

SINDH SOLAR ENERGY PROJECT (SSEP)

Feasibility Study Report

120 MW Solar PV Power Project



CLIENT

Energy Department, Government of Sindh

PROJECT TECHNICAL ADVISOR

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APPROVAL SHEET

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SYNOPSIS:

This document is a feasibility study report of the 120MW Solar PV Power Project being developed by Sindh Solar Energy Project. It contains the hardware specifications, energy yield estimates, electrical interface, civil works design and the project cost. It also includes the initial environmental examination and other site-specific information. This report has been prepared by Renewable Resources (Pvt.) Ltd and reviewed and approved by Tractebel Engineering GmbH, Germany.

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LIST OF ABBREVIATIONS

AC	Alternate Current
AEDB	Alternate Energy Development Board
CDM	Clean Development Mechanism
CER	Carbon Emission Reduction
CFCs	Chlorofluoro Carbons
cm	Centimeter
CO ₂	Carbon dioxide
CPPA	Central Power Purchasing Agency
DC	Direct Current
DHI	Diffuse Horizontal Irradiation
DISCOs	Distribution Companies
DNI	Direct Normal Irradiation
EE	Energy Efficiency
EMP	Environment Management Plan
EPA	Energy Purchase Agreement
EPC	Engineering Procurement Construction
GDP	Gross Domestic Product
GHG	Green House Gas
GHI	Global Horizontal Irradiance
GIS	Geographic Information System
GoP	Government of Pakistan

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IEE	Initial Environmental Examination
IPPs	Independent Power Producers
ITMOs	Internationally Transferred Mitigation Outcomes
JI	Joint Implementation
km	Kilometer
kV	Kilovolt
kW	Kilowatt
LOS	Letter of Support
LPG	Liquefied Petroleum Gas
m ²	Meter square
MEPCO	Multan Electric Power Company
MoP	Mitigation outcome Project
MTDF	Medium Term Development Framework
MW	Megawatt
N ₂ O	Nitrous Oxide
NCS	National Conservation Strategy
NDC	National Determined Contribution
NEPRA	National Electricity Power Regulatory Authority
NEQS	National Environmental Quality Standards
NHA	National Highways Authority
NOCs	No Objection Certificates
NREL	National Renewable Energy Laboratories
NTDC	National Transmission and Dispatch Company

O & M	Operation & Management
PEPA	Pakistan Environment Protection Act
PMD	Pakistan Meteorological Department
PPDB	Punjab Power Development Board
QCBS	Quality and Cost based Selection
RE	Renewable Energy
RE2	Renewable Resources (Pvt.) Ltd
RMSD	Root Mean Square Deviation
SEPA	Sindh Environmental Protection Agency
SRA	Solar Resource and Energy Yield Assessment
UNFCCC	United Nations Framework Convention on Climate Change
WAPDA	Water and Power Development Authority

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1 EXECUTIVE SUMMARY

1.1 PROJECT OVERVIEW AND BACKGROUND

The Sindh Solar Energy Project (SSEP) falls under the overall ambit of development of Renewable Energy projects in the Province of Sindh through an international standard competitive bidding framework with a wider application to the rest of Pakistan. The Energy Department, Government of Sindh (ED GoS, SED or the Client) received funding from the World Bank Group in the form of a loan to finance the technical studies and development of various projects under SSEP. The Client floated an RFP on 8th March 2019 for Transaction Advisory for Utility Scale Solar in the Sindh Province. The Joint Venture (JV) of Bridge Factor (Pvt) Limited from Pakistan and Tractebel Engineering GmbH from Germany was shortlisted as 'Transaction Advisor' for the Project vide letter dated 04th October 2019, following a competitive Quality and Cost based selection process (QCBS). The contract between the Client and the Transaction Advisor ("TA") was signed on 6th December 2019 for this assignment (the Contract).

Tractebel Engineering GmbH (TEG), Bridge Factor Pvt. Ltd (BF), Renewable Resources Pvt. Ltd (RE2), Axis Law Chambers, collectively henceforth referred to as "the Transaction Advisor" for this Project site. Tractebel Engineering GmbH and Renewable Resources Pvt. Ltd, collectively henceforth referred to as "the Technical Advisor" and Bridge Factor, henceforth referred to as "the Financial Advisor".

The main objectives of the assignment include:

- 1) Develop the mechanisms of solar park tariff-based competitive bidding and substation-based tariff based competitive bidding using international best practices following World Bank Procurement Regulations while encompassing Pakistan's specific NEPRA Regulations [Phase 1]
- 2) Support the implementation of the first round of solar park tariff-based competitive bidding until the selection of the lowest evaluated responsive Bidder(s) and till the financial close of the project [Phase 2]
- 3) depending on the results of Phase 1, support the implementation of a substation-based solar tariff-based competitive bidding (optional under the present contract) [Phase 3]

KE has allied with Sindh Energy Department (SED) and the World Bank to develop a solar park with an aggregate capacity of 350 MW under the ambit of the 'Sindh Solar Energy Project' (SSEP). The objective of SSEP is to increase solar power generation and access to electricity in Sindh Province. The purpose is to develop and implement sustainable, cost-effective, and competitive utility-scale IPPs in Karachi under a competitive bidding structure.

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The solar IPPs would be constructed and owned by competitively selected private sector developers. Once complete, the power from the project (s) would be inducted into KE's grid via power off-take agreements, enhancing its ability to serve the current and evolving needs of its growing consumer base.

With this background, this document is the feasibility study for 120 MWp Solar Power Project at Deh Halkani, District West, Karachi, Sindh (the "Project").

1.2 PROJECT TEAM

1.2.1 Client

The Energy Department, Government of Sindh (ED GoS, SED) is referred as the Client for the development of Sindh Solar Energy Project (SSEP). The World Bank (WB) is the financier for development of the entire program including this project of 120 MWp at Deh Halkani, District West, Karachi, Sindh, Pakistan.

1.2.2 Project Consultant

Tractebel Engineering GmbH, Bridge Factor Pvt. Ltd, Renewable Resources Pvt. Ltd, Axis Law Chambers, collectively henceforth referred to as "the Transaction Advisor" for this Project site. Tractebel Engineering GmbH and Renewable Resources Pvt. Ltd, collectively henceforth referred to as "the Technical Advisor" and Bridge Factor, henceforth referred to as "the Financial Advisor".

1.3 FEASIBILITY STUDY

The technical feasibility study of the solar PV project comprises the following topics:

- ❖ Geotechnical Studies
- ❖ Topographic Survey
- ❖ Initial Environmental Examination (IEE)
- ❖ Transportation Studies
- ❖ Grid Interconnection Studies
- ❖ Technology and Equipment Details
- ❖ Solar Resource Assessment and Energy Yield Estimation using Solar GIS data
- ❖ Flood Risk Assessment Studies

The above-mentioned studies are provided along with this report in the form of Annexures. The purpose of the feasibility study is to facilitate the Bidders as reference resource and guidelines. However, Bidders are recommended to carry out their own research and validation. The Bidders would be responsible to take a view as part of their design and bid preparation. The primary role of the feasibility study is to help secure relevant regulatory approvals by providing an outline of the project.

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1.4 SITE ASSESSMENT

The Site for the Project is located in Deh Halkani at Mangho Pir Taluka, District West, Karachi, Sindh, Pakistan. The overall condition of route via Qasim Port road to the National and Super highway link road then Karachi-Hyderabad M-9 Motorway to Karachi Northern Bypass M10 towards Project site is much better than the other route going through N-5. The total distance is around 74.9 km starting from Port Qasim to the Project site. The Project Company has been allocated with the land by Government of Sindh (GoS) for the development of the Project. The project site has a latitude of 25.029533° N and longitude of 66.993153° E with elevation of around 50 meters.

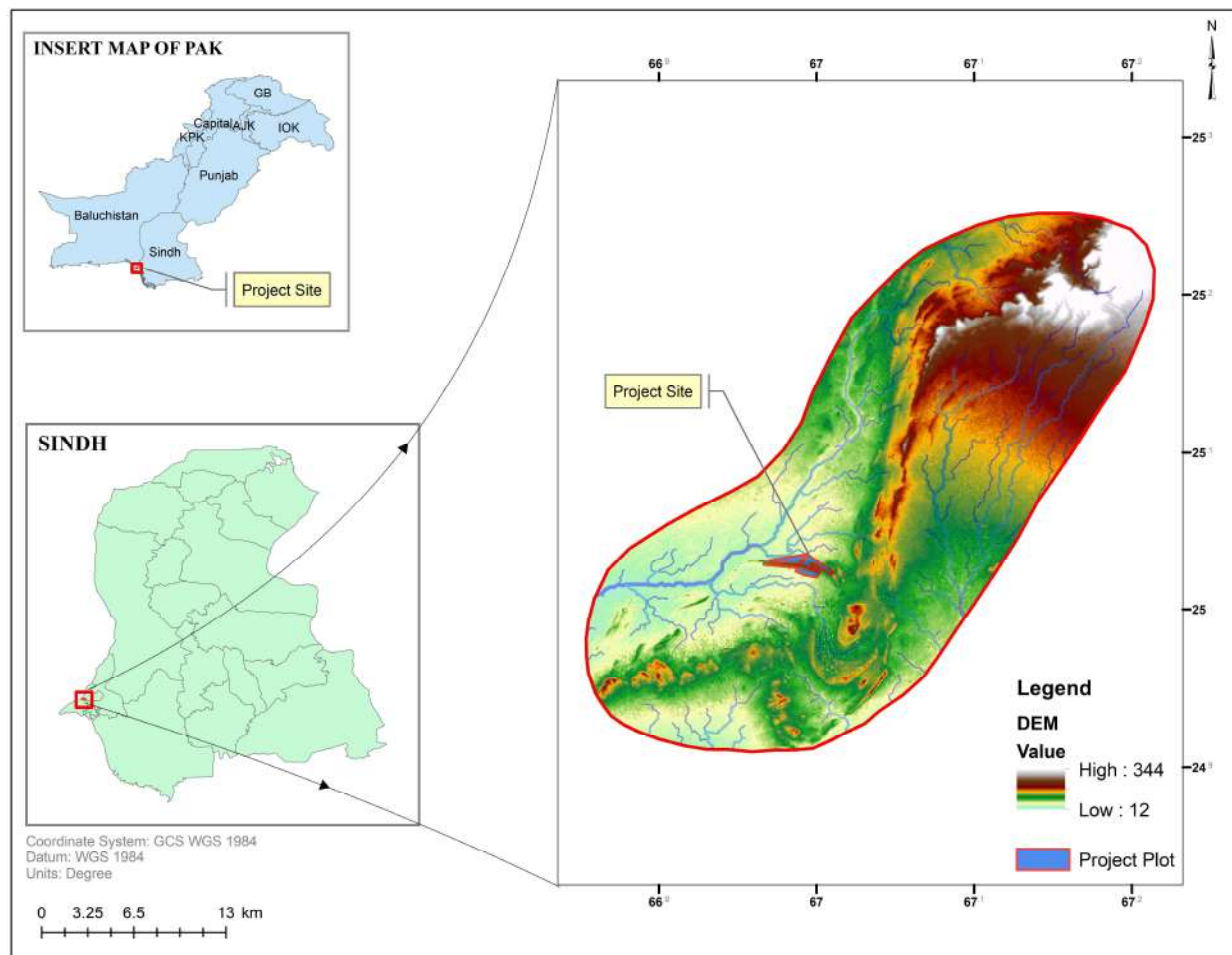


Figure 1-1: Project Site Overview

1.5 SITE LOCATION

The Project site is located at Northern side of the Karachi city in District West near Hazratnabad on Northern Bypass road which is approximately 74.9 km from Port Qasim, Karachi; Pakistan's commercial hub and main port city. The Project site spans across 612 acres of land. According to the

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information provided by the Client, the land has been leased by the Project Company from Government of Sindh. The access to the site from Port Qasim will be through the National and Super highway link road then Karachi-Hyderabad M-9 Motorway to Karachi Northern Bypass M10 towards Project site. The major section of the track from Karachi to the site is a multi-lane, relatively flat road. The Project site is surrounded by the small graveyards, chicken sheds, residential area, connecting road, agricultural land, small goths and hills which will be neglected while the solar micro-siting and technical study of project area will be done.

The Project site has no vegetation and consists of flat terrain with small undulations on the surface. Many small seasonal streams were observed in the proposed land area which can be redirected in the construction phase for safety of the installed structures in the area. The Project location and site boundary is shown in the Figure 1-2 and Figure 1-3 respectively.

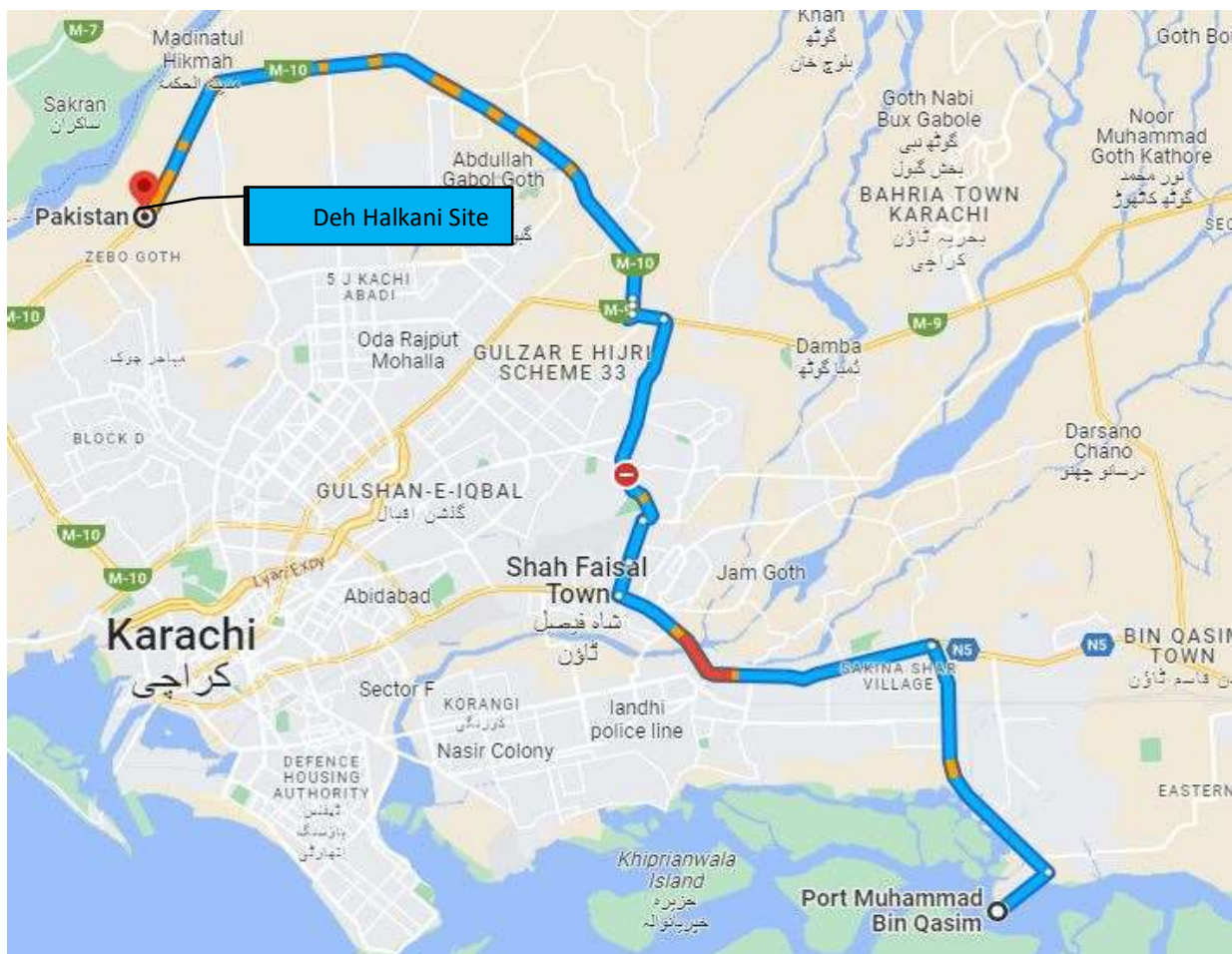


Figure 1-2: Project Location from Qasim Port Karachi (Google Map)

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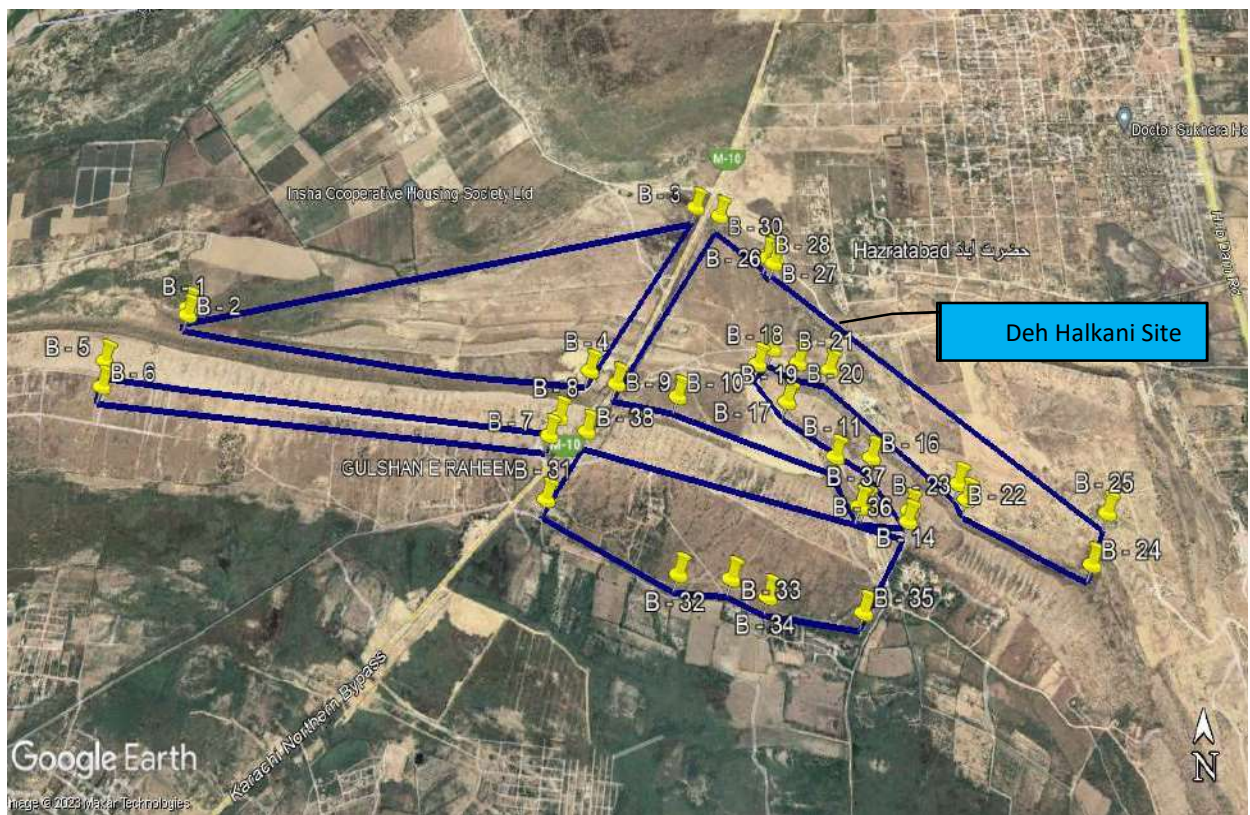


Figure 1-3: Geographical Location of Project Site and Project Boundary (source: Google Earth)

The Boundary coordinates of the project site is mentioned below in **Error! Reference source not found..**

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Table 1-1: Boundary Coordinates of Project Site

Boundary	Latitude/Longitude	Boundary	Latitude/Longitude	Boundary	Latitude/Longitude
1	25° 1'51.49"N	14	25° 1'25.50"N	27	25° 1'59.40"N
	66°58'12.11"E		67° 0'8.67"E		66°59'48.06"E
2	25° 1'52.55"N	15	25° 1'32.11"N	28	25° 1'59.95"N
	66°58'12.05"E		67° 0'3.27"E		66°59'48.43"E
3	25° 2'6.81"N	16	25° 1'39.40"N	29	25° 2'5.52"N
	66°59'36.35"E		66°59'50.32"E		66°59'40.34"E
4	25° 1'43.63"N	17	25° 1'44.48"N	30	25° 1'27.05"N
	66°59'18.66"E		66°59'45.90"E		66°59'11.98"E
5	25° 1'45.09"N	18	25° 1'46.52"N	31	25° 1'17.82"N
	66°57'59.74"E		66°59'48.32"E		66°59'32.57"E
6	25° 1'41.67"N	19	25° 1'44.63"N	32	25° 1'17.29"N
	66°57'59.72"E		66°59'52.39"E		66°59'40.74"E
7	25° 1'35.13"N	20	25° 1'43.72"N	33	25° 1'15.09"N
	66°59'12.26"E		66°59'57.45"E		66°59'46.28"E
8	25° 1'37.48"N	21	25° 1'28.86"N	34	25° 1'13.20"N
	66°59'13.80"E		67° 0'16.64"E		67° 0'0.70"E
9	25° 1'41.84"N	22	25° 1'26.85"N	35	25° 1'24.17"N
	66°59'22.99"E		67° 0'17.71"E		67° 0'8.37"E
10	25° 1'40.12"N	23	25° 1'18.72"N	36	25° 1'25.89"N
	66°59'32.80"E		67° 0'35.74"E		67° 0'0.86"E
11	25° 1'32.18"N	24	25° 1'25.17"N	37	25° 1'35.66"N
	66°59'57.55"E		67° 0'39.42"E		66°59'18.33"E
12	25° 1'26.04"N	25	25° 1'59.17"N		
	67° 0'1.11"E		66°59'49.58"E		
13	25° 1'26.00"N	26	25° 1'58.64"N		
	67° 0'1.80"E		66°59'49.17"E		

1.6 PROJECT CAPACITY

The Project site consists of 612 acres of land and the Project shall have an installed capacity of 120MWp on Single Axis Tracking based PV system.

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1.7 PROJECT STATUS AND CALENDAR

The planned and achieved project milestones is provided on the next page for reference and information purposes:

Table 1-2: Project Milestones (Achieved & Planned) Calendar

Sr. No	Project Milestones/ Activities	No of Days	Date
1	**NTP from SSEP		17-Nov-22
2	Initiation of project studies	10	27-Nov-2022
3	Issuance of EOI	1	28-Nov-22
4	"Finalization of studies	69	5-Feb-23
5	Run RFQ in parallel (NCBT exception) "		
6	Submission of RFP to NEPRA	15	20- Feb-23
7	*NEPRA Hearing	75	6-May-23
8	*RFP Approval by NEPRA	60	5-Jul-23
9	Run the Bidding process	60	3-Sep-23
10	Deadline for bid submission	1	4-Sep-23
11	**Evaluation and selection of successful Bidder	60	3-Nov-23
12	Submission of Bid evaluation to NEPRA	10	13-Nov-23
13	Issuance of LOI to SB	5	8-Nov-23
14	SPV formation by successful Bidder	21	4-Dec-23
15	Filing of Tariff and GL application with NEPRA	30	3-Jan-24
16	*Tariff and GL approval by NEPRA	30	2-Feb-24
17	Finalization of project agreements and submission of EPA to NEPRA	15	17-Feb-24
18	*Approval of EPA by NEPRA	30	18-Mar-24
19	Financial Close	180	1-Jul-24
20	COD	300	27-Apr-25

*timeline dependent on NEPRA

**timeline dependent on SED /GOS/SSEP and concurrence on land parcels by KE and SED

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1.8 GEOLOGICAL CONDITIONS

The land area mainly consists of dense to very dense gravel, medium dense to very dense sand, very stiff to hard silt and very stiff clay. Groundwater table was not encountered up to the explored depth of 5.0 meters in any of the boreholes drilled at the site.

The design soil parameters are based on grain size, material type, SPT N-values, field and laboratory testing data and design water table. For the purpose of analysis, considering similar soil condition and field investigated locations, three (03) design profiles are made for analysis. Geotechnical report addresses general design recommendations of shallow foundations. Allowable net bearing pressures have been given for shallow pad foundations at the depth of 1.5 meters below the existing ground level as presented in Table 1-3.

Table 1-3: List of Design Soil Profiles

Profile	Borehole(s) Covered	Proposed Foundation Type
1	BH-03, BH-11, BH-14, BH-16, BH-17, BH-19, BH-20, BH-21, BH-24 to BH-32	Pad foundation / Piles
2	BH-02, BH-07 & BH-23	Pad foundation / Piles
3	BH-01, BH-12, BH-15 & BH-22	Pad foundation / Piles

The allowable pile capacities calculated for 0.20m, 0.30m & 0.40m diameter bored cast in-situ concrete piles to the maximum depth of 3.0 to 5.0 meters below existing ground level are presented in the Geotechnical investigation report along with loading. Geotechnical Investigation and Earth Resistivity Study report of the project site can be found in the report as Annex IV.

The exposure of underground concrete to aggressive chemicals is found to be 'negligible' for sulphates and chlorides which have influenced the selection of cement for underground concreting and it is recommended to use Ordinary Portland Cement for all underground concrete works.

1.9 GENERAL PLANT CONCEPT AND EQUIPMENT

1.9.1 Initial Plant Assessment with Different Solar Technologies

An initial assessment of applicable technologies has been conducted. Four solar PV module technologies were analysed, including Trina solar (Si-Mono), Trina Solar (Si-Mono Bifacial), Trina Solar (Si-poly), and First solar (Thin-film/Cdte).

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Two types of PV mounting structure design were considered as follows:

1. Fixed tilt structure with 2 modules in Y-axis in portrait orientation and 50 modules along X-axis, module spacing of 2 cm at each side. The orientation of the modules is due south.
2. Single Axis tracking system with sheds having 2 modules in X-axis in landscape orientation and 50 modules along Y-axis, module spacing of 2 cm at each side. The axis of rotation is horizontal orientated North-South with the modules facing toward the East in the morning and the West in the afternoon.

The Consultant explored the possible options and performed PVsyst simulation on each of those options. The case selected for the Project in consultation with the Client was specified in the RFP for tariff auction for this Project. The PVsyst assessment results of different technologies are shown in Table 1-4.

Table 1-4: Different PV Technology Yield Assessment and Performance Ratio Comparison

Technology Used	Shed Design	Tilt	Pitch (m)	Performance Ratio PR	Produced Energy MWh/year	Specific prod. kWh/kWp /year	Near Shadings %	Capacity Factor %
		Angle						
Trina (mono)	S/A	+/-90	7.5	77.01	221438	1845	5.68	21.06
Trina (bifacial)	F/T *	22	7.5	80.14	339997	1700	2.52	19.41
	S/A *	+/-90	7.5	80.65	231905	1932	5.68	22.10
Trina (Poly)	F/T	22	7.5	77.18	327440	1637	2.55	18.68
First Solar (Thin film)	F/T	22	7.5	79.20	336000	1667	2.55	19.17
	S/A	+/-90	7.5	78.89	226829	1890	5.68	21.57

***: Selected Case**

F/T: Fixed tilt

S/A: Single axis tracking

1.9.2 Plant Layout and Configuration

A preliminary general layout for 200 MWp Fixed tilt PV system installation is shown in Figure 1-4.

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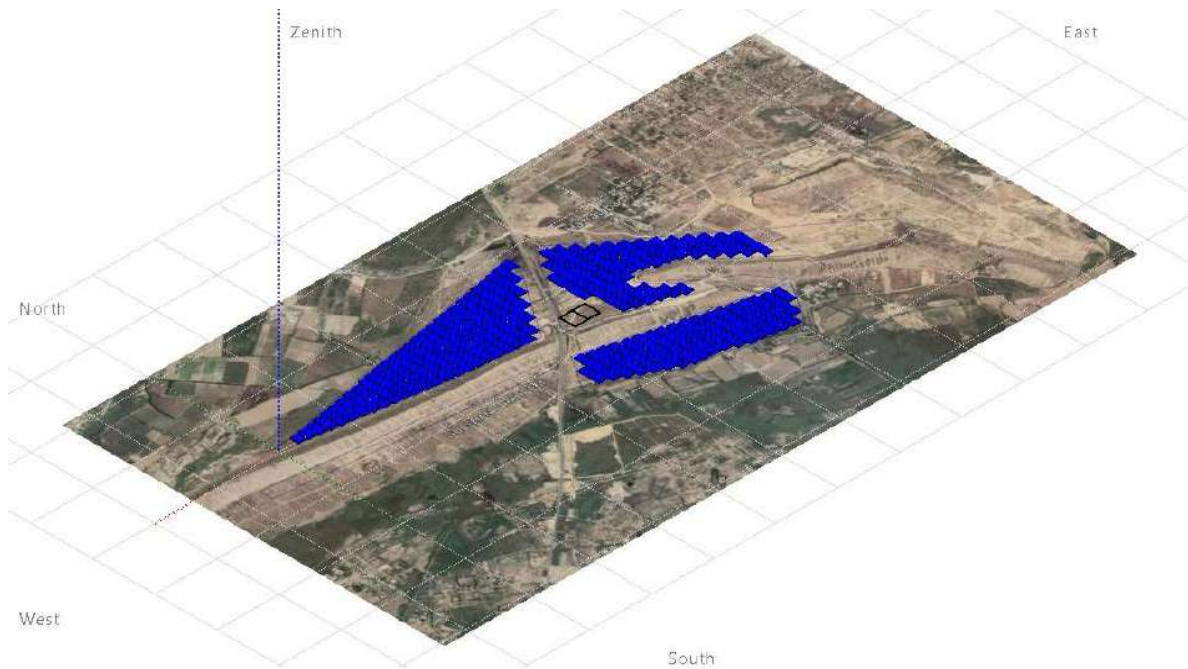


Figure 1-4: Preliminary Plant Layout (Fixed Tilt System)

A preliminary general layout for 120 MWp Single Axis tracking PV system installation is shown in Figure 1-5.

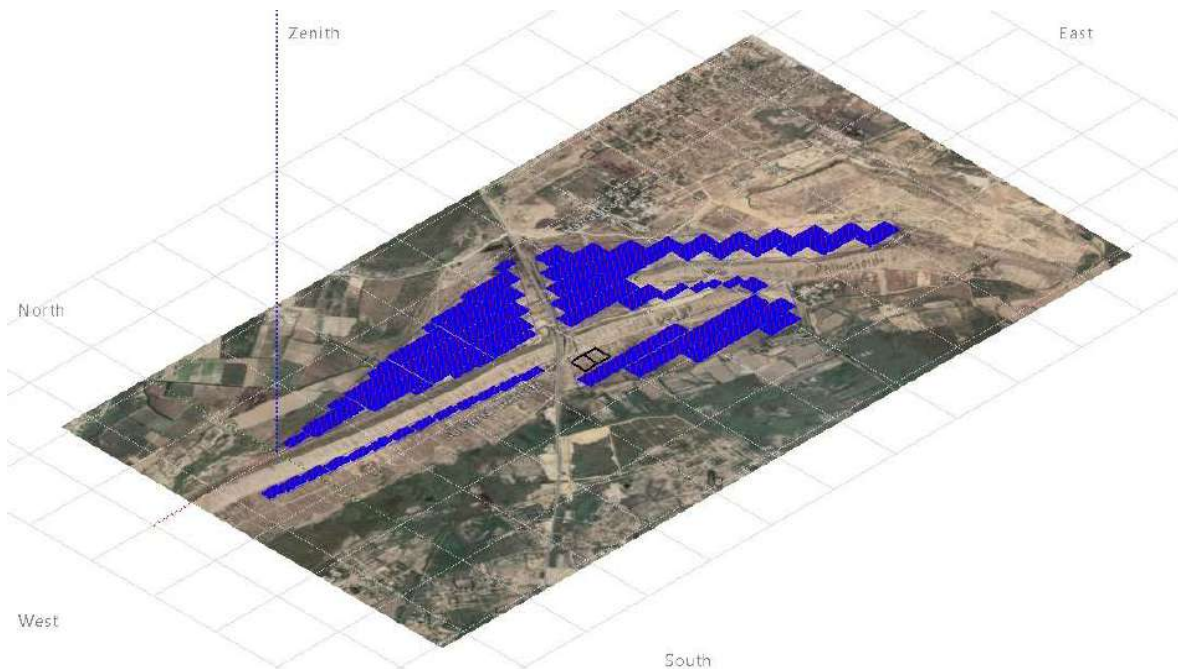


Figure 1-5: Preliminary Plant Layout (Single Axis Tracking System)

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The major technical configuration, technical specification of PV modules and inverter considered in general layout concept and energy yield estimation in this report, are shown in Table 1-5 and Table 1-6. The PV module and inverter type considered in this report were selected by the Consultant as no preference was provided by the Client. Criterion for selection of PV panels and Inverters are based on the various simulations performed by the Consultant which can be seen in Table 1-4. On the basis of better energy yield and performance ratio, Bifacial PV modules from Trina Solar and Sungrow inverter was selected for preliminary design of the Plant. Central inverters are preferred on String inverters based on below mentioned advantages;

High efficiency: Central inverters are very efficient, with conversion efficiency ranging from 95% to 98%. This means they can convert much of the direct current produced by the solar panels into alternating current electricity fed into the grid.

Cost-effective: Central inverters are cost-effective, especially in large solar power plants. Their cost per watt is lower than micro-inverters or string inverters.

Easy maintenance: Central inverters are easy to maintain and have fewer parts to replace. They also have a longer lifespan, so they must be replaced less often.

The final selection of components including PV modules and Inverters will be made by the Successful Bidder at later stage of the Project during optimisation of plant design within the guidelines specified in the RfP.

The technical datasheets of PV module and inverter selected for preliminary design are provided in equipment datasheets as Annex VIII of this report.

Table 1-5: Major Technical Characteristics of PV Module

Parameters	Description
Module Model	TSM-650DE21
Manufacturer	Trina Solar
Nominal Power [W]	650
Efficiency [%]	20.96
Power Tolerance [%]	± 1.5
Cell Type	Si-mono Bifacial
Open Circuit Voltage [V]	45.5
Short Circuit Current [A]	18.35
MPP Voltage [V]	37.5
MPP Current [A]	17.36
Power Coefficient of Temperature [-%/C]	-0.34
Nominal Operating Cell Temperature (NOCT)	25
Height X Width X Thickness [mm]	2384 X 1303 X 35

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Table 1-6: Major Technical Characteristics of Inverter

Parameters	Description
Inverter Model	SG2500HV
Manufacturer	Sungrow
Nominal AC Capacity	2500 kW
Maximum DC Input Power	3500 kWp
MPP voltage Range	800 V – 1300 V
Maximum DC Current	3508 A
Nominal AC Current	2624 A
Maximum Efficiency	0.990
European Efficiency	0.987
Operating Temperature Range	-30°C to +50°C

The Consultant assumed the configuration between PV modules and inverters described in Table 1-7.

Table 1-7: Plant Configuration – PV Module and Inverter

Parameter	Value	
System Type	Fixed Tilt	Single Axis tracking (N-S)
Module Type	Si-Mono (Bifacial) 650Wp	
Inverter Type	SG2500HV - 2500 kW @ 25°C	
Pitch	7.5m	7.5m
Tilt	22 degree*	Variable
Installed Capacity (DC)	200MWp	120MWp
Total Number of Modules	307,692	184,643
Modules per inverter	4,274	4196
Number of Modules in series	28	29
DC/AC Ratio	1.11	1.09
Number of inverters	72	44
Nominal AC Power of One Inverter [kW]	2500	
Total AC Power [kW]	180,000	110,000

Note:

*The Consultant highlights that 25-degree tilt will be the optimum with regards to amount of irradiation incident on the plane of array. However, considering general layout presented in this report with pitch of 7.5m, it is found that energy yield will be slightly higher (0.1% more) if the panels are tilted 22° instead of 25° to the perfect south. This is because of lower row-row shading. Due to this reason, 22° tilt has been considered for the energy yield estimation in SRA report.

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1.10 ELECTRICAL GRID INTERCONNECTION

The key components of the solar plant will be PV panels, mounting structure, cabling, inverters, step up transformers and switchgear. PV panels convert the solar radiation into DC electrical energy which then will be converted into AC energy by inverters. The Project connection point is looping IN-OUT of 220 kV Single Circuit between 220 kV Baldia Substation and 220 kV Surjani Substation of KE network.

The electrical network within the vicinity of the site of the plant will comprises of LV (22/33 kV) and HV (220 kV) lines. A separate electrical and grid interconnection study was conducted by a third party i.e. Power Planners International (Pvt) Ltd, for the project including Power Quality, Load Flow, Short Circuit and Power Evacuation. The electricity generated by the Project will be directly fed to 220 kV Baldia Grid and 220 kV Surjani Grid station via loop in – out arrangement as pointed out in Grid Interconnection study or as advised by the KE (Power Purchaser).

More details related to Grid Interconnection and load flow studies can be seen in Grid Interconnection Study (GIS) attached with this report as Annex VII.

1.11 DESIGN OF MECHANICAL WORKS

For the mechanical works, the project should use the most advanced technological approach available for optimized design. The mechanical design shall consider site specific conditions and information including but not limited to corrosion, wind loads and gusts. The sub-structures will be procured through suppliers with prequalified technology and design.

All the mechanical works and structures should be as per international standards and recommended prudent practices applicable. This will be carried out by the successful Bidder after the auction process through its EPC contractor.

1.12 DESIGN OF CIVIL WORKS

The civil works will include but not be limited to:

- ❖ Cleaning and preparations of the site including cutting of trees.
- ❖ Erecting and installing the laydown area according to requirements in the Design Basis. The area must be cleared, levelled, compacted and fenced.
- ❖ Installation of water supply line to the control building using the borehole as the preferred source. Provision should also be made for storage of drinking water.
- ❖ Construction / pre-fabrication of the control building including foundations, electricity supply, air-conditioning, water and sewage tank.
- ❖ Make provision for water supply during construction as well as operations.
- ❖ Excavating and backfilling of trenches as per specification, relevant drawings, norms and regulations.

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- ❖ PV Array foundations and Substation & Control Building foundations according to the requirements of the Project.
- ❖ Foundations of the containerized inverter/transformer solution.
- ❖ Internal roads according to the preliminary design drawings and specifications.
- ❖ Access road according to preliminary design drawings.
- ❖ Preparing the ground for works.
- ❖ Surveying of the area including: fencing, significant points of the substructure, internal roads, and trenches.
- ❖ Installing drainage and storm water management systems as per design.

The design of civil works shall be according to the soil and seismic conditions; and to bear high winds / gusts. This will be carried out by the successful Bidder after the auction process through its EPC contractor.

1.13 CONSTRUCTION MANAGEMENT

Like many power projects in Pakistan, the structure of EPC contract will be on a “turnkey” basis. Everything will be managed from one platform (one window) of the EPC contractor. The partners of EPC contractor shall be underneath that platform such that the guarantees and warranties mechanism does not deviate from the basic concept and international practices. In this way, the role of Client will become to supervise and monitor everything and there could be a construction supervision engineer hired for this purpose.

The arrangement of EPC contract shall be back-to-back with the requirements of Energy Purchase Agreement (EPA).

However, this remains in the domain of the party who will put up the project after being successful in auction process.

1.14 ENVIRONMENTAL MANAGEMENT

Information related to the environmental management works will be provided as Annex VI of this feasibility report.

A separate environment analysis is in process by environmental consultant. After completion of all the relevant studies, Initial Environmental Examination (IEE) report will be submitted to Sindh Environmental Protection Agency (SEPA) for NOC issuance. The same report will be shared as an Annex VI to this report.

1.15 PARIS AGREEMENT ROLE IN PROJECT

The Project is a power generation project with renewable resource and zero emissions. When put into operation, the project will provide power to the southern Pakistan power grid, which currently is mainly relying on fossil fuel. Therefore, it can help to reduce GHG emissions from coal

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or oil-fired power generation. It can deliver significant environmental and social benefits. The project also aligns with the Paris Agreement's goal of promoting sustainable development, as it will provide clean energy to the region and contribute to economic growth. The Paris Agreement encourages the development and deployment of renewable energy technologies, such as solar power, as a means of reducing GHG emissions while promoting sustainable development. CERs can provide an extra financial resource for the project, that can enable the project to mitigate foreseeable techno-commercial risks, improve its bankability, and ensure additionality. It will provide favourable conditions for project financing, improve the competitiveness of the project, and reduce investment risk during the project implementation process.

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2 COUNTRY PROFILE

Area	:	796,096 sq. km ²
Population ¹	:	207,770,000 (Approx)

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

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

The country has a total area of 796,940 km² and is nearly four times the size of the United Kingdom. From Gwadar Bay in south-eastern corner, the country extends more than 1,800 km to the Khunjerab Pass on China's border.

2.1 COUNTRY AND INDUSTRY OVERVIEW

Electricity in Pakistan is generated, transmitted, distributed, and retail supplied by two vertically integrated public sector companies, Water and Power Development Authority (WAPDA) responsible for the production of hydroelectricity and supplied to the consumers by the power distribution companies (DISCOS) under the Pakistan Electric Power Company (PEPCO). Currently, there are 11 distribution companies and one National Transmission and Dispatch Company (NTDC) all in the public sector (except Karachi), and the Karachi Electric (K-Electric) for the city of Karachi and its surrounding areas.

According to State of Industry Report 2022, Pakistan's total installed power generation capacity is 43,775 MW, of which 60% of energy comes from thermal (fossil fuels), 25% from hydro, and 6.48% from renewable (wind, solar and biomass) and 8.27% from nuclear. In the current scenario, renewable energy (RE) resources can play an important role in closing the deficit. With current government's tilt towards renewable energy, Ministry of Energy revised the current Renewable Energy (RE) Policy 2019 recently. According to the revised RE policy, Government of Pakistan aims to derive 60 percent of energy from renewable sources including hydro by 2030 that would wean Pakistan's dependence on imported fuel products.

¹ Source: Pakistan Bureau of Statistics latest census in 2017

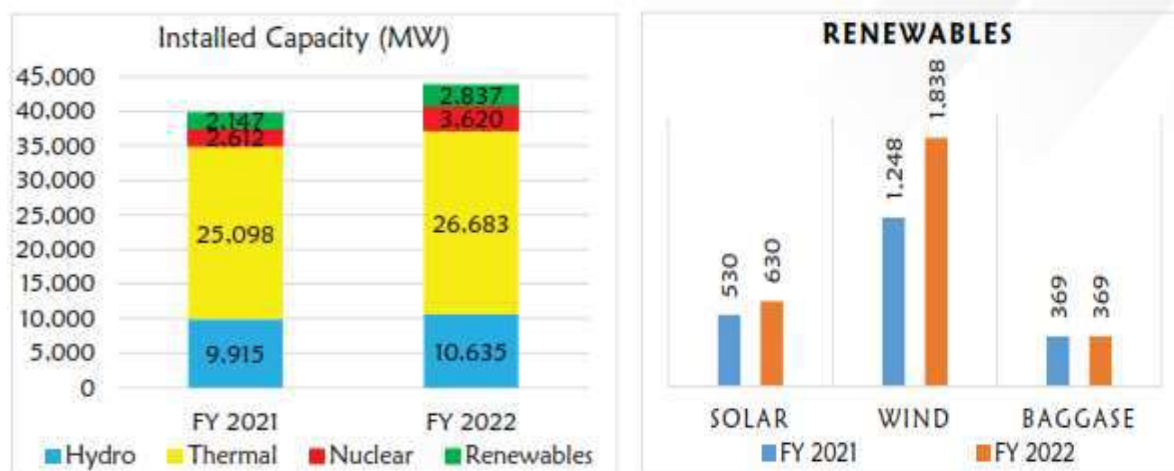
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	As on 30-06-2021	As on 30-06-2022	Variation		Comments
			Capacity (MW)	(%)	
A. CPPA-G SYSTEM					
WAPDA Hydel	9,443	9,443	0	0	Additions (a) Karot HPP (b) Lucky Electric (c) KANUPP-III (d) 12 Wind IPPs (e) Zhenfa Energy (f) Punjab Thermal (under testing) (g) BQPS-III Unit I (h) (under testing)
IPPs Hydel	472	1,192	720	152.54	
Total: Hydel	9,915	10,635	720	7.26	
GENCOs	4,881	4,731	-150	-3.07	
IPPs	17,276	18,750	1,474	8.53	
SPPs/CPPs	340	340	0	0.00	
Nuclear	2,475	3,620	1,145	46.26	
Total: Thermal including Nuclear	24,972	27,441	2,469	52.47	
Wind	1,248	1,838	590	47.28	
Solar	430	530	100	23.26	
Bagasse/Biomass	369	369	0	0.00	License Expired (a) GENCO-IV (b) Reshma Power (c) Gulf Power (d) Southern Electric (e) Japan Power (f) Altern Energy
Total: CPPA-G System	36,934	40,813	3,879	10.50	
B. KE SYSTEM					
KE Own	2,084	2,345	261	12.52	
IPPs	366	366	0	0.00	
SPPs/CPPs	151	151	0	0.00	
KANUPP	137	0	-137	-100.00	
Solar	100	100	0	0.00	
Total: KE System	2,838	2,962	124	4.37	
Grand Total:	39,772	43,775	4,003	10.06	

Source: GENCOs/WAPDA/IPPs/DISCOs/KE

Figure 2-1: Pakistan Installed Power Capacity (As per State of Industry Report 2022)

The graphical representation of installed capacity and bifurcation of Renewables for FY 2020-21 and FY 2021-22 is given below:



Pakistan's electricity sector is a developing market. For years, the matter of balancing the country's supply against the demand for electricity had remained a largely unresolved matter. The country faced significant challenges in revamping its network responsible for the supply of electricity. Electricity generators were seeking a parity in returns for both domestic and foreign investors indicating it to be one of the key issues in overseeing a surge in electricity generation when the country was facing growing shortages. Other problems included lack of efficiency, rising demands for energy, and political instability.

The maximum total demand coming from residential and industrial estates stands at nearly 31,000 MW, whereas the transmission and distribution capacity is stalled at approximately 22,000 MW. This leads to a deficit of about 9,000 MW when the demand peaks. This additional 9,000 MW required cannot be transmitted even though the peak demand of the country is well below its installed capacity of 43,775 MW.

Power outages are common in all cities and villages of Pakistan. Situation is worse in rural and remote areas. At some places there is no electricity for up to 18 hours a day. Many rural or remote areas are still not electrified due to lack of transmission lines. Electricity demand in Pakistan has reached all time high due to the ever-increasing population. Major blackouts also regularly happen in Pakistan due to engineering faults or blasts in transformers. These blackouts can affect huge areas and remain for many days till the issue is resolved. Electricity distribution infrastructure is also outdated and of substandard quality throughout the country. Hence, Pakistan is still facing electricity concerns, power outages and load shedding. Government is trying to increase the electricity generation, upgrade the electricity distribution infrastructure, reduce transmission losses, eradicate power outages and make electricity cheaper in the future.

Pakistan's energy sector remains one of the main obstacles to economic growth. Although Pakistan has managed to increase power generation since 2013 and mitigate power blackouts that plagued the country over the past decade, expensive fuel sources, a reliance on imported energy products, chronic natural gas shortages, major debt in the power sector, and aging and insufficient transmission and distribution systems have prevented the sector from growing and modernizing. Weak governance, uncoordinated energy policymaking and a lack of long-term energy planning only add to Pakistan's current energy woes. U.S. and international assistance have helped Pakistan make some major strides in addressing these problems but without major reforms, Pakistan's energy future remains challenging.

The detailed stats and situation of energy in Pakistan, specific information and prospects of coal and international trends in coal-based power sector is explained in next section.

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3 PAKISTAN ENERGY AND ELECTRICITY MARKET

The contents of this part have been derived from in-house research and knowledge of the Consultant together with authentic and official documents such as NEPRA's State of Industry Report 2022 and HDIP's Pakistan Energy Yearbook 2021.

3.1 ENERGY OUTLOOK

Pakistan's energy requirements are met through Oil, Gas, Hydro, Nuclear, Coal, Wind and Solar. While others are used only for electricity generation with reference to energy, Oil and Gas are used to supply other applications as well.

The data presented here is from latest available energy yearbook for the year 2021. The share of each source in primary energy supplies for 2020-21 was: oil: 24.13%, gas: 4.3%, LNG import: 19.24%, LPG: 8.83%, coal: 12.36%, nuclear electricity: 13.58%, renewable electricity: 4.12% and imported electricity: 2.99%. However, the overall primary commercial energy supply mix during 2020-21 has increased by 3.3% as compared to the previous year.

Oil production slightly decreased by 1.58% from 76,739 barrels per day in 2019-20 to 75,530 barrels per day in 2020-21. Natural gas production moved down slightly by 2.57% from 3,597 MMCFD in 2019-2020 to 3,505 MMCFD in 2020-21.

Import of petroleum products was increased in 2020-2021 by 34.19% as compared to the last year. Import of crude oil by refineries also increased by 30.93%. The oil import bill increased from US\$ 6.7 billion in 2019-20 to US\$ 8.2 billion in 2020-21. The overall oil consumption during 2020-21 increased significantly by 17.18% from 17.03 million tonnes to 19.96 million tonnes.

During 2020-21, coal production stood at 9.23 million tonnes showing growth of 5.66% as compared to previous year. The import of coal was also increased by 14.78% during 2020-21 over the previous year.

As per NEPRA State of industry report, the total installed generation capacity of public sector power plants in the country as on 30-06-2022 was 23,045 MW while the installed generation capacity of private sector power plants, including KE, was 20,730 MW. The installed capacity of CPPA-G system is 40,813 MW out of which 23,821 MW is thermal (GENCOs, IPPs, SPPs), 10,635 MW hydroelectric, 1,838 MW wind, 530 MW solar, 369 MW bagasse and 3,620 MW nuclear. The addition of 1,145 MW K-3 Nuclear Power Plant has significantly increased the nuclear power generation capacity in the country. Whereas, the installed capacity of KE's own generation is 2,345 MW. It is noted that KE's own generation capacity is not sufficient to meet the demand. Therefore, KE also purchased electric power from external sources including 366 MW Thermal (including 262 MW from Retired IPPs, Tapal Energy and Gul Ahmad), 100 MW Solar, 151 MW SPPs/CPPs and around 1,100 MW from CPPA-G system.

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3.2 ELECTRICITY GENERATION

The representations over here are providing glimpse of contribution of various sources that supply electricity in Pakistan. The thermal sources collectively include Oil, Gas, RLNG and Coal.

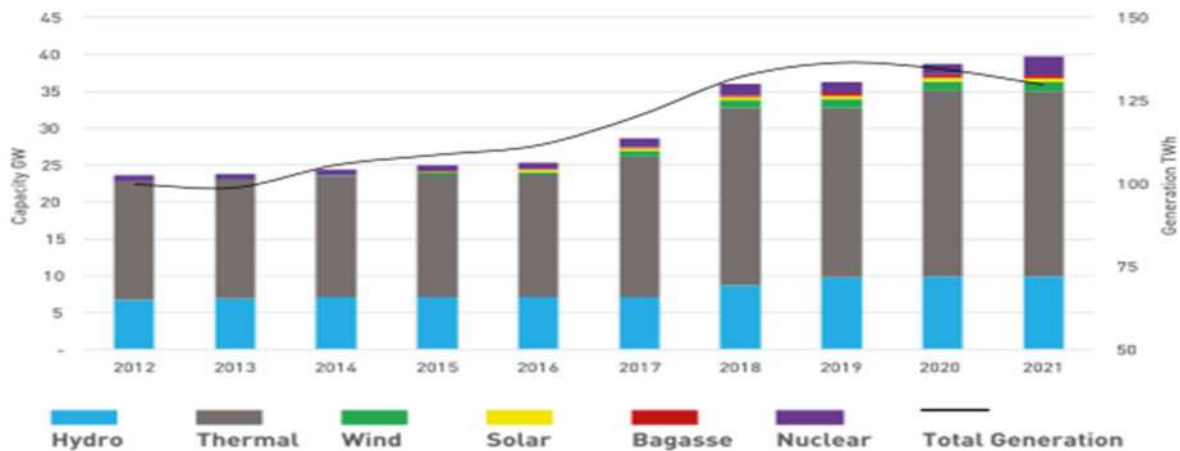


Figure 3-1: Electricity Installed Capacity (GW) and Generation (TWh) by Source

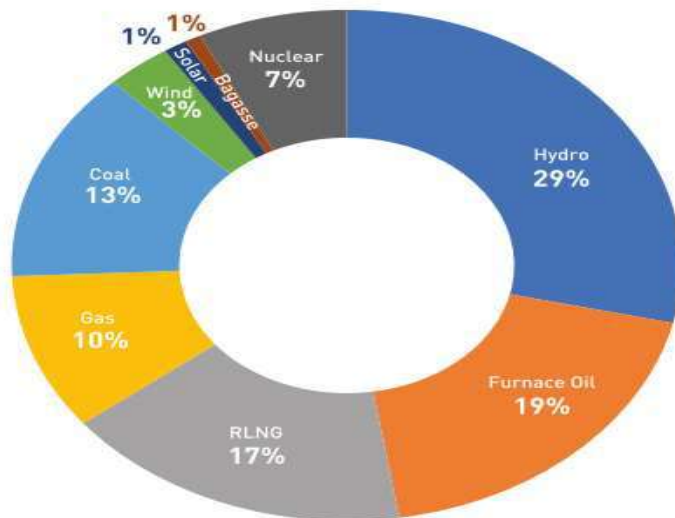


Figure 3-2: Electricity Installed Capacity (%) by Source

3.3 ELECTRICITY CONSUMPTION

By the year 2021-22, total number of electricity consumers in the country have reached to 36,595,128 out of which 31,594,985 belong to domestic category, 3,984,802 belong to commercial category, 391,442 consumers fall under industries, 371,449 are agriculture consumers and other consumers are 252,450 as shown in Figure 3-3.

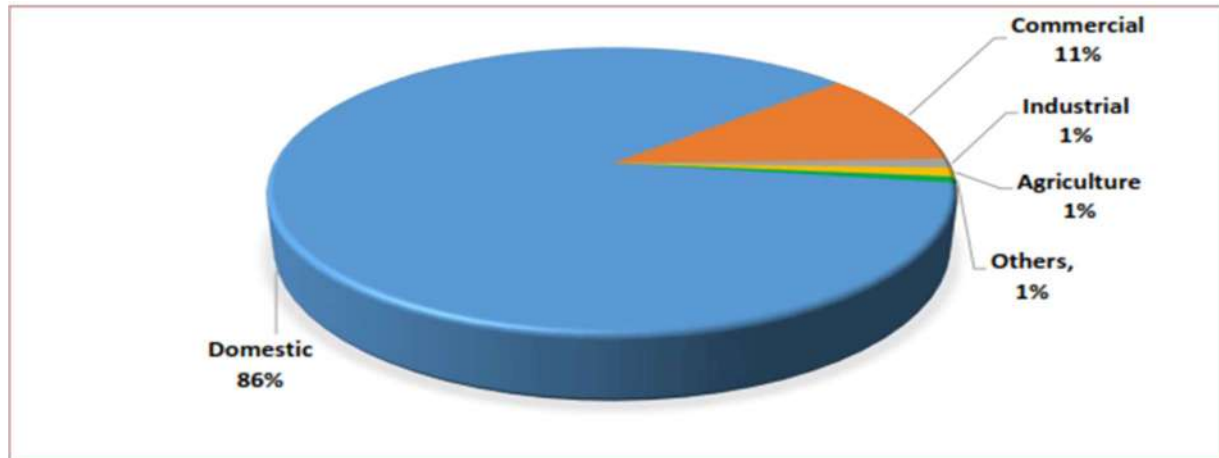


Figure 3-3: Percentage Mix of Electricity Consumer's by number

During the year 2021-22, total electricity consumption in country reached to 124,630 GWh, out of which domestic consumption had a share of 60,410 GWh, commercial consumption was 9,233 GWh, industrial consumption was 33,958 GWh, agriculture consumption was 11,033 GWh and 9,996 GWh had been consumed by other categories as shown in Figure 3-4.

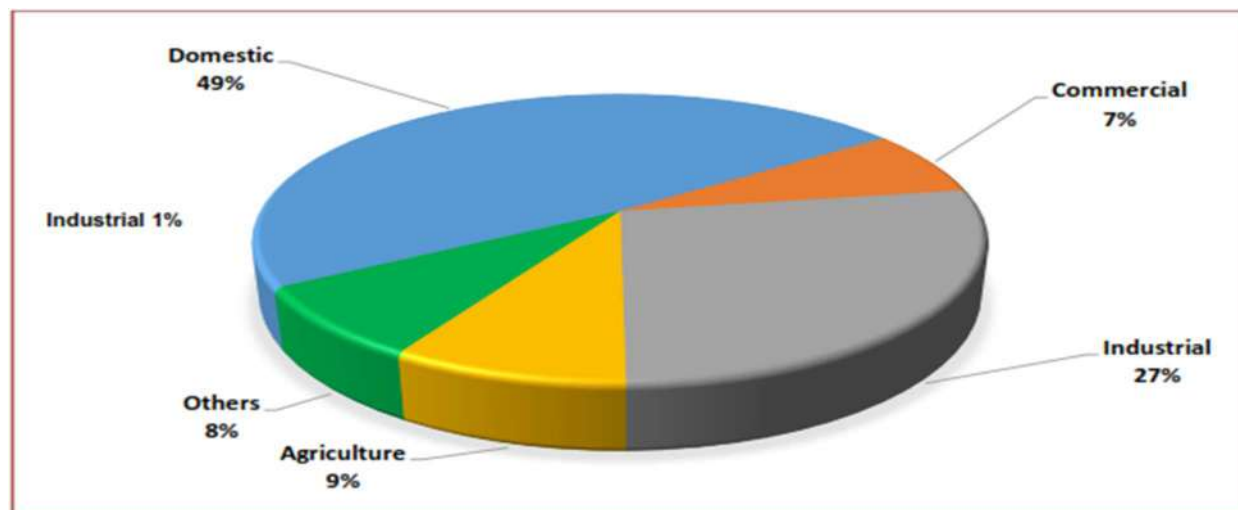


Figure 3-4: Percentage Mix of Electricity Consumers by Consumption

Usually, increase in electricity demand is directly linked to the growth of the country's economy. Therefore, Pakistan's demand for electricity can be expected to increase in future given that a

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growing trend is observed. In other words, for the country to maintain its growth, the expansion in electricity generation is expected to continue.

It is equally important that the generation of electricity takes place through cheaper and economical sources according to the situation of the country. For example, Pakistan needs hydro and renewable sources to dominate its electricity mix, both being rich and cheap.

In this regard, NTDC has carried out extensive demand – supply assessment of future and prepared IGCEP, which has been approved by NEPRA. It is an ongoing plan and is updated every year.

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4 SOLAR INDUSTRY IN PAKISTAN

4.1 PAKISTAN'S ELECTRICITY ISSUES

With a relatively slow expansion in Pakistan in the power generation sector seen over the years, the country keeps facing shortfall for quite a few decades. Sometimes due to lack of generation and sometimes due to inability to operate expensive power plants. While the current applications and usages remain interrupted or disturbed, this also disables from implementing the modern-day technology applications that run on electricity.

The problem here is two folded. One that the expansion in generation capacity has never reached the same pace as increase in demand. The planning exercises have always setup future requirements and targets. Contrary to those plans and targets, the actual implementation has always remained slow. This has repeatedly resulted in revision of those targets into more aggressive ones. This can be seen if the trends are computed in planning targets set at different times together with year-wise actual implementation.

The second is the cost of generation of electricity. The mix has always remained heavily dependent on imported fuels. The cost of those fuels cannot be controlled through internal factors and the impact of currency exchange also plays a role. This causes a heavy burden on the import bills. It couples with technical losses and lack of recovery of electricity bills, which have always remained a priority of every Government, yet there is lesser success. Ultimately, the Government has to fund the gaps and the power sector remains the biggest and a very massive contributor of circular debt.

It is imperative for Pakistan to look for indigenous/cheap energy resources for sustainable growth through self-reliance. Solar PV is the key and is placed with aggressive targets in the current Alternate and Renewable Energy Policy and in Integrated Generation and Capacity Expansion Plan.

4.2 SOLAR POWER PROJECTS – A NATURAL CHOICE

To ensure a sustainable energy future for Pakistan, it is necessary that the energy sector be accorded a high priority. Moreover, it is considered that solar power generation could become a significant contributor to Pakistan's electricity supply in future. The development of solar generation projects also supports the environmental objectives of the Government of Pakistan. The contributions are:

- ❖ Reducing dependence on fossil fuels for thermal power generation.
- ❖ Increasing diversity in Pakistan's electricity generation mix.
- ❖ Meeting the targets of ARE policy of 30% renewables by 2030.
- ❖ Reducing greenhouse gas emissions through avoidance of thermal power generation; and
- ❖ Helping in reduction of the exorbitant trade deficit.

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Pakistan has a huge Solar potential which can be effectively and efficiently utilized for the economical generation of Power. Pakistan is estimated to possess a 2.9 TW solar energy potential. Country has a large number of remote villages that do not have electricity supplies.

For 10 h a day, average solar radiation intensity ranges from 1500 W/m²/day to 2750 W/m²/day in Pakistan especially in Southern Punjab, Sindh and Balochistan regions throughout the year. In an area of 100m², 45 MW to 83 MW power per month may be generated in the above-mentioned regions.

The generation cost from solar is far cheaper than the thermal sources as of today. It further balances out the reliance in dollar-based imports during its operations. Therefore, it can play a role in solving all the more problems being faced by the power sector.

4.3 CURRENT STATUS OF SOLAR IPPs IN PAKISTAN

The solar energy sector of Pakistan has evolved and matured now. Ground solar data of almost 7 years is available for multiple locations of Sindh and Punjab i.e. Sukkur, Layyah, Bahawalpur, Sahiwal and Khushab. All the stakeholders are now at the same frequency and are fully motivated to facilitate the development of Solar power in the Country.

A total of 630 MW (9 PV projects) are in operation and 150 MW (3 PV projects) are under construction. PV Panels from all the renowned manufacturers (Xinjiang Sun Oasis, LONGI, Canadian Solar, Trina) are installed in Pakistan. All the projects of solar power until now have been either on the basis of cost plus (negotiated) or an upfront (feed-in) tariff.

4.3.1 Projects in Operations Phase

Following projects with aggregated capacity of 630 MW have achieved their CODs and are in operations:

Table 4-1: Solar PV Power Projects in Operation

Sr.No	Project Name	Capacity (MW)	COD
1	Quaid-e-Azam Solar Power (Private) Limited	100	15-July-15
2	Appolo Solar Development Pakistan Limited	100	31-May-16
3	Best Green Energy Pakistan Limited	100	31-July-16
4	Crest Energy Pakistan Limited	100	31-July-16
5	Harappa Solar (Private) Limited	18	14-Oct-17
6	AJ Power (Private) Limited	12	13-Dec-17
7	Oursun Pakistan Limited	50	30-Nov-18
8	Gharo Solar Limited	50	23-Dec-19
9	Zhenfa Pakistan New Energy Company (Pvt.) Limited	100	08-Dec-22

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4.3.2 Projects in Construction Phase

Following projects with aggregated capacity of 150 MW are in Construction Phase.

Table 4-2: Solar Power Projects in Construction Phase

Sr. No	Project Name	Capacity (MW)	Expected Schedule of Commissioning
1	Meridian Energy (Pvt.) Ltd	50	Apr-23
2	HND Energy (Pvt.) Limited	50	Apr-23
3	Helios Power (Pvt.) Limited	50	Apr-23

4.3.3 Projects at Development Stages

There are several LOIs issued by federal and provincial governments for various projects till date. Many of those have lands obtained from the provincial governments and feasibility studies have been completed. These projects started their development in the era of Renewable Energy Policy of 2006. While the ARE Policy 2019 leaves auctions being the only mode of procurement from renewables including solar, the ARE Policy 2019 also provides a mechanism to provide opportunity to all under development projects. The projects that fulfill certain criteria will be entitled to participate in an auction process where they will have round of competition amongst each other. This list amounts to 3369.5 MW and 57 projects.

Above being said, the future deployment of solar projects through auctions according to the mechanism stipulated in the ARE Policy 2019 is set to take place in parallel.

4.4 SOLAR TARIFF

The current tariff level of solar power is at an all-time low in Pakistan. The graph in Figure 4-1 shows the history of levelized solar power tariffs given by NEPRA over time.

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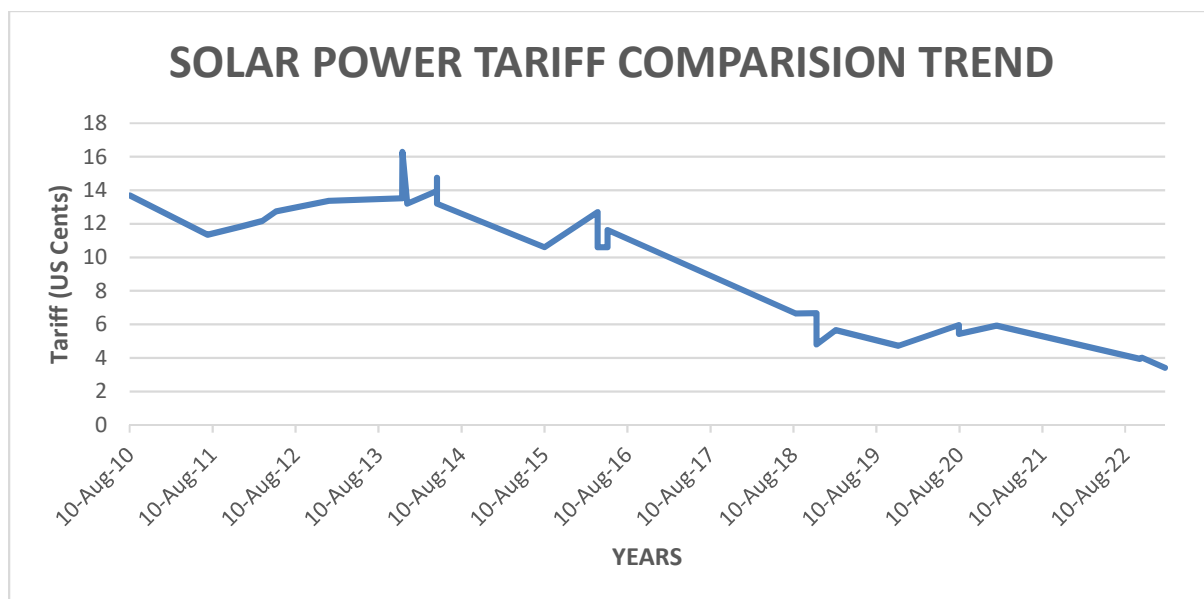


Figure 4-1: Levelized Tariff of Solar Power Projects

4.5 OTHER CONSIDERATIONS

4.5.1 Solar Tariff is Cheaper than other Technologies

The solar tariffs are even lower than each of the newly constructed / under construction / under pipeline projects of Hydro and Thermal. Moreover, the Thermal tariffs are not expected to come down in future due to imported fuel charge whereas the solar power tariff does not have a fuel charge at all.

The chart shown in Figure 4-2 is of the technology wise average tariffs lately determined by NEPRA:

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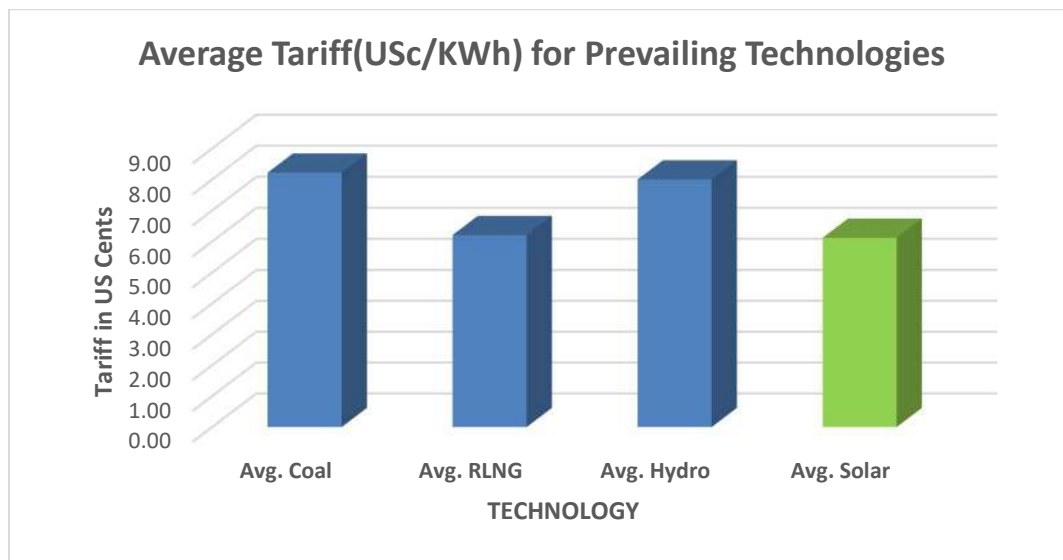


Figure 4-2: Average Tariff for Prevailing Technologies

It is very important to note that the above chart is based on the levelized tariffs determined by NEPRA from time to time. In reality, considering prevailing fuel prices and currency conversions, the cost of generation from thermals have gone massively higher and creates a serious dent on basket price of a heavily thermal dominated energy mix. This can be seen from the “Merit Order” containing O&M costs of power plants. The below graph is based on the Merit Order dated 16th February 2023 and provides energy payments (per kWh tariff when operating the plants). These are excluding the capacity payments, which are over and above.

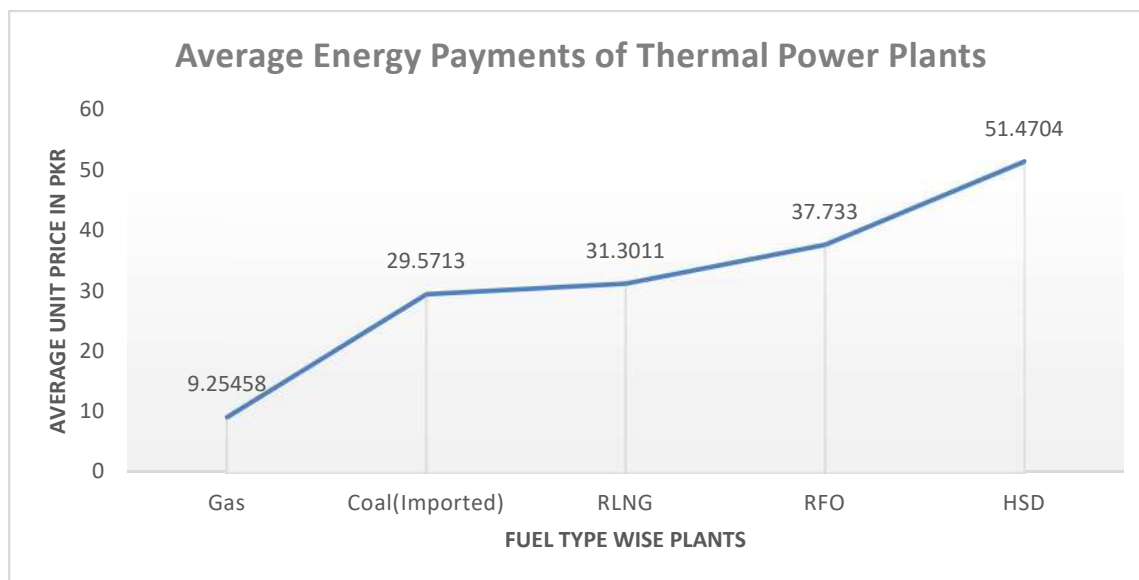


Figure 4-3: Average Energy Payments per kWh of Thermal Power Plants – Fuel Type Wise

It is pertinent to note that solar power generation becomes even more useful in cases where secure base load is available. The cheaper electricity offered by solar projects can be utilized as

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much as possible when available and demand in low solar irradiation period can be supplemented through base load plants.

It will be extremely detrimental for Pakistan as a whole to lose out on the benefits of solar power while debating issues such as the quota of solar power, commenting on further decrease in the solar tariff values (which are at an all-time low) etc. Every single unit of electricity generated by a solar power project will reduce the burden faced by the national exchequer from generation through other foreign fuel dependent sources.

4.5.2 Sustainability of Power Sector – Need to look back in history

The presumption that Pakistan will overcome its electricity shortfall due to current pipeline projects, therefore no further expansion in generation capacity is required, can prove to be fatal in the years to come. A similar situation existed after the Thermal IPPs were constructed in late 1990's and early 2000's. The country struggled big time and then some capacity was added. Then in mid 2010's, the same thought process emerged again and brought the same results.

As a result, Pakistan is one of the few developing countries during last two decades that experienced crippling electricity shortfalls of as much as 8-10 hours per day in urban areas and 15-18 hours per day in rural areas.

Hence there is a need to not only expand with renewable energy sources like solar but also displace expensive thermal power with such sources.

The dynamics of the power sector are such that new power projects cannot be planned and implemented over short period of time or on emergency basis. Typically, development of a batch of projects from the LOI stage till commencement of commercial operations, takes approximately five (05) years given the processes involved in Pakistan. For large hydro projects this period may stretch to up to ten (10) years. These timings are evident in each development era of the power sector in Pakistan.

Another factor that must be highlighted is that demand for electricity is constantly expected to increase. Current demand forecasts for Pakistan are based on the suppressed demand that exists during a power crisis. Future demand forecasting should not merely account for the increase in demand from existing consumers; rather, it should also account for consumption of electricity from other sources (like electric trains, electric buses, public infrastructure, rural electrification, electrical heating etc.), which have contributed to the accelerated development of western nations when they had more electricity than they required.

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5 REGULATORY REGIME IN PAKISTAN

The regulatory regime for the solar power sector in Pakistan is governed by several laws and policies, mainly the National Electricity Policy 2021, Alternate and Renewable Energy Policy 2019 and the National Electric Power Regulatory Authority (NEPRA) Act. There are a number of stakeholders involved in the cycle, as follows:

- ❖ Power Division, Ministry of Energy (MoE)
- ❖ National Electric Power Regulatory Authority (NEPRA)
- ❖ Alternative Energy Development Board (AEDB)
- ❖ National Transmission and Despatch Company (NTDC)
- ❖ Central Power Purchasing Agency Guarantee Ltd. (CPPA-GL)
- ❖ Provincial Energy Department

5.1 POWER DIVISION, MINISTRY OF ENERGY

The Ministry of Energy (Power Division) in Pakistan is responsible for overseeing the country's energy sector, including the generation, transmission, and distribution of electricity. Its main goal is to ensure the availability of energy services to consumers in an efficient, reliable, and sustainable manner, while promoting economic growth and development.

The responsibilities of the Ministry of Energy (Power Division) in Pakistan include the following:

- ❖ Formulating and implementing energy policies and strategies.
- ❖ Overseeing the generation, transmission, and distribution of electricity.
- ❖ Promoting energy efficiency and conservation.
- ❖ Encouraging the development of renewable energy sources.
- ❖ Facilitating the development of new energy projects.
- ❖ Regulating and supervising the energy sector to ensure compliance with laws and regulations.
- ❖ Encouraging private sector participation in the energy sector.
- ❖ Providing technical and financial assistance to energy sector organizations and projects.
- ❖ Collaborating with international organizations and other countries on energy-related issues.
- ❖ Monitoring and analyzing energy market trends and providing regular reports on the energy sector.

5.2 NATIONAL ELECTRIC POWER REGULATORY AUTHORITY (NEPRA)

The National Electric Power Regulatory Authority (NEPRA) is an independent regulatory body in Pakistan responsible for the regulation of the electricity sector in the country and issuing tariffs for power generation from renewable energy sources, including solar. It was established in 1997 under the National Electric Power Regulatory Authority Act.

NEPRA has been created to introduce transparent and judicious economic regulation, based on sound commercial principles, in the electric power sector of Pakistan. NEPRA regulates the

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

NEPRA's main responsibilities include the following:

- ❖ Regulating and supervising the generation, transmission, distribution, trading and supply of electric power in the country.
- ❖ Determining tariffs for power generation, transmission and distribution companies.
- ❖ Licensing of power generation and distribution companies.
- ❖ Monitoring the performance of power companies and acting in case of non-compliance.
- ❖ Approving projects for the expansion of the electricity transmission and distribution network.
- ❖ Ensuring the reliability and quality of power supply.
- ❖ Promoting investment in the power sector.
- ❖ Protecting the rights of consumers.
- ❖ Encourage the use of renewable energy resources.
- ❖ Coordinating with other government agencies and departments to ensure the efficient and effective use of energy resources.

NEPRA also works in collaboration with other Governmental organizations, Provincial Governments and Private Sector to make sure all the activities in power sector are working efficiently, economically and reliable manner.

5.3 NATIONAL TRANSMISSION AND DESPATCH COMPANY (NTDC)

National Transmission & Despatch Company (NTDC) Limited was incorporated on 3rd August 1998 and commenced commercial operation on 1st March 1999. It was organized to take over all the properties, rights and assets obligations and liabilities of 220kV and 500kV Grid Stations and Transmission Lines/Network owned by Pakistan Water and Power Development Authority (WAPDA). NTDC operates and maintains fourteen 500 KV and thirty-eight 220 KV Grid Stations, 5110.48 km of 500 KV transmission line and 9686.32 km of 220 KV transmission line in Pakistan.

NTDC's main responsibilities include:

- ❖ Operating and maintaining the transmission system, including high-voltage transmission lines and substations, to ensure a reliable and efficient power supply.
- ❖ Scheduling the supply of electricity to the distribution companies.
- ❖ Planning and implementing the expansion of the transmission network to accommodate the growth in electricity demand.
- ❖ Coordinating with other transmission companies, power generation companies, and distribution companies to ensure the reliable and efficient operation of the power system.
- ❖ Ensure that all the rules and regulations, tariff and codes are followed for transmission and despatch of electricity

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- ❖ Coordinating with other national and international organizations to facilitate power transmission and trade.
- ❖ Protecting the rights of consumers and ensuring the quality of service.
- ❖ Design and construct the interconnection facilities (Grid Station and Transmission Lines) on behalf of CPPA-GL according to the Grid Interconnection Studies and the EPA.
- ❖ Grant approval of various designs (mainly of the electrical balance of plant) of the Project during construction phase in accordance with the requirements of the EPA.

NTDC is governed by a Board of Directors appointed by the Federal Government and it has several departments such as Technical, finance and commercial to ensure smooth operations. It also closely works with organizations such as NEPRA, CPPA-G, GENCOs and DISCOs to make sure all the transmission activities are carried out in efficient, reliable and economically viable manner.

5.4 ALTERNATIVE ENERGY DEVELOPMENT BOARD (AEDB)

Alternative Energy Development Board (AEDB) is the sole representing agency of the Federal Government that was established in May 2003 with the main objective to facilitate, promote and encourage development of Renewable Energy in Pakistan and with a mission to introduce Alternative and Renewable Energies (AREs) at an accelerated rate as to achieve sustainable economic growth. The administrative control of AEDB was transferred to Ministry of Water and Power in 2006.

The Government of Pakistan has inter alia mandated AEDB to:

- ❖ Implement policies, programs and projects through private sector in the field of ARE.
- ❖ Assist and facilitate development and generation of ARE to achieve sustainable economic growth.
- ❖ Encourage transfer of technology and develop indigenous manufacturing base for ARE Technology.
- ❖ Promote provision of energy services that are based on ARE resources.
- ❖ Undertake ARE projects on commercial scale.

The Federal Government established AEDB as a statutory organization by announcing and promulgating the AEDB Act in May 2010. The Act bestowed upon AEDB the authorities and the responsibilities for the promotion and development of AREs. The first renewable energy policy came in 2006 and many projects were completed under it. Currently, the policy in effect is Alternate and Renewable Energy Policy 2019, which sets target of achieving share of renewable energies to be 20% of the total generation capacity by 2025 and 30% of the total generation capacity by 2030.

The functions of AEDB have been determined as given below:

- ❖ To develop national strategy, policies and plans for utilization of alternative and renewable energy resources to achieve the targets approved by the Federal Government in consultation with the Board.

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- ❖ To act as a forum for evaluating, monitoring and certification of alternative or renewable energy projects and products.
- ❖ To facilitate power generation through alternative or renewable energy resources by:
 - Acting as one window facility for establishing, promoting and facilitating alternative or renewable energy projects based on wind, solar, small-hydel, fuel cells, tidal, ocean, biogas, biomass etc.
 - Setting up alternative and renewable energy power pilot projects on its own or through joint venture or partnership with public or private entities in order to create awareness and motivation of the need to take such initiatives for the benefit of general public as well as by evaluation concepts and technologies from technical and financial perspective
 - Conducting feasibility studies and surveys to identify opportunities for power generation through alternative and renewable energy resources.
 - Undertaking technical, financial and economic evaluation of the alternative or renewable energy proposals as well as helping in filling of required licensing applications and tariff petitions to National Electric Power Regulatory Authority (NEPRA).
 - Interacting and coordinating with the National and International agencies for promotion and development of alternative energy.
 - Assisting the development and implementation of plans with concerned authorities and provincial Governments for off-grid electrification.

5.5 CENTRAL POWER PURCHASING AGENCY GUARANTEE LIMITED (CPPA-GL)

The Central Power Purchasing Agency Guarantee Limited (CPPA-GL) is a state-owned company in Pakistan responsible for the procurement of electricity from power generation companies on behalf of distribution companies and other bulk consumers. It was established in 2000 and it is a subsidiary of the Water and Power Development Authority (WAPDA). Since June 2015, CPPA-GL has assumed the business pertaining to the market operations and presently functioning as the Market Operator in accordance with Rule-5 of the NEPRA Market Operator (Registration, Standards and Procedure) Rules, 2015 (the “Market Rules”).

CPPA-GL's main responsibilities include:

- ❖ Procurement of electricity from power generation companies and independent power producers under contracts known as "Power Purchase Agreements" (PPAs) or “Energy Purchase Agreements” (EPAs).
- ❖ Dispatching and scheduling of electricity to distribution companies and other bulk consumers.
- ❖ Acting as an intermediary between power generation and distribution.
- ❖ Administering payments to power producers.
- ❖ Monitoring the performance of power producers to ensure compliance with contract terms and conditions.

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- ❖ Coordinating with other government agencies and departments to ensure the efficient and effective use of energy resources.

CPPA-GL plays a key role in the Power sector of Pakistan by ensuring the procurement of electricity from various sources and providing the same to distribution companies and bulk consumers as per their requirement. It also closely works with organizations such as NTDC, NEPRA, GENCOs and DISCOs to ensure the smooth operation of power sector.

5.6 PROVINCIAL ENERGY DEPARTMENTS

The provincial Governments have established their own departments of energy. These departments work in collaboration with the federal Ministry of Energy (Power Division) to ensure the availability of energy services to consumers in an efficient, reliable, and sustainable manner.

The provincial energy departments are responsible for:

- ❖ Implementing energy policies and programs at the provincial level.
- ❖ Overseeing the generation, transmission, and distribution of electricity within the province.
- ❖ Encouraging the development of renewable energy sources within the province.
- ❖ Regulating and supervising the energy sector within the province to ensure compliance with laws and regulations.
- ❖ Collaborating with local communities and stakeholders to address energy-related issues and opportunities.

The specific names and responsibilities of the provincial energy departments may vary, but they all play a crucial role in ensuring access to energy services and promoting energy sector development within their respective provinces.

5.7 K-ELECTRIC

K-Electric (formerly Karachi Electric Supply Company Limited) is a publicly listed company that is responsible for the generation, transmission, and distribution of electric power to the city of Karachi and parts of the surrounding Sindh province in Pakistan. The company was privatized in 2005 and is currently majority-owned by the Chinese state-owned enterprise, Shanghai Electric Power Company Limited.

K-Electric is responsible for the generation, transmission, and distribution of electricity to over 2.6 million customers in the region. It operates a diverse mix of power generation assets, including coal, gas, and renewable power plants including solar.

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5.8 SINDH TRANSMISSION DISPATCH COMPANY

The Sindh Transmission Dispatch Company (STDC) is a subsidiary of the provincial government of Sindh in Pakistan. It is responsible for the transmission and dispatch of electricity in the province of Sindh.

The main functions of STDC include:

- ❖ Operating and maintaining the high-voltage transmission network in the province of Sindh.
- ❖ Dispatching electricity from the generation companies to the distribution companies and other consumers.
- ❖ Ensuring the safe and reliable transmission of electricity in the province.
- ❖ Monitoring and controlling the power flow within the transmission network to ensure system stability and security.

STDC plays a critical role in ensuring the availability of electricity in Sindh by ensuring the safe and reliable transmission of electricity from the generation companies to the distribution companies and other consumers. This helps to promote economic growth and improve access to energy services in the province.

5.9 KHYBER PAKHTUNKHWA TRANSMISSION & GRID SYSTEM COMPANY (KPTGSC)

Khyber Pakhtunkhwa Transmission & Grid System Company (KPTGSC) is a public sector company in Pakistan that is responsible for the transmission and distribution of electricity in the Khyber Pakhtunkhwa province.

KPTGSC is responsible for the construction, operation, and maintenance of the transmission and grid system within its jurisdiction. The company's mission is to provide reliable and efficient transmission and distribution services to its customers while ensuring the safety and protection of its employees and the environment.

KPTGSC operates under the supervision of the National Transmission and Dispatch Company (NTDC), which is responsible for the management of the country's national grid. KPTGSC is also regulated by the National Electric Power Regulatory Authority (NEPRA), which sets tariffs and regulates the electricity industry in Pakistan.

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6 RELEVANT PROGRESS IN POLICY AND REGULATORY FRAMEWORK

The renewable energy power sector was governed under the ARE Policy 2006, which extended several times upon each expiry. The projects were developed and constructed based on either a negotiated (cost plus) tariff or a feed-in (upfront) tariff.

Looking at the maturity of the industry and needs for further advancement, various studies and works were conducted between 2016 and 2021 in order to evaluate many aspects such as; prospects of deploying more renewable energy projects, the ideal share of renewable energy in the overall mix, the realistic targets, the tariff mechanisms etc.

The ultimate outcomes have been captured in the ARE Policy 2019 and IGCEP 2022-31.

This entire scheme has stood on the following:

6.1 VARIABLE RENEWABLE ENERGY (VRE) INTERGATION – PLANNING STUDY

The VRE Study was funded by the World Bank and was performed by international consultants. The objective was to identify the best suited share of renewable energies in the overall energy mix of Pakistan at different times in future. The basis was both technical as well as financial.

The VRE Study proposes 22,600 MW of renewable energy in the overall mix by year 2025 and 32,500 MW of renewable energy by year 2030. Out of these targets, the share of wind in terms of MW is as follows:

- ❖ By 2025 = 4600 MW
- ❖ By 2030 = 6900 MW

6.2 VARIABLE RENEWABLE ENERGY (VRE) INTERGATION – LOCATIONAL STUDY

The Locational Study was funded by the World Bank and was performed by international consultants. It was an extension of the VRE Planning Study. The objective was to use the outcomes of VRE Planning Study and further assess how much quantum could be installed without major upgrades in the grid infrastructure and how much with reinforcement. The study recommended specific locations for renewable projects.

The VRE Locational Study has identified over 100 suitable potential project sites for new solar and wind power plants across Pakistan, mostly based on existing grid infrastructure, have been identified and evaluated; out of these, 19 potential project sites are located in Sindh Province, out of which Jhimpir region has been identified as a biggest region for hybrid (wind + solar) installation.

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6.3 ARE POLICY 2019

ARE Policy has completely withdrawn the cost plus and upfront tariff from future solar power projects, except G2G special cases. Accordingly, the tariff mechanism available to solar projects is through competitive bidding (auctions). However, the projects that were in process under ARE Policy 2006 at the time of ARE Policy 2019 were provided a way forward in ARE Policy 2019 by listing those in different categories in the light of a decision by the Federal Cabinet. The projects were placed into three categories according to their respective progress in development at that time. Category I and Category II were permitted to proceed with cost plus tariff. Category III was permitted to go through competitive bidding provided they fall within the zones identified by NTDC for interconnection.

The new policy focuses on proactive approach rather than inducting RE projects on a reactive basis and a new policy direction has been set whereby Pakistan intends to have 20% of its generation capacity from ARE technologies by 2025 and 30% by 2030. These targets are also aligned with recommendations of various World Bank supported technical studies and Government's Integrated Generation and Capacity Expansion Plan (IGCEP 2021-30). To achieve this target, government requires to setup up additional 17,536 MW capacity renewable projects by 2031. Various studies and data have evidenced the usefulness of this size of renewable energies in the overall mix and the Government is accordingly working towards it.

6.4 INTEGRATED GENERATION AND CAPACITY EXPANSION PLAN (IGCEP)

IGCEP is prepared by NTDC (in consultation with other stakeholders) and approved by NEPRA. IGCEP elaborates the capacity addition in power sector each year and aligns itself with the findings of VRE Study, the findings of Locational Study and the targets of ARE Policy 2019. In conclusion, a year wise list of projects is part of IGCEP.

A longer term IGCEP was prepared in 2020 and it covers from year 2020 to 2030. For recurring exercise, IGCEP 2021-30 was approved on 24th September 2021. The currently prevailing is IGCEP 2022-31, which was approved on 3rd February 2023.

For Renewable Energy, IGCEP considers following capacity addition in each year:

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Table 6-1: Yearly Renewable Energy Targets as per IGCEP 2022-31

Year	Renewable Energy Capacity (MW)
2022	2,802
2023	630
2024	2,830
2025	8,707
2026	1,039
2027	941
2028	1,270
2029	702
2030	680
2031	680
Total	20,281

6.5 SINDH SOLAR ENERGY PROGRAM (A WORLD BANK INITIATIVE)

The development objective of Sindh Solar Energy Project for Pakistan, aims to increase solar power generation and access to electricity in Sindh Province.

This project has four components.

- ❖ The first component, Utility-Scale Solar, aims for identification and development of a series of publicly owned solar parks, and support for the competitive selection of private sector developers through solar auction for the construction of solar power plants in the solar parks.
- ❖ The second component, Distributed Solar, aims for procurement and installation of solar PV systems and associated energy management systems on rooftops and other available space on and around public sector buildings.
- ❖ The third component, Solar Home Systems, aims for deployment of affordable SHSs in prioritized areas with low or no access to electricity, analysis and identification of priority areas, activities to enhance consumer awareness and financial literacy, product certification and quality control, and Monitoring and evaluation (M and E) activities.
- ❖ The fourth component, Capacity Building and Technical Assistance, aims to support the design and implementation of the project and compliance with fiduciary, gender, M and E, procurement, and safeguards requirements.

6.6 FRAMEWORK GUIDELINE – FAST TRACK SOLAR PV INITIATIVES 2022

In order to ensure the GOP policy objectives of energy security, affordability of electricity, environmental protection, and sustainable development, the GOP has envisioned to deploy solar power on a fast track basis to eventually complement and/or substitute the expensive fossil fuels

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currently being used for power generation. This not only will ensure savings of foreign reserves that are being incurred on import of expensive fossil fuels for power generation but will also help in provision of affordable electricity supply to consumers and pave the way for a sustainable power sector in long run. On this basis, GOP has passed Frame Work Guideline from the Federal Cabinet to implement a fast track program of Solar PV initiatives.

6.6.1 SUBSTITUTION OF EXPENSIVE IMPORTED FOSSIL FUELS WITH SOLAR PV ENERGY

6.6.1.1 Background

Under this initiative, Solar PV based power generation capacity shall be solicited for substitution of expensive imported fossil fuels used for power generation.

This will bring about lowering of the average basket cost of generation for the system by utilizing solar energy during the day time in substitution of the imported fossil fuels based thermal generation at that time while utilizing the same thermal power generation capacity at night to meet the peak demand at that time.

6.6.1.2 Framework Guidelines

- ❖ Appropriate capacity for Solar PV generation will be procured based on CPPA identification of imported fuel based thermal power plants whose fuel can be substituted with solar energy during the day according to the technical and contractual limitations.
- ❖ Such fuel substitution capacity shall be established in IPP mode through a competitive bidding or G2G process.
- ❖ Project and shall be acquired by NTDC and provided to the project sponsors on lease by the Government of Pakistan through AEDB.
- ❖ Grid Interconnection will be provided by NTDC.
- ❖ CPPA will purchase all power generated by the project.
- ❖ Term of the project shall be 25 Years on BOOT basis.
- ❖ Bid bond, performance guarantee and fees for different stages of the process will be as per Annexure – 1 of framework guidelines.
- ❖ Total foreign exchange cost component of the project shall be arranged by the successful Bidder through foreign funding sources.
- ❖ NEPRA will determine a unit based (PKR per kWh) benchmark tariff for conducting the competitive bidding by AEDB.
- ❖ Single-stage, two-envelope bidding approach will be adopted.
- ❖ Seventy percent (70%) of the total tariff will be indexed on quarterly basis with exchange rate variation (USD/ PKR). No other indexation will be provided for the term of the project.
- ❖ Tariff under G2G mode must be lower than the Tariff achieved through competitive bidding process under this initiative.
- ❖ Projects are required to achieve COD within twenty (20) months from the date the EPA and IA are signed.

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- ❖ All machinery, equipment and other related goods and materials required for deployment of Solar PV projects shall be exempted from all import related duties and taxes. If required necessary amendments in the relevant laws will be initiated by FBR.
- ❖ Profits and gains derived from sale of electricity by an PP from an electric power generation project shall be subject to 15% income tax for the term of the project.
- ❖ In addition to the GOP Guarantee, the payment under the EPA will be ensured on 60th day after invoice through bank debit from a dedicated solar account to be maintained by CPPA.

6.6.2 SOLAR PV GENERATION ON 11KV FEEDERS

6.6.2.1 Background

Significant number of electricity consumers in Pakistan suffer from poor power quality (scheduled & unscheduled outages, low voltage, etc.). Decentralized, medium-scale Solar PV power can contribute cost efficiently to alleviate some of these problems by feeding directly into the medium-voltage (MV) network, thereby improving the local losses and voltage situation. Furthermore, the injection of Solar PV power into the MV network would provide cheap electricity into the national grid without any augmentation or major upgrade of the grid infrastructure. Accordingly, Solar PV projects of suitable capacity up to maximum 4MW will be procured through competitive bidding process at 11 kV feeder level.

6.6.2.2 Framework Guidelines

- ❖ Suitable Solar PV capacity will be installed at 11 kV Feeders of the DISCOs through Competitive Bidding.
- ❖ NEPRA will provide a unit based (PKR per kWh) benchmark tariff for conducting the competitive bidding by DISCOs.
- ❖ A single-stage, two-envelope bidding approach will be adopted.
- ❖ Fifty percent (50%) of the total tariff will be indexed on quarterly basis with Pakistan CPI up to maximum of 15%. No other indexation will be provided for the term of the project.
- ❖ Projects are required to achieve COD within two hundred (200) days from the date the EPA is signed.
- ❖ DISCO will purchase all power generated by the projects under an EPA.
- ❖ Term of the project shall be 25 Years on BOO basis which may be extended with mutual consent of the parties subject to approval by NEPRA.
- ❖ Bid bond, performance guarantee and fees for different stages of the process will be furnished by the Bidders as per Annexure-1 of framework guidelines.
- ❖ Payment under the EPA will be guaranteed on 30th day after invoice through first charge on collection account of DISCOs that will be assigned to the IPPs in lieu of the IA/GoP Guarantee.
- ❖ Fiscal incentives for Solar PV projects under the laws of Pakistan prevalent on the date of the bid submission will continue to apply.

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6.6.3 SOLARIZATION OF PUBLIC SECTOR BUILDINGS

6.6.3.1 Background

Solarization of public sector buildings is a well-recognized concept particularly in developing world that helps in meeting certain portion of electricity load through clean solar energy technology, reduce electricity bills of public offices and relieve electricity utilities/ distribution companies from long-term dues besides encouraging Solar PV deployment on small to medium size buildings of common house-holds and commercial buildings.

6.6.3.2 Framework Guidelines

- ❖ Building-specific Solar PV net-metering based systems will be installed through Bidding by public sector entities on (i) Lease Model (10-year BOOT basis); and (ii) Own-cost model.
- ❖ Government departments will provide space for Solar PV installations.
- ❖ Minimum annual energy yield will be guaranteed by the vendor/lessor.
- ❖ All power generated by Solar PV systems will become property of the Government department.
- ❖ For Lease Model, fixed quarterly payment will be determined through bidding and the quarterly payments will be guaranteed in advance for first eight years and remaining two years in arrears through Revolving Bank Guarantee or any other appropriate arrangement ensuring timely payment to Lessor.
- ❖ AEDB will prepare the standard bidding documents and contract agreements to facilitate the public sector entities for procurement of net-metering based systems by the said entities.
- ❖ AEDB will maintain a pool of third-party consultants for technical evaluation of the bids and certification of the installed Solar PV systems.

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7 PROJECT IN TERMS OF POLICY AND REGULATORY FRAMEWORK

7.1 IDENTIFICATION OF LAND

Utility scale solar farms generally consist of multiple arrays of Photovoltaic (PV) Panels which collect and convert solar energy into electrical energy. For identification of land, it is necessary to locate most viable site that has a high solar radiation. The site selection should also include basic requirements for a PV plant such as availability of local grid, barren (unutilised) land, roads, water, and good climatic conditions.

7.2 ACQUISITION OF LAND

Government of Sindh has given Allotment Letter for the land that has the year-wise cost of lease. The lease of the land to the Project for its life is currently in process, the terms of which lease would be governed by a land lease agreement entered into between the parties. This would include, inter alia, that the land being leased is free of all encumbrances, liens and rights of any third parties. The Land Lease Agreement is governed by Pakistani law. The Project shall be required to pay [SED/SSEP] the Solar Park fee which shall include annual land lease and the ancillary costs incurred by the [SED/SSEP] in respect of the Project.

7.3 COMPETITIVE BIDDING (AUCTION) MECHANISM

As per ARE Policy 2019 and NEPRA (Electric power Procurement) Regulations, 2022, the Client has opted for Site Specific Competitive Tariff bidding mechanism for development of project on BOOT basis. A brief process is described here but the governing details will come in the PQD and RFP documentation in due course.

Competitive Bidding Mechanism will enable to solicit proposals from multiple vendors in order to select the most suitable and cost-effective solution, while maintaining fairness, transparency, competitiveness and value for money in procurement process.

The competitive bidding process typically includes the following steps:

- ❖ Development of bid specifications: The organization outlines the requirements for the product or service and prepares detailed specifications to be used as the basis for the bidding process.
- ❖ Issuance of bid invitation: The organization invites potential vendors to submit proposals in response to the bid specifications.
- ❖ Submission of bids: Vendors submit their proposals, which may include technical and commercial information, pricing, and other relevant details.

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- ❖ Evaluation of bids: The organization evaluates the received bids to determine which vendor is the best match for the requirements. The evaluation criteria may include price, quality, delivery time, and other relevant factors.
- ❖ Award of contract: The organization awards the contract to the winning vendor and executes the necessary legal agreements.

Competitive bidding serves the same purpose for power projects where the ultimate sale commodity is electricity.

7.3.1 Pre- Qualification

The Pre-Qualification process is the preliminary stage where potential Bidders are evaluated for their qualifications and suitability to build and operate the power project to ensure that only the most qualified and capable candidates are invited to submit a formal proposal. This is done by floating Pre-Qualification Documents (PQD). This process has been initiated for the Project and is in progress.

7.3.2 Request for Proposal and Benchmark Tariff

Request for Proposal (RFP) has been prepared carrying detailed terms & conditions, requirements of bid, process to prepare & submit the bid and the forms of agreements that will be signed with the successful Bidders.

The main project agreements in this regard are the land lease and the energy purchase agreement. The RFP package also contains the complete feasibility report including the technical studies necessary for the development of solar PV plant. The RFP package will be submitted to NEPRA for review and approval. Together with approval, NEPRA will issue the benchmark tariff to serve as a ceiling for the Bidders to offer their price.

On the basis of approval from NEPRA, the Client or whosoever is the auction administrator in this case will start the process by issuing the RFP to pre-qualified Bidders.

7.3.3 Bid Evaluation

After conducting the bidding process, the Client (or the auction administrator) will submit a Bids Evaluation Report along with the record complete in all respect to NEPRA for approval of Successful Bidder. Upon approval of Bids Evaluation Report from NEPRA, the next steps can take place. The immediate next important milestone is the issuance of Letter of Intent (LOI) from the Power Purchaser (K-Electric in this case).

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7.4 GENERATION LICENSE, TARIFF, OTHER APPROVALS

The Successful Bidder after issuance of LOI will apply for the grant of generation license and tariff petition from NEPRA in-line with its submitted bid and in accordance with the National Electric Power Regulatory Authority Regulations, 2021.

The successful Bidder will also obtain other necessary approvals such as project specific IEE and Grid Interconnection Studies.

7.5 ENERGY PURCHASE AGREEMENT (EPA)

After securing Generation License and Tariff from NEPRA, successful Bidder will sign the EPA with the Power Purchaser (KE).

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8 PROJECT SITE

8.1 SITE DETAILS:

The Project site is located at Northern side of the Karachi city in District West near Hazratabad on Northern Bypass Road which is approximately 74.9 km from Port Qasim, Karachi; Pakistan's commercial hub and main port city. The project site has a latitude of 25.029533° N and longitude of 66.993153° E with elevation of around 50 meters. The Project site spans across 612 acres of land. According to the information provided by the Client, the land has been leased by the Project Company from Government of Sindh. The access to the site from Port Qasim will be through the National and Super highway link road then Karachi-Hyderabad M-9 Motorway to Karachi Northern Bypass M10 towards Project site. The major section of the track from Karachi to the site is a multi-lane, relatively flat road.

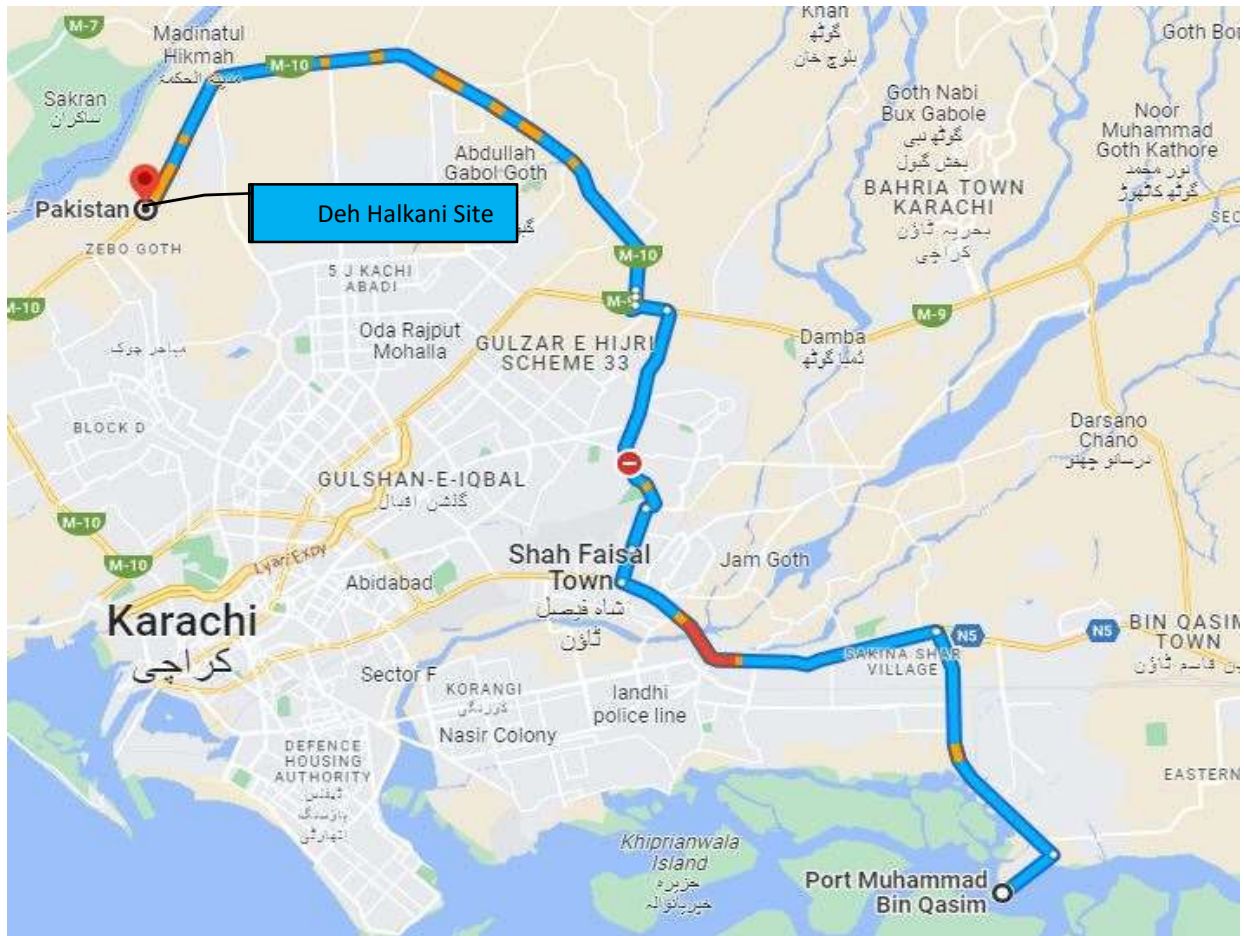


Figure 8-1: Project Location (via Google Map)

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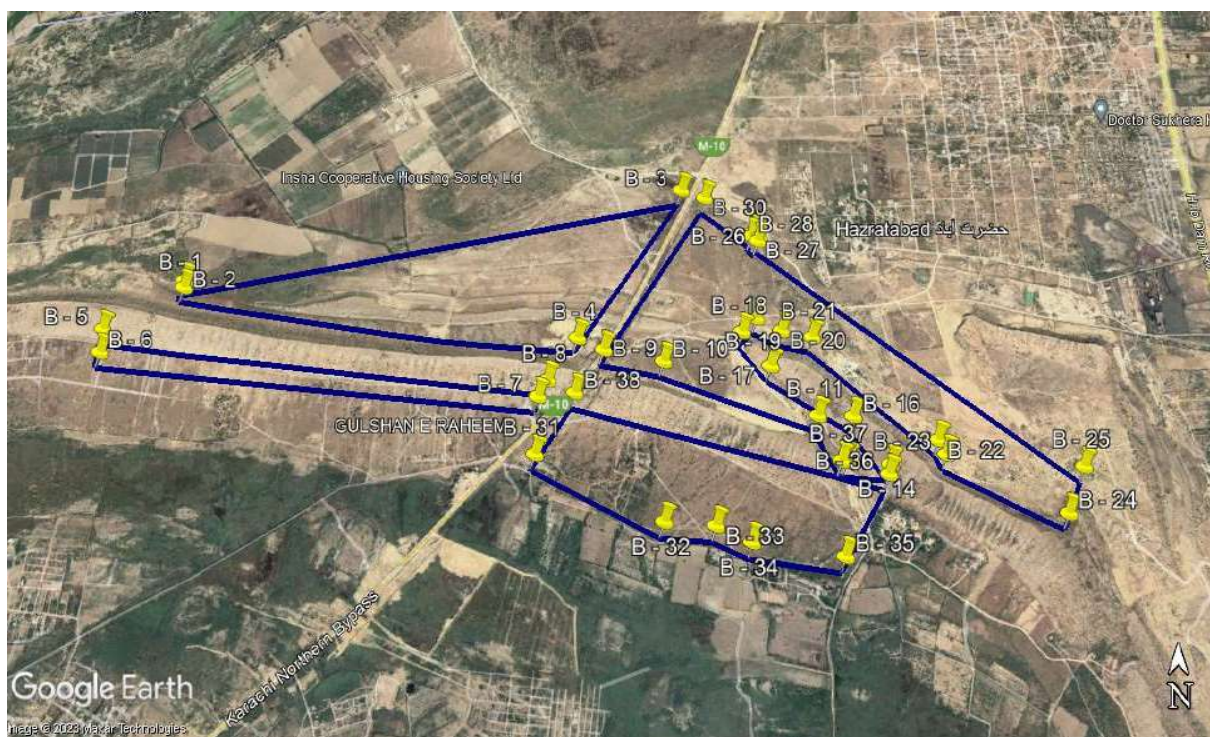


Figure 8-2: Deh Halkani Site Google Earth Imagery

The Project is intended to build in the approximate area of 612 acres. The project site is irregularly shaped and has four (04) sections very close to each other as shown in Figure 8-2. Section 1 is of area 230 acres, Section 2 is of 140 acres, Section 3 is of 195 acres and Section 04 is of 45 acres. The maximum distance between any two sections is 250 m.

Technical arrangements and their implementation in respect of right of way and cable crossings between these 04 sections should be planned and pursued by the successful bidder. The Client may consider extending support with the necessary approvals and permissions (such as for land use) for this interconnectivity within the project. This should be addressed in the RFP with more relevant details and clarity during auction tender process.

8.1.1 Land Characteristics

The Project site is surrounded by the small graveyards, chicken sheds, residential area, connecting road, agricultural land, small goths and hills which will be neglected while the solar micro-siting and technical study of project area will be done. The Project site has no vegetation consisting of flat terrain with small undulations on the surface and no settlements inside project boundary. There is no anthropogenic and natural land use and land cover. No major horizon shading is expected for the project site. The average slope of the site in West to East direction is 4.0%, while that in North to South direction is 5.1% as seen in the Figure 8-3 and Figure 8-4 respectively.

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Figure 8-3: Elevation profile of Project Site W-E



Figure 8-4: Elevation profile of Project Site N-S



Figure 8-5: Panoramic View of West to East Slope Area

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8.1.2 Geography of the Area

Karachi West District is an administrative district of Karachi Division in Sindh, Pakistan. The district contains mix population including Sindhi, Baloch, Punjabis, Pashtuns and Muhajirs. No single ethnic group form established majority in the district. In 2000, Karachi West District was abolished and divided in to 5 towns namely: Lyari town, Kemari town, Site town, Baldia town and Orangi town. On 11 July 2011 Sindh Government restored again Karachi West District. In 2020, Kemari District was carved out from Karachi West District. So Kemari town, SITE town and Baldia town ended up being part of Kemari District. Lyari became part of Karachi South district in 2015.

Karachi West District is spreading over an area of 370 sq. km and has a population of 2,077,228 as per Census of District population in 2017. The rural population was 160,904 (7.75%) and urban 1,916,324 (92.25%). The literacy rate is 68.29%: 71.27% for males and 65.03% for females. Administrative town in Karachi West is Orangi town which has 13 union councils. Dehs in Karachi West organised by 04 Taluka namely: Mauripur Taluka (9 Dehs), Mangho Pir Taluka (11 Dehs), Orangi Taluka (1 Deh) and Baldia Taluka (2 Dehs).

The project site is located at Deh Halkani and Deh Bund Murad in Mangho Pir Taluka. Population in those areas is around 45,000 as per PBS data of 2017.

8.2 TRANSPORTATION AND ACCESS NETWORK

A Transportation and Access Study has been carried out and is attached as Annex I. The Bidders are required to perform their due diligence for transportation and access to the Site. There is no construction or rehabilitation of road networks being specifically committed or guaranteed under the auction process. However, the relevant government departments responsible for road networks are expected to perform their routine jobs.

There are two routes which can be used to access the site from Karachi. It is evident that most of the transportation will be made from Port Qasim.

Route 1 is from Port Qasim to Project site via N-5 National Highway to Super Highway Link road. Then Karachi-Hyderabad M-9 Motorway to Karachi Northern Bypass M10 towards Project site. Major part the track is a multi-lane road. This route is suitable for transportation of equipment to the Project site. The total distance is around 74.9 km starting from Port Qasim to the Project site. NOC from National Highway and Motorway Police NH&MP and National Highways Authority NHA is required before start of transportation. Site access route can be seen below in Figure 8-6.

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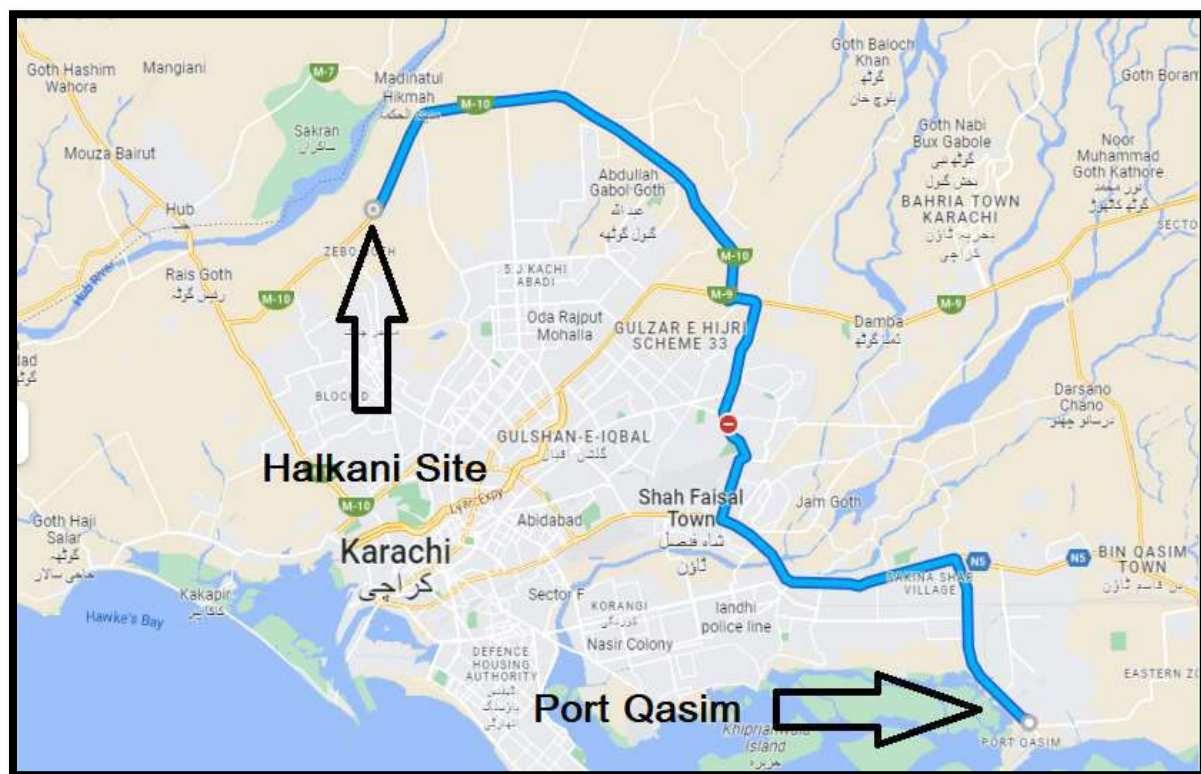


Figure 8-6: Overview of Site Access Route 1 from Google Maps

Route 2 to the site from Port Qasim will be through the National and Super highway link road then Karachi-Hyderabad M-9 Motorway to Karachi Northern Bypass M10 Road towards Project site. The main part of the Karachi trail at the site is a multi-lane route, relatively flat. The Distance of alternate route slightly long from the main access route to the site. The total length of the alternate route is 86 km from Qasim Port (Karachi) to the Halkani project site. The alternative route can be used while congestion on the main transport road or blocking the main road during freight transport.

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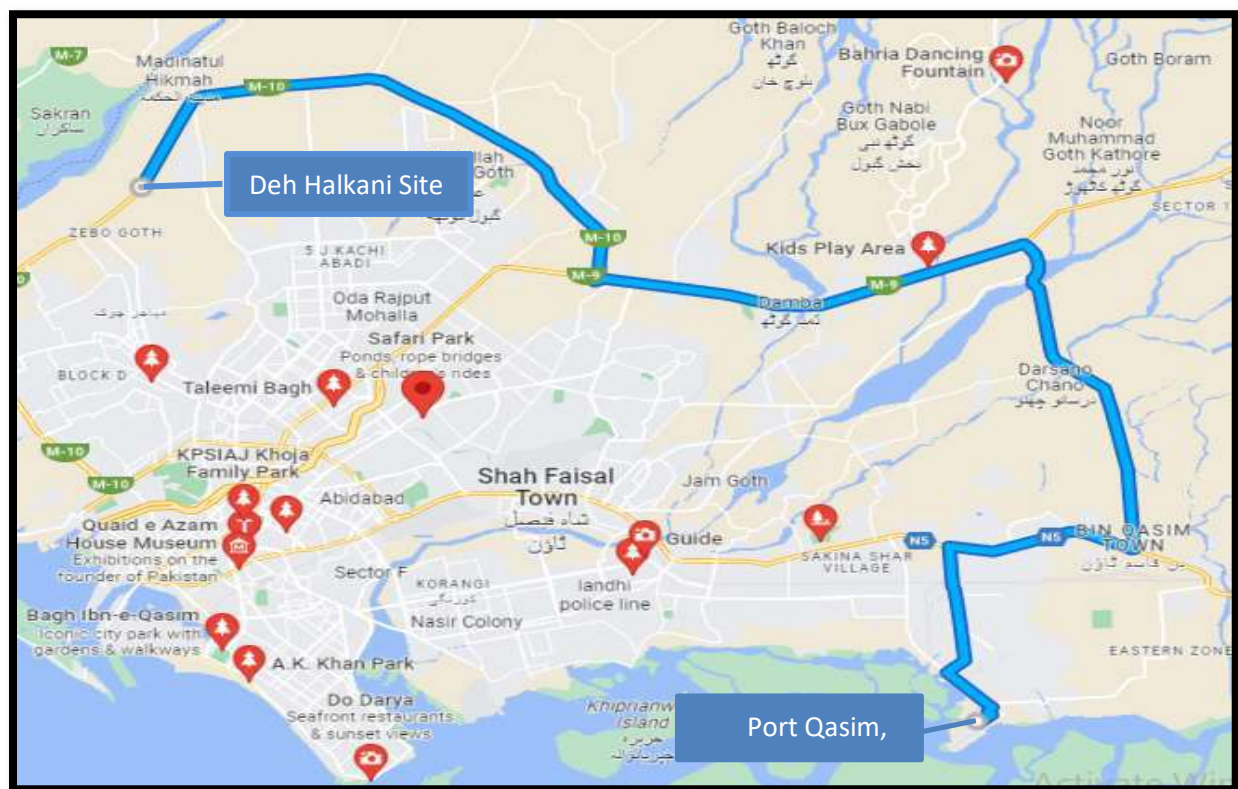


Figure 8-7: Overview of Site Access Route 2 from Google Maps

The Port Qasim being the major port of Pakistan, ideally could be the point of delivery of equipment for the proposed solar PV power plant. While the aerial distance between the port and the project site is about approximately 45.5 km, the distance by road is approximately 74.9 km. There is no need of access road construction due to location of project is on the main highway. Based on physical inspection, the access to the site is appears to be good enough for construction and operation of PV plant. It is expected that the EPC contractor will carry out detailed investigation on access road during pre-construction assessment.

8.3 CLIMATIC CONDITIONS

Deh Halkani has an arid climate with hot summers and mild winters. The Summer season persists for the longest period during the year. Deh Halkani also receives the rains from July to September (Monsoon) and experiences a tropical climate encompassing warm winters and hot summers. The humidity levels usually remain high from March to November, while they are very low in winter as the wind direction in winter is north-east. As per weather forecasting website, the warmest month in Deh Halkani is June, with an average high-temperature of 36.0°C and an average low-temperature of 27°C. While winter are dry and cold. The coldest month is January and temperature ranges from average high 26°C to an average low of 12°C. The average rainfall of the district is 145 mm, (ranges from 1 mm to 52 mm) per annum. Deh Halkani has 9.6 hours of sunshine daily on average yearly basis. May has the most sunshine of the year, with an average

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of 12.8 hrs of sunshine. The month with the least sunshine is August, with an average of 6.75 hrs of sunshine.



Figure 8-8: Average Annual Temperatures of Project Location (in °C)

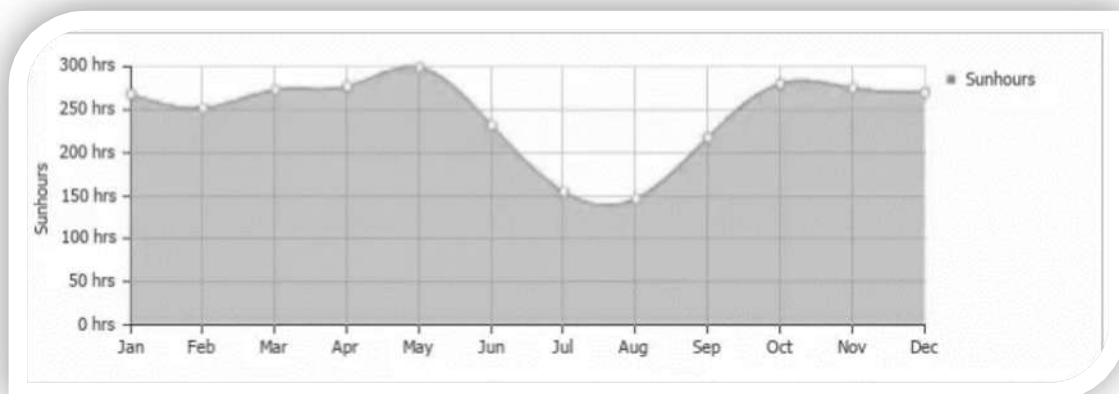


Figure 8-9: Average Monthly Sun hours of Project Location

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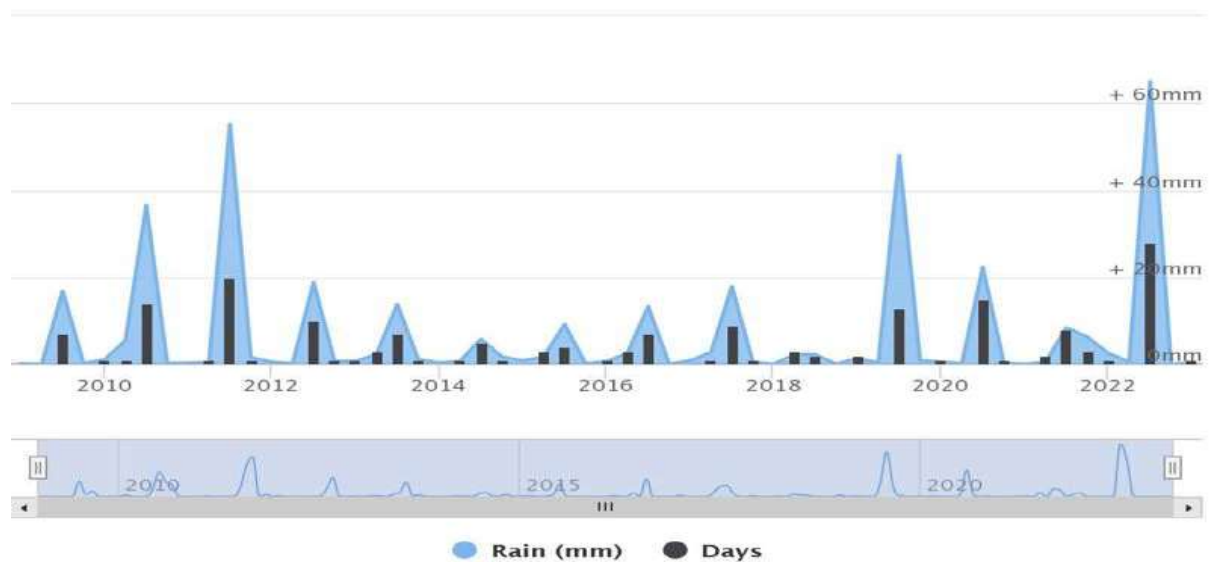


Figure 8-10: Average Yearly Rainfall Chart of Project Location

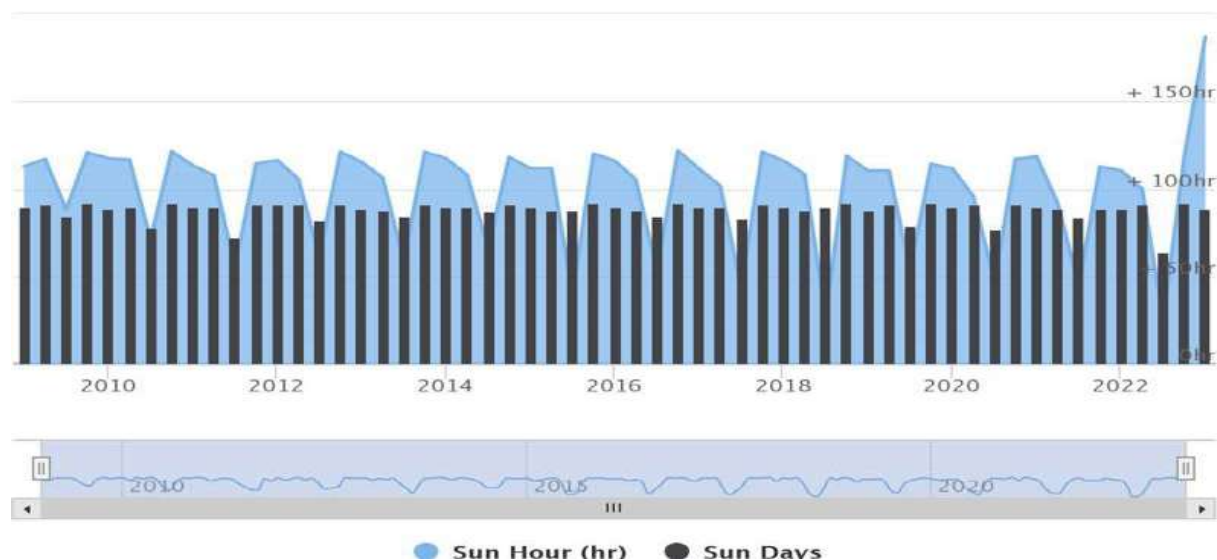


Figure 8-11: Average Yearly Sun Hours of Project Location

8.4 TOPOGRAPHIC MAP AND FLOOD STUDY

A Topographic Survey map has been prepared and attached as Annex II. A Flood Risk Assessment Study has been carried out and is attached as Annex V. There are certain recommendations in the Flood Risk Assessment Study Report to be considered for construction and operation of the plant.

The topographic survey map and the flood study have been supplied as a resource. The Bidders are required to perform their own assessment of the situation and devise their own plan for site improvement as required according to their design philosophy. In particular, the Bidders should

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evaluate their considerations for site improvements wiz-a-wiz design provisions including safety of foundations and structures.

8.5 TELECOMMUNICATION

PTCL telephone service is not available but mobile carriers have partial coverage on the site area.

8.6 EARTHQUAKES

According to the seismic zoning map of Pakistan, the Deh Halkani project site region falls in ZONE II-B with moderate to severe damage area probability. This has been separately covered in the Geotechnical Study and the Initial Environmental Examination.

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9 SOLAR RESOURCE ASSESSMENT

The solar resource assessment for the Project site was estimated by analysing solar data and accuracy from different databases that are commonly used in the current PV market. Solar data generated from Solargis at the location of the site, is used as representative data for this Project. The Solargis data has been procured under a license and will be provided as part of the RFP. The Bidders may carry out their own due diligence (and procurement of resource data, if necessary), including any required calculations.

The annual average solar irradiation on horizontal plane (GHI) on the Project site corresponds to 1960 kWh/m². The blue spot in the Figure 9-1 below shows the site location.

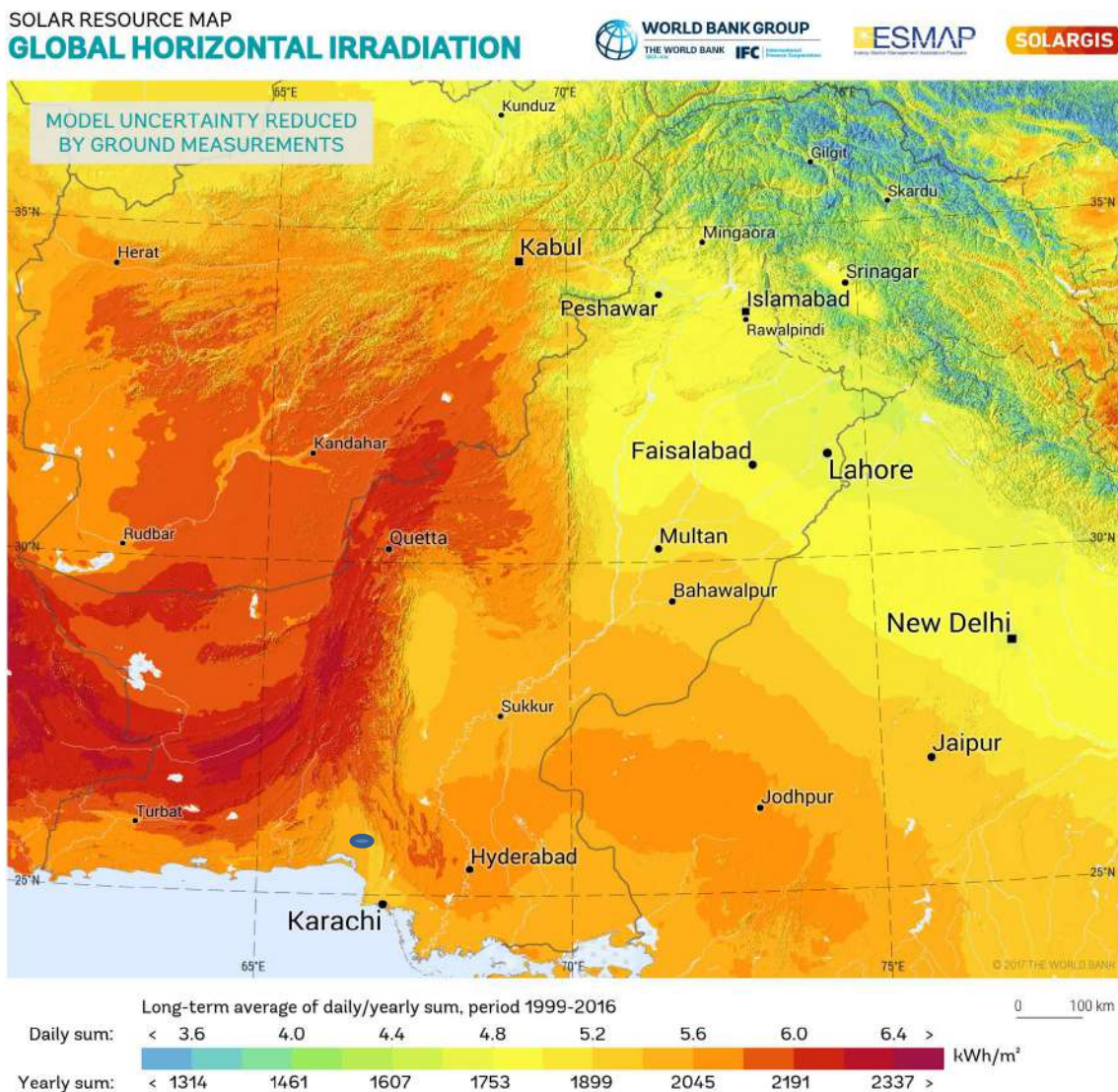


Figure 9-1: GHI Solar Resource Map of Pakistan (source: SolarGIS)

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The quality of Solargis data is determined by underlying models, spatial and temporal resolution of atmospheric and meteorological inputs, and their accuracy. Solargis data has been validated at 250+ public and many commercial locations, where high quality measurements were available. Statistics such as bias and RMSD are used for estimation of user's uncertainty. Solargis model demonstrates stable performance globally, and uncertainty lies within the margins. Uncertainty of Solargis GHI and DNI yearly summaries for 80% of observations is within the range of $\pm 4\%$ and $\pm 8\%$ ($\pm 5\%$ and $\pm 10\%$ for 90% of observations), respectively. In complex geographies and extreme cases, uncertainty of GHI and DNI yearly summaries can be as high as $\pm 8\%$ and $\pm 15\%$, respectively.

9.1 SOLAR DATA FOR PROJECT SITE

Solar data for the Project site is purchased from SolarGIS database. SolarGIS has provided the time series data 1999-2021 and Typical Meteorological Year (TMY) data for the Project location. The Typical Meteorological Year (TMY) data are generated based on 23 year's time series data, which is used by the Consultant for energy yield estimation.

Table 9-1 shows the monthly GHI, Diffuse Horizontal Irradiation (DHI) and ambient temperature breakdown of TMY at the Project location. Based on the statistics, the annual average GHI at Project location is expected around 1960 kWh/m² and annual average temperature around 26.5°C. Direct Normal Irradiation (DNI) at project location on annual average basis is 1564 kWh/m². The respective annual average Diffuse Horizontal solar Irradiance (DHI) corresponds to 927 kWh/m².

Table 9-1: Typical Meteorological Year GHI, Average DHI and Ambient Temperature

Month	GHI [kWh/m ²]	DHI [kWh/m ²]	Ambient temperature [°C]
January	134	53	19.2
February	149	57	21.7
March	194	75	25.4
April	211	85	28.6
May	218	101	30.3
June	182	104	30.9
July	138	99	29.8
August	134	94	28.8
September	161	86	28.8
October	172	68	28.5
November	138	55	25.2
December	127	50	20.6
Annual	1960	927	26.5

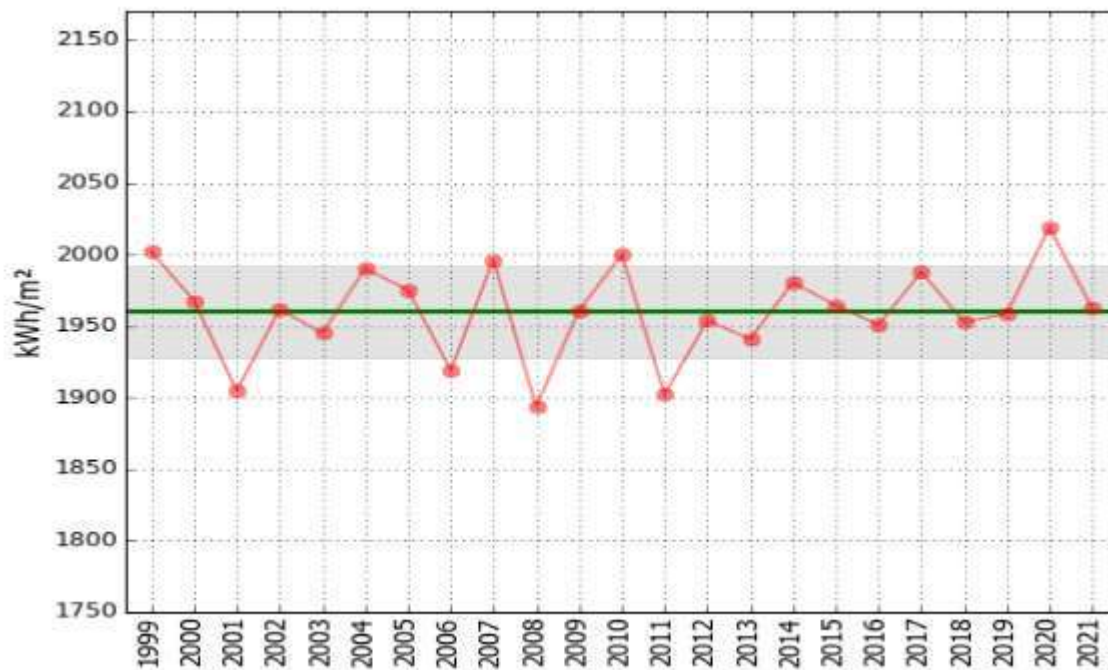


Figure 9-2: GHI Inter-annual Variation with Average line & STDEV band

Figure 9-2 shows the Inter-annual variation on GHI compared to its long-term average for the period between 1999 and 2021. The uncertainty of the annual GHI value, based on the site-adapted Solargis data, is estimated to $\pm 2.2\%$. The standard deviation of annual GHI between 1999 & 2021 is estimated as 1.7% of long-term average annual GHI.

In conclusion, the Typical Meteorological Year (on hourly steps) data representing annual average GHI of 1960 kWh/m², annual average DHI of 927 kWh/m², and annual average temperature of 26.5°C are used for energy yield assessment for the Project. The uncertainty on annual average GHI, according to Solargis is $\pm 4.5\%$.

9.2 PLANT LAYOUT AND CONFIGURATION

A preliminary general layout for 200MWp Fixed tilt PV system installation is shown in Figure 9-3.

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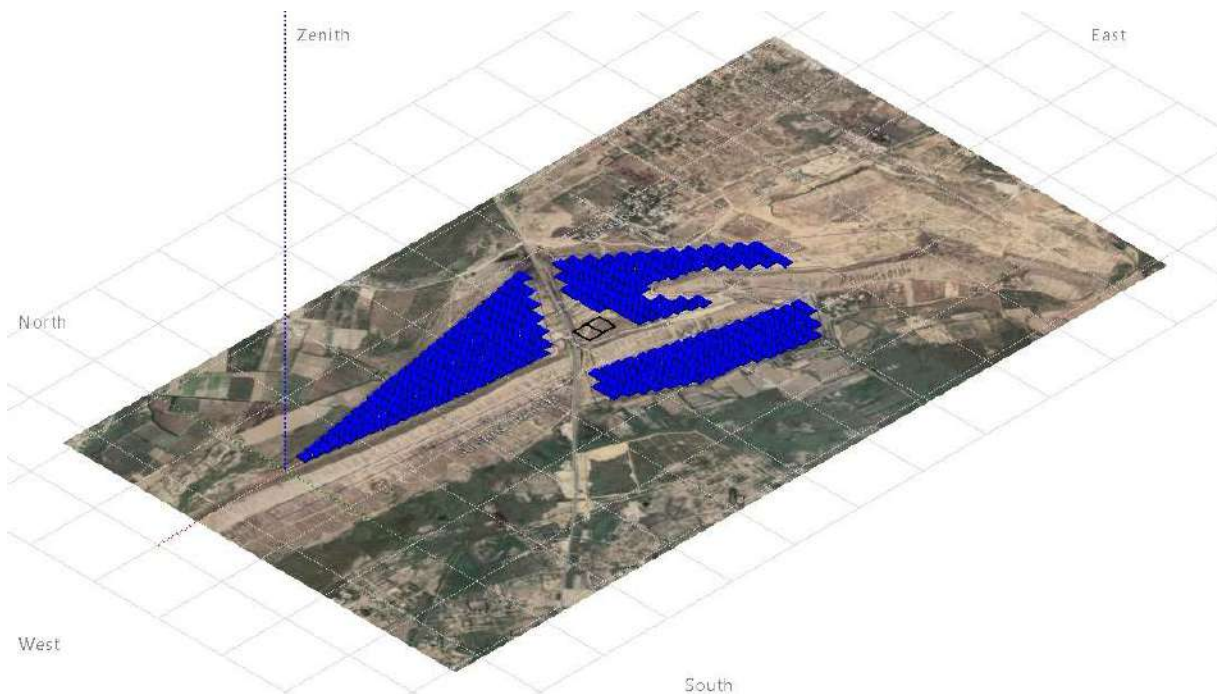


Figure 9-3: Preliminary Plant Layout of 200MWp (Fixed Tilt System)

A preliminary general layout for 120MWp Single Axis tracking PV system installation is shown in Figure 9-4.

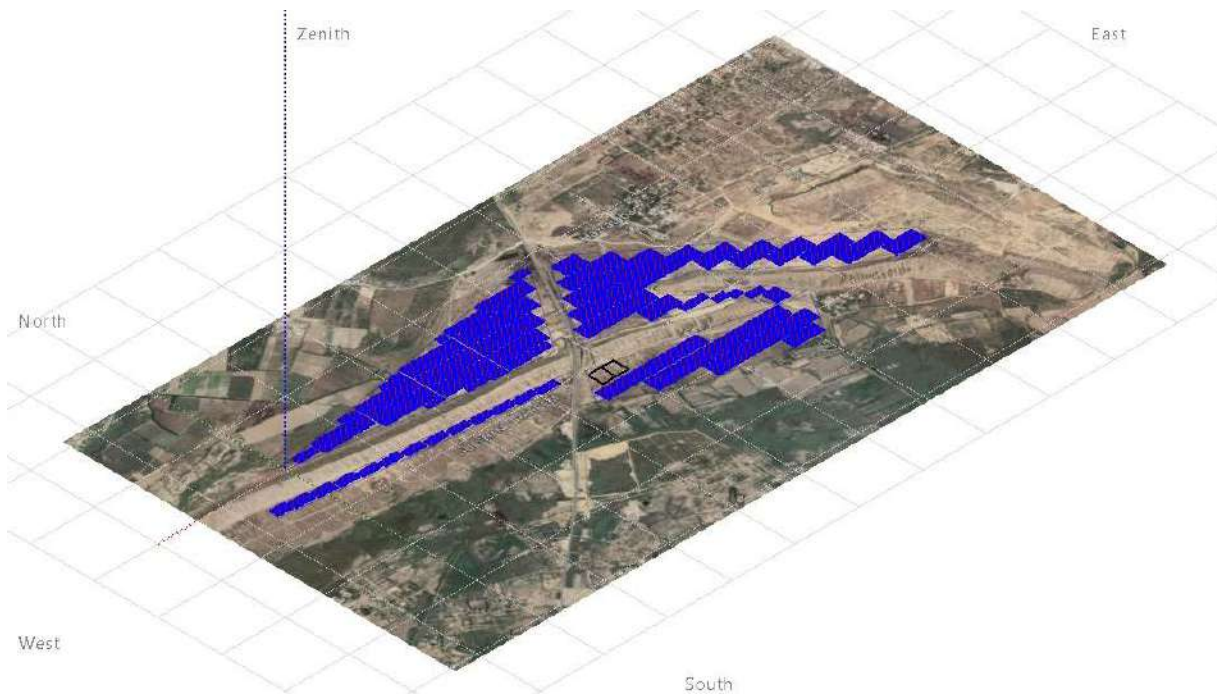


Figure 9-4: Preliminary Plant Layout of 120MWp (Single Axis Tracking System)

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9.3 PLANT CONFIGURATION AND SPECIFICATIONS

The major technical configuration, technical specification of PV modules and inverter considered in general layout concept and energy yield estimation in this report are shown in Table 9-2 and Table 9-3. The PV module and inverter type considered in this report are randomly selected by the Consultant. No preference was provided by the Client. It should be noted that the final equipment will change upon completion of bidding process and will come from the bid of the successful Bidder. Afterwards, there could be further optimisation during design phase in the light of EPA.

Table 9-2: Major Technical Characteristics of PV Module

Parameters	Description
Module Model	TSM-650DE21
Manufacturer	Trina Solar
Nominal Power [W]	650
Efficiency [%]	20.96
Power Tolerance [%]	± 1.5
Cell Type	Si-mono Bifacial
Open Circuit Voltage [V]	45.5
Short Circuit Current [A]	18.35
MPP Voltage [V]	37.5
MPP Current [A]	17.36
Power Coefficient of Temperature [-%/C]	-0.34
Nominal Operating Cell Temperature (NOCT)	25
Height X Width X Thickness [mm]	2384 X 1303 X 35

Table 9-3: Inverter Main Characteristics

Parameters	Description
Inverter Model	SG2500HV
Manufacturer	Sungrow
Nominal AC Capacity	2500 kW
Maximum DC Input Power	3500 kWp
MPP voltage Range	800 V – 1300 V
Maximum DC Current	3508 A
Nominal AC Current	2624 A
Maximum Efficiency	0.990
European Efficiency	0.987
Operating Temperature Range	-30°C to +50°C

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The Consultant has considered the configuration between PV modules and inverters as described in Table 9-4.

Table 9-4: Plant Configuration – PV Module and Inverter

Parameter	Value	
System Type	Fixed Tilt	Single Axis tracking (N-S)
Module Type	Si-Mono (Bifacial) 650Wp	
Inverter Type	SG2500HV - 2500 kW @ 25°C	
Pitch	7.5m	7.5m
Tilt	22 degree*	Variable
Installed Capacity (DC)	200MWp	120MWp
Total Number of Modules	307,692	184,643
Modules per inverter	4,274	4196
Number of Modules in series	28	29
DC/AC Ratio	1.11	1.09
Number of inverters	72	44
Nominal AC Power of One Inverter [kW]	2500	
Total AC Power [kW]	180,000	110,000

Note:

*The Consultant highlights that 25-degree tilt will be the optimum with regard to amount of irradiation incident on the plane of array. However, considering general layout presented in this report with pitch of 7.5m, it is found that energy yield will be slightly higher (0.1% more) if the panels are tilted 22° instead of 25° to the perfect south. This is because of lower row-row shading. Due to this reason, 22° tilt has been considered for the energy yield estimation in this report.

9.4 ENERGY YIELD ESTIMATION

The Consultant used PVsyst 7.3.3 for the plant modelling and estimation of energy yield for the Project considered in this study.

The following technical parameters (for this Project) are required as input in PVsyst for the energy yield estimation:

- ❖ Site characteristics (geographical location, land characteristics, slope, shading objects);
- ❖ Meteorological data sets (GHI, T_{amb} , wind speed);
- ❖ Module orientation (tilt, azimuth);
- ❖ Technical characteristics of plant component (module, inverter);
- ❖ Array configuration (no. of modules per string, no. of strings per inverter);
- ❖ Array layout (distance between two rows, width of the row);
- ❖ Losses assumptions (soiling, module quality, mismatch losses, cable losses, etc.);

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The uncertainties on solar irradiation data are considered based on the information provided along with the solar data. Further uncertainties on assumptions in energy yield calculations are estimated based on the Consultant's experience. The long-term energy yield and Probability of Exceedance (PoE) on energy yield is calculated by considering estimated uncertainties and annual degradation of the modules.

9.5 SUMMARY OF LOSSES:

A description of the losses mechanism in PV system is presented in this section. The described losses outline the significant, non-negligible losses which may pose a risk if the plant is not designed properly. The table below summarizes the estimation of losses value for the Project.

Table 9-5: Losses Estimation Summary

Losses Type	Fixed Tilt	Single Axis	Calculated [C] or Defined [D]
Front Side			
Global Incident in Coll. Plane	+8.2%	+22.2%	C
Near Shading	-2.52%	-5.68%	C
IAM factor on global	-1.85%	-1.02%	C
Soiling losses	-3.0%	-3.0%	D
Ground reflection on front site	+0.09%	+0.59%	C
Back side			
Ground reflection loss	-80%	-80%	C
View factor for rear side	-50.48%	-76.03%	C
Sky diffuse on rear side	+9.65%	+39.84%	C
Shading loss on rear side	-15.0%	-15.0%	D
Both sides			
Module Degradation Loss	-0.45%	-0.45%	D
PV loss due to irradiance level	-0.49%	-0.29%	C
Spectral Correction	-0.0%	+0.0%	D
Losses due to temperature	-6.98%	-7.08%	C
Auxiliaries	-0.53%	-0.58%	D
Module quality loss	+0.37%	+0.37%	D
Light Induced Degradation	-2.0%	-2.0%	D
Module Array Mismatch loss	-2.10%	-2.10%	C
Mismatch for back irradiance	-0.44%	-0.81%	C
Ohmic wiring loss	-1.15%	-1.20%	C
MV Line Ohmic loss& AC Ohmic Loss	-0.10%	-0.08%	C
Medium Voltage Transformer Loss	-1.06%	-1.03%	C
Inverter loss	-1.23%	-1.18%	C
Unavailability loss	-2.10%	-2.03%	C

9.6 LONG TERM ENERGY YIELD ESTIMATION

The long-term energy yield estimation is prepared based on the first-year energy production and applying PV module manufacturer's guaranteed value of annual degradation. The long-term energy yield is also prepared at different Probability of Exceedance levels (P50, P75 and P90). The results are discussed and presented in the following sections.

9.6.1 Degradation

The long-term energy yield is estimated for the project life of 25 years and considering an annual average degradation (from year 2 and onwards) of 0.45% of reduction in module name plate power. This degradation value is in line with the guarantees provided for the selected module by the manufacturer. For clarification, the first-year energy already includes the degradation of 2.0% which is also in line with the manufacturer's power guarantee provided for the module considered in this assessment.

For clarity purpose, the module performance (specifically LID and degradation) values included in this energy yield estimation represents the Consultant's conservative assumptions, mainly due the project being in early stage of development.

9.6.2 Uncertainty Estimation

The following table shows the uncertainty evaluation of presented energy yield result in Solar Resource and Energy Yield Assessment (SRA) report. These parameters and values are based on the Consultant's project experiences. The total uncertainty as a result is calculated at 5.27 % for the energy yield estimation presented in SRA report.

Table 9-6: Uncertainties – Energy Yield Estimation

Uncertainties	1-Years	10-Years
Irradiance	4.3%	4.0%
Conversion to inclined surface (PVsyst)	2.0%	2.0%
Soiling	0.5%	0.5%
Spectral uncertainty (AM)	0.5%	0.5%
Albedo	0.5%	0.5%
Reflection	0.5%	0.5%
Deviation from module specs	0.5%	0.5%
Inverter and transformer losses	1.0%	1.0%
Mismatch	1.0%	1.0%
Ohmic losses	1.0%	1.0%
Shading losses	1.5%	1.5%
Availability	1.0%	1.0%
Total uncertainty	5.51%	5.27%

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The total uncertainty on long term (eg.10 yrs.) energy yield estimation is 5.27%. Similarly, the uncertainty for energy estimation for 1-year period is estimated as 5.51%. This includes the variability effect of solar data which is generated based on standard deviation of 1.7% of long-term average GHI (for 23 year's time series data). Therefore, the uncertainty of 5.51% is used to estimate POE - 1 year and the uncertainty value of 5.27% is used to estimate POE-10 year's energy production.

9.6.3 Probability of Exceedance (PoE-10 Years) (Fixed Tilt)

The probability of Exceedance (PoE) describes how confident a calculated result is; in this case, the energy production. Beside the 50% (P50) confidence level, common PoE levels for financial calculations and institutions in the renewable energy sector are 75% (P75) and 90% (P90) in Pakistan. The Table 9-7 summarizes the long-term energy yield estimation at different PoE levels of 200MWp installed capacity with Fixed tilt system at 7.5m Pitch and 22-degree orientation.

Table 9-7: Annual Breakdown of Long-Term Energy Yield (25 Years– 200MWp Fixed Tilt – POE 10 year)

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-1 (without Degradation)	346,936	334,602	323,501
Year-1	339,997	327,910	317,031
Year-2	338,442	326,410	315,581
Year-3	336,887	324,910	314,131
Year-4	335,332	323,410	312,681
Year-5	333,776	321,910	311,231
Year-6	332,221	320,411	309,781
Year-7	330,666	318,911	308,330
Year-8	329,111	317,411	306,880
Year-9	327,556	315,911	305,430
Year-10	326,000	314,411	303,980
Year-11	324,445	312,911	302,530
Year-12	322,890	311,411	301,080
Year-13	321,335	309,911	299,630
Year-14	319,780	308,411	298,179
Year-15	318,224	306,911	296,729
Year-16	316,669	305,411	295,279
Year-17	315,114	303,911	293,829
Year-18	313,559	302,412	292,379
Year-19	312,003	300,912	290,929
Year-20	310,448	299,412	289,478
Year-21	308,893	297,912	288,028
Year-22	307,338	296,412	286,578
Year-23	305,783	294,912	285,128
Year-24	304,227	293,412	283,678
Year-25	302,672	291,912	282,228

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9.6.4 Probability of Exceedance (PoE – 1 Year) (Fixed Tilt)

The POE-1-year estimation of 200MWp installed capacity with Fixed tilt system at 7.5m Pitch and 22-degree orientation is presented below in Table 9-8.

Table 9-8: Annual Breakdown of Long-Term Energy Yield (25 Years – 200MWp Fixed Tilt – POE 1 year)

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-1 (without Degradation)	346,936	334,054	322,460
Year-1	339,997	327,373	316,011
Year-2	338,442	325,876	314,565
Year-3	336,887	324,378	313,120
Year-4	335,332	322,881	311,674
Year-5	333,776	321,383	310,229
Year-6	332,221	319,886	308,783
Year-7	330,666	318,388	307,338
Year-8	329,111	316,891	305,892
Year-9	327,556	315,393	304,447
Year-10	326,000	313,896	303,001
Year-11	324,445	312,398	301,556
Year-12	322,890	310,901	300,110
Year-13	321,335	309,403	298,665
Year-14	319,780	307,906	297,219
Year-15	318,224	306,409	295,774
Year-16	316,669	304,911	294,328
Year-17	315,114	303,414	292,883
Year-18	313,559	301,916	291,437
Year-19	312,003	300,419	289,992
Year-20	310,448	298,921	288,546
Year-21	308,893	297,424	287,101
Year-22	307,338	295,926	285,655
Year-23	305,783	294,429	284,210
Year-24	304,227	292,931	282,764
Year-25	302,672	291,434	281,319

9.6.5 Probability of Exceedance (PoE-10 Years) (Single Axis Tracking)

Table 9-9 summarizes the long-term energy yield estimation at different PoE levels – 10 Years of 120MWp installed capacity with Single Axis tracking system (N-S Orientation).

Table 9-9: Annual Breakdown of Long-Term Energy Yield (25 Years – 120MWp Single Axis – POE 10 year)

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-1 (without Degradation)	236,637	228,225	220,653
Year-1	231,905	223,660	216,240
Year-2	230,844	222,637	215,251
Year-3	229,783	221,614	214,262
Year-4	228,722	220,591	213,273
Year-5	227,662	219,568	212,284
Year-6	226,601	218,545	211,295
Year-7	225,540	217,522	210,306
Year-8	224,479	216,499	209,316
Year-9	223,419	215,476	208,327
Year-10	222,358	214,453	207,338
Year-11	221,297	213,430	206,349
Year-12	220,236	212,407	205,360
Year-13	219,175	211,384	204,371
Year-14	218,115	210,361	203,382
Year-15	217,054	209,337	202,393
Year-16	215,993	208,314	201,403
Year-17	214,932	207,291	200,414
Year-18	213,872	206,268	199,425
Year-19	212,811	205,245	198,436
Year-20	211,750	204,222	197,447
Year-21	210,689	203,199	196,458
Year-22	209,628	202,176	195,469
Year-23	208,568	201,153	194,480
Year-24	207,507	200,130	193,490
Year-25	206,446	199,107	192,501

9.6.6 Probability of Exceedance (POE – 1 Year) (Single Axis Tracking)

The POE-1-year estimation of 120MWp installed capacity with Single Axis tracking system (N-S Orientation) is presented below in Table 9-10.

Table 9-10: Annual Breakdown of Long-Term Energy Yield (25 Years - 120MWp Single Axis – POE 1 year)

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-1 (without Degradation)	236,637	227,851	219,943
Year-1	231,905	223,294	215,544
Year-2	230,844	222,273	214,558
Year-3	229,783	221,251	213,572
Year-4	228,722	220,230	212,586
Year-5	227,662	219,208	211,600
Year-6	226,601	218,187	210,614
Year-7	225,540	217,166	209,628
Year-8	224,479	216,144	208,643
Year-9	223,419	215,123	207,657
Year-10	222,358	214,102	206,671
Year-11	221,297	213,080	205,685
Year-12	220,236	212,059	204,699
Year-13	219,175	211,037	203,713
Year-14	218,115	210,016	202,727
Year-15	217,054	208,995	201,741
Year-16	215,993	207,973	200,755
Year-17	214,932	206,952	199,769
Year-18	213,872	205,930	198,783
Year-19	212,811	204,909	197,797
Year-20	211,750	203,888	196,811
Year-21	210,689	202,866	195,825
Year-22	209,628	201,845	194,839
Year-23	208,568	200,823	193,853
Year-24	207,507	199,802	192,867
Year-25	206,446	198,781	191,882

9.7 RECOMMENDATIONS ON SOLAR RESOURCE ASSESSMENT

Following are the few recommendations to be considered in order not to deviate the uncertainty range estimated for energy yield in the SRA report.

➤ Land Utilization

- The Allotment Letter for the land does not specify the exact boundary co-ordinates. It locks the area in acres (612 acres) and the location on town planning maps. The exact boundary co-ordinates will be marked at the stage of land lease by the concerned department of GOS while staying in the same location and area identified in the Allotment Letter.
- For the purpose of this study, the coordinates have been marked jointly by the representatives of Client and Consultant based on site surveys and judgements. As a result, the Project feasibility study is based on the land co-ordinates given in **Error! Reference source not found.**, which must be considered at the time of land lease
- The procedure followed above is as per the practices for allocation and utilization of land at GOS.
- The project land is clear which contain only small bushes and shrubs. The Project site in general has no shading due to terrain or natural objects that can cast shading on PV arrays.
- The Project is intended to build in the approximate area of 612 acres. The project site is irregularly shaped and has four (04) sections very close to each other as shown in Figure 8-2. Section 1 is of area 230 acres, Section 2 is of 140 acres, Section 3 is of 195 acres and Section 04 is of 45 acres. The maximum distance between any two sections is 250 m.
- Technical arrangements and their implementation in respect of right of way and cable crossings between these 04 sections should be planned and pursued by the successful bidder. The Client may consider extending support with the necessary approvals and permissions (such as for land use) for this interconnectivity within the project. This should be addressed in the RFP with more relevant details and clarity during auction tender process.

➤ Design Phase

- Appropriate spacing between rows to be considered to minimize near shading loss.

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- Technical characteristics of components in similar range as considered in the preliminary concept design.

➤ Construction Phase

- All the construction activities should be according to the plant design.
- Checking PV modules flash test data to ensure the module power are within the positive tolerance range.
- Sorting of PV modules during actual installation to minimize the mismatch losses.

➤ Operation & Maintenance Phase

- Timely operation and maintenance (O&M) are mandatory.
- Cleaning PV modules frequently to keep soiling loss not more than 3.0%.
- Design and implement suitable PV modules cleaning system. Robotic systems must have proven track record for successful operation in similar ambient environment and must be suitable for prevailing extreme ambient conditions.
- Maintaining inverter operating temperature within the manufacturer's recommendation range.
- Considering plant performance and/or plant availability as guarantee from O&M contractor during operation period.

9.8 SUMMARY OF SOLAR RESOURCE ASSESSMENT RESULTS

Following are the main conclusions for solar resource and energy yield estimation:

- ❖ The site is generally flat having no buildings, trees or any obstruction in surrounding that could hinder the production. In this respect, site seems to be suitable for PV installation.
- ❖ The Typical Meteorological Year data for the Project site corresponds to the annual average GHI of 1960 kWh/m², annual average DHI of 927 kWh/m², and annual average temperature of 26.5°C. TMY data sets were used for energy yield assessment for the Project.
- ❖ The energy yield estimation was performed using the standard practice and the result shows that the 200MWp Solar PV project for Fixed tilt system at 22 Degree Orientation and 7.5m Pitch:

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- With fixed tilt system, the project is expected to produce maximum 339,997 MWh/year in comparison to different scenarios and technologies during its first year of operation. The corresponding annual average performance ratio and capacity factor are estimated as 80.14% and 19.41% respectively.
- ❖ The energy yield estimation is performed using the standard practice and the result shows that the 120MWp Solar PV project for Single Axis tracking system at N-S Orientation and 7.5m Pitch:
 - With single axis system, the project is expected to produce maximum 231,905 MWh/year in comparison to different scenarios and technologies during its first year of operation. The corresponding annual average performance ratio and capacity factor are estimated as 80.65% and 22.1% respectively.
- ❖ The uncertainty on long term annual energy estimation is +/- 5.27%.

Based on above results, any further requirements for the Project will come into the RFP of tariff bidding. The Client and KE are interested that Single Axis tracking based system is installed, which is considered plausible for better yield, higher efficiency and network stability.

The detailed solar resource and energy yield assessment report of the project carried out that includes deliberation of land layout, Plant layout design, grid conditions, site topology as well as calculation of performance ratio along with energy numbers.

Solar Resource and Energy Yield Assessment report can be seen as Annex III of this report.

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10 CARBON CREDITS

A carbon credit reflects the potential of a clean energy project to mitigate emissions of greenhouse gases (GHGs), in particular, carbon dioxide (CO₂), measured in tonnes of CO₂ equivalent. The carbon credit is realized after following due process as required under the relevant provisions as specified in globally recognized standards and methodologies. Once realized, the carbon credit being issued as Carbon Emission Reduction (CER) certificate, is termed as a tradable commodity that can be sold in international/national carbon markets or to individual buyers like businesses, organizations, trading platforms, etc. The buyers of the carbon credits can use these for their contribution towards their pledge of net-zero emissions ambition, and compensate their footprints, while the sellers get a financial gain that is ultimately used to finance their green projects.

10.1 BACKGROUND AND PROVISIONS

The Paris Agreement, which was adopted in 2015, aims to keep the global temperature increase well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius. The CO₂ emissions mitigation projects are those projects which reduce, avoid or remove GHG emissions from the atmosphere. The projects are implemented and rewarded with CER certificates in terms of the provisions, mechanisms, and methodologies given in the Paris Agreement. Article-6 has nine clauses to support the reduction of GHG with a broad framework like ITMOs (Internationally Transferred Mitigation outcomes) towards NDC (National Determined Contribution) and Sustainable Development.

The demand for carbon credits is expected to increase exponentially, especially driven by the surge of corporate climate pledges that will boost activities in the voluntary market. As of November 2022, over one-third of the world's largest publicly traded companies have announced net-zero targets. These companies are set to use carbon credits they purchase to offset emissions that are hard to completely abate, alongside actions to decarbonize their emission activities.

10.2 ROLE OF PARIS AGREEMENT IN THE PROJECT

The Project is a power generation project with renewable resource and zero emissions. When put into operation, the project will provide power to the southern Pakistan power grid, which currently is mainly relying on fossil fuel. Therefore, it can help to reduce GHG emissions from coal or oil-fired power generation. It can deliver significant environmental and social benefits. The project also aligns with the Paris Agreement's goal of promoting sustainable development, as it will provide clean energy to the region and contribute to economic growth. The Paris Agreement encourages the development and deployment of renewable energy technologies, such as solar power, as a means of reducing GHG emissions while promoting sustainable development. CERs can provide an extra financial resource for the project, that can enable the project to mitigate foreseeable techno-commercial risks, improve its bankability, and ensure additionality. It will

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provide favourable conditions for project financing, improve the competitiveness of the project, and reduce investment risk during the project implementation process.

10.3 MITIGATION PROGRAM

To register under Article 6 of the Paris Agreement and receive CER credits, the project will need to demonstrate that its solar energy production represents a real and verifiable reduction in GHG emissions compared to a baseline scenario. This may involve the development of a detailed project plan, monitoring and reporting of emissions reductions, and verification by an accredited third-party auditor.

To manifest the overall financial stream that can be channelled through Mitigation Outcome Project (MoP), a brief calculation is provided herein. The calculation methodology for carbon emission reductions is based on the formula: [Proposed Targeted Installed Capacity x Capacity Factor (20%²) x Number of Hours in a Year (8760hrs) x Baseline Emission Factor for Electricity System (assume 0.6 tCO₂/MWh³, however, the actual number is to be calculated based on the feasibility study). The assumption-based calculation is given below:

Table 10-1: CER Credits and Annual GHG Reduction

Estimated Local & Global Environmental benefits including CER Credits & Annual GHG Reduction (Assumption)					
Capacity (MW)	CF (20%)	Year (h)	Baseline Emission Factor	Carbon Credits	Units
120	0.2	8760	0.6	126,144	Qty
Yearly Global Environment Benefits (GHG Reduction)				126,144	tCO ₂ /MWh
Yearly Earning (Considering 4\$/carbon credit ⁴ @280PKR/\$)				141,281,280	PKR

10.4 REGISTRATION CYCLE

The registration cycle for a Mitigation Outcome Project requires developing a detailed Mitigation Outcome Design Document (MoDD), that typically begins with feasibility and environment and social impact assessments, estimating the potential of the project to mitigate CO_{2e} emissions, techno-commercial additionality that manifests that revenues earned from the sale of carbon credits make the project feasible. Once these assessments are completed and the project is

² Tentative, this will be actualized as a result of detailed energy estimates in the technical feasibility study.

³ Tentative, this will be actualized as a result of baseline emission factor calculation for the electricity system of Pakistan.

⁴ Tentative based on current market price and may vary at the time of selling the credits due to prevailing market conditions.

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deemed feasible and environmentally sound, it can be submitted to the relevant ministry for approval.

Once the project has been approved by the ministry, it can be submitted for registration under Article 6 of the Paris Agreement with Art 6 Advisory Board or in the voluntary carbon market under the Verra Standard or Gold Standard. The registration process involves project verification, which certifies that the project is compliant with approved methodologies and standards.

After the project has been verified, the relevant registration entity issues a certificate to this effect. Yearly verification is required to ensure that the project continues to meet standards and to assign CER credits. This verification process involves monitoring and reporting on GHG emissions reductions and may require the involvement of accredited third-party auditors. As an outcome, the project is issued verified certificates/credits that manifest the amount of GHG emissions it has reduced or avoided. These credits can be used to offset emissions in other sectors or sold in carbon markets to entities seeking to meet emissions reduction targets.

In summary, the registration cycle for a Mitigation Outcome Project involves feasibility and environmental assessments, ministry approval, registration, project verification, and yearly verification for CER credit issuance. By completing this cycle, a project can contribute to global efforts to mitigate climate change and earn financial benefits through participation in carbon markets. The overall carbon crediting cycle is shown in Figure 10-1 below:

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Figure 10-1: CER Credits Registration Cycle

Whereas:

1. PoA: Program of Activity
2. EIA: Environmental Impact Assessment
3. PDD: Project Designed Document
4. NDC: Nationally Determined Contribution
5. HCA: Host Country Agreement ⁵
6. MOCC: Ministry of Climate Change
7. DoE: Designated Operational Entity⁶
8. PA Experts: Paris Agreement Expert Bodies
9. UNFCCC: The United Nations Framework Convention on Climate Change
10. CER-Credits: Carbon Emission Reduction Credits

⁵ to be awarded by MOCC as National Designated Entity (NDE) of Govt. of Pakistan to UNFCCC

⁶ An entity registered with the PA Experts for verification of the projects/programs being submitted for claiming emissions reduction

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11 GEOLOGICAL CONDITIONS

In order to collect detailed regional geological information, Geotechnical Investigation and Earth Resistivity Study was carried out and is attached as an Annex IV to this report.

Boreholes were drilled as part of the field investigation along with relevant in-situ tests. Soil/rock samples were also collected during the field investigation. Laboratory testing of these samples has been carried out in the laboratory.

The ground conditions observed at the site indicate the presence of following subsurface deposits:

- ❖ Dense to very dense gravel
- ❖ Medium dense to very dense sand
- ❖ Very stiff to hard silt
- ❖ Very stiff clay

Keeping these conditions under consideration design parameters, design criteria for shallow foundations, allowable bearing pressures for shallow foundations, modulus of subgrade reaction, allowable pile capacities, seismic soil profile has been taken as 'Sc' in accordance with UBC-97 based on SPT N method approach. Tests on soil samples obtained from the borehole indicate negligible chloride and sulphate exposure. In continuation with the findings listed in the detailed report, type of cement recommended for these conditions is 'Ordinary Portland Cement'.

Groundwater table was not encountered up to the explored depth of 5.0 meters in any of the boreholes drilled at the site.

Geotechnical Investigation and Earth Resistivity Study was carried out by Soil Testing Services (STS) Pvt Ltd and is attached as an Annex IV to this report. However, this has been provided as a resource material and the Bidders are required to make their own evaluations as required for basis of detailed design.

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12 CIVIL WORKS

The Geotechnical investigation report and Topographical Survey map for the site of Deh Halkani are attached as Annex IV and Annex II. The civil works include the following structures:

- ❖ Foundation of Solar Arrays
- ❖ Foundation of substation and grid interconnection apparatus, i.e. transformer, switchgear etc.
- ❖ Construction of permanent buildings (residence and offices) of O&M staff.

The design of the civil infrastructure works shall comply with all current applicable Pakistani and international regulations, design codes and standards.

All buildings and module mounting structures installed at project shall have a design life of 25 years. International standards shall be adopted while designing the equipment, plant, and civil structures of Complex. The appearance of the substation building, and the type and colour of materials used to build the substation shall comply with the requirements of and agreed with the appropriate authority before construction commences. The layout and design of the building shall be reviewed and approved by the Client prior to construction.

The architectural layout of substation shall be according to the requirements of the Grid Code, local requirements, Project Company's requirements, and the provisions of the EPA.

The Complex shall have buildings for accommodation, offices, control room, workshop, warehouse, auxiliary building and any other requirement for smooth operation of the plant as per Pakistani regulations. Civil design of plant must have provision for flood water outlet. All grey water from the plant needs to be treated according to Pakistani and local regulations before they are discharged from the site. All civil works associated with the provision of temporary and permanent access roads on the site with suitable drainage arrangements. Watch towers at the project boundary and substation area are to be considered.

The inverters' and transformers' installation design are both container type with suitable protection level and ventilation for prevailing extremes of site ambient conditions, so there is no need to build the room for inverter and transformer.

All the civil structures shall be designed according to the topography of the area. While designing shading analysis must be considered to avoid any shading on the solar panels area to impact the performance of plant.

The design of civil works shall be according to the soil and seismic conditions; and to bear prevailing maximum winds / gusts specified in the RFP. This will be carried out by the successful Bidder after the auction process through its EPC contractors.

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13 ELECTRICAL WORKS

13.1 GRID INTERCONNECTION STUDY

A separate electrical and grid interconnection study was conducted by a third party i.e. Power Planners International (Pvt) Ltd, for the project including Power Quality, Load Flow, Short Circuit and Power Evacuation scheme. This study will be approved by the Power Purchaser. The electricity generated will be directly fed into any existing Grid Station of the Power Purchaser as pointed out in Grid Interconnection study or as advised by the KE (Power Purchaser). Grid Interconnection Study is attached as Annex VII of this report.

13.2 PV PLANT ELECTRICAL OVERVIEW

The detailed design of the electrical works shall be carried out by the EPC contractor prior to start of construction. The detailed design must be reviewed and approved by the Power Purchaser. The following sub-sections provide an overview of the solar PV power plant.

The key electrical components of the plant shall include the PV panels, cabling, inverters, step up transformers and switchgear and complete installation material.

The conversion of solar radiation into electrical energy (DC power) shall be performed using the PV panels. The PV panels shall be split in multiple groups since that will allow for the use of lower current carrying capacity cables and shall offer more redundancy in contingency conditions.

The DC electricity from the panels shall be converted into 50Hz AC via the inverters. There may be some support apparatus such as junction boxes between the inverter and the panels.

The output voltage of the inverter can be classified as low voltage (LV), and therefore, shall require stepping up to medium voltage level (MV) i.e. 22 kV or 33 kV by means of step up transformers.

Once stepped up to 22 kV or 33 kV through transformers, the power shall be transmitted to the substation where it will be stepped up to the KE's grid voltage (i.e. 220 kV). The substation will serve as the interconnection point to the utility transmission grid system.

Bidders must observe available grid characteristics as e.g. Total Harmonic Distortion (THD) level and THD limit value as per grid code when designing the PV plant (e.g. installation of filters for compliance with THD levels to be checked).

Appropriate rainwater drainage system on the entire Project site shall be designed and implemented. Suitable installation level for electrical and mechanical equipment shall be designed keeping safety margin from max. recorded 50 years flood levels.

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A pictorial representation of the plant is given below:

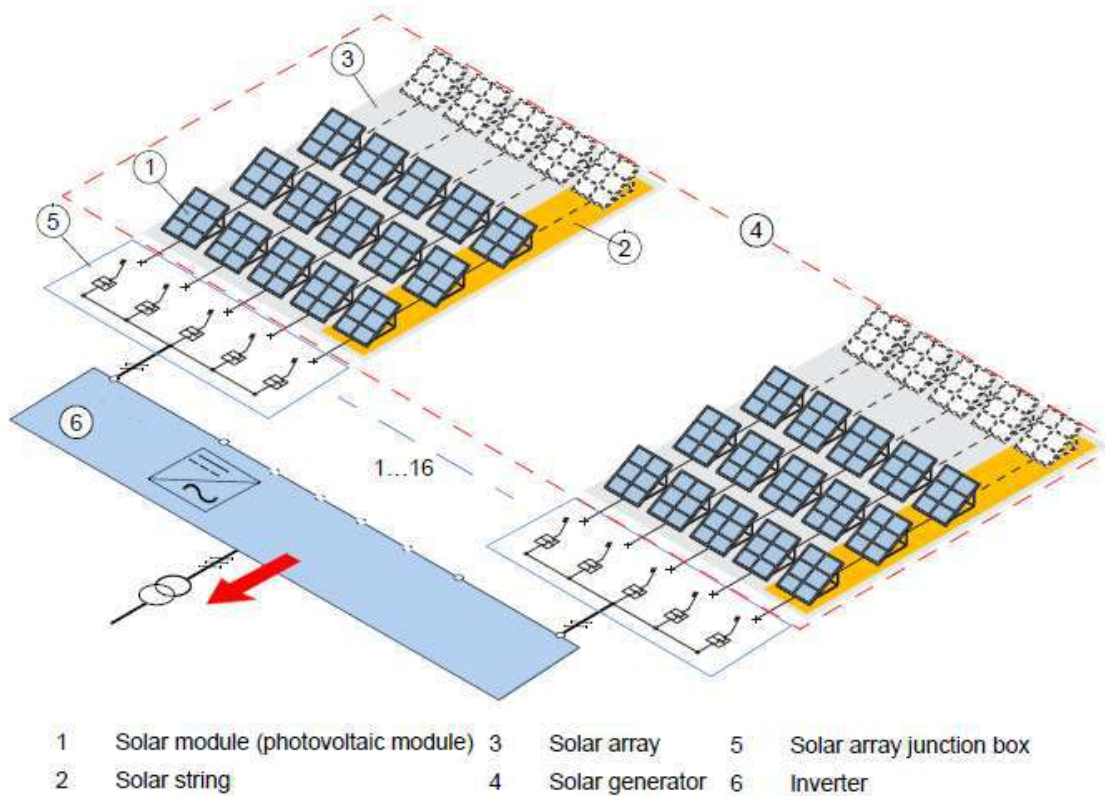


Figure 13-1: Block Diagram of Single PV Group

13.3 INTERCONNECTION OF PV MODULES AND FORMATION OF ARRAYS

The interconnection of PV modules and formation of arrays will be designed by the EPC contractor. The overall layout shall consist of PV arrays, inverters, control room/building and substation. Factors influencing the design include:

- ❖ PV module rating and dimensions
- ❖ Inverter rating and dimensions
- ❖ Principle direction of sunlight
- ❖ Topography and shape of land
- ❖ Type of sub-structure
- ❖ Geotechnical conditions
- ❖ Shading objects
- ❖ Weather and other environmental conditions
- ❖ Existing infrastructure
- ❖ Local regulation and legislation
- ❖ Utility requirements

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13.4 SCADA System

The entire plant equipment shall be connected to a SCADA system with system redundancies to monitor and display in the Plant's control room all required plant & equipment's data and signals including alarms. SCADA servers need to be fully redundant (2 x 100%) and contain hard disks for storage of plant's historic operation data. All signals required by the grid code need to be transferred to the control centre of the grid operator.

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14 CONSTRUCTION MANAGEMENT

The arrangement of EPC contract shall be back-to-back with the requirements of Energy Purchase Agreement (EPA).

Project shall ensure the Plant is designed, its components manufactured, erected and configured in such a way that it will achieve high availability and reliability with minimum power production costs, and it shall be designed to optimize the use of the solar resource for generating electricity. All plant equipment and systems shall be built to appropriate internationally recognized standards and shall comply with all the applicable national codes and statutory codes.

The PV system will be built sequentially in blocks or zones making partial connections of the facility possible if desired/feasible. A detailed execution plan will be prepared by the EPC contractor and validated by the Project Company once the relevant arrangement under the EPA and the other relevant agreements are made public, so as to make an optimized schedule for the execution of the plant within the legal boundaries.

The imported equipment (including but not limited to inverter solutions, modules, trackers, interconnection and monitoring solutions and HV equipment) may come via Karachi Sea Port. The civil work materials will be arranged from the nearest local markets / dealers. Certain items (steel accessories, local cables, electrical accessories will be delivered from appropriate cities including Islamabad, Karachi and Lahore.

The Project Company's and owner's engineer's personnel will supervise construction activities right from the beginning. The team will monitor construction schedule. The EPC contractor is to complete the project within given time frame and in-line with HSE guidelines. The Project Company shall prepare a Construction Management Master Plan, which shall be the basis that shall consider all relevant aspects. The master plan shall be regularly reviewed, updated and shared with all project stakeholders.

For the proper management of construction activities, the Project Company is expected to appoint professional consulting company to act as a "Construction Supervisor / Owner's Engineer" which shall monitor the quality and progress of all contractors and give approvals of milestones.

The project will create jobs that can be taken up by the local people. Training will be provided to unskilled labour. However, this remains in the domain of the party who will put up the project after being successful in auction process.

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15 INITIAL ENVIRONMENT EXAMINATION

The Initial Environment Examination (IEE) has been carried out as per the Pakistan Environmental Protection Act, 1997, according to the requirements of Environmental Protection Agency, Government of Sindh.

A data collection survey, which 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 the available secondary information or through data collected in the field. The primary data was collected to establish baseline conditions for the soil, water (surface and ground) quality, flora and fauna, and noise. The secondary data was collected for land, ecology, climate, and socioeconomic factors.

According to the study conducted, the prime benefit of the Project will be the replacement of conventional power generation with renewable energy and efficient utilization of the grid system. Added energy will help counteract fossil fuel powered generation, and therefore reduce suspended particulate matter and greenhouse gas emissions into the atmosphere.

This study of Initial Environmental Examination (IEE) of 120MWp solar PV project is conducted by EMC Pakistan Private Limited and is attached as Annex VI of this report.

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16 CONCLUSIONS OF FEASIBILITY STUDY

The detailed feasibility of the project has been conducted which covers all aspects required for developing the Project.

The site is feasible for the Project with suitable access for the transportation of equipment. The climatic conditions at the project site are moderate and the telecommunication and transportation facilities are adequate.

The Project shall not have negative environmental impact during its life cycle. Instead, the project will bring positive development and improve the socio-economic conditions of the area through generation of employment opportunities and contribute in environmental sustainability of the area.

Significantly improvement in the economic activities in the surrounding areas due to generation of direct and indirect employment opportunities.

The Project Area does not fall under any sensitive, protected area.

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