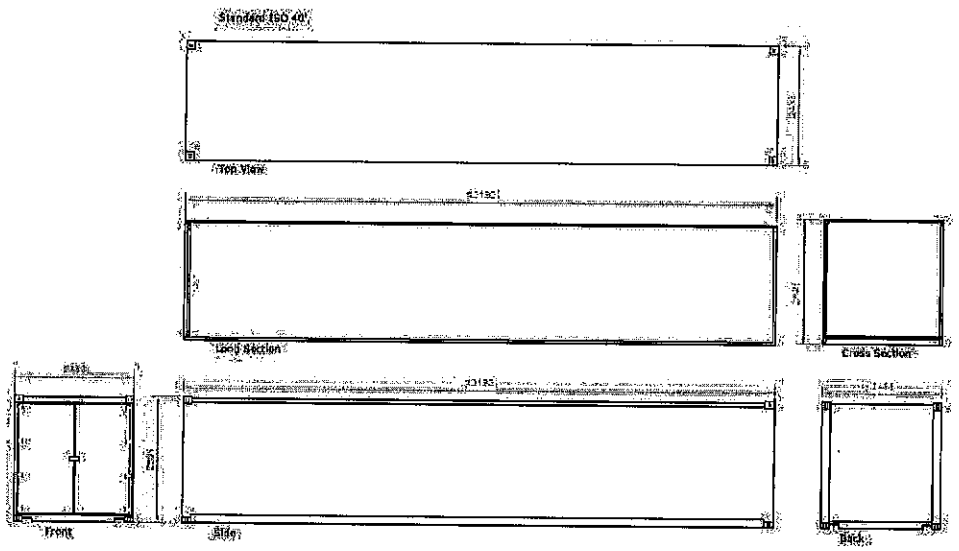


Figure 38 showing typical ISO 40' container

- **Access and Site Tracks**: The development will be connected to the public road network via the existing access road. Existing access tracks on site will be used during construction and operation with some additional sand and gravel tracks installed off the existing access tracks to allow easy access for construction, operation and maintenance.

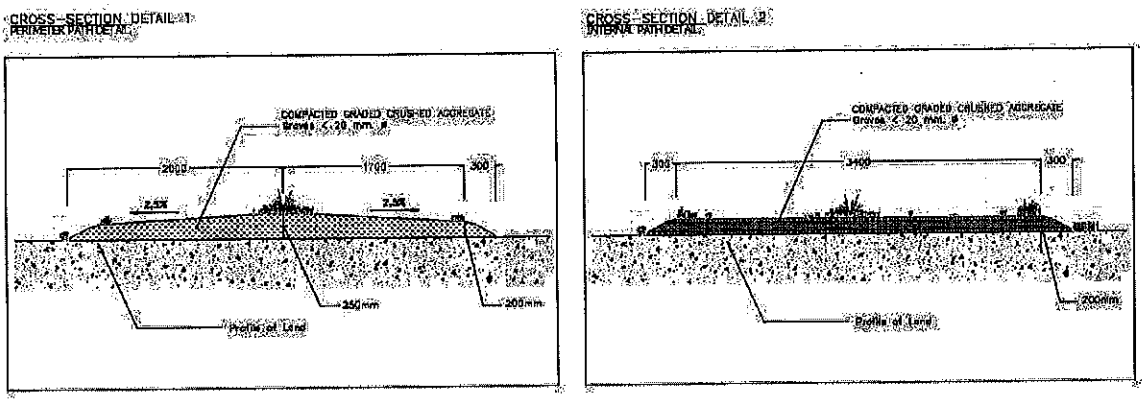



Figure 39 showing typical section of access and site tracks

## 5.6.2 Layout

During the design period, the layout of any solar farm is extremely important to ensure the most efficient use of the land available and prevent any unnecessary impacts on the landscape. It is also important to ensure that no shading occurs on the solar arrays so that they can produce as much electricity as possible from the daylight they receive. The proposed layout has been prepared by ibvogt's in-house technical team and has taken account of all features on site, such as wind turbines and overhead lines. More details are presented in the section on "Yield Assessment".

The total area of the site is 25.25 hectares. Almost 40% of this area will be covered with the proposed solar panels. The remainder of the site will remain as steppe apart from some sand and gravel tracks that will be laid on site as shown on the site layout. The layout in high-resolution can be found in Annexure A.

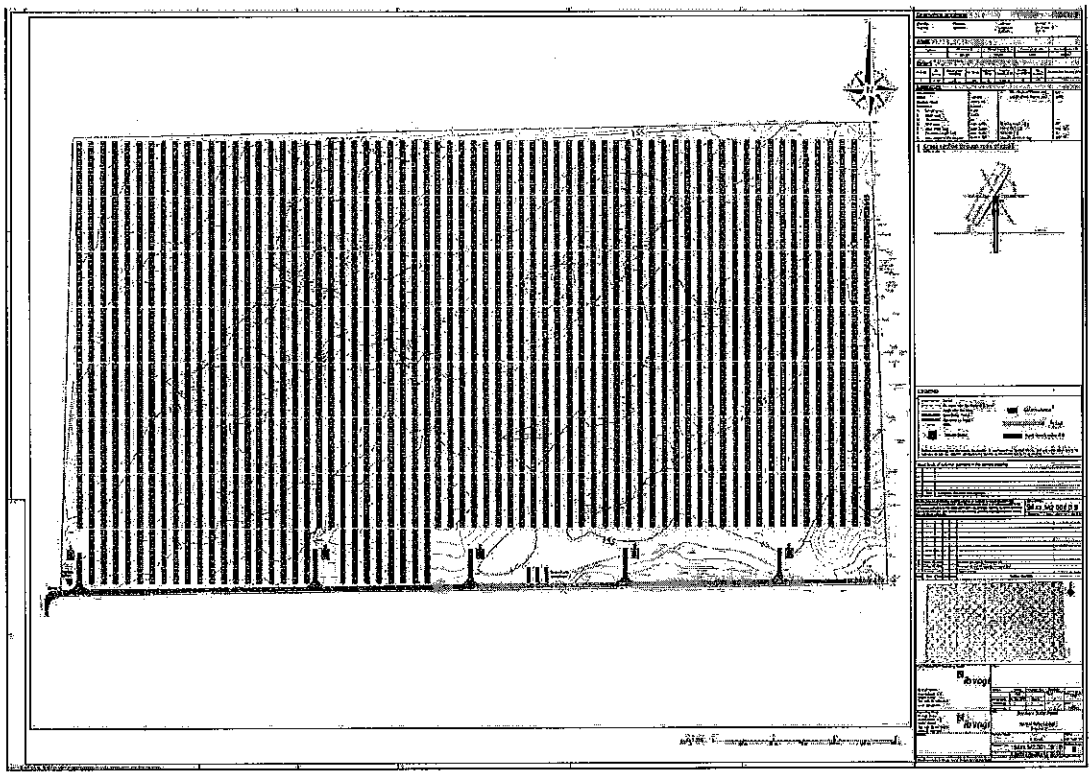


Figure 40 showing PV solar farm layout plan

### 5.6.3 Location

The location of the proposed solar farm has been influenced by several factors. The most important being the need to find a suitable location to support the maximum irradiation potential of the sun. Accordingly, a clear view south, south-facing or a flat site with minimal shadowing are usually considered ideal locations. An available point of connection to the electricity distribution network is also of prime importance, while also satisfying other technical and planning criteria for solar farms.

### 5.6.4 Construction Access

The site will be accessed from the road as shown on the accompanying Site Layout. A new gate entrance will be installed. The area already consists of a firm surface suitable for vehicles entering the site. The site access point has the benefit of being located along a straight stretch of road ensuring excellent sight visibility. During the operational period of the proposed solar farm, low levels of traffic will be generated from the following activities;

- Operations and maintenance staff will visit the site a couple of times a month in a transit van or a 4 x 4 type vehicle;
- Visits per year to clean the panels, which will involve trucking in water.

Occasional tours of the solar farm may be facilitated for educational purposes once it is fully operational. Decommissioning of the site will broadly reflect the same traffic levels experienced during the construction period.

## 5.7 Construction Phase

A maximum of up to 40-60 construction workers are anticipated to be on site during peak times during the construction period. A temporary construction compound will be provided on the site. This will also act as a storage area, parking for contractors and turning for heavy-duty vehicles. A comprehensive construction plan will be prepared before the start of construction. Typically, the construction plan would last up to 34 weeks in total, limited to specific hours by planning condition with limited working at weekends.

The first stage comprising preparation and installation works will take around five months. On completion, there would be a further month of testing and commissioning prior to the development becoming fully operational. A typical sequence of construction works is as follows:

- Field survey/setting out
- Preliminary earth works
- Onsite trenching and cable laying
- Piling to support framework
- Erection of support framework
- Panel Installation
- Electrical Installation
- Construction of transformer buildings
- Connection of inverters
- Security fencing
- Security installation/communication system
- Site remedial works and completion
- Off-site trenching and cabling
- Testing and commissioning

Traffic to the site following the completion of the development will be on an intermittent basis, and should not impact on the conditions of local roads and lanes. Movement of dust during construction will be mitigated via regular module cleaning, as necessary.

# 6. Grid Connection

## 6.1 Current Installation

The 66/11kV Mankera Grid Station is located on Bhakkar-Jhang Road. The grid station is currently equipped with one 10/13MVA (ONAN/ONAF) power Transformer. The general single line diagram of similar grid station is also shown in the figure 41. FESCO is solely responsible for maintenance, extension, augmentation and up-gradation of subject grid station. The 66/11kV Mankera grid station is feeding from one 66kV transmission line of 132kV Bhakkar grid station and having a currently 10/13MVA (ONAN/ONAF) power transformer. An initial survey was carried out to determine the space for new 11kV incoming lines, from solar power plant having capacity of almost 12.5MW AC, enough space is available. The 12.5MW AC solar power plant site is located at a distance of approx. 4.2km away from grid station.

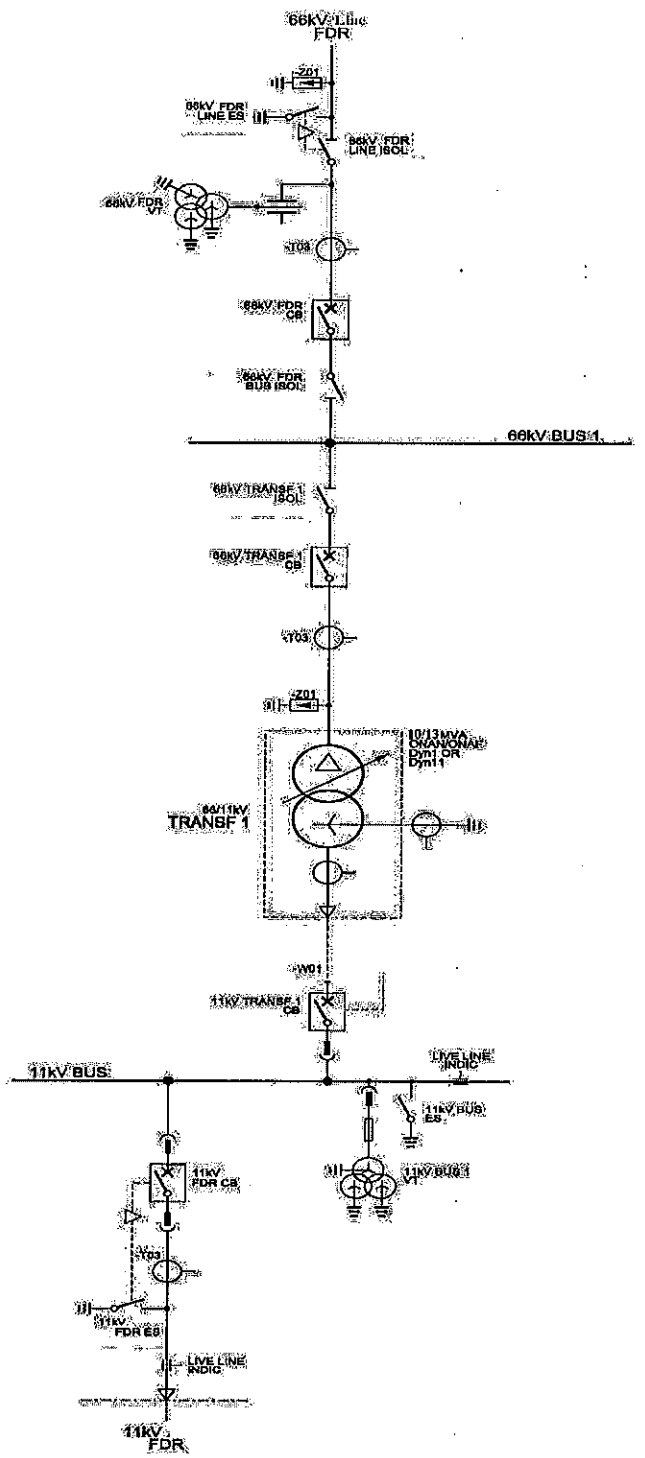



Figure 41 – SLD of 66/11kV Grid Station.

## 6.2 PV plant MV system

As per the Plant SLD, one collector group is having twenty-five string inverter of 105kVA capacity each that are connected to one transformer station of 0.8/0.230kV, 2750kVA capacity. The output voltage of each inverter is 0.8kV, following with 0.8/0.230kV Transformer. The total five collector groups formed are used to accumulate all available power from PV panels to 11kV bus bar. A XLPE insulated 400mm$^2$ and 185mm$^2$ AL cable will be used to connect the output of 0.8/11kV transformer to main 11kV bus bar to avoid losses. Each inverter of model SUN2000-105KTL-H1 make Huawei is connected with approx. 297 strings, each string having 28 modules. Each module is having a capability of peak power is 360W$_p$. Furthermore, the 0.8/11kV, 2750kVA transformer is connected with twenty-five string inverters. The detailed block level modeling is shown in figure 42 below.

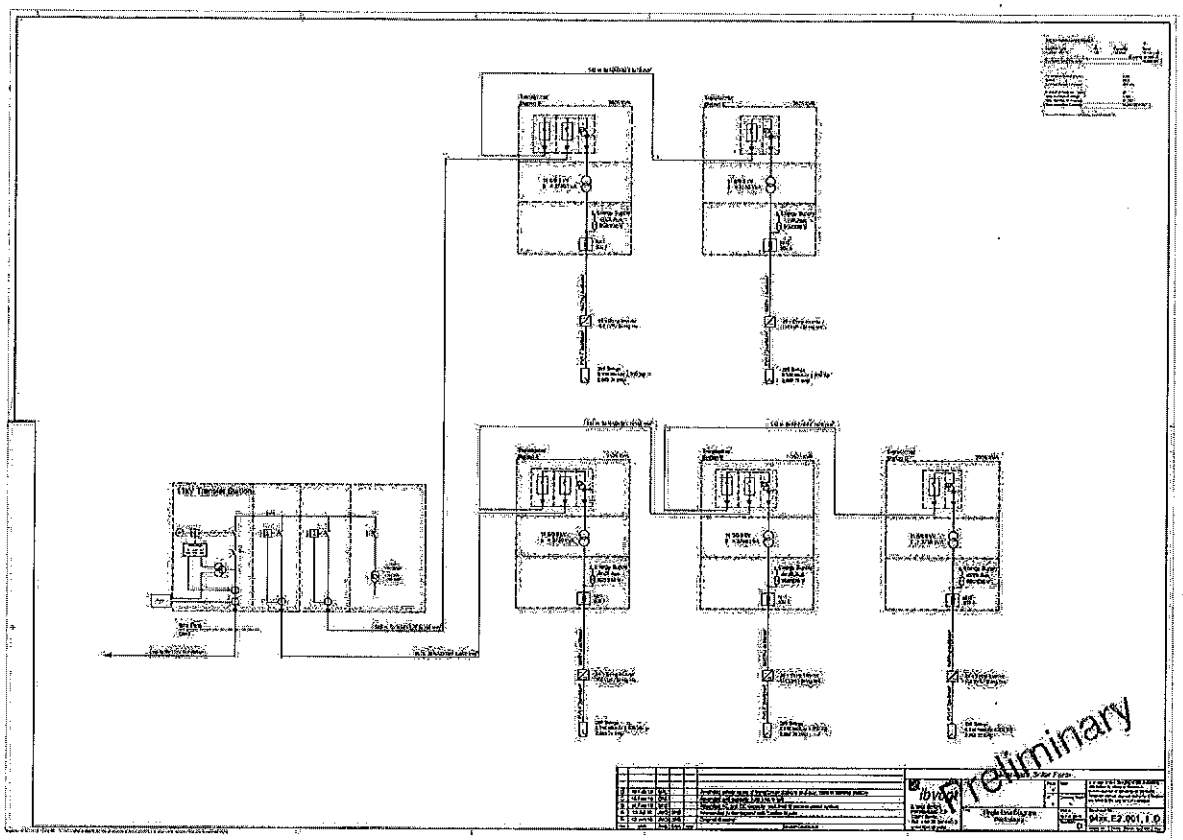



Figure 42 – Single Line Diagram (SLD) for 12.5MW AC Solar Power Plant

The maximum gross installed DC power is 14968.8kW$_p$. The net power (AC) will be normally around 12.5MW and maximum goes up to 13.125MW. As according to CPPA Renewable guidelines if power that is to be evacuated is greater than 12.5MW AC then interconnection would be at 132kV voltage level which nullifies the viability of subject small solar power plant. Therefore, the net available power will be restricted to 12.5MW AC, whereas the auxiliary load will be 110kW approx.

Furthermore, the PV panels are also equipped with single axis tracker having a range of +/- 60.3° to track maximum available power from sun. the detailed layout plan of PV panels with single axis tracker is shown in figure 43.

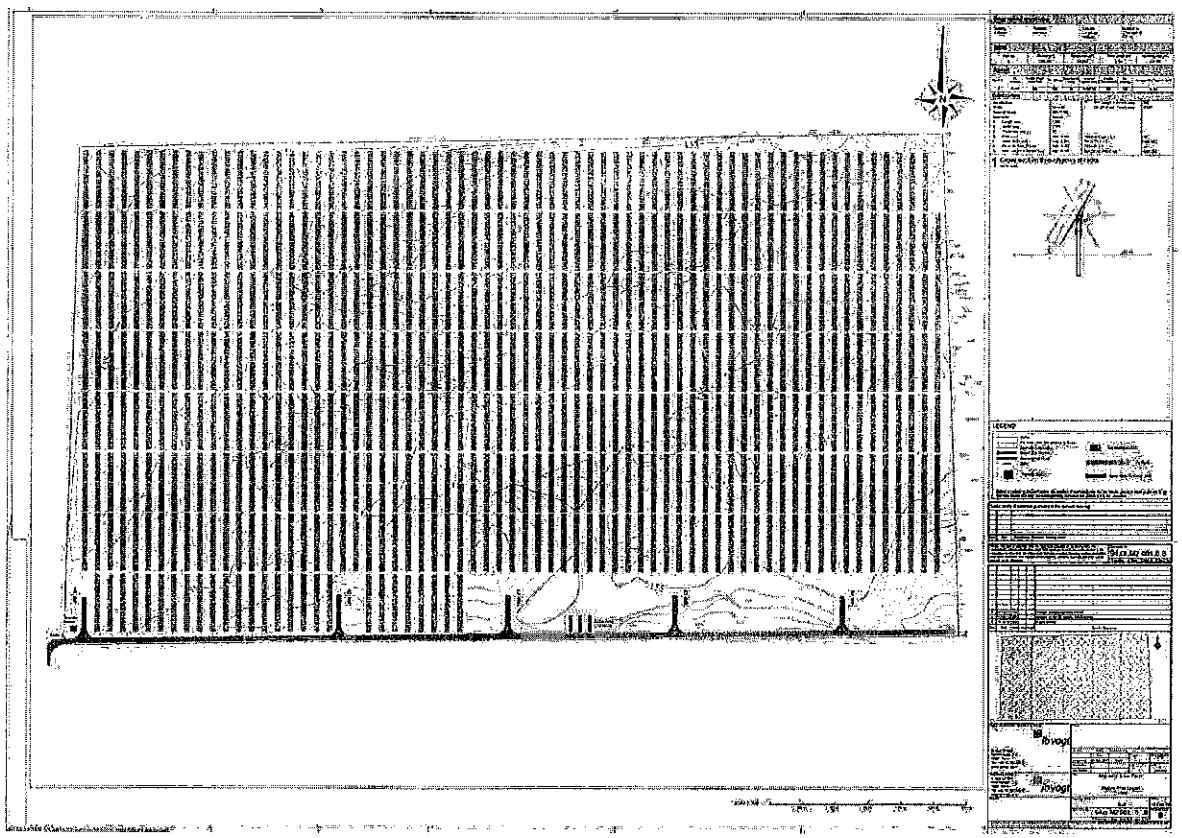


Figure 43 – Module Array Layout Tracker

## 6.3 Grid connection of solar plant

During the site visit, only one suitable, economical possibility of interconnection was discussed. From an engineering perspective, the possible interconnection is described below:

- Connection of the 11kV bus of PV plant to 66/11kV Mankera grid station with 03 Nos. 11kV transmission lines on OSPRAY conductor.
- In N-1, two (02 Nos.) conductors will serve the purpose to ensure reliability of power from 12.5 MW AC solar power plant.

With interconnection of subject power plant, the key considerations must be

- That net maximum power that is injected into the national grid/system will be less than 12.5MW AC in any case.
- That MVAR compensation, to meet grid code requirement of ±0.95 P.F, SVC of 4.2MVAR will be installed.
- That the Quality of power not to be compromised means very much less THD level. Therefore, a detailed load flow, PQ capability and dynamic study would be conducted.
- That the interconnection arrangement must adhere to the local norms and standards.

Furthermore, the stringing of 11kV transmission lines on OSPRAY conductor is not so much expensive. The general topology along with protection scheme, interconnection of 12.5MW AC solar plant with existing 66/11kV Mankera grid station is hereby shown in figure 44.

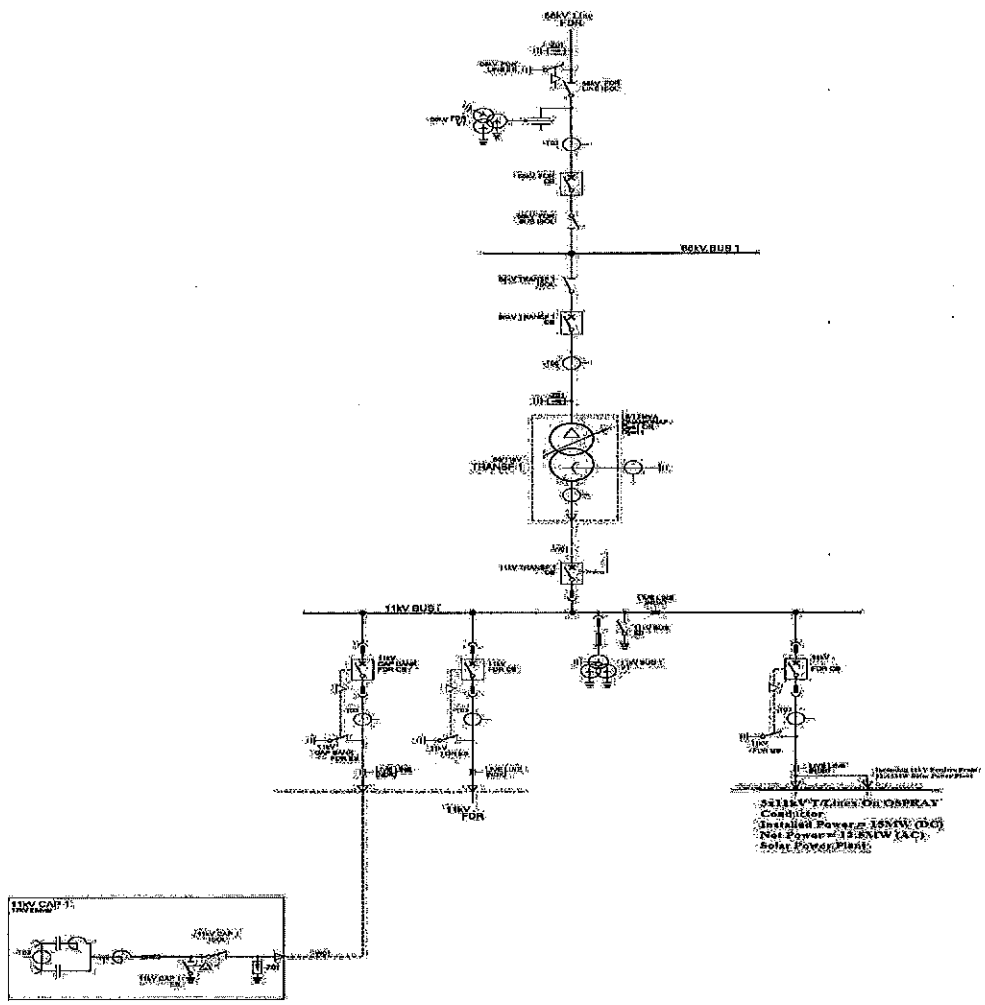


Figure 44 – General Interconnection Topology of 12.5MW AC Solar Power Plant with 66/11kV Mankera Grid Station through 03 Nos. 11kV T/L.

## 6.4 Summary of Grid connection and recommendation

Based on the discussion above, a 12.5MW AC solar power plant will be connected to 66/11kV Mankera Grid Station through 03 Nos. 11kV transmission lines on OSPRAY conductor. In N-1 condition, there will be no constraints of power in the system. Hence, the above discussed option is feasible and recommended.

**Note:**

Detailed Grid Interconnection study is under approval process with FESCO and also submitted with NTDC, attached here as annexure J.

# 7. Energy Yield Assessment

A solar cell is the smallest semiconductor element within a PV module to perform the immediate conversion of sunlight into electrical energy by the photovoltaic effect. Depending on the employed technology, the degree of efficiency amounts up to 18%. This value seems to be quite low, but the free supply of primary energy (solar radiation) and the corresponding absence of power dissipation in the conventional sense should be taken into consideration. By using appropriate technology, such as inverters, the direct current generated by the solar modules is converted into alternating current that can be fed into the public power supply.

The conversion into alternating current implicates losses depending on the PV system configuration, the choice of components and to a minor degree on the local site conditions. If these losses are identified and evaluated, the system operation quality – the performance ratio (PR) – can be ascertained.

The PR is stated as percent and describes the relationship between the actual and theoretical energy outputs of the Solar farm considering module efficiency.

PR = energy yield / (unshaded annual irradiation on array surface * module efficiency as per STC)

$$PR = 100 \times \left[\frac{E_{AC}}{E_{Irradiation} \times A_{Array} \times \eta_{STC}}\right]$$

$E_{AC}$ = energy coming from the inverter in kWh

$E_{Irradiation}$ = unshaded irradiation at module level in kWh

$A_{Array}$ = total surface of all solar modules in m²

$\eta_{STC}$ = module efficiency at STC

The module efficiency, in contrast to the cell efficiency, considers the gross module surface and can be calculated as follows:

$$\eta_{STC} = \left[\frac{P_{Module}}{A_{Module} \times 1000}\right]$$

## 7.1 System Operation Quality / Performance Ratio

A fundamental step in understanding this important quality criterion is the explanation of the typical loss factors affecting the energy yield with different weights. In every simulation step, all described aspects have an hourly impact on the overall result.

## 7.2 Irradiation gain by inclination of modules

In non-equatorial zones, the degree of irradiation at module level can be improved by the inclination of modules southwards (northern hemisphere) or northwards (southern hemisphere) against the horizontal. When reaching a normal module inclination angle of 25-30 degrees, the irradiation gain can amount up to 13-15% in temperate zones. It is expressed by the surface factor F(A) ~ 1,13 – 1,15. The inclination angle causes an additional irradiation because the ground reflects the light onto the modules. This reflection on different soil types is expressed by the Albedo Factor. There are empirical values for different soil surfaces. For example, the solar reflectance of grassland and cropland is about 20%. The effect on the energy yield is relatively low but, even so, is considered in the yield simulations. The product of irradiated amount of energy at module level and module efficiency (not cell efficiency, which is higher) is the basis for the initial value for the PR calculation and is defined to be 100%.

## 7.3 Description of types of technical losses:

### 7.3.1 Technical losses because of shading

If there are objects in the immediate environment of the planned solar farm causing shading of the solar generator, these shadings can be considered and simulated previously within a shading analysis. A distinction is made between "horizon shading" and "nearby shading".

Horizon shading causes a shading effect which has a permanent impact on the entire generator field. The simulation considers this effect by adjusting the horizon line. Objects that are in a large distance to the modules, e.g. mountain ranges, are typical horizon shadings. Such shadings always affect a larger module field, i.e. an array. The relatively flat terrain at and around the Mankera site allows for minimal consideration of horizon shading effects.

Nearby shading has a temporally and spatially impact only on several parts of the generator field. Other parts of the plant remain unaffected. Objects at close distance to the modules act as cast shadows, e.g. power poles, trees but also row shading in large rack mounted solar fields. The potential shading from existing trees at the site was accounted for in the design.

Depending on the site conditions, these aspects are considered in the yield simulation.

### 7.3.2 Technical losses because of dirt

Dirt on the modules also causes shading effects which can change over time and seasonally. This shading impact on the energy yield depends for example on the surrounding landscape, cultivation and precipitation. The impact can only be appraised and is based on experience values. Consequently, the uncertainty is high.

Then again, the degree of this shading effect is quite low and amounts to 1-2% under normal conditions. The Mankera site is characterized by a relatively dusty and windy environment creating higher than normal soiling conditions. Thus, the shading effect from soiling would potentially reach higher percentage amounts.

### 7.3.3 Technical losses because of part-load operation

The intensity of irradiation in solar plants changes during the year. The conversion into electricity does not happen linearly to the changing irradiation conditions.

### 7.3.4 Technical losses because of temperature fluctuation

Ambient temperature and degree of irradiation have an influence on the cell temperature and so affect the energy conversion process. As per the defined STC value of 25° C, the electrical power output decreases with higher cell temperature and increases with lower cell temperature. The module model shows this characteristic by means of temperature coefficients for current and voltage. The temperature ranges at the Mankera site would need to be accounted for.

### 7.3.5 Technical losses because of reflection

Inclined irradiation causes reflection of sunlight at the glass and cell surface. Although this is a small effect, it is considered by an empirically determined factor: IAM (Incidence Angle Modifier). By default, the factor is set to 0.05. With the latest anti-reflective coating, a more realistic factor of 0.04 is used as current industry standards.

### 7.3.6 Technical losses because of fluctuations in module performance

Due to production reasons, the module performances are subject to slight fluctuations (see data sheet „module performance "). Because of the different manufacturing technologies, the module wiring to module strings causes the so-called mismatch effect. Further information can be found for an example module data sheet in Annexure D.

### 7.3.7 Technical losses because of weathering and degradation

Changes in the energy yield because of weathering are not considered in the simulation. Performance guarantees of the manufacturer and different practical results diverge a lot. Former long-term study findings cannot be applied easily to modules produced with today's manufacturing processes and product features. But it is assumed that today's processes and technologies lead to a higher module quality. The consideration of a correction value for weathering / degradation is recommended for the overall result. To varying degrees depending on the method used and frequency, cleaning of the modules may contribute to the overall degradation of the modules over time.

### 7.3.8 Technical losses because of cable losses

The whole wiring of the solar farm is subjected to cable losses due to the natural resistance of conductors - the so-called ohmic resistance. Due to small-scaled plant design and cable dimensioning for maximum performance, losses normally amount to 1-2%.

### 7.3.9 Technical losses because of DC/AC inversion

The conversion of direct current into grid compatible alternating current entails inevitable losses. The conversion losses of the inverters vary according to the chosen inverter type e.g. central inverters, sting inverters, etc.

### 7.3.10 Technical losses because of transformation (transformer losses)

Transformer losses depend simultaneously on several parameters and thus, unfortunately, cannot be simulated with precision. For this reason, depending on transformer quality, the performance ratio and the yields include a blanket value.

### 7.3.11 Technical losses because of self-consumption

Inverters (operation, fans, heating, etc.), monitoring and security systems as well as communication systems consume power. During energy production, the necessary power is reducing the current output of the Solar farm.

### 7.3.12 Technical losses because of Light-Induced Degradation (LID)

LID or also called initial degradation is a potential slight power drop during the first few days under solar radiation that can affect some solar cells. Manufacturers of crystalline modules do not always consider potential LID effects in the power specifications on the identification plate. If a manufacturer fails to take initial degradation into account in their power classification this value is used to regard this effect within the simulation.

## 7.4 Configuration of the PV Generator and Irradiation

Within the solar farm, the solar modules are connected to strings. Most of these strings are collected in DC distribution boxes and generator junction boxes, where they are connected to the inverter. The result is a cascading structure.

## 7.5 Solar module

Bifacial 72 cell modules with a rated nominal power of 360 Wp are used in the design. The maximum open circuit voltage of the modules is at 1500V. Considering the minimum temperatures at the site, 28 modules are connected in series to form a PV string.

## 7.6 Inverters

The solar farm is equipped with string inverters system and each inverter with a nominal active power of 105 kW. A Data sheet of Huawei Inverters can be seen as Annexure C.

## 7.7 Mounting Structure

The plant design corresponds to a single axis tracking system. The titled axis is set at 0° whereas the rotation of the mounting structure is limited between 0° to 60° either way east or west.

This provided for a balance between the irradiation received on the module plane and row shading losses.

## 7.8 Technical losses considered for the energy yield simulation:

### 7.8.1 Technical losses because of shading

Shadings leading to losses due to nearby shading result from the planned installation of modules which is by means of racks arranged in rows. Distance between the rows is kept at 8m. This will lead to a shading angle of 9.7° in summer where the module tilt is 10°and during the winter at a module tilt of 30° the shading angle is 23.8°. By comparison, the lowest position of the midday sun during one year (northern hemisphere December 21st – winter solstice) is at 41.4°. Further shading results from external objects; for the site trees pose external shading on the module array. For the 3D model, all possible positions of the trees were considered. The plant was simulated as 3D model in the simulation program (see Figure 41). Furthermore, the simulation calculated the annual shading ratio. This intermediate result was then factored into the actual yield simulation.

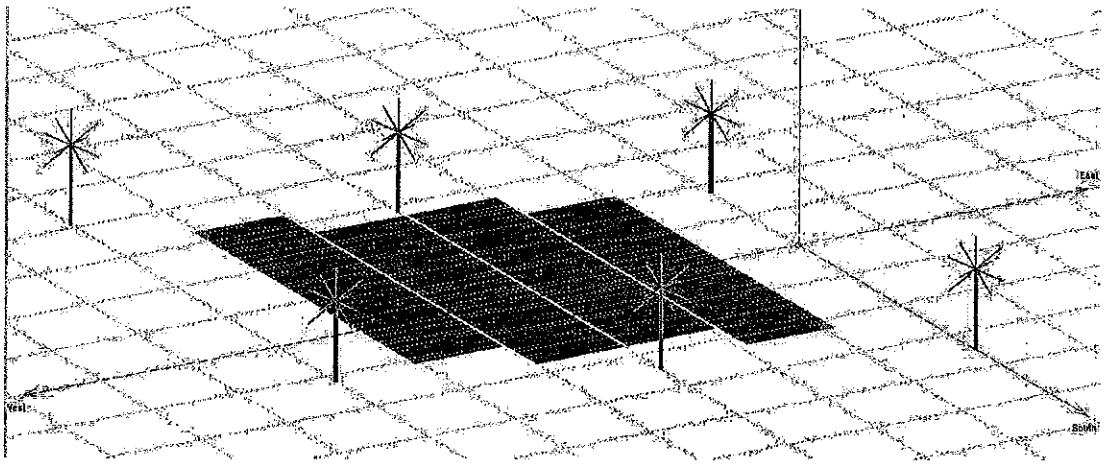


Fig 45 showing 3D Model and shading analysis carried out due to pylnons

The simulation was performed with PVSyst version 6.72, an application developed by the University of Geneva and PVsyst SA, Switzerland. The complete output of the simulation for the PV side can be found in Appendix E. The source data of the simulation is based on simulated half hourly data.

## 7.8.2 Technical losses because of dirt

Based on the company's extensive portfolio of plants, both those that reached the preliminary design stage and those fully constructed, ib vogt has developed a range for typical percentage losses due to dirt for certain climates. In this case, energy yield losses because of dirt on the modules were set at the higher end at 2.0% of the energy generation based on the scope of O&M, considering the prolonged dry seasons and low rainfall at the site, and scheduled module cleaning according to current operation and maintenance industry standards.

## 7.8.3 Technical losses because of fluctuations in module performance

Calculation models according to industry standards were applied for the modules. The current industry standard performance variation is typically at 0/+3%. To consider the gain of the positive sorting of modules the parameter 'module quality' was set to -0.5%. Losses due to mismatch effects are assumed to amount of 0.2% considering a low deviation of $V_{MPP}$ and $I_{MPP}$. Accordingly the LID losses were set at 0.8%.

### 7.8.4 Technical losses because of cable losses

According to the proposed design specifications, the ohmic losses of the DC installations are set to 1.5% under STC conditions. The cable losses on the AC side were set at 1.0% under STC conditions. Further information on cable losses can be found in the simulation output in Appendix E.

### 7.8.5 Technical losses because of DC/AC inversion

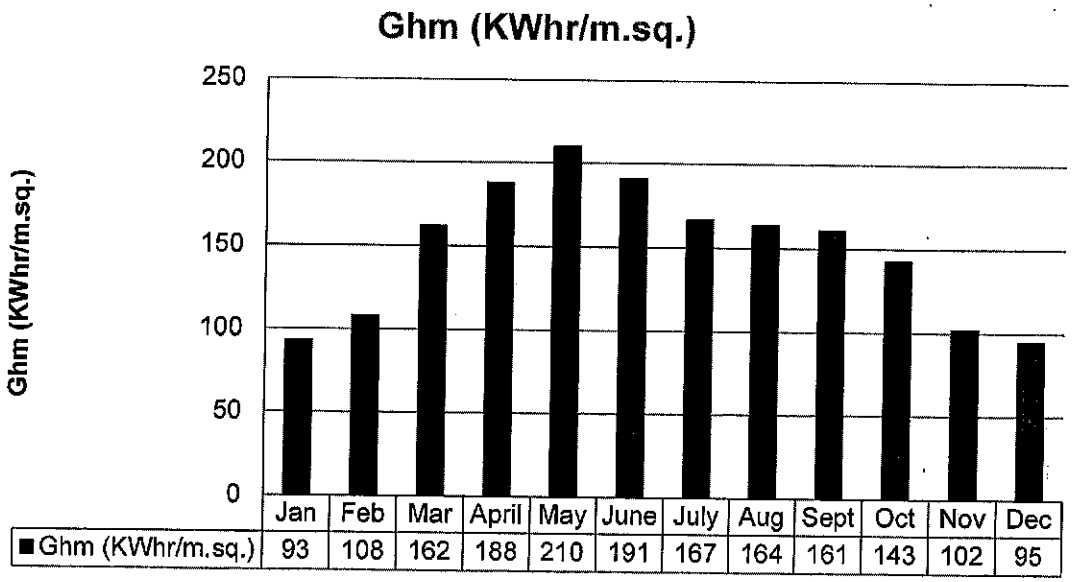
Industry standard central inverters are chosen for the design and accordingly represented in the energy yield simulation. The operating characteristics of the inverter as for yield optimization by efficient MPP tracking could not be displayed in the simulation. The DC/AC ratio is 1.23. This ratio falls in line with many of the successfully operating solar farms across the globe, including solar farms commissioned by ibvogt. Short periods with overload are possible.

### 7.8.6 Technical losses because of transformation (transformer losses)

Losses of external transformers were set at with 0.1% for iron losses and 1.0% for resistive/inductive losses according to the widely-used industry standard equipment.

## 7.9 Irradiation conditions

For the simulation irradiation data from the provider SolarGIS for the years 1999 – 2018 at a resolution of 30 minutes was used. SolarGIS provides irradiation data based on calculations from satellite images. The spatial resolution is 1.5 arc-minutes (about 3 km right below the satellite at 0° N, 0° E).




| | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ghm (KWhr/m.sq.) | 93 | 108 | 162 | 188 | 210 | 191 | 167 | 164 | 161 | 143 | 102 | 95 |

Fig 46 showing GHI values for Mankera solar farm site

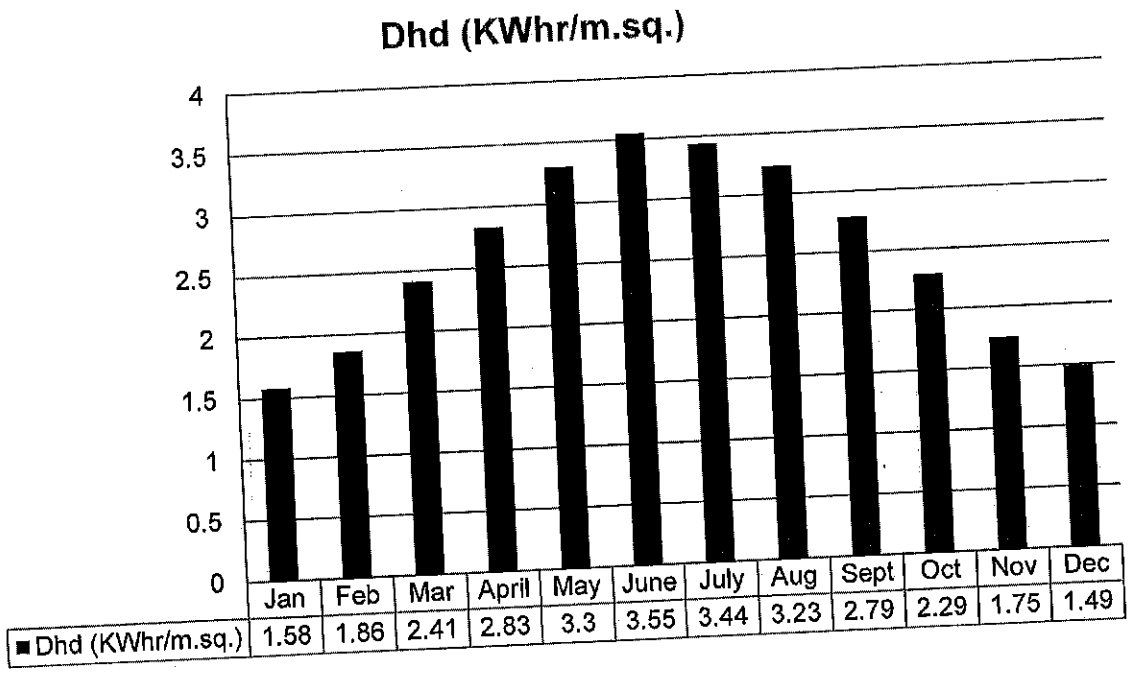



Fig 47 showing diffused horizontal irradiation values for Mankera solar farm site

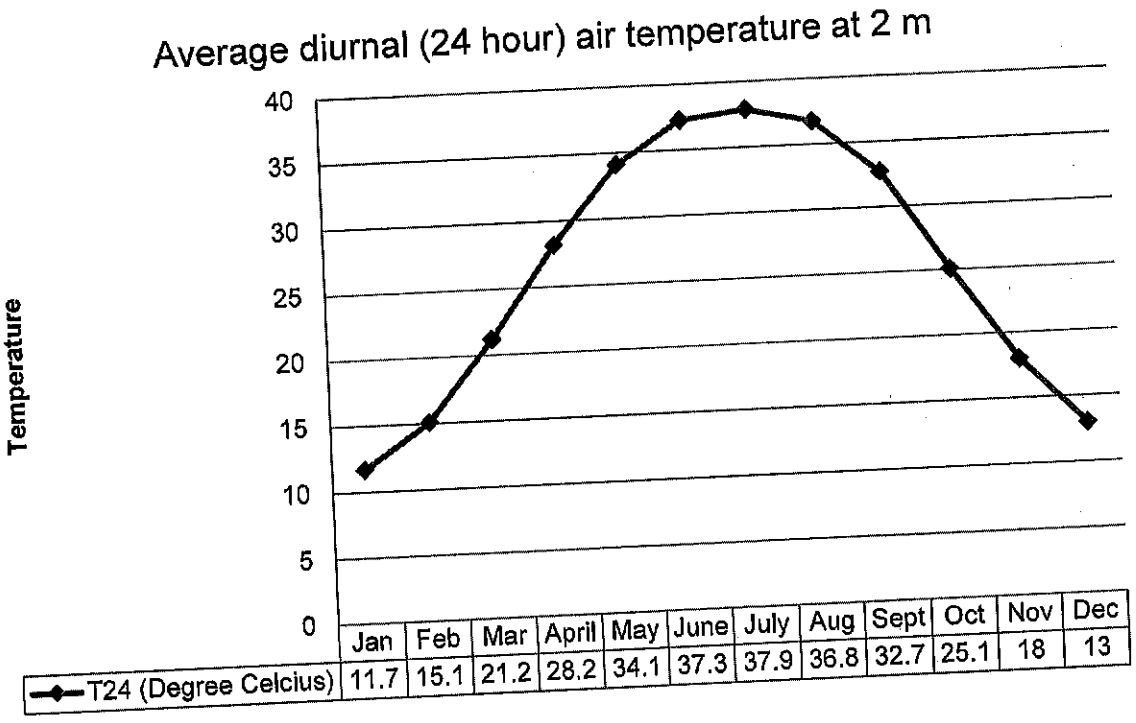



Fig 48 showing average diurnal air temperature at 2m

## 7.10 Energy Yield Prediction Results

The energy yield assessment was carried out using standard market software acceptable for 3rd party assessment. For yield assessment ibvogt engineers evaluate all possible solutions for

system design using fixed tilt, seasonal tilt and single axis trackers. After first Panel of Experts meeting on 8th of February 2019, a revised yield assessment was carried out while using bifacial solar panels with single axis tracker and string inverter. The results of yield assessment were compared and analyzed with the yield results previously submitted to PPDB before first POE meeting.

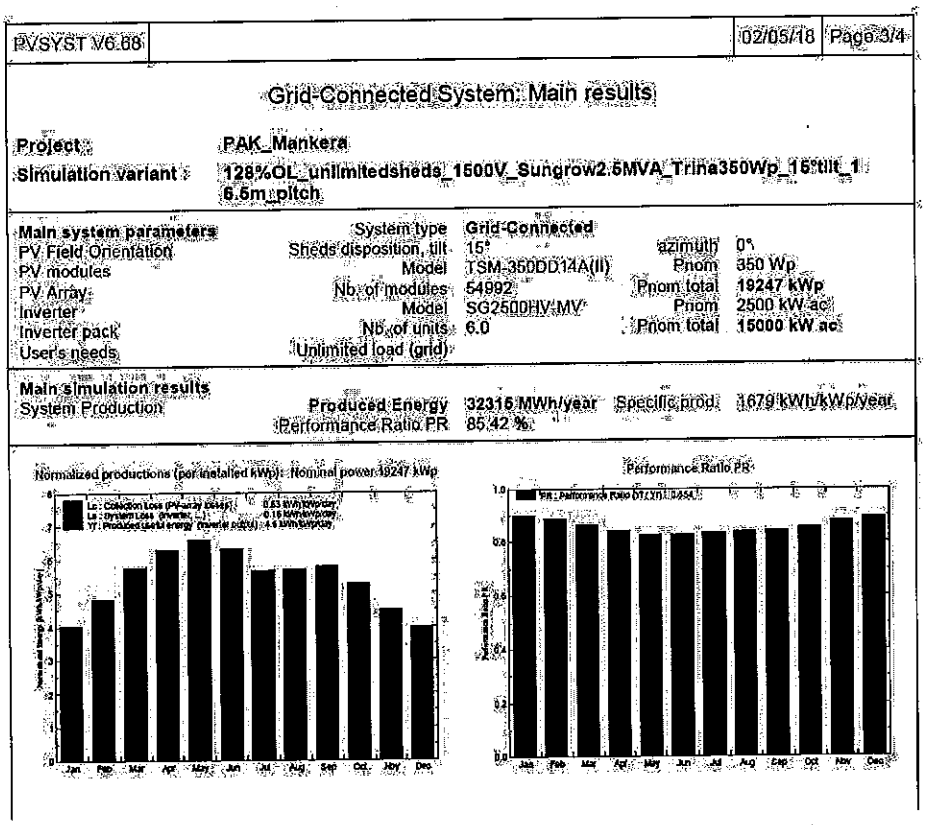
All the specific yields were put into financial model to evaluate project feasibility and most feasible solution was than finalized for Mankera solar farm project.

### 7.10.1 Fix Tilt System

As mentioned above, the energy yield calculation was performed using the software PVSyst 6.72.

To simulate the daily irradiation at Mankera site, the percentage of diffuse radiation must be identified as per the Liu-Jordan correlations model. Then, the percentages of direct and diffuse radiation are applied to the inclination and adjustment of the solar generator as per the calculation model of Perez.

The hourly / daily variation in irradiance is based on a statistical method using daily values. This method traces back to the data evaluation of numerous weather stations worldwide. These results in a surface-factor applied for the variation in irradiance (irradiation on the horizontal or on the inclined module surface).



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Grid-Connected System: Main results

Project: PAK_Mankera

Simulation variant: 128%OL_unlimitedsheds_1500V_Sungrow2.5MVA_Trina350Wp_15°tilt_1 6.5m_pitch

| | | | | | |
|---|---|---|---|---|---|
| Main system parameters | System type | Grid-Connected | | | |
| PV Field Orientation | Sheds disposition, tilt | 15° | | azimuth | 0° |
| PV modules | Model | TSM-350DD14A(II) | | Pnom | 350 Wp |
| PV Array | Nb. of modules | 54992 | | Pnom total | 19247 kWp |
| Inverter | Model | SG2500HV-MV | | Pnom | 2500 kW ac |
| Inverter pack | Nb. of units | 6.0 | | Pnom total | 15000 kW ac |
| User's needs | Unlimited load (grid) | | | | |
| Main simulation results | | | | | |
| System Production | Produced Energy | 32316 MWh/year | | Specific prod. | 1679 kWh/kWp/year |
| | Performance Ratio PR | 85.42 % | | | |

Normalized productions (per installed kWp): Nominal power 19247 kWp

Performance Ratio PR

Figure 49 showing yield assessment of solar farm site for fixed tilt system with monocrystalline modules and central inverters

**128%OL_unlimitedsheds_1500V_Sungrow2.5MVA_Trina350Wp_15°tilt_16.5m_pitch**

**Balances and main results**

| | GlobHor kWh/m² | DiffHor kWh/m² | T_Amb °C | GlobInc kWh/m² | GlobEff kWh/m² | EArray MWh | E_Grid MWh | PR |
|---|---|---|---|---|---|---|---|---|
| January | 99.6 | 44.9 | 8.70 | 124.5 | 118.7 | 2227 | 2156 | 0.900 |
| February | 113.8 | 51.1 | 11.50 | 134.6 | 128.9 | 2376 | 2297 | 0.887 |
| March | 160.7 | 71.4 | 16.00 | 178.7 | 171.1 | 3076 | 2973 | 0.864 |
| April | 180.3 | 83.0 | 20.60 | 186.6 | 180.5 | 3172 | 3065 | 0.844 |
| May | 202.9 | 99.5 | 25.00 | 203.4 | 194.4 | 3355 | 3242 | 0.828 |
| June | 192.9 | 107.5 | 26.00 | 189.6 | 180.9 | 3128 | 3023 | 0.828 |
| July | 177.6 | 107.5 | 25.70 | 175.3 | 166.8 | 2910 | 2814 | 0.834 |
| August | 172.7 | 100.5 | 25.10 | 176.3 | 168.1 | 2935 | 2837 | 0.836 |
| September | 160.4 | 78.1 | 22.80 | 173.3 | 165.9 | 2909 | 2811 | 0.843 |
| October | 141.6 | 65.9 | 18.80 | 163.2 | 156.1 | 2783 | 2691 | 0.857 |
| November | 108.4 | 47.8 | 13.60 | 134.3 | 128.4 | 2353 | 2277 | 0.881 |
| December | 96.2 | 42.2 | 9.80 | 123.6 | 118.0 | 2190 | 2126 | 0.894 |
| Year | 1807.0 | 899.4 | 18.68 | 1965.4 | 1877.9 | 33424 | 32315 | 0.854 |

| Legends | | | | |
|---|---|---|---|---|
| GlobHor | Horizontal global irradiation | GlobEff | Effective Global, corr. for IAM and shadings |
| DiffHor | Horizontal diffuse irradiation | EArray | Effective energy at the output of the array |
| T_Amb | Ambient Temperature | E_Grid | Energy injected into grid |
| GlobInc | Global incident in coll. plane | PR | Performance Ratio |

Table 9 showing balances and main results of yield assessment for fixed tilt system, with monocrystalline modules and central inverters

**Annual Specific Yield for fixed tilt: 1679 kWh/kWp**

**Performance Ratio: 85.42%**

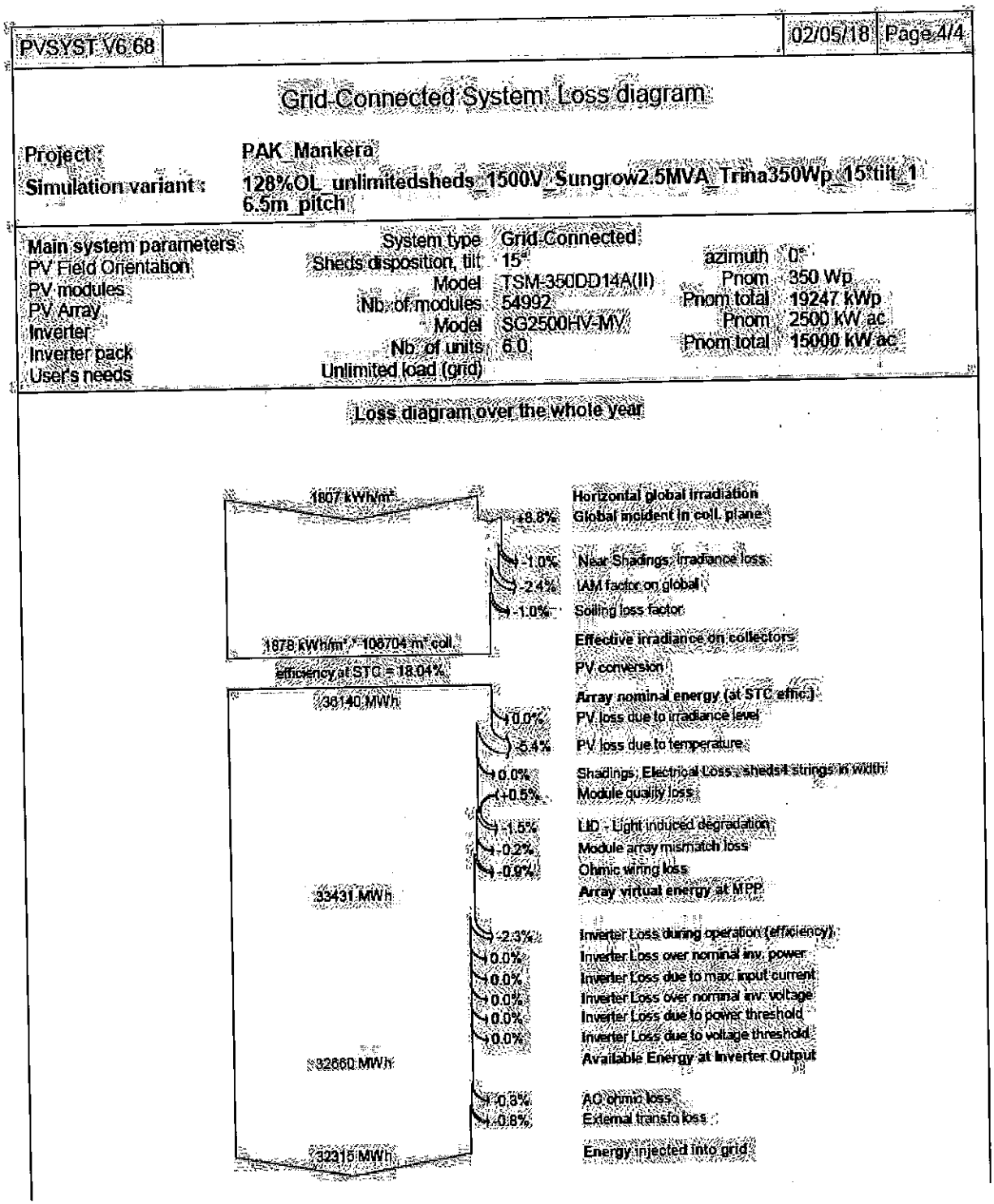
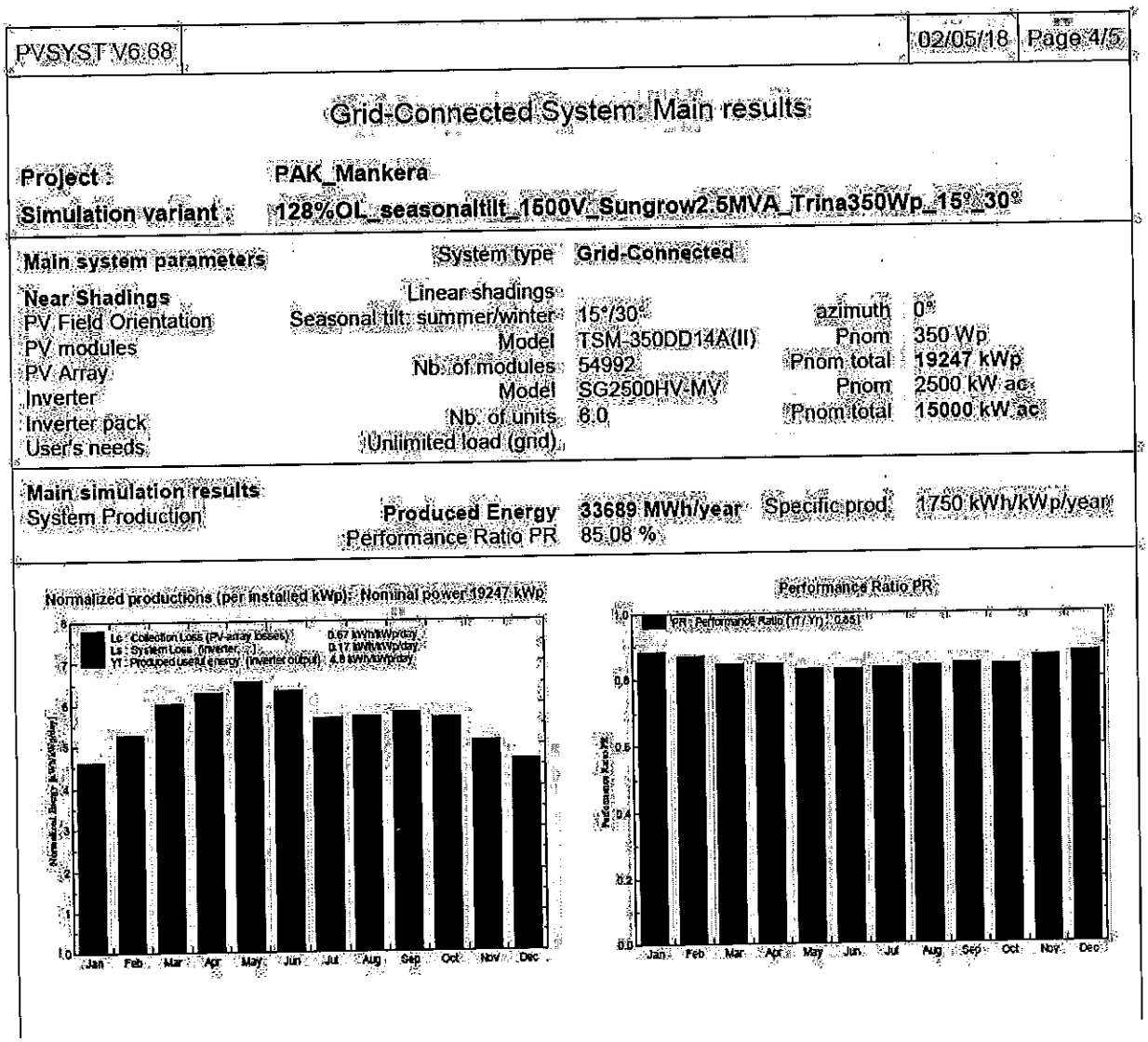



Figure 50 showing grid connected system loss diagram with monocrystalline modules and central inverters

## 7.10.2 Seasonal Tilt

To assess the suitable technical design for the site, additional seasonal tilt design was also prepared by ib vogt design team for comparison with Fixed Tilt and Single Axis tracker yields.



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**Grid-Connected System: Main results**

**Project :** PAK_Mankera

**Simulation variant :** 128%OL_seasonaltilt_1500V_Sungrow2.5MVA_Trina350Wp_15°_30°

| | | | | |
|---|---|---|---|---|
| **Main system parameters** | System type | **Grid-Connected** | | |
| **Near Shadings** | Linear shadings | | | |
| PV Field Orientation | Seasonal tilt: summer/winter | 15°/30° | azimuth | 0° |
| PV modules | Model | TSM-350DD14A(II) | Pnom | 350 Wp |
| PV Array | Nb. of modules | 54992 | Pnom total | 19247 kWp |
| Inverter | Model | SG2500HV-MV | Pnom | 2500 kW ac |
| Inverter pack | Nb. of units | 6.0 | Pnom total | 15000 kW ac |
| User's needs | Unlimited load (grid) | | | |

| | | | | |
|---|---|---|---|---|
| **Main simulation results** | | | | |
| System Production | **Produced Energy** | **33689 MWh/year** | Specific prod. | 1750 kWh/kWp/year |
| | Performance Ratio PR | 85.08 % | | |



Figure 51 showing seasonal tilt, yield assessment for solar farm using manual seasonal tilt mounting structure, with monocrystalline modules and central inverters

**128%OL_seasonaltilt_1500V_Sungrow2.5MVA_Trina350Wp_15°_30°**
**Balances and main results**

| | GlobHor kWh/m² | DiffHor kWh/m² | T_Amb °C | GlobInc kWh/m² | GlobEff kWh/m² | EArray MWh | E_Grid MWh | PR |
|---|---|---|---|---|---|---|---|---|
| January | 99.6 | 44.9 | 8.70 | 142.6 | 135.1 | 2516 | 2433 | 0.887 |
| February | 113.8 | 51.1 | 11.50 | 148.1 | 140.7 | 2574 | 2487 | 0.873 |
| March | 160.7 | 71.4 | 16.00 | 187.1 | 177.3 | 3166 | 3059 | 0.850 |
| April | 180.3 | 83.0 | 20.60 | 188.6 | 181.1 | 3180 | 3073 | 0.847 |
| May | 202.9 | 99.5 | 25.00 | 203.4 | 195.0 | 3365 | 3251 | 0.831 |
| June | 192.9 | 107.6 | 26.00 | 189.6 | 181.5 | 3139 | 3033 | 0.831 |
| July | 177.5 | 107.5 | 25.70 | 175.3 | 167.4 | 2920 | 2823 | 0.837 |
| August | 172.7 | 100.5 | 25.10 | 176.3 | 168.7 | 2945 | 2847 | 0.839 |
| September | 160.4 | 78.1 | 22.80 | 173.3 | 166.4 | 2918 | 2819 | 0.845 |
| October | 141.6 | 65.9 | 18.80 | 175.9 | 166.8 | 2957 | 2858 | 0.844 |
| November | 108.4 | 47.8 | 13.60 | 152.9 | 145.3 | 2644 | 2656 | 0.869 |
| December | 96.2 | 42.2 | 9.89 | 144.2 | 136.7 | 2632 | 2448 | 0.882 |
| Year | 1807.0 | 899.4 | 18.68 | 2057.2 | 1961.9 | 34855 | 33689 | 0.851 |

Legends:
GlobHor Horizontal global irradiation
DiffHor Horizontal diffuse irradiation
T_Amb Ambient Temperature
GlobInc Global incident in coll. plane
GlobEff Effective Global, corr. for IAM and shadings
EArray Effective energy at the output of the array
E_Grid Energy injected into grid
PR Performance Ratio

Table 10 showing balances and main results of yield assessment using manual seasonal tilt system, with monocrystalline modules and central inverters

**Annual Specific Yield for manual seasonal tilt: 1750 kWh/kWp**

**Performance Ratio: 85.08%**

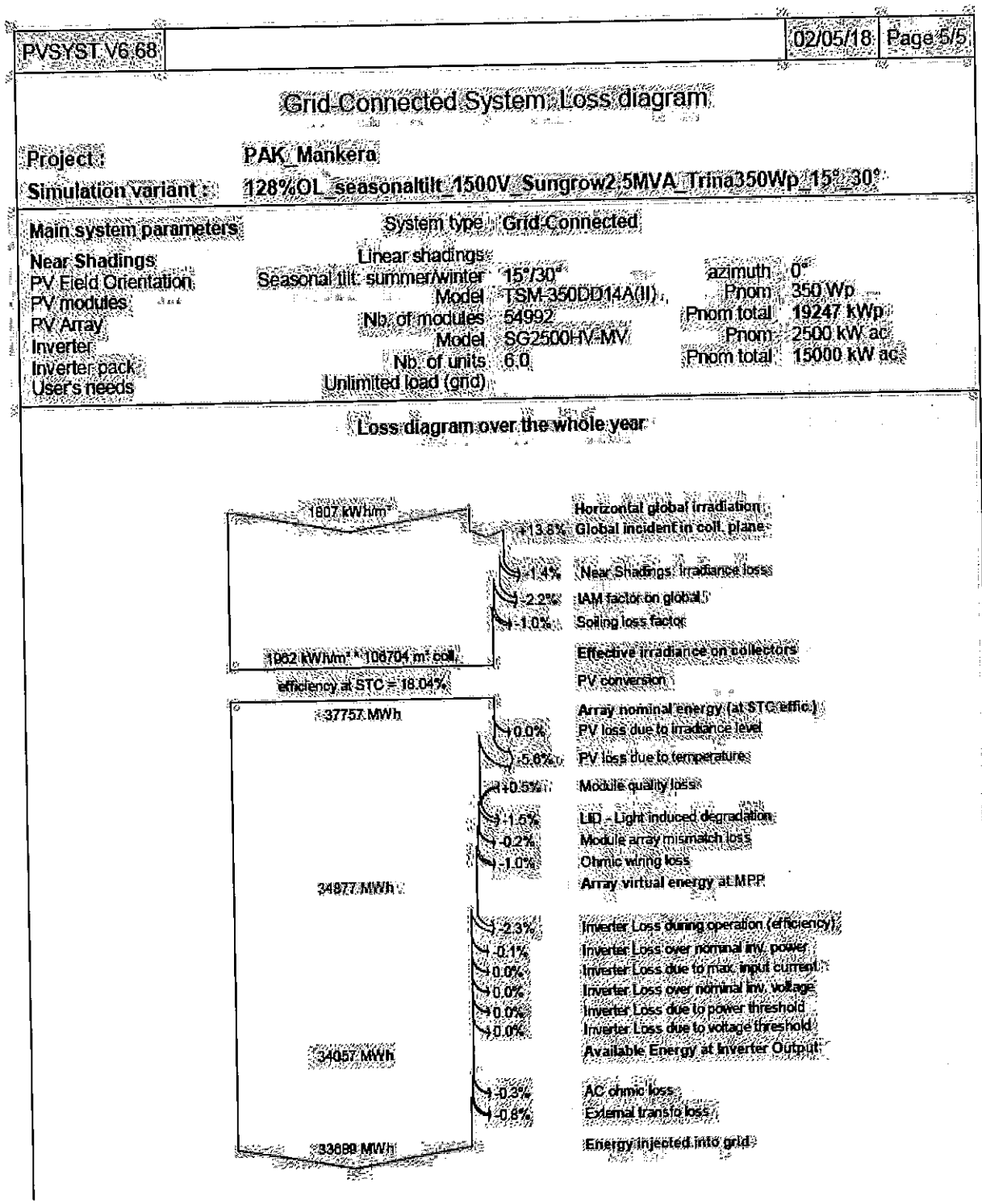
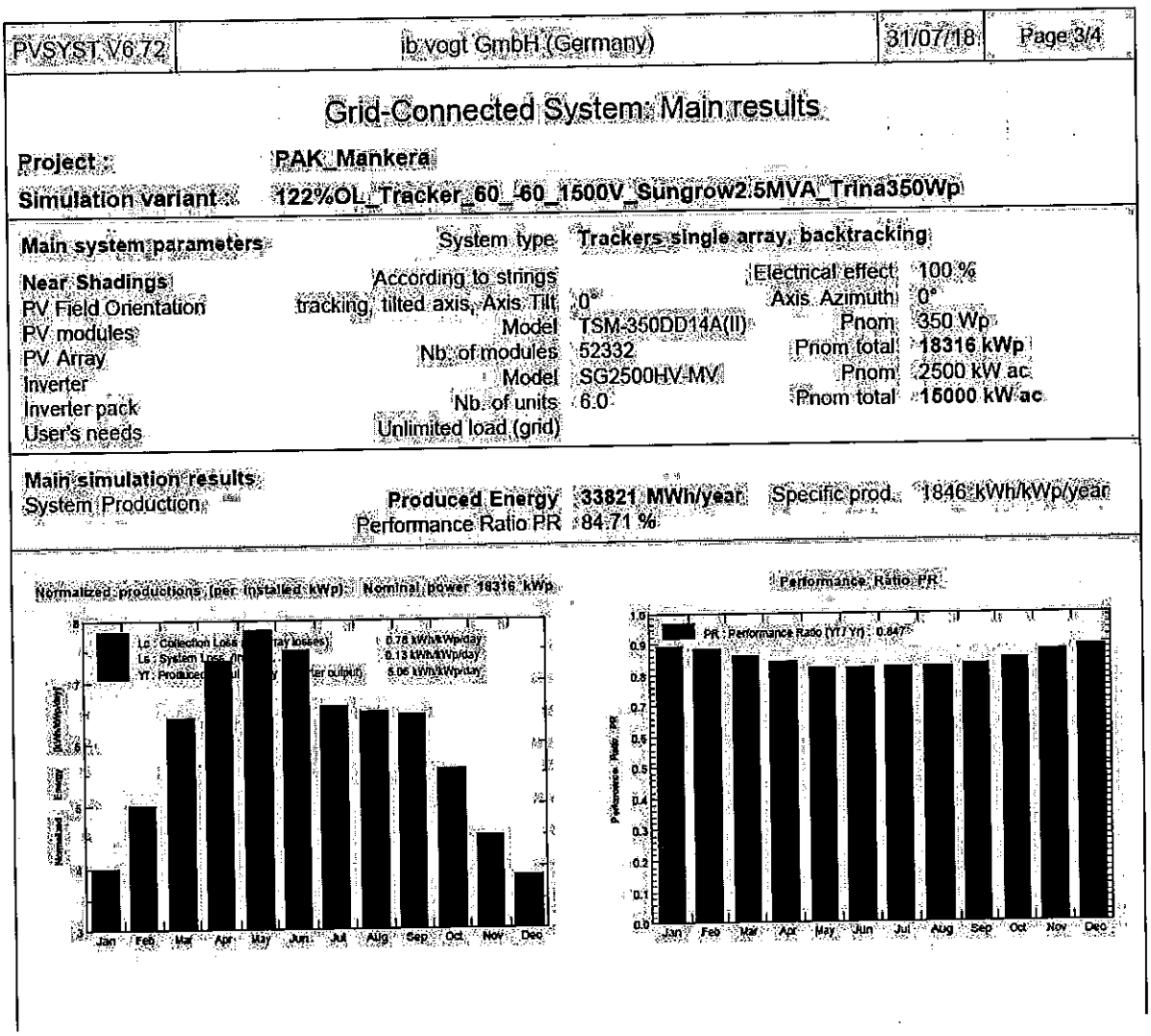



Figure 52 showing grid connected system loss diagram for Seasonal Tilt, using monocrystalline modules and central inverters

## 7.10.3 Single Axis trackers

Single axis tracker design was carried out to compare the yield output with Fixed tilt and Seasonal tilt.



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|---|---|---|---|

**Grid-Connected System: Main results**

**Project :** PAK_Mankera

**Simulation variant :** 122%OL_Tracker_60_60_1500V_Sungrow2.5MVA_Trina350Wp

| **Main system parameters** | System type | Trackers single array, backtracking | | |
|---|---|---|---|---|
| **Near Shadings** | According to strings | | Electrical effect | 100 % |
| PV Field Orientation | tracking, tilted axis, Axis Tilt | 0° | Axis Azimuth | 0° |
| PV modules | Model | TSM-350DD14A(II) | Pnom | 350 Wp |
| PV Array | Nb. of modules | 52332 | Pnom total | **18316 kWp** |
| Inverter | Model | SG2500HV-MV | Pnom | 2500 kW ac |
| Inverter pack | Nb. of units | 6.0 | Pnom total | **15000 kW ac** |
| User's needs | Unlimited load (grid) | | | |

| **Main simulation results** | | | | |
|---|---|---|---|---|
| System Production | **Produced Energy** | **33821 MWh/year** | Specific prod. | 1846 kWh/kWp/year |
| | Performance Ratio PR | 84.71 % | | |



Figure 53 showing, yield assessment for solar farm using single axis trackers, with monocrystalline modules and central inverters

**122%OL_Tracker_60_-60_1500V_Sungrow2.5MVA_Trina350Wp**

**Balances and main results**

| | GlobHor kWh/m² | DiffHor kWh/m² | T Amb °C | GlobInc kWh/m² | GlobEff kWh/m² | EArray MWh | E_Grid MWh | PR |
|---|---|---|---|---|---|---|---|---|
| January | 99.6 | 44.9 | 8.70 | 124.0 | 115.8 | 2079 | 2029 | 0.894 |
| February | 113.8 | 51.1 | 11.50 | 140.1 | 131.9 | 2325 | 2267 | 0.883 |
| March | 160.7 | 71.4 | 16.00 | 199.0 | 188.1 | 3223 | 3141 | 0.862 |
| April | 180.3 | 83.0 | 20.60 | 220.4 | 208.6 | 3485 | 3395 | 0.841 |
| May | 202.9 | 99.6 | 25.00 | 242.6 | 229.2 | 3749 | 3652 | 0.822 |
| June | 192.9 | 107.5 | 26.00 | 225.1 | 211.7 | 3469 | 3380 | 0.820 |
| July | 177.5 | 107.5 | 25.70 | 204.4 | 191.6 | 3168 | 3087 | 0.825 |
| August | 172.7 | 100.5 | 25.10 | 201.3 | 188.8 | 3130 | 3050 | 0.827 |
| September | 160.4 | 78.1 | 22.80 | 194.2 | 183.2 | 3060 | 2982 | 0.838 |
| October | 141.6 | 65.9 | 18.80 | 173.2 | 162.7 | 2772 | 2703 | 0.852 |
| November | 108.4 | 47.8 | 13.60 | 135.0 | 126.8 | 2225 | 2172 | 0.878 |
| December | 96.2 | 42.2 | 9.89 | 120.3 | 112.5 | 2010 | 1962 | 0.890 |
| Year | 1807.0 | 899.4 | 18.68 | 2179.7 | 2050.9 | 34694 | 33821 | 0.847 |

Legends:

| | | | |
|---|---|---|---|
| GlobHor | Horizontal global irradiation | GlobEff | Effective Global, corr. for IAM and shadings |
| DiffHor | Horizontal diffuse irradiation | EArray | Effective energy at the output of the array |
| T Amb | Ambient Temperature | E_Grid | Energy injected into grid |
| GlobInc | Global incident in coll. plane | PR | Performance Ratio |

Table 11 showing balances and main results of yield assessment using single axis trackers with monocrystalline solar panels and central inverter as a design solution

**Annual Specific Yield for Single Axis trackers: 1846 kWh/kWp**

**Performance Ratio: 84.71%**

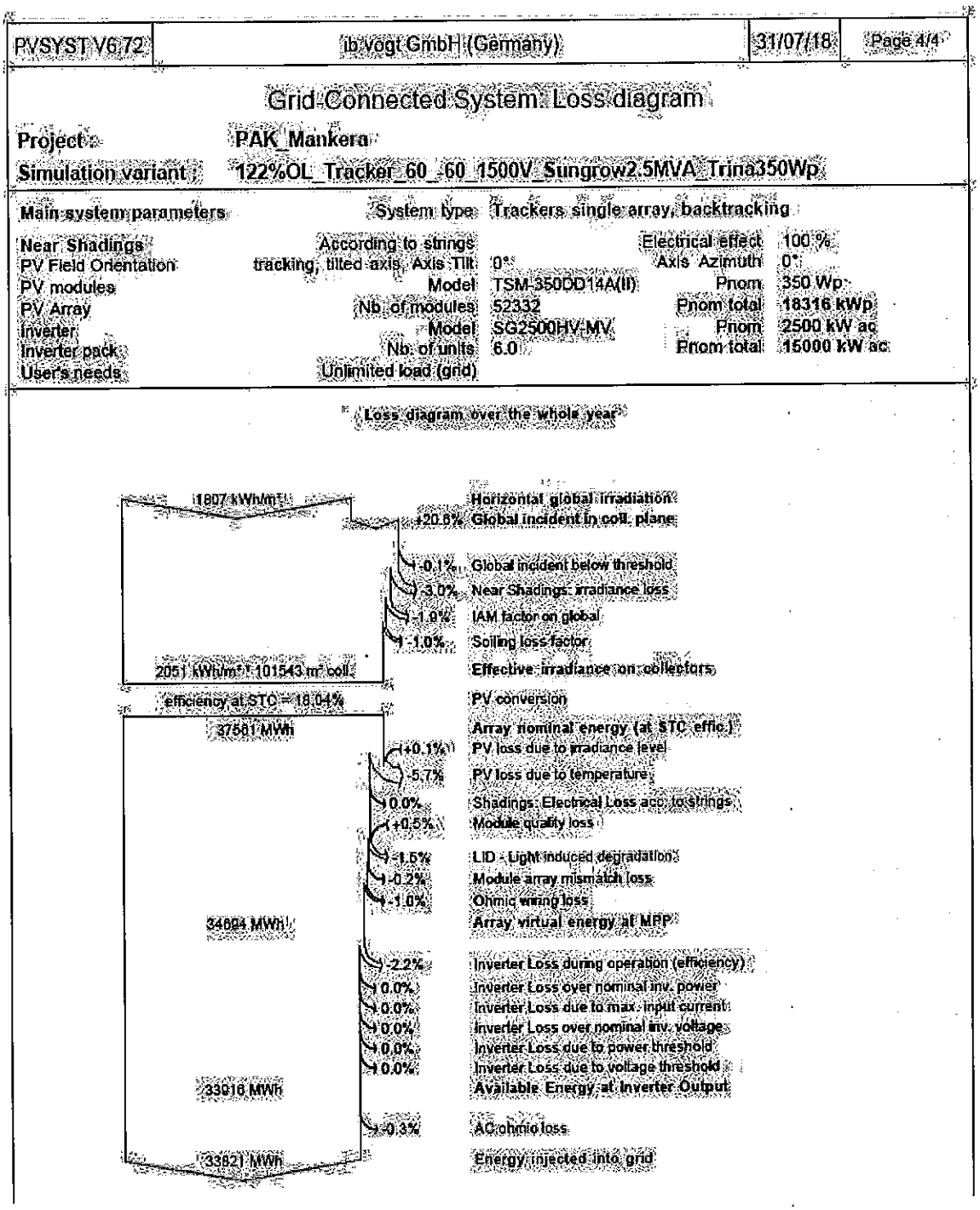



Figure 54 showing grid connected system loss diagram for single axis trackers, using monocrystalline modules and central inverters

### 7.10.4 Single Axis trackers using bifacial solar panels

Subsequently to first Panel of Experts (POE) meeting for the Mankera Solar Project. A revised yield assessment was carried on the basis of two major inputs from experts:

1. Project Size / DC Capacity
2. Usage of SMAP data of the site

The project size of the site was changed from 15MW DC to 18.3 MW DC. Similarly reducing site AC Capacity from 15MW AC – 12.5 MW AC.

The ESMAP solar irradiation data for the site is not available. The nearest station data available to the site is of Multan weather station which is almost 170 Km away from the site. Also the data available for the site is only for the two years which is not sufficient to base your P50 results on. As the minimum years of weather data on which P50 values should be based on, is 15-20 years to understand the variability on an annual scale. On basis of our 18 years engineering experience sometime we have seen a deviation of about 15 to 20 % between the best and the worst years within a 20-year period data.

And such deviation cannot be analyzed in one or two-year data. As the project life is for 25 years and basing our yield forecast on one-year data from a meteo station located almost 150 km away from the site is not possible and will not be acceptable to the banks.

Hence to improve the results ibvogt engineers moved towards revised design by using bifacial solar panels along with single axis trackers and string inverters.

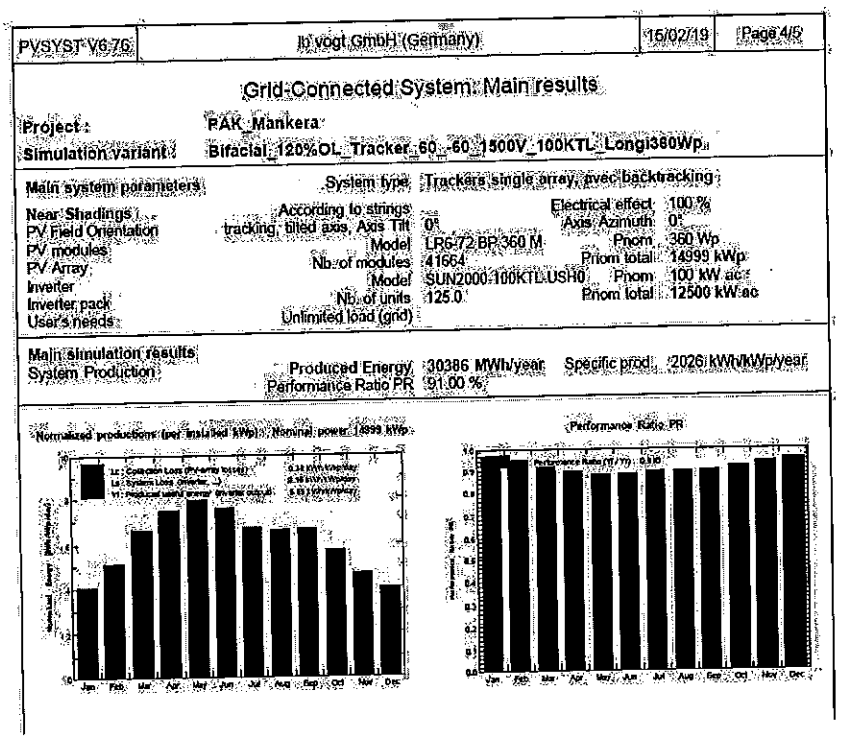



Figure 55 showing, yield assessment for solar farm using single axis trackers, bifacial solar panels and string inverter

**Bifacial_120%OL_Tracker_60_-60_1500V_100KTL_LongI360Wp**

**Balances and main results**

| | GlobHor kWh/m² | DiffHor kWh/m² | T_Amb °C | GlobInc kWh/m² | GlobEff kWh/m² | EArray MWh | E_Grid MWh | PR |
|---|---|---|---|---|---|---|---|---|
| January | 99.6 | 44.9 | 8.70 | 126.7 | 118.4 | 1873 | 1825 | 0.960 |
| February | 113.8 | 51.1 | 11.50 | 144.1 | 135.3 | 2099 | 2041 | 0.945 |
| March | 160.7 | 71.4 | 16.00 | 204.1 | 192.3 | 2899 | 2814 | 0.919 |
| April | 180.3 | 83.0 | 20.60 | 226.1 | 212.1 | 3127 | 3032 | 0.898 |
| May | 202.9 | 99.5 | 25.00 | 246.7 | 232.0 | 3366 | 3262 | 0.882 |
| June | 192.9 | 107.5 | 26.00 | 228.5 | 213.9 | 3128 | 3033 | 0.885 |
| July | 177.5 | 107.5 | 25.70 | 207.8 | 193.9 | 2871 | 2787 | 0.894 |
| August | 172.7 | 100.5 | 25.10 | 204.8 | 191.4 | 2836 | 2753 | 0.896 |
| September | 160.4 | 78.1 | 22.80 | 198.6 | 186.7 | 2762 | 2680 | 0.900 |
| October | 141.6 | 65.9 | 18.80 | 176.5 | 165.6 | 2492 | 2422 | 0.915 |
| November | 108.4 | 47.8 | 13.60 | 139.3 | 130.4 | 2014 | 1962 | 0.939 |
| December | 96.2 | 42.2 | 9.89 | 124.0 | 115.8 | 1820 | 1774 | 0.954 |
| Year | 1807.0 | 899.4 | 18.68 | 2226.2 | 2087.8 | 31286 | 30386 | 0.910 |

Legends: GlobHor — Horizontal global irradiation; DiffHor — Horizontal diffuse irradiation; T_Amb — Ambient Temperature; GlobInc — Global incident in coll. plane; GlobEff — Effective Global, corr. for IAM and shadings; EArray — Effective energy at the output of the array; E_Grid — Energy injected into grid; PR — Performance Ratio

Table 12 showing balances and main results of yield assessment using single axis trackers with monocrystalline bifacial solar panels and string inverters

**Annual Specific Yield for Single Axis trackers: 2026 kWh/kWp**

**Performance Ratio: 91%**

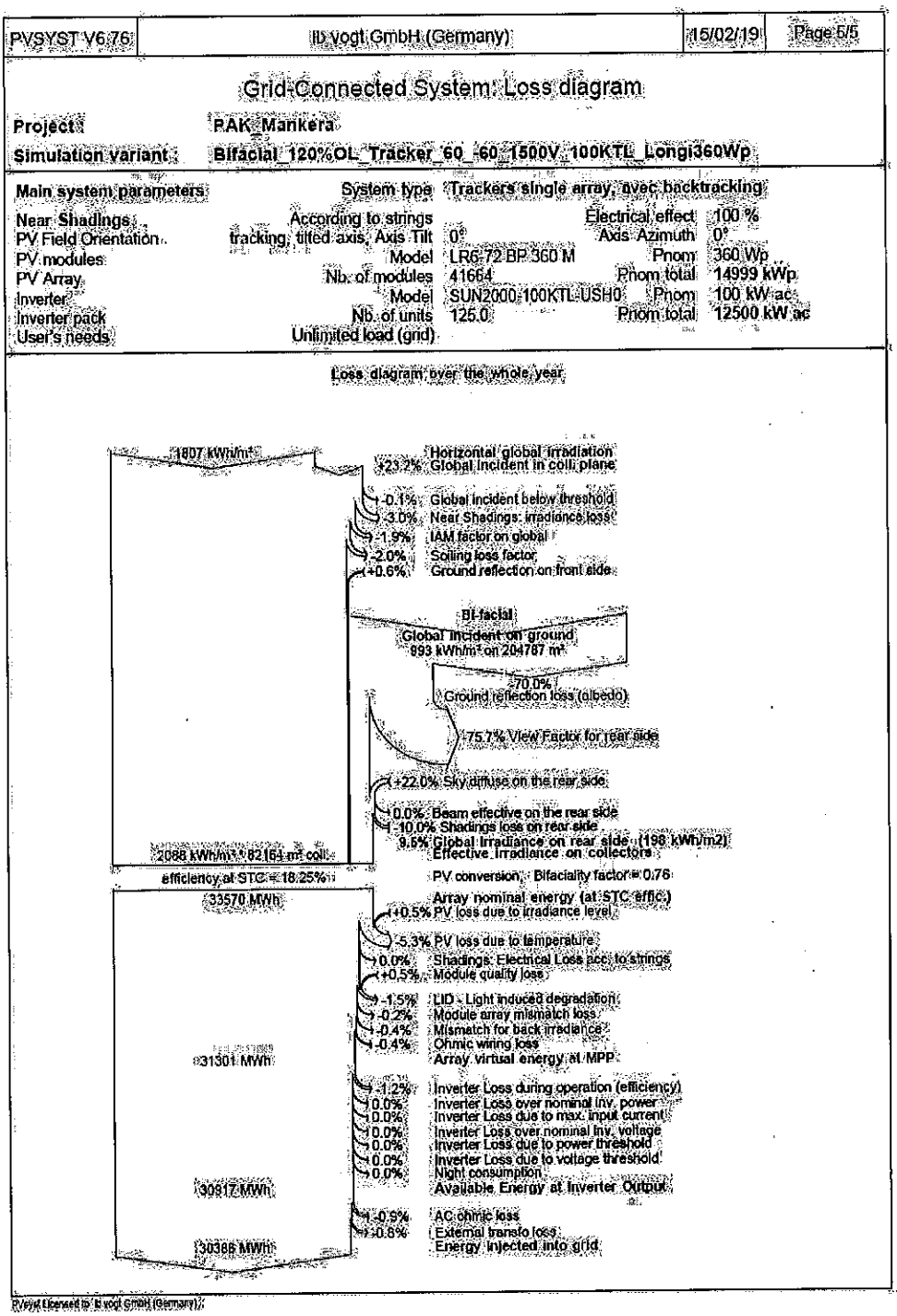



Figure 56 showing grid connected system loss diagram for single axis trackers, bifacial panels and string inverters

**Summary:**

The solar resource assessment for fixed tilt system, seasonal tilt, single axis tracker using monocrystalline panels & central inverters design was compared with bifacial solar panel, single axis trackers and use of string inverter for Mankera site to show which solution has better yield output.

Annual yield for fixed tilt system using mono crystalline modules & central inverters= 1679 KWhr/ KWp

Annual yield for seasonal tilt system mono crystalline modules & central inverters = 1750 KWhr/ KWp

Annual yield for S-axis trackers mono crystalline modules & central inverters = 1846 KWhr/KWp

Annual yield for S-axis trackers with bifacial solar panels (mono) & central inverters = 2026 KWhr/ KWp

From energy production point of view clearly single axis using bifacial solar panels with string inverters solution is more viable option, but it will also have a cost impact on the project. As mounting structure cost for single axis trackers is higher as compared to fixed tilt and manual seasonal tilt system. Also it will increase the operation and maintenance cost of the project per megawatt as bifacial solar panels will need more cleaning and although the string inverters are smaller in size but due to increase in number. The O&M cost will increase as well.

Single axis trackers with bifacial solar panels and string inverter solution can only become viable if the excess energy produced overcomes the increase project cost and gives better project IRR when compared with fixed tilt, seasonal Tilt, single Axis tracker using mono crystalline and Central inverters.

A detailed financial modeling needed to be carried out to support the better technical solution of single axis trackers using bifacial solar panels and string inverters.

# 8. Economic Analysis

8.1 The economic analysis of a project represents one of the main steps in the assessment of the project's feasibility. Based on the technical aspects of the solar farm design as well as the findings of earlier analysis, ib vogt has developed an in depth economic analysis for a Solar PV power plant to be set up at Mankera, Punjab in Pakistan.

In addition to a project's viability analysis, different design options have been compared from a financial aspect, therefore optimizing the design and adding value to a potential project. During ib vogt's earlier high level analysis of the potential Mankera project a comparison of technologies and varying system sizes had been conducted. As a solid result of the analysis, a single-axis trackers technology has been identified as optimal technology. Besides a higher financial profitability, the single-axis trackers system also has various advantages over a seasonal tilt system during both construction and operation & maintenance phase of the project.To further reduce the risk associated with possible volatilities of different assumptions, such as the yield value, inflation, various associated costs and interest rate of debt financing; several sensitivity analyses have also been conducted.

## 8.2 Financial Model Assumptions

The analysis is carried out using a designated, industry standard financial model, which was designed to suit the project needs.

The figures used and the assumptions made in the economic analysis are based on ib vogt's experience with solar projects around the world, and most importantly the guidelines provided by NEPRA in order to determine the tariff. Moreover, the SBP's revised financing scheme for renewable energy projects has been thoroughly considered in regards to the debt financing terms. However, this preliminary economic assessment is provided to demonstrate the likely feasibility of the project, and the final financial parameters would emerge upon reaching the advanced stage of the project.

The installed capacity of this project is 15 MWp. Within the first year of operating period, the annual power production will be approx. 30,380 MWh. In the subsequent years of operation, the power production should reduce with the degradation factor of 0.5% pa (standard assumption). The construction period is considered six months that is regarded as an ideal assumption for solar PV projects ranging from 10 MWp to 20 MWp.

### 8.2.1 Inputs

Inputs to the financial model are listed as follows.

**I. Total Project Costs**

**1. EPC Cost:**

Since the size of this project does not leverage the advantages associated to the economies of scale, for a 2019 built project modules' costs can be expected to be in the range of USD 0.30 per MW – USD 0.35 per MW. Nevertheless, the dramatic fall of EPC costs over the last few years allows a realistic assumption of EPC costs (including grid costs, inverter costs and balance of system (BOS) costs, contingency, etc.) to be at USD 0.858 per MW, when utilizing single-axis trackers technology and Tier-1 monocrystalline bifacial solar panels. Furthermore, the EPC price allows the choice of equipment and suppliers with recognized quality, performance and bankability.

It has been noted that the Authority approved degradation factor of 0.5% in the latest cost-plus tariffs of solar technology, and hence, the aforementioned EPC costs of USD 0.858 per MW need to be adjusted for a degradation factor of 3.62% (levelized rate), either by increasing the EPC costs upfront or by making it a part of the approved total project cost based on the levelized rate of the EPC costs thereby adjusting the tariff. It is kindly requested that the authority shall consider this as a very important exercise. The table below details the components for EPC:

| EPC | Cost (USD million) |
|---|---|
| EPC Excluding Degradation | 12.87 |
| **Degradation** | 0.47 |
| Total Construction Phase (EPC) Cost | 13.34 |

Table 13 showing EPC cost

Under the claimed EPC cost ibvogt GmbH shall install the equipment of the following brands, however these are subject to change following the completion of project design:

| No. | Equipment | Brands |
|---|---|---|
| 1 | PV Modules | Tier 1 (Hanwah Q-Cells, Jinko, Trina, Longi solar or similar) |
| 2 | Single-axis Tracker | Leading Global Supplier (Arctech, Soltec, Schletter etc) |
| 3 | Inverter | ABB, GE, Sungrow, Huawei etc |
| 4 | DC/AC brand | Faber or similar |
| 5 | Step – up transformers | Siemens, ABB, TBEA, QRE, Chint etc |
| 6 | Medium voltage switch gear and 132KV substation | Siemens, ABB, Chint etc |
| 7 | SCADA | Gatner, ABB, Schneider, etc |
| 8 | Civil works | ibvogt local entity or No limit local civil contractor |
| 9 | Project Management | Ibvogt Gmbh |
| 10 | Construction Supervision | Ibvogt Gmbh |

Table 14 showing equipment that will be used on the site and available brands

2. **Land Cost:**

The land for the project has already been determined at the rate of 12,666 per MW amounting the land acquisition cost of approx. USD 189,990 for a total land area of 62.4 acres.

3. **Non-EPC and Project Development Cost:**

Such costs intend to include all expenses related to development, licenses, permits, legal & tax advisor fees, due diligence costs and other establishment costs. Based on ib vogt's experience with solar projects around the world, the Non-EPC and Project Development Cost are assumed at USD 35,000 per MW (~USD 0.53 million).

4. **Insurance During Construction:**

As per the recently notified NEPRA Guidelines June 2018, the insurance cost during construction has been assumed as 0.4% of the proposed EPC Cost. Therefore, the total insurance cost for the construction period of 6 months is calculated as USD 0.05 million.

5. **Financing Fees & Charges:**

The NEPRA's Tariff Guidelines June 2018 (SRO 763), the Authority has suggested a financing fee to be 2.0% of debt amount. Keeping in view, the project assumes a financing fee of 2% of debt amount, the amount under this head amounts to USD 0.23 million. It is kindly requested that the authority shall assess the financing fee benchmark again based on actual costs.

6. **Interest During Construction:**

The The interest during construction (IDC) is calculated as ~USD 0.25 million. This interest is determined on 6 month LIBOR 2.86% + *Spread 4.25%. The financing parameters are discussed in the subsequent section.

As the above project costs under various heads is given hereunder:

| Project Cost | (USD Million) |
|---|---|
| **EPC Cost** | 13.34 |
| **Land Cost** | 0.19 |
| **Project Development Cost** | 0.53 |
| **Insurance during construction** | 0.05 |
| **Financing Fee & Charges** | 0.23 |
| **Interest During Construction** | 0.25 |
| **Total** | **14.58** |

Table 15 showing project cost breakdown

The table below details the components for Non-EPC:

| Non-EPC | Costs (USD Million) |
|---|---|
| **Project Development Cost** | 0.53 |
| **Land Acquistion** | 0.19 |
| **Insurance During Construction** | 0.05 |
| **Financial Charges** | 0.23 |
| Total Non EPC Cost | **1.0** |

Table 16 showing non EPC cost breakdown

## II. Capacity Utilization Factor

A capacity utilization factor of 23.12% is targeted to be achieved by installing the latest equipment including the sun tracking system. The capacity utilization factor is 6.12% higher than the NEPRA benchmark of 17% for the Northern region, this signifies the cutting edge solar technology being used in the local context.

The table below details the Capacity:

| Capacity/ Size | Units | Amount |
|---|---|---|
| **Plant Size** | MWp | 15 |
| **Capacity Utilization Factor** | % | 23.12% |
| **Annual Generation** | MWh Year | 30,380 |

Table 17 showing project size and capacity factor

## III. Degradation Factor

The degradation factor of 0.50% has been incorporated in the workings and has been done so in light of NEPRA's approvals of past projects, and this level being allowed in different parts of the world.

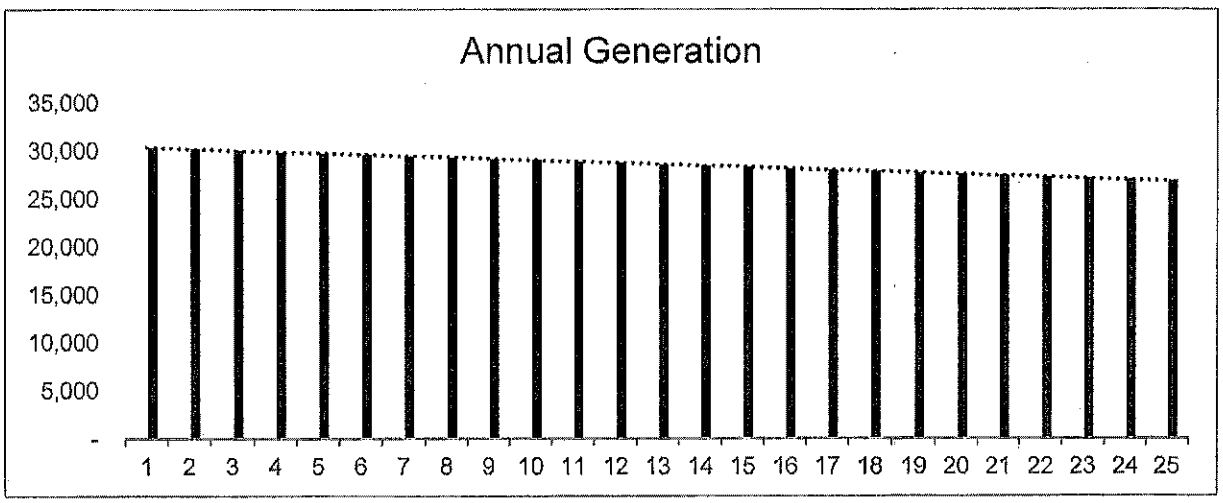



Figure 57, the annual generation shows a downward trend due to 0.5% degradation per annum.

## IV. Total Operating Costs

### 1. Operation & Maintenance (O&M) Costs:

The O&M costs here include various annual costs related to operation & maintenance, inverter/spare part reserve, asset management, accounting & legal, utilities, security, facility fee and other operating expenses. These costs commonly are one of the strongest drivers of project's annual operating expenditures and are strongly linked to country specific factors. The calculated tariff is based on annual O&M costs of USD 0.02 million/MW.

| O&M Assumptions | Period | USD / MW |
|---|---|---|
| **O&M Foreign** | Per Year | 6,000 |
| **O&M Local** | Per Year | 10,000 |
| Total | | **16,000** |

Table 18 showing foreign and local O&M component

### 2. Insurance During Operation:

As per the recently notified NEPRA (Benchmarks for Tariff Determination) Guidelines June 2018, the insurance cost during operation has been assumed as 0.4% of the proposed EPC Cost. Therefore, the annual insurance cost during operation is calculated as USD 0.05 million.

## V. Financing Parameters

The assumed financing terms for modelling and analysis purpose are primarily based on the NEPRA (Benchmarks for Tariff Determination) Guidelines, SBP's revised financing scheme for renewable energy projects, and upon conducting initial market study.

A debt to equity ratio of 80% is assumed in the financial model. The interest rate for the debt financing is set based on LIBOR plus 4.25% per year. The loan tenor is calculated as of 12 years. Moreover, the debt is assumed 100% foreign. The premium of 4.25% has been based on NEPRA's Tariff Guidelines June 2018 (SRO 763).

Furthermore, as an industry standard and additional security for the lender, the required Debt Service Reserve Account (DSRA) equivalent to 6 months' debt installment will be funded from the operating cash flow of the initial years.

## VI. Revenues

Based on the Capacity Utilization Factor of 23.12% for this project and the industry standard assumption on an availability factor of 98% for single-axis trackers design, the first year power production would be approx. 30,380 MWh. However, this scenario assumes the NEPRA tariff will be adjusted for the loss in production due to degradation. Consequently, the degradation is set to 0.5% to compute revenues for the plant's operating life of 25 years. The amount of USD 0.47 million has been made part of the approved project cost based on the levelized rate of 3.62% of the allowed EPC cost.

The tariff for this project has been calculated based on NEPRA tariff methodology while assuming the return on equity at 16% and determined total project costs (including the adjusted for degradation). The revenues are based on the tariff of US Cents 7.273 per Kwh during the debt-servicing period and US Cents 2.465 per Kwh thereafter, for electricity injected into the grid. This leads to a levelised tariff of US Cents 6.07 per Kwh. For details relating to the tariff calculation, please refer to the respective excel workbook. The authority shall kindly note that the project is located in the Northern Pakistan where solar irradiance levels are lower, thus a higher tariff shall be applied for the same.

All Cash Flows are calculated on a yearly basis and the project lifetime is fixed at 25 years. Furthermore, a corporate tax rate of 0% is assumed since profits derived from renewable electric power generation are exempt from tax in Pakistan.

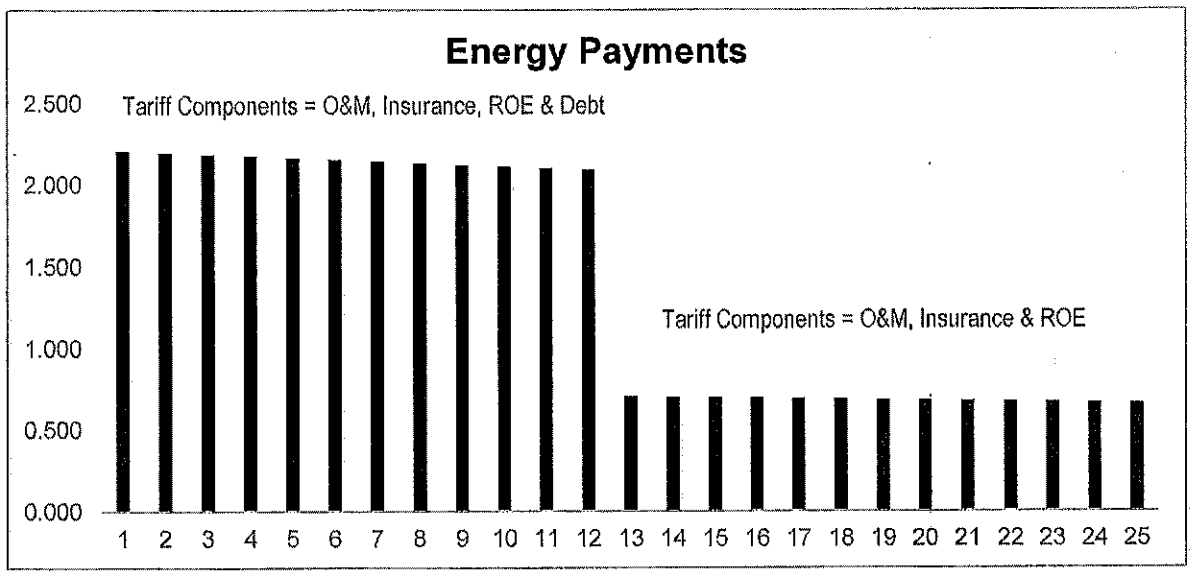



Figure 58 shows, for the stipulated period of year 1-12 the tariff component will be relatively higher as it contains the Debt component, however after the debt servicing period the Tariff component will fall as the Debt service period shall end.

## VII. Return of Equity

The return on equity at 16% on IRR basis has been assumed for Tariff calculation.

## VIII. Construction Period

The construction period has been set at 6 months. Similar sized projects also opted for upfront tariff with a construction period of 6 months. This duration has been set in light of previous approvals by NEPRA.

The following details the generation tariff alongside the terms of ibvogt Gmbh

| Tariff Components (USc per Kwh) | Year 1-14 | Year 15-25 |
|---|---|---|
| **Operations & Maintainenece Cost** | 0.79 | 0.79 |
| **Insurance During Operation** | 0.2195 | 0.2195 |

| | | |
|---|---|---|
| **Return on Equity** | 1.51 | 1.51 |
| **Debt Servicing** | 4.4809 | - |
| Total | **7.005** | **2.524** |

Table 19 showing tariff components

- Levelized tariff works out to be US Cents 6.16 per Kwh
- The aforementioned tariff is applicable for twenty-five (25) years
- Debt service shall be paid in the first 14 years of commercial operation of the plant
- Debt Servicing has been worked out using six months LIBOR (2.86%) + Spread (4.5%).
- Debt to Equity of 80:20 has been used
- Return on Equity during construction and operation of 16% has been used.
- Construction period of six (6) months has been allowed for the workings of ROEDC and IDC
- Insurance during Operation has been calculated as 0.50% of the allowed EPC Cost.
- Reference Exchange Rates of 120 PKR/USD has been used.
- Detailed component wise tariff Schedule is attached as Annex-I of this Economic Analysis.

## 8.3 Results

The economic feasibility of the project has been carried out evaluating the following Key Performance Indicators (KPIs):

- Leveraged Equity IRR based upon the cash flows to equity
- Net Present Value (NPV) of future cash flows (CF) at a target IRR of 16%
- Capital Requirement:
    - Total Project Costs
    - Initial Equity Investment required
    - Debt from Banks
- Minimum DSCR and Average DSCR
- NPV of Equity Investment

### 8.3.1 Summary of Profitability Analysis

The table below summarizes the assumptions of the various costs determined for this project, and the aforementioned KPIs obtained as a result of financial modelling & project valuation in regards to profitability.

When analyzing the cash flows to equity on a yearly basis as graphed in the figure below, the cash flows are levelised with the first 12 years representing the years in which the higher tariff is received and the debt service payments are applicable. Furthermore, it can be observed that the real cash flows to equity are considerably higher during the first 12 years of operation (debt service period) than those in later years. It is due to the decreasing energy production over the years (0.5% degradation) and the lower tariffs post-debt servicing.

Summary:

| Project Company | K1 Solar Power Lahore Pvt Ltd | |
|---|---|---|
| Sponsor | Ibvogt | |
| Capacity | 15 MWp | |
| Project Location | Mankera, Punjab | |
| Concession period | 25 years | |
| Capacity Factor | 23.12% | |
| | | |
| Project Cost | USD (Million) | |
| EPC Cost | 12.87 | |
| Degradation | 0.47 | |
| Adjusted EPC Cost | 13.34 | |
| Project Development | 0.53 | |
| Land Cost | 0.19 | |
| Pre-COD Insurance cost | 0.05 | |
| Financing fee & charges | 0.23 | |
| Interest during construction | 0.25 | |
| Total Project Cost | **14.58** | |
| Financing structure | Debt: 80% | Equity: 20% |
| Debt composition | 100% Foreign | |
| Interest rate | 6 month LIBOR + 4.25% pa | |
| Debt repayment term | 12 years | |
| Repayment basis | Semi-Annual | |
| Return on Equity | 16% | |
| Insurance during operations | 0.05 | |
| Operations cost | **0.24** | |
| Tariff | PKR/Kwh | US Cents/ Kwh |
| Year (1-14) | 8.73 | 7.273 |
| Year (15-25) | 2.96 | 2.465 |
| Levelized Tariff | **7.29** | **6.07** |
| Exchange Rate | 1 USD=120 PKR | |

Table 20 showing financial parameters considered for the project and viable tariff

## Tariff Sheet:

| US Cents per Kwh | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Concession period | O&M - Foreign | O&M – Local | Insurance during Operations | ROE | ROEDC | Foreign Debt Service | | Local Debt Service | | Total Tariff |
| | | | | | | Financial charges | Principal payment | Financial charges | Principal payment | *US Cents per Kwh* |
| 1 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 2.6922 | 2.1160 | - | - | 7.273 |
| 2 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 2.5391 | 2.2691 | - | - | 7.273 |
| 3 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 2.3748 | 2.4334 | - | - | 7.273 |
| 4 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 2.1988 | 2.6094 | - | - | 7.273 |
| 5 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 2.0099 | 2.7983 | - | - | 7.273 |
| 6 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 1.8074 | 3.0008 | - | - | 7.273 |
| 7 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 1.5903 | 3.2179 | - | - | 7.273 |
| 8 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 1.3574 | 3.4508 | - | - | 7.273 |
| 9 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 1.1077 | 3.7005 | - | - | 7.273 |
| 10 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 0.8399 | 3.9683 | - | - | 7.273 |
| 11 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 0.5527 | 4.2555 | - | - | 7.273 |
| 12 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | 0.2448 | 4.5634 | - | - | 7.273 |
| 13 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 14 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 15 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 16 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 17 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 18 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 19 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 20 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 21 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 22 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 23 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 24 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| 25 | 0.2963 | 0.4938 | 0.1756 | 1.43 | 0.067 | - | - | - | - | 2.465 |
| | 0.2963 | 0.4938 | 0.1756 | 1.4331 | 0.0675 | 1.3897 | 2.2195 | - | - | 6.07 |

No. PPDB/R.E/MRE/ 97 /2019

**PUNJAB POWER DEVELOPMENT BOARD**
**ENERGY DEPARTMENT**
1st Floor, Irrigation Secretariat
Old Anarkali, Lahore
(Ph: 042-99213878 Fax: 042-99213875)

Dated: 07/03 /2019

To,

1. **Managing Director NTDC,** WAPDA House, Lahore
2. **Chief Executive Officer AEDB,** 2nd Floor OPF Building, Sector G-5/2, Islamabad
3. **Chief Executive Officer FESCO,** West Canal Road, Abdullah Pur, Faisalabad
4. **Director General PCRET,** PCRET No. 25, Sector H-9, Islamabad
5. **Chief Executive Officer QASPL,** 3rd Floor, 83 A-E/1, Main Boulevard, Gulberg III, Lahore (Co-opted member)
6. **Representative, University of Engineering & Technology, Lahore** (Co-opted member)

Subject: **MINUTES OF 2ND PANEL OF EXPERTS (POE) MEETING: REVISED FEASIBILITY STUDY FOR DEVELOPMENT OF 15 MW SOLAR POWER PROJECT BY M/S. IB VOGT GmbH AT MANKERA, BHAKKAR, PUNJAB**

Please refer to 2nd Panel of Experts (POE) meeting held on February 27, 2019 at Committee Room of PPDB office to review the revised feasibility study for 15 MW solar power project by M/s. ib Vogt GmbH.

Enclosed please find the Minutes of Meeting (MoM) of 2nd POE for the same.

With best regards,

**MANAGING DIRECTOR**
**PUNJAB POWER DEVELOPMENT BOARD (PPDB)**

C.C:

i. P.S. to Additional Chief Secretary (Energy), Government of the Punjab, Lahore
ii. P.S. to Secretary, Government of the Punjab, Energy Department, Lahore
iii. M/s. ib vogt GmbH, SPV M/s. K1 Solar Power Lahore Private Limited: 216 Landmark Plaza, Jail Road, Gulberg Lahore

**PUNJAB POWER DEVELOPMENT BOARD**
**ENERGY DEPARTMENT**
**GOVERNMENT OF THE PUNJAB**

**Subject: MINUTES OF 2ND PANEL OF EXPERTS (POE) MEETING: REVISED FEASIBILITY STUDY FOR DEVELOPMENT OF 15 MW SOLAR POWER PROJECT BY M/S. IB VOGT GmbH AT MANKERA, BHAKKAR, PUNJAB**

The second Panel of Experts (POE) meeting was convened on February 27, 2019 at 11:30 hours under the Chairpersonship of Managing Director, PPDB to review the revised Feasibility Study (FS), in view of first POE observations, for development of 15 MW Solar Power Project (SPP) by M/s. ib vogt GmbH at Mankera, Bhakkar. POE meeting was held in the Committee Room of Punjab Power Development Board (PPDB), 1st Floor, Irrigation Secretariat, Old Anarkali, Lahore. The following were the participants of the meeting:

**PRESENT:**

| | | |
|---|---|---|
| 1. | Mrs. Saniya Awais | Managing Director PPDB **(Convener)** |
| 2. | Mr. Fahad Hassan | Assistant Manager (Planning) NTDC |
| 3. | Mr. Rana Delair Tariq | Assistant Director FESCO |
| 4. | Mr. Iqbal Hussain | Director PCRET |
| 5. | Mr. Aziz Ahmed | Deputy Director PCRET |
| 6. | Mr. Sajjad A. Sajid | Chief Technical Officer, QA Solar Power (Pvt) Ltd – Co-opted member |
| 7. | Mr. Waqas Khalid | Senior Research Officer UET Lahore – Co-opted member |

**ON INVITATION:**

| | | |
|---|---|---|
| 8. | Mr. Adeel Ahmed | Manager Business Development ib vogt |
| 9. | Mr. Muhammad Abbas | Financial Advisor EY |
| 10. | Mr. Akhtar Chaudhary | Chief Executive Officer ARCO |

| | | |
|---|---|---|
| 11. | Mr. Khawaja Ibran | System Studies Engineer ARCO |
| 12. | Mr. Jasim Iqbal | Jr. System Studies Engineer ARCO |
| 13. | Ms. Mashaal Waqar | Associate HaiderMota BNR&Co. |
| 14. | Ms. Arooshay Shehryar | Associate HaiderMota BNR&Co. |

**IN ATTENDANCE:**

| | | |
|---|---|---|
| 15. | Mr. Salman Aizad | Director Renewable Energy PPDB |
| 16. | Mr. Ahmad Salman | Director Technical Coordination/Finance PPDB |
| 17. | Ms. Afifa Jabeen | Director Legal PPDB |
| 18. | Mr. Amir Shahzad Butt | Manager Renewable Energy PPDB |
| 19. | Mr. Shahzeb Ahmed | Manager Thermal/Tariff PPDB |
| 20. | Mr. Muhammad Hassan Akhlaq | Associate Renewable Energy |

**PROCEEDINGS:**

The meeting started with the formal introduction of all POE members and representatives/consultants of M/s. ib Vogt (the "Company"). Thereafter, agenda of the meeting was steered with the permission of the Chairperson; proceedings of which have been narrated as follows:

| Discussion | Decision |
|---|---|
| The Chair invited Director Renewable Energy, PPDB (DRE) to brief POE members for earlier observations raised by the members. DRE explained that the earlier observations were circulated through Minutes of Meeting to all POE members issued vide No. PPDB/R.E/MRE/68/2019 dated February 18, 2019. POE earlier decision was as below;<br>1. Project capacity / Plant size must be firmed up to avoid power evacuation constraints. Tariff model must also be re-worked in line with revised / firm capacity<br>2. Project power connectivity arrangements must be in line with amended NTDC Grid Code requirements and consent of power purchaser FESCO<br>3. Actual solar irradiation data requires to be used for improved capacity factor and better energy yield | After detailed deliberation, it was resolved that the Company have now addressed the earlier observations raised by POE in the revised Feasibility Study of 15 MW Solar Power Project at Mankera. The feasibility study has completed major ingredients including, issuance of NOC from EPA Punjab and submission of Grid Interconnection Study (GIS) to FESCO.<br>After detailed deliberation POE unanimously approved the revised FS on cost plus basis at |

| | |
|---|---|
| 4. Financial assumptions such as debt/equity ratio, LIBOR spread, IDC etc. require to be adjusted in line with NEPRA Tariff Guidelines June 2018<br><br>It was further informed that the Company has submitted the revised Feasibility Study (FS) to PPDB in view of 1st POE earlier observations. The revised FS was forwarded to POE members for review and comments.<br><br>The Chair then asked the Company representative/consultants to present the revised findings of FS before POE and also invited viewpoints of POE point wise;<br><br>**1. Firm Project Capacity & Revised Tariff Model**<br><br>Mr. Adeel, Company's representative informed that Project Capacity has now been firmed up to 15MWp DC & 12.5 MW AC. Previously, it was 18.316 MWp DC & 12.45 MW AC. Company's representative referred NEPRA guidelines (SRO 1266/2015 dated December 2, 2015 and SRO 730(I)/2018 dated June 07, 2018) for interconnection of Renewable generation, power capacity ranging from 1-15 MW can be connected at 11KV voltage level. He said the project capacity is now in line with the LOI capacity of 15 MW issued by PPDB. He further said that the revised tariff model of project FS is now based on 15 MW capacity.<br><br>The Chair then invited viewpoints from POE member.<br><br>**i) Viewpoint of NTDC Planning Representative**<br><br>NTDC representative acknowledged the abovementioned NEPRA's guidelines. He, however, was of the view that the project power evacuation matter may be dealt with NTDC Grid Code while reviewing the final vetting of Grid Interconnection Study (GIS).<br><br>**ii) Viewpoint of FESCO Representative**<br><br>FESCO representative was of the view that the GIS earlier submitted to FESCO has now been revised by the Company's consultant in view of FESCO observations. Revised GIS has been submitted to FESCO. FESCO, in short time, shall review and provide further feedback, if any, on the connectivity issue of 12.5 MW at 11kV voltage level. | levelized tariff of US Cents 6.07/kWh with subject to approval of Grid Interconnection Study (GIS) by power purchaser FESO/vetting by NTDC. The POE, however, advised that if after review of GIS there is a major change in power evacuation scheme which significantly changes project/tariff, the matter will be referred back to the POE.<br><br>The final ultimate levelized tariff shall be approved by NEPRA. |

After deliberation, it was concluded that the project capacity has now been firmed up as 15 MWp by the Company in revised FS. Further, FESCO is already in review of revised GIS, therefore the earlier observation of POE has now been addressed. However, any major power evacuation constraints/limitations for that matter, if found, may be communicated by FESCO accordingly.

**2. Project Connectivity Arrangements**

The Company's consultant explained that the connectivity of proposed 15 MWp SPP at Mankera would be made available at 11kV line. The consultant further said they had meeting with NTDC Planning team on this issue and they briefed them about power evacuation arrangements for this project. The consultant communicated that the revised GIS has already been submitted to FESCO for their review.

DRE requested to share the cover letter of revised GIS submitted to FESCO.

The chair then invited viewpoints form representatives of NTDC Planning & FESCO

**i) Viewpoint by NTDC Planning representative**

NTDC representative said that the he is not aware of the consultant meeting with NTDC Planning team on connectivity arrangement for this project. He, however, was of the view that after the consent/approval of GIS by power purchaser FESCO for the proposed project, NTDC shall vet the GIS in accordance with NTDC Grid Code.

**ii) Viewpoint of FESCO representative**

FESCO representative confirmed that the revised GIS, in view of FESCO's earlier observations, has been submitted to FESCO and it is under review. If no further feedback/comments were found, the revised GIS will be ready to approve in one week time.

The Chair requested FESCO representative to expedite the review/approval process of revised GIS in shortest possible time. After deliberation, POE concluded that this observation has been addressed by the Company apart from any change if appears regarding major connectivity issue

& associated cost of grid/line.

**3. Use of Ground Solar Irradiation data**

The Company representative was of the view that World Bank ESMAP solar irradiation ground data is available for two years & nearest at Multan which is almost 170 Km away from the project site. He said Satellite based data for 25 years such as solar GIS, Meteonorm, NASA has been used for solar irradiation p50 calculation. In addition, he said in order to improve the annual energy yield results, Company engineers/design team have recommended revised design by using bifacial solar panels (mono-crystalline) along with single axis trackers. This revised panel would have peak power capacity of 350 Wp instead of 330 Wp. Similarly, inverters made model & numbe of strings have also been adjusted in revised design scheme. By this design arrangement, the plant capacity factor has been increased to 2.47% i.e. from 20.65% to 23.12% highest so far for North Punjab.

The chair then enquired if Company has done any comparison of ESMAP solar irradiation ground data (extra-polated values) with satellite based data. Company's representative said at the moment this comparison is not available, however, this comparison would be shared later with PPDB. The Chair explained the basic purpose for using actual solar irradiation data, at nearest site to get realistic plant capacity factor.

The Chair further enquired the use of bi-facial solar PV panels in any other project by M/s. ib Vogt is developed in Pakistan or elsewhere. In response, he said the bi-facial solar panel technology has been used in Egypt. This project is, however, under construction stage. He further said the claimed annual energy yield for 15 MWp SPP would be around 30GWh by using bi-facial PV panels & central inverters (2026 kWh/kWp).

DRE further commented that the structural cost with bi-facial arrangements would be increased and hence EPC cost would also be increased. Company's representative, in response said, the EPC cost, including grid cost, inverter cost & balance of plant cost, has now been increased from 0.77 to 0.858 Million USD/MW. Project cost has now been revised from 0.85 to 0.97 Million USD/MW by using bi-facial arrangements.

The chair then invited comments from POE members.

**i) Viewpoint of representative form PCRET**

The representative from PCRET inquired about the commercial scale testing requirements for both cell efficiency & Panel efficiency. He further said the testing of solar cell as well as solar panel is of great importance for utility scale as well as for commercial outfits. PCRET has its own testing facility lab for solar cells/panels. The Company representative replied that PV panels are tested before shipping and at reaching final destination after the shipment as well. There is also a specific time period guarantee given by the manufacturer as well.

The Chair further clarified that at post LOS stage during Energy Purchase Agreement, an Independent Engineer is mutually hired by the project company and NTDC which ensures the Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) of solar cells & PV panels. Further, a fixed annual energy yield is fixed by NEPRA

After deliberation, POE concluded that this observation has been addressed in the revised FS mainly because of change in revised design scheme of bi-facial PV panels with single tracker axis and increased plant capacity factor.

**4. Revised Financial Assumptions as per NEPRA tariff guidelines 2018**

The Company's financial consultant presented the following revised financial assumptions as per NEPRA Tariff regulations 2018;

- Debt Equity Ratio = 80: 20 - previous 75:20
- Interest rate LIBOR6 months plus 4.25% - previous 4.5%
- EPC cost 13.335 Million USD for 15 MWp – previous 14.103 Million USD for 18.316 MWp (increased from 0.77 to 0.858 Million USD/MW
- Insurance during Construction increased increased from USD 28,207 to USD 53,444
- Financing fees and charges reduced to USD 225,668

- Interest during construction reduced from USD 459,702 to USD 246,083
- Annual O&M cost has been increased to USD 16,000/MWp – previous USD 12,910/MWp
- Annul Degradation 0.5%
- Total Project cost revised 14.575 Million USD for 15 MWp – previous 15.564 Million USD for 18.316 MWp (Project cost has been increased from **0.85 to 0.97** Million USD/MW)
- Exchange rate 1USD =120 PKR instead of 115 PKR
- Capacity Utilization factor claimed 23.12% - previous 20.65%
- Return on Equity 16% (IRR based) same

By considering above assumptions, the levelized tariff for 15 MWp SPP, based on 25 years, has been reduced from US Cents **6.1273/kWh** to US Cents **6.07/kWhr**.

POE observed that reduction in levelized tariff is primarily based on the increased plant capacity factor of 23.12% though the project cost has been increased from 0.85 to 0.97 Million USD/MW.

POE concluded that this observation has now been addressed in the revised FS as per NEPRA Tariff Regulations June 2018. The ultimate tariff shall, however, be approved by NEPRA.

The Company's representative at the end also presented the project timelines. He said the Company is targeting to file tariff application before NEPRA by end March 2019. The expected Financial Close would be in December 2019.

The meeting ended with vote of thanks from and to the Chair.

x----x----x

# Annexure Q

# Annexure Q – Schedule Part I

## The Project Site

The project is located in Mankera District Bakhar, Punjab. The geographical coordinates of our project are as follows:

| S.No. | Entry | Details |
|---|---|---|
| 1 | Site Name | Mankera Solar Farm |
| 2 | Site Coordinates | P1= 31°24'3.62"N, 71°28'42.77"E<br>P2= 31°24'15.96"N, 71°28'42.54"E<br>P3= 31°24'16.54"N, 71°29'8.41"E<br>P4= 31°24'4.38"N, 71°29'7.94"E |
| 3 | Altitude | 164 m (Highest recorded value)<br>162 m (Lowest recorded value) |
| 4 | Proposed AC and DC capacity | 12.5 MW AC ~ 15 MW DC |
| 5 | Global irradiation levels | 1784 KWh / $m^2$ (Solar GIS) |

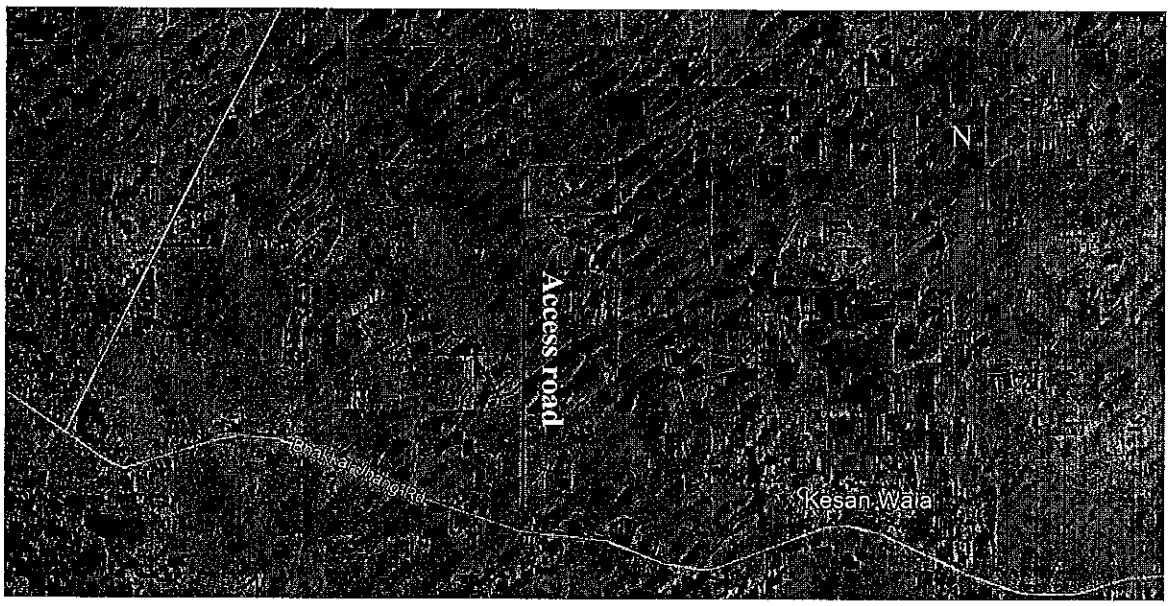



Fig 1 showing location of the Mankera Solar farm site

## Selection of Technology

The project will use bifacial monocrystalline 360W solar panels with single axis trackers and string inverters SUN2000-105KTL. The site will be connected through a 11kV connection with 66/11kV Mankera Grid.

1. PV Modules

| Longi Solar LR6-72BP 360Wp Bifacial monocrystalline modules. | |
|---|---|
| Specification | Data |
| Cell-type | PERC monocrystalline, 6 inch cells |
| Bifaciality | ≥75% |
| Cell Orientation | 72 (6x12) |
| Dimensions | 1977x996x40mm |
| Weight | 26.5 kg |
| Junction box | IP67, 3 diodes |
| Output Cable | 4mm², 300mm in length |
| Packaging | 26pcs per pallet |

2. Single Axis Tracker

Arctech Solar Skysmart tracker specifications

| | |
|---|---|
| Tracking type | Independent Horizontal Single Axis Tracker |
| Tracking Range | Up to $120^0$ ($\pm 60^0$) |

| | |
|---|---|
| Driving System | One Slewing Gear, 24VDC Motor |
| Modules per Tracker | Up to 90 modules per tracker |
| System Voltage | 1000 Volt or 1500 Volt |
| Ground Coverage Ratio | 1000 Volt or 1500 Volt |
| Foundation options | Ramming / Pre-drilling/Concrete Piles/Screw Pile |
| Terrain Adaption | Up to 20% N-S Slope |
| Structure Material | Hot Dipped Galvanized/Pre-Galvanized Steel |
| Power Supply | Self-powered PV series |
| Daily Energy Consumption | Typical 0.08KWh |
| Standard Wind Design | 105mph(47m/s) per ASCE7-10, higher wind load available |
| Wind Protection | Stow when wind speed > 18m/s |
| Module Supported | Most commercially available |
| Operation Temperature | $-30^0$ to $60^0$C |

Electronic Controller Specifications

| | |
|---|---|
| Control System | 1 Controller per 3 trackers |
| Control Algorithm | Astronomical Algorithms + Tilt Sensor Close Loop |
| Tracking Accuracy | $\leq \pm 2^0$ |
| Backtracking | Yes |
| Communication | RS 485 cable/LoRa wireless |
| Night Position | Yes |

3. Inverters

| Model No. | SUN2000-105KTL-H1 |
|---|---|
| Input Data(DC) | |
| Max. DC Voltage | 1500 V |
| Rated DC Voltage | 1080 V |
| Min. DC Voltage to Start Feed In | 650 V |
| Max. DC Current | 150 A |
| MPP(T) Voltage Range | 600~1500 V |
| No of MPP Trackers | 6 |

| | |
|---|---|
| DC Inputs | 12 |
| Output Data (AC) | |
| Max. AC Power | 116 kW |
| Rated AC Voltage | 800 V |
| Max. AC Current | 84.6 A |
| Rated AC Current | 75.8 A |
| Frequency | 50, 60 Hz |
| Power Factor (cosθ) | 0.8 |
| Distortion (THD) | < 3 % |
| No of feed-in phases | 3 |
| Max. Efficiency | 99% |
| Euro Efficiency | 98.80% |
| General Data | |
| Dimensions (H/W/D) | 1075x605x310 mm |
| Weight | 79 kg |
| Operating Temperature | -25 ~ +60 °C |
| Transformer | Transformerless |
| Protection Class | IP65 |
| Humidity | 0-100 % |
| Cooling | Natural |
| Max. Altitude | 4000 m |

| | |
|---|---|
| Interface | RS 485, USB, Bluetooth |
| Display | LED |
| Protection Features | |
| Protection Features | Anti Island Protection(ENS), Overcurrent Protection, Residual Current Device (RCD), Reverse Polarity Protection, Surge Protection |

4. Step-up transformers

Five step up transformer of 2750KVA, 0.8/11kV will be used to connect 12.5MW AC to National Grid.

5. SCADA

Monitoring and control of the photovoltaic system is to be supplied by Gantner Instruments. Meteorological data as well as key electrical measurements will be logged and processed to trouble shoot system faults and to evaluate the photovoltaic systems performance.

Additional Plant Technical Details

Plant Configuration:

1. Installed Capacity: 15 MWp
2. Capacity at Operating Conditions: 13.602 MWp (at $50^0$C)
3. Auxiliary Consumption approx.: 120 KvA
4. Output Capacity: 12.5 MW (AC)
5. Life of facility 25 years

The Project will be set up using [polycrystalline] PV modules, which will be installed in arrays, and their DC output will be converted in to AC through inverters. Thereafter, a group of arrays/inverters will be routed to step-up transformer(s)/switchgear(s) for connecting to the system as per the interconnection scheme.

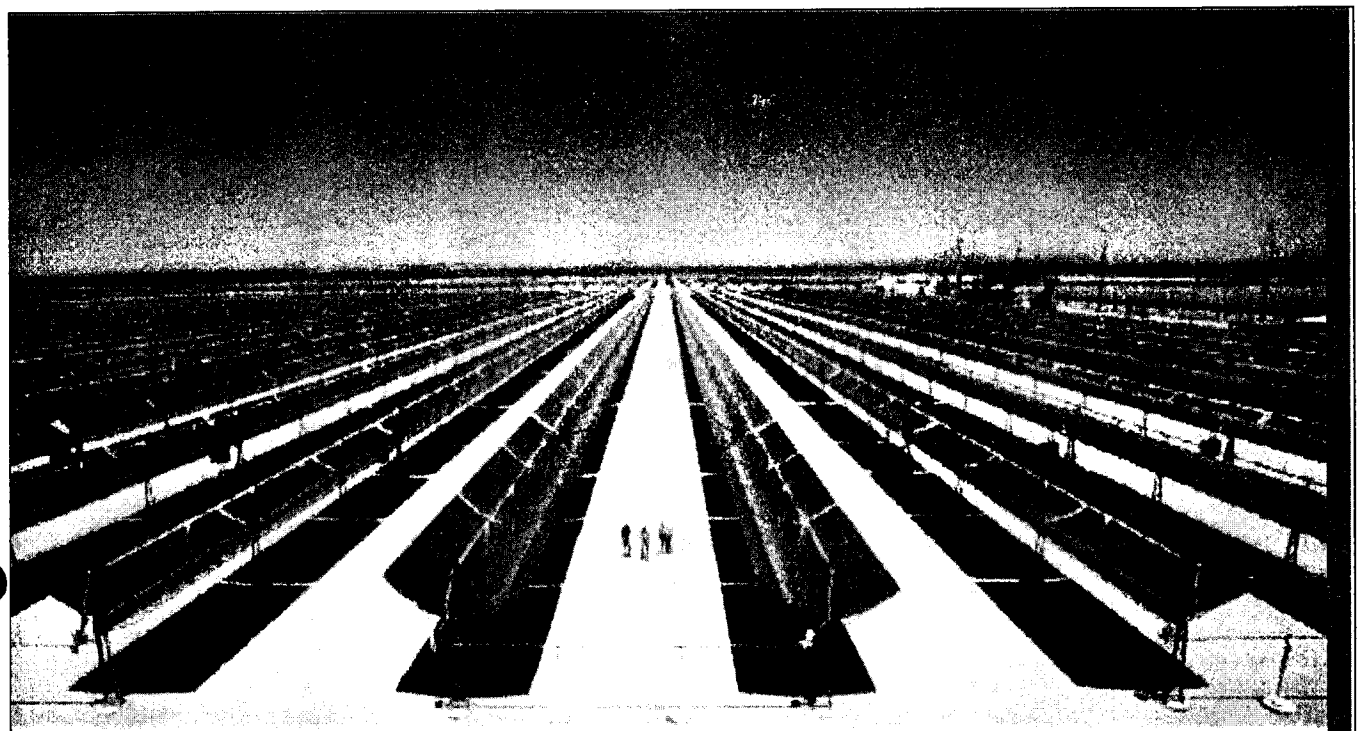
## PLANT CONFIGURATION

## ANNEXURE Q – PART II

The Total Installed Gross ISO Capacity of the Generation Facility / Solar Plant 15 MWp, Total Annual Full Load (Hours), Average Sun Availability, Total Gross Generation of the Generation Facility/Solar Farm (in kWh), Annual Energy Generation 30,386 equivalent Net AEP) kWh and Net Capacity Factor of the Generation Facility /Solar farm of Applicant is given in this Annexure Q – Part II.

PLANT CONFIGURATION OF K1 SOLAR POWER LAHORE (PRIVATE) LIMITED
ANNEXURE Q – PART II

| | | **Site Overall** |
|---|---|---|
| 1. | Total PV Installed Capacity of Generation Facility | 15 MWp |
| 2. | Average sun hour availability /day (Irradiation on inclined surface) | 10 Hrs |
| 3. | Days per year | 365 |
| 4. | PV Plant generating capacity annually (As Per Simulation) | 30386 MWh |
| 5. | Expected total generation in [25] years life span | 759,650 MWh |
| 6. | Generation per year from plant keeping 24 hrs working | 15 x 24 x 365 = 131400 MWh |
| 7. | Net Capacity Factor (4/6) | 23.12% |



# GRID INTERCONNECTION ASSESSMENT OF 15MWp IB VOGT SOLAR PV PP

ARCO Energy

Final Report
February, 2019


ARCO Energy

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# CONTENTS

# EXECUTIVE SUMMARY

This Grid Interconnection Assessment (GIA) report provides the documentation of an assessment that has been performed for the connection of a 15MWp (DC) = 12.5MW (AC) Solar PV Power Generation project by Ib Vogt to the Faisalabad Electric Supply Company (FESCO) transmission system at 11kV. The '12.5MW (AC) Solar PV Power Generation project' located in Tehsil Mankera, District Bhakkar, Faisalabad, Punjab, Pakistan and has a commercial operation date of December 2019. The project will be connected to 66/11kV Mankera substation by lying three circuits of Osprey conductor at 11kV of 4.5km length.

| IB VOGT SOLAR PARK (MW) SUMMARY | | |
|---|---|---|
| GROSS POWER (MW) | AUXILARY LOAD (kW) | NET POWER (MW) |
| 12.5 | 100 | 12.4 |

Steady state power flow assessment has been performed using the already available network data of FESCO. Pre-project power flow study was conducted to analyze the magnitude and phase angles of bus voltages, line loadings and power flows under steady-state conditions. Post project power flow analysis has also been performed after the interconnection of the proposed project with the FESCO transmission system. The power flow results for the system intact and for the contingency conditions shows that the power flows on all the transmission line branches are within their normal thermal loading limit. There is no capacity constraint in terms of power flow or voltage ratings within the study area.

Dynamic stability analysis has been performed to access the dynamic impact of the Solar power plant on national grid system due to disturbances at the power plant and vice versa. The results of dynamic stability analysis indicate that the power system is stable for the interconnection proposal and it also fulfils all the criteria for generation connection with the power system.

Short circuit analysis has been performed to evaluate the contribution of the proposed project in fault current levels of substations in its electrical locality. Fault currents have been computed based on simulation of three-phase and single-line-to-ground faults by applying the criteria as mentioned in the IEC-60909 standard. Result of the analysis shows that the calculated fault currents are below the circuit-breaker interrupt ratings of existing grid stations located in locality of the project.

Based on the study results, it is concluded that proposed generation interconnection assessment for 12.5MW Solar PV Power Generation project meets the NEPRA grid code planning criteria.

# 1 INTRODUCTION

## 1.1 Project Description

This Grid Interconnection Assessment (GIA) report provides the documentation of an assessment that has been performed by ARCO Energy Consultants in response to a request made by Ib Vogt "Project Owner" or "PO") for the connection of a 12.5MW (AC) = 15MWp (DC) Solar PV Power Generation project ("Project") to the Faisalabad Electric Supply Company (FESCO) transmission System at 11kV. The PO has proposed a commercial operation date of December, 2019 for the Project.

The project is located in Tehsil Mankera, District Bhakkar, Punjab. Figure 1.1 shows Google site map of the project. The pre-project and post-project geographical representation of power plant is shown in Figure 1.2 and Figure 1.3.

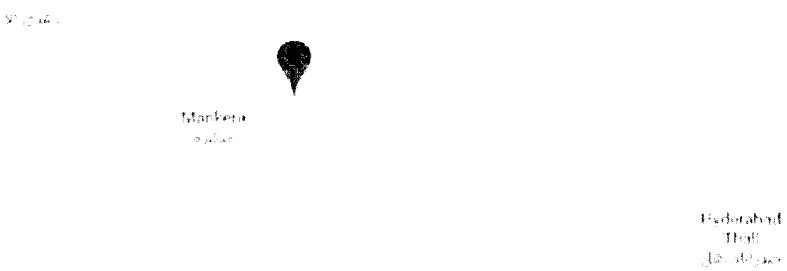

Figure 1.1: Google Site Map of the Solar PV Power Generation Project.

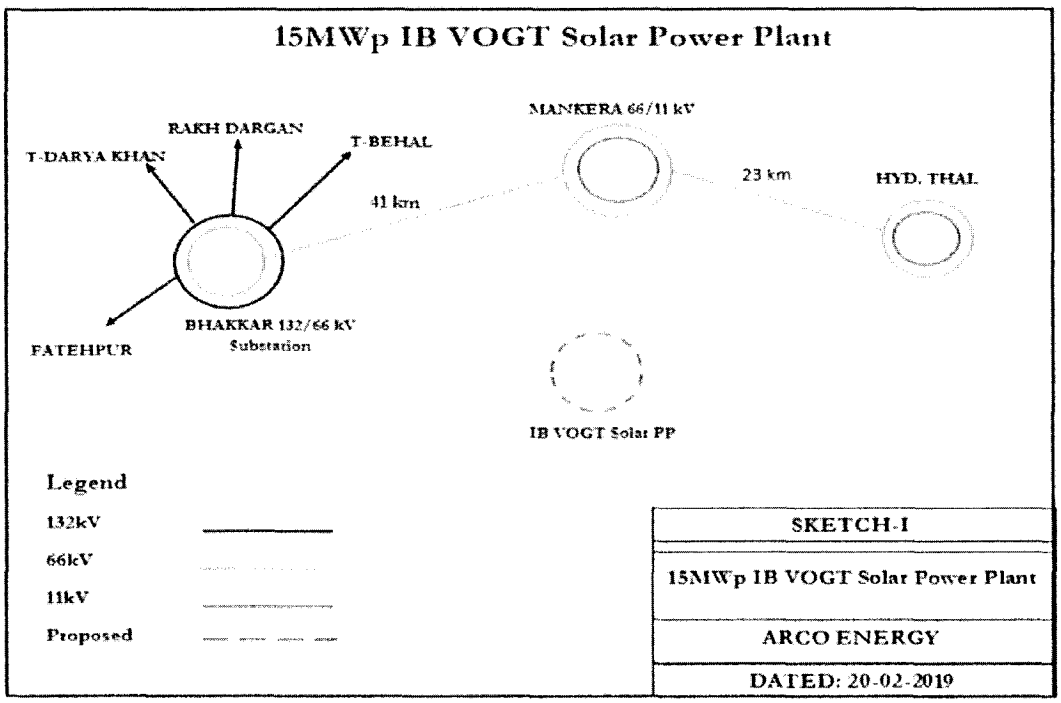


Figure 1.2: Existing Network around IB VOGT Solar Plant

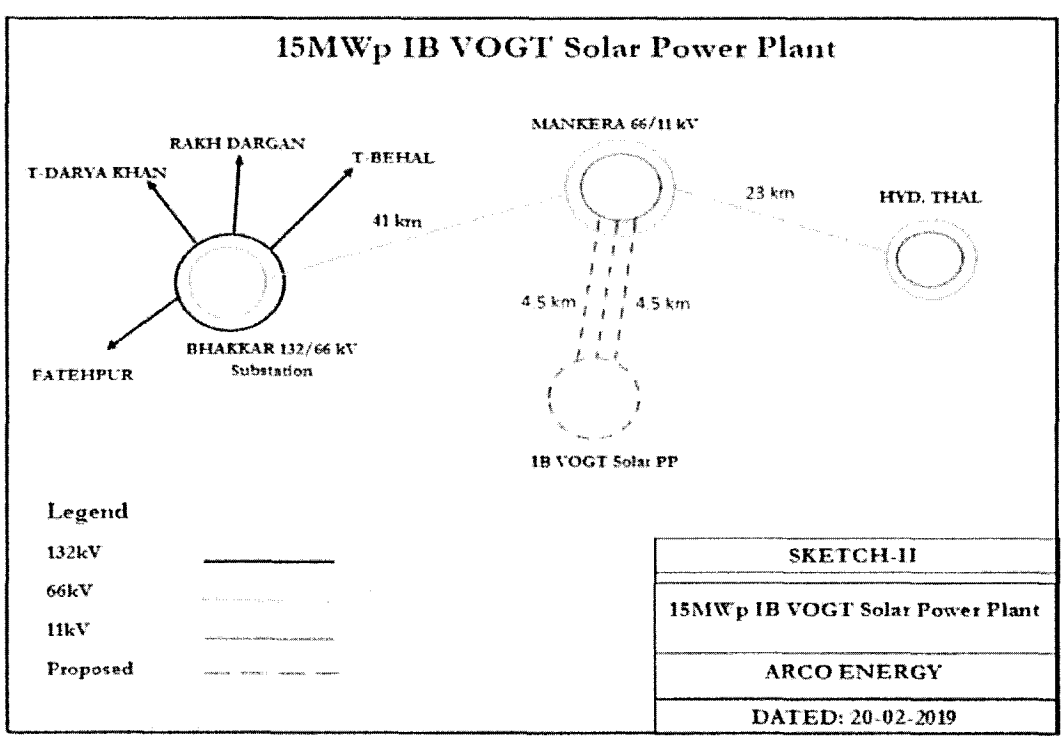


Figure 1.3: Interconnection Proposal of IB VOGT Solar Plant

## 1.2 Grid Interconnection Arrangement

The project will be connected to 66/11kV Mankera substation by lying three circuits at 11kV of length 4.5km on Osprey conductor. The objective of the GIA is to evaluate the impact of the proposed solar power plant on the FESCO transmission system.

## 1.3 Study Components

GIA includes the following four types of analyses to evaluate the impact of interconnecting the proposed project:

i) Steady State Analysis.
ii) Dynamic Stability Analysis.
iii) Short Circuit Analysis.
iv) Power Quality Analysis

This report documents the results of the steady state, dynamic stability, short circuit and power quality analysis. The steady state analysis includes pre-project and post project power flow assessment. Dynamic stability analysis includes the post project dynamic stability assessment during occurrence of any fault. Short circuit analysis includes pre-project and post project short circuit current levels assessment at different buses in the vicinity of the project.

# 2 STUDY METHODOLOGY

## 2.1 Study Criteria

GIA has been carried out based on the National Electric Power Regulatory Authority (NEPRA) Grid Code planning criteria. Key parameters and their corresponding limits have been summarized in table below.

| Parameter | | Range |
|---|---|---|
| **Voltage** | Normal Condition | ±5 % p.u at load grids 132kV and below +8%,-5% p.u at generation switchyards, 220kV Grid Stations and above |
| | Contingency | ±10 % p.u |
| **Thermal loading** | Normal Condition | 100% |
| | Contingency | 100% |
| **Frequency** | Nominal | 50 Hz |
| | Steady State Variation | 49.8 Hz - 50.2 Hz |
| | Contingency Band | 49.4 Hz - 50.5 Hz |
| **Power Factor** | Lagging | 0.95 |
| | Leading | 0.95 |

## 2.2 Steady State Analysis

The purpose of steady-state analysis is to analyse the impact of the proposed solar power plant on transmission system facilities under steady-state conditions. It involves two distinct analyses: thermal loading analysis and voltage analysis. Power flow solutions using the PSS/E® program (Version 33.4) has been performed.

A "study area" was defined to represent the areas of interest which includes the following areas within FESCO:

- BHAKKAR
- T-DARYA KHAN
- PIPLAN
- RAKH DAGRAN
- MANKERA
- HYD. THAL

### 2.2.1 Normal Condition Analysis

The incremental impact of the project on line loading of transmission facilities under normal condition was evaluated by comparing transmission system power flows without and with the proposed project. Loadings of the transmission facilities without and with the project were tabulated and compared. The criteria to flag transmission line overloads are 100% of continuous facility rating (Rate A in the power flow model).

### 2.2.2 Contingency Analysis

The contingency analysis for this study consists of single branch (N-1) outage in the study area.

### 2.2.3 Transmission Line Loading Analysis

66kV rated transmission facilities in the study area have been monitored for thermal loadings.

### 2.2.4 Voltage Analysis

Voltages at buses inside the study area have been monitored for possible pre and post project voltage violations in accordance with NEPRA Grid Code guidelines.

## 2.3 Dynamic Stability Analysis

The purpose of dynamic stability analysis is to analyse the impact of the proposed solar power plant on transmission system facilities under transient conditions. The system is considered to be stable if the system recovers with good damping after the transients die out and the synchronism is retained.

Fault clearing time for different voltage levels in accordance with NEPRA Grid Code guidelines is presented in table below.

| Voltage Level | Fault Type | Fault Clearing Time |
|---|---|---|
| 11kV | 3-Phase | 9 Cycles (180 msec) |

## 2.4 Short Circuit Analysis

The purpose of short-circuit analysis is to investigate the fault current levels at nearby substations without and with the proposed project online. And to propose and check whether there is the need of installing or upgrading Circuit Breaker and to check that the calculated pre-project and post-project fault currents are within the already installed circuit breaker interrupt ratings. Short circuit analysis has been carried out by applying the criteria as mentioned in the IEC-60909 standard.

Key assumptions in IEC-60909 are given below.

- Tap ratios to unity
- Line charging to zero
- Shunts are set to zero in positive sequence
- Desired voltage magnitude at bus bars is set to 1.1p.u in maximum and 1.0p.u in minimum fault levels.

# 3 STEADY STATE ANALYSIS

## 3.1 Model Development

Project specific data was provided by the plant owner and it has been compiled and presented in Annexure-A. The steady state model of the power plant is presented in table below:

| **Generator** | |
|---|---|
| No. of Collector Units | 5 |
| Generation size of each collector (MVA) | 2.625 |
| Active Power of each collector Pgen. (MW) | 2.5 |
| Power Factor | 0.95 lagging, 0.95 leading |
| Qmin, Qmax (MVAR) | -0.8217, 0.8217 |
| Rated Frequency | 50 Hz |
| Generation Voltage | 0.8kV |
| Xsource | ∞ |
| **Generation Step Up (GSU) Transformer** | |
| No. of Transformer units | 5 |
| MVA Capacity of each GSU | 2.75 |
| Rating | 0.8/11kV |
| % Reactance (X) | 7% |
| (X+ve) = (Xzero)<br>At 100MVA system base. | 2.54 p.u |
| **Auxiliary Transformer** | |
| No. of Transformer units | 1 |
| kVA Capacity of each GSU | 100 |
| Rating | 0.4/11kV |
| % Reactance (X) | 0.4 % |
| (X+ve) = (Xzero)<br>At 100MVA system base. | 4 p.u |
| **Static VAR Compensator (SVC)** | |
| No. of units | 1 |
| MVAR | 4.2 , -4.2 |

Steady state power flow assessment has been performed using the already available network data of FESCO.

## 3.2 Pre Project-Power Flow Assessment

A pre-project power flow study was conducted to analyze the magnitude and phase angles of bus voltages, line loadings and power flows under steady-state conditions.

The results of the pre-project power flow analysis are in **Annexure-C**.

### 3.2.1 Base Year 2020: Peak Loading Summer

Power flow analysis has been performed on the peak loading summer (September) case of FESCO network. This base case included a detailed representation of the FESCO transmission system in the study area.

The power flow results for the normal conditions show that the power flows on all the transmission line branches are within their loading limits. There is no capacity constraint in terms of power flow or voltage ratings within the study area. The results of the pre-project power flow analysis are plotted in **Annexure-C**.

## 3.3 Post Project Power Flow Assessment

Post project power flow study was conducted to determine the reliability impact of the proposed 12.5MW (AC) Ib Vogt Solar project on the FESCO transmission system. This includes the performance of a contingency analysis to identify any facility overload or voltage condition that violates the NEPRA planning criteria. Any such violation that is either directly attributable to this project or for which it will have a shared responsibility is included in this report.

The results of the post project power flow analysis are plotted in **Annexure-D.**

### 3.3.1 Base Year 2020: Peak Loading Summer

A base case has been developed for peak loading summer (September) 2020 that allow us to judge the maximum impact of Ib Vogt Solar project on the FESCO network.

Post-project power flow analysis has been performed after the interconnection of the proposed project with the FESCO transmission system. This includes the detailed representation of the power plant. A simulation of all possible worst contingencies within the NEPRA Grid Code planning criteria has also been carried out.

The steady state results for the normal and contingency conditions depicts that the power flows on all the transmission line branches are within their loading limits. There is no capacity constraint in terms of load flow or voltage ratings around the study area.
Results from the power flow analysis are presented in table below.

| Condition | Contingent Branch | Figure No. | Steady State Result |
|---|---|---|---|
| Normal | -N.A- | Figure D-1 | No overloading |
| Contingency | IB VOGT to MANKERA LV line out | Figure D-1.1 | No overloading |
| Contingency | RAKH DAGRAN to FAZAL line out | Figure D-1.2 | No overloading |
| Contingency | T-DARYA KHAN to PIPLAN line out | Figure D-1.3 | No overloading |
| Contingency | FAZAL to PIPLAN line out | Figure D-1.4 | No overloading |
| Contingency | PIPLAN to CHASHM-L line out | Figure D-1.5 | No overloading |

### 3.3.2 Base Year 2020: Peak Loading Winter

A base case has been developed for peak loading winter (January) 2020 that allow us to judge the maximum impact of Ib Vogt Solar project on the FESCO network.

Post-project power flow analysis has been performed after the interconnection of the proposed project with the FESCO transmission system. This includes the detailed representation of the power plant. A simulation of all possible worst contingencies within the NEPRA Grid Code planning criteria has also been carried out.

The steady state results for the system intact and contingency conditions depicts that the power flows on all the transmission line branches are within their loading limits. There is no capacity constraint in terms of load flow or voltage ratings around the study area.
Results from the power flow analysis are presented in table below.

| Condition | Contingent Branch | Figure No. | Steady State Result |
|---|---|---|---|
| Normal | -N.A- | Figure D-2 | No overloading |
| Contingency | IB VOGT to MANKERA LV line out | Figure D-2.1 | No overloading |
| Contingency | RAKH DAGRAN to FAZAL line out | Figure D-2.2 | No overloading |
| Contingency | T-DARYA KHAN to PIPLAN line out | Figure D-2.3 | No overloading |
| Contingency | FAZAL to PIPLAN line out | Figure D-2.4 | No overloading |
| Contingency | PIPLAN to CHASHM-L line out | Figure D-2.5 | No overloading |

### 3.3.3 Base Year 2020: Off Peak Loading Summer

A base case has been developed for off peak loading summer (September) 2020 that allow us to judge the impact of Ib Vogt Solar project on the FESCO network.

Post-project power flow analysis has been performed after the interconnection of the proposed project with the FESCO transmission system. This includes the detailed representation of the power plant. A simulation of all possible worst contingencies within the NEPRA Grid Code planning criteria has also been carried out.

The steady state results for the system intact and contingency conditions depicts that the power flows on all the transmission line branches are within their loading limits. There is no capacity constraint in terms of load flow or voltage ratings around the study area.

Results from the power flow analysis are presented in table below.

| Condition | Contingent Branch | Figure No. | Steady State Result |
|---|---|---|---|
| Normal | -N.A- | Figure D-3 | No overloading |
| Contingency | IB VOGT to MANKERA LV line out | Figure D-3.1 | No overloading |
| Contingency | RAKH DAGRAN to FAZAL line out | Figure D-3.2 | No overloading |
| Contingency | T-DARYA KHAN to PIPLAN line out | Figure D-3.3 | No overloading |
| Contingency | FAZAL to PIPLAN line out | Figure D-3.4 | No overloading |
| Contingency | PIPLAN to CHASHM-L line out | Figure D-3.5 | No overloading |

## 3.4 Conclusion

Steady state power flow assessment has been performed using the already available network data of FESCO. Pre-project power flow study was conducted to analyze the magnitude and phase angles of bus voltages, line loadings, and power flows under steady-state conditions. Post project power flow analysis has also been performed after the interconnection of the proposed project with the FESCO transmission system. The power flow results for the normal and for the contingency conditions showed that the power flows on all the transmission line branches are within their loading limit. There is no capacity constraint in terms of power flow or voltage ratings within the study area.

The steady state results found no capacity constraint in terms of power flow and voltage ranges.

# 4 DYNAMIC STABILITY ANALYSIS

Dynamic stability analysis has been performed to access the dynamic impact of the solar power plant on national grid system due to disturbances at the power plant and vice versa.

## 4.1 Dynamic Model Development

Dynamic models, available in the PSSE model library and data provided by PO, for the solar power plant have been used to develop the dynamic model of the power plant. Dynamic model of the power plant is presented in table below:

| Component | Model |
|---|---|
| Generator | PVGU1 |
| Electrical | PVEU1 |
| Mechanical | PANELU1 |
| Pitch | IRRADU1 |
| SVC | CSVGN1 |

## 4.2 Post-Project Dynamic Stability Assessment

### 4.2.1 Base Year 2020: Peak Loading Summer

Dynamic stability analysis has been carried out for the Base Year 2020 peak loading summer conditions. To access the dynamic behavior of power plant and system towards the disturbances, simulations have been carried out of 3 Phase faults at IB Vogt bus cleared in 9 cycles.

Each simulation has been performed for one second to depict steady state condition. Then fault is applied and system has been simulated for the fault clearance time. Post-fault condition has been simulated, from clearance of fault followed by a certain contingency, till 15 seconds.

### 4.2.2 3 Phase fault at 11kV IB VOGT cleared in 9 cycles

Three phase fault has been applied at IB VOGT, fault has been cleared in 180msec (9 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

**Fault E-1:** 3 Phase fault at 11kV IB VOGT bus cleared in 9 cycles

| No. | Contingency | Monitored Element | Figure No. | System Response |
|---|---|---|---|---|
| E-1.1 | 11kV line from IB VOGT to MAKERA LV | Bus Voltages of:<br>(i) 11kV IB VOGT<br>(ii) 11kV MANKERA LV<br>(iii) 66kV MANKERA<br>(iv) 132kV BHAKKAR | E-1.1A | Stable |
| | | Frequency at 11kV IB VOGT | E-1.1B | Stable |
| | | MW and MVAR of IB VOGT | E-1.1C | Stable |
| | | Rotor Angles w.r.t. Muzaffar Garh Slack Bus:<br>(i) JINNAH<br>(ii) C-1/C-2<br>(iii) CHASHMA | E-1.1D | Stable |
| | | Active (P) and Reactive (Q) power flows on interconnecting lines from:<br>(i) IB VOGT to MANKERA LV CIRCUIT 1<br>(ii) IB VOGT to MANKERA LV CIRCUIT 2<br>(iii) IB VOGT to MANKERA LV CIRCUIT 3 | E-1.1E | Stable |

### 4.2.3 3 Phase fault at 11kV Mankera cleared in 9 cycles

Three phase fault has been applied at Mankera, fault has been cleared in 180msec (9 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

**Fault E-2:** 3 Phase fault at 11kV Mankera bus cleared in 9 cycles

| No. | Contingency | Monitored Element | Figure No. | System Response |
|---|---|---|---|---|
| | | Bus Voltages of:<br>(i) 11kV IB VOGT<br>(ii) 11kV MANKERA LV<br>(iii) 66kV MANKERA<br>(iv) 132kV BHAKKAR | E-2.1A | Stable |

| No. | Contingency | Monitored Element | Figure No. | System Response |
|---|---|---|---|---|
| | | Frequency at 11kV IB VOGT | E-2.1B | Stable |
| | | MW and MVAR of IB VOGT | E-2.1C | Stable |
| | | Rotor Angles w.r.t. Muzaffar Garh Slack Bus:<br>(i) JINNAH<br>(ii) C-1/C-2<br>(iii) CHASHMA | E-2.1D | Stable |
| | | Active (P) and Reactive (Q) power flows on interconnecting lines from:<br>(i) IB VOGT to MANKERA LV CIRCUIT 1<br>(ii) IB VOGT to MANKERA LV CIRCUIT 2<br>(iii) IB VOGT to MANKERA LV CIRCUIT 3 | E-2.1E | Stable |

Dynamic Stability Analysis Results are attached in **Annexure-E**.

## 4.3 Conclusion

Dynamic stability analysis has been performed to access the dynamic impact of the solar power plant on national grid system due to disturbances at the power plant and vice versa. The results of dynamic stability analysis indicate that the power system is stable for the interconnection proposal and it also fulfils all the criteria for generation connection with the power system.

# 5 SHORT CIRCUIT ANALYSIS

Short circuit analysis has been performed to determine the need for any breaker replacements due to impacts of the solar power plant project and determining the rating of Circuit breaker to propose at power plant switchyard. Single-line-to-ground and three-phase fault current values have been calculated for buses in the vicinity of the solar power plant project. The calculated fault currents observed at these buses were compared with the interrupting current capabilities of corresponding circuit breakers to determine need for upgrading existing circuit breakers.

## 5.1 Short Circuit Model Development

Short circuit database provided by FESCO has been used as a base case to perform short circuit assessment. The study project has been added to the base case to develop the post-project case.

## 5.2 Post-Project Short Circuit Assessment

With the addition of power plant, short circuit current at each bur bar is increased, so the circuit breaker capacity has analysed. Post-project short circuit assessment has been performed to evaluate the contribution of the proposed project in fault current levels of substations in its electrical locality and to compute the fault levels at IB VOGT Solar PV Plant.

### 5.2.1 Maximum Short Circuit: Base Year 2020

The maximum short circuit levels have been computed according to IEC-60909 standard. Pre and Post project maximum short circuit levels at the buses within the study area in the year 2020 have been presented in table below:

| Bus Name | Bus kV | Pre-Project | | Post Project | |
|---|---|---|---|---|---|
| | | 1-Φ Fault Level (kA) | 3-Φ Fault Level (kA) | 1-Φ Fault Level (kA) | 3-Φ Fault Level (kA) |
| IB VOGT LV | 11 | -N.A- | -N.A- | 3.50 | 2.97 |
| MANKERA LV | 11 | 3.84 | 3.25 | 4.16 | 3.52 |
| MANKERA | 66 | 0.84 | 1.14 | 0.88 | 1.21 |
| BHAKKAR | 132 | 3.30 | 4.92 | 3.32 | 4.95 |
| PIPLAN | 132 | 5.67 | 7.63 | 5.68 | 7.65 |

Maximum Pre and Post short circuit analysis summary for the base year 2020 is attached in **Appendix F-1 and F-2**.

### 5.2.2 Minimum Short Circuit: Year 2020

The minimum short circuit levels have been computed according to IEC-60909 standard. Post project minimum short circuit levels at the buses within the study area in the year 2020 have been presented.

Post project minimum short circuit analysis summary for the base year 2020 are attached in **Appendix F-3** respectively.

## 5.3 Conclusion

Short circuit analysis has been performed to evaluate the contribution of the proposed project in fault current levels of substations in its electrical locality. Fault currents have been computed based on simulation of three-phase and single-line-to-ground faults by applying the criteria as mentioned in the IEC-60909 standard. The short circuit value is well within the limit of Circuit Breaker as per approved NTDC Specification. Therefore, CB rating of 40kA is recommended. Further it shows that the calculated fault currents are below the circuit-breaker interrupt ratings of existing grid stations located in locality of the project.

# 6 Power Quality Analysis

## 6.1 Power Quality Study Objectives

Power quality problems associated with solar power plants are due to the involvement of power electronics components. These problems are created by the switching of power electronic devices and can cause damage and malfunctions to power system equipment on the utility side and sensitive loads on the customer side. Power quality issues regarding voltage and flicker are primarily prominent in the weak power systems having low short circuit strength. Hence, these issues have been inspected in the following scenario for the proposed interconnection strategy.

i. Minimum short circuit of base year 2020

The objective of this analysis was to study the behaviour of solar PV power plant and the related possible power quality issues. Following power quality parameters have been evaluated;

a. Flicker.
b. Voltage Un-balance.

## 6.2 Power Quality Study Criteria

Power quality analysis is performed under the following criteria;

- Minimum short circuit case of 2020 has been used to calculate the parameters which are required for the power quality analysis.
- Power quality analysis is conducted according to International Electro technical Commission (IEC) standard IEC61400-21 titled *"Measurement and assessment of power quality characteristics of grid connected wind turbines"*

  and

  IEC-61727 standard titled *"Photovoltaic (PV) systems – Characteristics of the utility interface"*

## 6.3 Flicker

For the computation of flicker quantity in the steady- state continuous performance, IEC 61400-21 standard has been used. The probability of 99th percentile flicker, during the continuous operation for the brief momentary from single inverter is PstΣ and for the prolong time, the flicker level is P1tΣ. Following formula is used to calculate the flicker level:

$$P_{st\Sigma} = P_{lt\Sigma} = \frac{1}{S_k} \cdot \sqrt{\sum_{i=1}^{N_{wt}} (c_i(\Psi_k, \upsilon_a) \cdot S_{n,i})^2} \quad (6.1)$$

Where;

$\mathbf{S_n}$ is the rated apparent power of the one inverter.

$\mathbf{S_k}$ is the short-circuit apparent power at POI.

$\mathbf{N_{wt}}$ is the number of inverters connected to the POI.

c ($\Psi_k$) cannot be greater than 1, its value '1' is considered here assuming its worst case. POI stands for the point of interconnection that is the 11kV bus of the common solar PV switchyard.

Whereas the voltage variation for one cluster at the POI of the solar power plant can be computed by the following formula:

$$\Delta u_a = k_{imax} \cdot \frac{S_{rE}}{S_{kV}} \quad (6.3)$$

Where;

$k_{imax}$= Maximum inrush current in relation to the nominal current.

$S_{kV}$= Short-circuit power at the POI.

$S_{rE}$= Nominal apparent power of the Solar PV unit that is to be connected.

The formula discussed above is primarily for computation of the upper safe margin. $k_{imax}$ is assumed to be 1 in this case. The apparent power and short circuit value obtained are as follows:

i. **Base year 2020**

$S_{kV}$ = 48.45MVA

$S_{rE}$ = 0.105 MVA

Using equation (6.3), we get;

$u_a$ = 0.002167 = 0.2167 %

The above voltage variation is far less the acceptable limit of 2.34 % in IEC 61400-21 standard.

## 6.5 Conclusions of Power Quality Analysis

The major criteria of the power quality items i.e. flicker, voltage un-balance, has been investigated for the 'ib vogt 15 MWp solar PV power plant' for the worst cases and the obtained values are compared with the standard IEC values. The results show that all the parameters remain within the acceptable range of the IEC standards.

# 7 CONCLUSIONS

## 7.1 Steady State Assessment

Steady state power flow assessment has been performed using the already available network data of FESCO. Pre-project power flow study was conducted to analyze the magnitude and phase angles of bus voltages, line loadings, and power flows under steady-state conditions. Post project power flow analysis has also been performed after the interconnection of the proposed project with the FESCO transmission system. The power flow results for the normal and for the contingency conditions showed that the power flows on all the transmission line branches are within their loading limit. There is no capacity constraint in terms of power flow or voltage ratings within the study area.

The steady state results found no capacity constraint in terms of power flow and voltage ranges.

## 7.2 Dynamic Stability Assessment

Dynamic stability analysis has been performed to access the dynamic impact of the solar power plant on national grid system due to disturbances at the power plant and vice versa. The results of dynamic stability analysis indicate that the power system is stable for the interconnection proposal and it also fulfils all the criteria for generation connection with the power system.

## 7.3 Short Circuit Assessment

Short circuit analysis has been performed to evaluate the contribution of the proposed project in fault current levels of substations in its electrical locality. Fault currents have been computed based on simulation of three-phase and single-line-to-ground faults by applying the criteria as mentioned in the IEC-60909 standard. The short circuit value is well within the limit of Circuit Breaker as per approved NTDC Specification. Therefore, CB rating of 40kA is recommended. Further it shows that the calculated fault currents are below the circuit-breaker interrupt ratings of existing grid stations located in locality of the project.

## 7.4 Power Quality Analysis

The major criteria of the power quality items i.e. flicker, voltage un-balance, has been investigated for the 'ib vogt 15 MWp solar PV power plant' for the worst cases and the obtained values are compared with the standard IEC values. The results show that all the parameters remain within the acceptable range of the IEC standards.

**Hence, it is concluded that based on the study results the proposed generation interconnection assessment for 15MWp IB VOGT Solar Park meets the NEPRA grid code planning criteria.**