SINDH SOLAR ENERGY PROJECT

SINDH SOLAR ENERGY PROJECT (SSEP)
Feasibility Study Report

120 MW Solar PV Power Project

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APPROVAL SHEET

TITLE : Feasibility Study Report of 120 MW Solar PV Project

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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.

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DATE: **September 2024**

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXURES

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

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
MoP	Mitigation outcome Project
MTDF	Medium Term Development Framework
MW	Megawatt
N_2O	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

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 Renewable Resources (Pvt.) Ltd. (The Consultant) is hired by SSEP (The Client) for complete feasibility of the Project.

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.

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

Renewable Resources Pvt. Ltd, henceforth referred to as "the Consultant" for this Project site.

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.

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.

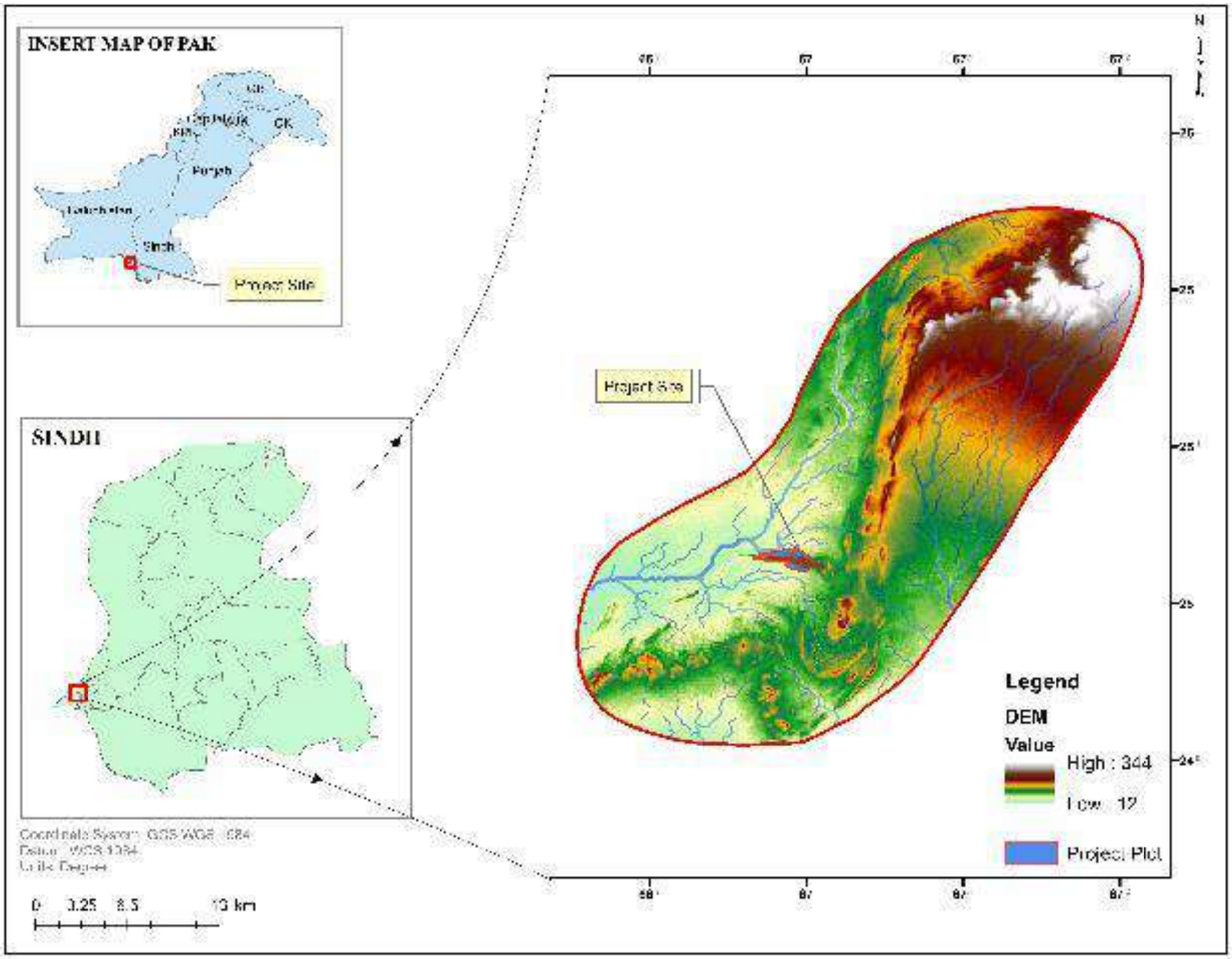


Figure 1-1: Project Site Overview

1.5 SITE LOCATION

The Project site is located at Northern side of the Karachi city in District West near 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 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. 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 location and site boundary is shown in the Figure 1-2 and Figure 1-3 respectively.

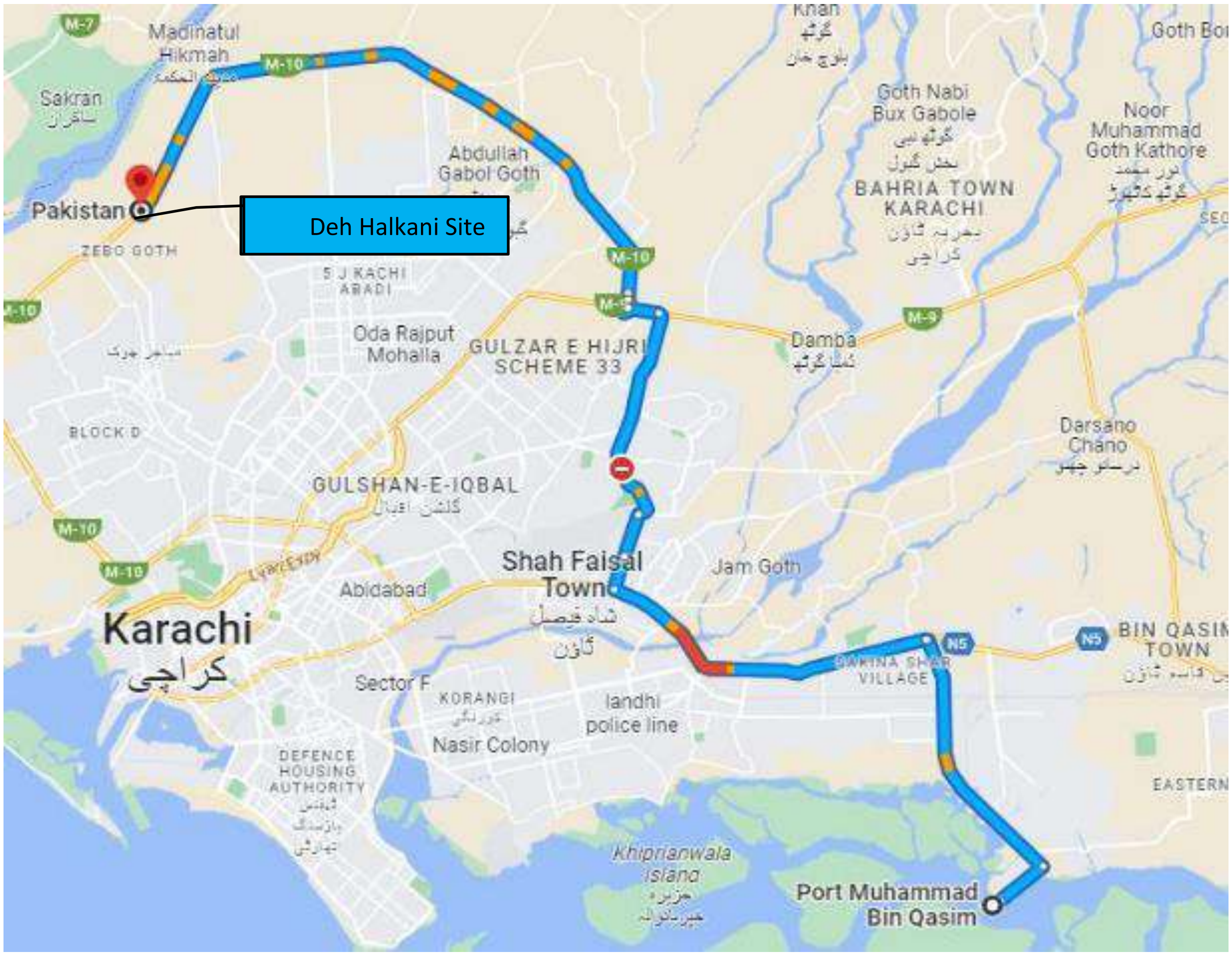


Figure 1-2: Project Location from Qasim Port Karachi (Google Map)

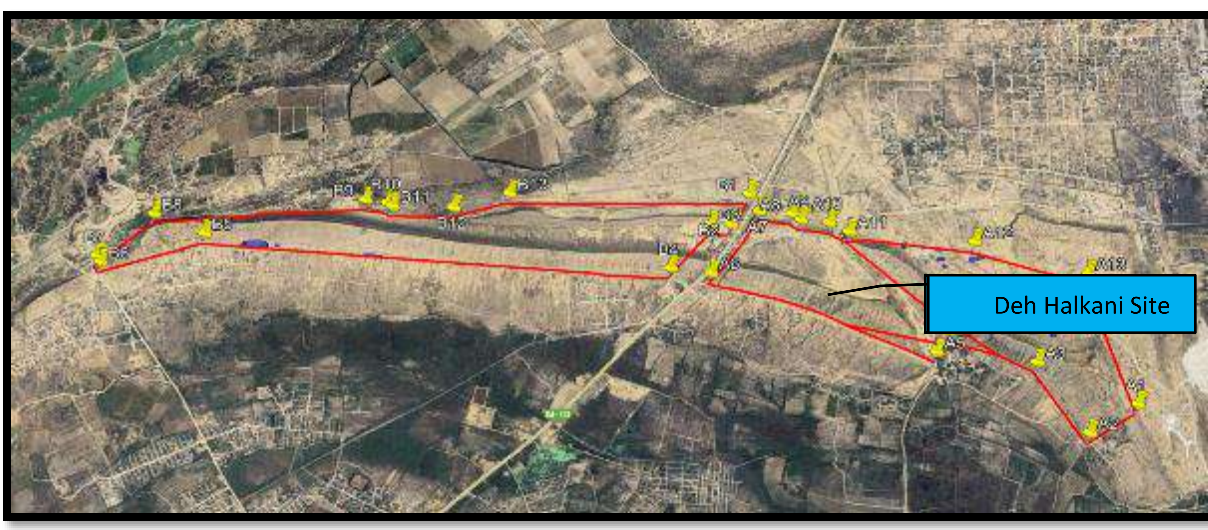


Figure 1-3: Geographical Location of Project Site and Project Boundary (source: Google Earth)

The Boundary coordinates of the project site is mentioned below in Table 1-1.

Table 1-1: Boundary Coordinates of Project Site

Boundary	Latitude	Longitude
A1	25° 1'7.62"N	67° 0'45.53"E
A2	25° 1'2.03"N	67° 0'35.52"E
A3	25° 1'16.57"N	67° 0'25.60"E
A4	25° 1'23.49"N	67° 0'7.91"E
A5	25° 1'19.11"N	67° 0'5.17"E
A6	25° 1'36.36"N	66°59'19.33"E
A7	25° 1'48.93"N	66°59'29.76"E
A8	25° 1'48.22"N	66°59'36.54"E
A9	25° 1'46.88"N	66°59'38.31"E
A10	25° 1'46.25"N	66°59'44.13"E
A11	25° 1'44.16"N	66°59'48.22"E
A12	25° 1'41.50"N	67° 0'14.13"E
A13	25° 1'34.45"N	67° 0'37.11"E
B1	25° 1'52.54"N	66°59'27.82"E
B2	25° 1'46.32"N	66°59'23.82"E
B3	25° 1'46.39"N	66°59'19.67"E
B4	25° 1'37.58"N	66°59'10.98"E
B5	25° 1'47.03"N	66°57'34.52"E
B6	25° 1'41.58"N	66°57'12.98"E
B7	25° 1'42.92"N	66°57'12.12"E
B8	25° 1'51.30"N	66°57'24.06"E
B9	25° 1'53.25"N	66°58'7.94"E
B10	25° 1'52.47"N	66°58'12.57"E
B11	25° 1'51.76"N	66°58'13.58"E
B12	25° 1'51.25"N	66°58'26.20"E
B13	25° 1'53.93"N	66°58'37.96"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.

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	Deadline for bid submission	1	30-Sep-24
2	Evaluation and selection of successful Bidder	20	20-Oct-24
3	Submission of Bid Evaluation to NEPRA	15	04-Nov-24
4	NEPRA Approval of Auction Evaluation Report	26	30-Nov-24
4	Issuance of LOI to SB	2	02-Dec-24
5	SPV formation by successful Bidder	7	09-Dec-24
6	Application to NEPRA by the Successful Bidder for Generation License and Tariff Approval	16	25-Dec-24
7	Tariff and GL approval by NEPRA	40	03-Feb-25
8	Submission of EPA to NEPRA for approval	7	10-Feb-25
9	Execution of Project Agreements including Site sub-lease agreement/Approval of EPA by NEPRA	79	30-Apr-25
10	Financial Close	30	30-May-25
11	COD	300	26-Mar-26

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), JA Solar (Si-Mono Bifacial) and First solar (Thin-film/Cdte).

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 Angle	Pitch (m)	Performance Ratio PR	Produced Energy MWh/year	Specific prod. kWh/kWp/year	Near Shadings %	Capacity Factor %
Trina (mono)	S/A	+/-60	7.5	76.98	221365	1844	5.68	21.06
Trina (Bifacial)	S/A	+/-60	7.5	80.57	231675	1930	5.68	22.04
Canadian Solar (Mono)	S/A	+/-90	7.5	76.2	219092	1826	5.68	20.84
JA Solar (Bifacial)	S/A	+/-60	6.3	85.31	237681	1981	2.1	22.6
First Solar (Thin film)	S/A	+/-60	7.5	78.85	226701	1889	5.68	21.56

1.9.2 Plant Layout and Configuration

A preliminary general layout for 120 MWp Single Axis tracking PV system installation is shown in Figure 1-4.

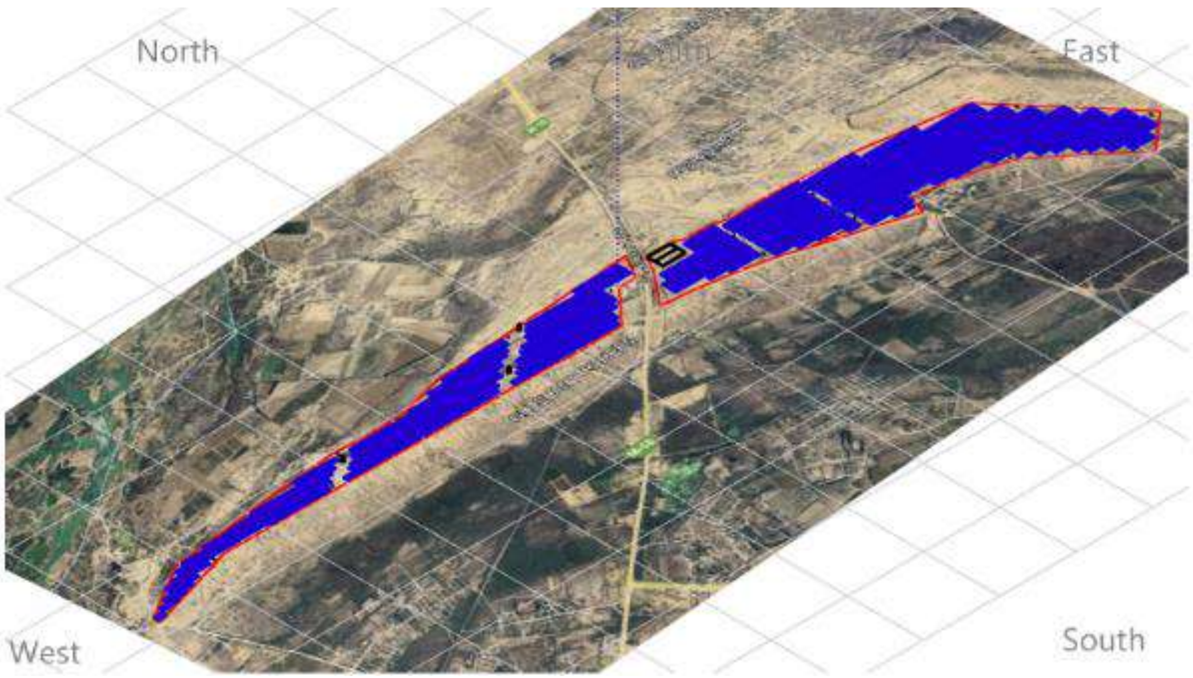


Figure 1-4: Preliminary Plant Layout (Single Axis Tracking System)

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 JA 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	JAM66D45-620/LB
Manufacturer	JA Solar
Nominal Power [W]	620
Efficiency [%]	23
Power Tolerance [%]	± 5
Cell Type	Si-mono
Open Circuit Voltage [V]	48.5
Short Circuit Current [A]	17.42
MPP Voltage [V]	1500
MPP Current [A]	35
Power Coefficient of Temperature [-%/C]	-0.3
Nominal Operating Cell Temperature (NOCT)	45± 2
Height X Width X Thickness [mm]	2382X 1134 X 30

Table 1-6: Major Technical Characteristics of Inverter

Parameters	Description
Inverter Model	Sungrow-8800kW
Manufacturer	Sungrow
Nominal AC Capacity	8800 kW
Maximum DC input Power	10560 kWp
MPP voltage range	938V – 1500 V
Maximum DC current	11840 A
Nominal AC Current	9240 A
Maximum Efficiency	99
European Efficiency	98.7
Operating temperature range	-35°C to +60°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	Single Axis
Module Type	Si-Mono (Bifacial)
Inverter Type	SG8800
Pitch	6.3m
Tilt	Variable
Installed capacity (DC)	120MWp
Total Number of Modules	193,564
Modules per inverter	16,130
Number of Modules in series	28
DC/AC Ratio	1.14
Number of inverters	12
Nominal AC Power of One Inverter [kW]	8800
Total AC Power [kW]	105,600

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.
- 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 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.

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 km^2 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 spanning more than 1,800 km.

Electricity in Pakistan is generated, transmitted, distributed, and retailed by two vertically integrated public sector companies. The Water and Power Development Authority (WAPDA) is responsible for the production of hydroelectricity, which is then supplied to consumers by 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) in the public sector, excluding Karachi. For the city of Karachi and its surrounding areas, Karachi Electric (K-Electric) is responsible for electricity supply.

According to the State of Industry Report 2022, Pakistan's total installed power generation capacity is 43,775 MW. Of this capacity, 60% is generated from thermal sources (fossil fuels), 25% from hydro, 6.48% from renewable sources (wind, solar, and biomass), and 8.27% from nuclear. Renewable energy (RE) resources have significant potential to help close the energy deficit. Reflecting the current government's focus on renewable energy, the Ministry of Energy recently revised the Renewable Energy (RE) Policy 2019. According to the revised policy, the Government of Pakistan aims to derive 60% of its energy from renewable sources, including hydro, by 2030, reducing the country's dependence on imported fuel products.

[1] **Source: Pakistan Bureau of Statistics latest census in 2017**

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.

	As on 30-06-2021	As on 30-06-2022	Variation Capacity (MW)	Variation (%)	Comments
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) **License Expired** (a) GENCO-IV (b) Reshma Power (c) Gulf Power (d) Southern Electric (e) Japan Power (f) Altern Energy **Decommissioned** (a) BQPS-I Unit-III (b) KANUPP
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	
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:

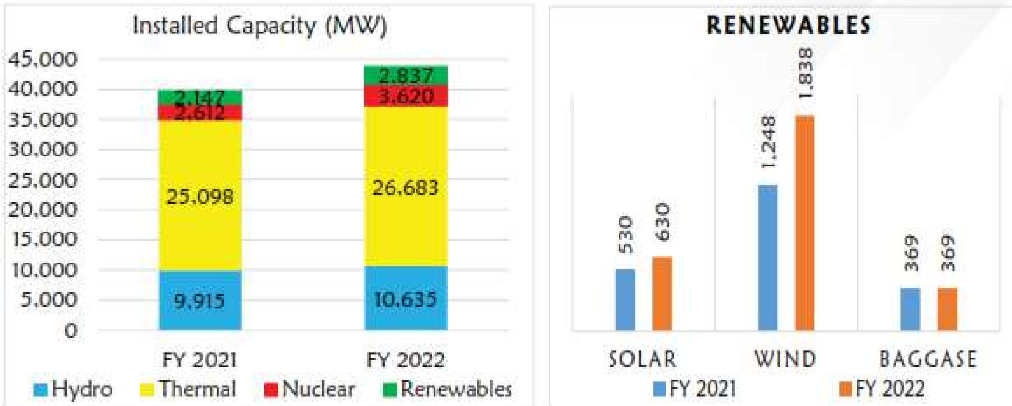


Figure 2-2: installed capacity and bifurcation of Renewables for FY 2020-21 and FY 2021-22

Pakistan's electricity sector is a developing market that has struggled for years to balance supply and demand. The maximum total demand from residential and industrial sectors stands at nearly 31,000 MW, while the transmission and distribution capacity is approximately 22,000 MW. This results in a deficit of about 9,000 MW during peak demand periods. Despite the peak demand being well below the installed capacity of 43,775 MW, the inability to transmit the additional required 9,000 MW worsens the problem. The outdated and substandard quality of the electricity distribution infrastructure further contributes to persistent power outages and load shedding.

The government is making efforts to increase electricity generation, upgrade the distribution infrastructure, reduce transmission losses, eradicate power outages, and make electricity more affordable in the future. Although power generation has remarkably increased since 2013 thereby mitigating the frequent power blackouts of the past decade, the sector still faces challenges such as expensive fuel sources, reliance on imported energy products, chronic natural gas shortages, substantial debt, and aging transmission and distribution systems.

This entire situation and availability of rich wind + solar resources make a qualified case for putting up renewable energy-based plants in Pakistan.

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.

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 2023 and HDIP's Pakistan Energy Yearbook 2022-23.

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 the latest available energy yearbook for the year 2022-23. The share of each source in primary energy supplies for 2022-23 was: oil: 24.3%, natural gas: 28.9%, LNG import: 9.7%, LPG: 1.9%, coal: 15.2 %, electricity (Hydro, Nuclear, Renewable): 19.9%. However, the overall primary commercial energy supply mix during 2022-23 has decreased by 12.1 % as compared to the previous year.

Oil production slightly decreased by 5.3% from 73,436 Barrels per day in 2021-22 to 69,513 Barrels per day in 2022-23. Natural gas production moved down slightly by 4% from 3,390 MMCFD in 2021-2022 to 3,259 MMCFD in 2022-23.

Import of petroleum products has decreased in 2022-2023 by 37.6% as compared to the last year. Import of crude oil by refineries also decreased by 29.4%. The oil import bill for the year 2022-23 was 13.6 billion US dollars. The overall oil consumption during 2022-23 decreased significantly by 26.49% from 22.8 million tonnes to 16.7 million tonnes.

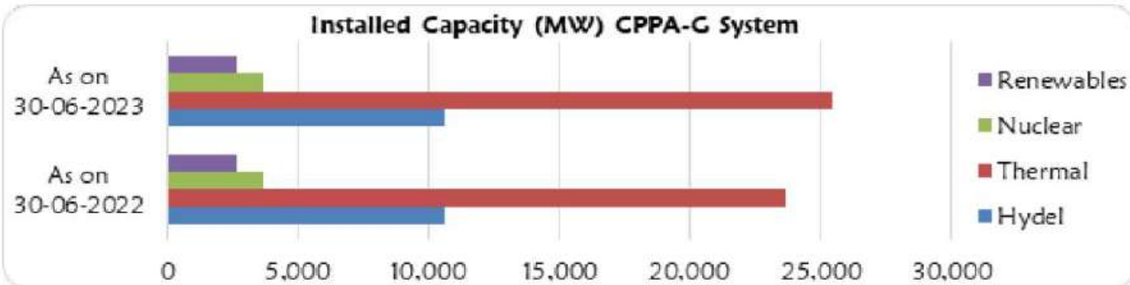
During 2022-23, coal production stood at 15.01 million tonnes showing growth of 56.47% as compared to previous year. The import of coal has decreased by 50.8% during 2022-23 over the previous year.

As per the latest NEPRA State of Industry Report 2023, the total installed generation capacity of public sector power plants in Pakistan as of June 30, 2023, was 22,847 MW, while the installed generation capacity of private sector power plants, including K-Electric (KE), was 23,038 MW. The installed capacity of the CPPA-G system stands at 42,362 MW, consisting of 25,490 MW from thermal power (GENCOs, IPPs, and SPPs), 10,635 MW from hydroelectric sources, 1,838 MW from wind power, 530 MW from solar energy, 249 MW from bagasse, and 3,620 MW from nuclear sources. The recent addition of the 1,145 MW K-3 Nuclear Power Plant has significantly enhanced the country's nuclear generation capacity.

KE's own installed generation capacity is 2,816 MW, which is insufficient to meet the growing demand. To address this shortfall, KE procures additional electricity from various external sources, including 366 MW from thermal IPPs, 100 MW from solar, 139 MW from SPPs/CPPs, and approximately 1,100 MW from the CPPA-G system.

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.



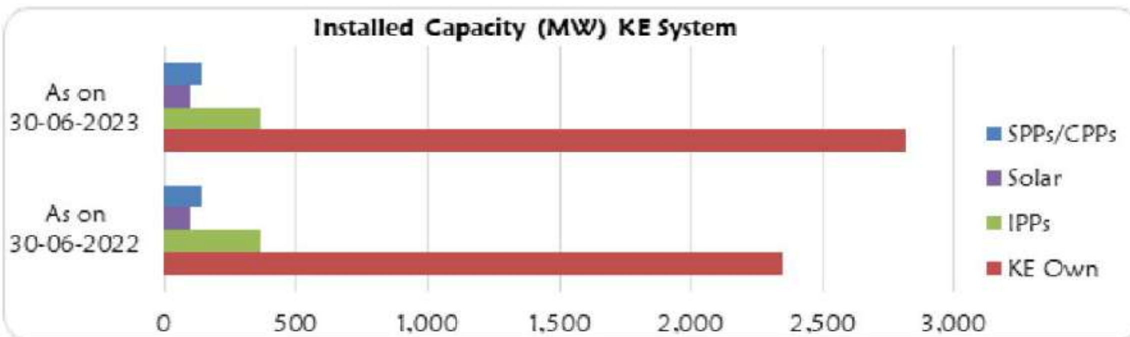


Figure 3-1: Electricity Installed Capacity (GW) by Source

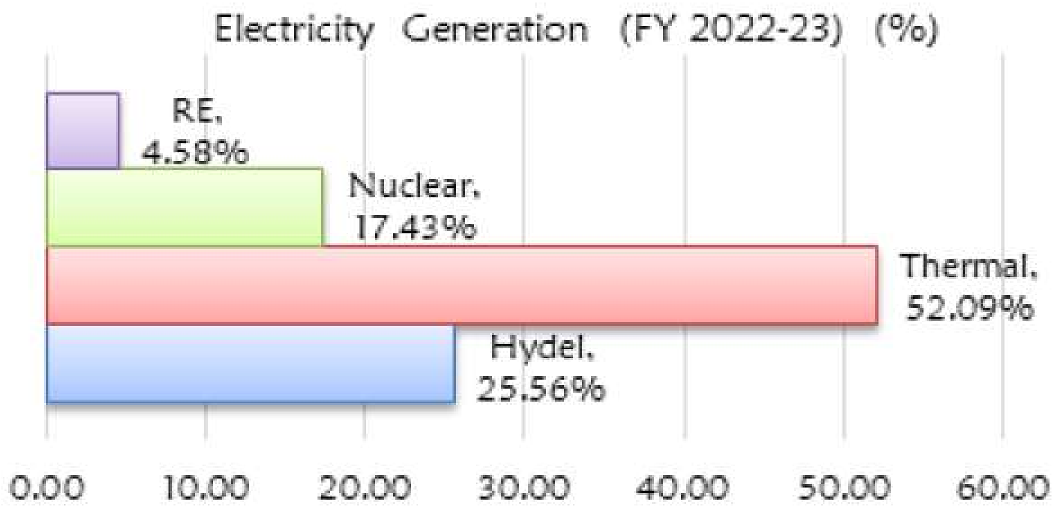


Figure 3-2: Electricity Generation (%) by Source

3.3 ELECTRICITY CONSUMPTION

In FY 2022-23, Pakistan's total electricity sales reached 112,891.20 GWh**,** reflecting a 10.40% decline compared to FY 2021-22. Domestic consumption dropped by 12.87% to 53,522.91 GWh, while industrial consumption fell by 9.23% to 31,088.00 GWh**.** Agricultural consumption experienced a 14.45% decrease to 9,639.68 GWh, and commercial consumption decreased by 3.84% to 8,891.62 GWh**.** In contrast, public lighting grew by 11.10% to 459.59 GWh, and bulk supply increased by 8.44%**.** Electricity supplied to K-Electric (KE) decreased slightly by 0.85% as shown in Figure 3-3.

Category	FY 2020-21	FY 2021-22		FY 2022-23	
	Units Sold (GWh)	Units Sold (GWh)	Growth (%)	Units Sold (GWh)	Growth (%)
Domestic	57,855.86	60,408.89	4.23	53,522.91	-12.87
Commercial	8,396.55	9,233.35	9.06	8,891.62	-3.84
Industrial	29,885.94	33,957.77	11.99	31,088.00	-9.23
Agricultural	10,237.02	11,032.61	7.21	9,639.68	-14.45
Public Lighting	589.89	408.59	-44.37	459.59	11.10
Bulk Supply	3,613.08	4,078.89	11.42	4,454.68	8.44
Others	4,863.06	5,508.80	11.72	4,834.72	-13.94
Total	**115,441.40**	**124,628.90**	7.37	**112,891.20**	**-10.40**
Supplied to KE	6,118.04	9,036.54	32.30	8,960.81	-0.85

Figure 3-3: Electricity Sales by Consumer Category and Growth (FY 2020-21 to FY 2022-23)

Furthermore, Industrial consumption was recorded at 31,088.00 GWh, and agriculture consumed 9,639.68 GWh. The remaining 4,834.72 GWh was consumed by other categories.

In FY 2022-23, Pakistan's total electricity consumption dropped by 10.40%, reaching 112,891.20 GWh. This decline was spread across key sectors:

- Domestic consumption decreased by 12.87%, down to 53,522.91 GWh.
- Industrial consumption fell by 9.23%, to 31,088.00 GWh.
- Agricultural consumption saw the largest drop, with a 14.45% reduction to 9,639.68 GWh.
- Commercial consumption slightly decreased by 3.84%, totaling 8,891.62 GWh.

Despite the current reductions, Pakistan’s energy demand is projected to rise in the future. To meet this demand sustainably, the Indicative Generation Capacity Expansion Plan (IGCEP) highlights a shift toward hydro and renewable sources. This strategy, approved by NEPRA, is updated yearly to ensure a balanced and cost-effective approach to energy generation.

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.

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/m^2/day to 2750 W/m^2/day in Pakistan especially in Southern Punjab, Sindh and Balochistan regions throughout the year. In an area of 100m^2, 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 780 MW (12 PV projects) are in operation. 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-Jul-15
2	Appolo Solar Development Pakistan Limited	100	31-May-16
3	Best Green Energy Pakistan Limited	100	31-Jul-16
4	Crest Energy Pakistan Limited	100	31-Jul-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.)	100	08-Dec-22
10	Meridian Energy (Pvt.) Ltd	50	31-Jan-24
11	HND Energy (Pvt.) Limited	50	31-Jan-24

12	Helios Power (Pvt.) Limited	50	31-Jan-24

4.3.2 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 mechansim to provide opportunity to all under development projects. The projects that fulfill certain criteira 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 mechansim 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.

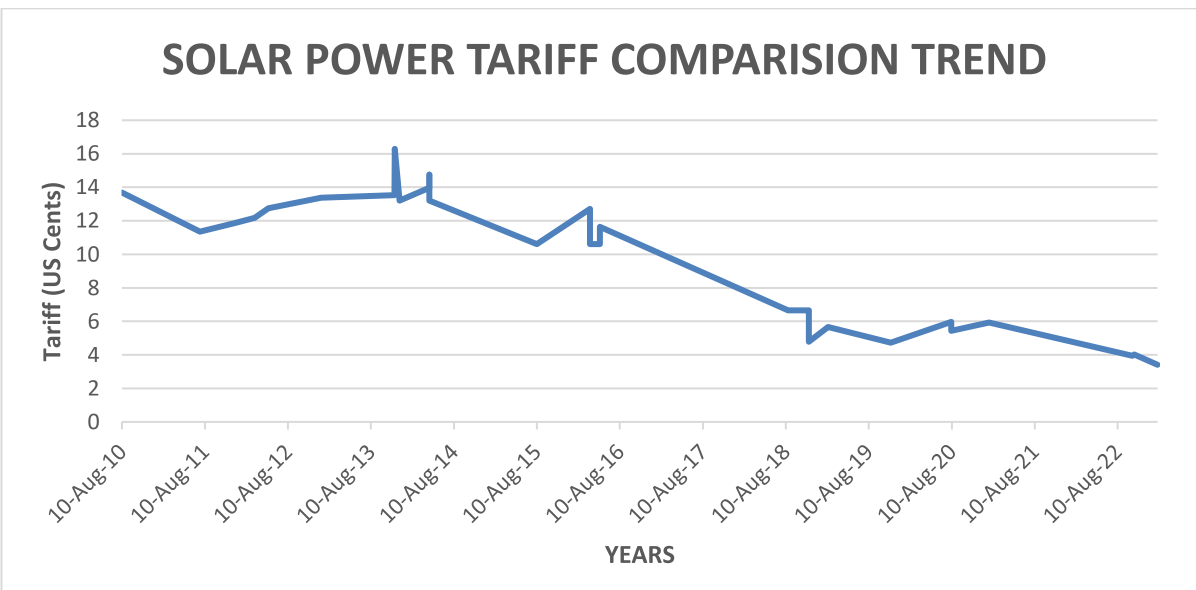


Figure 4-1: Levelized Tariff of Solar Power Projects

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:

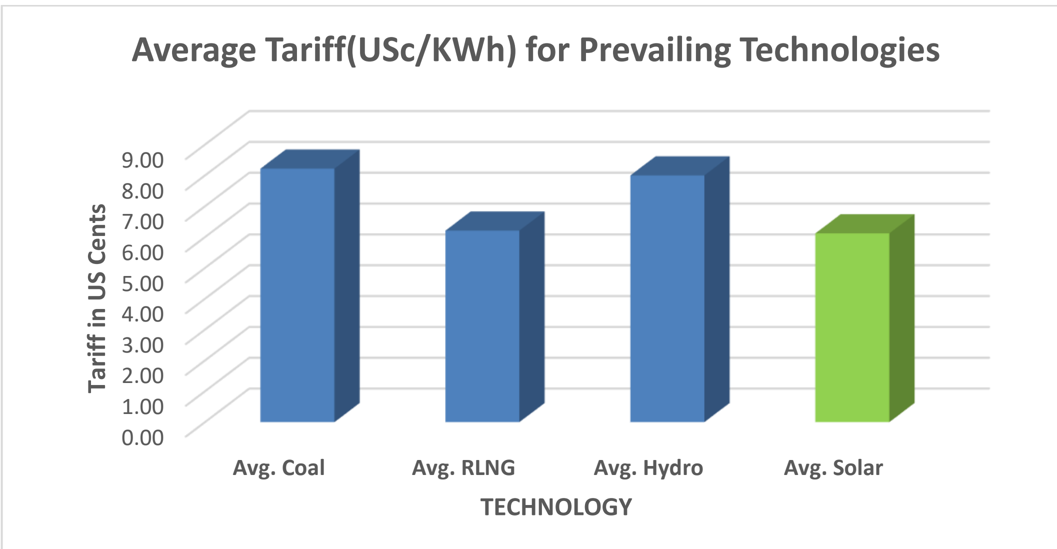


Figure 4-2: Average Tariff for Prevailing Technologies

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.

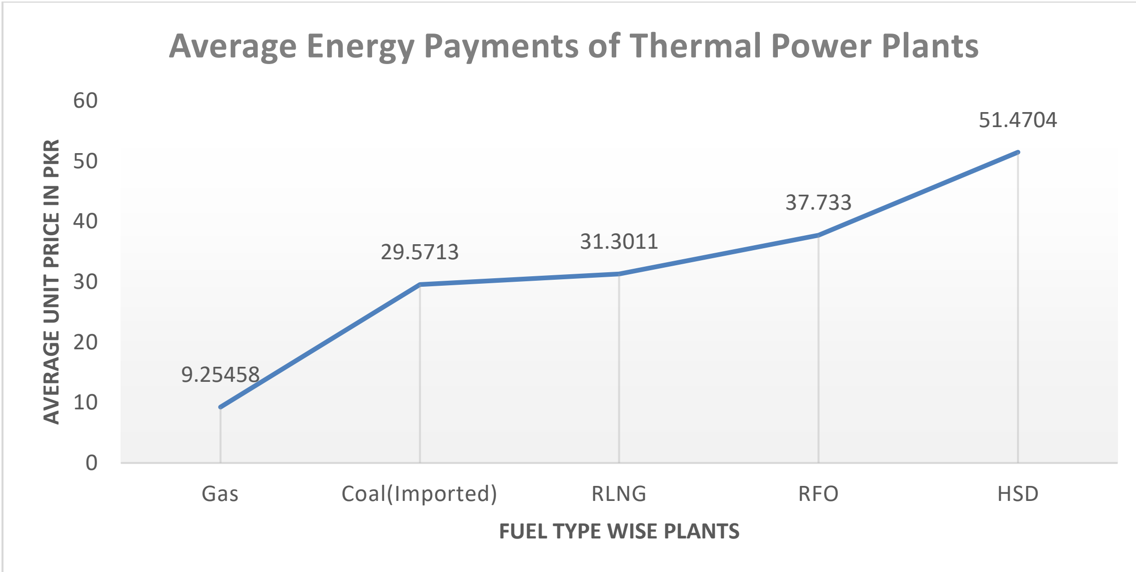


Figure 4-3: Average Energy Payments per kWh of Thermal Power Plants – Fuel Type Wise

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 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.

5 REGULATORY REGIME IN PAKISTAN

The renewable energy power sector in Pakistan was initially governed under the ARE Policy 2006, which was extended multiple times upon expiry. Projects were developed and constructed based on either a negotiated (cost plus) tariff or a feed-in (upfront) tariff. Recognizing the need for industry advancement, various studies were conducted between 2016 and 2021 to evaluate prospects for more renewable energy projects, ideal shares of renewable energy in the overall mix, realistic targets, and tariff mechanisms. These outcomes were captured in the ARE Policy 2020 and IGCEP 2022-31. This entire scheme has stood on the following:

5.1 VARIABLE RENEWABLE ENERGY (VRE) INTEGRATION – PLANNING STUDY

Funded by the World Bank and performed by international consultants, the VRE Planning Study aimed to identify the optimal share of renewable energies in Pakistan's energy mix, considering both technical and financial aspects. The study proposed targets of 22,600 MW of renewable energy by 2025 and 32,500 MW by 2030, with wind energy contributing 4,600 MW by 2025 and 6,900 MW by 2030.

5.2 VARIABLE RENEWABLE ENERGY (VRE) INTEGRATION – LOCATIONAL STUDY

Also funded by the World Bank, the Locational Study extended the VRE Planning Study by assessing how much renewable energy capacity could be installed without major grid upgrades. The study identified over 100 potential project sites, with 19 in Sindh Province, including the Jhimpir region as a significant location for hybrid wind and solar installations.

5.3 ARE POLICY 2020

ARE Policy 2020 withdrew the cost plus and upfront tariff mechanisms for future renewable projects, except in government-to-government cases. Instead, it introduced competitive bidding (auctions). Projects under the 2006 policy were categorized based on their development progress, with some allowed to continue under the old tariff and others required to participate in competitive bidding. The policy aims for 20% of generation capacity from renewable sources by 2025 and 30% by 2030, requiring an additional 17,536 MW capacity by 2031.

5.4 INTEGRATED GENERATION AND CAPACITY EXPANSION PLAN (IGCEP)

Prepared by NTDC and approved by NEPRA, IGCEP details yearly capacity additions in the power sector, aligning with the VRE and Locational Studies and ARE Policy 2020 targets. The most current plan, IGCEP 2022-31, outlines renewable energy capacity additions annually, totalling 20,281 MW by 2031.

5.5 SINDH SOLAR ENERGY PROGRAM (A WORLD BANK INITIATIVE)

The Sindh Solar Energy Project aims to increase solar power generation and access to electricity in Sindh Province. It includes four components: development of utility-scale solar parks, procurement and installation of distributed solar systems on public buildings, deployment of solar home systems in areas with low or no electricity access, and capacity building and technical assistance.

5.6 FRAMEWORK GUIDELINE – FAST TRACK SOLAR PV INITIATIVES 2022

The GOP is implementing a Framework Guideline to deploy solar power on a fast-track basis, aiming to complement or substitute expensive fossil fuels for power generation. This initiative seeks to save foreign reserves spent on fuel imports, provide affordable electricity, and promote sustainable development in the long run.

5.7 KE's SHORT TERM INITIATIVES

K-Electric (KE), the primary electricity provider for Karachi, is advancing a strategic renewable energy plan that could reshape the city's power landscape. The company has taken significant steps towards adding more renewable capacity to the local grid. KE's ongoing auctions which are provided as under are all in line with open competitive bidding regulations established by the National Electric Power Regulatory Authority (NEPRA). These projects aim to diversify the KE's energy mix while driving down costs and reducing environmental impact.
The six projects include:

1. **50 MW Solar Project at Winder, Balochistan**
2. **100 MW Solar Project at Bela, Balochistan**
3. **220 MW Site Neutral Hybrid Project at Dhabeji**
4. **120 MW Sindh Solar Energy Project (SSEP) at Deh Halkani**
5. **150 MW Sindh Solar Energy Project (SSEP) at Deh Metha Ghar**
6. **300 MW Wind Project in Category III**: PPIB will conduct the auction, and KE will be the off-taker.

These initiatives are part of KE's larger effort to embrace renewable energy sources to reduce its dependence on more expensive thermal fuel and lower overall emissions. These projects also align with the broader national objective to increase the share of renewable energy in the energy mix by 2030 and KE's strategic initiative aims to introduce 1,200 MW of renewable energy into its portfolio by 2030.

5.8 Key Regulatory Bodies and Their Functions in Pakistan's Energy Sector

The regulatory landscape involves multiple stakeholders, including:

- 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

5.8.1 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 analysing energy market trends and providing regular reports on the energy sector.

5.8.2 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 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.

5.8.3 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
- 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.

5.8.4 PRIVATE POWER AND INFRASTRUCTURE BOARD (PPIB)

Private Power and Infrastructure Board (PPIB) is the sole representing agency of the Federal Government to handle and facilitate the power projects including those based on renewables.

PPIB was established in 1994 and renewable energies were not primarily part of its scope. Later in May 2003, Alternative Energy Development Board (AEDB) was created as a separate body to introduce Alternative and Renewable Energies (AREs) at an accelerated rate as to achieve sustainable economic growth. After making solid progress, the Government of Pakistan decided to create synergies between the functions of PPIB and AEDB. Hence, the governing Act of AEDB was repealed and that of PPIB was amended to merge AEDB into it.

5.8.5 CENTRAL POWER PURCHASING AGENCY GUARANTEE LIMITED (CPPA-G)

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.
- 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.

5.8.6 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.

5.8.7 K-ELECTRIC

K-Electric (KE) is a vertically-integrated power utility in Pakistan, responsible for the generation, transmission, and distribution of electric energy. Serving over 3.4 million customers, KE's operational territory spans across Karachi, Dhabeji, Gharo in Sindh and Uthal, Vinder, Bela in Balochistan, covering a total area of 6,500 square kilometres.

Founded in 1913 as the Karachi Electric Supply Company, KE has undergone significant transformations, including privatization in 2005 and rebranding in 2014. The company has invested over PKR 474 billion across the power value chain to enhance its infrastructure and service delivery. KE operates its own generation units with an installed capacity of 1,875 MW and sources an additional 1,680 MW from external producers, including 1,100 MW from the national grid. The transmission system comprises approximately 1,354 kilometres of high-voltage lines and 71 grid stations.

KE’s extensive distribution network ensures reliable power supply to residential, commercial, industrial, and agricultural consumers. The company has implemented advanced metering infrastructure and grid automation technologies to improve operational efficiency and customer service.

In terms of renewable energy, KE is actively pursuing projects to diversify its energy mix. The company has planned significant investments in solar and wind energy projects to increase the share of renewables in its portfolio to 30% by 2030. This initiative is part of KE’s broader strategy to reduce reliance on fossil fuels, lower emissions, and promote sustainable energy practices.

Additionally, KE has also conducted a Variable Renewable Energy (VRE) Integration Study with international consultants to determine the optimal capacity for renewables, identify necessary network upgrades, and explore strategies to maximize renewable utilization.

KE's efforts in modernizing its infrastructure and enhancing operational efficiency have been recognized globally, making it a key player in Pakistan's energy sector. Furthermore, the company’s Power Acquisition Programme is set to introduce 1,200 MW of renewable energy into its portfolio by 2030, aligning with national energy goals and contributing to the country's sustainable development.

5.8.8 SINDH TRANMISSION 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.

5.8.9 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.

6 RELEVANT PROGRESS IN POLICY AND REGULATORY FRAMEWORK

6.1 Competitive Bidding (Auction) of Tariff

Under the ARE Policy 2019 and NEPRA (Electric Power Procurement) Regulations, 2022, the Project is participating in a Site-Specific Competitive Tariff bidding process for the development of the hybrid project on a BOOT basis.

6.2 Pre-Qualification and Bid Submission against RFP

The Pre-Qualification process evaluates potential Bidders' qualifications and suitability to ensure only the most qualified candidates are invited to submit formal proposals. This has been done by done by KE. The Request for Proposal (RFP) includes detailed terms, bid requirements, proformas and agreement forms to be signed with successful Bidders. The entire tender package has been approved by NEPRA. This auction does not carry feasibility studies with the RFP because its site neutral in nature and each bidder is participating with a project developed at its own land. Hence, the project has to prepare the feasibility study and submit with its tariff bid.

6.3 Arrangement of Land

The land shall be provided by the SSEP for the construction of the Complex at the Site and the Successful Bidder/SPV shall pay the Solar Park Fee to the GOS (or the nominee of the same) in accordance with the terms set in the KE RFP.

6.4 Bids Evaluation

After the bidding process, KE will evaluate the bids and submit an evaluation report to NEPRA for approval.

6.5 Letter of Intent (LOI)

After the bidding process, KE will issue an LOI to the successful bidder, which will stipulate next steps till the financial closing.

6.6 Generation License, Tariff, Energy Purchase Agreement (EPA)

After receiving the LOI, the successful bidder will apply for a generation license and tariff at NEPRA. Subsequent to tariff award, the EPA will be signed with KE.

7 PROJECT SITE

7.1 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.

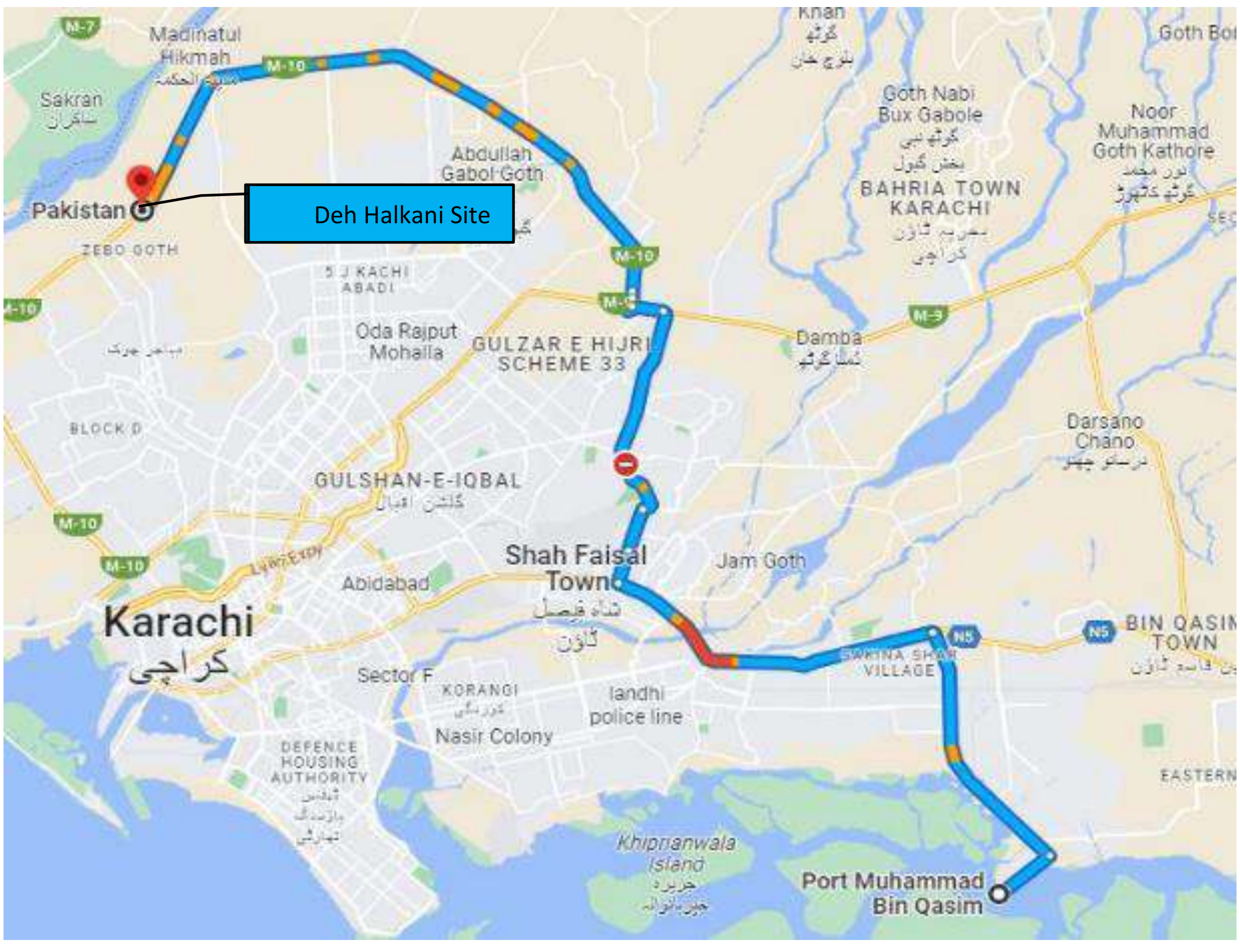


Figure 7-1: Project Site location

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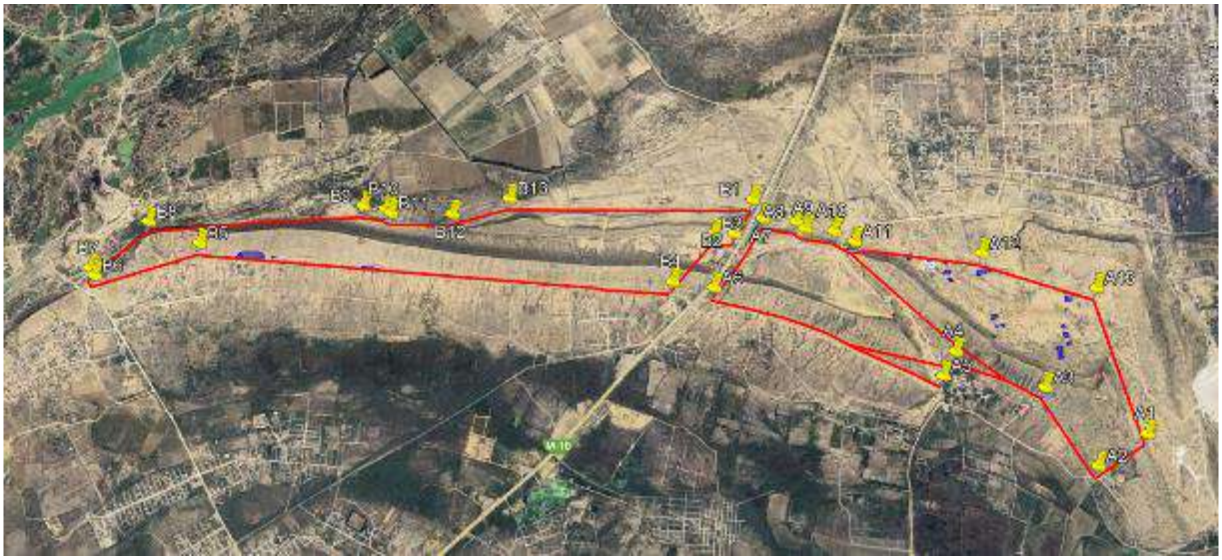

Figure 7-3: Deh Halkani Site Google Earth Imagery

The Project is intended to build in the approximate area of 612 acres. The project site is irregularly shaped and has two (02) sections very close to each other as shown in Figure 7-3. Two transmission lines are crossing from the partial B of the project site.

Technical arrangements and their implementation in respect of right of way and cable crossings between these 02 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.

7.1.1 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 3.9%, while that in North to South direction is 11.9% as seen in the Figure 7-4 and Figure 7-5 respectively.

Figure 7-4: Partial A Elevation profile of Project Site W-E

Figure 7-5: Partial A Elevation profile of Project Site N-S

The average slope of the partial B in West to East direction is 4.9%, while that in North to South direction is 18.3% as seen in the Figure 7-6 and Figure 7-7 respectively.

Figure 7-6: Partial B Elevation profile of Project Site N-S

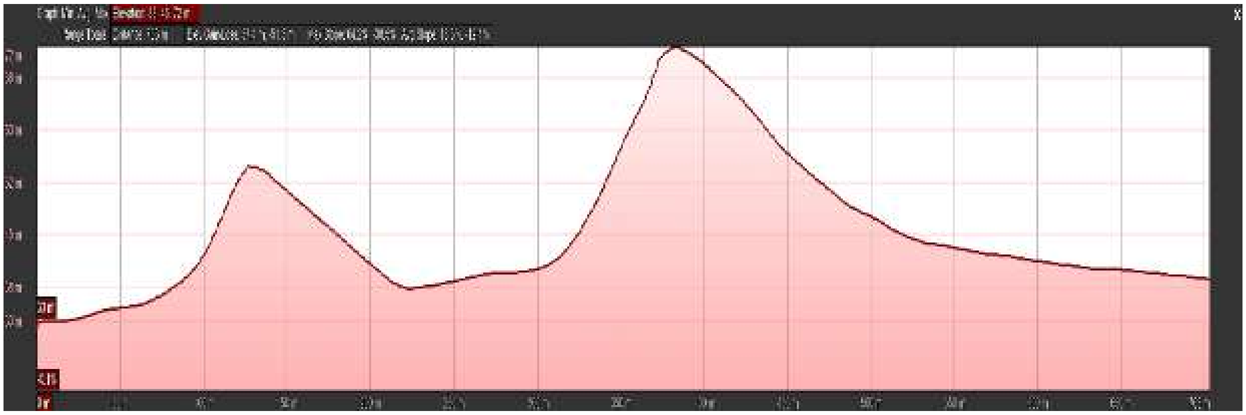

Figure 7-7: Partial B Elevation profile of Project Site N-S

Figure 7-8: Panoramic View of West to East Slope Area

There are small hills in the site area that can compromise the installation of PV modules in some pockets and hence reducing total installed capacity. These are visible in the topographic maps of the site and also seen physically at site. The impacted area is approx. 330 acres.

Refer to below image for high level identification of impacted are identified in blue.

Figure 7-9: Impacted area

The Client has informed that the hills / inclined area will be removed / smoothened, such that the complete site area has maximum 10-degree slope. Same has been assumed for setting up the PV field layout in the Solar Resource Assessment and Energy Yield Estimation Report. The Client has further informed that a revised contour map will be prepared and circulated to the respective bidders for using as basis.

However, the Client is internally assessing whether such flattening will be arranged by the Client or if the bidders will be required to assume this activity in their scope. Such clarifications are recommended to go in the Tariff RFP package.

There are also two HV transmission lines passing through the west side land parcel of the site which are marked in green in the figure below. The exact coordinates for the transmission line are presented in the updated Topographical survey map.

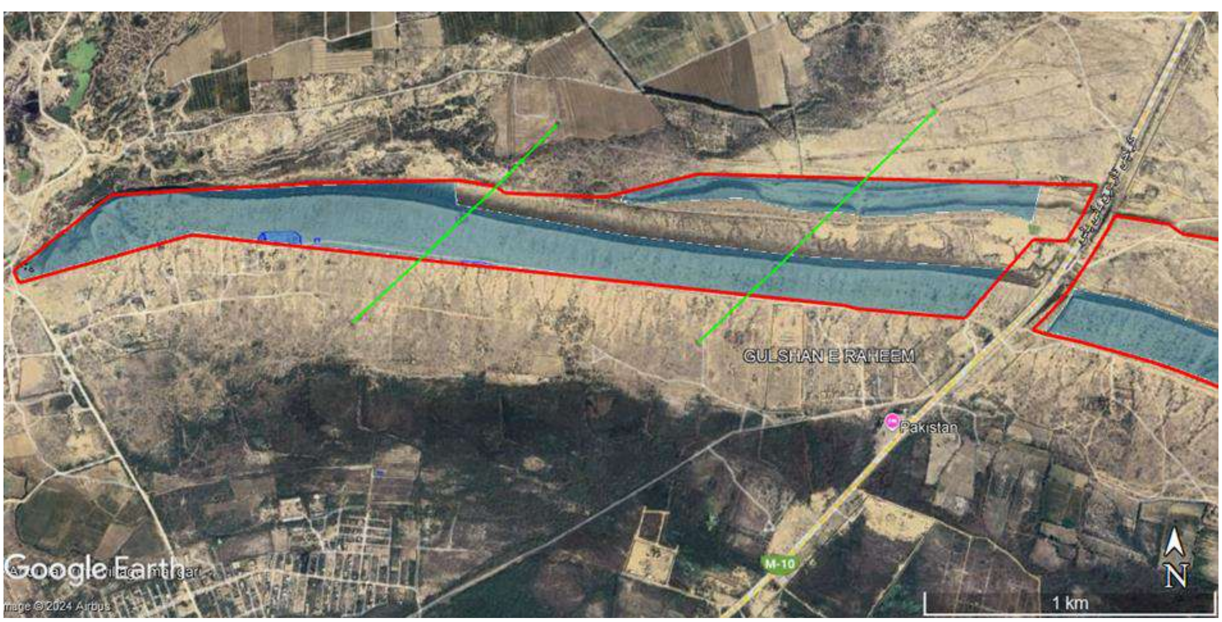

Figure 7-10: Location of HV Transmission lines in the map

The Consultant has considered all the land marks presented above while developing the layout for the 120MWp solar project and has left sufficient space around these obstacles considering the safety margins and access. The layout is shown in Section 4.2.2.

7.1.2 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 into 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.

7.2 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 7-11.

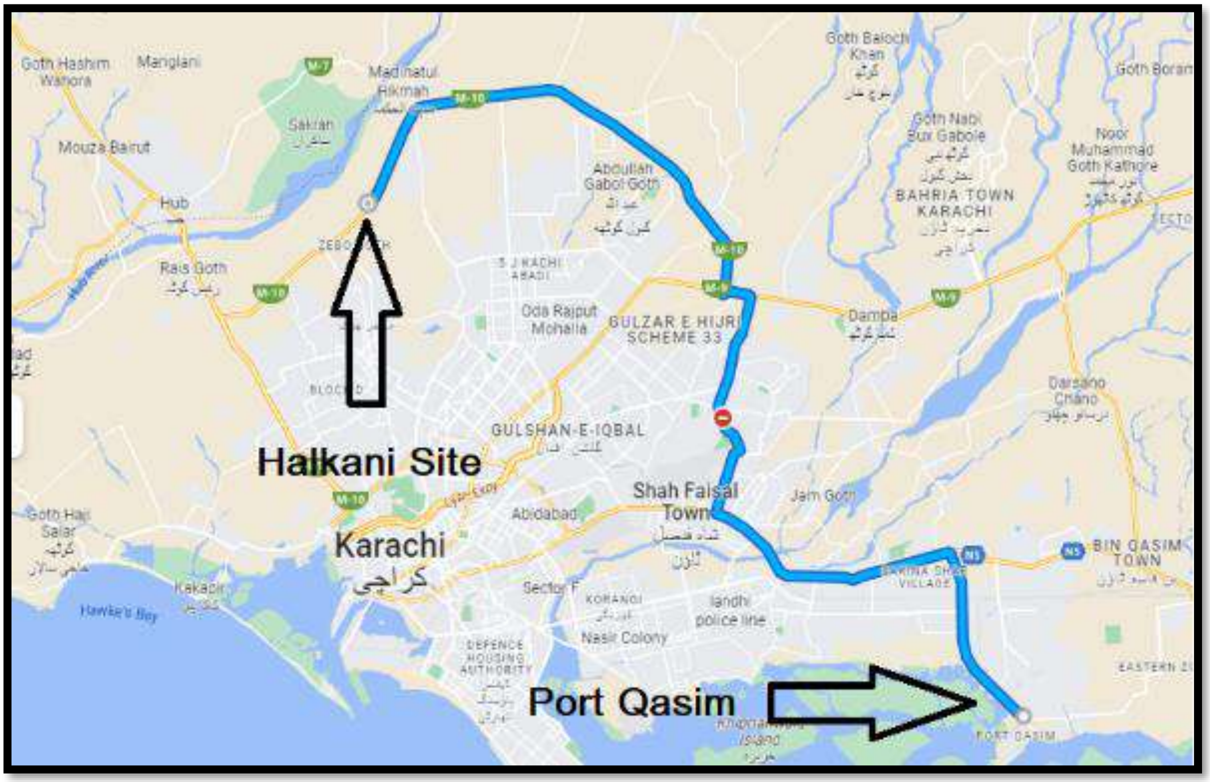

Figure 7-11: Overview of Site Access Route 1 from Google Maps

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.

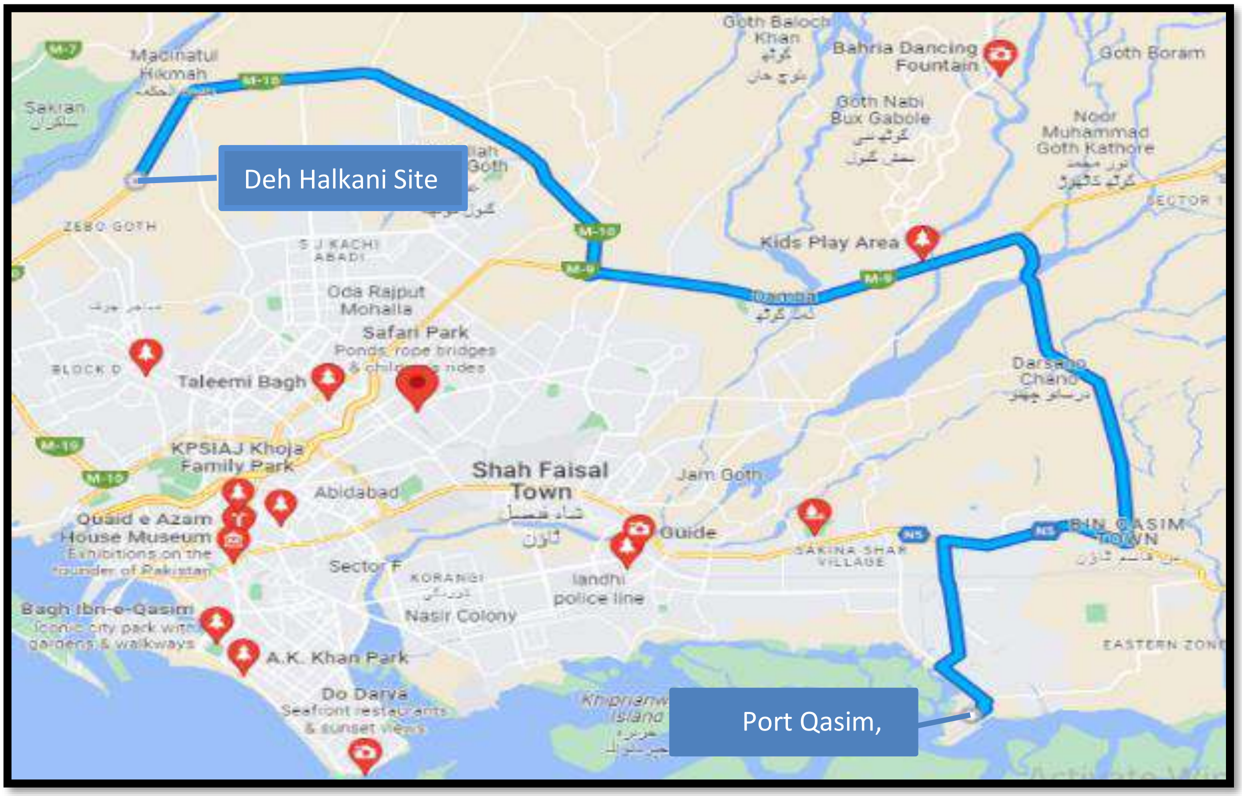

Figure 7-12: Overview of Site Access Route 2 from Google Maps

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.

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

Figure 7-13: Average Annual Temperatures of Project Location (in °C)

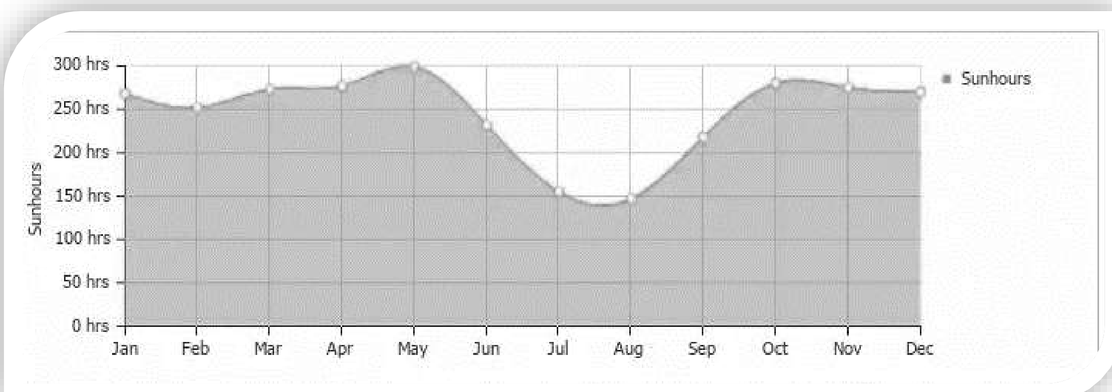

Figure 7-14: Average Monthly Sun hours of Project Location

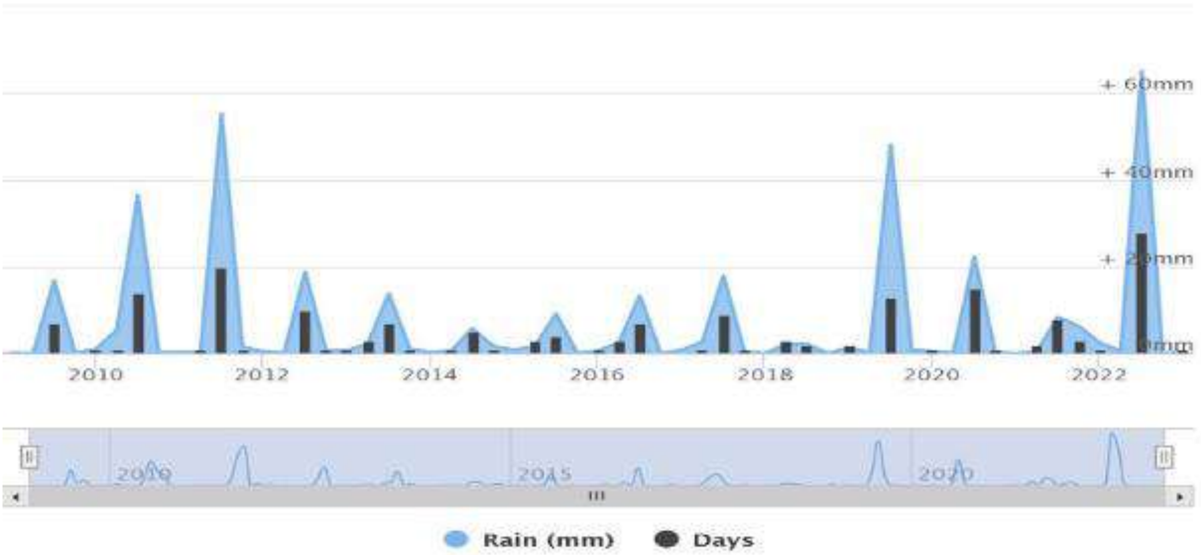

Figure 7-15: Average Yearly Rainfall Chart of Project Location

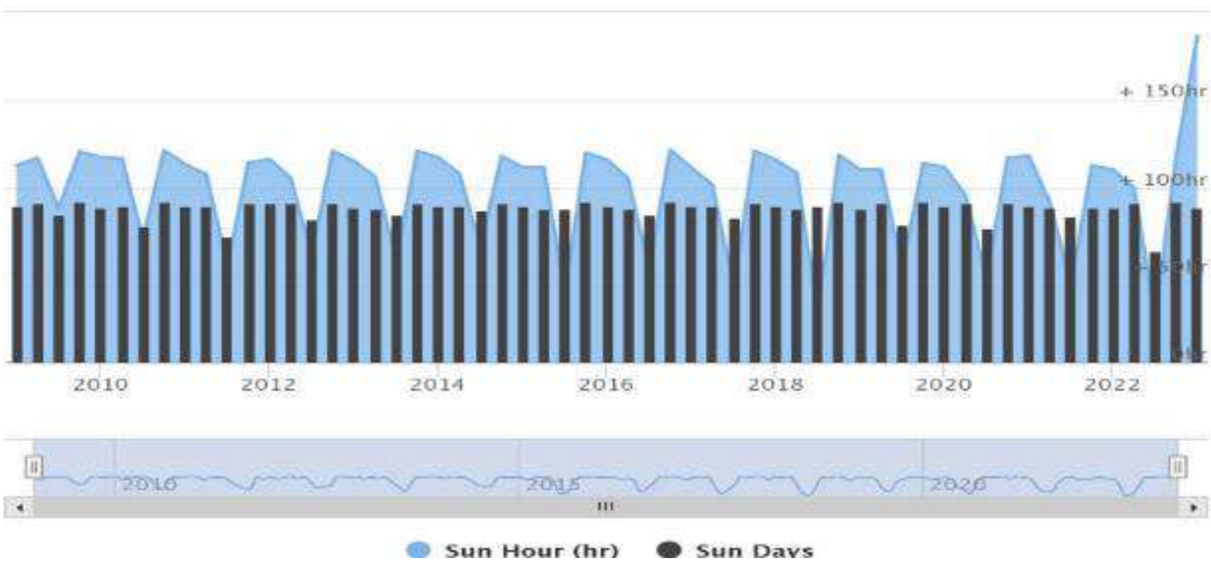

Figure 7-16: Average Yearly Sun Hours of Project Location

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

7.5 TELECOMMUNICATION

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

7.6 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.

8 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 1960.6 kWh/m². The blue spot in the Figure 8-1 below shows the site location.

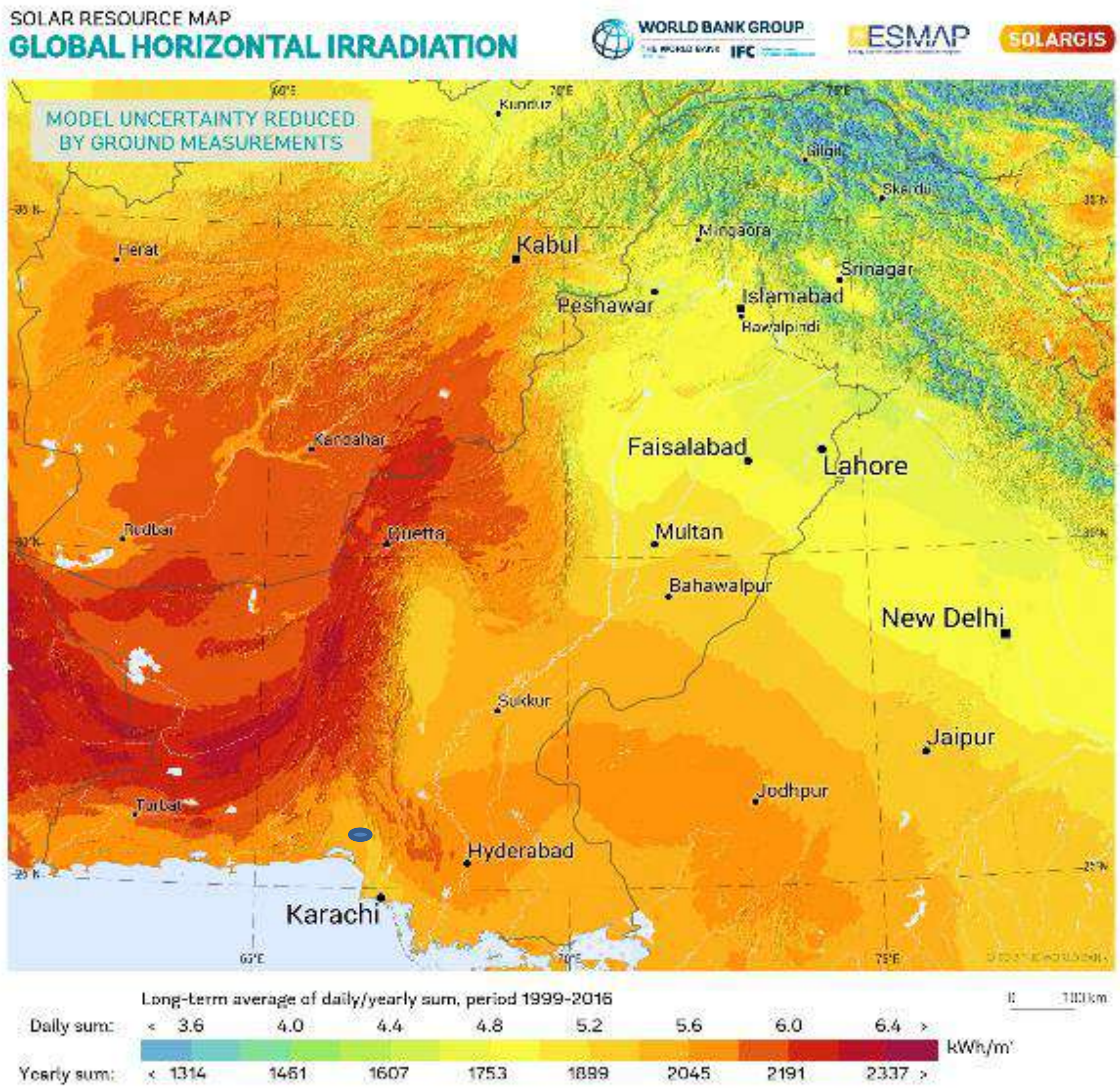

Figure 8-1: GHI Solar Resource Map of Pakistan (source: SolarGIS)

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 ±4% and ±8% (±5% and ±10% for 90% of observations), respectively. In complex geographies and extreme cases, uncertainty of GHI and DNI yearly summaries can be as high as ±8% and ±15%, respectively.

8.1 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 8-1 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 1960.6 kWh/m² and annual average temperature around 26.22°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 930.8 kWh/m².

Table 8-1: Typical Meteorological Year GHI, Average DHI and Ambient Temperature

Month	GHI [kWh/m²]	DHI [kWh/m²]	Ambient temperature [°C]
January	132	52	18.76
February	149.9	58.7	19.64
March	195.7	76.3	25.96
April	210.9	85.3	28.76
May	219	102.6	30.40
June	182.9	101.4	30.93
July	141.8	103.6	29.99
August	130.9	90.1	29.10
September	160.3	85.8	27.91
October	172	68.5	27.82
November	138.9	56.9	25.26
December	126.3	49.5	19.69
Annual	**1960.6**	**930.8**	**26.22**

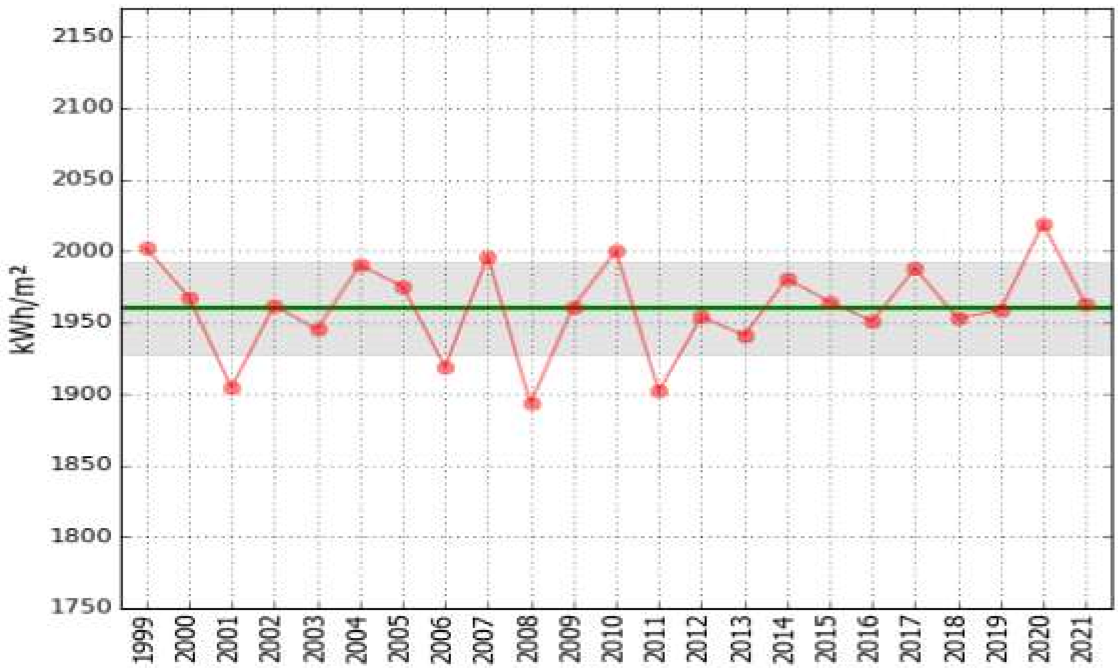

Figure 8-2: GHI Inter-annual Variation with Average line & STDEV band

Figure 8-2 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 ± 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 +/- 5%.

8.2 PLANT LAYOUT AND CONFIGURATION

A preliminary general layout for 120MWp Single Axis tracking PV system installation is shown in figure below.

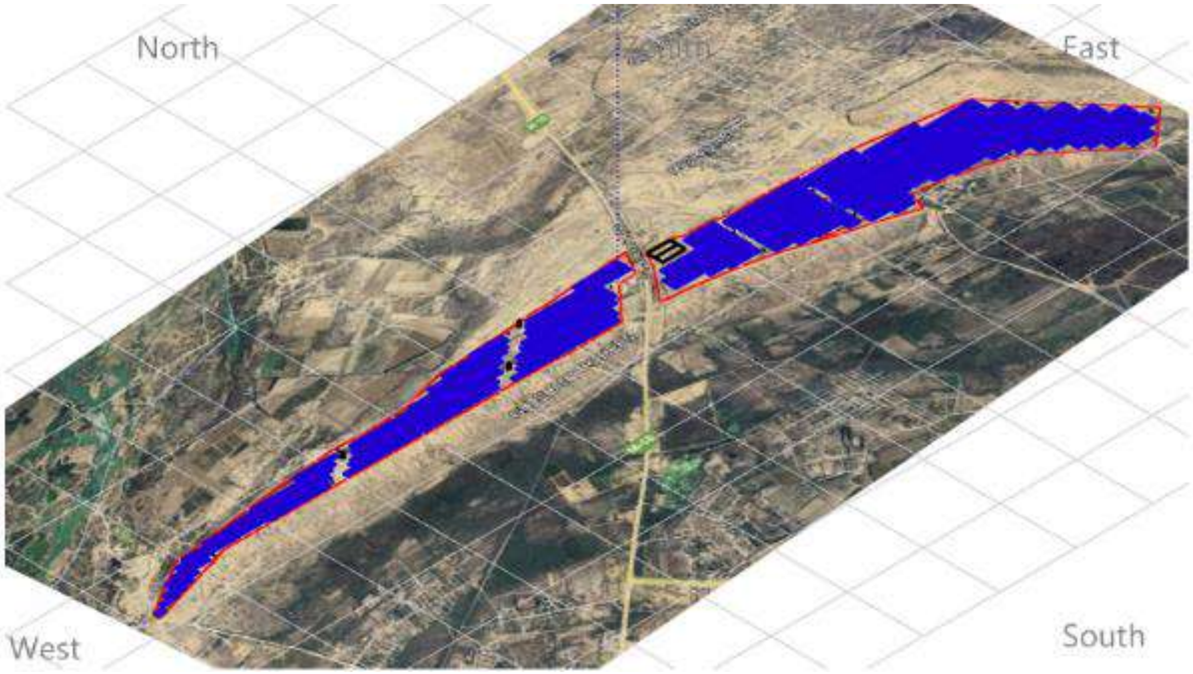

Figure 8-3: Preliminary Plant Layout of 120MWp (Single Axis Tracking System)

8.3 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 8-2 and Table 8-3. 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 8-2: Major Technical Characteristics of PV Module

Parameters	Description
Module Model	JAM66D45-620/LB
Manufacturer	JA Solar
Nominal Power [W]	620
Efficiency [%]	23
Power Tolerance [%]	± 5
Cell Type	Si-mono
Open Circuit Voltage [V]	48.5
Short Circuit Current [A]	17.42
MPP Voltage [V]	1500
MPP Current [A]	35
Power Coefficient of Temperature [-%/C]	-0.3
Nominal Operating Cell Temperature (NOCT)	45± 2
Height X Width X Thickness [mm]	2382X 1134 X 30

Table 8-3: Inverter Main Characteristics

Parameters	Description
Inverter Model	Sungrow-8800kW
Manufacturer	Sungrow
Nominal AC Capacity	8800 kW
Maximum DC input Power	10560 kWp
MPP voltage range	938V – 1500 V
Maximum DC current	11840 A
Nominal AC Current	9240 A
Maximum Efficiency	99
European Efficiency	98.7
Operating temperature range	-35°C to +60°C

The Consultant has considered the configuration between PV modules and inverters as described in Table 8-4.

Table 8-4: Plant Configuration – PV Module and Inverter

Parameter	Value
System Type	Single Axis
Module Type	Si-Mono (Bifacial)
Inverter Type	SG8800
Pitch	6.3m
Tilt	Variable
Installed capacity (DC)	120MWp
Total Number of Modules	193,564
Modules per inverter	16,130
Number of Modules in series	28
DC/AC Ratio	1.14
Number of inverters	12
Nominal AC Power of One Inverter [kW]	8800
Total AC Power [kW]	105,600

8.4 ENERGY YIELD ESTIMATION

The Consultant used PVsyst 7.4.8 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.);

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.

8.5 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 8-5: Losses Estimation Summary

Losses Type	Value%	Calculated [C] or Defined [D]
Front Side		
Global Incident in Coll. Plane	18.40%	C
Near Shading	-2.10%	C
IAM factor on global	-0.30%	C
Soiling losses	-3.00%	D
Ground reflection on front site	0.42%	C
Back side		
Ground reflection loss	-80%	C
View factor for rear side	-71.66%	C
Sky diffuse on rear side	25.88%	C
Shading loss on rear side	5.00%	D
Both sides		
Module Degradation Loss	-0.45%	D
PV loss due to irradiance level	-0.19%	C
Losses due to temperature	-5.99%	C
Auxiliaries	-0.78%	D
Module quality loss	0.75%	D
Light Induced Degradation	-2.00%	D
Module Array Mismatch loss	-2.15%	D
Mismatch for back irradiance	-0.66%	D
Ohmic wiring loss	-1.22%	C
Inverter loss	-1.48%	C
Unavailability loss	-1.93%	D
Medium Voltage Transformer Loss	-1.04%	C
MV Line Ohmic Loss	-0.20%	C
High Voltage Transformer Loss	-1.20%	C

8.6 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.

8.6.1 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 0.4% 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.

8.6.2 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 5.28 % for the energy yield estimation presented in SRA report.

Table 8-6: Uncertainties – Energy Yield Estimation

Uncertainties	1-Years	10-Years
Irradiance	5.3%	5.0%
PV Module modelling/parameters	1.0%	1.0%
Inverter efficiency uncertainty	0.5%	0.5%
Soiling and mismatch uncertainty	1.0%	1.0%
Degradation uncertainty	1.0%	1.0%
Total uncertainty	5.50%	5.28%

The total uncertainty on long term (eg.10 yrs.) energy yield estimation is 5.28%. Similarly, the uncertainty for energy estimation for 1-year period is estimated as 5.50%. This includes the variability effect of solar data which is generated based on standard deviation of 1.0% of long-term average GHI (for 23 year's time series data).

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

Table 8-7 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 8-7: Annual Breakdown of Long-Term Energy Yield (25 Years –POE 10 year)

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-1 (without Degradation)	242,532	233,899	226,129
Year-1	237,681	229,221	221,606
Year-2	236,711	228,285	220,701
Year-3	235,741	227,349	219,797
Year-4	234,771	226,414	218,892
Year-5	233,801	225,478	217,988
Year-6	232,830	224,543	217,083
Year-7	231,860	223,607	216,179
Year-8	230,890	222,671	215,274
Year-9	229,920	221,736	214,370
Year-10	228,950	220,800	213,465
Year-11	227,980	219,865	212,561
Year-12	227,010	218,929	211,656
Year-13	226,040	217,994	210,752
Year-14	225,069	217,058	209,847
Year-15	224,099	216,122	208,943
Year-16	223,129	215,187	208,038
Year-17	222,159	214,251	207,134
Year-18	221,189	213,316	206,229
Year-19	220,219	212,380	205,325
Year-20	219,249	211,444	204,420
Year-21	218,279	210,509	203,516
Year-22	217,308	209,573	202,611
Year-23	216,338	208,638	201,707
Year-24	215,368	207,702	200,802

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-25	214,398	206,766	199,898

8.6.4 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 8-8.

Table 8-8: Annual Breakdown of Long-Term Energy Yield (25 Years -POE 1 year)

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-1 (without Degradation)	242,532	233,529	225,426
Year-1	237,681	228,858	220,917
Year-2	236,711	227,924	220,015
Year-3	235,741	226,990	219,114
Year-4	234,771	226,056	218,212
Year-5	233,801	225,122	217,310
Year-6	232,830	224,187	216,409
Year-7	231,860	223,253	215,507
Year-8	230,890	222,319	214,605
Year-9	229,920	221,385	213,703
Year-10	228,950	220,451	212,802
Year-11	227,980	219,517	211,900
Year-12	227,010	218,583	210,998
Year-13	226,040	217,649	210,097
Year-14	225,069	216,715	209,195
Year-15	224,099	215,780	208,293
Year-16	223,129	214,846	207,391
Year-17	222,159	213,912	206,490
Year-18	221,189	212,978	205,588
Year-19	220,219	212,044	204,686
Year-20	219,249	211,110	203,785

Year of Operation	Annual Yield P50 [MWh]	Annual Yield P75 [MWh]	Annual Yield P90 [MWh]
Year-21	218,279	210,176	202,883
Year-22	217,308	209,242	201,981
Year-23	216,338	208,308	201,080
Year-24	215,368	207,373	200,178
Year-25	214,398	206,439	199,276

8.7 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 site land has some hills / inclined areas within the site boundary. The hills / inclined area will be removed / smoothened, such that the complete site area has maximum 10-degree slope. Same has been assumed for the purposes of this Solar Resource Assessment and Energy Yield Estimation Report.
- The Project is intended to build in the approximate area of 612 acres. The project site is irregularly shaped and has two (02) land parcels very close to each other as shown in Figure 3-8. There are two transmission lines crossing through the west land parcel of the project site.
- Technical arrangements and their implementation in respect of right of way and cable crossings between these 02 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.

- 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.

8.8 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 1960.6 kWh/m^2, annual average DHI of 930 kWh/m^2, and annual average temperature of 26.22°C. TMY data sets were used for energy yield assessment for the Project.
- 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 6.3m Pitch:

- With single axis system, the project is expected to produce maximum 237,681 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 86.40% and 22.6% respectively.

❖ The uncertainty on long term annual energy estimation is +/- 5.28%.

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.

9 CARBON CREDITS

A carbon credit reflects the potential of a clean energy project to mitigate emissions of greenhouse gases (GHGs), in particular, carbon dioxide (CO_2), measured in tonnes of CO_2 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.

9.1 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 CO_2 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.

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

9.3 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 tCO_2/MWh[3], however, the actual number is to be calculated based on the feasibility study). The assumption-based calculation is given below:

Table 9-1: 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

9.4 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.

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 9-1 below:

Figure 9-1: 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 Entity[6]
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

10 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.

11 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.

12 ELECTRICAL WORKS

12.1 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.

12.2 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.

A pictorial representation of the plant is given below:

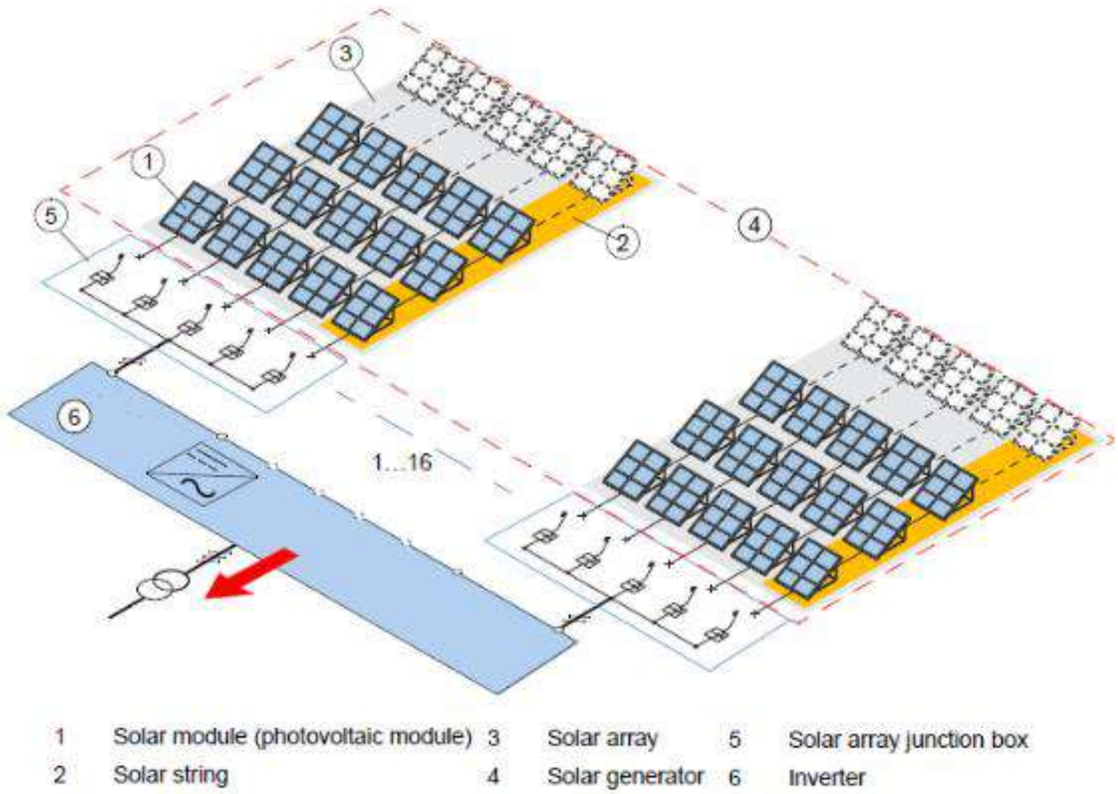

Figure 12-1: Block Diagram of Single PV Group

12.3 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

12.4 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.

13 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.

14 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.

15 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.