BEFORE
THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY (NEPRA)

APPLICATION FOR A GENERATION LICENSE FOR WIND POWER GENERATION FACILITY

PURSUANT TO ENABLING PROVISIONS OF NEPRA ACT 1997 READ WITH ENABLING PROVISIONS OF RULES MADE THEREUNDER, LICENSING (APPLICATION & MODIFICATION PROCEDURE) REGULATIONS AND LICENSING (GENERATION) RULES 2000 & THE FEDERAL GOVERNMENT'S 'POLICY OF RENEWABLE ENERGY FOR POWER GENERATION 2006'

ON BEHALF OF

SINO WELL (PRIVATE) LIMITED

FOR NEPRA'S GRANT OF GENERATION LICENSE FOR WESTERN ENERGY (PRIVATE) LIMITED

FOR A POWER PROJECT OF 50 MW (THE **PROJECT**)

AT

JHIMPIR, DISTRICT THATTA, PROVINCE OF SINDH, PAKISTAN

DATED: November 14, 2018

SINO WELL (PRIVATE) LIMITED
ADDRESS : F-25, BLOCK 5, KEHKASHAN, CLIFTON, KARACHI, PAKISTAN
PHONE # : +92-21-35876994-7
FAX # : +92-21-35876991&3

SINO WELL (PRIVATE) LIMITED

SINO WELL (PRIVATE) LIMITED
Registered Office: F-25 · Block 5 · Rojhan Street · Kehkashan · Clifton
Karachi · 75600 · Pakistan

Tel: +92-21-35876994-97
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THE REGISTRAR
National Electric Power Regulatory Authority
NEPRA Tower, Attaturk Avenue (East)
G-5/1,
Islamabad.

Date: - 14th November 2018
Ref.: - SWL/NERPA/001/19

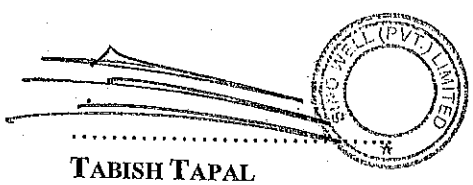
SUBJECT: **APPLICATION FOR THE GRANT OF GENERATION LICENSE ON BEHALF OF SINO WELL (PRIVATE) LIMITED IN RELATION TO ITS 50MW WIND POWER GENERATION PROJECT TO BE LOCATED AT JHIMPIR, DISTRICT THATTA, PROVINCE OF SINDH**

I, **TABISH TAPAL**, being the duly authorized representative of SINO WELL (PRIVATE) LIMITED (a company incorporated under the laws of Pakistan with its registered office located at F-25, Block 5, Kehkashan, Clifton, Karachi, Pakistan) hereby, pursuant to Rule 3 of the National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, apply to the National Electric Power Regulatory Authority (**NEPRA**) for the grant of the Generation License to SINO WELL (PRIVATE) LIMITED.

I certify that the documents in support attached with this application are prepared and submitted in conformity with the provisions of the National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, and undertake to abide by the terms and provisions of the same. I further undertake and confirm that the information provided in the attached documents in support is true and correct to the best of my knowledge and belief.

We are submitting with this Generation License Application the required generation license fee through a non-refundable bank draft in the amount of PKR 326,272/- (Pakistani Rupees Three Hundred Twenty Six Thousand Two Hundred and Seventy Two Only) dated 13th November 2018 drawn in favor of NEPRA.

Sincerely,
For and on behalf of SINO WELL (PRIVATE) LIMITED



TABISH TAPAL
CEO & AUTHORIZED REPRESENTATIVE

SINO WELL
(PRIVATE) LIMITED

CERTIFIED TRUE COPY
OF RESOLUTION OF THE BOARD OF DIRECTORS
OF SINO WELL (PRIVATE) LIMITED
PASSED ON NOVEMBER 5, 2018

WHEREAS the Company has obtained a Letter of Intent from the Directorate of Alternative Energy, Energy Department, Government of Sindh for the establishment and operation of a 50 MW wind power project proposed to be located at Jhimpir, Thatta, in the province of Sindh (Project).

AND WHEREAS the Company has hired various consultants to undertake the feasibility study, environmental impact assessment and other studies required to be undertaken prior to the construction of the Project and most of the work in respect of the aforesaid has been completed and the Company is moving closer to the financing and construction of the Project.

AND WHEREAS the Company is desirous of filing the Generation License Application with the National Electric Power Regulatory Authority (NEPRA) (required to be filed pursuant to the Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of) 1997 (NEPRA Act) and rules/regulations made thereunder), which generation license would enable the Company to operate the Project and generate electricity therefrom.

AND WHEREAS the Company desires to authorize certain of its officers to file such Generation License Application with the NEPRA and to take all required steps and actions in connection therewith.

"It is hereby unanimously resolved that:

a) the Company do file an application to the National Electric Power Regulatory Authority for seeking a generation license for the 50 MW wind power project to be constructed at Jhimpir, pursuant to and under Sections 7(2)(a) and 15 of the NEPRA Act read with other enabling provisions of the NEPRA Act, the National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations 1999, National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, and in accordance with the Policy for Development of Renewable Energy for Power Generation 2006.

b) Mr. Tabish Tapal, the Chief Executive Officer of the Company be and is hereby authorized to do, execute, transact and perform for and on behalf and in the name of the Company all such acts deeds and things as may be necessary or required or desirable to be done or executed by the Company for or in connection with or in relation to the application to the National Electric Power Regulatory Authority for seeking a generation license under the NEPRA Act and without limiting the generality of the foregoing and in connection therewith to do any or all of the following acts deeds and things, namely, to file applications, swear affidavits, review documents and information, make correspondence, letters, submissions, claims, objections of all kinds and to file or submit them before the National Electric Power Regulatory Authority and to appear and represent the Company before the National Electric Power Regulatory Authority or any other regulatory authority or body and to accept the terms

SINGWELL
(PRIVATE) LIMITED

and conditions on which a Generation License is granted by the National Electric Power Regulatory Authority."

c) Mr. Tabish Tapal, Chief Executive Officer of the Company, be and is hereby authorized to delegate in writing all or any of the above powers in respect of the foregoing to any other person as he may deem appropriate"

SING WELL (PVT.) LIMITED

Mr. Tabish Tapal
Chief Executive Officer

1. BACKGROUND TO GENERATION LICENSE APPLICATION

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

1.1.1 Issuance of "Letter of Intent"

SINO WELL (PRIVATE) LIMITED (a company duly organized and existing under the laws of Pakistan, with its office located at F-25, Block 5, Kehkashan, Clifton, Karachi, Pakistan) (the **Project Company**), was incorporated on 14th June 2016 to develop, own and operate a 50 MW Wind Power Project in Jhimpir, Thatta (the **Project**) pursuant to a Letter Of Intent dated 1st March 2016 issued by the Energy Department Government of Sindh (the **EDGoS**) vide its letter No. DAE/Wind/99/2015/58 (the **LOI**), which was issued by the EDGOS to the sponsors of Western Energy (Pvt.) Ltd. Subsequent to incorporation of the Project Company, the EDGOS has recognized that the Project Company will undertake the Project pursuant to the LOI, as evidenced by EDGOS letter No. DAE/Wind/99/2015 dated 9th August 2016. The LOI was subsequently extended by EDGOS vide its letter dated 3rd November, 2017. As such, the LOI is currently valid until 22nd February, 2019. Copies of the LOI and its extension are attached hereto as **ANNEXURE J** for NEPRA's perusal.

1.1.2 Submission of the Feasibility Study

Pursuant to the relevant provisions of the Policy for Development of Renewable Energy for Power Generation 2006 (the **RE Policy 2006**) and the LOI, the Project Company hired technical consultants, M/s. Pakistan Alternative Engineering Services (Private) Limited, who completed the detailed technical feasibility study (the **Project Feasibility Study**) for the Project which was submitted by the Project Company to the EDGOS. A copy of Project Feasibility Study is attached hereto as **ANNEXURE A** for National Electric Power Regulatory Authority's (**NEPRA**) perusal.

1.1.3 Submission of Initial Environmental Examination.

The Project Company hired consultants, M/s. First Wind (Private) Limited, who completed the initial environmental examination for the Project (the **Initial Environmental Examination**) and the Project Company submitted the same to the Sindh Environmental Protection Agency (the **SEPA**) on December 15, 2016.

After careful review and analysis of the Initial Environmental Examination, the SEPA accorded its approval for the Project through its decision (Ref: EPA/2016/12/16/IEE/103) dated January 03, 2017 (the **IEE Approval**

Decision). A copy of the IEE Approval Decision is attached hereto as ANNEXURE **B** for NEPRA's perusal.

1.1.4 **Grid Interconnection Studies**

The Project Company engaged independent consultants, M/s. Power Planners International for, the grid interconnection studies (the **Grid Interconnection Studies**). The NTDC has vide letter No. GMPP/CEMP/TRP-380/3220 dated June 07, 2017 accorded its approval of the grid interconnection studies and issued Power Evacuation Certificate to the Project Company. A copy of the Grid Interconnection Studies, a copy of the Approval of the Grid Interconnection Studies and a copy the Power Evacuation Certificate are attached hereto as **Annexure C**.

1.1.5 **Request for grant of a generation license**

Based on the matter provided in Section 1.1.1, 1.1.2, 1.1.3 and 1.1.4 above whereby the Project Company, on its part, has undertaken and completed all activities required for procurement of approvals of the relevant matters from various stakeholders – including the procurement of approvals of its IEE Report from SEPA – it is submitted that the requirements of the regulatory process for applying to NEPRA for grant of a generation license for the Project Company are complete.

1.2 SUBMISSION

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

1.2.2 PURSUANT TO the Sections 7 (2) (a) and 15 of the NEPRA Act read with other enabling provisions of the NEPRA Act, the National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations 1999, National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, AND in accordance with the RE Policy 2006: SINO WELL (PRIVATE) LIMITED HEREBY SUBMITS, for NEPRA's kind and gracious consideration, the application for the grant of a generation license along with supporting documents (the **Generation License Application**) for its 50 MW power generation facility to be located at Jhimpir, District Thatta, Sindh, Pakistan.

1.2.3 In order to highlight the advanced stage of the progress made by the Project Company with regard to the EPC arrangements, financing arrangements and other activities necessary to culminate the generation facility to its commercial operation, milestones achieved to date are mentioned in section 13 (*Implementation Schedule).* EDGoS

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

1.2.5 This Generation License Application is submitted in triplicate.

1.2.6 The generation license fee, payable by the Project Company, in respect of this Generation License Application is also enclosed in the form of a pay order for an amount of PKR 326,272/- (Pakistani Rupees Three Hundred Twenty Six Thousand Two Hundred and Seventy Two only) drawn in favor of NEPRA.

2. APPLICANT – SINO WELL (PRIVATE) LIMITED

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

2.2 The Project Company (following grant of a generation license and approval of the Project Company's reference generation tariff by NEPRA) proposes to design, engineer, construct, insure, commission, operate and maintain the Project constituting of a 50 MW power generation facility (the **Facility**) to be located at Jhimpir, District Thatta, Province of Sindh, Pakistan (the **Site**).

2.3 For the purposes of designing, engineering, procuring, constructing, installing, testing, completing, commissioning, operation and maintenance of the Project, the Project Company has invited EPC Bids from major local and international EPC companies. The evaluation of bids has been completed and EPC Contract with the reputable company has been signed. Based on the Wind Resource Assessment studies on various WTGs having footprints in Pakistan and considering the height limitation due to PAF Bholari Air Base, Gamesa G114 - 2.0 is found most appropriate for the site. Therefore this application is being submitted on Gamesa G114 – 2.0 WTG.

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

DOCUMENTS	ANNEXURE
Shareholding Pattern of the Project Company	ANNEXURE D
Memorandum and Articles of Association of the Project Company	ANNEXURE E
Certificate of Incorporation of the Project Company	ANNEXURE F

3. FACILITY UTILIZATION

3.1 ELECTRICITY DEMAND & WIND CORRIDOR

3.1.1 Pakistan is a developing economy having a constant growth in industrialization coupled with a constantly rising demand for electricity. The non-availability of natural resources for expansion of the power sector has widened the gap between demand and supply, which has resulted in excessive and frequent load shedding. The shortfall in supply could be the major cause for stunned growth in the industrial sector in Pakistan. The total installed capacity of Pakistan as on June 30, 2017 was 28,399 MW; of which 26,186 MW was connected with NTDC system of which 8,868 MW (33.87%) was Gas/RLNG, 6,785 MW (25.91%) was Oil, 7,116 MW (27.17%) was Hydro, 1,142 MW (4.36%) was Nuclear, 810 MW (3.09%) was Coal and 1465 MW (5.59%) was Renewables whereas 2,213 MW was connected with K-Electric Limited.

3.1.2 The demand for electricity has continued to increase by out pacing the growth rate of the economy. The shortfall at times crosses 6,000MW and this is the time when urban areas have 8-12 hours of load shedding and small cities/ rural areas have 18 hours of load shedding. The industry, having its self- generation on gas, has a suspended supply of gas for 2-3 days a week during winters. As mentioned above, Pakistan's major electricity sources at present are thermal and hydro generation, meeting approximately 97% of the country's annual electricity demand. The primary thermal generation fuels employed are furnace oil and gas. While both fuels are produced domestically, demand for them already outstrips supply by a considerable amount. Oil imports are already a significant burden on the national exchequer and the increasing import bill continues to exert further pressure on the foreign exchange reserves. Therefore, securing alternative fuels and the technical management should be strengthened to solve these problems and wind power can play a very important role in overcoming Pakistan's growing energy crisis.

3.1.3 The wind power program in Pakistan was initiated around ten (10) years ago by installation of wind measuring stations in the coastal areas of Sindh, Pakistan. The energy potential of 346,000 MW in the country is estimated by National Renewable Energy Laboratory, USA and only the Gharo – Keti Bander – Hyderabad wind corridor (the **Wind Corridor**) has a potential of 43,000 MW of wind power generation. If harnessed adequately, wind energy alone would eradicate energy shortages in the country. The Government of Pakistan is currently looking to build wind farms in the Wind Corridor, some of which are regions where electricity supply through the national grid has been a challenge.

3.1.4 The Government of Pakistan has clearly articulated its support for the development of renewable energies. Due to the fact that the use of wind energy is actually the most economical renewable energy production technique, the focus is on supporting the development of wind farms through wind based independent power producers (the **Wind IPPs**).

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

3.1.6 The proposed Project has the advantage of being located in the Wind Corridor and thus will, following its completion, contribute towards relieving the shortage of electric power in the country.

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

3.2 POWER OFF-TAKE

Following commercial operation date of the Project, the electricity generated will be sold to National Transmission and Despatch Company Limited (through its Central Power Purchasing Agency) on behalf of ex-Wapda distribution companies (the **Power Purchaser**) pursuant to an energy purchase agreement (the **EPA**), which in turn will distribute and modulate the electricity generated by the Project Company.

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

4. THE SPONSORS

4.1 AN INTRODUCTION

The sponsor financing the Project is the TAPAL GROUP, principals of AMEEJEE VALLEEJEE & SONS (PRIVATE) LIMITED and major shareholders of TAPAL ENERGY (PRIVATE) LIMITED (which is a 126 MW diesel engine based power project in operation and under the management of the owners of the Project Company for the past 21 years).

AMEEJEE VALLEEJEE & SONS (PRIVATE) LIMITED is a business house established in 1867 dealing in engineering and construction related products, chemicals and consumer products. It represents some of the most renowned international companies like Steinmuller, Lurgi, Standard, Chint, Buhler, Kessel, Henkels, Dorr Oliver, Atlas Copco etc. dealing in engineering equipment and has been a key player in installation of several power plants in public utility companies and various industries in Pakistan.

TAPAL ENERGY (PRIVATE) LIMITED is a Karachi based company that owns a 126 MW power generation project formed under the Power Policy of 1994 at a project cost of US$ 130 million. The development of the project was jointly done by Tapal Group and Wartsila Corporation who was also the EPC contractor. Tapal Energy (Private) Limited has the privilege of being one of the first projects to start its operations under the Power Policy of 1994.

Tapal Energy (Pvt) Limited has internationally acclaimed companies like Sithe Mauritius Limited, Mauritius, a subsidiary of Marubeni Corporation, Japan as its joint venture partners and shareholders.

The management of Tapal Energy (Private) Limited is with the Tapal Group, with Mr. Tabish Tapal as the Chief Executive. Tapal Energy (Private) Limited has been successfully providing reliable, uninterrupted power to the public utility K-Electric Limited (former Karachi Electric Supply Corporation) for the past twenty one (21) years. Tapal Energy (Private) Limited is one of the few independent power producers in Pakistan that are operated and maintained by its sponsors without any external operations and maintenance contractor.

4.2 THE TAPAL GROUP BUSINESS

Tapal Group has been in business for the past 145 years. The reason for its successful existence in the highly competitive corporate sector for such a long period is its good standing as a professionally managed group. Tapal Group follows a strict code of conduct regulated by properly documented policy guidelines, which are periodically reviewed and modified according to the changing times.

Tapal Group is proud of its dependable human resource pool comprising of highly qualified professionals in the field of engineering, business

administration and finance. The Tapal Group companies have a defined set of organograms, documented job descriptions and a clearly defined hierarchy. New projects are taken up by our group after forming a committee from within our resource pool to do the development work.

Tapal Group's development team members are experienced developers of power projects. Induction of additional resources for the expansion of Tapal Group's development team are done as and when the projects progress.

The pride of the Tapal Group is its technical resource pool which comprises of highly qualified engineers who are capable to operate and maintain all kinds of plant and machinery.

Besides Tapal Group's in house resource pool, it has alliances with engineering firms of repute around the world. In addition, it is are also aligned with various local construction companies who can undertake the local construction works on all Tapal Group's projects.

The key board of directors in various companies and concerns forming the Tapal Group are as follows:

(a) Mr. Moiz Tapal;
(b) Mr. Tajwar Tapal;
(c) Mr. Tabish Tapal; and
(d) Mr. Muhammad Sadiq Tapal

The key financial figures of the Tapal Group are illustrated below for reference:

Rupees in '000

	Tapal Energy	
	2017	2016
Revenue	8,201,847	6,936,802
Profit before tax	1,321,481	1,356,438
Taxation	8,668	24,101
Total Assets	4,630,490	4,429,364
Total Liabilities	1,014,109	867,423

Rupees in '000

AVS	
2017	2016
576,494	606,336
36,334	30,584
36,714	27,997
576,940	529,472
159,371	111,516

4.3 FINANCIAL HIGHLIGHTS

Tapal Group's main financial highlights for the year ended June 30, 2017 include a turnover of Rs. 8.778 billion and its cost of assets nearing Rs.5.207 billion. The Tapal Group has contributed to a yearly income tax of Rs. 45 Million.

4.4 COMMITMENT TO PROJECT

The Tapal Group is committed to playing its part in the development of Pakistan's various sectors. Realizing the role of clean energy in the development of the nation, the Tapal Group has now ventured into the wind power generation sector by planning to install the Project through the Project Company.

The unmatched standards of corporate governance, efficiency, safety and operations established by Tapal Group in its diversified businesses are expected to be replicated in its wind power generation venture – thus raising the bar for all future wind power projects.

5. RESOURCES

5.1 SENIOR MANAGEMENT & PERSONNEL

5.1.1 The Project Company has access to and has engaged the highly qualified personnel of Tapal Group for the development of the Project. The Project Company is presently under the process of appointing various personnel and details of the same will be provided upon finalization of the terms and conditions of their appointment.

5.1.2 In addition, the curriculum vitae of the following individuals currently engaged by the Project Company are attached herewith at ANNEXURE G:

	NAME OF INDIVIDUALS	POSITION	ANNEXURE
1.	TABISH TAPAL	CHIEF EXECUTIVE OFFICER	G
2.	SYED RAZA ABBAS	SR. MANAGER TECHNICAL	G
3.	IMRAN ADHI	SR. MANAGER FINANCE	G

5.2 THE O&M CONTRACTOR

5.2.1 In addition to recruitment of its own management, staff and personnel for the purposes of the Project, the operations and maintenance (the **O&M**) of the Project will be performed by the selected O&M Contractor (the **Operator**), for ten (10) years following Commercial Operations Date. The Project Company has not yet finalized the O&M Contractor however intends to have a comprehensive contractual structure, that contains all commercial, technical and legal terms and arrangements with the Operator for the **turn-key O&M** of its Project.

5.3 LEGAL ADVISER

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

6. CAPITAL BUDGET

6.1 The estimated total Project cost expressed in United States Dollars, has been calculated after thorough analysis, evaluation and understanding of the dynamics that affect the development and operation of a wind farm and comes to approximately US$ 85.396 million (United States Dollars Eighty Five Million Three Hundred and Ninety Six Thousand) (the **Total Project Cost**).

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

		USD IN THOUSANDS
DEBT (FOREIGN AND LOCAL)	75%	64,050
EQUITY	25%	21,346
TOTAL PROJECT COST		85,396

7. FINANCIAL PLAN

The Total Project Cost is to be financed in a debt to equity ratio of 75:25, which is in accordance with the RE Policy 2006.

7.1 DEBT

7.1.1 The debt for the Project (the **Debt**) will be financed through a mix of local and foreign lenders with 50:50 ratio. United Bank Limited is acting as an arrangers for the local and foreign currency loans.

7.1.2 The terms and conditions for the Debt shall be firmed up once the financing document for debt financing have been executed prior to the financial close.

7.2 EQUITY

7.2.1 Based on the Debt to Equity ratio of 75:25, the equity required to be injected-, by the sponsors, amounts to USD 21.346 Million (the **Equity**). The Tapal Group will subscribe to the total amount of the Equity required for the Project from time to time.

7.2.2 The financial strength and net worth of Tapal Group (being the primary sponsor of the Project Company) is illustrated by the Auditor's Report for the year ended June 30, 2017 attached as ANNEXURE **H**, of Ameejee Valleejee & Sons and Tapal Energy (Private) Limited – the same being the flagship concerns of the Tapal Group. Further, the last filed annual returns of the Project Company are also attached hereto as ANNEXURE **I**.

8. THE FACILITY

8.1 TECHNOLOGY

8.1.1 Technology Selection Criteria

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

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

(b) safe transportation of equipment to the wind farm site;

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

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

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

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

8.1.2 The Selected Technology

After a consummate search, an elaborate process and thorough due diligence, the following WTGs have been selected for the Project:

MANUFACTURER	SIEMENS GAMESA
WIND TURBINE GENERATOR	GAMESA G114-2.0 MW
HUB HEIGHT	80 M
NUMBER OF TURBINES	25 (Twenty Five)
TOTAL INSTALLED CAPACITY	50 MW

The Facility configuration consists of 25 numbers of G114-2.0 WIND TURBINE GENERATORS (the **WTG**); 75 (seventy five) blades (56m length); electrical equipment, together with ancillary equipment and other goods and machinery.

All functions of the selected G114-2.0 WTG are monitored and controlled by a SCADA system. In addition the wind turbines are equipped with a remote monitoring system.

The design used by the G114-2.0 WTG is aimed at achieving high safety and environment mechanisms. Moreover, as per the Project Company's analysis, the equipment is suited to the conditions at the Project's Site.

The 2 MW series is Gamesa's most widely deployed wind turbine and is known for its:

- conformance and compliance to the International Electrotechnical Commission (the IEC) standards;
- high availability in a variety of wind classes;
- continual investment for achievement of highest capacity factor in its class; and
- sharing of components that ensures consistent workhorse reliability, ease of maintenance planning and high commonality in spare parts.

8.1.3 WTG System Specifications

(a).	**Rotor**	
(i).	Number of Blades	3
(ii).	Rotor Diameter	114 m
(iii).	Swept Area	10207 m^2
(iv).	Power Regulation	Pitch Control & generator/convertor torque control
(v).	Rated Speed	13.07 m/s
(vi).	Cut-in wind speed	3 m/s

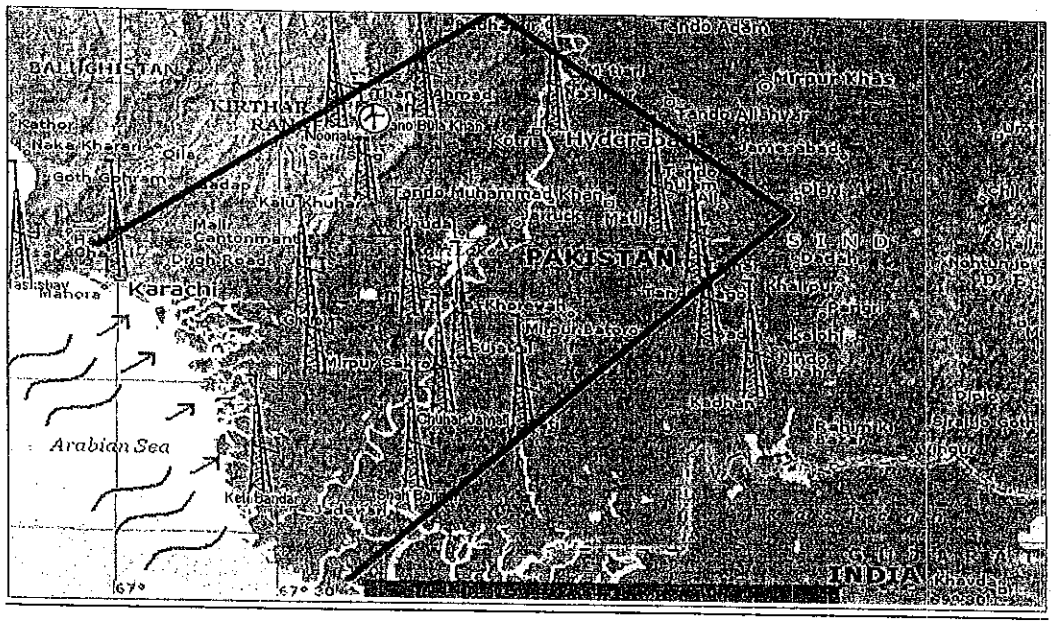
(vii).	Cut-out wind speed	25 m/s
(viii).	Survival wind speed	59.5 m/s, 3s average
(ix).	Pitch regulation	Electric motor drives a ring gear mounted to the inner race of the blade pitch bearing
(b). Blades		
(i).	Blade Length	56 m
(ii).	Material	Composite material reinforced fiberglass through resign infusion technology
(c). Gear Box		
(i).	Type	3 combined stages: 1 stage planetary, 2 paralled shift gears
(ii).	Gear ratio	1:128.5
(iii).	Main shaft	Cast shaft
(d). Generator		
(i).	Power	2040 kVA
(ii).	Voltage	690 V
(iii).	Type	Double-fed with coil rotor and slip rings
(iv).	Degree of Protection	IP 54 Turbine – IP21 Ring Body
(v).	Coupling	Flexible coupling
(vi).	Power Factor	0.95
(e). Yaw System		
(i).	Yaw Bearing	PETP
(ii).	Brake	Active Yaw
(iii).	Yaw Drive	Motor Drive
(iv).	Speed	0.42 degree/s

(f). Control System		
(i).	Type	Automatic or manually controlled
(ii).	Grid Connection	Via IGBT converter
(iii).	Scope of Monitoring	Remote monitoring of different parameters, e.g. temperature sensors, pitch parameters, speed, generator torque, wind speed and direction, etc.
(iv).	Recording	Production data, event list, long and short-term trends
(g). Brake		
(i).	Design	Mechanical brakes
(ii).	Operational Brake	Aerodynamic brake achieved by feathering blades
(iii).	Secondary Brake	Mechanical brake on (high speed) shaft of gearbox
(h). Tower		
(i).	Type	Conical barrel tube
(ii).	Hub Heights	80 m

8.2 THE PROJECT SITE

The Site of the Project (as defined below) is located near the village of Jhimpir, District Thatta, Sindh. The Jhimpir area has been selected for implementing the Project on the basis of its exceptional wind regime, flat terrain and nearness to the national and local grid. The area has been extensively surveyed and is identified as having strong potential for the proposed wind farm. The following other parameters have also been considered for the implementation of the Project at the proposed Site:

- Forecasted power output
- Access to the proposed site (materials and equipment transport feasibility study)
- Suitability for the surrounding environment

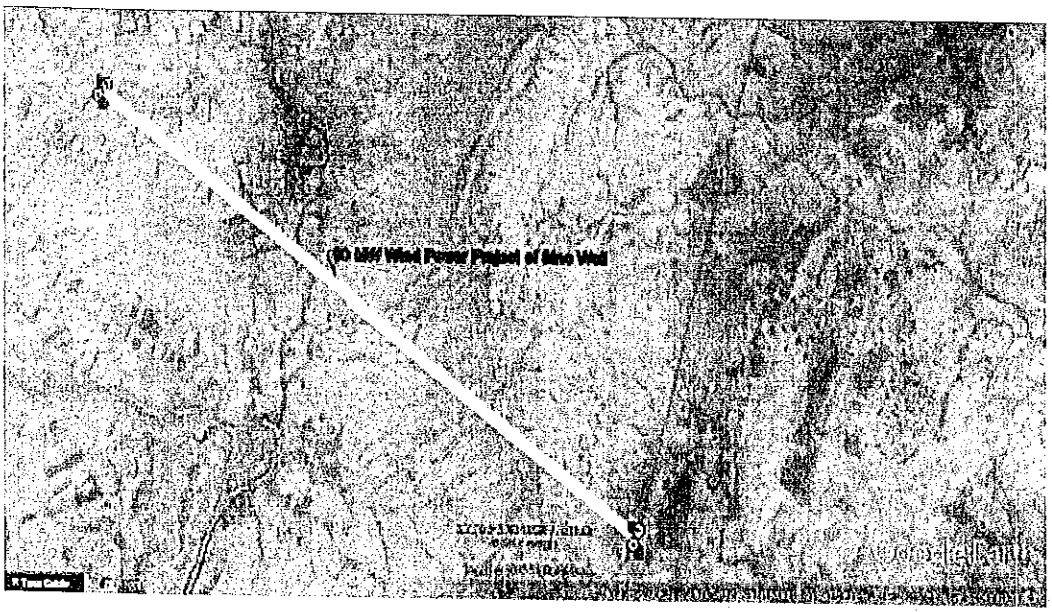


Sino Well has received allocation of land from Government of Sindh (GoS) for the development of the Project. The Project's site is located about 95 km (aerial distance) northeast of Karachi. The nearest settlement to the proposed site is Nooriabad (28km southwest). The site is located in a strong and partly rocky area at 44m to 82m above sea level (the **Site**). The size of the Project's land is 335 (Three Hundred and Thirty Five) acres.

The coordinates of Sino Well wind farm site are given under:

TOTAL LAND AREA: 335 ACRES		
	Geodetic Coordinates	
SR. NO.	Latitude	Longitude
1	25° 10' 08.14" N	68° 02' 01.95" E
2	25° 10' 04.21" N	68° 01' 58.86" E
3	25° 07' 16.19" N	68° 06' 30.89" E
4	25° 07' 20.82" N	68° 06' 32.69" E

The satellite image of the Project's site is given below:



SINO WELL (PVT.) LIMITED

9. ENVIRONMENTAL AND SOCIAL SOUNDNESS

9.1 INVESTIGATION SUMMARY

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

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

It was observed that the area is highly underdeveloped and there is no industrialization in the area and thus the baseline emissions are very low. The nearest settlements of human habitats are located 2 (two) Km away from the Project Site. There is very sparse vegetation in the forms of herbs and shrubs, there being no reserved forest site or sanctuary located within the Project land area that needs to be demolished. The Site is located in remote areas with very little social and commercial activity and thus limiting the long term social impact.

Noise impacts will be around 60 DB(A) which are within the range as per National Environmental Quality Standards (NEQs) of Pakistan. There are no exceeds of shadow from the permissible limits calculated for all WTG type scenarios. The environmental disturbance normally associated with construction activities will be minimized through an Environment Management Plan (EMP), implementation of which will continue during Project operation and which includes monitoring arrangements.

There exist high potential of wind energy at the Site and the proposed Project will help in tapping this potential without impairing the environmental conditions of the area. It is envisaged that the more is the wind power generation from the Facility, the less is the GHG gases emissions – thus resulting in cleaner environment.

9.2 IEE REPORT APPROVAL FROM THE ENVIRONMENTAL PROTECTION AGENCY, SINDH

As already submitted in Section 1 (*Background to Generation License Application*) above, the Sindh EPA has already accorded its **approval** to the IEE Report for the Project through its decision dated January 03, 2017.

10. SAFETY

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

11. TRAINING AND DEVELOPMENT

11.1 While the Project Company will engage professional and competent contractors to undertake the operations and maintenance of the Facility for a period of up to ten (10) years following commercial operations of the Project, training of the Project Company's own staff forms an essential part of the Project Company's twenty five (25) year plan for the Project.

11.2 The EPC and O&M Terms & Arrangements will contemplate on-site and off-site training of the Project Company's staff. Such training, as per the scope of the contractors set out in the EPC and O&M Terms & Arrangements, will aim at preparing the Project Company's staff in operating and maintaining the Facility in accordance with international standards. The training will be conducted with an aim to teach the Project Company's staff the functions of each Facility system so that the staff is informed of the Facility's (or any part thereof) functions in question.

12. PROJECT FEASIBILITY STUDY

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

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

13. IMPLEMENTATION SCHEDULE

13.1 The following provides the key milestones achieved during the Project's development to date:

MILESTONES ACHIEVED TO DATE	
ACTIVITIES	**COMPLETION DATE**
Issuance of Letter of Intent by EDOS	March 1, 2016
Allocation of Land	August 22, 2016
Grid Interconnection Study completed & submitted to CPPA	September 20, 2016
Site Studies & Topography Survey completed & submitted to EDOS	December 7, 2016
IEE approval by Sindh EPA	January 3, 2017
Technical Feasibility Study completed & submitted to EDOS	January 12, 2017
Installation of Wind Mast & Instruments	February 13, 2017 and *site specific data from the wind mast is being collected since February 2017*
Signing of EPC Contract	March 20 & 24, 2017
Grid Interconnection Study approved by NTDC	June 1, 2017
Power Evacuation Certificate granted by NTDC	June 7, 2017
Letter of Interest received from Bank	November 7, 2018

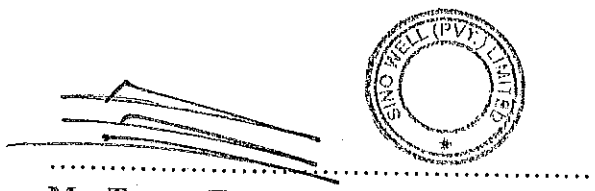
14.2 The following provides the key upcoming milestones and expected time for the Project's development:

MILESTONES TO BE ACHIEVED	
ACTIVITIES	COMPLETION DATE
Grant of Generation License	Upon NEPRA's approval
Reference Tariff Determination	Upon NEPRA's determination
Submission of Performance Guarantee by Project Company for issuance of LOS	Fifteen (15) days after Tariff determination by NEPRA
Issuance of LOS to Project Company by Government of Pakistan	Seven (7) days after submission of Performance Guarantee
Site Lease agreement with Government of Sindh	In progress prior to the Project's financial close and in accordance with Government of Sindh requirements
EPA Signing with NTDC	Within the time period allowed under the LOS
IA Signing with Government of Pakistan	Within the time period allowed under the LOS
Project Financial Close & ordering of equipment	Within the time period allowed under the LOS
Commercial Operation Date	Fifteen (15) months following Financial Close
Adjustment of reference tariff by NEPRA	Following Commercial Operations Date

CONCLUSION

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

Respectfully submitted for and on behalf of:
SINO WELL (PRIVATE) LIMITED



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MR. TABISH TAPAL
CHIEF EXECUTIVE OFFICER & AUTHORIZED REPRESENTATIVE OF
SINO WELL (PRIVATE) LIMITED

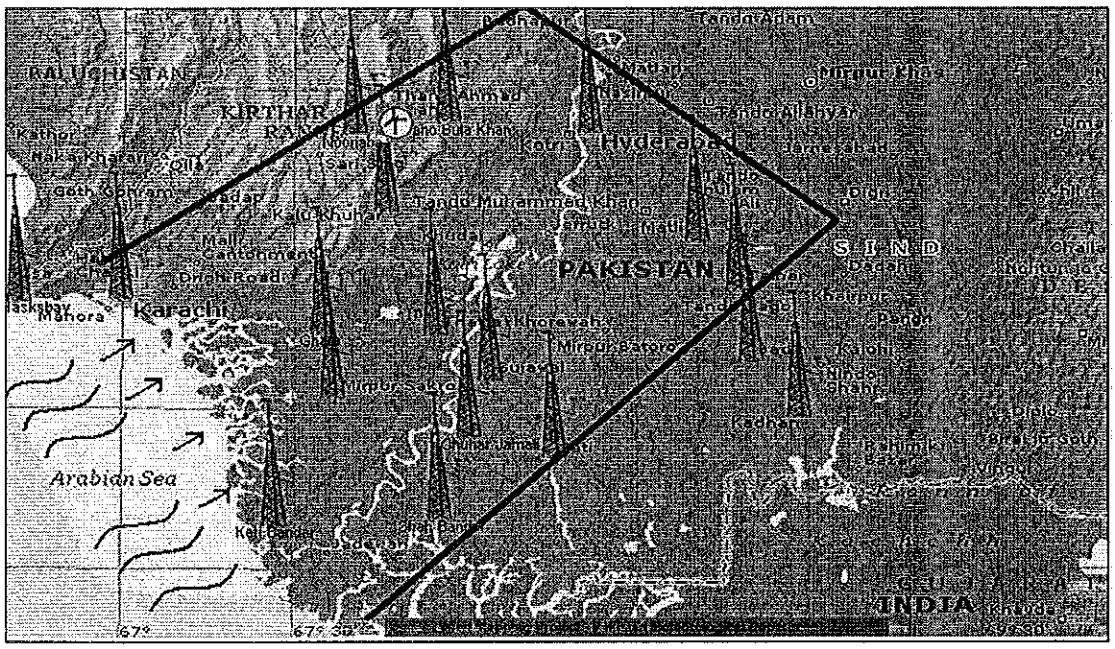
SCHEDULE-I

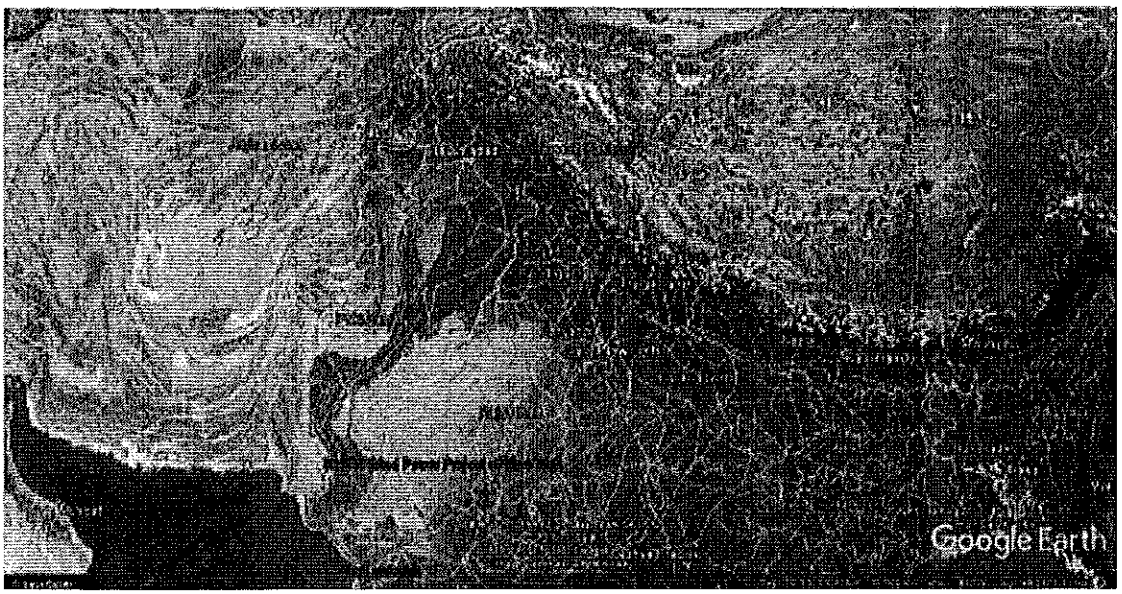
The Location, Size (i.e. Capacity in MW), Type of Technology, Interconnection Arrangements, Technical Limits, Technical/ Functional Specifications and other details specific to the Generation Facility of the Licensee are described in this Schedule.

Location
of Generation Facility/Wind Power Plant

Located near the village Jhampir, District Thatta, Sindh. Sino Well has received allocation of 335 acres from Government of Sindh (GoS) on lease for the development of 50MW wind power project. The project site is located about 95 km northeast of Karachi. The nearest settlement to the proposed site is Nooriabad (22km Southwest).

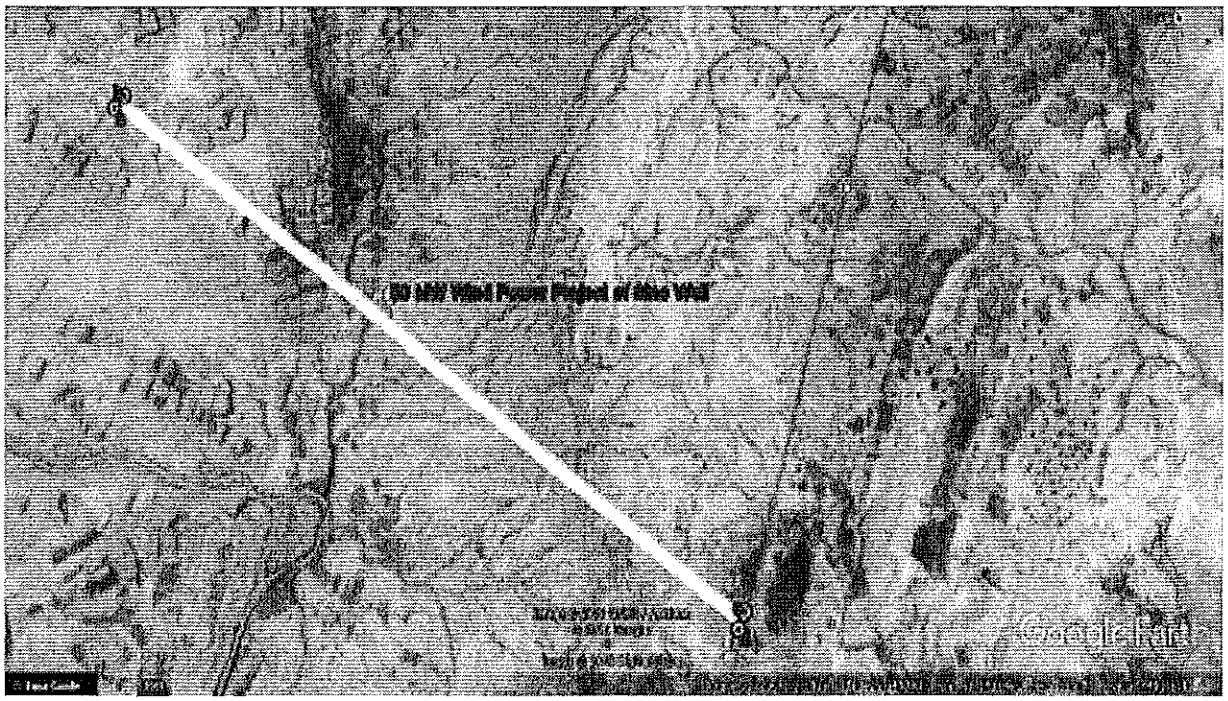
The geographical location of the site is given below:



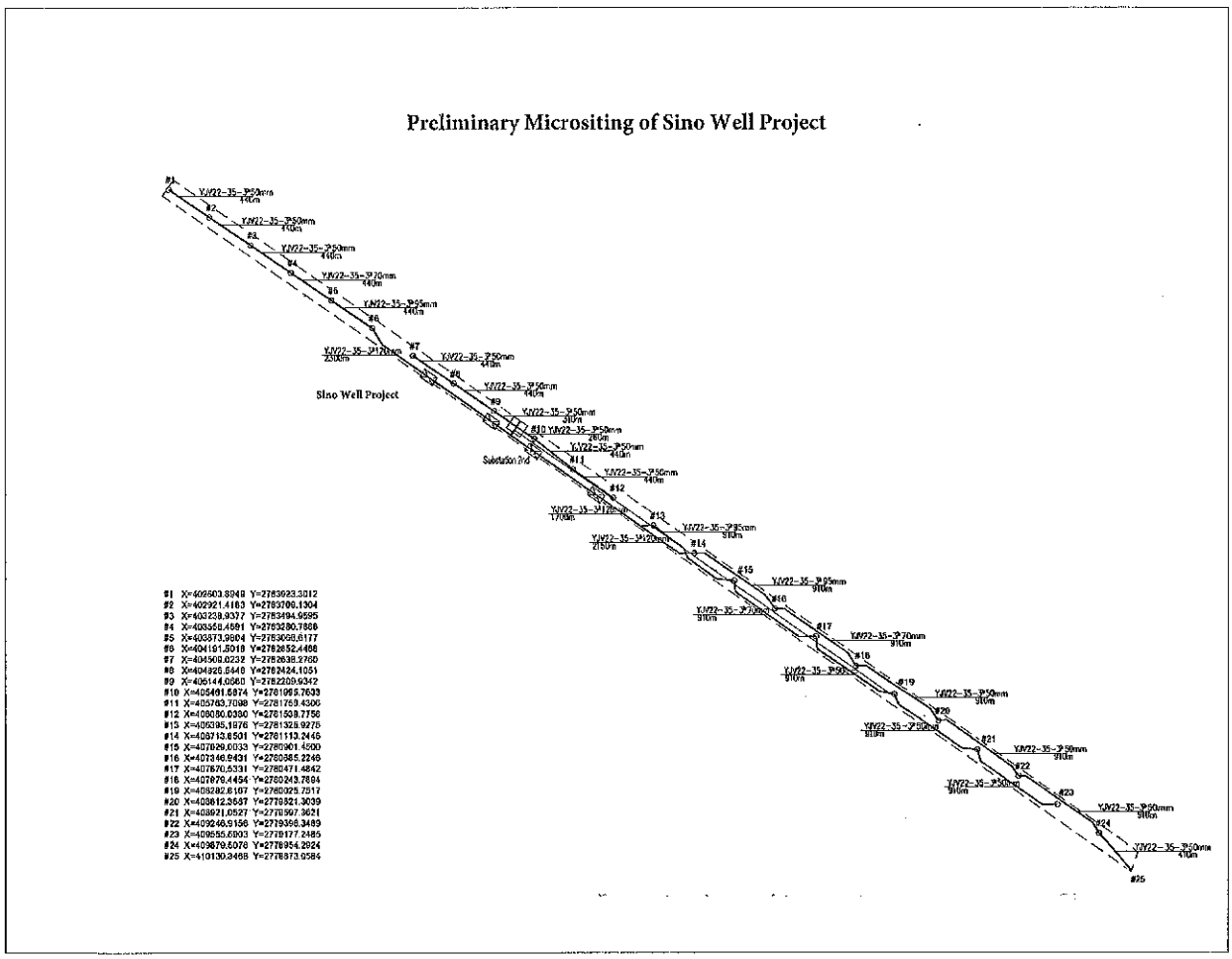


Land
of the Generation Facility/Wind Power Plant

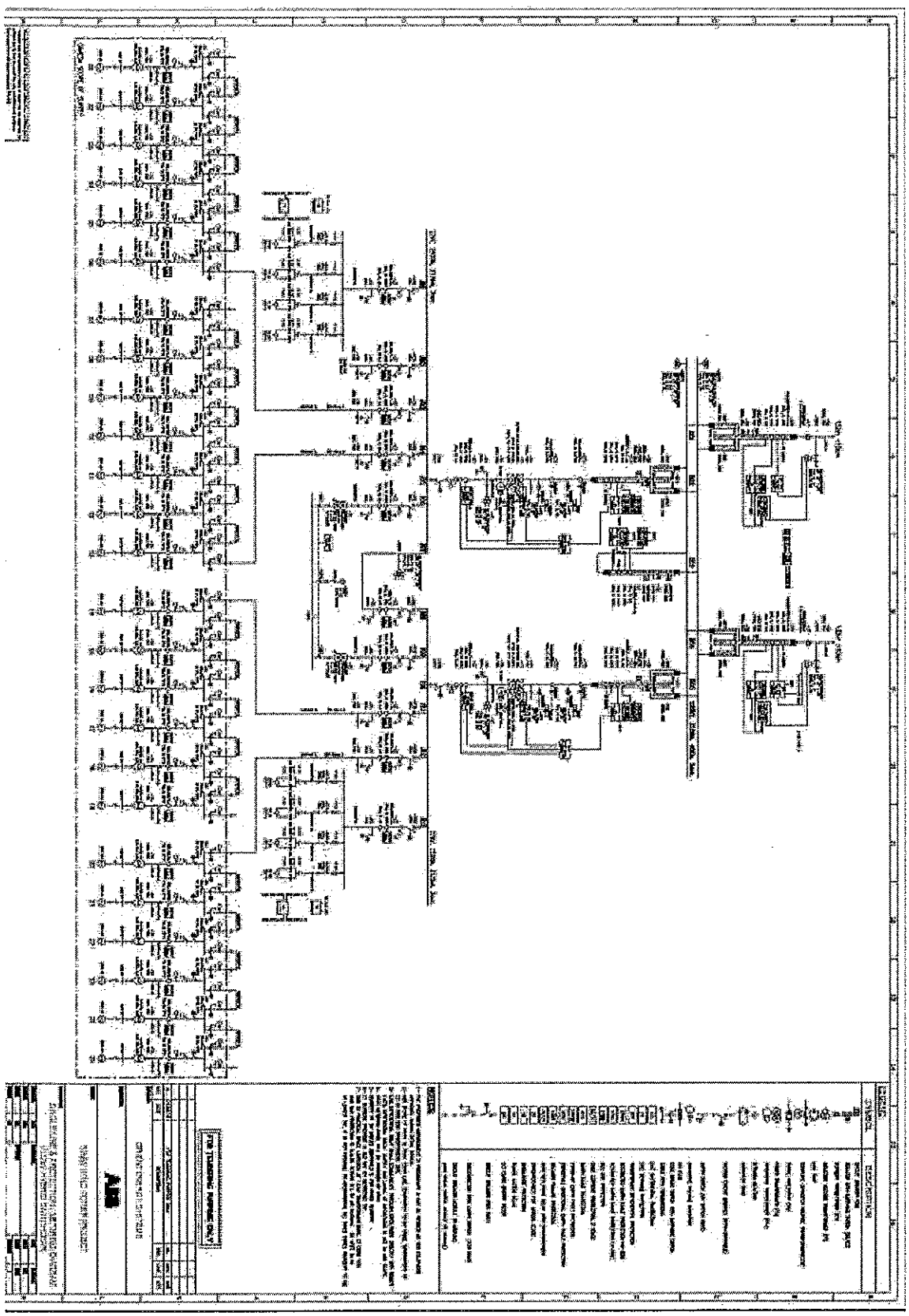
TOTAL LAND AREA: 335 ACRES Geodetic Coordinates		
SR. NO.	Latitude	Longitude
1	25° 10' 08.14" N	68° 02' 01.95" E
2	25° 10' 04.21" N	68° 01' 58.86" E
3	25° 07' 16.19" N	68° 06' 30.89" E
4	25° 07' 20.82" N	68° 06' 32.69" E



Micro-Sitting
of the Generation Facility/Wind Power Plant



Single Line Diagram
of the Generation Facility/Wind Power Plant



Interconnection Arrangement/Transmission Facilities for Dispersal of Power from Generation Facility/Wind Power Plant

1) The electric power generated from the Generation Facility/Wind Power Plant of SWPL shall be dispersed to the National Grid through the load center of HESCO.

2) The proposed Interconnection Arrangement/Transmission Facilities for dispersal of power from Generation Facility/ Wind Power Plant of SWPL will consist of the following:-

(a). A 132 KV double circuit transmission line approx.. 3 km long on Rail conductor for looping in-out on the 132 kV single circuit from Jhimpir-1 to T.M. Khan.

3) The scheme of interconnection of Wind Power Plant of SWPL also proposes the following reinforcement already in place at the southern part of Jhimpir cluster:-

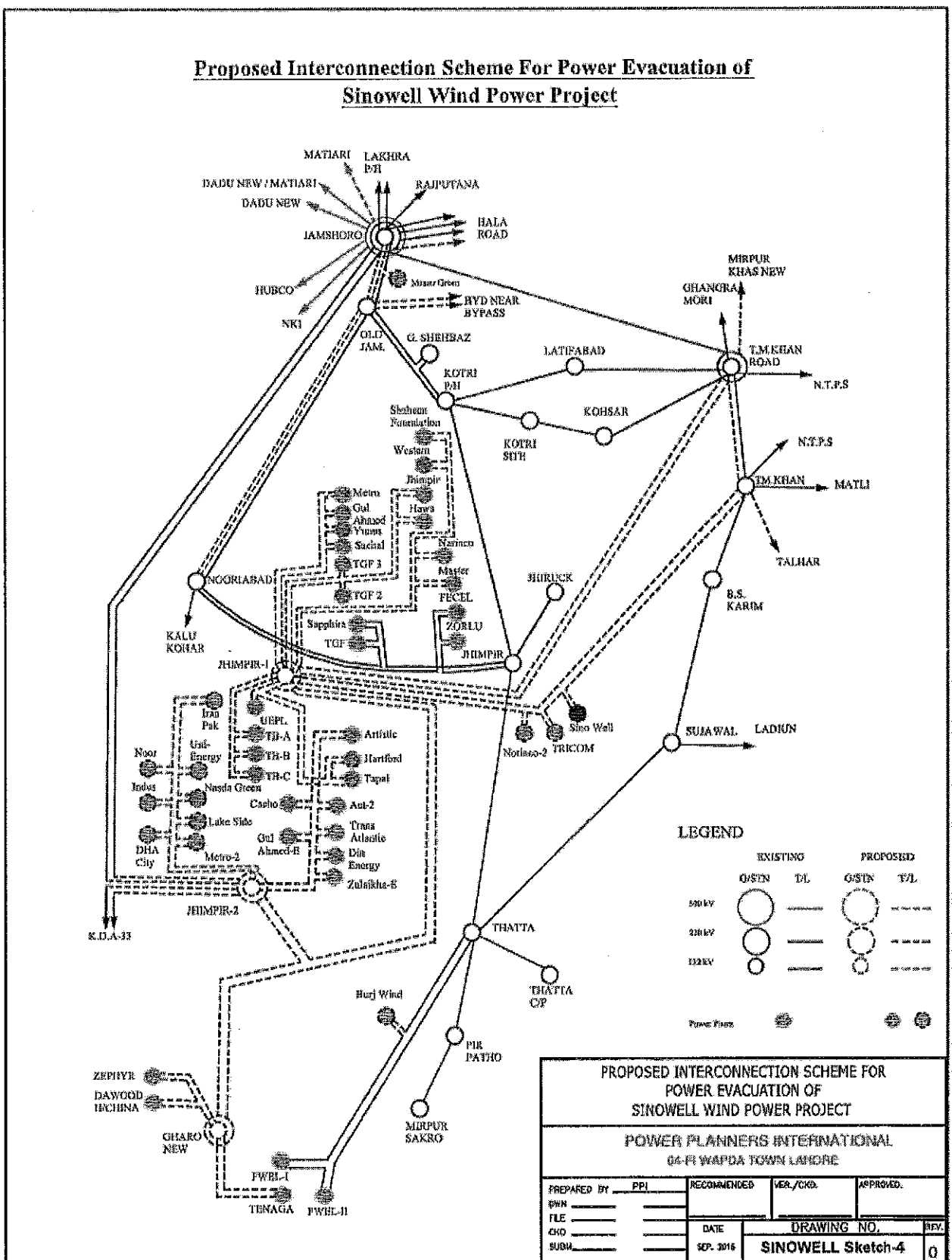
(a). 220 kV D/C transmission line, approximately 18 km long, on twin-bundled Greeley conductor for looping In/Out of second circuit of the existing Jamshoro-KDA-33 D/C transmission line at the proposed Jhimpir-2 220/132 kV substation;

(b). Addition of 4th 220/132 kV transformer at the newly proposed Jhimpir-2 220/132 kV substation;

(c). 132 kV D/C transmission line, approximately 88 km long, on twin-bundled Greeley conductor for connecting 8 WPPs including Lakside, Indus, DHA City, Noor, Metro-2, Iran Pak, Nasda, Uni-energy to Jhimpir-2 220/132 kV newly proposed substation;

4) Any change in the above mentioned Interconnection Arrangement/Transmission Facilities duly agreed by SWPL, NTDC and HESCO, shall be communicated to the Authority in due course of time.

Schematic Diagram of Interconnection Arrangement/Transmission Facilities for Dispersal of Power from Generation Facility/Wind Power Plant



Details of Generation Facility/Wind Power Plant

(A). General Information

(i).	Name of Applicant/Company	Sino Well (Pvt.) Limited.
(ii).	Registered/Business Office	F-25, Block 5,, Rojhan Street Kehkashan, Clifton Karachi, Pakistan.
(iii).	Plant Location	Jhimpir, District Thatta, Sindh
(iv).	Type of Generation Facility	Wind Power Plant

(B). Wind Farm Capacity & Configuration

(i).	Wind Turbine Type, Make & Model	Gamesa G114-2.0 MW
(ii).	Installed Capacity of Wind Farm (MW)	50 MW
(iii).	Number of Wind Turbine Units/Size of each Unit (KW)	25 x 2.0 MW

(C). Wind Turbine Details

(a).	**Rotor**	
(i).	Number of Blades	3
(ii).	Rotor Speed	7~14.7 RPM
(iii).	Rotor Diameter	114 m
(iv).	Swept Area	10207 m^2
(v).	Power Regulation	Combination of blade pitch angle adjustment and generator /converter torque control
(vi).	Rated wind speed	13.07 m/s

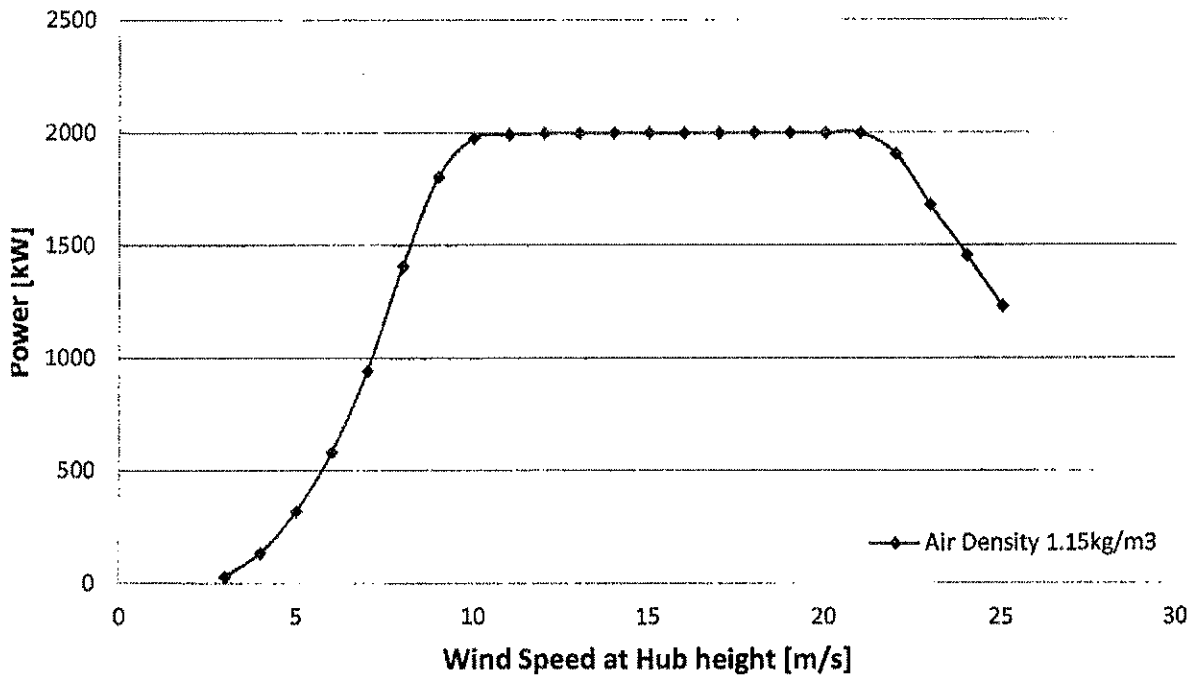
(vii).	Cut-in wind speed	3 m/s
(viii).	Cut-out wind speed	25 m/s
(ix).	Survival wind speed	59.5 m/s (Maximum 3s)
(x).	Pitch regulation	Pitch control hydraulic system consisting of independent hydraulic actuators for each blade
(b). Blades		
(i).	Blade Length	56 m
(ii).	Material	Composite material reinforced with fiberglass through resign infusion technology
(iii).	Weight	13 Tons x 3
(c). Gear Box		
(i).	Type	3 combined stages: 1 stage planetary , 2 parallel shift gears
(ii).	Gear ratio	1:128.5
(iii).	Weight	18.5 Tons
(iv).	Oil quantity	490 Ltr
(v).	Main shaft bearing	One step planetary gear and two steps parallel
(d). Generator		
(i).	Power	2040 kVA
(ii).	Voltage	690 V
(iii).	Type	Double feed induction generator with coil rotor and slip rings
(iv).	Speed	1680RPM
(v).	Enclosure class	IP 54 Turbine- IP21 Ring Body
(vi).	Coupling	Main shaft: Cone collar High Speed Shaft: Flexible Coupling
(vii).	Efficiency	98%

(viii).	Weight	9.15 Ton (Gen + Cooler)
(ix).	Power Factor	0.95 inductive-0.95 capacitive
(e). Yaw System		
(i).	Yaw Bearing	PETP
(ii).	Brake	Active Yaw
(iii).	Yaw Drive	Motor drive
(iv).	Speed	0.42/s Controlling speed
(f). Control System		
(i).	Type	PLC Control System
(ii).	Grid Connection	IGBT Converter
(iii).	Scope of Monitoring	Remote monitoring of different parameters, eg: temperature, pitch parameters speed, generator torque ,wind speed and direction
(iv).	Recording	Production data ,event list , long and short term trends
(g). Brake		
(i).	Design	Mechanical brakes
(ii).	Operational Brake	Aerodynamic brake achieved by feathering blades
(iii).	Secondary Brake	Mechanical brakes on high speed shaft of gear box
(h). Tower		
(i).	Type	Conical barrel tube
(ii).	Hub Heights	80 m

(D). Other Details

(i).	Project Commercial Operation Date-COD (Anticipated)	On or before June, 2020
(ii).	Expected Life of the Generation Facility/WPP from COD	25 years

Power Curve of Wind Turbine Generator of Gamesa G114-2.0 MW (Graphical)



Power Curve of Wind Turbine Generator of Gamesa G114-2.0 MW (Tabular)

Wind Speed (m/s)	Power (kW)
3	29
4	135
5	319
6	581
7	943
8	1408
9	1804
10	1977
11	1993
12	1999
13	2000
14	2000
15	2000
16	2000
17	2000
18	2000
19	2000
20	2000
21	2000
22	1906
23	1681
24	1455
25	1230

SCHEDULE-II

The Total Installed/Gross ISO Capacity (MW), Total Annual Full Load Hours, Average Wind Turbine Generator (WTG) Availability, Total Gross Generation of the Generation Facility/Wind Farm (in GWh), Array & Miscellaneous Losses (GWh), Availability Losses (GWh), Balance of Plant Losses (GWh) and Annual Energy Generation (GWh) of the Generation Facility /Wind Farm of Licensee is given in this Schedule

SCHEDULE-II

(1).	Total Installed Gross ISO Capacity of the Generation Facility /Wind Farm (MW/GWh)	50 MW
(2).	Total Annual Full Load Hours	3241 Hrs
(3).	Average Wind Turbine Generator (WTG) Availability	95.0 %
(4).	Total Gross Generation of the Generation Facility/Wind Farm (in GWh)	200.77 GWh
(5).	Array & Miscellaneous Losses GWh	24.62 GWh
(6).	Availability Losses GWh	8.81 GWh
(7).	Balance of Plant Losses GWh	5.28 GWh
(8).	Annual Energy Generation (25 year equivalent Net AEP) GWh	162.06 GWh
(9).	Net Capacity Factor	37 %

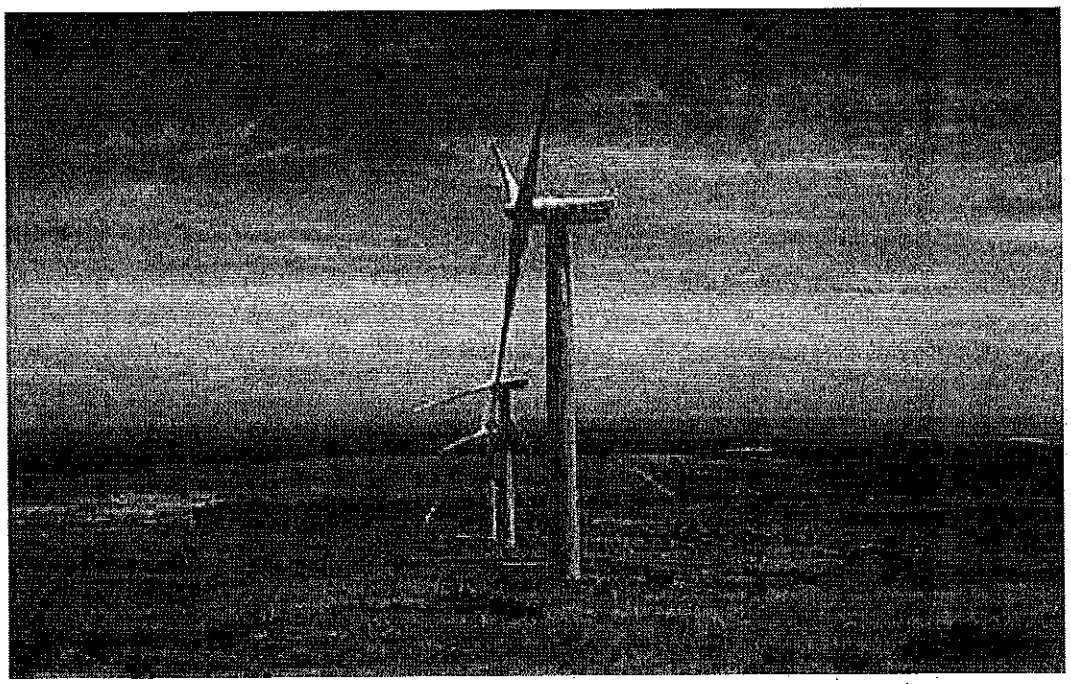
Note

All the above figures are indicative as provided by the Licensee. The Net energy available to NTDC for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

Annexure A – Project Feasibility Study

PROJECT FEASIBILITY REPORT

50 MW WIND POWER PROJECT AT JHAMPIR, THATTA



Project Company

SINOWELL PRIVATE LIMITED

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Acknowledgements

The management of Sinowell Private Limited (Sinowell) is thankful to Energy Department, Government of Sindh for generous support at all stages of project development and looks forward to continue for future milestones.

Disclaimers

This report has been prepared for the benefit of Sinowell (the "Client"), and may not be relied upon or disclosed to any other person for any purpose, other than as stated below, without the prior written consent of the Client in each specific case. The information contained in this report is intended to be used by the Client for such other purpose as may be necessary for the development and implementation of the Project.

Copyright Notice

COMPANY CONTACT INFORMATION

The Company's office is located at:

Sinowell Private Limited	
Address	F-25, Block 5, Rojhan Street Kehkashan, Clifton Karachi, Pakistan. Tel: 0092 21 35876994 Fax: 0092 21 35876991
Contact Person	Mr. Syed Raza Abbass

CONSULTANT CONTACT INFORMATION

The Company's office is located at:

Pakistan Alternative Engineering Services Private Limited	
Address	107-C, Mezzanine Floor, Jami Commercial Street No. 11 Phase-VII, DHA Karachi, Pakistan. Tel: 0092 21 35311736-8
Contact Person	Mr. Salman Ahmed, CEO
Email	salman@paespl.com

Document Information

Purpose and Scope

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

1 EXECUTIVE SUMMARY

1.1 PROJECT OVERVIEW

In light of the threefold global crisis mankind is facing currently – the energy crisis, the finance crisis and the environment/climate crisis – it is becoming more and more obvious that wind energy offers solutions to all of these huge challenges, offering a domestic, reliable, affordable and clean energy supply.

At this point of time it is difficult to predict the short-term impacts of the credit crunch on investment in wind energy. However, in the mid to long term it is clear that wind energy investments will rather be strengthened due to their low-risk character and societal and additional economic benefits. Investment in a wind turbine today means that the electricity generation cost is fixed to the major extends over the lifetime of the wind turbine. Wind energy implies no expenses on fuel and operation and maintenance costs are usually well predictable and rather marginal, in relation to the overall investment.

Pakistan is also facing the severe problem of high energy demand to sustain the economic growth and development. This comes with the dire fact that the conventional sources of energy, the fossil fuels, are depleting. The environmental impacts of these conventional energy sources are also alarming. This has led towards the development of alternative energy resources especially wind energy so that fuel diversification is achieved and energy systems are not highly vulnerable to shortages or prices increases of a particular fuel.

Wind resource studies conducted by the Government of Pakistan (GoP) through Pakistan Metrological Department (PMD) and Alternative Energy Development Board (AEDB) have shown very encouraging results. Based on these studies, GoP has offered private investors the opportunity to develop Independent Power Producer (IPP) companies for generating power through wind in the coastal regions of the Sindh province.

Sinowell intends to develop, own and operate a 50MW Wind Farm in Jhampir, Thatta. This feasibility study, deals with the 50 MW Sinowell wind enerrgy Project at Jhampir, will serve the purpose for making the executive decision based on the technical viability of the project by Sinowell authorities regarding project implementation.

The Jhampir area has been selected for implementing the project on the basis of its exceptional wind regime, flat terrain and closeness to the National and local grid. The area has been extensively surveyed and is identified as having strong potential site for the proposed wind farm.

The electricity generated from the 50 MW wind farm would be sold to Central Power Purchase Agency (CPPA-G) on the 132/220kV grid. The Energy Purchase Agreement (EPA) would be signed with the Central Power Purchase Agency (CPPA-G) for a project life of 20 years.

1.2 ENERGY PRODUCTION ESTIMATION

Sinowell intends to develop, own and operate a 50 MW Wind Farm in Jhampir, Thatta (the "Project"). The energy yield calculations for the 50 MW wind farm have been calculated using the wind turbine generator (WTG) of CSIC H111L-2.0 MW having hub height of 80m.

Three wind measuring masts have been considered for this study namely, FFC Energy Mast (12 km in the southwest of Project site), Yunus Energy Mast (5.4 km in the southwest of Project site) and the wind measuring mast of Master Energy Mast (9.5 km in the southwest of Project site).

The wind measuring mast of Yunus Energy Limited (YEL) has been selected for the calculation of annual energy yield at the wind farm site of Sinowell due to the following reasons:

- Installation arrangements of the mast are of IEC compliance
- Measnet Calibrated Anemometers
- Long term data
- Good data coverage for all the instruments during the measurement period
- Time series is good enough to generate a bankable wind resource assessment report
- Computed regression coefficient for anemometers installed at FFC Energy mast with legends V85-a and V85-b is very good ($r^2 = 0.9895$) & correlation with other neighboring masts is also very good.
- Site conditions of project site are similar to that of YEL mast site.
- In close proximity of the project site than the other neighboring wind measuring masts.

The annual energy productions for 50 MW wind farm, using long term time series developed at YEL Mast, on the proposed wind turbine generator have been estimated using WAsP. The summary of estimated annual energy productions of the 50 MW wind farm using YEL mast is shown in Table 1-1 below.

Table 1-1: Summary of Estimated Annual Energy Production Calculated Using Time Series of YEL Mast

Sinowell Wind Farm	Wind Turbine Generator CSIC H111L-2.0MW
Turbine Capacity (kW)	2000
Number of WTG	25
Installed Wind Farm Capacity (MW)	50
Hub Height (meters)	80
Rotor Diameter (m)	111
Gross Electrical Output of Wind Farm (GWh)	227.465
Wake Losses (GWh)	26.025
Net Electrical Output of Wind Farm (GWh)	201.440
Power Curve density correction Losses (3.5%) - (GWh)	7.050
Availability (95%) - (GWh)	9.719
Power Curve Losses (2%) - (GWh)	3.693
Blade Degradation (0.5%) - (GWh)	0.905
Temperature Losses (2%) – (GWh)	3.601
Electrical Losses (3%) - (GWh)	5.294
Scheduled maintenance/ Miscellaneous (1.0 %) - (GWh)	1.712
P50 Wind Farm Yield (GWh/annum)	169.465
P50 Capacity Factor (%age)	38.691

1.3 UNCERTAINITY ANALYSIS

The uncertainties associated with the wind speed measurement accuracy, long term wind speed predictions, wind flow model, array loss modeling, instruments, topography, simulation software have been estimated. Annual Energy production of the wind farm is calculated at different probability level. The results obtained for different confidence levels are summarized in Table 1-2 below:

Table 1-2: Energy Production Estimates for proposed 50 MW Wind Farm using Yunus Energy Mast

WTG Type	H111L-2.0 MW
P50 Wind Farm Yield (GWh/annum)	169.465
P50 Capacity Factor (%age)	38.691
P70 Wind Farm Yield (GWh/annum)	151.58
P70 Capacity Factor (%age)	34.606
P80 Wind Farm Yield (GWh/annum)	140.57
P80 Capacity Factor (%age)	32.093
P90 Wind Farm Yield (GWh/annum)	125.43
P90 Capacity Factor (%age)	28.637

2 PROJECT SITE

2.1 GENERAL AREA

The Gharo – Keti-Bandar wind corridor, identified by Alternative Energy Development Board, lies between the coastal towns of Gharo and Ketibandar stretching more than 80 Km along the coast of Arabian Sea and runs more than 170 km deep inland towards Hyderabad. The area has been surveyed by AEDB and Pakistan Meteorological Department (PMD) which shows a high wind speed regime within the corridor. The study carried out for wind mapping of Pakistan by NREL in 2006 also confirms the presence of high wind speed regime in the coastal areas of Sindh.

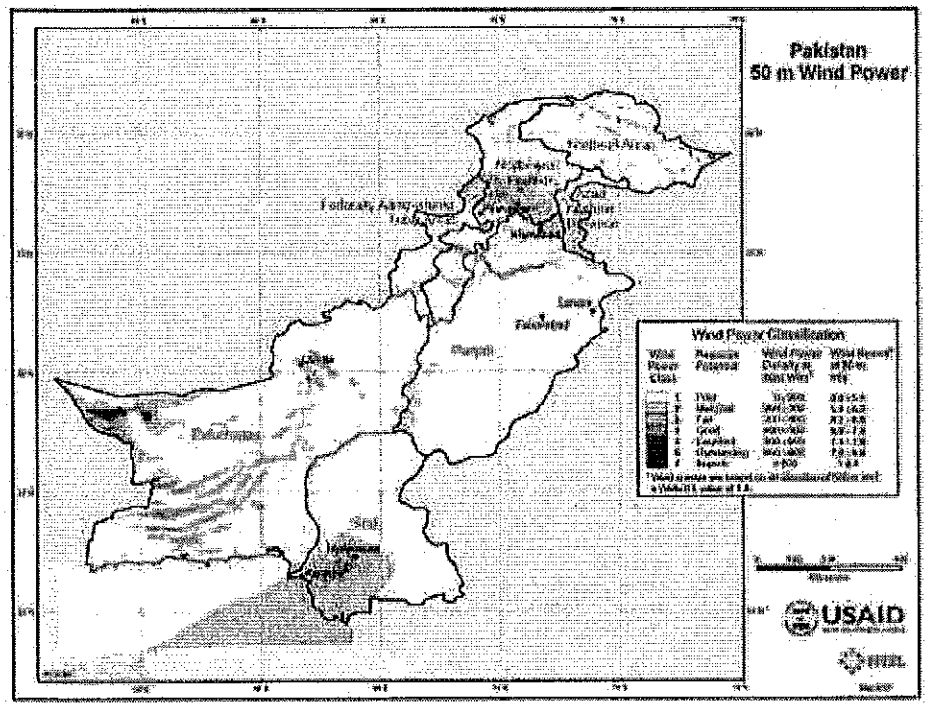


Figure 2-1: Pakistan wind map[1]

[1] www.aedb.org

2.2 SELECTION OF PROPOSED SITE

The project site of Sinowell is located near the village Jhampir, District Thatta, Sindh. The Jhampir area has been selected for implementing the project on the basis of its exceptional wind regime, flat terrain and nearness to the National and local grid. The area has been extensively surveyed and is identified as having strong potential site for the proposed wind farm. The following other parameters have also been considered for the implementation of the project at the proposed site.

- Forecasted power output
- Access to the proposed site (materials and equipment transport feasibility study)
- Suitability for the surrounding environment

2.3 LOCATION OF THE PROJECT SITE

Sinowell has received the project land from Government of Sindh (GoS) on lease basis for the development of 50 MW wind power project. The project site is located about 109km (aerial distance) northeast of Karachi. The nearest settlement to the proposed site is Nooriabad (25km west). The site is located in a strong and partly rocky area at 43m to 99m above sea level. The size of the whole wind farm is 340.417 acres. The coordinates of Sinowell wind farm site are given under:

Table 2-1: Land Coordinates

	UTM Coordinates; zone 42R		Geodetic Coordinates	
	Easting [m]	Northing [m]	Latitude	Longitude
1	402554.2151	2783883.0206	25° 10' 4.24"N	68° 1' 58.93"E
2	402642.9568	2784004.0320	25° 10' 8.20"N	68° 2' 2.04"E
3	410185.0587	2778801.9785	25° 7' 20.75"N	68° 6' 32.71"E
4	410131.7272	2778656.5243	25° 7' 16.03"N	68° 6' 30.81"E

The geographical location of the site on the map is given below.

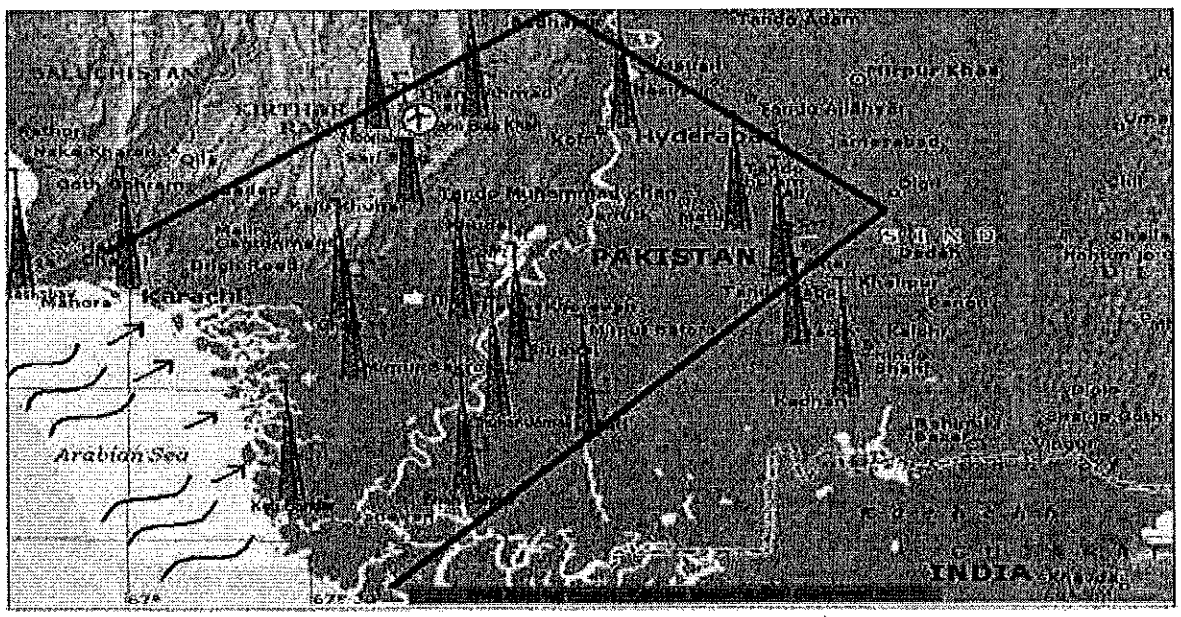


Figure 2-2: Site Location on Map

The terrain is flat at the project site with little plantation. There are some small and scattered pieces of agriculture land within the project site & surroundings. The area has a dry climate. The satellite map of the project site is given below:

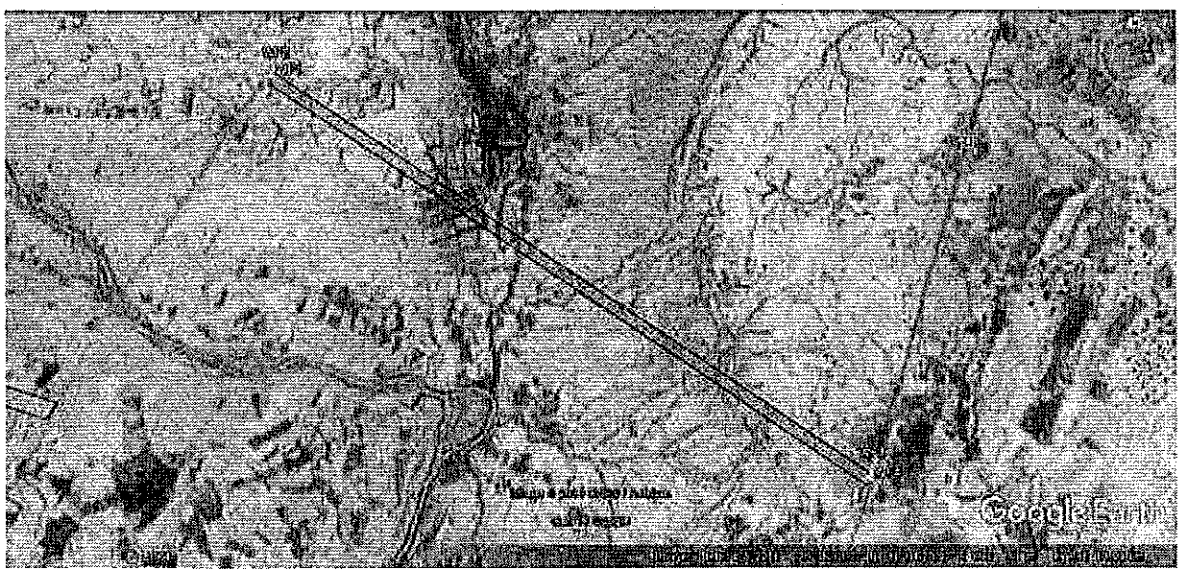


Figure 2-3: Sinowell Wind Farm Site Location on Map

2.4 CLIMATIC CONDITIONS

The climate of southern parts of the Sindh province is characterized by fluctuating temperatures and sparse rainfall. The summers are hot and humid with average temperature ranging between 33 °C to 37 °C. The temperature in summers may reach up to 45 °C. The winters are pleasant with average temperature in the range of 12 °C to 15 °C. The months of July and August generally observe the annual monsoon rainfalls. The climatologically information of Karachi is shown in table 2-2 below. The recorded monthly temperature data at 85m height from the neighboring mast of Yunus Energy Limited (YEL) is given in table 2-3 below. The monthly mean temperature at the YEL site which is on the same plane of the project site and is located at a distance of ~5.4 km in the south-west, ranges between 18.24 °C to 32.1 °C. Maximum temperature at the neighboring mast of YEL is recorded as 44.67 °C.

Table 2-2: Karachi Climatological Information

Month	Average Temperature (°C)		Relative Humidity (%)		Total Rainfall (mm)
	Min	Max	am	Pm	Mean
Jan	13	25	63	45	3.6
Feb	14	26	72	49	6.4
Mar	19	29	79	57	8.3
Apr	23	32	87	62	4.9
May	26	34	88	68	0
Jun	28	34	86	69	3.9
Jul	27	33	28	73	64.4
Aug	26	31	90	74	44.8
Sep	25	31	89	71	22.8
Oct	22	33	83	57	0.3
Nov	18	31	68	49	1.7
Dec	14	27	64	45	4.5

Table 2-3: Monthly Temperature conditions at Neighboring Mast of YEL

Year	Month	Mean (°C)	Min (°C)	Max (°C)
2008	Nov	23.94	19.05	31.21
2008	Dec	19.82	12.65	29.94
2009	Jan	18.6	10.62	25.81
2009	Feb	23.24	14.67	34.08
2009	Mar	26.88	19.53	35.4
2009	Apr	30.77	21.86	42.35
2009	May	31.93	25.92	43.39
2009	Jun	31.29	25.68	41.91
2009	Jul	30.22	22.91	42.2
2009	Aug	29.04	23.74	38.12
2009	Sep	28.16	24.4	34.77
2009	Oct	29.5	22.44	40.32
2009	Nov	25.17	16.11	35.39
2009	Dec	20.87	13.55	27.54
2010	Jan	19.64	9.14	27.38
2010	Feb	22.34	11.51	33.54
2010	Mar	29.04	19.77	39.75
2010	Apr	30.7	21.89	40.57
2010	May	32.1	25.75	44.28
2010	Jun	30.3	22.24	40.03
2010	Jul	30.24	25.3	40.78
2010	Aug	29.01	23.99	37.9
2010	Sep	29.16	23.68	36.81
2010	Oct	29.78	22.15	38.61
2010	Nov	25.46	16.89	33.16
2010	Dec	19.94	12.81	27.75
2011	Jan	18.24	5.85	27.38
2011	Feb	21.16	14.55	29.29
2011	Mar	27.17	14.89	39.01
2011	Apr	29.77	21.67	39.11
2011	May	30.59	24.4	43.35
2011	Jun	31.04	27.2	44.67
2011	Jul	30.01	26.49	38.47

2011	Aug	28.67	23.54	35.71
2011	Sep	-	-	-
2011	Oct	-	-	-
2011	Nov	-	-	-
2011	Dec	-	-	-
2012	Jan	18.49	9.92	26.53
2012	Feb	19.74	9.06	31.05
2012	Mar	25.89	17.56	40.39
2012	Apr	29.68	20.91	40.03
2012	May	31.13	25.38	43.27
2012	Jun	30.42	26.49	41.88
2012	Jul	29.59	26.38	37.87
2012	Aug	29	25.89	36.93
2012	Sep	28.66	24.34	36.42
2012	Oct	28.98	23.18	37.31
2012	Nov	26.34	18.16	34.25
2012	Dec	20.89	10.62	30.39
2013	Jan	19.62	10.31	28.52
2013	Feb	20.89	12.27	28.64
2013	Mar	26.87	16.39	34.97
2013	Apr	29.13	19.85	39.46
2013	May	31.48	24.83	41.78
2013	Jun	31.57	26.87	37.87
2013	Jul	-	-	-
2013	Aug	27.78	25.51	31.1
2013	Sep	29.91	24.81	38.88
2013	Oct	30.07	23.21	38.89
2013	Nov	25.76	18.54	33.37

3 WIND DATA ANALYSIS

3.1 WIND DATA SOURCES

A total of four (04) wind measuring masts have been considered for this study namely:

- Karachi Airport Weather Station
- 81.5m High Wind Measuring Mast of FFC Energy Limited
- 85m High Wind Measuring Mast of Yunus Energy Limited
- 80m High Wind Measuring Mast of Master Wind Energy Pvt. Limited

Wind Data analysis has been made on the above mentioned wind measuring masts. The data analysis on these masts is presented below.

3.2 KARACHI AIRPORT WEATHER STATION

3.2.1 WEATHER STATION OVERVIEW

The weather station close to the wind farm site of Sinowell is the weather station in Karachi airport, which is located in the southwest side of the Project site in Karachi, the center of the observation field has a coordinate of 24° 54'N and 67° 08'E, with an altitude of 21m above sea-level, and the height of wind instrument is 7m. The weather station was built in 1928, and now is one of the stations participating in the global meteorological information exchange of the World Meteorological Organization (WMO), the unified number of which in WMO is 41780.

The weather station is located in the southwest of the site of the Sinowell wind farm site, and the linear distance between the center of the Project site and the weather station is about 96.76 km. The Project site is an open and flat terrain, with a good topography and climate consistency.

Observing parameters including mainly the temperature (°C), precipitation (mm), wind speed (knot), and wind direction has been observed and recorded for three times every day, respectively at 5:00/8:00 a.m. and 5:00 p.m. local time before the year of 20112 in the airport weather station. From the beginning of 2012, these observing parameters were recorded hourly.

3.2.2 ANALYSIS OF METEOROLOGICAL DATA

3.2.2.1 Meteorological Element Statistics

Meteorological parameters of Karachi airport weather station are shown in Table 3-1.

Table 3-1: Meteorological Parameters Statistics of Karachi Airport Weather Station

Item	Unit	Index	Remark
Average temperature of many years	°C	26.6	
Maximum temperature	°C	47.8	
Minimum temperature	°C	0.0	
Average precipitation of many years	mm	204	
Relative humidity of many years	%	76	
Annual average of wind speed	m/s	2.38	

3.2.2.2 Mean Wind Speed

Statistics results of daily mean wind speed at 5:00/8:00 a.m. and 5:00 p.m. in the weather station of Karachi airport from 1980 to 2011 are shown in Table 3-2 and Fig. 3-1. Average wind speed of years at 5:00 a.m. is 1.69 m/s; Average wind speed of many years at 8:00 a.m. is 1.72 m/s; Average wind speed of years at 5:00 p.m. is 3.75 m/s, and average wind speed of many years is 2.38 m/s.

Statistics results of monthly mean wind speed from 1980 to 2011 in the airport weather station are shown in Table 3-3 and Fig. 3-2. Yearly mean wind speed from April to September is higher, and lower from October to March of the following year. Maximum mean wind speed is in August, which is 3.87 m/s, and minimum mean wind speed is in November, which is 1.10 m/s.

Table 3-2: Annual Mean Wind Speed Statistics

Year	5:00 a.m.	8:00 a.m.	5:00 p.m.	Average
1980	1.41	1.62	3.57	2.20
1981	1.53	1.69	3.91	2.38
1982	1.29	1.69	3.76	2.25
1983	1.50	1.59	3.71	2.27
1984	1.23	1.52	3.61	2.12
1985	1.14	1.86	3.53	2.18
1986	1.05	1.41	3.32	1.93
1987	1.39	1.83	3.79	2.34
1988	1.72	1.74	3.35	2.27
1989	1.26	1.69	3.36	2.10
1990	1.66	1.17	3.63	2.35
1991	1.45	1.51	3.46	2.14
1992	1.26	1.44	2.94	1.88
1993	1.19	1.33	3.11	1.88
1994	1.63	1.56	3.01	2.07
1995	1.58	1.53	3.38	2.16
1996	1.65	1.42	3.85	2.31
1997	1.98	1.79	4.06	2.61
1998	1.80	1.83	3.59	2.41
1999	1.95	2.16	3.80	2.64
2000	2.44	2.15	4.55	3.05

2001	2.07	1.90	3.98	2.65
2002	2.36	2.22	4.54	3.04
2003	2.04	1.84	4.12	2.67
2004	2.27	2.02	4.46	2.92
2005	2.00	1.81	4.01	2.61
2006	2.01	1.75	3.94	2.57
2007	1.29	1.25	3.78	2.11
2008	1.96	1.71	4.09	2.53
2009	1.85	1.72	4.02	2.47
2010	2.02	1.72	3.67	2.61
2011	2.03	1.81	3.97	2.38
Average	**1.69**	**1.72**	**3.75**	**2.38**

Table 3-3: Monthly Mean Wind Speed Statistics (m/s)

Month	**5:00 a.m.**	**8:00 a.m.**	**5:00 p.m.**	**Average**
January	0.73	0.73	2.57	1.35
February	0.93	0.74	3.27	1.65
March	1.02	0.86	3.81	1.90
April	1.41	1.67	4.12	2.40
May	2.40	2.86	4.92	3.39
June	3.06	3.22	5.01	3.77
July	3.32	3.32	4.98	3.87
August	3.16	3.12	4.48	3.59
September	2.38	2.45	4.12	2.98
October	0.71	0.66	3.03	1.47
November	0.45	0.42	2.42	1.10
December	0.69	0.55	2.21	1.15
Average	**1.69**	**1.72**	**3.75**	**2.38**

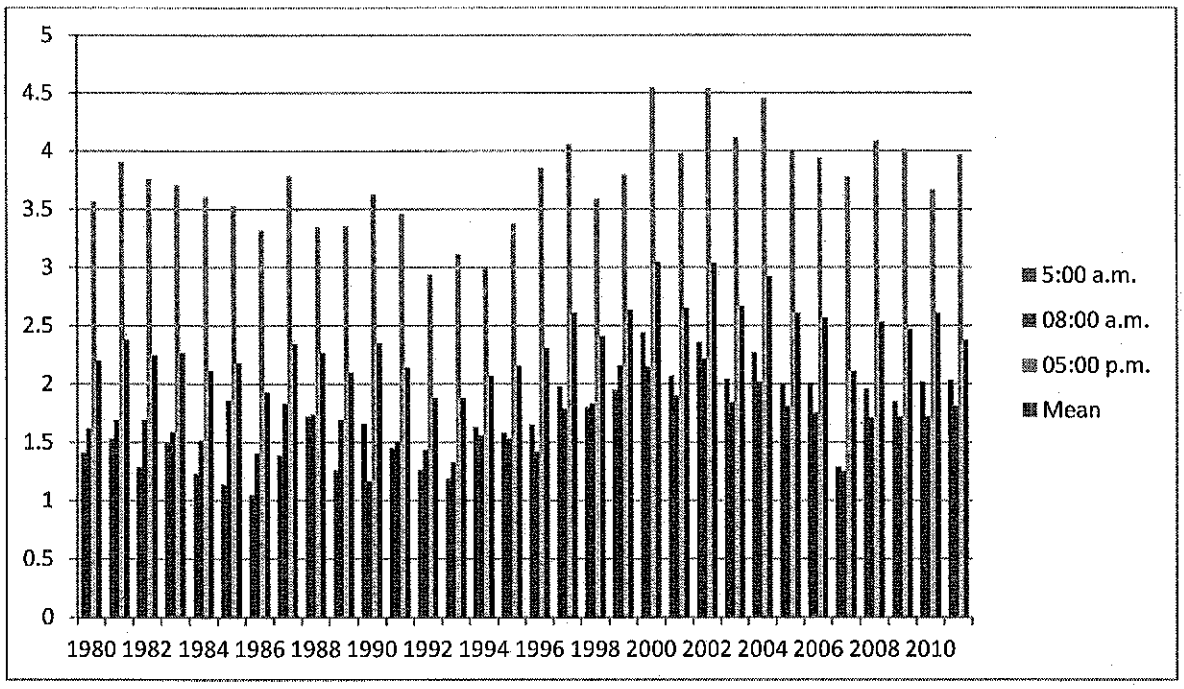


Figure 3-1: Annual Wind Speed Statistics

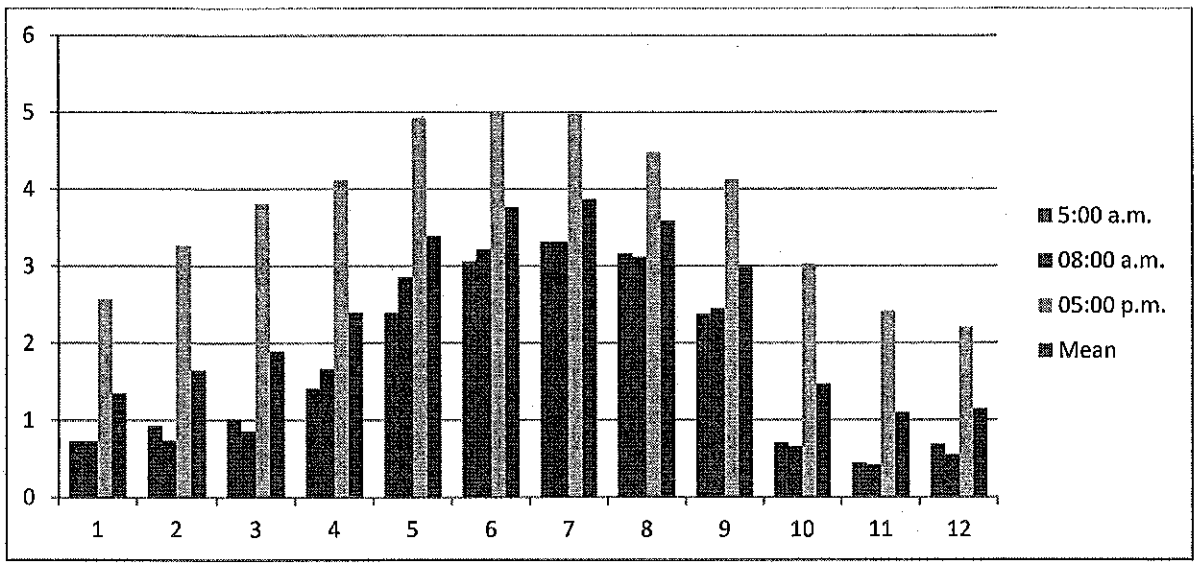


Figure 3-2: Monthly Wind Speed Statistics

3.2.2.3 Wind Direction

Statistics results of wind direction and mean wind direction at 5:00/8:00 a.m. and 5:00 p.m. from 2010 to 2011 in the airport weather station are observed. Prevailing wind direction at 5:00 a.m. is W (west), followed by N (north); Prevailing wind direction at 8:00 a.m. is N (north), followed by W (west); Prevailing wind direction at 5:00 p.m. is SW (southwest). Annual average prevailing wind direction is SW, followed by W/N.

3.2.2.4 Air Temperature

Karachi has a high temperature in its whole region, which is a hotter area, with the obvious temperature variation of tropical regions.

Statistics results of annual average air temperature from 1980 to 2009 in the airport weather station are shown in Table 3-4 and Fig. 3-3. Annual average temperature of many years is 26.6 °C in the airport weather station, with a trend of gradually increasing; annual average temperature is 26.2 °C between 1980 and 1998, and 27.3 °C between 1998 and 2009, with an obvious trend.

Statistics results of monthly average temperature from 1980 to 2009 in the airport weather station are shown in Table 3-5 and Fig. 3-4. Monthly average temperature change is relatively small; the average temperature from April to October is high, with an average temperature of 30 °C; Minimum average temperature is in January, which is 18.6 °C; Maximum average temperature is in July, which is 31.9 °C.

Table 3-4: Annual Average Temperature Statistics of the Karachi Weather Station

Year	Average Temperature	Year	Average Temperature
1980	26.4	**1995**	26.6
1981	26.3	**1996**	26.4
1982	26.2	**1997**	26.2
1983	25.9	**1998**	27.3
1984	25.6	**1999**	26.7
1985	26.1	**2000**	27.1
1986	25.8	**2001**	27.9
1987	26.5	**2002**	26.8
1988	27.2	**2003**	27
1989	26.1	**2004**	27.3
1990	25.9	**2005**	27
1991	26.21	**2006**	27.4
1992	26.3	**2007**	27.5
1993	27.2	**2008**	26.8
1994	26.1	**2009**	27.6

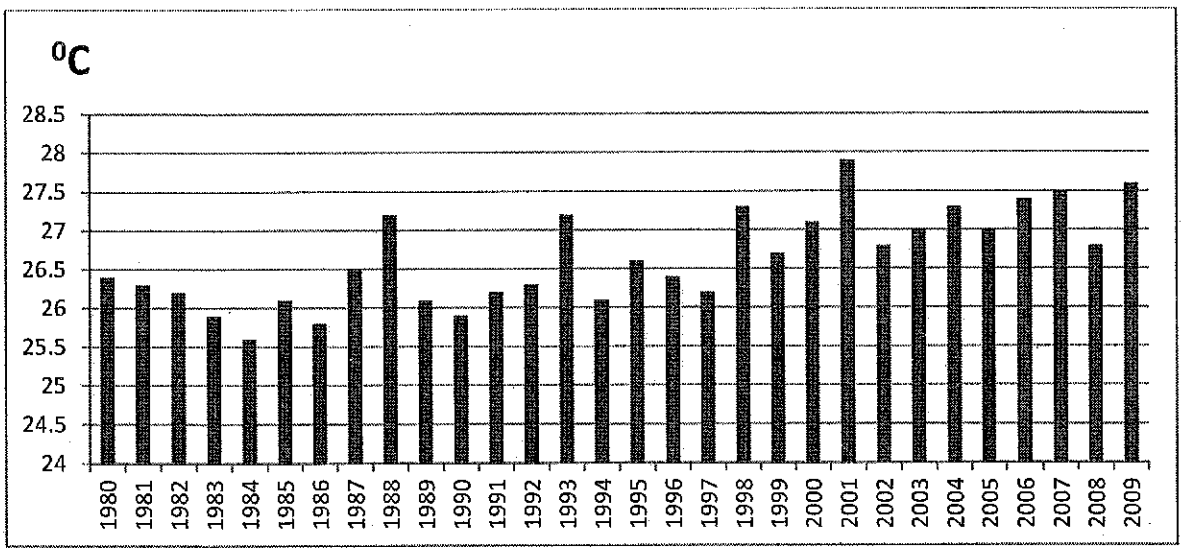


Figure 3-3: Annual Average Temperature Change of the Airport Weather Station over the Years

Table 3-5: Monthly Average Temperature Statistics of Airport Weather Station

Month	Average Temperature
Jan	18.6
Feb	21.2
Mar	25.3
Apr	28.9
May	31
Jun	31.9
Jul	30.5
Aug	29.2
Sep	29.4
Oct	28.8
Nov	24.6
Dec	20.4
Average	**26.6**

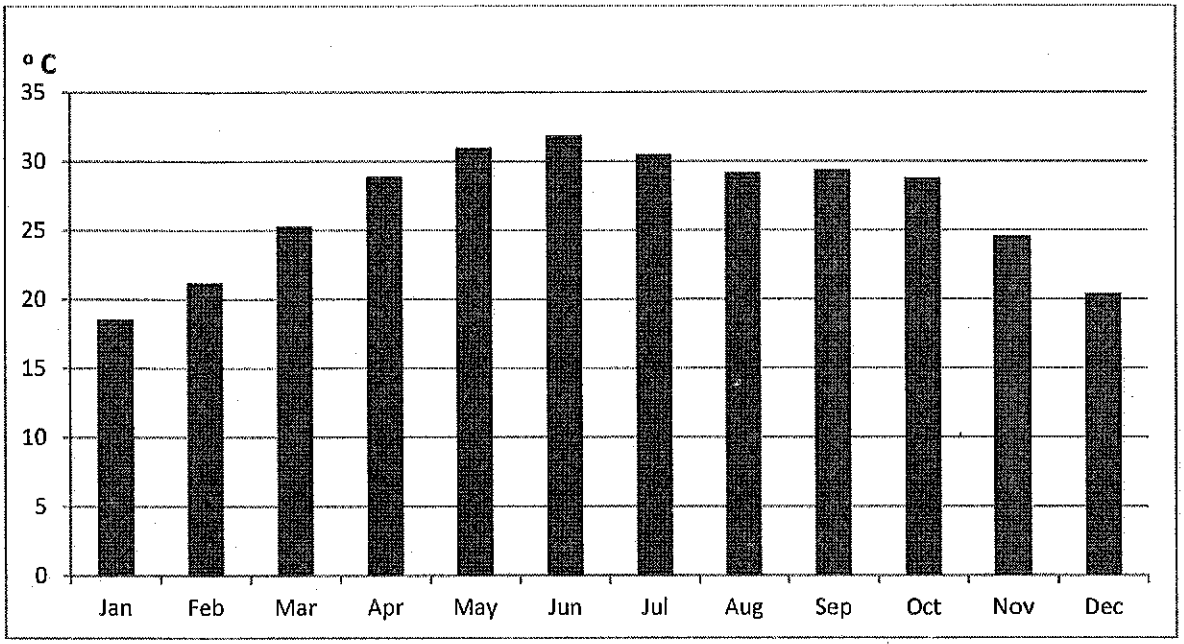


Figure 3-4: Average Monthly Temperature at Karachi Airport Weather Station

3.2.2.5 Tropical Cyclone

Tropical cyclone weather occurs in the Arabian Sea in the south of Pakistan, the incidence of which is about 1% of the global total cyclones. Tropical cyclones occurred in recent years in the Arabian Sea region are shown in Table 3-6.

Table 3-6: Arabian Sea Tropical Cyclone Statistic in Recent Years

No.	Date	Type	Location	Maximum Wind Speed (m/s)
1	1993.11.05~11.16	A typhoon	Northeast of Arabian Sea	41
2	1994.07.05~07.09	Tropical Storm	South of Arabian Sea	23
3	1995.10.11~10.18	Tropical Storm	Southeast of Arabian Sea	26
4	1996.06.15~06.25	A typhoon	Mideast of Arabian Sea	33
5	1996.10.14~11.02	A typhoon	Southeast of Arabian Sea	33
6	1998.06.01~06.09	C Typhoon	Southeast of Arabian Sea	54
7	1998.10.15~10.18	Tropical Storm	Mideast of Arabian Sea	18
8	1999.05.15~05.21	C Typhoon	Mideast of Arabian Sea	57
9	2001.09.26~09.28	C Typhoon	Mideast of Arabian Sea	57
10	2001.09.29~09.28	Tropical Storm	Mideast of Arabian Sea	18
11	2002.05.10~05.15	Tropical Storm	Mideast of Arabian Sea	23
12	2004.05.04~05.09	Tropical Storm	Southeast of Arabian Sea	23
13	2004.09.30~10.10	Tropical Storm	Northeast of Arabian Sea	18
14	2006.09.19~09.26	Tropical Storm	Middle of Arabian Sea	28
15	2007.05.30~06.08	Typhoon of level 5	Northwest of Arabian Sea	74
16	2007.06.20~06.27	Tropical Storm	Northeast of Arabian Sea	26
17	2009.11.09~11.11	Tropical Storm	Southeast of Arabian Sea	26
18	2010.05.30~05.06	Typhoon of level 4	West & North East of Arabian Sea	62
19	2011.06.09~06.21	Tropical Storm	Southeast of Arabian Sea	18
20	2011.11.25~12.01	Tropical Storm	Midwest of Arabian Sea	18

3.3 NEIGHBORING WIND MEASURING MAST OF FFC ENERGY LIMITED

3.3.1 GENERAL INFORMATION OF MAST

The 81.5m high FFC Energy Limited (FFCEL) wind measuring mast was installed in June 2007 and collected the wind data up to May 2012.This mast was replaced with new one under the EPA provisions.

The FFCEL Mast was located at distance of 12 km in the southwest of Sinowell wind farm site as shown below in figure 3-5. The mast was of lattice structure with triangular cross section with side width of approx. 2 ft. The view of FFCEL wind measuring mast can be seen from the figure 3-6 whereas the installation arrangement at the mast can be seen from the figure 3-7 given below.

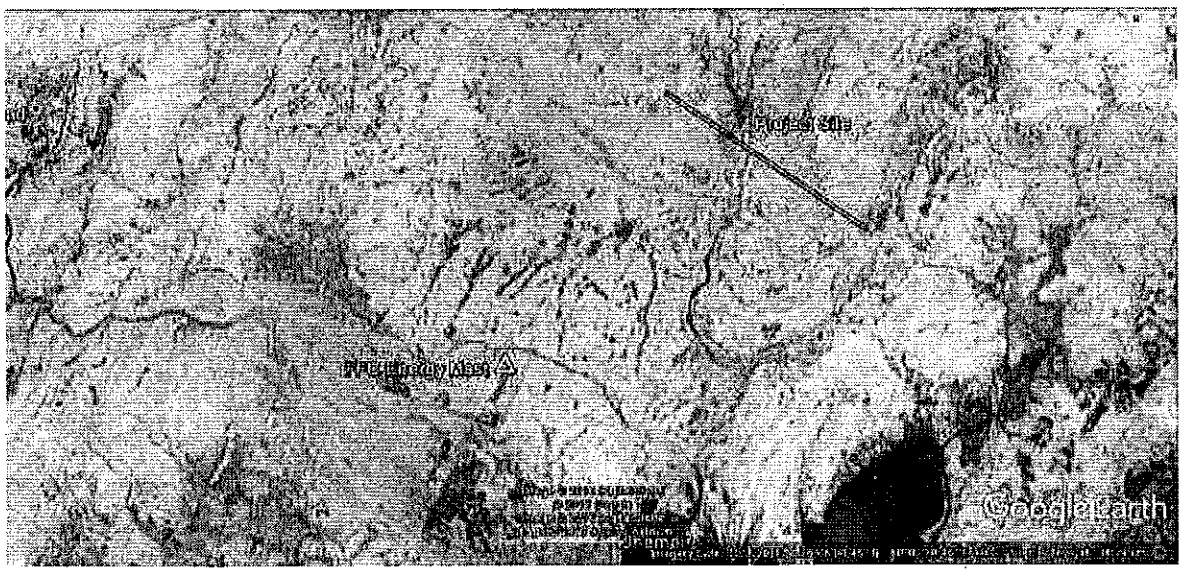


Figure 3-5: Neighboring Mast of FFCEL and Project Site

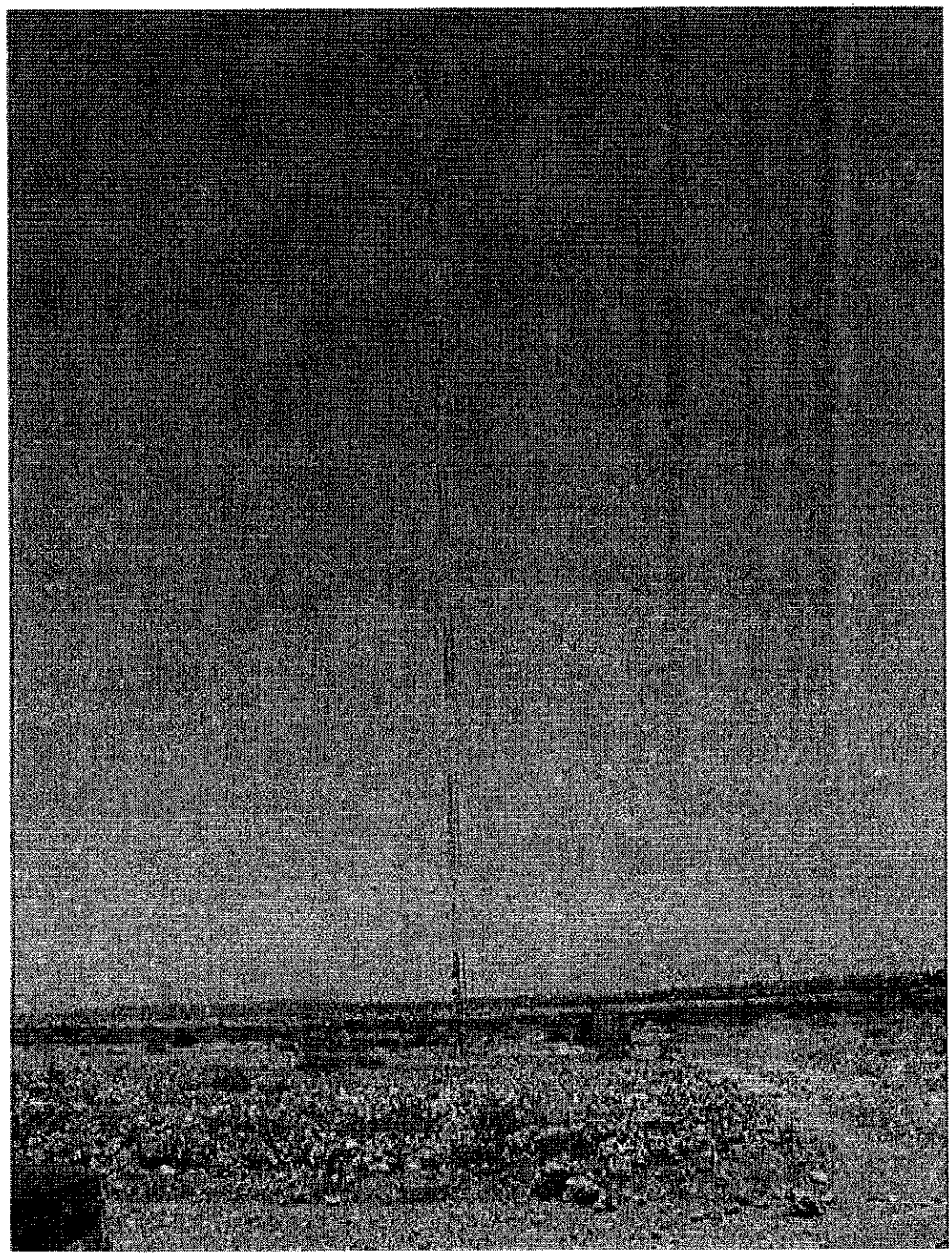


Figure 3-6: View of FFCEL Wind Measuring Mast

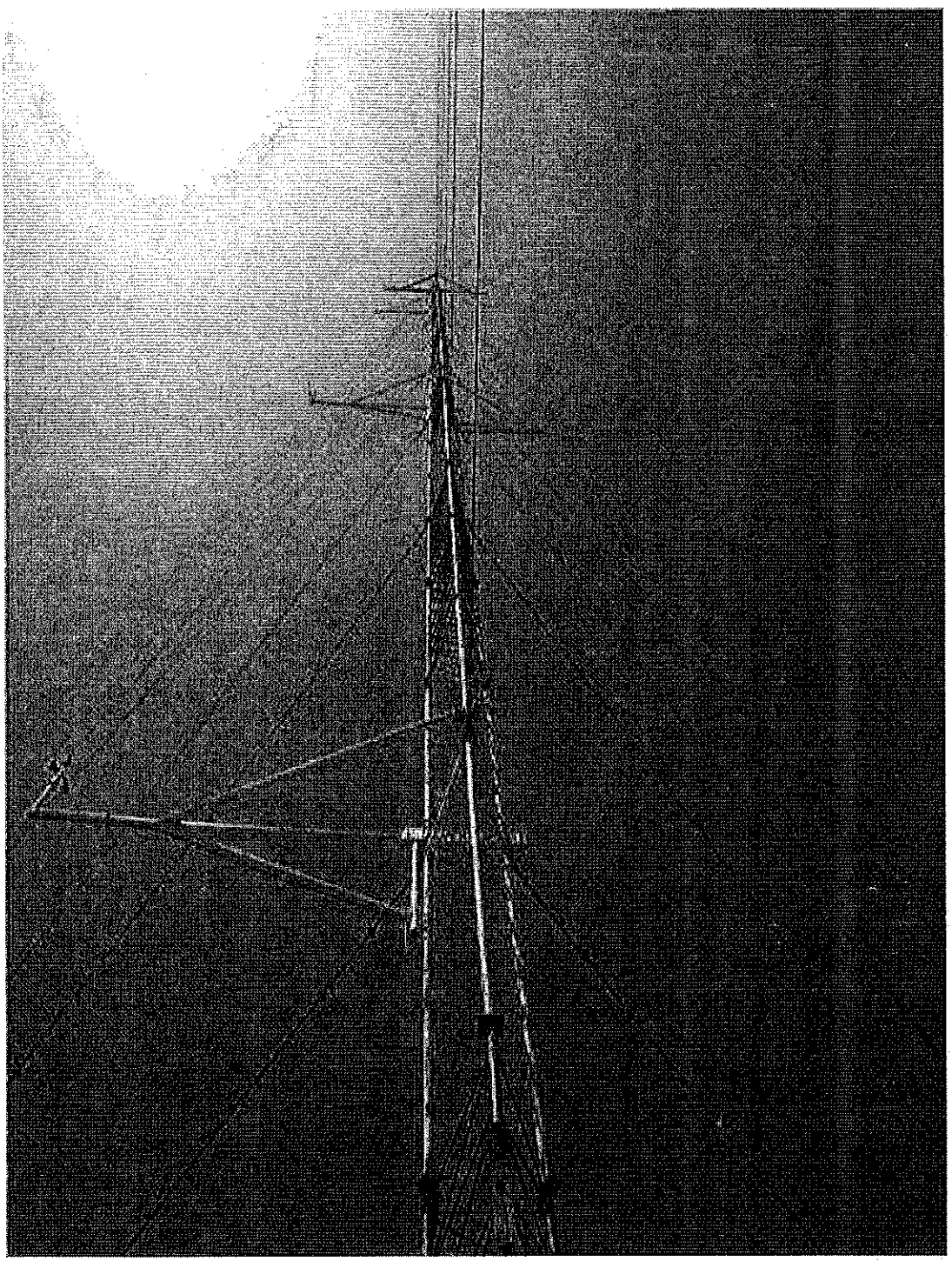


Figure 3-7: Installation Arrangements of Sensors installed at FFCEL Mast

3.3.2 INSTALLED SENSOR INFORMATION

Wind speed at FFCEL mast was recorded through five Theis first class anemometers installed at 81.5, 80, 60, 30 and 10m from ground level. The data from FFCEL mast was collected using Theis anemometers and NDL data logger. The anemometers were individually calibrated in the Measnet accredited wind tunnel at DKD.

The roughness of the FFCEL mast site is 0.0513m whereas the power law exponent calculated using the 4.9 year's data is 0.16. The specifications of FFCEL mast are shown in table 3-7 given below.

Table 3-7: Specification of FFCEL Mast

Latitude	25° 04' 33.20"N
Longitude	67° 58' 22.20"E
Observation	Wind speed, wind direction, temperature,
Observation height	wind speed: 81.5, 80, 60, 30 & 10m (Theis first class anemometers) wind direction: 78.5, 28.5m
Observation period	From June 2007-May 2012
Data used for the Study	June 2007 to May 2012 (4.9 years) 60m Wind Speed and 28.5m Direction

3.3.3 WIND DATA ANALYSIS

The data from the 81.5m high FFCEL wind measuring mast were collected over the period 1st June 2007 to 8th May 2012 (4.9 years). The data coverage was good for all the instruments during the measurement period. The data acquisition of FFCEL mast is presented in table below.

Table 3-8: Wind Data Acquisition ratio of FFCEL Mast

Installed Sensors	Data Acquisition Ratio
10m anemometer (V10)	89.81%
30m anemometer (V30)	89.65%
60m anemometer (V60)	89.38%
80m anemometer (V80b)	89.81%
81.5m anemometer (V80a)	89.81%
28.5m Wind Vane	89.81%
78.5m Wind Vane	89.81%

Data is analyzed using time series starting from 1st June 2007 to 8th May 2012. The computed regression coefficient for anemometers installed at 80 meters with legends V80-a and V80-b is 98.81% (r2 = 0.9881) without gaps filling whereas the regression coefficient after filling the missing gaps comes to 98.95% (r2 = 0.9895).

The computed regression coefficient for Dir78.5 and Dir28.5 is 91.82% (r2 = 0.9182) without the filling of gaps present in the data whereas the regression coefficient after filling the missing gaps comes to 82.76% (r2 = 0.8276)

3.3.3.1 MEAN WIND SPEED ANALYSIS

The wind data recoded at FFCEL Mast during the period i.e. June 2007 to May 2012 has been analyzed to determine the monthly mean wind speeds. The results are shown in table 3-9 and Figure 3-8 and 3-9 respectively.

Table 3-9: Monthly Mean Wind Speeds Calculated at FFCEL Mast

Year	Month	Mean WS 81.5m	Mean WS 80m	Mean WS 60m	Mean WS 30m	Mean WS 10m
		(m/s)	(m/s)	(m/s)	(m/s)	(m/s)
2007	Jul	8.711	8.608	8.514	7.942	6.9401
2007	Aug	8.973	8.75	8.737	8.122	7.1509
2007	Sep	8.348	8.191	8.078	7.414	6.3901
2007	Oct	6.064	6.066	5.716	4.837	3.6908
2007	Nov	5.243	5.25	4.925	4.062	2.9694
2007	Dec	7.145	7.184	6.715	5.499	4.1698
2008	Jan	7.115	7.144	6.727	5.61	4.3263
2008	Feb	5.243	5.238	5.047	4.338	3.3311
2008	Mar	6.631	6.613	6.333	5.594	4.5813
2008	Apr	7.5	7.357	7.222	6.536	5.5958
2008	May	11.852	11.526	11.597	10.893	9.7052
2008	Jun	9.035	8.876	8.87	8.369	7.4259
2008	Jul	10.243	9.872	10.07	9.539	8.5358
2008	Aug	9.464	9.127	9.257	8.706	7.7539
2008	Sep	8.173	7.944	7.912	7.249	6.3176
2008	Oct	6.88	6.833	6.553	5.705	4.577
2008	Nov	7.332	7.349	6.925	5.824	4.5347
2008	Dec	6.396	6.417	6.104	5.295	4.2777
2009	Jan	7.862	7.916	7.445	6.315	5.173

2009	Feb	6.121	6.09	5.82	5.036	4.0463
2009	Mar	6.472	6.412	6.209	5.508	4.577
2009	Apr	7.202	7.133	6.909	6.209	5.2341
2009	May	9.192	9.01	8.974	8.378	7.3794
2009	Jun	9.913	9.688	9.681	9.052	7.9439
2009	Jul	8.509	8.396	8.273	7.676	6.6652
2009	Aug	9.031	8.762	8.79	8.19	7.0768
2009	Sep	8.488	8.19	8.134	7.442	6.4088
2009	Oct	5.505	5.487	5.185	4.463	3.4949
2009	Nov	6.738	6.78	6.299	5.185	3.8398
2009	Dec	6.837	6.885	6.379	5.223	3.9339
2010	Jan	6.363	6.394	5.954	4.96	3.8057
2010	Feb	6.236	6.259	5.88	5.036	3.9362
2010	Mar	6.759	6.687	6.433	5.75	4.727
2010	Apr	8.234	8.058	7.877	7.252	6.2567
2010	May	10.134	9.901	9.786	9.184	8.1104
2010	Jun	10.065	9.695	9.748	9.212	8.1409
2010	Jul	8.125	7.969	7.864	7.393	6.5232
2010	Aug	7.111	6.935	6.799	6.246	5.391
2010	Sep	7.113	7.037	6.789	6.117	5.1597
2010	Oct	5.912	5.916	5.551	4.79	3.6567
2010	Nov	6.582	6.637	6.175	5.183	3.9453
2010	Dec	6.892	6.932	6.429	5.398	4.0969
2011	Jan	6.678	6.702	6.26	5.258	4.0449
2011	Feb	6.193	6.213	5.832	5.002	3.9636
2011	Mar	6.624	6.585	6.291	5.611	4.6392
2011	Apr	6.565	6.517	6.251	5.642	4.7625

2011	May	10.317	10.048	9.987	9.46	8.3834
2011	Jun	10.61	10.303	10.281	9.813	8.7191
2011	Jul	9.509	9.455	9.178	8.487	7.2776
2011	Aug	8.89	8.867	8.558	7.775	6.5086
2011	Sep	7.535	7.535	7.244	6.542	5.4291
2011	Oct	5.566	5.544	5.247	4.483	3.3614
2011	Nov	5.76	5.768	5.382	4.511	3.325
2011	Dec	6.918	6.958	6.432	5.252	3.7895
2012	Jan	6.335	6.351	5.978	5.004	3.7694
2012	Feb	6.591	6.615	6.168	5.179	4.0331
2012	Mar	6.736	6.682	6.372	5.65	4.5694
2012	Apr	6.972	6.898	6.636	5.994	5.0811
2012	May	6.888	6.83	6.589	5.943	4.9917

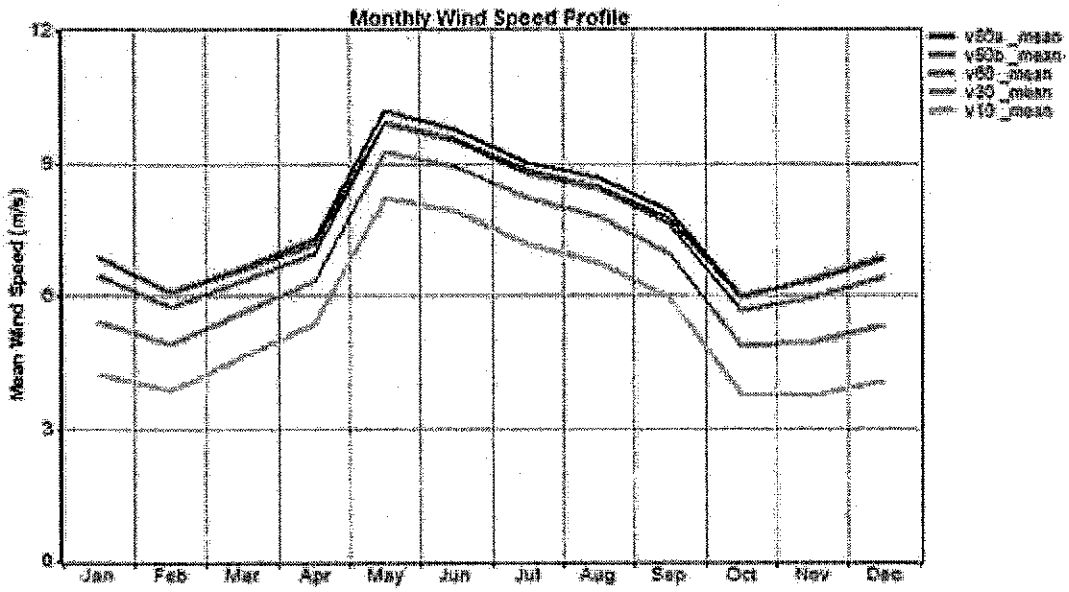


Figure 3-8: Mean of Monthly mean wind speeds at FFCEL Mast during 2007 – 2012

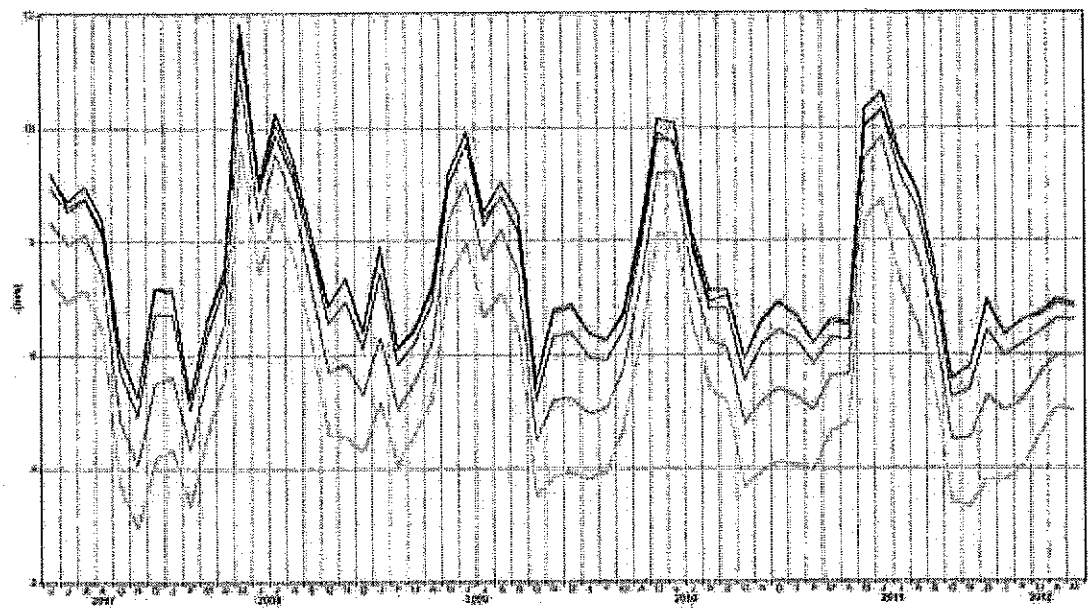
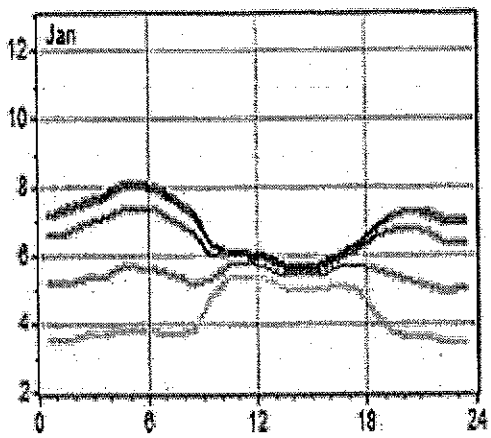
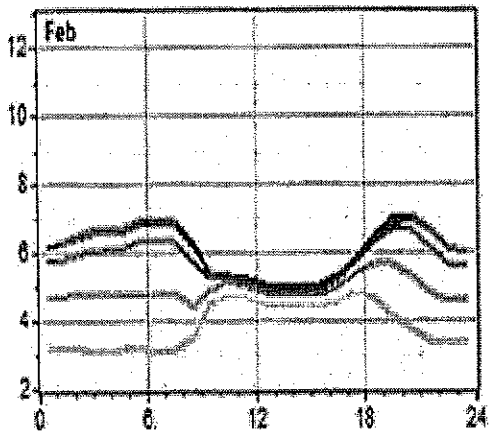


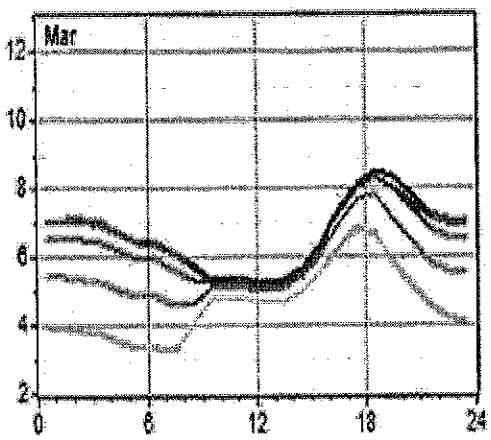
Figure 3-9: Monthly mean wind speeds at FFCEL Mast during 2007 – 2012

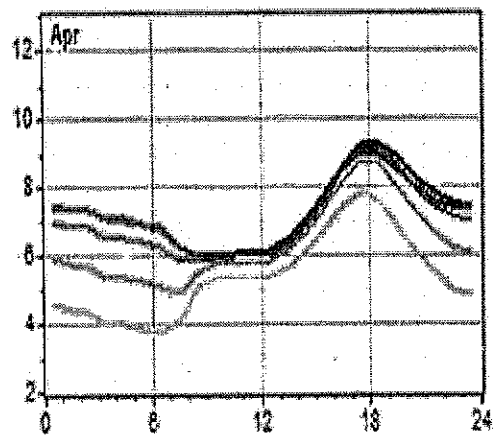
3.3.3.2 DIURNAL VARIATION

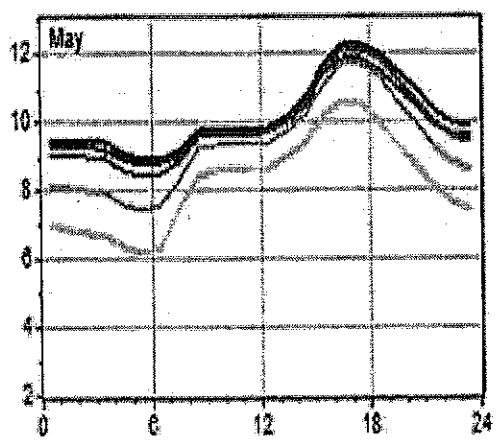
The monthly and annual diurnal variation of wind speed, for the wind data recorded during the period of Jun 2007 to May 2012 at 10, 30, 60, 80 and 81.5m are shown below in figure 3-10 and 3-11 respectively.

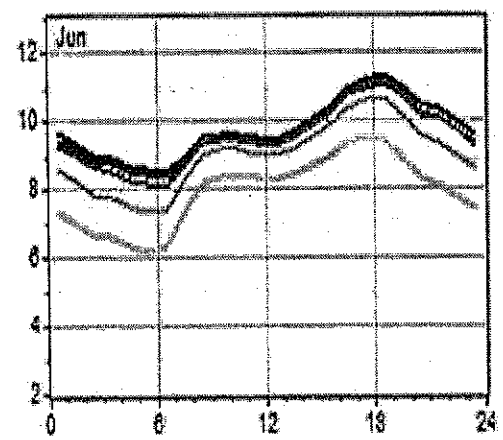

Jan
12
10
8
6
4
2
0
6
12
18
24


Feb
12
10
8
6
4
2
0
6
12
18
24


Mar
12
10
8
6
4
2
0
6
12
18
24


Apr
12
10
8
6
4
2
0
6
12
18
24


May
12
10
8
6
4
2
0
6
12
18
24


Jun
12
10
8
6
4
2
0
6
12
18
24

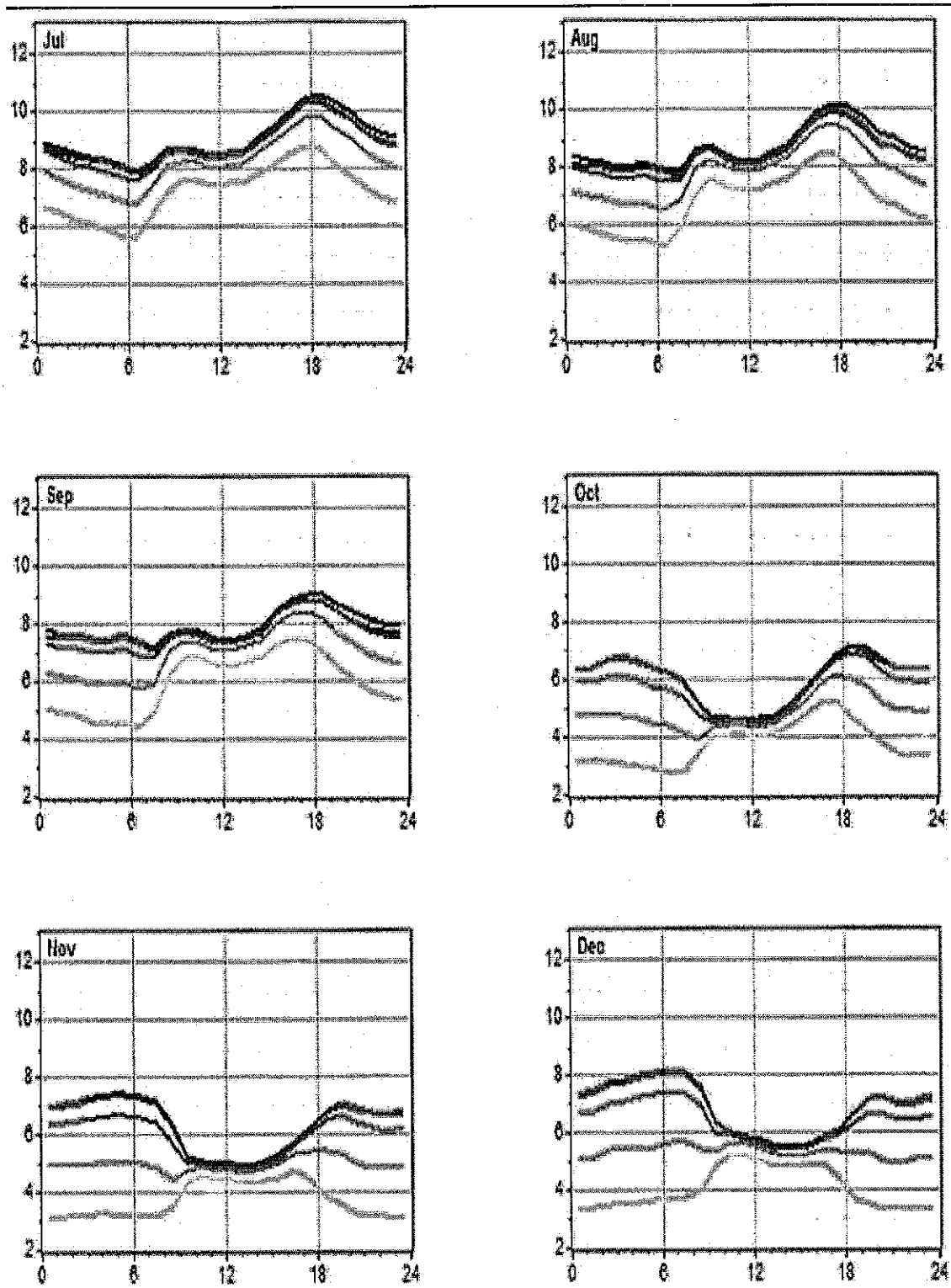


Figure 3-10: Monthly Diurnal Wind Speed Profile at FFCEL Site Wind Data

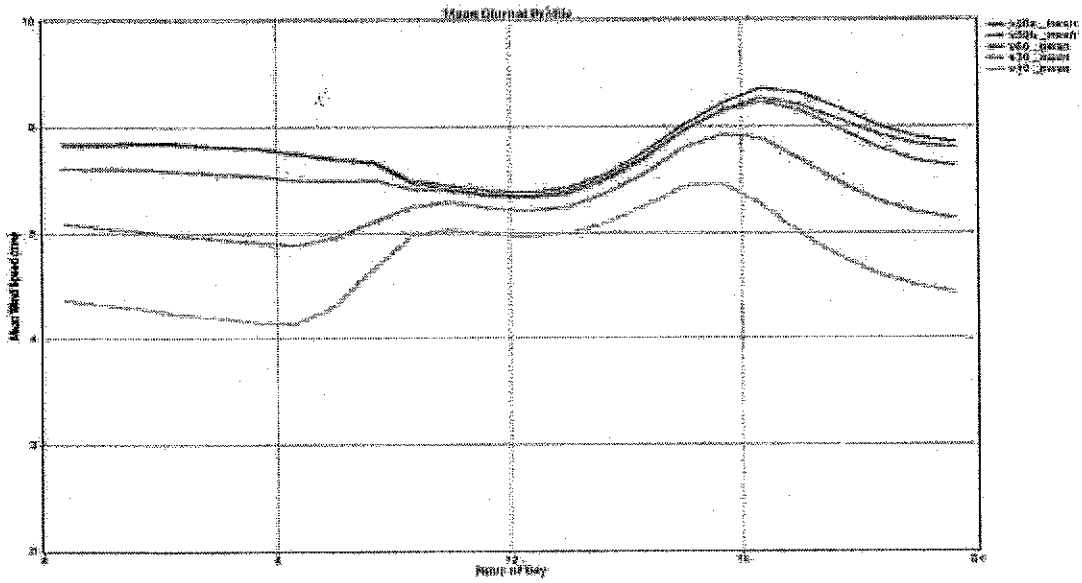


Figure 3-11: Annual Diurnal Wind Speed Profile at FFCEL Site Wind Data

3.3.3.3 WIND SHEAR PROFILE

The vertical and monthly wind shear profiles for the wind data recorded during the period of Jun 2007 to May 2012 have been computed. The results derived are given below.

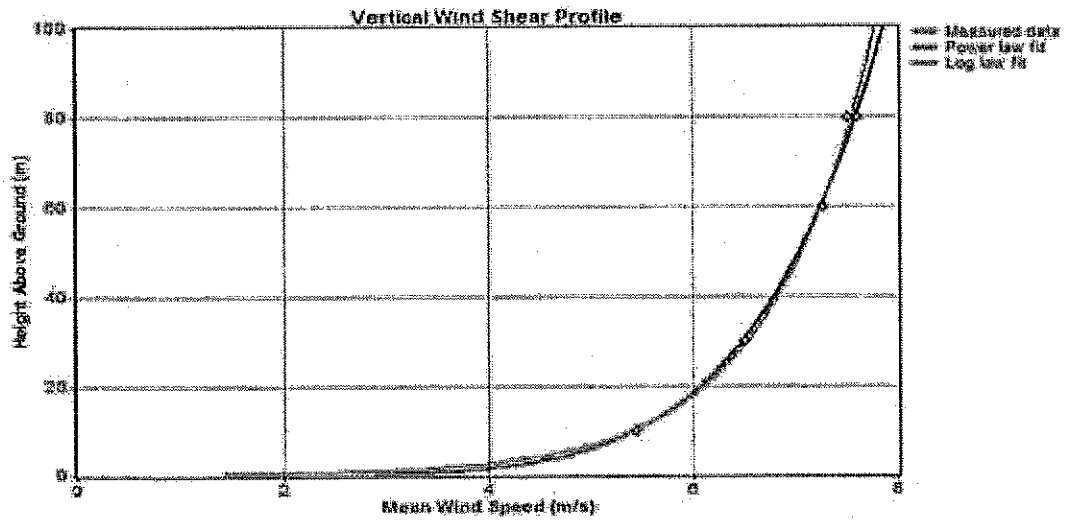


Figure 3-12: Vertical Wind Shear Profile at FFCEL Site

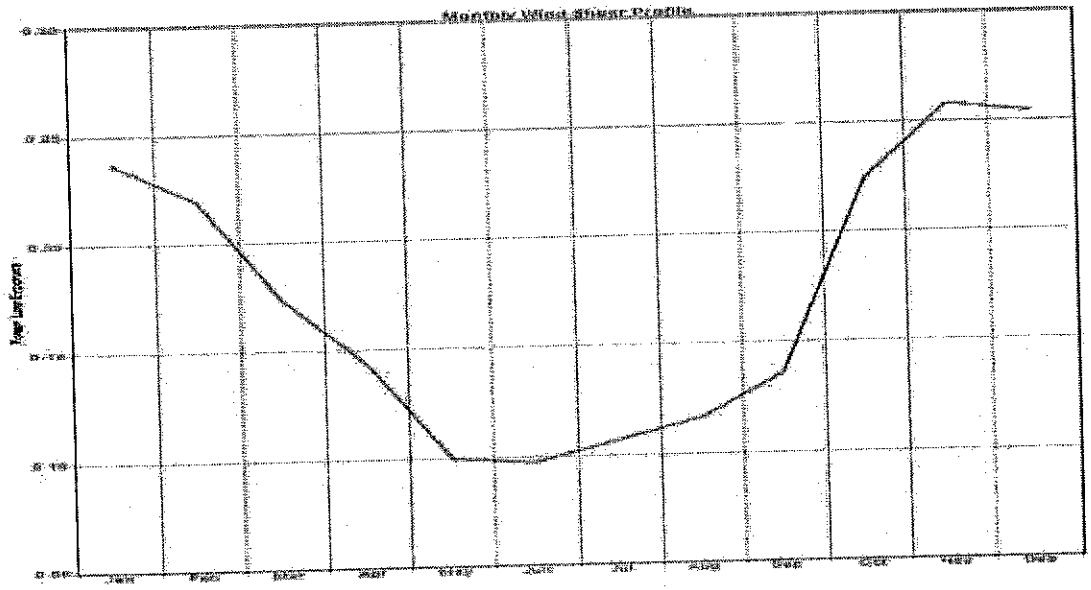


Figure 3-13: Monthly Wind Shear Profile at FFCEL Site

Table 3-10: Monthly Wind Shear Profile

Month	Power law Exponent
Jan	0.237
Feb	0.220
Mar	0.174
Apr	0.143
May	0.099
Jun	0.097
Jul	0.106
Aug	0.116
Sep	0.136
Oct	0.224
Nov	0.258
Dec	0.254

3.3.3.4 WIND DIRECTION AND FREQUENCY DISTRIBUTION

The annual and monthly wind rose developed using the FFCEL mast data (Jun 2007-May 2012) at 78.5m height are given below in Figure 3-14 and 3-15 respectively.

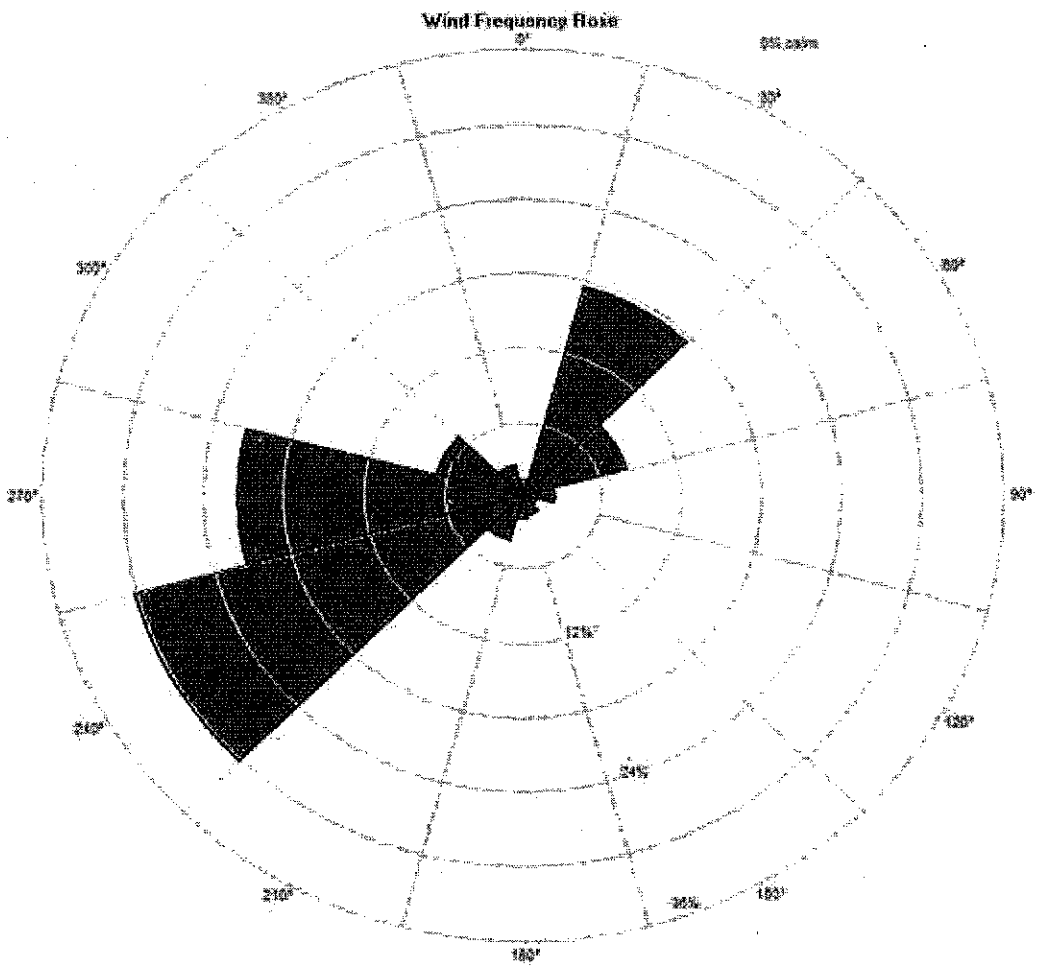
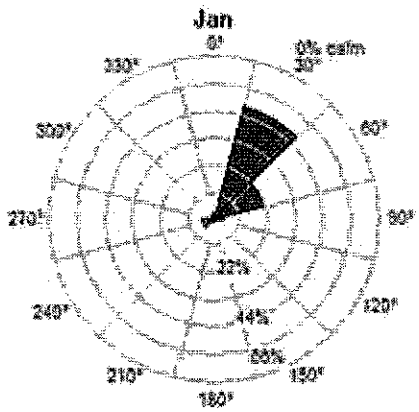
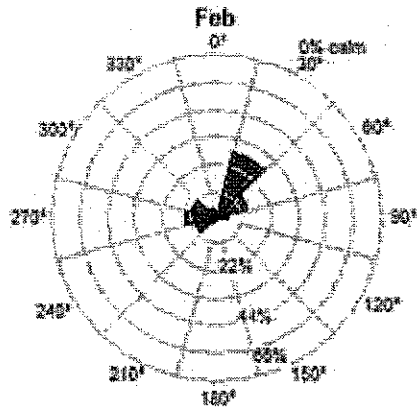
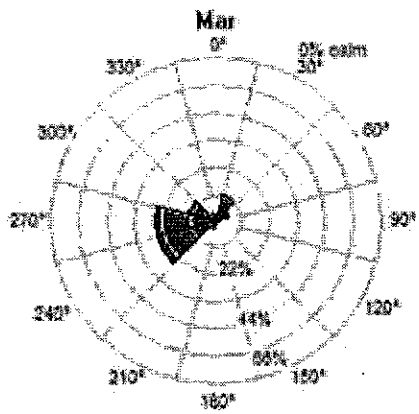
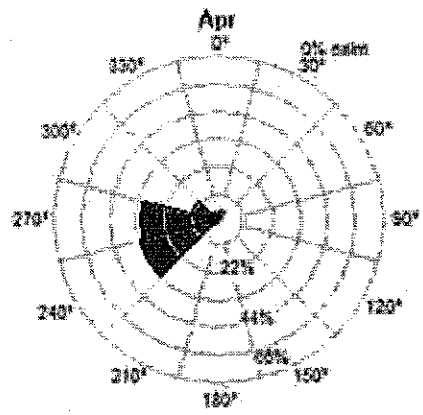


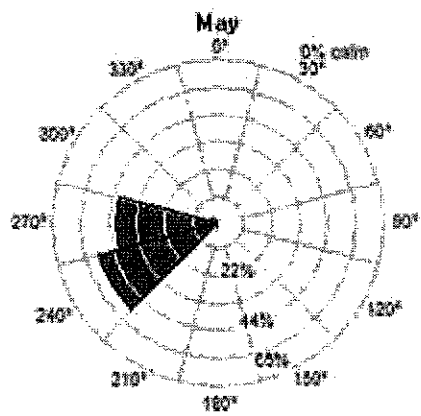
Figure 3-14: Wind Frequency Rose of FFCEL Mast at 78.5m

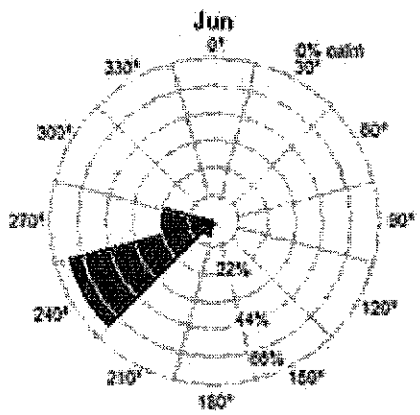

Jan
0% calm
22%
44%
66%


Feb
0% calm
22%
44%
66%


Mar
0% calm
22%
44%
66%


Apr
0% calm
22%
44%
66%


May
0% calm
22%
44%
66%


Jun
0% calm
22%
44%
66%

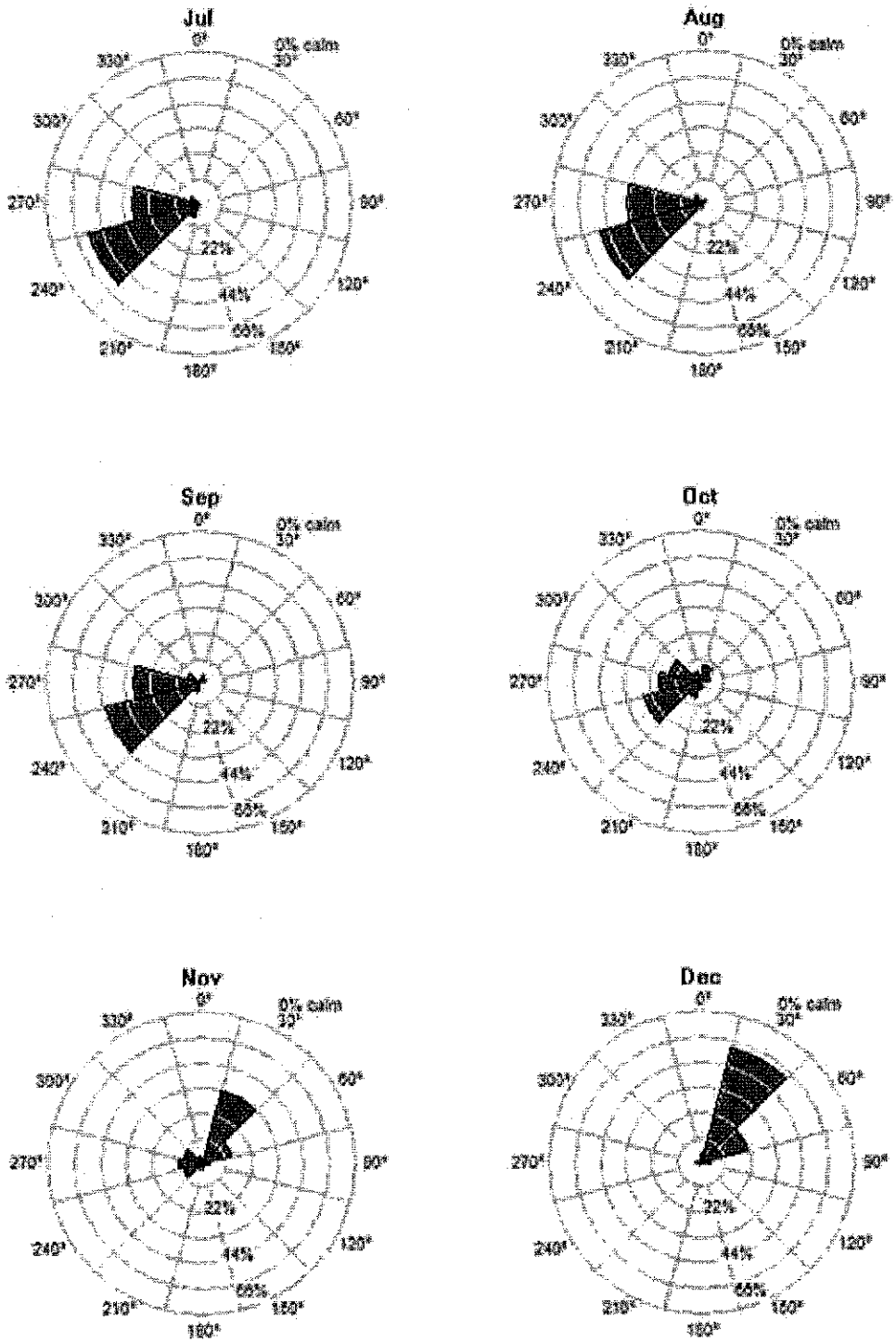


Figure 3-15: Monthly Wind Frequency Rose of FFCEL Mast at 78.5m

The annual and monthly wind rose developed using the FFCEL mast data (Jun 2007-May 2012) at 28.5m height are given below in Figure 3-16 and 3-17 respectively.

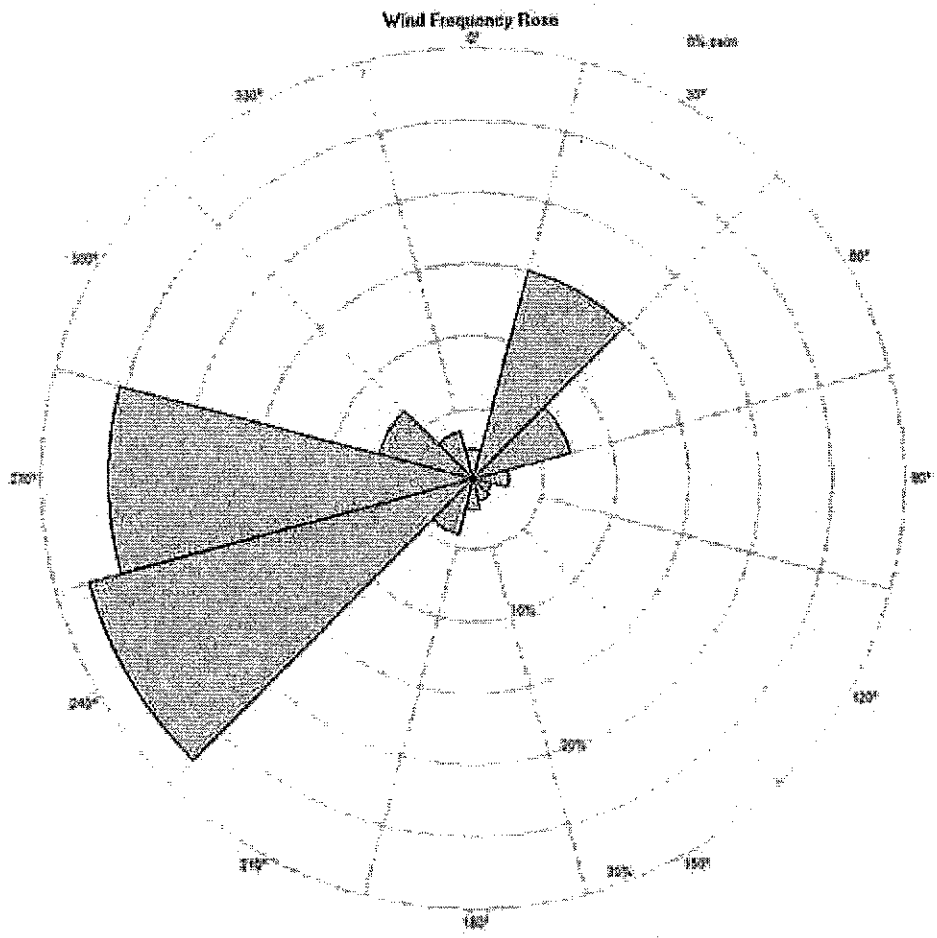
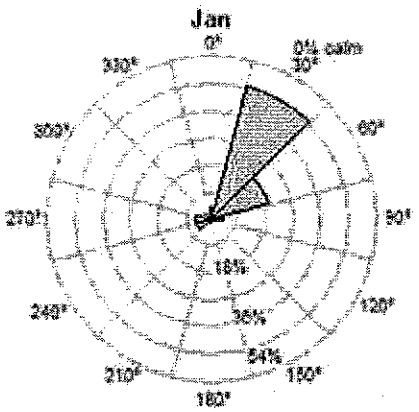
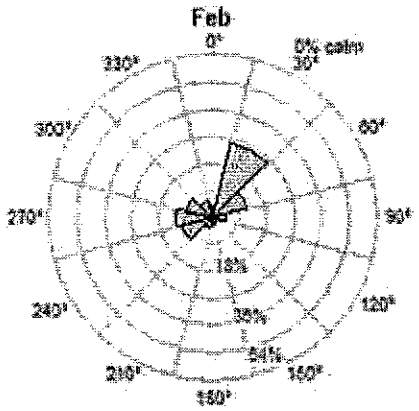
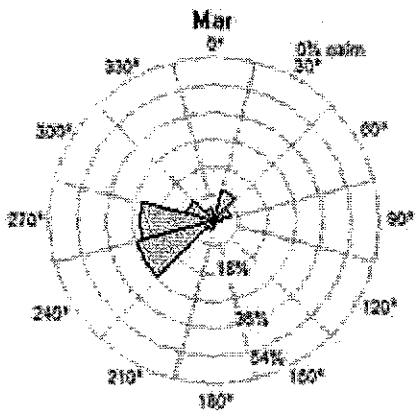
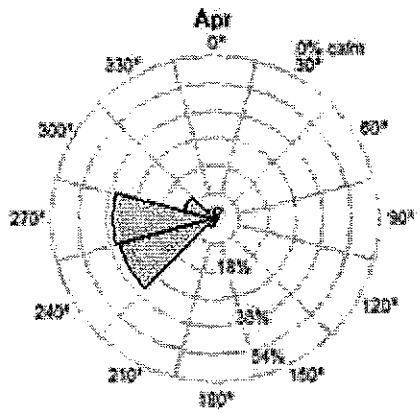


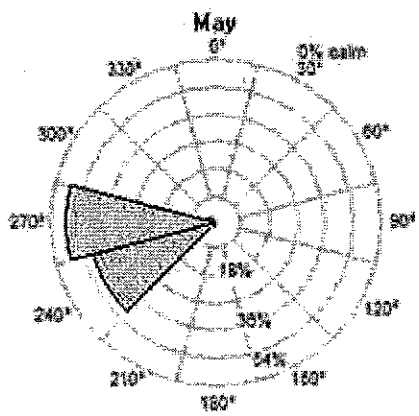
Figure 3-16: Wind Frequency Rose of FFCEL Mast at 28.5m

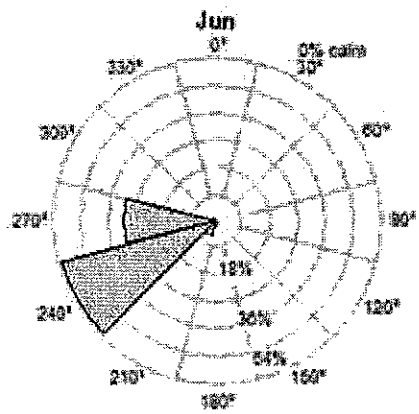

Jan
0° 0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
18%
36%
54%


Feb
0° 0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
18%
36%
54%


Mar
0° 0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
18%
36%
54%


Apr
0° 0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
18%
36%
54%


May
0° 0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
18%
36%
54%


Jun
0° 0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
18%
36%
54%

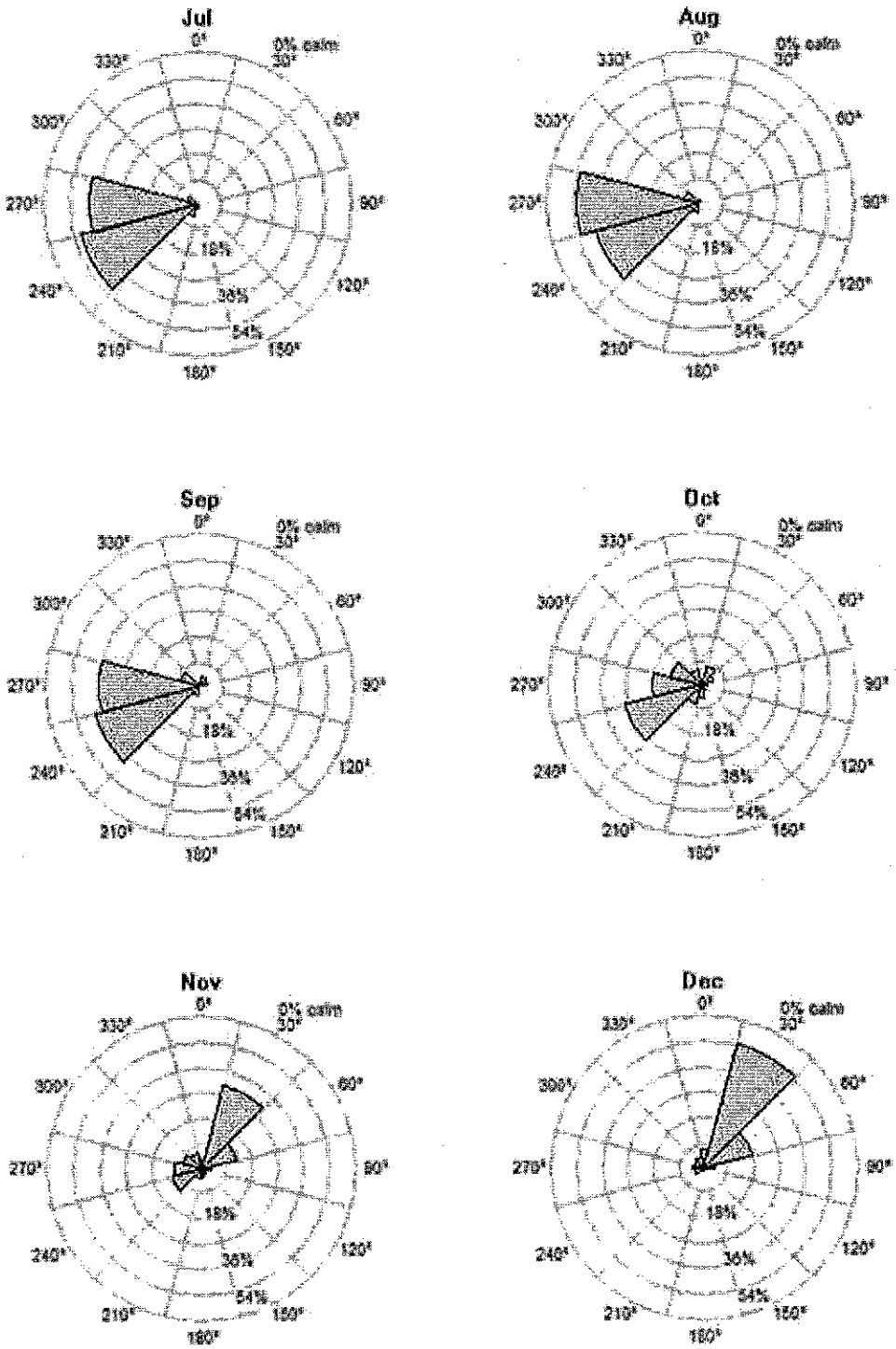


Figure 3-17: Monthly Wind Frequency Rose of FFCEL Mast at 28.5m

It can be seen from the wind rose given above that the predominant wind direction is southwest and west-southwest to a lesser extent west. The frequency distributions of the measurement are given in the following table.

Table 3-11: Wind Direction Data with Frequency Distribution

	Direction	Frequency (%)	
	Sector	Dir 28.5	Dir 78.5
1	345 - 15	2.15	1.7545
2	15 - 45	15.0876	16.3556
3	45 - 75	7.1473	7.7662
4	75 - 105	2.5529	2.5306
5	105 - 135	1.3986	1.2584
6	135 - 165	1.734	1.8223
7	165 - 195	2.3122	2.0915
8	195 - 225	4.089	4.3336
9	225 - 255	27.7575	30.0785
10	255 - 285	25.4495	21.914
11	285 - 315	6.8149	7.2393
12	315 - 345	3.5062	2.8541

3.4 NEIGHBORING WIND MEASURING MAST OF YUNUS ENERGY LIMITED

3.4.1 GENERAL INFORMATION OF MAST

The 85m high Yunus Energy Limited (YEL) wind measuring mast was installed in November 2008 and collected the wind data up to December 2013. Due to the malfunctioning of sensors, started after November 2013, the sensors were replaced with new ones at the mast.. YEL Mast is located at distance of approx. 5.4 km in the southwest of Sinowell wind farm site as shown below in Figure 3-18. The mast is of lattice structure with triangular cross section having side width of approx. 2 ft. The view of the Yunus energy mast can be seen from the figure 3-19 whereas the installation arrangement at the mast can be seen from the figure 3-20 given below.

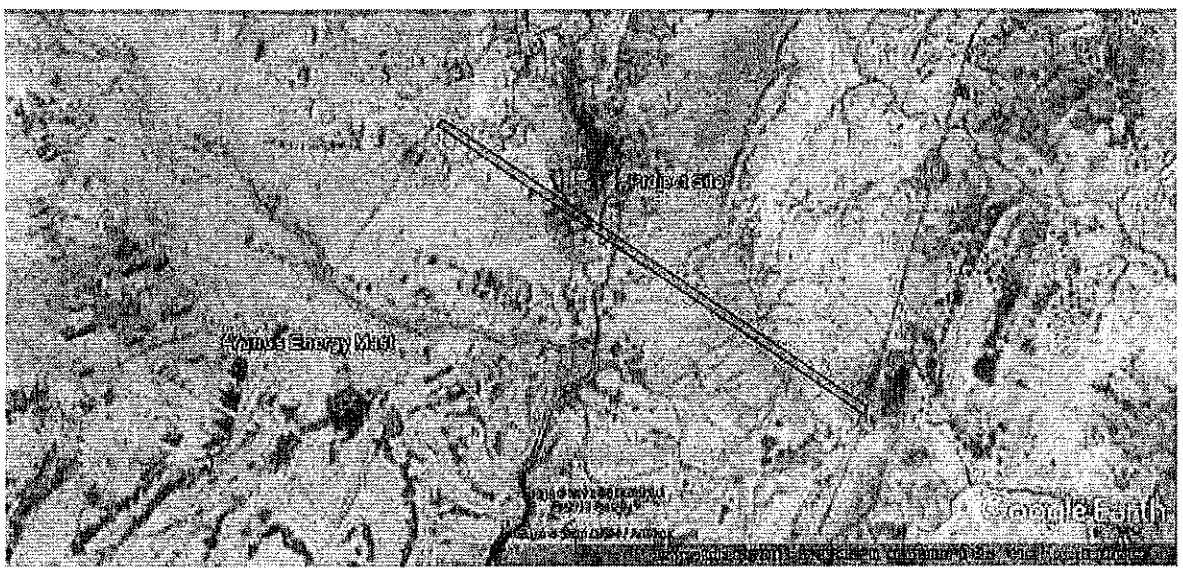


Figure 3-18: Neighboring Mast of YEL and Project Site Area

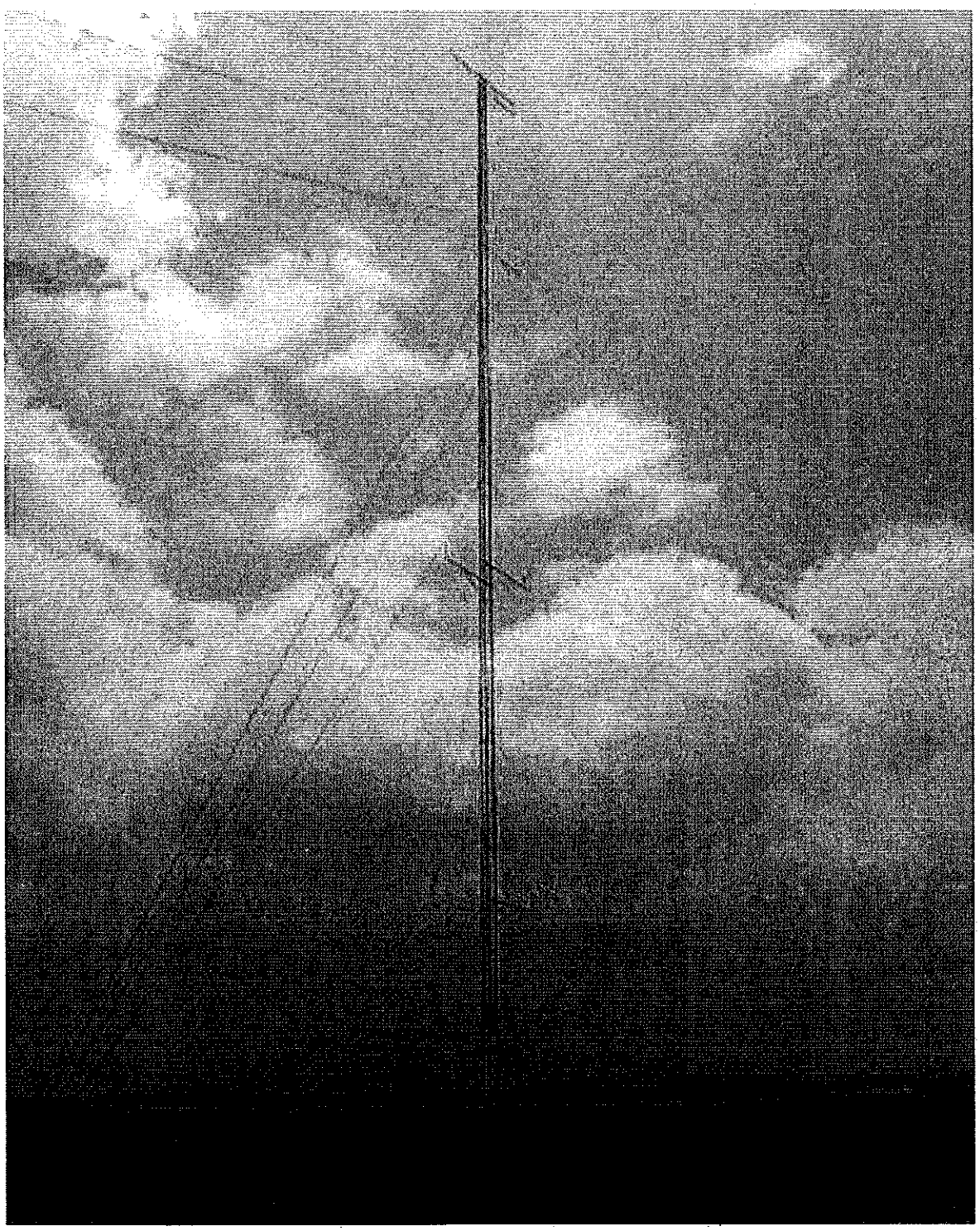


Figure 3-19: View of YEL Wind Measuring Mast

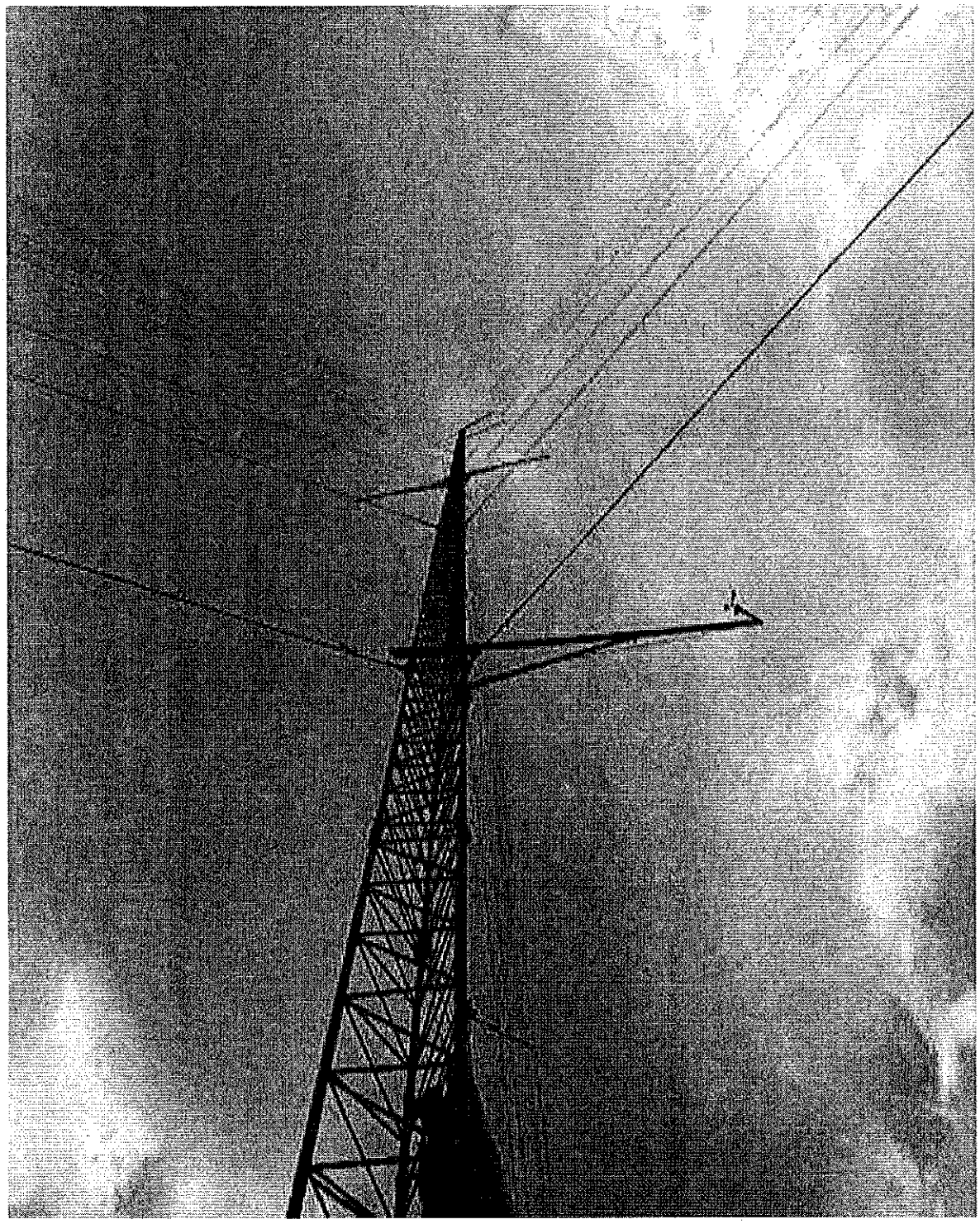


Figure 3-20: Installation Arrangements of Sensors installed at YEL Mast

3.4.2 INSTALLED SENSOR INFORMATION

Wind speed, of the selected time series, at YEL mast was recorded through five Theis first class anemometers installed at 85-a, 85-b, 60, 30 and 10m from ground level. The data from YEL mast was collected using Theis anemometers and NDL data logger. The anemometers were individually calibrated in the Measnet accredited wind tunnel at DKD.

The roughness of the YEL mast site is 0.0341m whereas the power law exponent calculated using the five (05) year's wind data is 0.15. The specifications of YEL mast are shown in table 3-12 given below.

Table 3-12: Specification of YEL Mast

Latitude	25° 08' 0.80"N
Longitude	67° 59' 46.9"E
Observation	Wind speed, wind direction, temperature,
Observation height	wind speed: 85-a, 85-b, 60, 30 & 10m (Theis first class anemometers) wind direction: 83.5, 28.5m
Observation period	From November 2008-November 2013
Data used for the Analysis	November 2008 to November 2013 (05 years)

3.4.3 WIND DATA ANALYSIS

The data from the 85m high YEL wind measuring mast were collected over the period 24th November 2008 to 13th November 2013 (~05 years). The data coverage was good for all the instruments during the measurement period. The data acquisition of YEL mast is presented in table below.

Table 3-13: Wind Data Acquisition ratio of YEL Mast

Installed Sensors	Data Acquisition Ratio
10m anemometer (V10)	94.47%
30m anemometer (V30)	94.47%
60m anemometer (V60)	94.47%
85-a m anemometer (V85a)	92.61%
85-b m anemometer (V85b)	86.68%
28.5m Wind Vane	86.62%
83.5m Wind Vane	94.38%

Data is analyzed using time series starting from 24th November 2008 to 13th November 2013. Wind vane installed at 28.5m height was recording the erroneous data for sector 15°-45° due to which erroneous data has been removed from the time series therefore the data coverage for the Dir 28.5 is 86.62.

The computed regression coefficient for anemometers installed at 85 meters with legends V85-a and V85-b is 99.96% (r2 = 0.9996) without gaps filling whereas the regression coefficient after filling the missing gaps comes to 99.93% (r2 = 0.9993).

The computed regression coefficient for Dir78.5 and Dir28.5 is 87.10% (r2 = 0.8710) without the filling of gaps present in the data whereas the regression coefficient after filling the missing gaps comes to 64.43% (r2 = 0.6443)

3.4.3.1 MEAN WIND SPEED ANALYSIS

The wind data recoded at YEL Mast during the period of five (05) years has been analyzed to determine the monthly mean wind speeds. The results are shown in table 3-14 and Figure 3-21 and 3-22 respectively.

Table 3-14: Monthly Mean Wind Speeds Calculated at YEL Mast

Year	Month	Mean WS 85m (a) (m/s)	Mean WS 85m (b) (m/s)	Mean WS 60 m (m/s)	Mean WS 30m (m/s)	Mean WS 10m (m/s)
2008	Nov	8.918	8.893	8.069	6.526	5.1125
2008	Dec	7.374	7.356	6.859	5.857	4.7326
2009	Jan	8.019	8.005	7.444	6.334	5.1507
2009	Feb	6.07	6.079	5.711	4.937	3.9816
2009	Mar	6.131	6.149	5.824	5.161	4.3107
2009	Apr	7.027	7.051	6.656	5.905	4.9913
2009	May	8.936	8.977	8.668	8.034	7.1246
2009	Jun	8.786	8.824	8.586	8.026	7.1841
2009	Jul	9.297	9.336	9.036	8.381	7.4504
2009	Aug	9.343	9.378	9.123	8.496	7.543
2009	Sep	8.446	8.487	8.105	7.343	6.3419
2009	Oct	5.685	5.691	5.331	4.585	3.6604
2009	Nov	6.853	6.84	6.353	5.233	3.9693
2009	Dec	7.11	7.084	6.552	5.297	4.0409
2010	Jan	6.477	6.458	6.082	5.07	3.9407
2010	Feb	6.17	6.169	5.775	4.966	3.98
2010	Mar	6.585	6.605	6.249	5.502	4.5774
2010	Apr	8.02	8.058	7.658	6.931	6.0052
2010	May	9.869	9.922	9.536	8.776	7.7361
2010	Jun	9.605	9.651	9.335	8.637	7.6486
2010	Jul	8.131	8.162	7.881	7.285	6.4308
2010	Aug	7.047	7.075	6.736	6.075	5.1983
2010	Sep	6.602	6.619	6.264	5.575	4.7248
2010	Oct	5.94	5.95	5.53	4.738	3.7843
2010	Nov	6.735	6.722	6.288	5.278	4.125
2010	Dec	7.328	7.314	6.731	5.509	4.2773
2011	Jan	6.677	6.662	6.22	5.198	4.0636
2011	Feb	6.29	6.275	5.901	5.026	3.9945

2011	Mar	6.693	6.709	6.296	5.529	4.6121
2011	Apr	6.526	6.546	6.203	5.548	4.7139
2011	May	10.039	10.087	9.775	9.079	8.0029
2011	Jun	10.662	10.718	10.414	9.672	8.5744
2011	Jul	9.441	9.486	9.236	8.603	7.6518
2011	Aug	8.295	9.239	8.008	7.359	6.4762
2011	Sep	7.716	-	7.234	6.337	5.3046
2011	Oct	5.954	-	5.596	4.787	3.7399
2011	Nov	5.904	8.683	5.542	4.596	3.5144
2011	Dec	7.09	7.046	6.57	5.342	4.0755
2012	Jan	6.477	6.451	6.057	5.112	4.0117
2012	Feb	6.748	6.719	6.291	5.312	4.2564
2012	Mar	6.615	6.59	6.231	5.487	4.5686
2012	Apr	6.773	6.757	6.44	5.767	4.9154
2012	May	8.624	8.604	8.383	7.759	6.8128
2012	Jun	10.78	10.765	10.572	9.812	8.7044
2012	Jul	10.923	10.903	10.743	10.018	8.8761
2012	Aug	9.243	9.217	9.073	8.469	7.5391
2012	Sep	6.824	6.813	6.517	5.886	5.1027
2012	Oct	5.309	5.291	5.038	4.4	3.5362
2012	Nov	5.231	5.207	4.932	4.154	3.1522
2012	Dec	6.627	6.606	6.193	5.276	4.2442
2013	Jan	5.959	5.937	5.561	4.653	3.6114
2013	Feb	7.019	6.993	6.492	5.549	4.5137
2013	Mar	6.404	6.38	6.006	5.214	4.3205
2013	Apr	6.611	6.59	6.297	5.687	4.9072
2013	May	9.671	9.645	9.394	8.685	7.6114
2013	Jun	8.698	8.792	8.635	8.077	7.2005
2013	Jul	-	-	-	-	-
2013	Aug	-	-	10.287	9.526	8.4166
2013	Sep	-	-	7.09	6.474	5.6655
2013	Oct	5.771	5.785	5.49	4.879	4.094
2013	Nov	5.615	5.609	5.28	4.498	3.5988

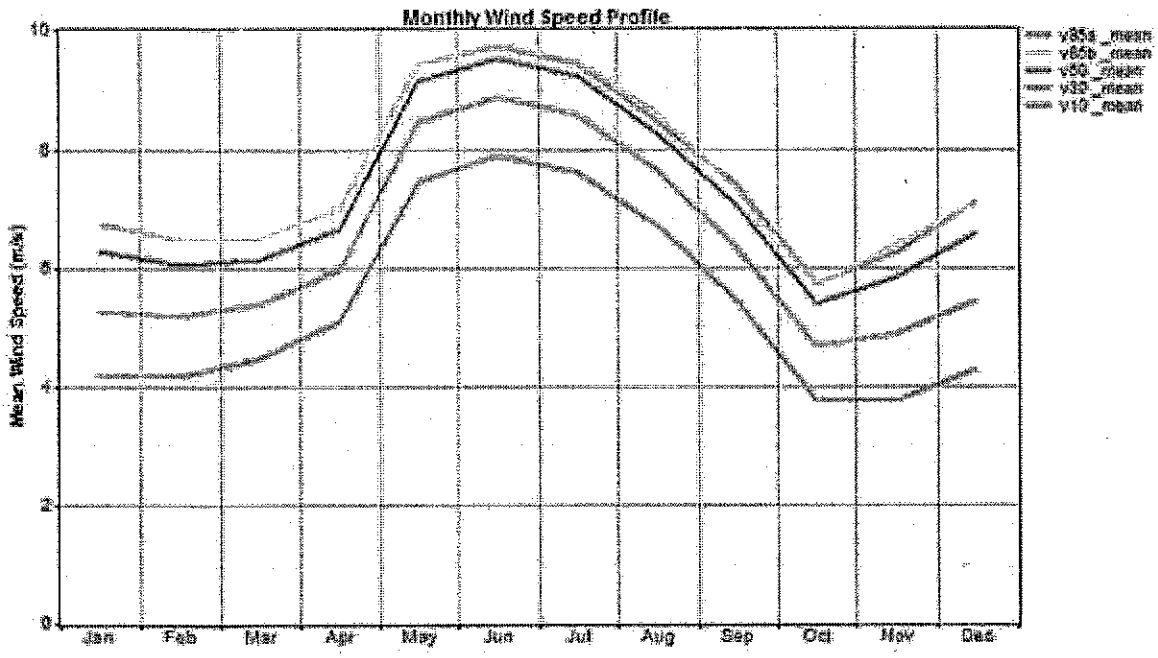


Figure 3-21: Mean of Monthly mean wind speeds at YEL Mast during 2008 – 2013

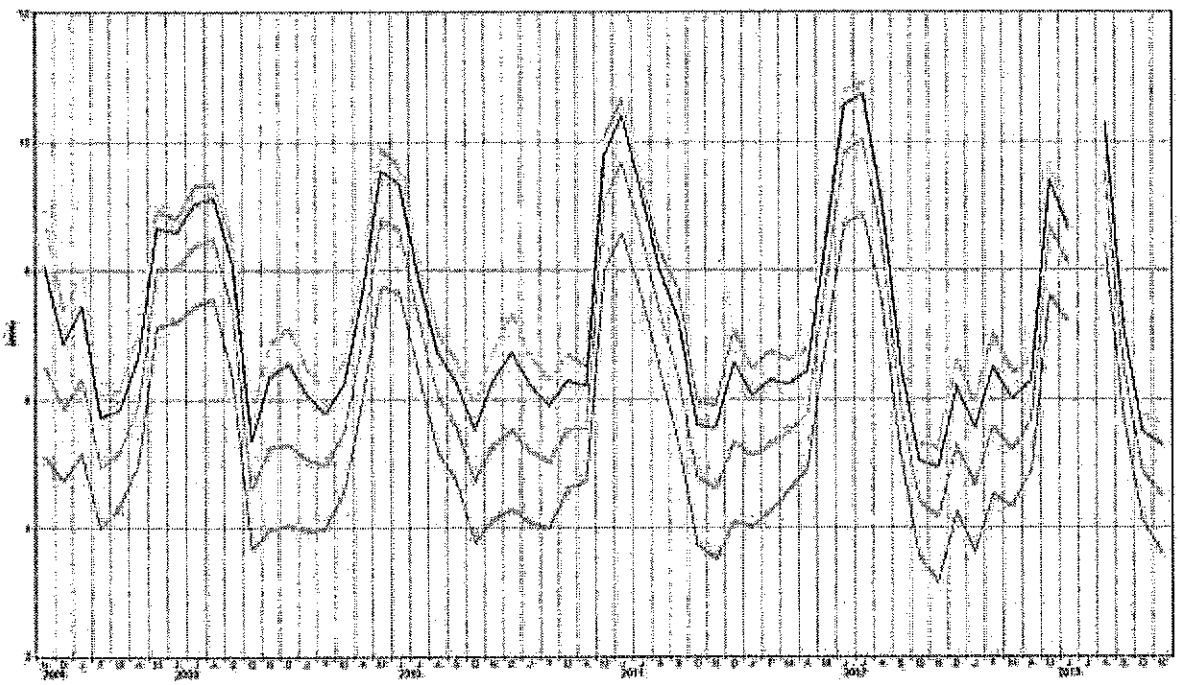
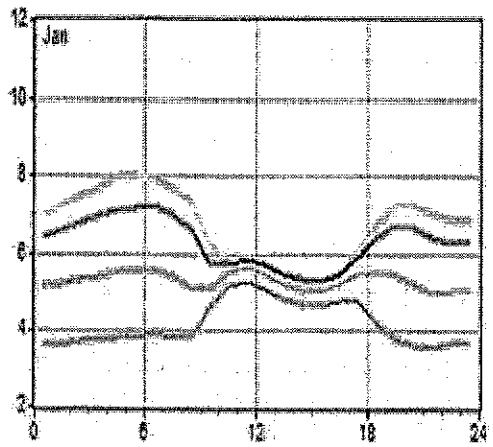
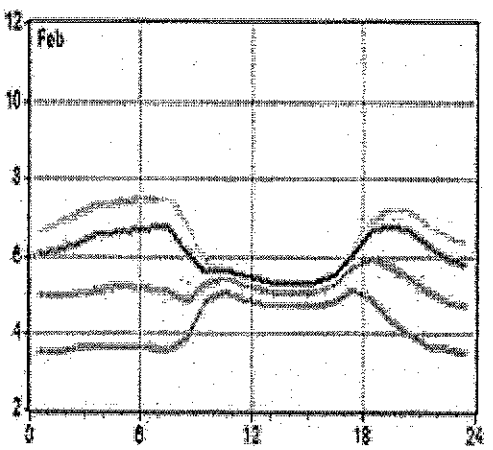


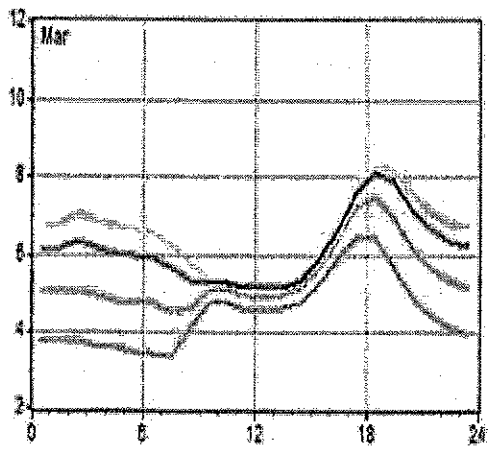
Figure 3-22: Monthly mean wind speeds at YEL Mast during 2008 – 2013

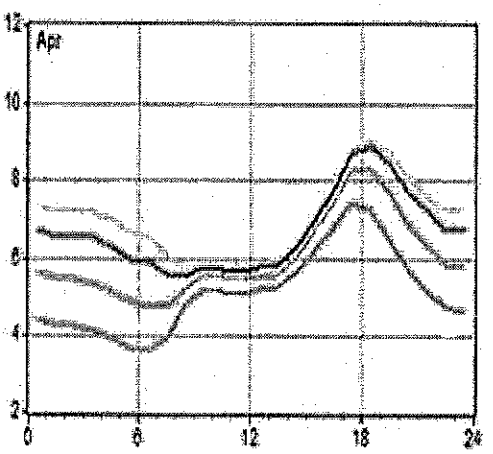
3.4.3.2. DIURNAL VARIATION

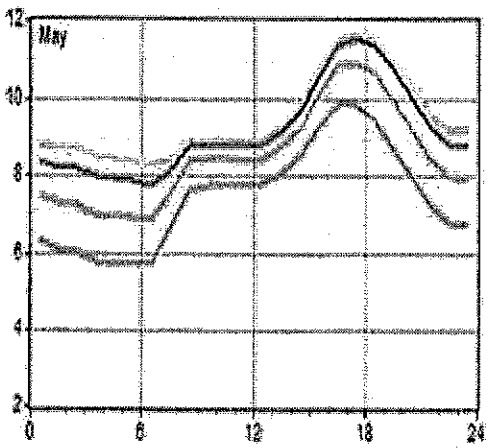
The monthly and annual diurnal variation of wind speed, for the wind data recoded during the period of November 2008 to November 2013 at 10, 30, 60, 85(a) and 85(b) m are shown below in figure 3-23 and 3-24 respectively

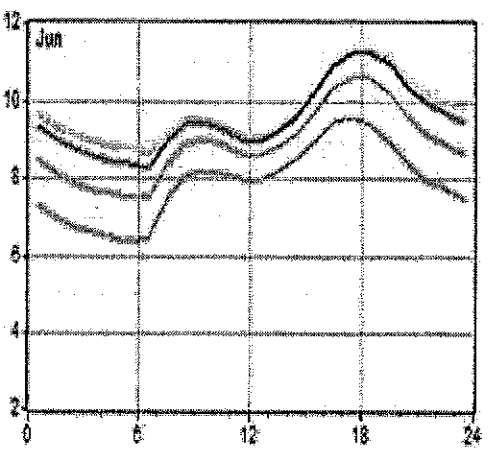

Jan
12
10
8
6
4
2
0
6
12
18
24


Feb
12
10
8
6
4
2
0
6
12
18
24


Mar
12
10
8
6
4
2
0
6
12
18
24


Apr
12
10
8
6
4
2
0
6
12
18
24


May
12
10
8
6
4
2
0
6
12
18
24


Jun
12
10
8
6
4
2
0
6
12
18
24

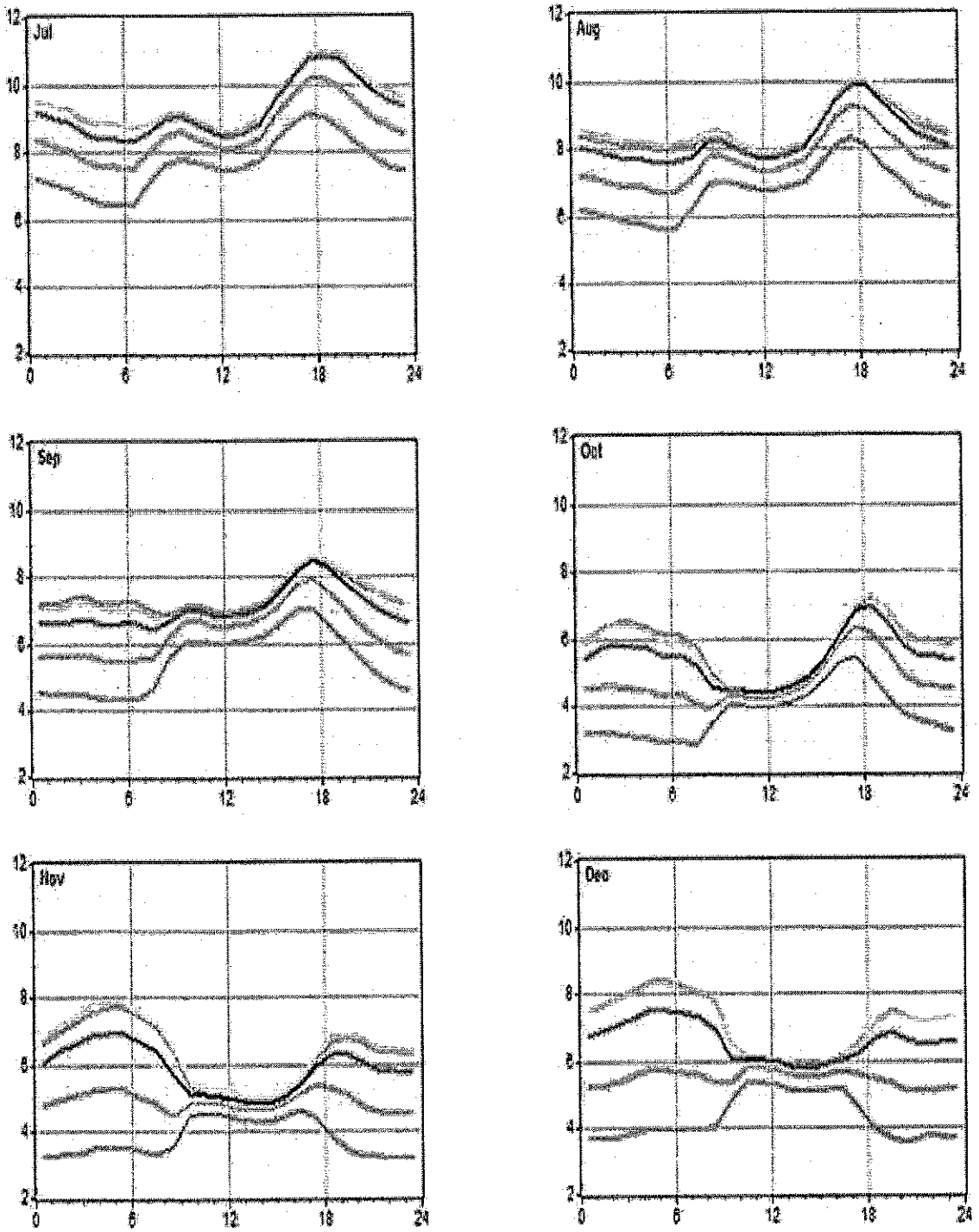


Figure 3-23: Monthly Diurnal Wind Speed Profile at YEL Site Wind Data

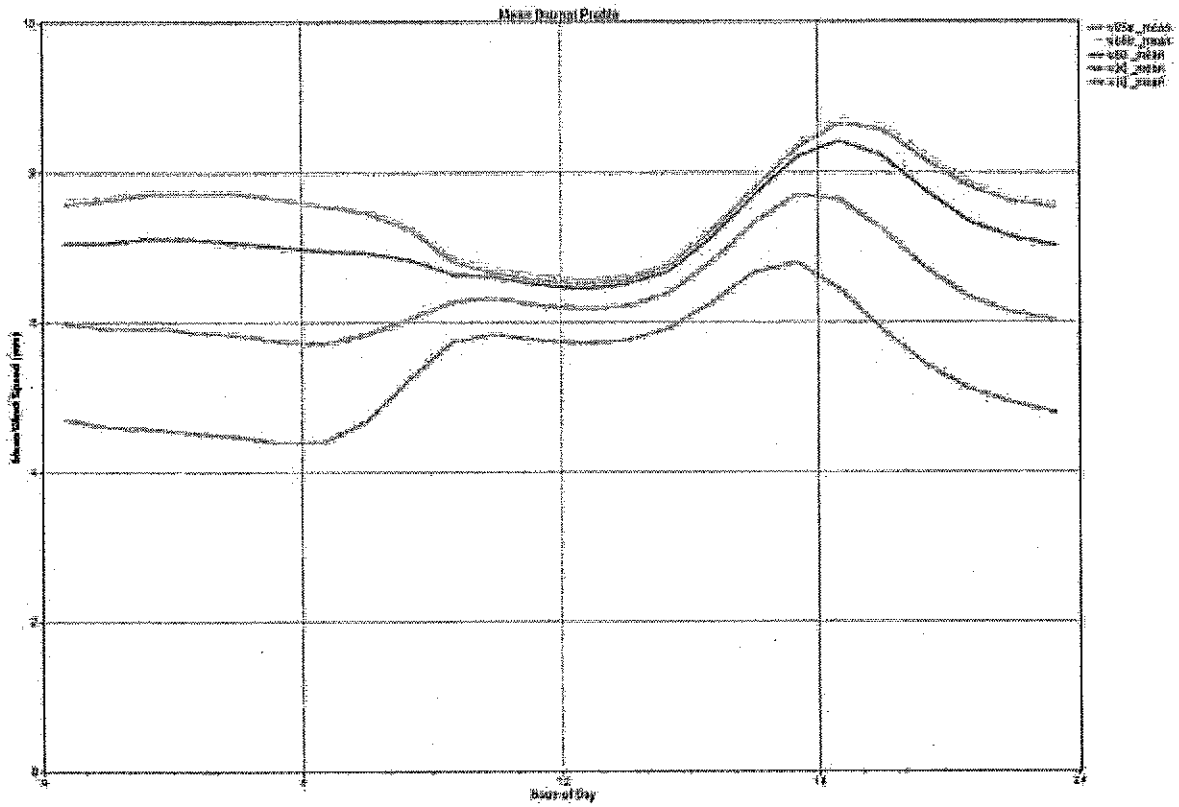


Figure 3-24: Annual Diurnal Wind Speed Profile at YEL Site Wind Data

3.4.3.3 WIND SHEAR PROFILE

The vertical and monthly wind shear profiles for the wind data recorded during the period of November 2008 to November 2013 have been computed. The results derived are given below.

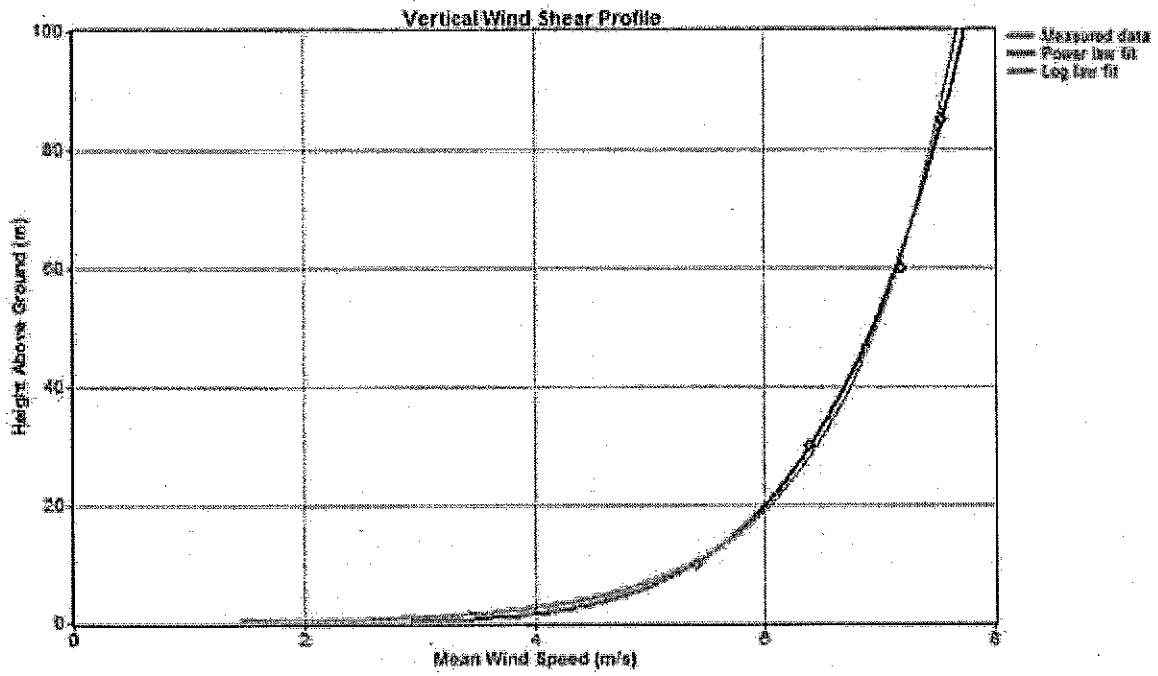


Figure 3-25: Vertical Wind Shear Profile at YEL Site

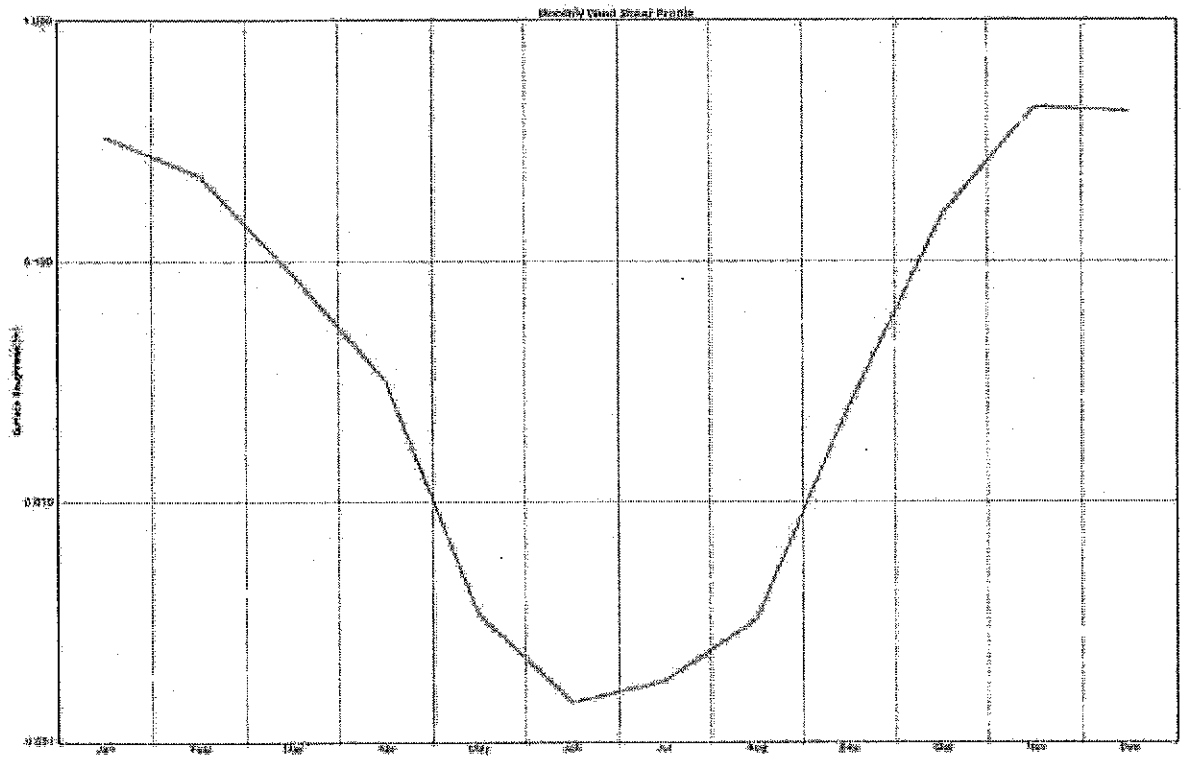


Figure 3-26: Monthly Wind Shear Profile at YEL Site

Table 3-15: Monthly Wind Shear Profile

Month	Power-law Exponent
Jan	0.226
Feb	0.208
Mar	0.174
Apr	0.148
May	0.111
Jun	0.102
Jul	0.104
Aug	0.111
Sep	0.142
Oct	0.193
Nov	0.242
Dec	0.239

3.4.3.4 WIND DIRECTION AND FREQUENCY DISTRIBUTION

The data from the 85m high YEL mast were collected over the period Nov 2008 to Nov 2013. The data coverage was good for all of the instruments during the measurement period.

Based on our experience of this region, the prevailing wind direction recorded at YEL mast was slightly more westerly than expected. The Yunus Energy wind direction data was compared with the wind direction data from other neighboring wind measuring masts. The comparison indicated that the direction vanes from the YEL mast were recording directional data approx. 10° higher than the neighboring mast data. Therefore, an offset of 10° was applied to the YEL directional data.

The annual and monthly wind rose developed using the YEL mast data (Nov 2008 - Nov 2013) at 83.5m height are given below in Figure 3-27 and 3-28 respectively.

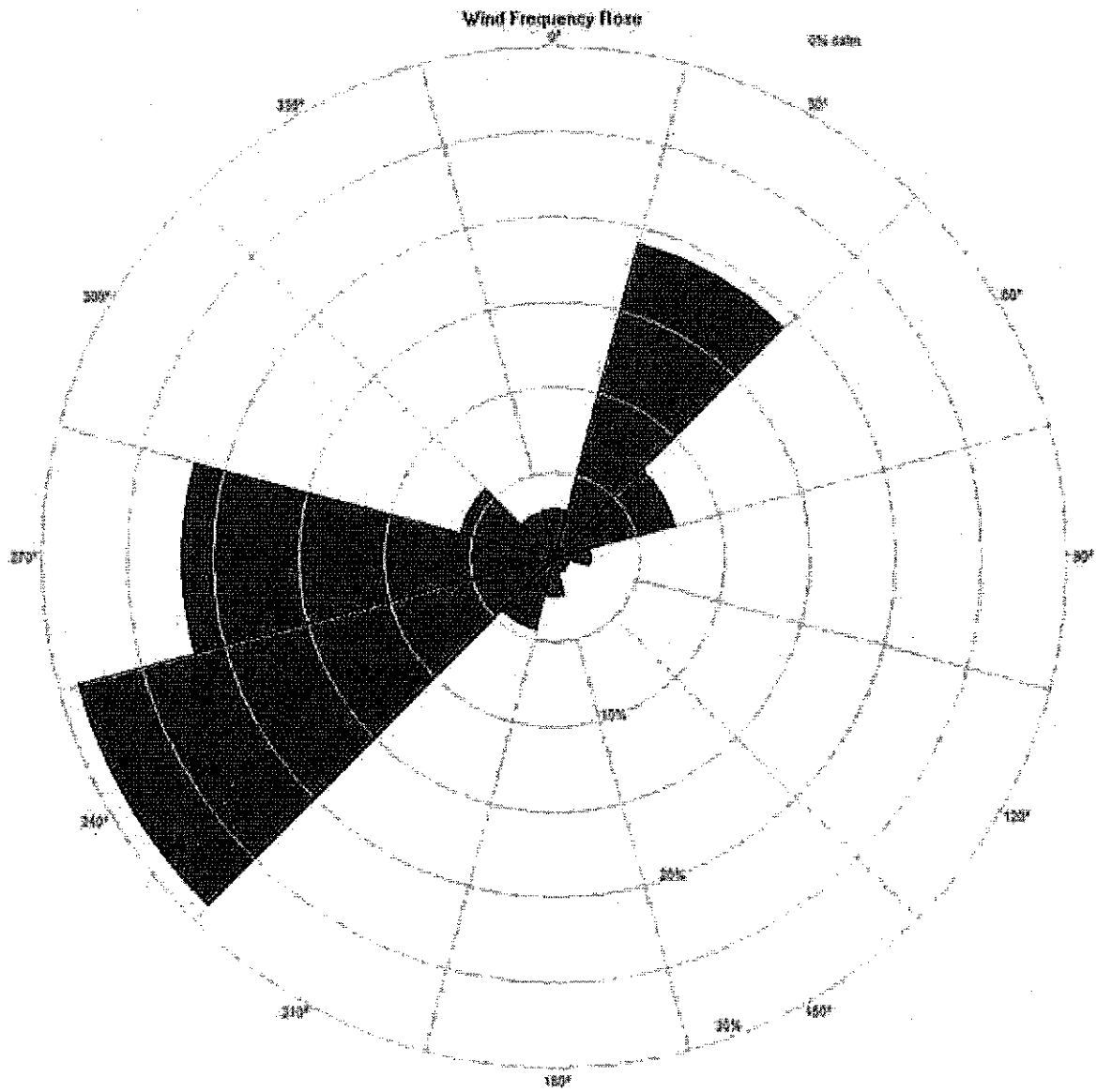
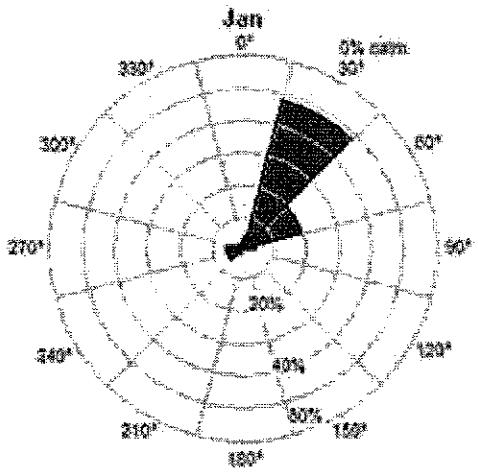
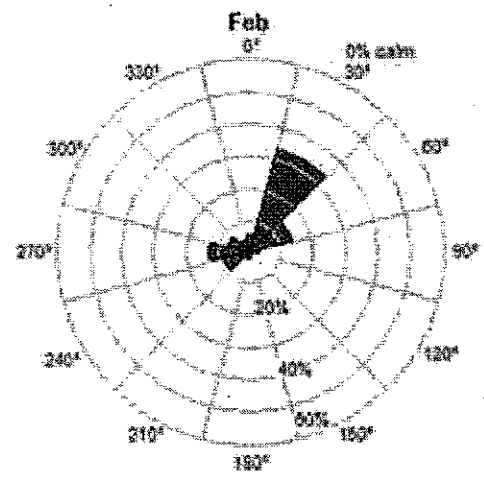
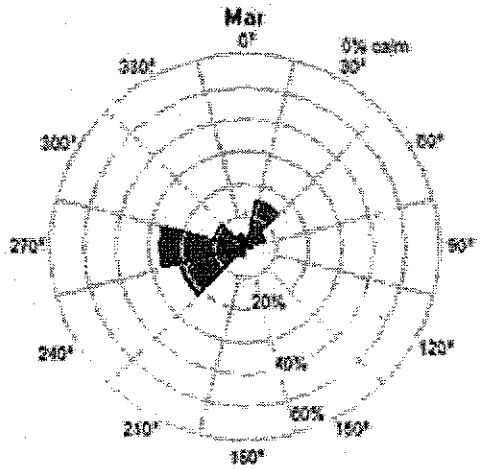
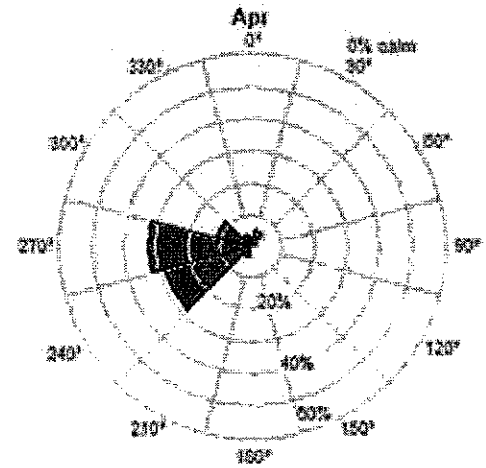


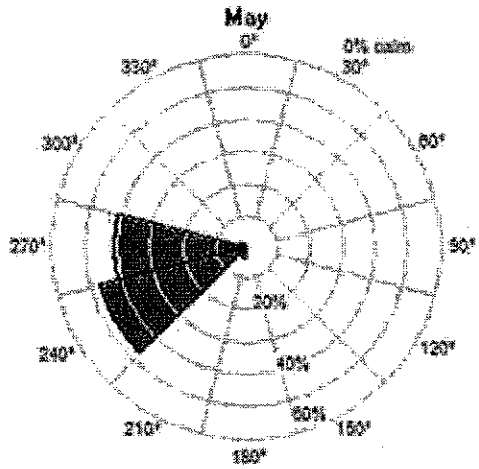
Figure 3-27: Wind Frequency Rose of YEL Mast at 83.5m

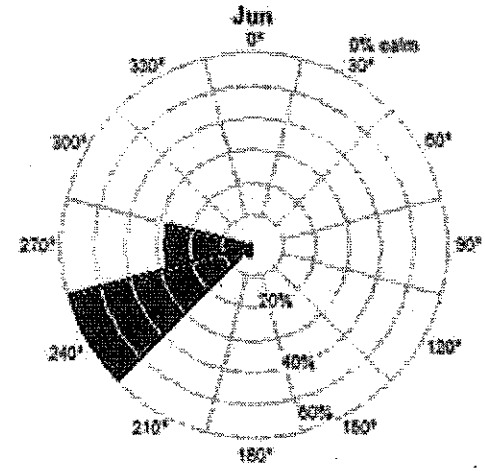

Jan
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0% calm
20%
40%
60%


Feb
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0% calm
20%
40%
60%


Mar
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0% calm
20%
40%
60%


Apr
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0% calm
20%
40%
60%


May
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0% calm
20%
40%
60%


Jun
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0% calm
20%
40%
60%

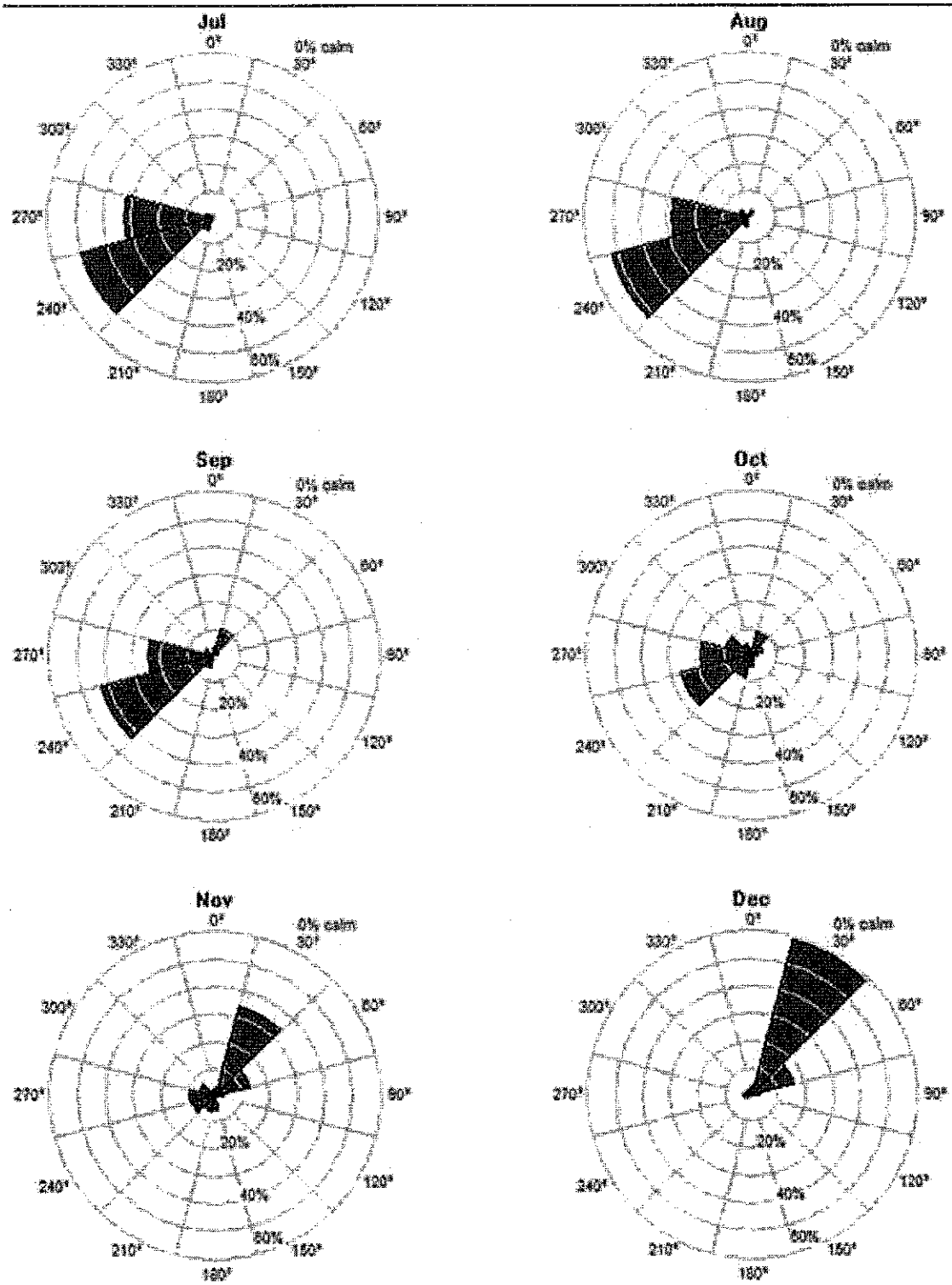


Figure 3-28: Monthly Wind Frequency Rose of YEL Mast at 83.5m

The annual and monthly wind rose developed using the YEL mast data (Dec 2008 - Mar 2012) at 28.5m height are given below in Figure 3-29 and 3-30 respectively.

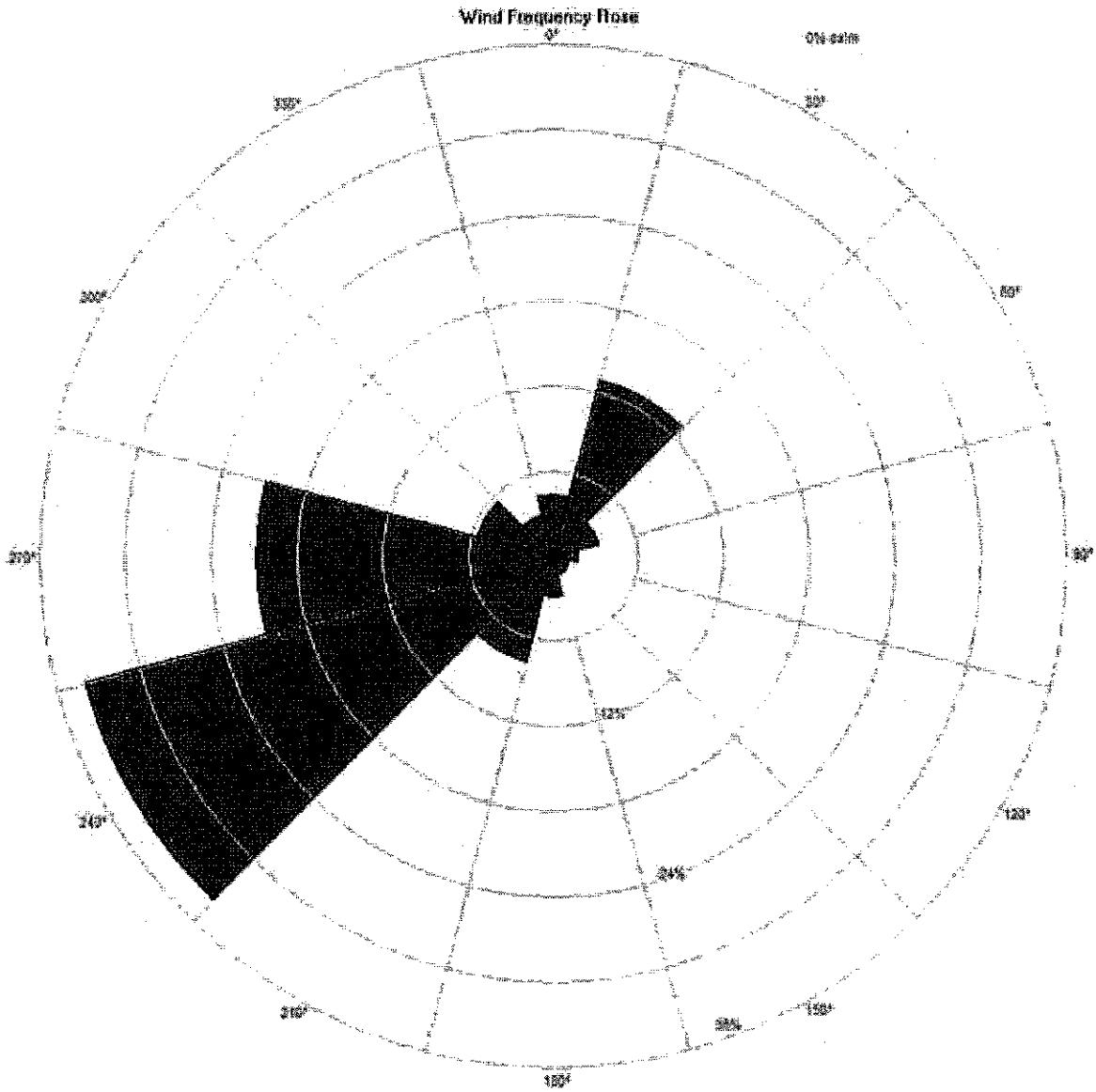
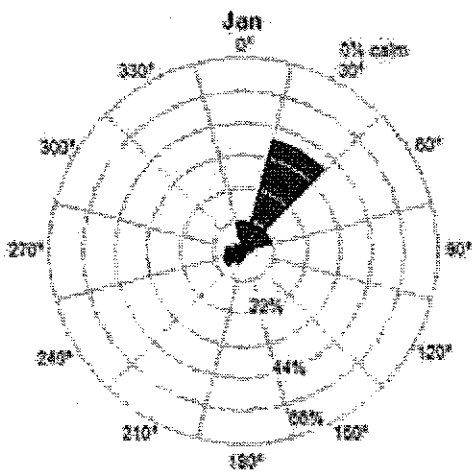
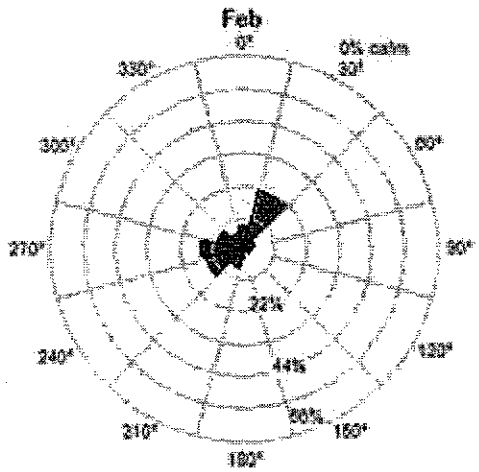
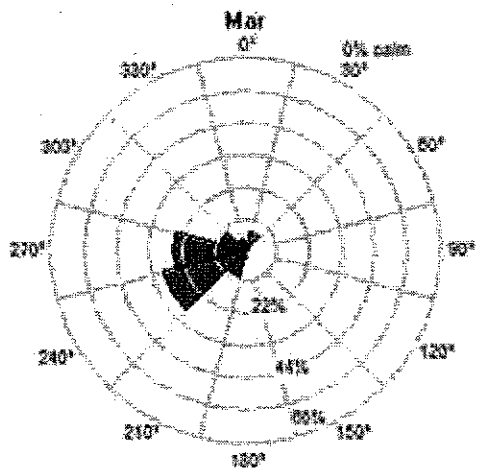
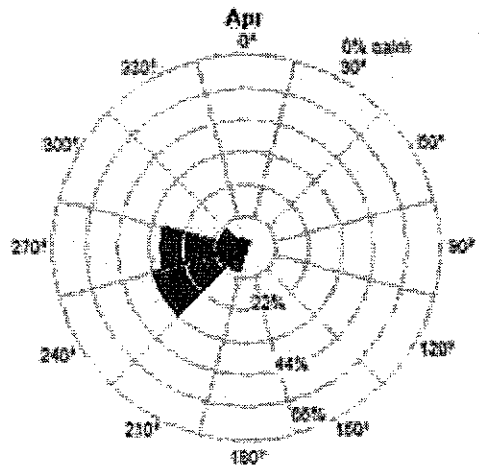


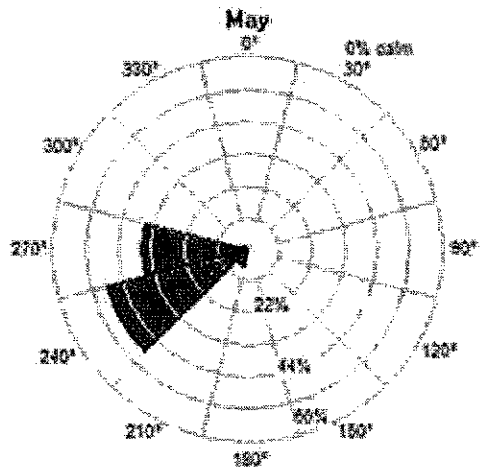
Figure 3-29: Wind Frequency Rose of YEL Mast at 28.5m

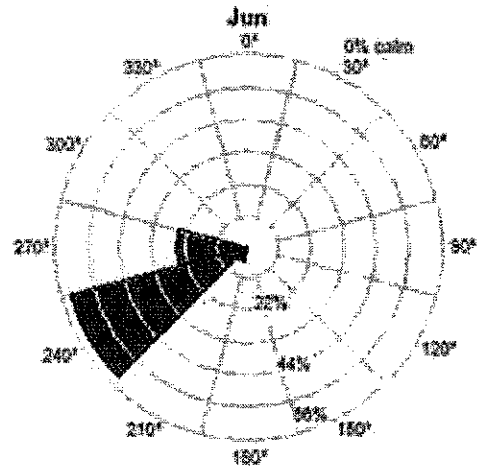

Jan
0°
0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
22%
44%
66%


Feb
0°
0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
22%
44%
66%


Mar
0°
0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
22%
44%
66%


Apr
0°
0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
22%
44%
66%


May
0°
0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
22%
44%
66%


Jun
0°
0% calm
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
22%
44%
66%

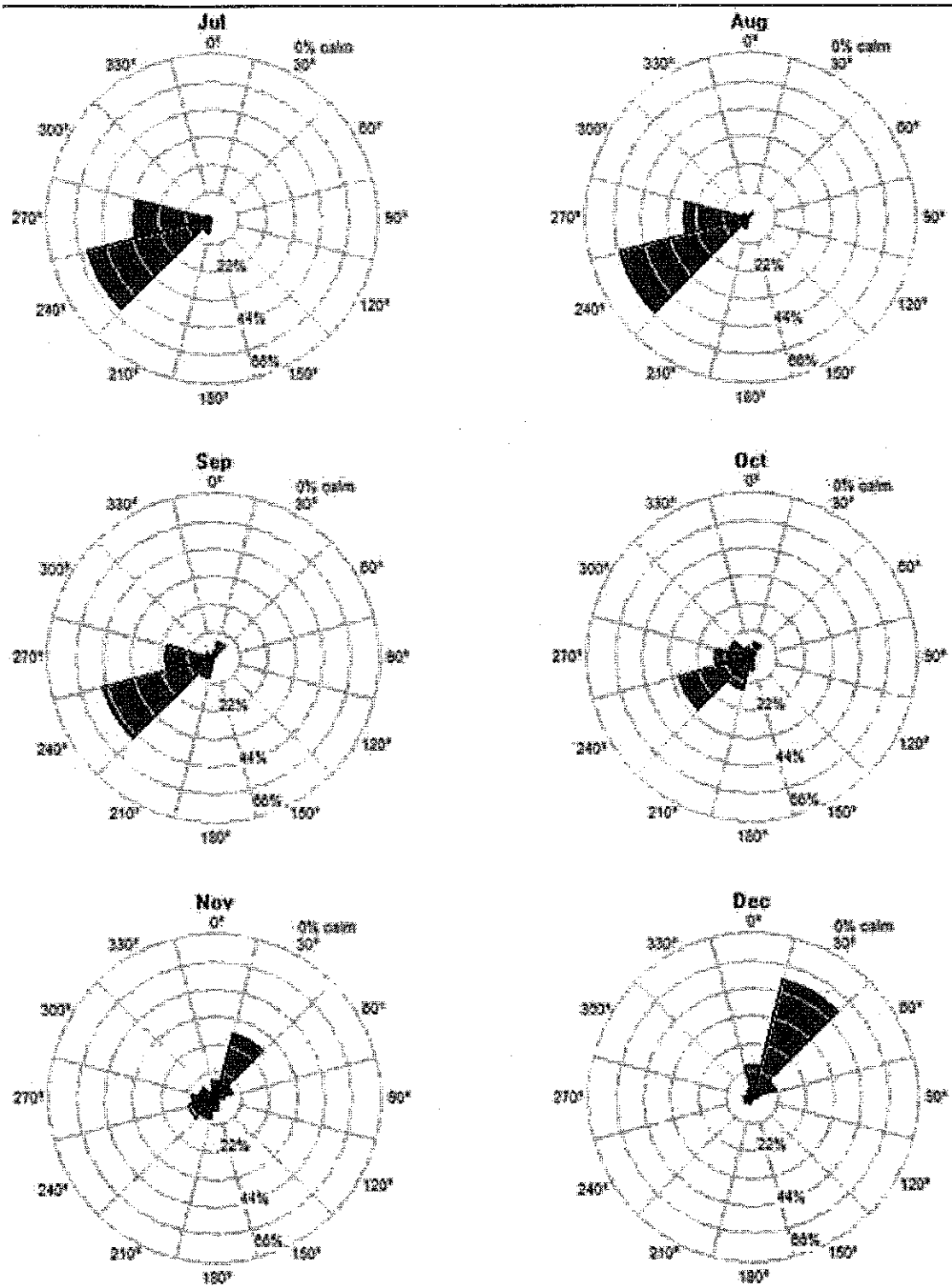


Figure 3-30: Monthly Wind Frequency Rose of YEL Mast at 28.5m

The frequency distribution of the measurement is given in the following table.

Table 3-16: Wind Direction Data with Frequency Distribution

	Direction	Frequency (%)	
	Sector	Dir 28.5m	Dir 83.5m
1	345 - 15	4.4062	2.9433
2	15 - 45	12.9016	19.1389
3	45 - 75	3.4746	7.4127
4	75 - 105	1.8053	2.1832
5	105 - 135	1.3353	0.9971
6	135 - 165	1.4767	1.0653
7	165 - 195	2.9141	2.3594
8	195 - 225	7.7753	4.4636
9	225 - 255	34.0963	28.8717
10	255 - 285	20.9861	21.9064
11	285 - 315	5.6846	5.8130
12	315 - 345	3.1433	2.8391

3.5 NEIGHBORING WIND MEASURING MAST OF MASTER WIND ENERGY PRIVATE LIMITED

3.5.1 GENERAL INFORMATION OF MAST

The 80m high Master Wind Energy Private Limited (MWEPL) wind measuring mast was installed in March 2007. The wind data available from the mast of MWEPL is up to March 2011. MWEPL Mast is located at distance of approx. 9.5 km in the southwest of Sinowell wind farm site as shown below in Figure 3-31. The mast is of lattice structure with triangular cross section having side width of approx. 2 ft. The view of the Master Energy mast can be seen from the figure 3-32 whereas the installation arrangement at the mast can be seen from the figure 3-33 given below.

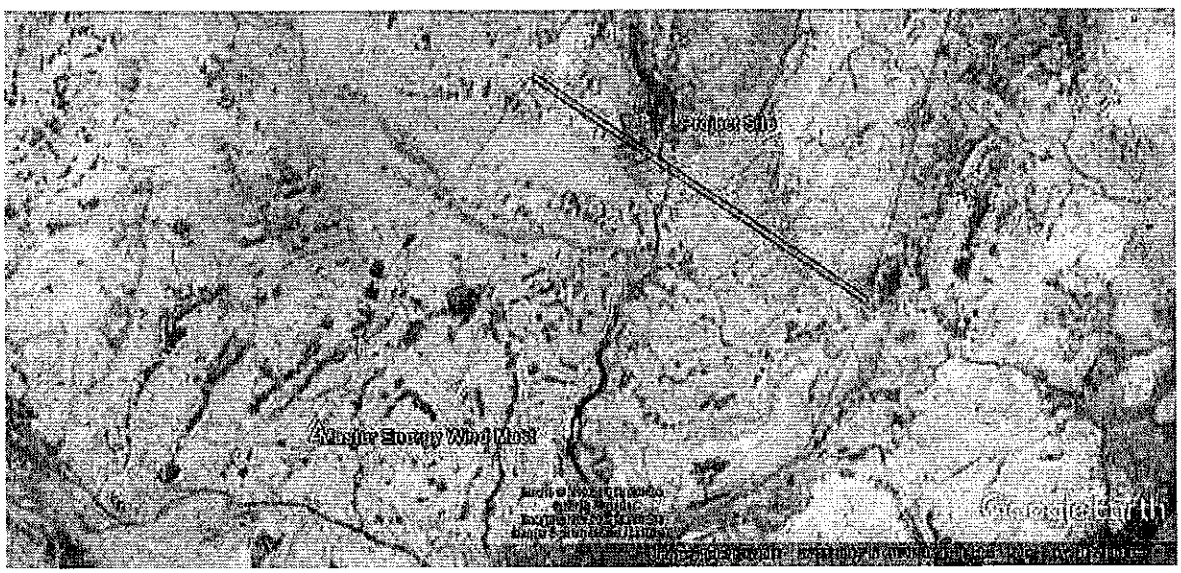


Figure 3-31: Neighboring Mast of Master Energy and Project Site Area

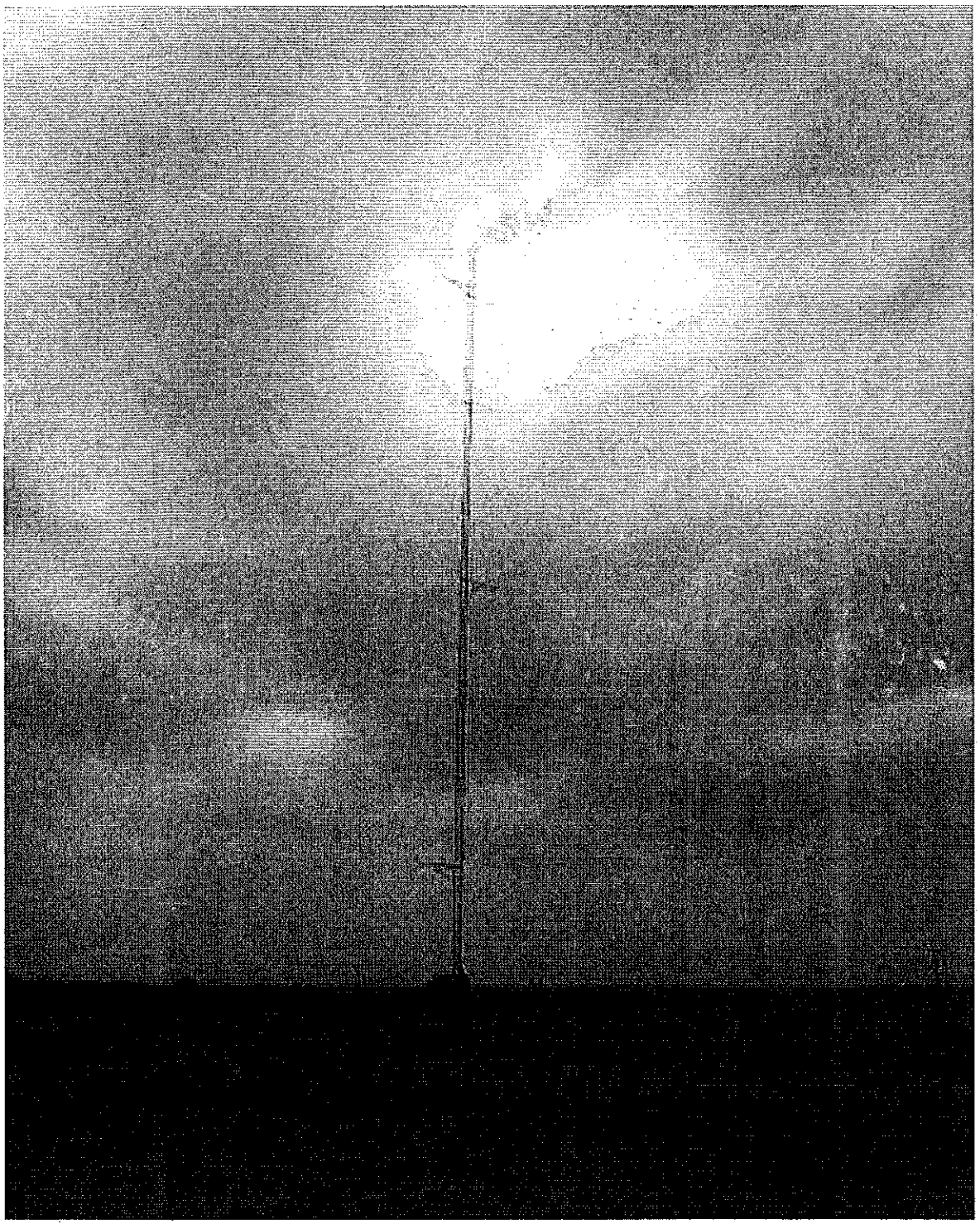


Figure 3-32: View of MWEPL Wind Measuring Mast

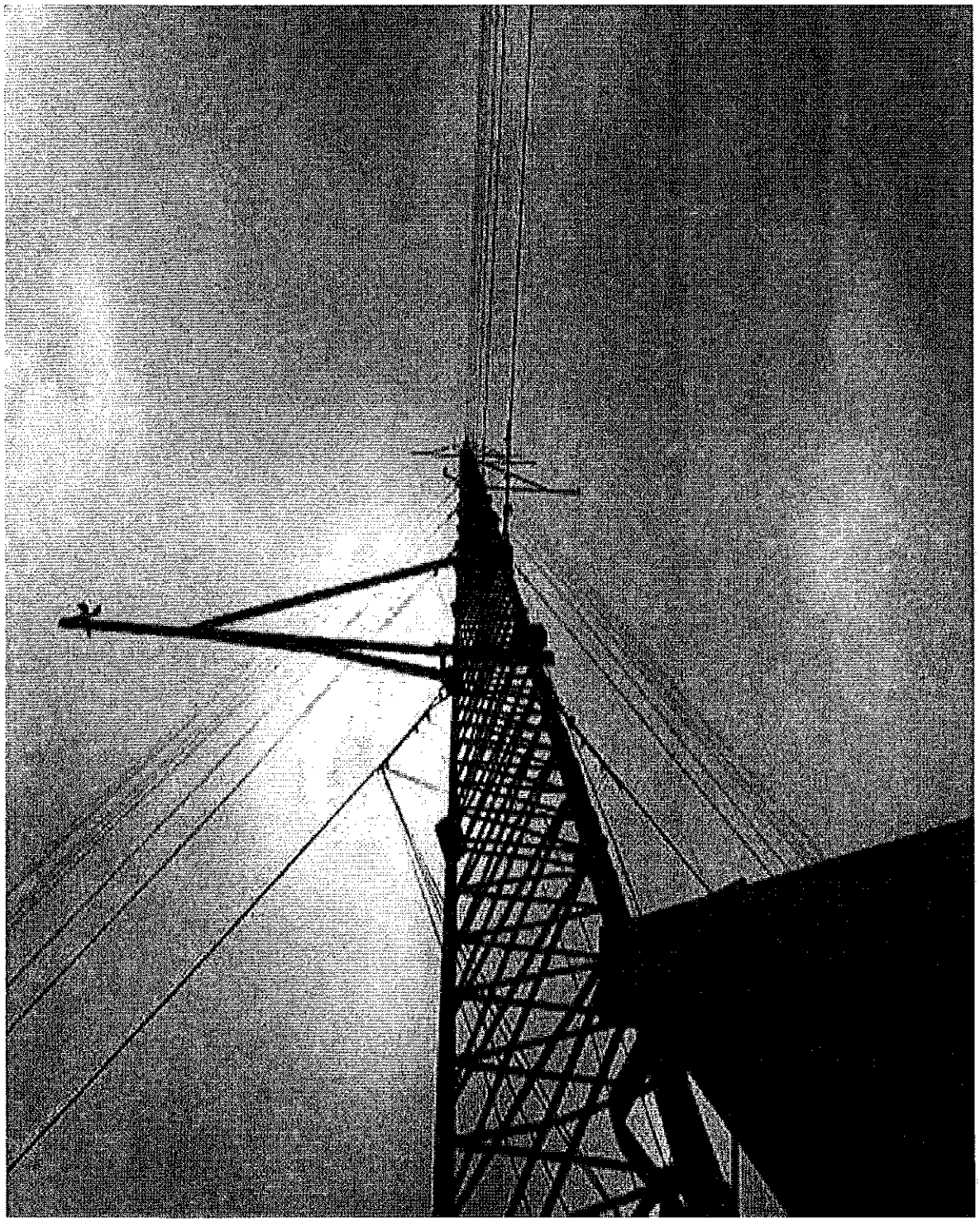


Figure 3-33: Installation Arrangements of Sensors installed at MWEPL Mast

3.5.2 INSTALLED SENSOR INFORMATION

Wind speed at MWEPL mast is recorded through five Theis first class anemometers installed at 80-a, 80-b, 60, 30 and 10m from ground level. The data from MWEPL mast were collected using Theis anemometers and NDL data logger. The anemometers were individually calibrated in the Measnet accredited wind tunnel at DKD.

The roughness of the MWEPL mast site is 0.0235m whereas the power law exponent calculated using the four (04) years data is 0.141. The specifications of MWEPL mast are shown in table 3-17 given below.

Table 3-17: Specification of MWEPL Mast

Latitude	25° 5'43.30"N
Longitude	67°59'6.80"E
Observation	Wind Speed, Wind Direction, Temperature,
Observation height	Wind Speed: 80a, 80b, 60, 30 & 10m (Theis first class anemometers) Wind Direction: 78.5, 28.5m
Observation period	From March, 2007 –March 2011
Data used for the Analysis	April 2007 to Mar 2011 (4 years)

3.5.3 WIND DATA ANALYSIS

The data from the 80m high Master Energy wind measuring mast were collected over the period 01st April 2007 to 31st March 2011 (04 years). The data coverage was good for all the instruments except anemometer V80_a, wind vane Dir 78.5 and Temp 80 during the measurement period. The data acquisition of MWEPL mast is given in table below:

Table 3-18: Wind Data Acquisition ratio of MWEPL Mast

Installed Sensors	Data Acquisition Ratio
10m anemometer (V10)	93.6%
30m anemometer (V30)	93.6%
60m anemometer (V60)	93.6%
80-a m anemometer (V85a)	75.0%
80-b m anemometer (V85b)	93.6%
28.5m Wind Vane	93.6%
78.5m Wind Vane	75.1%

Data is analyzed using time series starting from April 2007 to April 2011. Anemometer installed at 80m height (V80-a) and wind vane installed at 78.5m height started malfunctioning from 6th July 2010 till April 2011 due to which erroneous data has been removed from the time series therefore the data coverage for the V80-a and Dir 78.5 is 75% and 75.1% respectively.

The computed regression coefficient for anemometers installed at 80 meters with legends V80-a and V80-b is 99.73% (r2 = 0.9973) without gaps filling whereas the regression coefficient after filling the missing gaps comes to 99.78% (r2 = 0.9978).

The computed regression coefficient for Dir78.5 and Dir28.5 is 81.51% (r2 = 0.8151) without the filling of gaps present in the data whereas the regression coefficient after filling the missing gaps comes to 44.41% (r2 = 0.4441)

3.5.3.1 MEAN WIND SPEED ANALYSIS

The wind data recoded at Master Energy mast during the period of four (04) years has been analyzed to determine the monthly mean wind speeds. The results are shown in table 3-19 and Figure 3-34 and 3-35 respectively.

Table 3-19: Monthly Mean Wind Speeds Calculated at MWEPL Mast

Year	Month	Mean WS 80m_a (m/s)	Mean WS 80m_b (m/s)	Mean WS 60m (m/s)	Mean WS 30m (m/s)	Mean WS 10m (m/s)
2007	Apr	7.404	7.338	7.154	6.453	5.7797
	May	9.36	9.276	9.136	8.45	7.7246
	Jun	9.255	9.18	9.036	8.389	7.6709
	Jul	8.787	8.721	8.625	8.028	7.3614
	Aug	9.021	8.931	8.796	8.118	7.4176
	Sep	7.941	7.849	7.701	7	6.2867
	Oct	6.282	6.218	5.937	4.944	4.0306
	Nov	5.33	5.269	5.036	4.104	3.2371
	Dec	7.187	7.056	6.751	5.525	4.3678
2008	Jan	7.083	6.964	6.679	5.492	4.38
	Feb	5.327	5.267	5.116	4.422	3.6247
	Mar	6.504	6.432	6.184	5.367	4.6171
	Apr	7.463	7.392	7.202	6.45	5.7466
	May	11.796	11.674	11.561	10.752	9.8691
	Jun	9.095	9.021	8.94	8.398	7.7633
	Jul	9.799	9.79	9.433	8.598	7.4708

	Aug	9.517	9.417	9.328	8.69	7.9919
	Sep	8.212	8.115	7.955	7.213	6.452
	Oct	6.806	6.75	6.489	5.556	4.7224
	Nov	7.282	7.141	6.819	5.542	4.4346
	Dec	7.28	7.133	6.883	5.879	4.9223
2009	Jan	7.924	7.8	7.446	6.289	5.2982
	Feb	6.171	6.087	5.869	5.007	4.2035
	Mar	6.472	6.406	6.213	5.457	4.7242
	Apr	7.216	7.149	6.918	6.118	5.4021
	May	9.267	9.172	9.037	8.355	7.6232
	Jun	8.952	8.866	8.78	8.215	7.5925
	Jul	9.393	9.299	9.198	8.573	7.8997
	Aug	9.203	9.104	9.043	8.465	7.7986
	Sep	8.539	8.447	8.257	7.438	6.6646
	Oct	5.65	5.589	5.37	4.56	3.7916
	Nov	6.853	6.718	6.429	5.267	4.1577
	Dec	7.07	6.892	6.578	5.331	4.2324
2010	Jan	6.428	6.33	6.062	5.039	4.0572
	Feb	6.308	6.207	5.987	5.091	4.2021
	Mar	6.727	6.658	6.452	5.659	4.9046
	Apr	8.202	8.117	7.929	7.167	6.4223
	May	9.899	9.845	9.59	8.775	7.7917
	Jun	9.961	9.919	9.65	8.867	7.8484
	Jul	8.153	8.142	8.04	7.459	6.8297

	Aug	7.08	7.08	6.925	6.256	5.6054
	Sep	6.66	6.66	6.459	5.683	4.9641
	Oct	5.96	5.96	5.713	4.913	4.0737
	Nov	6.806	6.806	6.552	5.659	4.643
	Dec	7.023	7.023	6.753	5.535	4.4164
2011	Jan	6.651	6.651	6.371	5.303	4.2556
	Feb	6.336	6.336	6.103	5.172	4.2648
	Mar	6.76	6.76	6.553	5.789	5.0149

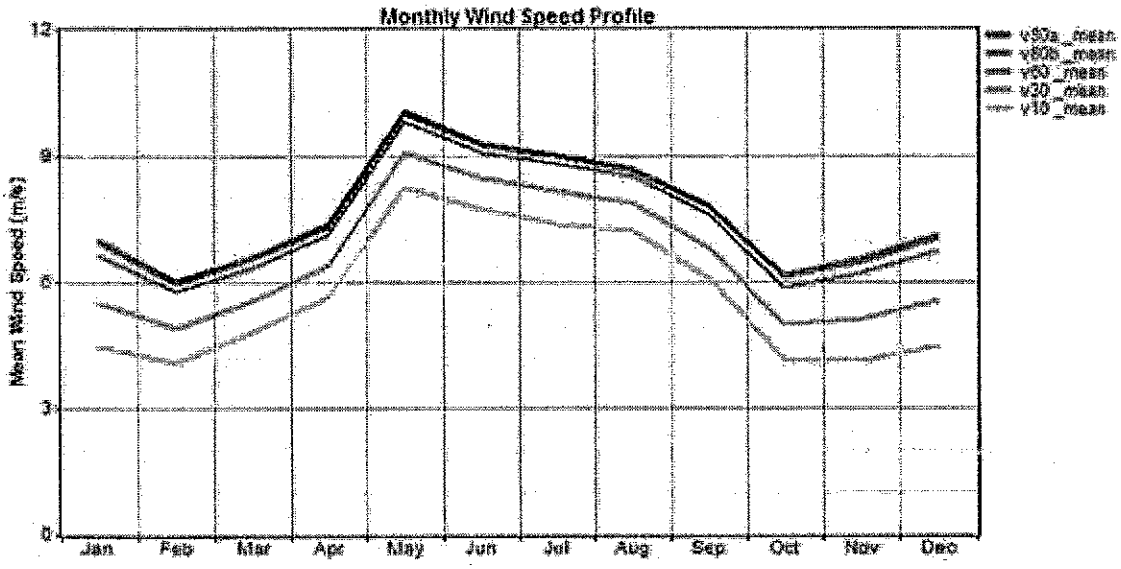


Figure 3-34: Mean of Monthly mean wind speeds at MWEPL Mast during 2007 – 2011

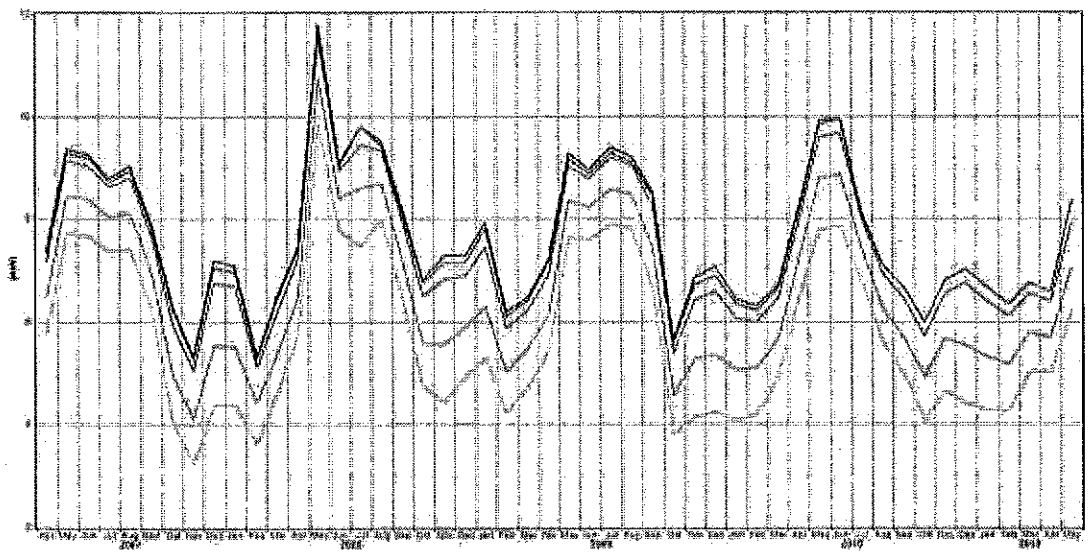
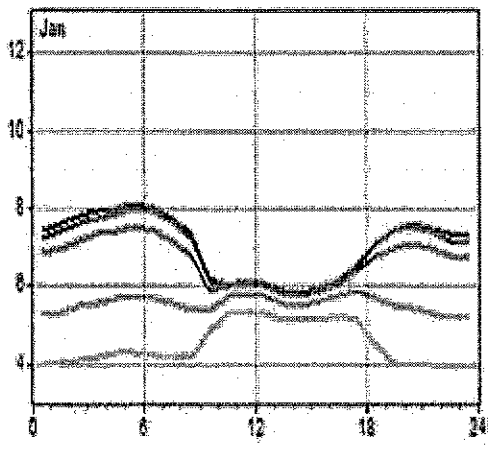
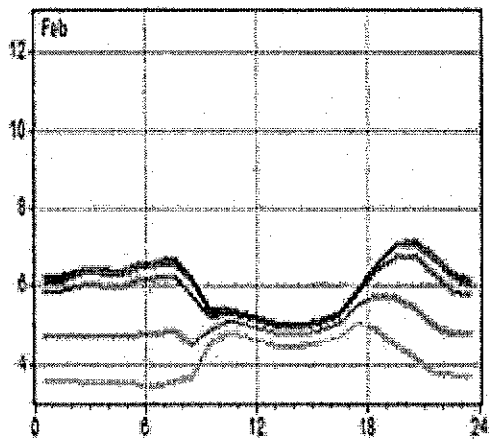


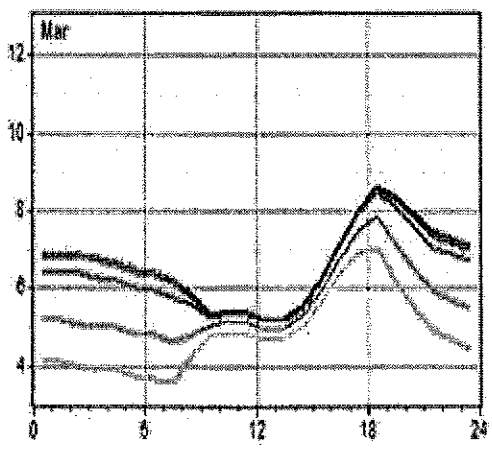
Figure 3-35: Monthly mean wind speeds at MWEPL Mast during 2007-2011

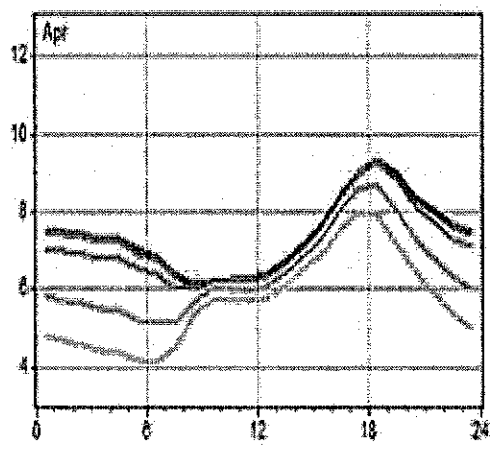
3.5.3.2 DIURNAL VARIATION

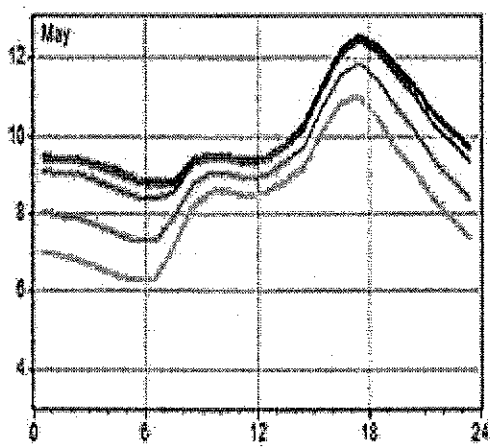
The monthly and annual diurnal variation of wind speed, for the wind data recoded during the period of April 2007 to March 2011 at 10, 30, 60, 80-a and 85-b m are shown below in figure 3-36 and 3-37 respectively.

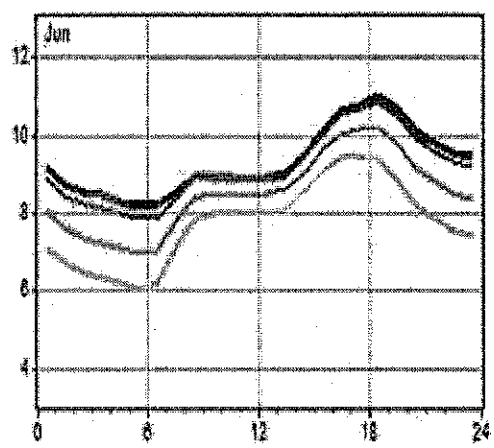

Jan
12
10
8
6
4
0
6
12
18
24


Feb
12
10
8
6
4
0
6
12
18
24


Mar
12
10
8
6
4
0
6
12
18
24


Apr
12
10
8
6
4
0
6
12
18
24


May
12
10
8
6
4
0
6
12
18
24


Jun
12
10
8
6
4
0
6
12
18
24

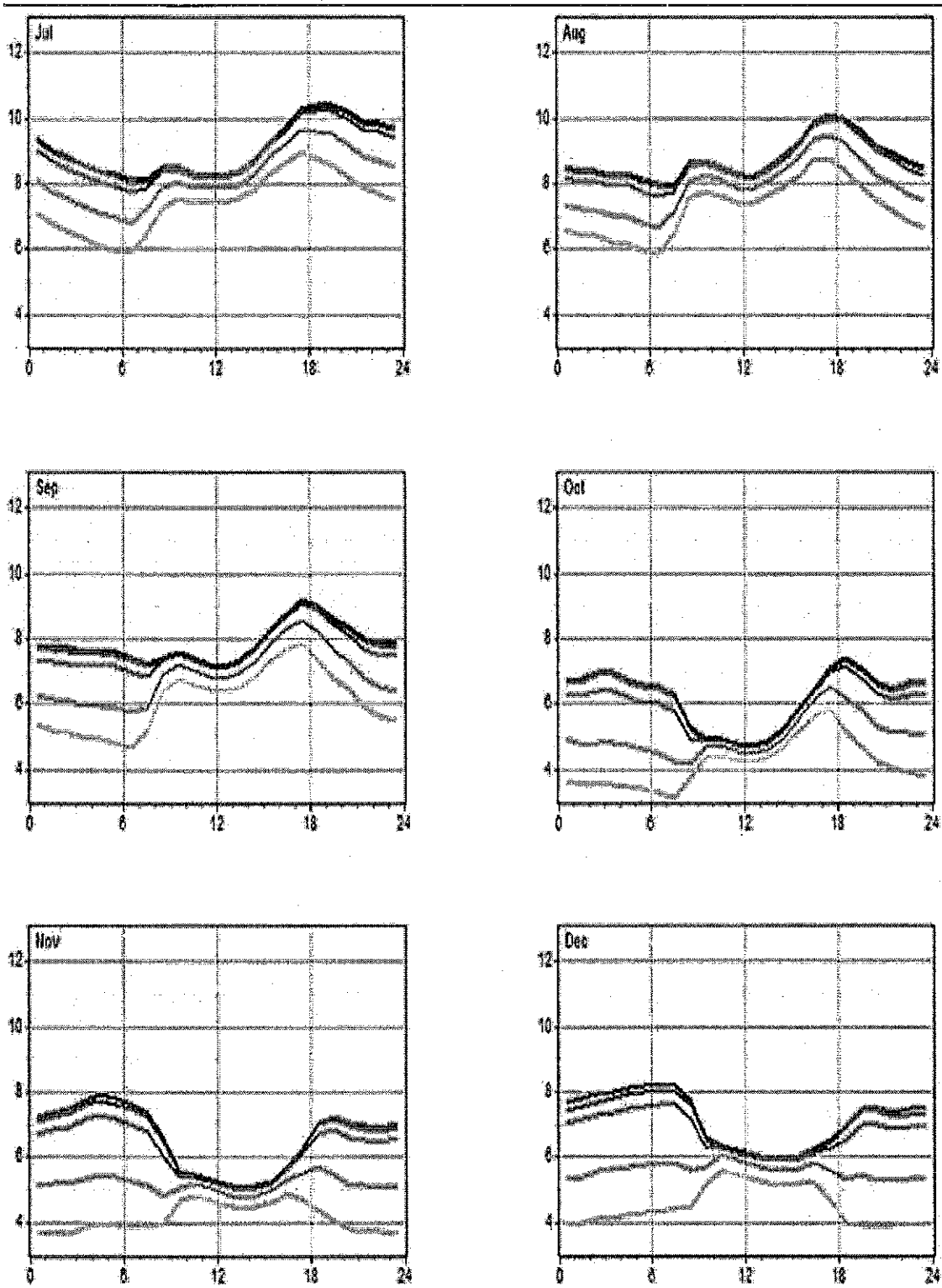


Figure 3-36: Monthly Diurnal Wind Speed Profile at MWEPL Site Wind Data

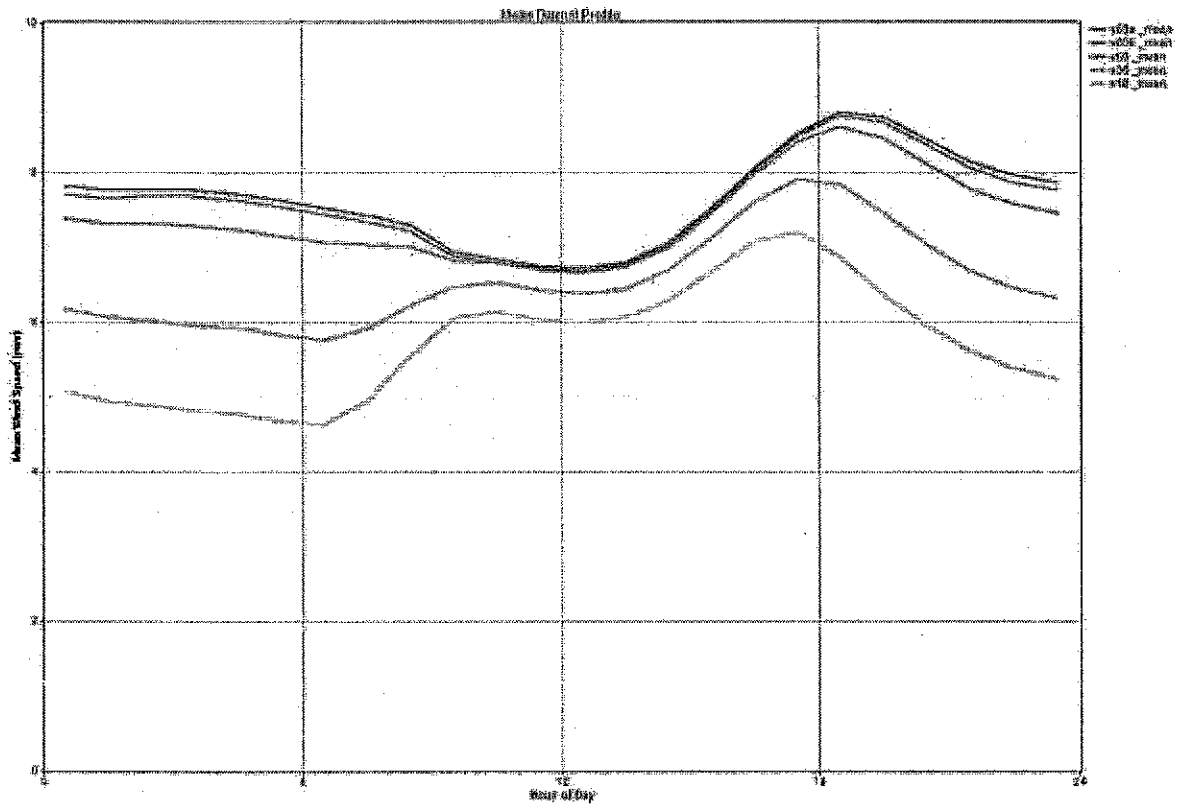


Figure 3-37: Annual Diurnal Wind Speed Profile at MWEPL Site Wind Data

3.5.3.3 WIND SHEAR PROFILE

The vertical wind shear and monthly wind shear profiles for the wind data recorded during the period of April 2007 to March 2011 have been computed. The results derived are given below:

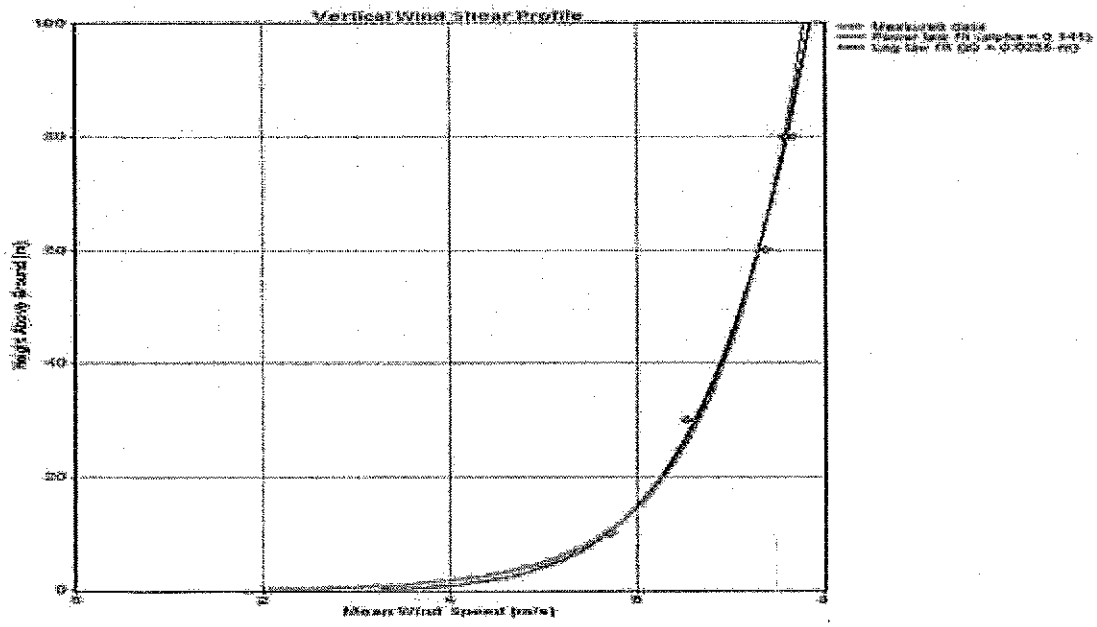


Figure 3-38: Vertical Wind Shear Profile at MWEPL Site

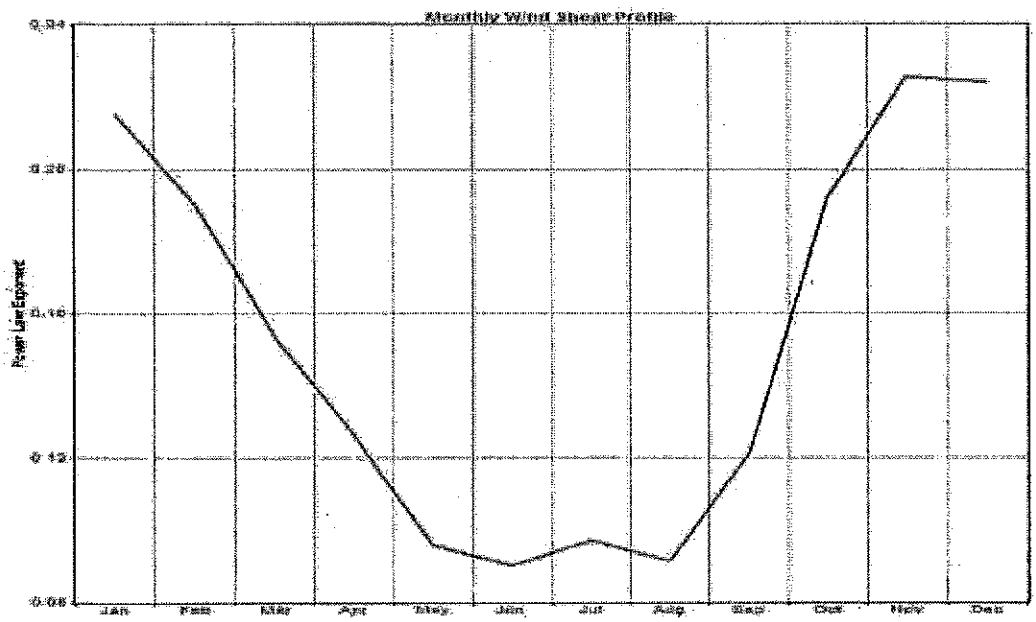


Figure 3-39: Monthly Wind Shear Profile at MWEPL Site

Table 3-20: Monthly Wind Shear Profile of MWEPL Mast

Month	Power Law Exponent
Jan	0.215
Feb	0.190
Mar	0.153
Apr	0.126
May	0.096
Jun	0.090
Jul	0.097
Aug	0.091
Sep	0.121
Oct	0.192
Nov	0.226
Dec	0.224

3.5.3.4 WIND DIRECTION AND FREQUENCY DISTRIBUTION

The data from the 80m high Master Energy mast were collected over the period April 2007 to March 2011. The annual and monthly wind roses developed using the MWEPL mast data (Apr 2007-Mar 2011) at 78.5m height are given below in Figure 3-40 and 3-41 respectively.

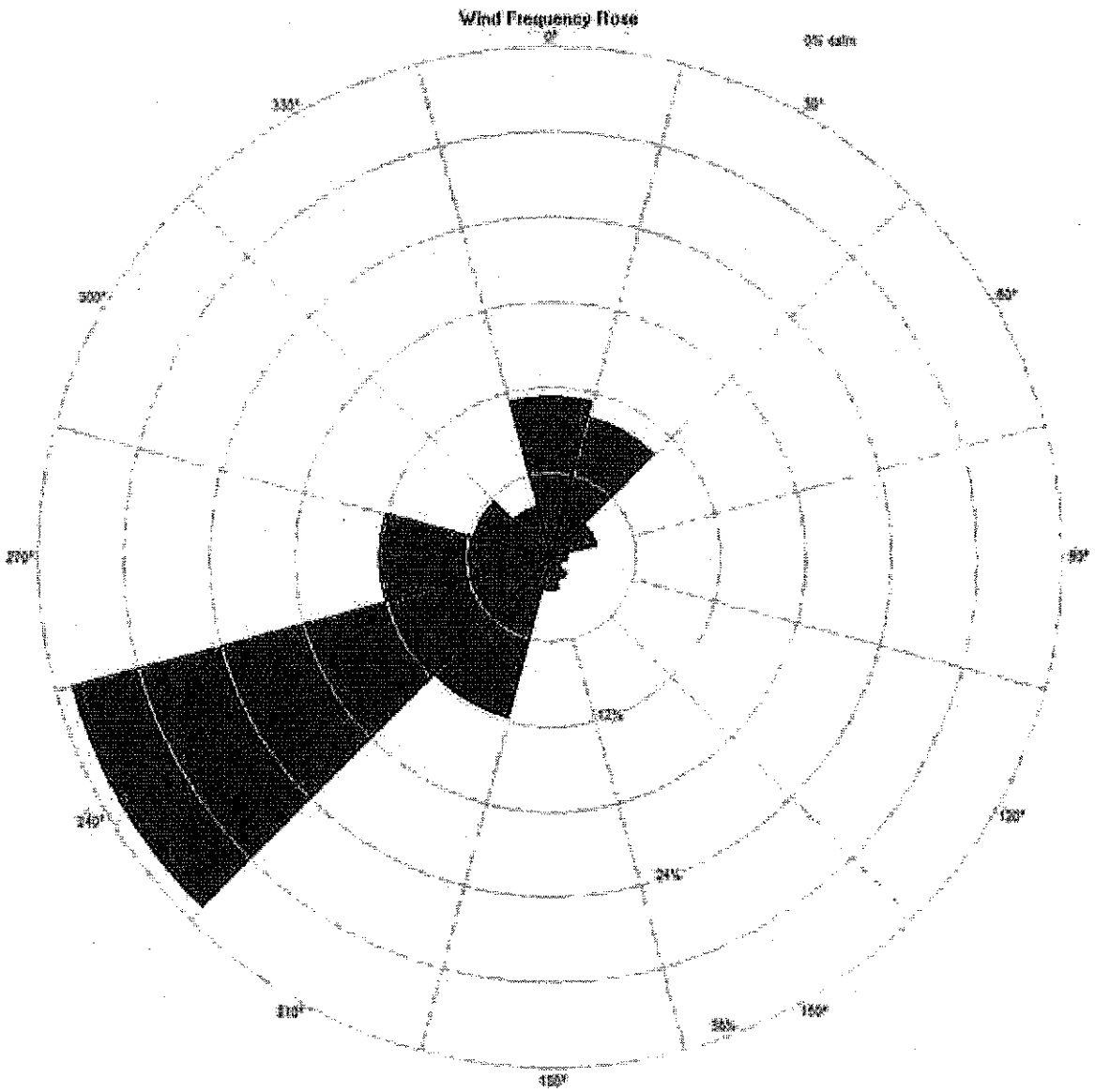
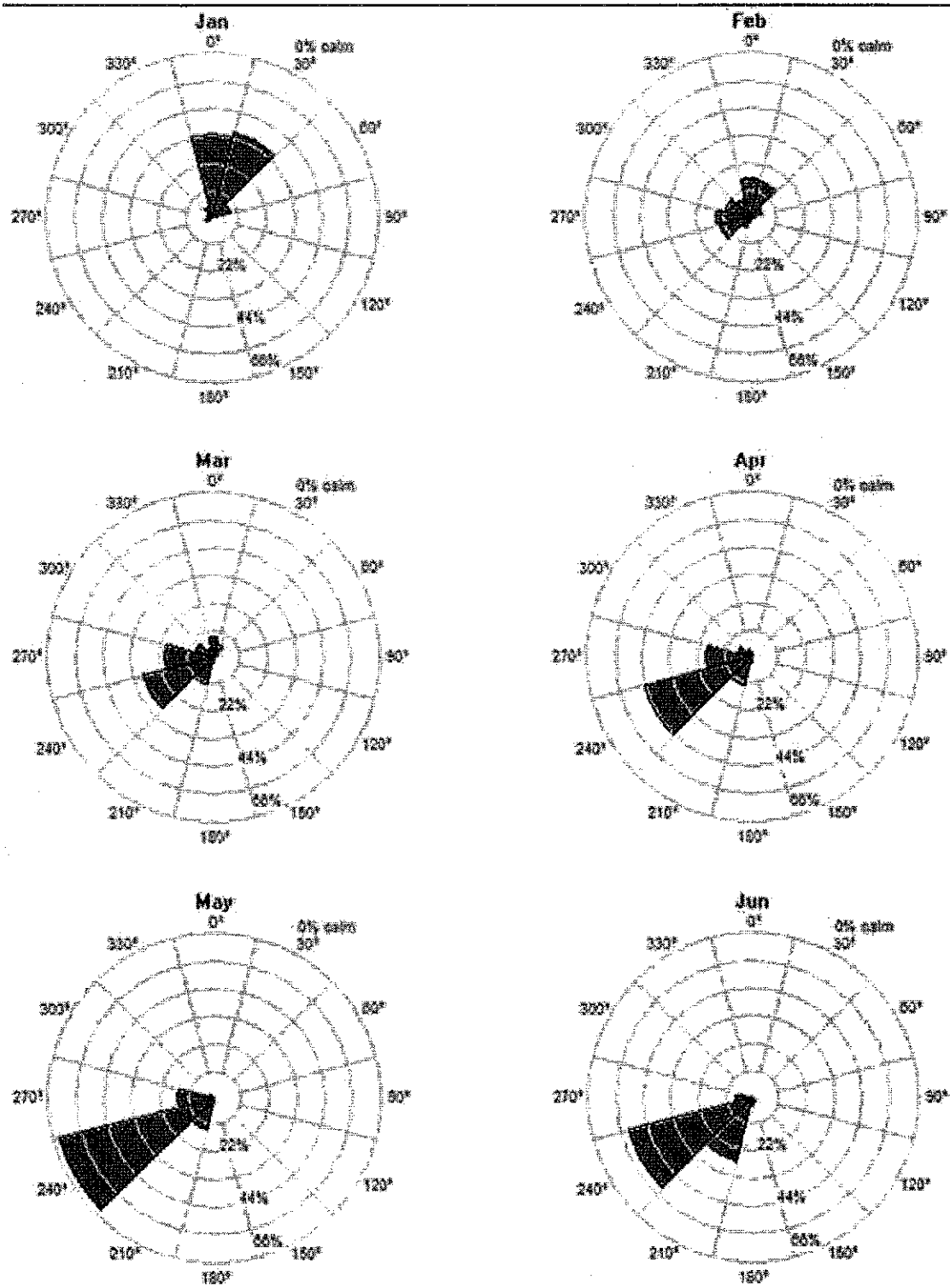


Figure 3-40: Wind Frequency Rose of MWEPL Mast at 78.5m


Jan
Feb
Mar
Apr
May
Jun
0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330°
0% calm
22%
44%
66%

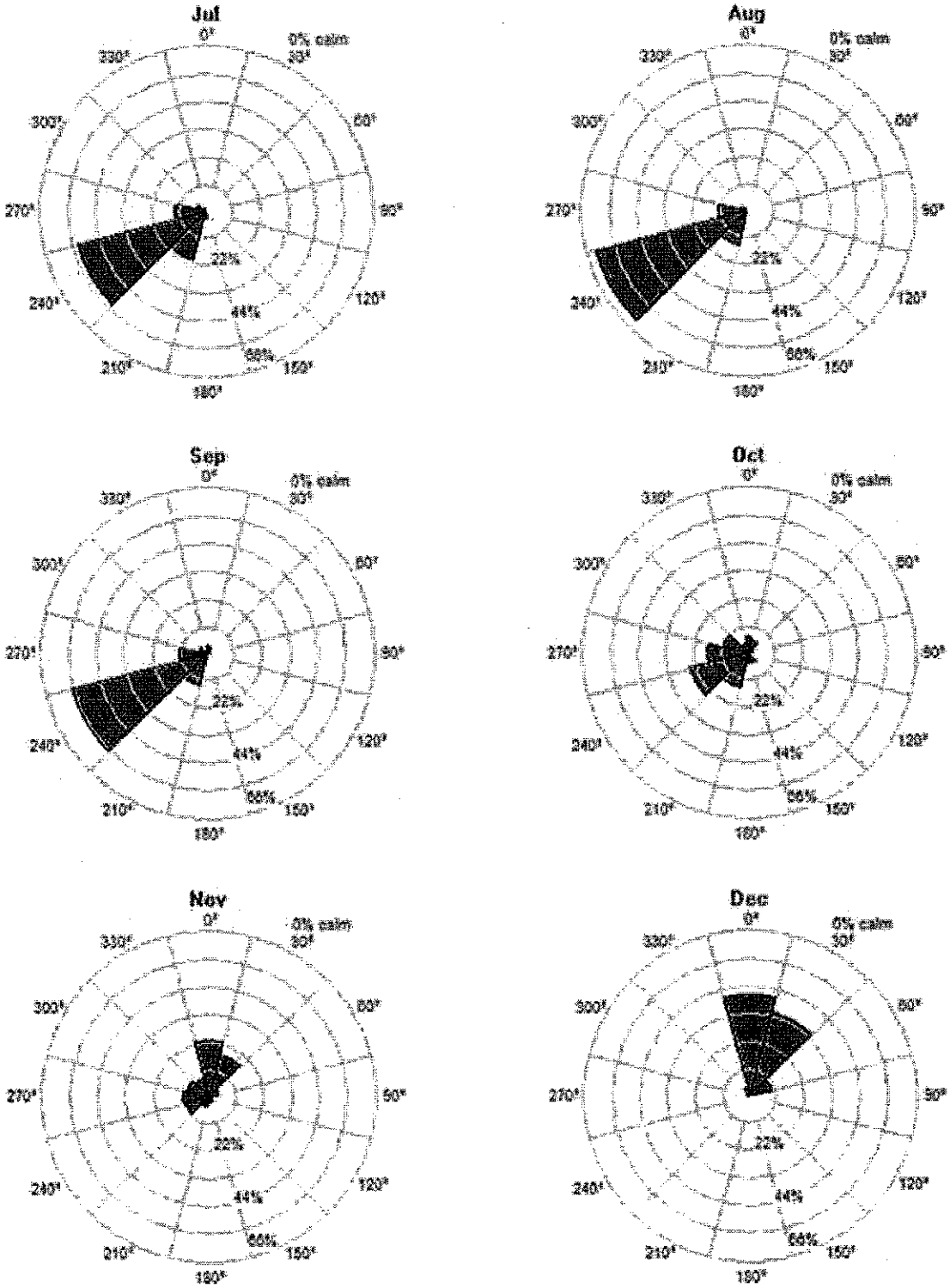


Figure 3-41: Monthly Wind Frequency Rose of MWEPL Mast at 78.5m

The annual and monthly wind rose developed using the Master Energy mast data (April 2007 – March 2011) at 28.5m height are given below in Figure 6-42 and 6-43 respectively.

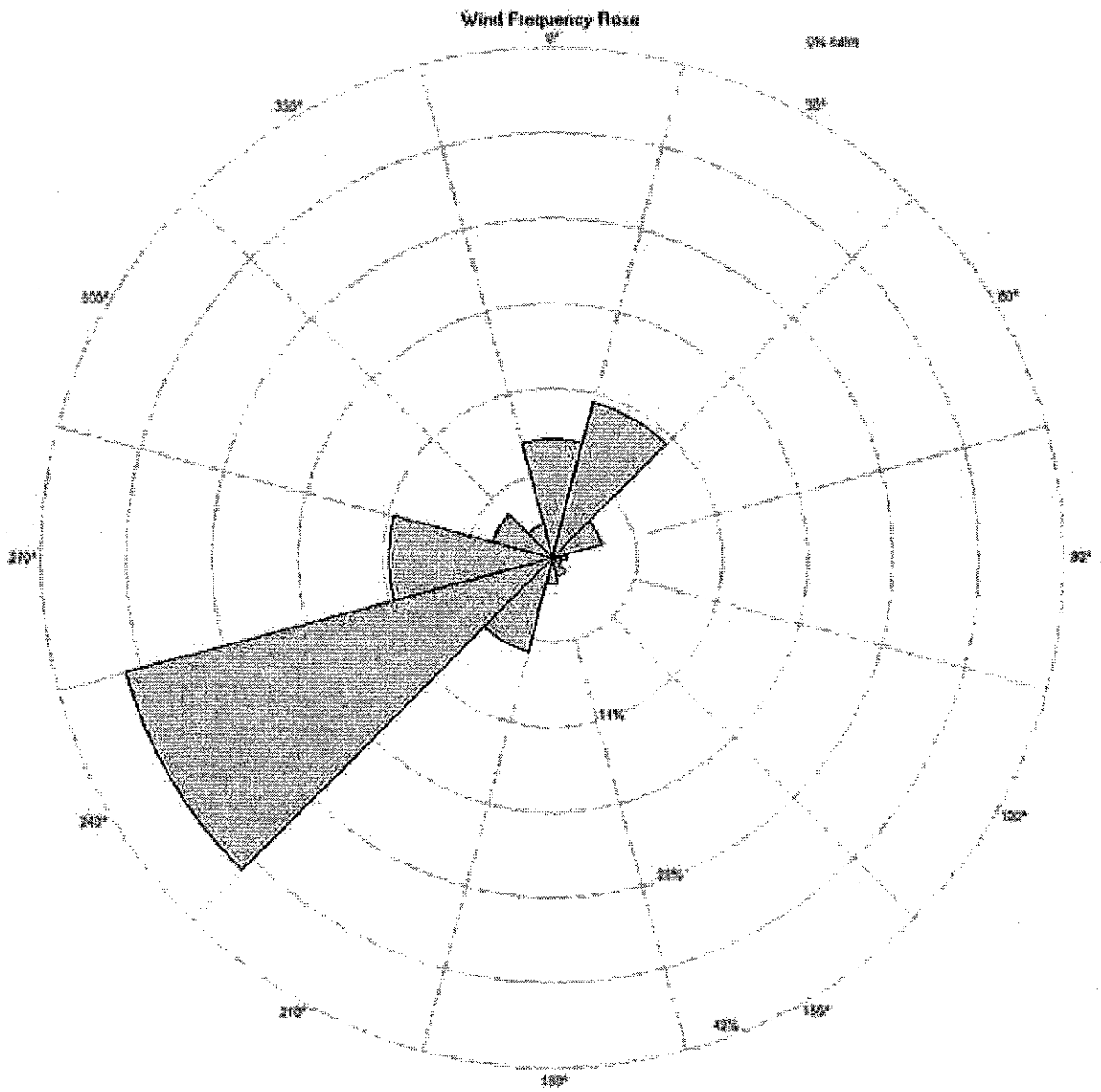
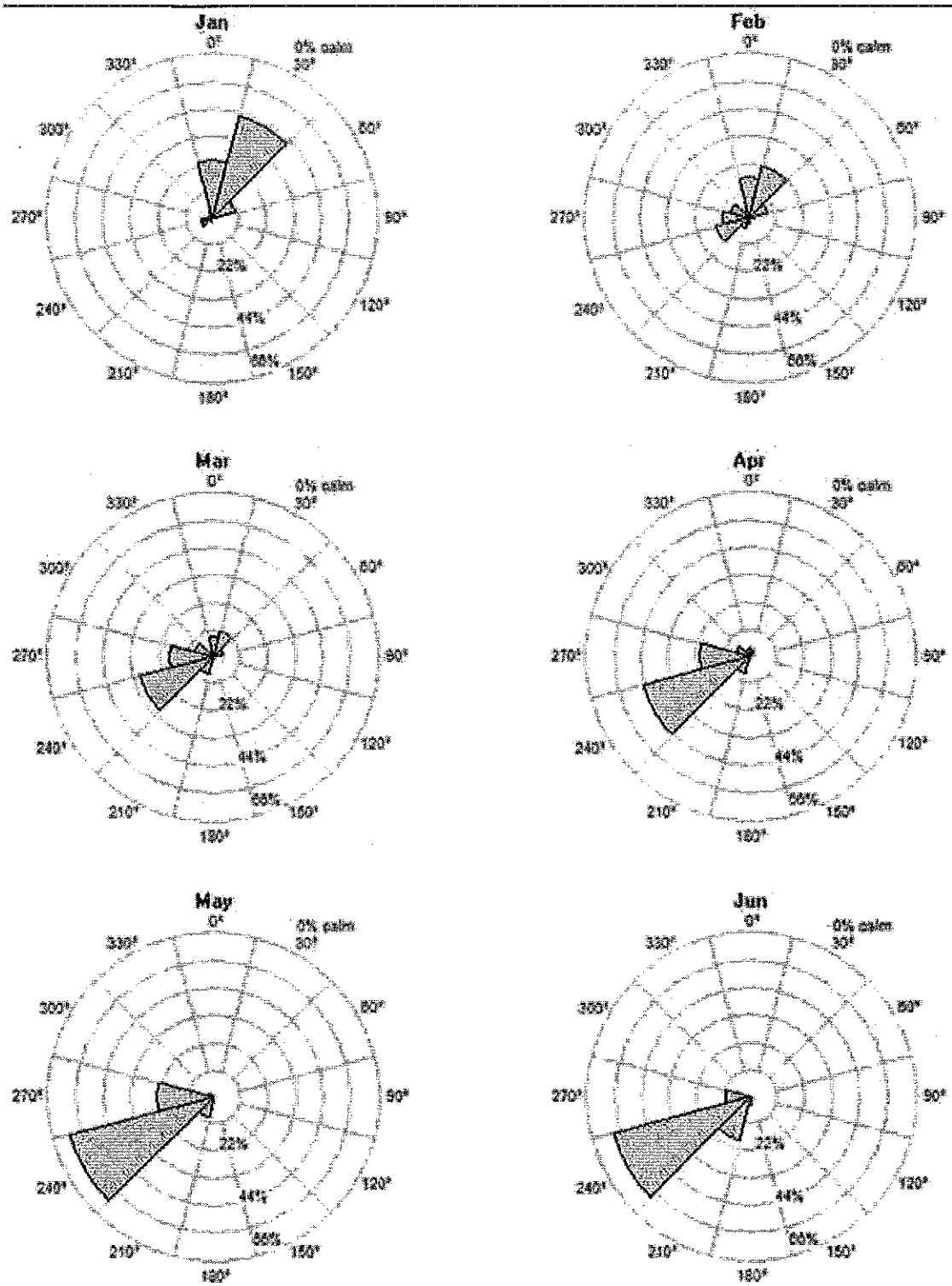


Figure 3-42: Wind Frequency Rose of MWEPL Mast at 28.5m


Jan
Feb
Mar
Apr
May
Jun
0% calm
22%
44%
66%

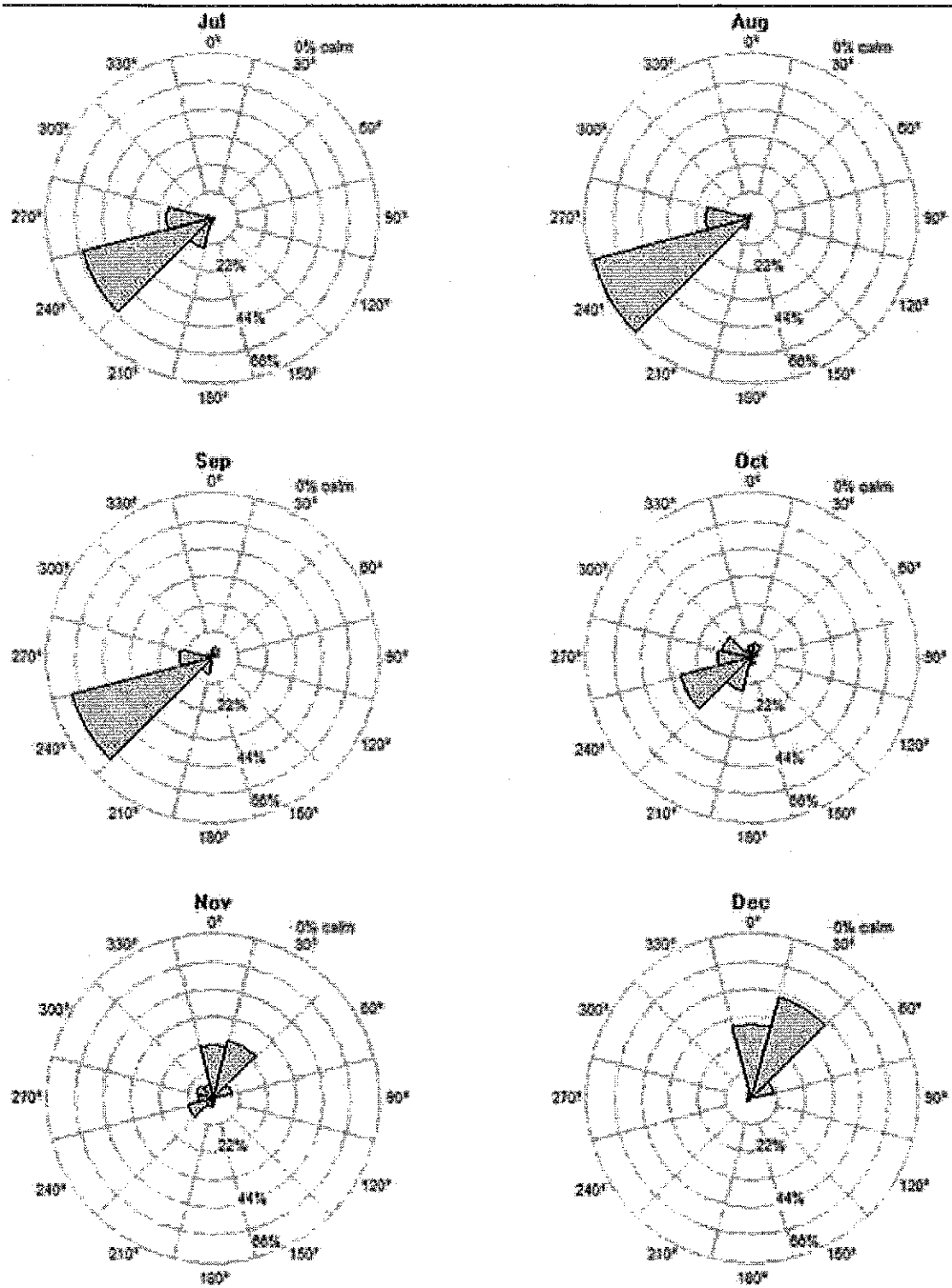


Figure 3-43: Monthly Wind Frequency Rose of MWEPL Mast at 28.5m

The frequency distribution of the measurement is given in the following table.

Table 3-21: Wind Direction Data with Frequency Distribution

	Direction	Frequency (%)	
	Sector	Dir 28.5m	Dir 78.5m
1	345 - 15	9.8279	11.4777
2	15 - 45	13.3086	10.3272
3	45 - 75	4.4103	3.4424
4	75 - 105	1.3884	1.2398
5	105 - 135	0.8691	0.9348
6	135 - 165	1.7200	1.7559
7	165 - 195	2.3106	2.4024
8	195 - 225	8.1172	11.7897
9	225 - 255	36.2862	34.8033
10	255 - 285	13.5400	12.1558
11	285 - 315	5.2333	5.7610
12	315 - 345	2.9692	3.8909

3.6 CORRELATION OF WIND DATA BETWEEN NEIGHBORING MASTS

In the assessment of the wind regime at a candidate wind farm site, it is desirable to correlate data recorded at the site with data recorded at a nearby/ neighboring long-term reference meteorological station. This allows the estimate of the long-term wind regime at the site to be representative of a longer historical period.

In order to have the long term synthesized data at the project site from the neighboring long-term reference meteorological station, a minimum of one year on-site data of the same period is required. Sinowell is in the process of installation of wind measuring mast at its project site. Therefore, it is not possible to carry out the MCP analysis for predicting the long term wind regime at the site using long term time series of reference mast.

The neighboring meteorological masts of Yunus Energy Limited (YEL), Master Wind Energy Private Limited (MWEPL) and FFC Energy Limited (FFCEL) have the long term time series and are in the neighbourhood of Sinowell wind farm site. Considering the flatness of the area, the neighboring meteorological masts also represent the candidate wind farm site and the measurements can be useable in WAsP analysis.

For the purpose of selecting a suitable neighboring wind measuring mast which represents the candidate wind farm site most & has the long term time series, the linear correlation of wind data between neighboring wind measuring masts of YEL, MWEPL and FFCEL was carried out.

The sensors installed at or closer to the hub height were considered for the purposes of performing correlation between neighboring masts. While doing the correlation, it was observed that the prevailing/ predominant wind direction of MWEPL mast does not correlate well with other neighboring wind measuring masts. An offset of 17.53 was computed and applied accordingly on the 78.5m high wind vane installed at MWEPL mast.

The results of the correlation made between neighboring wind measuring masts of YEL, MWEPL & FFCEL are presented below:

Table 3-22: Correlation of Wind Speed between Neighboring Masts

S.No.	Correlation between Masts	Regression Coefficient (r^2)
1.	Yunus Energy & FFC Energy	0.8600
2.	Yunus Energy & Master Wind Energy	0.8956
3.	FFC Energy & Master Wind Energy	0.9445

Table 3-23: Correlation of Wind Direction between Neighboring Masts

S.No.	Correlation between Masts	Regression Coefficient (r^2)
1.	Yunus Energy & FFC Energy	0.9622
2.	Yunus Energy & Master Wind Energy	0.9743
3.	FFC Energy & Master Wind Energy	0.9355

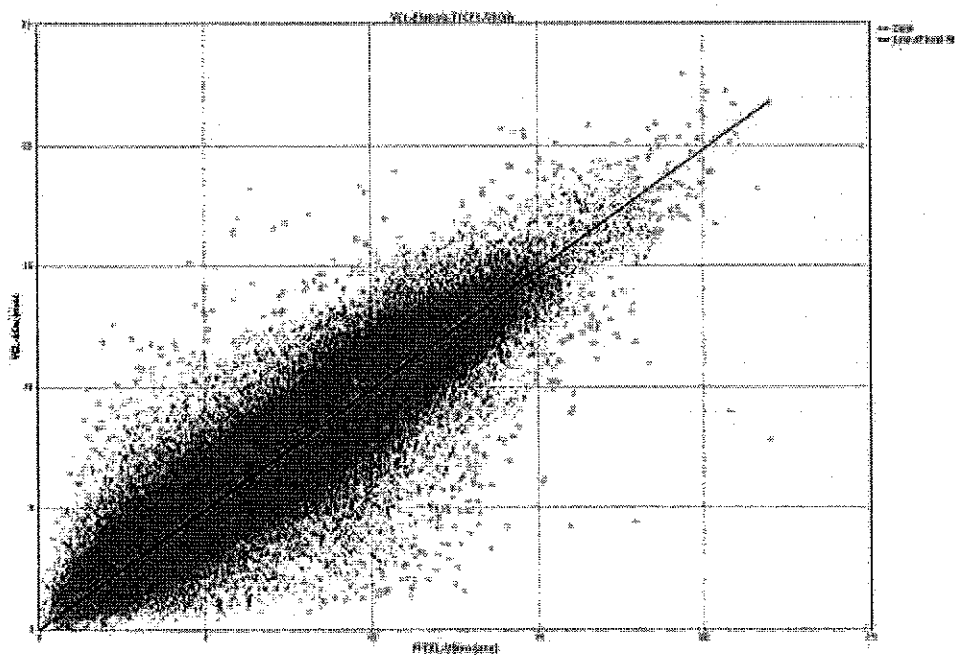


Figure 3-44: Correlation of Wind Speed between YEL & FFCEL Masts

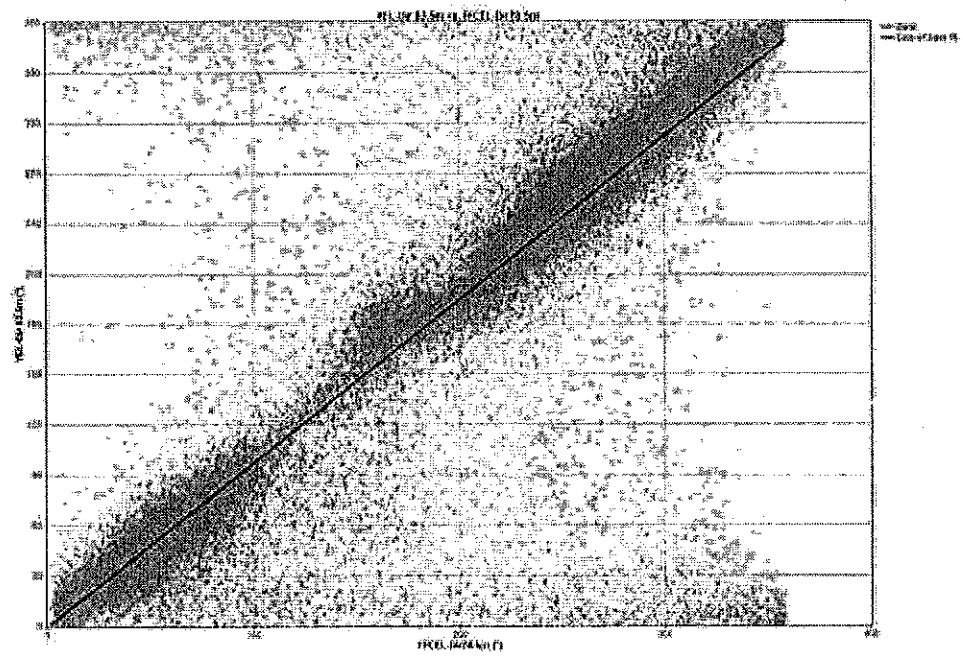


Figure 3-45: Correlation of Wind Direction between YEL & FFCEL Masts

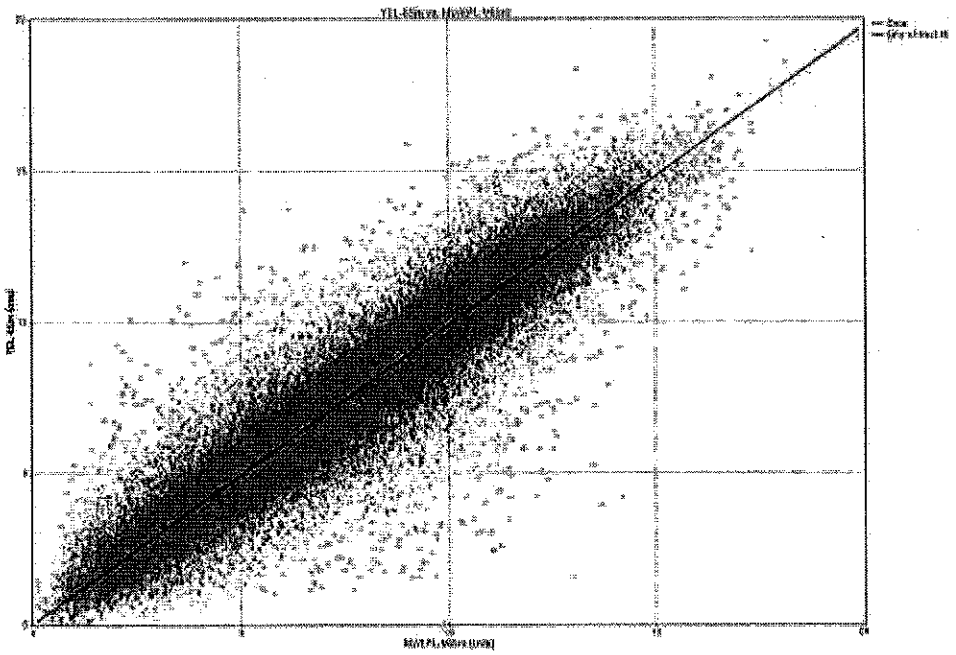


Figure 3-46: Correlation of Wind Speed between YEL & MWEPL Masts

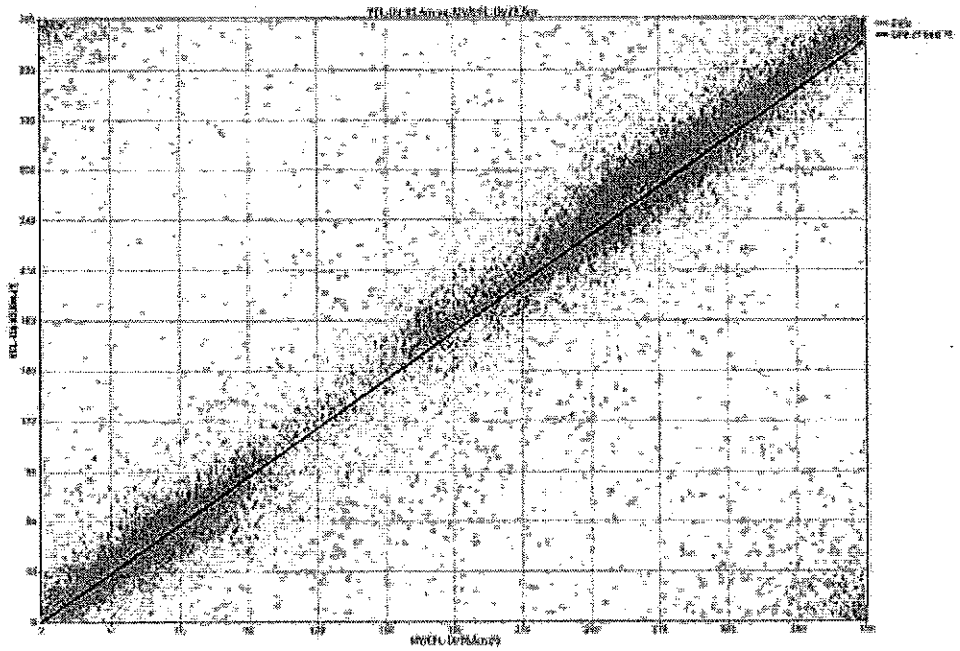


Figure 3-47: Correlation of Wind Direction between YEL & MWEPL Masts

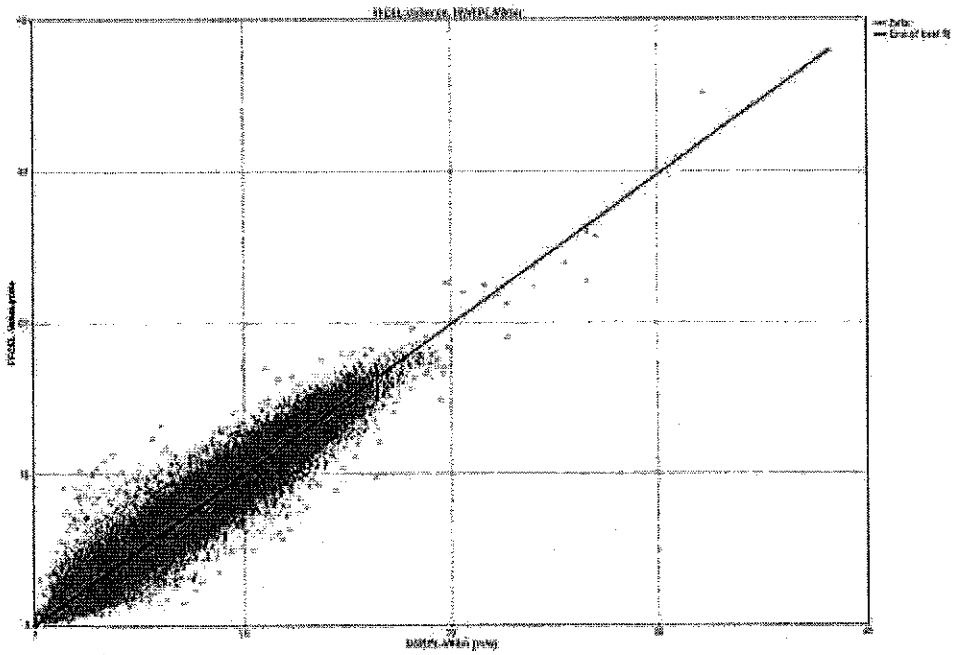


Figure 3-48: Correlation of Wind Speed between FFCEL & MWEPL Masts

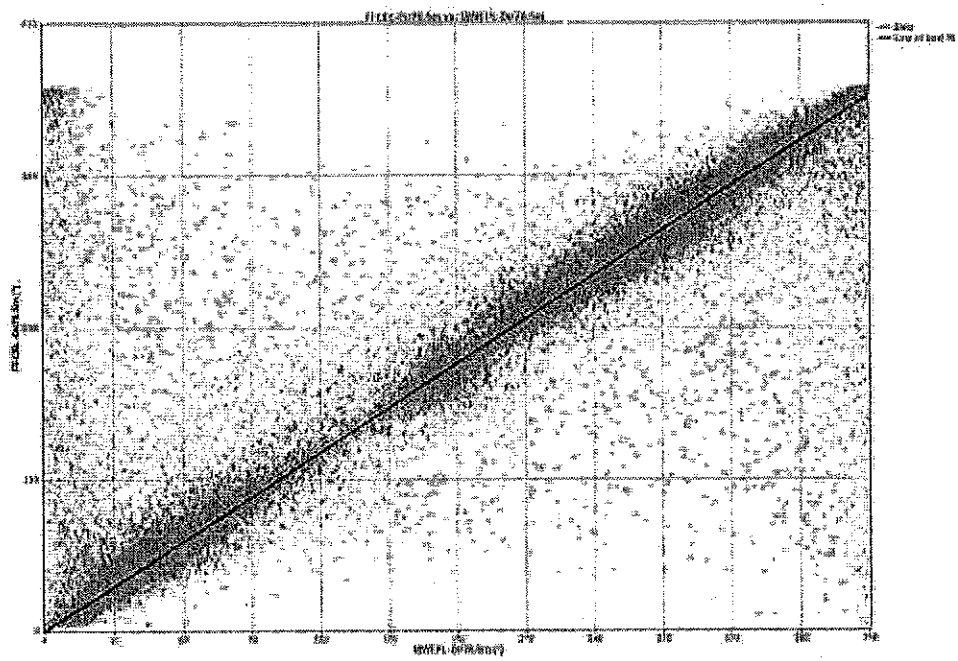


Figure 3-49: Correlation of Wind Direction between FFCEL & MWEPL Masts

3.7 FINDINGS & CONCLUSION

Based on the results from the analysis of wind data of neighboring wind measuring masts the following findings are made:

- The long-term mean wind speed at the locations of the neighboring masts are predicted to be:

Mast	Mean Wind Speed [m/s]
FFC Energy Limited	7.568 (80m)
Yunus Energy Limited	7.486 (85m)
Master Wind Energy Pvt. Limited	7.766 (80m)

- The predominant wind direction and frequency distribution observed at the neighboring masts are closely related.

- The neighboring meteorological masts represent the candidate wind farm site due to the flat terrain with almost same orography. Thus, the measurements can be useable in WAsP analysis for calculation of energy yield at candidate wind farm site.

- The correlation of the sensors installed at meteorological masts is summarized below.

S.No.	Correlation between Sensors	Regression Coefficient (r^2)
1.	FFC Energy Limited (V80a & V80b)	0.9881
2.	Yunus Energy Limited (V85a & V85b)	0.9996
3.	Master Wind Energy Pvt. Limited (V80a & V80b)	0.9973

Based on the findings, the wind measuring mast of Yunus Energy Limited has been selected for the annual energy yield calculation at 50 MW wind farm site of Sinowell in Jhampir. The Yunus Energy mast has been selected for the study due to the following reasons:

- Installation arrangements of the mast are of IEC compliance.
- Measnet Calibrated Anemometers
- Long term data
- Good data coverage for all the instruments during the measurement period
- Time series is good enough to generate a bankable wind resource assessment report.
- Computed regression coefficient for anemometers installed at Yunus Energy mast with legends V85-a and V85-b is very good (r^2 = 0.9996) & correlation with neighboring masts is also very good.
- Site conditions of project site are similar to that of Yunus Energy mast site.
- In close proximity of the project site than the other wind measuring masts.

4 LAYOUT DESIGN FOR 50MW PROJECT

4.1 LAYOUT OF WIND FARM

The wind turbine generator (WTG) of CSIC H111L-2.0MW has been used for the calculation of energy yield at the wind farm site of Sinowell. The Layout has been made using the 25 WTG of H111L-2.0MW. The maximum wind farm rated capacity is 50 MW. The micrositing of the wind farm has been done in a way so as to have the minimum wake losses and maximum power production numbers. The layout was developed based on the following criteria:

- Maximum installed capacity of 50MW
- Given boundaries of the wind farm area
- Prevailing wind direction
- Suitable spacing between WTGs
- Height restriction imposed by AHQ
- Consideration of orographical structure

Further following assumptions were made:

- **Option1:** Assuming the Sinowell wind farm will be the only one wind farm in Jhampir area (this was only made to find out the array losses and will not be described in detail). The layout made using option1 are shown in figure 4-1 below:

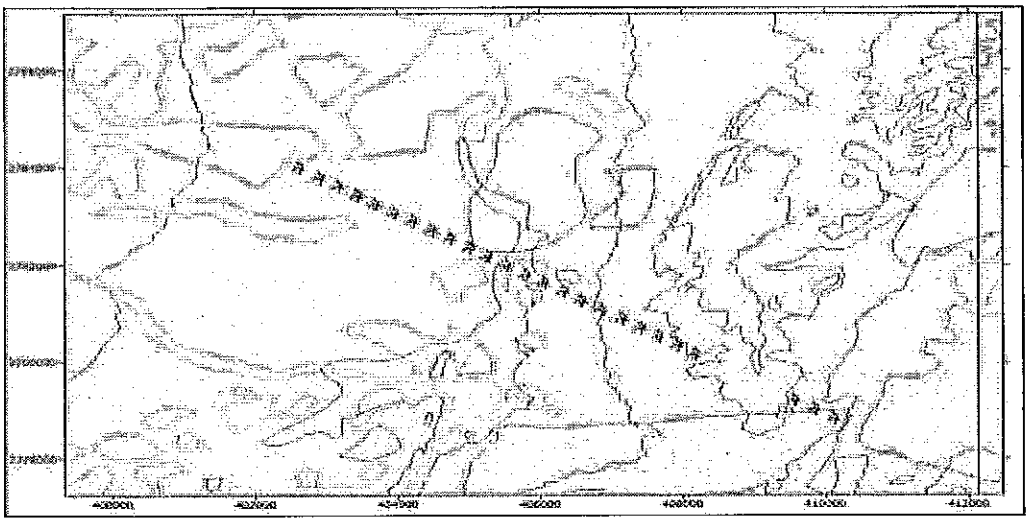


Figure 4-1: Sinowell Wind farm layout without considering neighbouring wind farms

- **Option2:** Assuming the Sinowell wind farm will be placed together with all other potential neighboring wind farms planned/ developed in the same vicinity. The detailed results are shown in the following section of this feasibility study. Since this option has the most influence to the wake losses, it was used for all further calculations. The layout made using option2 is shown in figure 4-2 below:

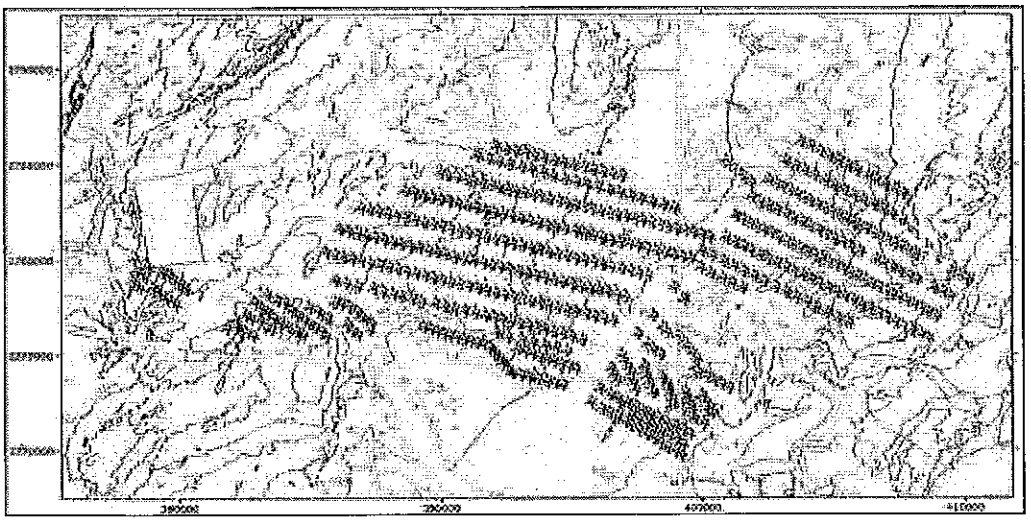


Figure 4-2: Sinowell wind farm layout with several other neighbouring wind farms

4.2 WIND RESOURCE ASSESSMENT

The wind resource map is generated using the wind data available at the wind measuring mast of Yunus Energy. The wind resource map developed using the wind data available at the wind measuring mast of Yunus Energy is given below.

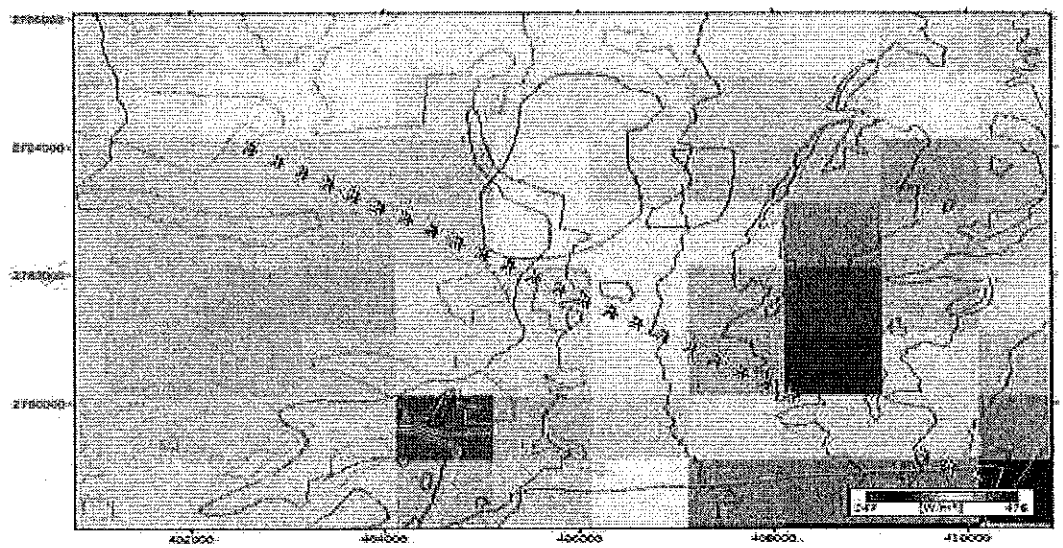


Figure 4-3: Wind Resource Map at 80m hub height using Yunus Energy Mast Data

4.3 WIND TURBINE LOCATIONS

The turbine coordinates for layout made using 25 WTGs of H111L-2.0MW are shown in table 4-1 below:

Table 4-1: Turbine Coordinates

	UTM WGS84 (Zone 42)	
WTG ID	X-Location [m]	Y-Location [m]
WTG1	402631.7	2783890
WTG2	402916.5	2783694
WTG3	403179.9	2783512
WTG4	403443.3	2783331
WTG5	403706.8	2783149
WTG6	403970.2	2782967
WTG7	404233.6	2782786
WTG8	404497	2782604
WTG9	404760.4	2782422
WTG10	405023.8	2782240
WTG11	405287.3	2782059
WTG12	405550.7	2781877
WTG13	405814.1	2781695
WTG14	406077.5	2781514
WTG15	406336.8	2781335
WTG16	406596.1	2781156
WTG17	406874	2780964
WTG18	407162.2	2780766
WTG19	407421.4	2780587
WTG20	407680.8	2780408
WTG21	407940.1	2780229
WTG22	408199.3	2780050
WTG23	409587.2	2779093
WTG24	409860.2	2778905
WTG25	410133	2778716

5 ANNUAL ENERGY YIELD CALCULATIONS

5.1 INTRODUCTION

The annual energy yield at the wind farm site of Sinowell has been calculated using long term time series recorded at the wind measuring mast of YEL. The YEL mast has been selected for the calculation of annual energy yield at the wind farm site of Sinowell due to the following reasons:

- Installation arrangements of the mast are of IEC compliance
- Measnet Calibrated Anemometers
- Long term data
- Good data coverage for all the instruments during the measurement period
- Time series is good enough to generate a bankable wind resource assessment report
- Computed regression coefficient for anemometers installed at YEL mast with legends V85-a and V85-b is very good ($r^2 = 0.9996$) & correlation with other neighboring masts is also very good.
- Site conditions of project site are similar to that of YEL mast site.
- In close proximity of the project site than the other neighboring wind measuring masts.

5.2 WIND FARM LAYOUT

The layout was designed considering the land boundary, prevailing wind direction, suitable spacing between WTGs, orography of the area and the height limitation imposed by AHQ in the region. It should be noted that numerous wind farms are under development in the vicinity of the Sinowell wind farm site. These wind farms have the major influence to the wake losses. The wake effects of all these under construction/ developed wind farms in the vicinity of the Project Site have been taken into account while performing the energy yield calculations.

5.3 ANNUAL ENERGY PREDICTION

5.3.1 WASP WIND FLOW MODEL

The wind rose, developed using the wind data of YEL mast, was introduced into the WAsP model, together with the topographic and roughness map for the area. Free stream wind speeds were then

predicted for each WTG location. The WAsP wind flow model was then used to calculate the topographic, roughness and obstacles effects across the Sinowell wind farm site.

5.3.2 ENERGY YIELD PREDICTION

The results derived were then modified by the application of a series of calculated and nominal effects and losses, in order to produce a final energy yield for the site.

5.3.3 WTG SPACING

The orientation of the wind farm area is a single strip and the same has been observed for the neighbouring wind farms of Western Energy and Hawa Energy. The upwind WTG spacing between Sinowell and Western Energy is observed to be 1800 meters (> 16 rotor diameter). Whereas, the downwind WTG spacing between Sinowell and Hawa Energy is observed to be 1150 meters (> 10 rotor diameter). The minimum crosswind WTG spacing is finalized as 315 meters (~ 3 rotor diameter). It is generally recommended that onshore turbine layouts have a minimum separation of 6 rotor diameters in the prevailing wind direction and 3 rotor diameters in the cross-wind direction. Closer spacing may increase wake-induced turbulence and may be of concern to WTG manufacturers. Moreover, the strong prevailing wind direction at this site reduces the impact of close crosswind spacing.

5.4 ANNUAL ENERGY PRODUCTION USING THE TIME SERIES OF YUNUS ENERGY MAST

The annual energy production for 50MW wind farm, using long term time series developed at YEL Mast, on the proposed wind turbine generator has been estimated using WAsP. The summary of annual energy yield calculated taking into account the other/ neighboring wind farms is shown below in Table 5-1. The details of the estimated annual energy production of the whole wind farm and individual wind turbines are given in section 5.4.1.

Table 5-1: Summary of Estimated Annual Energy Production

Sinowell Wind Farm	Wind Turbine Generator
	CSIC H111L-2.0MW
Turbine Capacity (kW)	2000
Number of WTG	25
Installed Wind Farm Capacity (MW)	50
Hub Height (meters)	80
Rotor Diameter (m)	111
Gross Electrical Output of Wind Farm (GWh)	227.465
Wake Losses (GWh)	26.025
Net Electrical Output of Wind Farm (GWh)	201.440
Power Curve density correction Losses (3.5%) - (GWh)	7.050
Availability (95%) - (GWh)	9.719
Power Curve Losses (2%) - (GWh)	3.693
Blade Degradation (0.5%) - (GWh)	0.905
Temperature Losses (2%) – (GWh)	3.601
Electrical Losses (3%) - (GWh)	5.294
Scheduled maintenance/ Miscellaneous (1.0 %) - (GWh)	1.712
P50 Wind Farm Yield (GWh/annum)	169.465
P50 Capacity Factor (%age)	38.691

5.4.1 INDIVIDUAL WTG WASP OUTPUTS

The details of estimated annual energy production (AEP) of the whole wind farm and individual wind turbines, considering the other / neighbouring wind farms in the region are shown in Table 5-2 & 5-3 respectively.

Table 5-2: Summary of Estimated Annual Energy Production

Parameters	Total	Average	Minimum	Maximum
Net AEP [GWh]	201.440	8.0576	7.474	8.409
Gross AEP [GWh]	227.465	9.0986	8.301	9.317
Wake Loss [%]	-	11.426	-	-

Table 5-3: Site Results of Sinowell wind farm

Site ID	Site x [m]	Site y [m]	Turbine	Elevation [m]	Height [m]	Net AEP [GWh]	Wake Loss
WTG1	402631.7	2783890	H111L-2.0MW	54	80	8.293	9.78
WTG2	402916.5	2783694	H111L-2.0MW	49	80	8.256	10.39
WTG3	403179.9	2783512	H111L-2.0MW	55	80	8.188	11.1
WTG4	403443.3	2783331	H111L-2.0MW	50	80	8.184	11.24
WTG5	403706.8	2783149	H111L-2.0MW	49	80	8.156	11.73
WTG6	403970.2	2782967	H111L-2.0MW	47	80	8.146	11.95
WTG7	404233.6	2782786	H111L-2.0MW	44	80	8.11	12.24
WTG8	404497	2782604	H111L-2.0MW	47	80	8.025	12.65
WTG9	404760.4	2782422	H111L-2.0MW	45	80	7.897	13.13
WTG10	405023.8	2782240	H111L-2.0MW	46	80	7.845	13.28
WTG11	405287.3	2782059	H111L-2.0MW	46	80	7.907	13.09
WTG12	405550.7	2781877	H111L-2.0MW	45	80	7.972	12.93
WTG13	405814.1	2781695	H111L-2.0MW	44	80	7.964	13.22
WTG14	406077.5	2781514	H111L-2.0MW	46	80	7.947	13.21
WTG15	406336.8	2781335	H111L-2.0MW	50	80	7.949	13.07
WTG16	406596.1	2781156	H111L-2.0MW	53	80	7.925	12.96
WTG17	406874	2780964	H111L-2.0MW	55	80	7.905	12.52
WTG18	407162.2	2780766	H111L-2.0MW	56	80	8.126	11.15
WTG19	407421.4	2780587	H111L-2.0MW	57	80	8.291	10.02
WTG20	407680.8	2780408	H111L-2.0MW	63	80	8.365	9.82
WTG21	407940.1	2780229	H111L-2.0MW	64	80	8.408	9.76
WTG22	408199.3	2780050	H111L-2.0MW	71	80	8.409	9.58
WTG23	409587.2	2779093	H111L-2.0MW	67	80	8.015	7.56
WTG24	409860.2	2778905	H111L-2.0MW	60	80	7.683	9.31
WTG25	410133	2778716	H111L-2.0MW	57	80	7.474	9.96

5.5 UNCERTAINTY ANALYSIS

The production estimates made on p50 exceedance level are the best estimates of the long term mean value to be expected from the project. There is therefore a 50% chance that, even when taken over very long periods, the mean energy production will be less than the values given. The uncertainties associated with the wind speed measurement accuracy, long term wind speed predictions, wind flow model, array loss modeling, instruments, topography, simulation software have been estimated. Annual Energy production of the wind farm is calculated at different probability level. Four sources of uncertainties are included in this analysis out of six sources of uncertainty considered for the analysis:

- The wind data are assumed to represent long term statistics. The uncertainty of that assumption – the inter annual variability on the wind speed – is estimated to be 7%.
- The wind flow model may have random uncertainty which is for the wind speed set to 10%. It is to be noted that the flatness of the area constitute near ideal condition for the software.
- Uncertainty owing to the difference between the RIX numbers of the site of prediction and the reference mast. The difference is negligible and not considered.
- Landscape and forest complexity not taken into account, this term is considered negligible.
- Set-up of the instruments is found to be on IEC standards; however we are taking here 2% uncertainty in the installation arrangement.
- The instrument was calibrated prior to the installation only and since then the anemometers are not calibrated. Lack of annual calibration of the instruments at the mast is considered to contribute with an uncertainty of 5% on the wind speed. It should be noted that the calibration error is not necessarily constant over time and is here considered as a random error

Each of the four uncertainty estimates mentioned above represents the variability of the parameter. It is important to stress that the parameter can be bigger as well as smaller, and that it statistically is bigger as often as it is smaller.

These uncertainty estimates are combined into a single uncertainty by use of the formula for independent stochastic processes:

$$\left(\frac{\Delta E}{E}\right)^2_{total} = \left(\frac{\Delta E}{E}\right)^2_{Wind\,Variability} + \left(\frac{\Delta E}{E}\right)^2_{model} + \left(\frac{\Delta E}{E}\right)^2_{instrument} + \left(\frac{\Delta E}{E}\right)^2_{calibration}$$

where

$$\left(\frac{\Delta E}{E}\right) \cong 2\left(\frac{\Delta u}{u}\right)$$

$$\left(\frac{\Delta u}{u}\right)^2_{total} = 2*\left(\frac{\Delta u}{u}\right)^2_{WindVariability} + \left(\frac{\Delta u}{u}\right)^2_{WAsP} + 2*\left(\frac{\Delta u}{u}\right)^2_{Instrument\,setup} + 2*\left(\frac{\Delta u}{u}\right)^2_{Calibration}$$

$$\left(\frac{\Delta u}{u}\right)^2_{total} = (2*0.07)^2 + (0.1)^2 + (2*0.02)^2 + (2*0.05)^2$$

These uncertainty estimates are combined into a single uncertainty and results in an overall uncertainty of 20.3% for YEL. Probability exceedance levels for the production estimates are found by Gaussian distribution. The results obtained for different confidence levels are summarized in Tables given below:

Table 5-4: Energy Production Estimates for proposed 50 MW Wind Farm using Yunus Energy Mast

WTG Type	H111L-2.0 MW
P50 Wind Farm Yield (GWh/annum)	169.465
P50 Capacity Factor (%age)	38.691
P70 Wind Farm Yield (GWh/annum)	151.58
P70 Capacity Factor (%age)	34.606
P80 Wind Farm Yield (GWh/annum)	140.57
P80 Capacity Factor (%age)	32.093
P90 Wind Farm Yield (GWh/annum)	125.43
P90 Capacity Factor (%age)	28.637

Annexure B – IEE Approval Letter from SEPA

Reference No: EPA/ 2016/12/16/IEE/103

ENVIRONMENTAL PROTECTION AGENCY
GOVERNMENT OF SINDH

Plot # ST-2/1, Sector 23, KIA, Karachi-74900
Ph: 5065950, 5065598, 5065637
5065532, 5065946, 5065621
epasindh@cyber.net.pk
Facsimile: 5065940

Dated: 03rd January, 2016

SUBJECT: DECISION ON INITIAL ENVIRONMENTAL EXAMINATION (IEE)

1.	**Name & Address of Proponent:**	Mr. Mustafa Lakdawala Director SINO WELL (Pvt.) Ltd F-25, Block-5, Kehkahan, Clifton, Karachi
2.	**Description of Project:**	Establishment of 50 MW SINO WELL (Pvt) Limited
3.	**Location of Project:**	Project site is located in Jhimpir about 80 km Northeast of Karachi and 55km Northeast of PQ.
4.	**Date of Filing of IEE:**	15-12-2016

5. After careful review and analysis of the Initial Environmental Examination (IEE) report, Sindh Environmental Protection Agency (SEPA) accords its approval subject to the following conditions:
   i) All mitigation measures recommended in IEE report should be complied with, for achieving negligible impacts on physical, biological, environmental and socio-economic resources of the area. Sindh Environmental Quality Standards (SEQS) shall be followed in letter and spirit.
   ii) A complete code of Health, Safety and Environment (HSE) shall be developed which should include efficient parameters at specific work place. For this purpose HSE setup should be established and supervised by a designated HSE officer at the senior level with sufficient administrative and technical authority to perform the designated functions. Proponent will make sure that the operating instructions and emergency actions are made available to every worker/labor at the site.
   iii) The proponent shall also appoint a reputable research institute or organization to conduct a detailed *cumulative* noise mapping/modeling study of the wind projects in the macroenvironment of project area and its impact on the **sensitive receptors**, if any. The report must be submitted to SEPA within 04 weeks from the date of issuance of this approval.
   iv) The proponent shall be under obligation to compensate for any significant adverse short term, long term and irreversible impact occurred due to windfarm operations.

During the project execution, safe distances of the under mentioned environmental sensitivities will be maintained:

- 500m from communities, industries and main transport network
- 300m from community water well
- 500m from archaeological / cultural site / monument
- Distance will be measured from the tip blade of turbines or / and transmission power lines associated.
- Project activity will not be carried out within buffer zone of any projected area designated under Sindh wildlife protection act.

v) Employment should be provided to local people and assured for unskilled jobs. Skilled jobs shall be given to locals after providing them proper field training, where a minimum training is required. Local people should be informed and explained well in advance about the operation. Compensation should be provided to inhabitants in case of loss of agriculture land, crop property, etc., in accordance with the rates, that are agreed upon. All conflicting issues regarding compensation etc. should be settled in advance prior to the start of activity. Benefits to local people will be offered under Corporate Social Responsibility (CSR) policy, community development schemes will be decided in consultation with local communities and may be facilitated by involving district / local Government office.

vi) Local people should be provided with community welfare schemes i.e., draught relief programmes, educational programmes, and establishment of health units, veterinary/live stock care unit etc., which should benefit them and develop mutual trust. Sustainability of these facilities should be ensured.

vii) Campsites will be located at least one kilometer away from any settlement to avoid disturbance to the local people.

viii) No industrial or residential activity will be permitted on the land allocated for wind energy projects.

ix) The project area will be restored to its original nature to the possible extent. For the purpose, documentation (Photographs) will be kept in record.

x) The project shall be constructed in the prescribed time strictly as per schedule, which shall be submitted to this office at the start of construction activity.

xi) Compensation will be provided to the inhabitants in case of loss of agriculture land, crop property, etc., in accordance with the rates, that are agreed upon.

xii) The proponent shall ensure facilitation to the EPA officer(s)/official(s) for the regular inspections to verify the compliance of the PEP Act, Rules and Regulations framed there under and the conditions contained in this approval.

xiii) The proponent shall appoint an Independent Monitoring Consultant (IMC) whose responsibility shall be to monitor the project activities. The IMC shall ensure that the activities at project site are undertaken in environment friendly manner and the

mitigation measures are implemented as per the recommendations of IEE. The report shall include pollutants measurement and analysis reports along with photographic records showing therein the environmental conditions at site during the construction and operation stages of project. The proponent shall be liable to submit monthly environmental monitoring reports to Sindh EPA.

6. This approval shall be treated cancelled if any of the conditions, mentioned in para-5 above is violated. In follow up of the cancellation of this approval prosecution under the provision of Sindh Environmental Protection Act, 2014 will be initiated against the proponent.
7. This approval does not absolve the proponent of the duty to obtain any other approval or consent that may be required under any other law in force.
8. The IEE report is meant only for proposed activities described in IEE only. Proponent should submit separate approval required under regulations, along with site specific Environment Management Plan for any consequent and subsequent activity for approval of Sindh EPA.

Muhammad Imran Sabir
Deputy Director (Technical-II)
For Director General

Annexure C – Grid Interconnection Study, NTDC Approval & Power Evacuation Certificate

NATIONAL TRANSMISSION & DESPATCH COMPANY

General Manager Power System Planning, NTDC

No.GMPP/CEMP/TRP-380/ 3220 Dated: 07-06-2017

CERTIFICATE

Subject: Approval of System Studies of 50 MW Sino Well (WPP) at Jhimpir, District Thatta, Sindh by M/s Sino Well Private Limited

NTDC hereby accords its approval in respect of System Studies submitted by M/s Sino Well Private Limited in respect of 50 MW Wind Power Project (WPP) at Jhimpir, District Thatta, Sindh. NTDC further certifies that the power to be generated by 50 MW Wind Power Project by M/s Sino Well Private Limited will be evacuated provided the study assumptions and results given in the approved grid interconnection study report of the subject project prevail. Also, the power injected through the above mentioned project will not have any adverse effect on the National Grid as required under the prevailing Grid Code.

Signature: _____

Name: Imtiaz Ahmad Shad

Designation: Chief Engineer (Resource Planning)

4th Floor, PIA Tower, Egerton Road, Lahore. | TEL:+92-42 99202613, Fax: +92 42 36307738|gmpp@ntdc.com.pk

NATIONAL TRANSMISSION & DESPATCH CO. LTD (NTDC)

General Manager Power System Planning, NTDC

No.GMPP/CEMP/TRP-380/3127-31

Dated: 01-06-2017

Chief Executive Officer CPPA(G) Ltd.
Shaheed-e-Millat Secretariat,
6th Floor, Jinnah Avenue, Blue Area,
Islamabad.
Fax#:051-9213616

Sub: Approval of Electrical Grid Study Report for 50 MW Sino Well (WPP) at Jhimpir, District Thatta, Sindh by M/s Sino Well Private Limited

Ref: CPPA-G letter No. CPPA(G)L/CEO/DGMT-II/MT-V/SWWPL/20780-81 dated 20-04-2017.

This office has received the final grid interconnection study report of the subject WPP vide above referred letter. After review of the report, it was found that some corrections in the studies were needed which were communicated to M/s PPI and M/s PPI submitted the required corrections on 30-05-2017. Therefore, the grid interconnection study report of Sino Well WPP is approved at NTDC end as per assumptions and study results presented in the report.

It is intimated that the Grid Code Addendum for Wind Power Projects is being updated at present and after its approval from NEPRA, the developers of the subject wind power project will be required to follow/implement the requirements/recommendations as given in the Grid Code Addendum for Wind Power Projects. It is added that during EPA, if there is any major change in the parameters of the subject WPP as used in the subject grid interconnection study, then relevant studies will have to be revised.

It is also important to intimate that the subject report has been approved only for power evacuation/ interconnectivity aspects of the subject WPP. Moreover, there may be some modification in the interconnection arrangement of the subject WPP depending on variation in its COD as well as other power plants in the area. Any commitment regarding project execution or for any other purpose should be discussed with CPPA(G) Ltd. and relevant departments of NTDC/HESCO. Moreover, the comments of HESCO on the subject report may also be obtained.

(Imtiaz Ahmad Shad)
Chief Engineer (Resource Planning)

cc:

- Chief Executive Officer, HESCO.
- General Manager (Services Division) NTDC.
- M/s Sino Well Pvt Limited, F-25, Block-5, Rojhan Street Kehkashan, Clifton, Karachi.
- M/s PPI, 64-F/1 Wapda Town, Lahore.
- *Master File (MP)*

Report No. PPI-216.2-Final-Sinowell-2/17

ELECTRICAL GRID STUDIES

For

50 MW Wind Power Plant by Sinowell (Pvt.) Limited, Jhimpir, Sindh

Final Report
(April 2017)

Power Planners International

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Executive Summary

- The study objective, approach and methodology have been described and the plant's data received from the client Sinowell (Pvt.) limited has been validated.
- The wind project by Sinowell (Pvt.) limited, referred to as Sinowell WPP in the remainder of the report, is expected to start commercial operation by summer 2019. Therefore, the scenario of August/September 2019 has been selected to carry out the study as it will help determine the maximum impact of the project.
- The latest generation, transmission plan and load forecast provided by NTDC has been used for the study, attached in Appendix – 2, vide data permission letter no. GMPP/CEMP/TRP-380/5240-45 dated 06-12-2016.
- Recently a study of 10 WPPs was carried out by NTDCL planning department to fill the power capacity vacated by NBT Wind Power Pakistan II & III. A new 220kV grid station with the name of Jhimpir-2 was proposed which was connected by loop in-loop out configuration of Jamshoro – KDA 220kV single circuit and Jhimpir-1 – Gharo 220kV single circuit. This study is carried out for 15 new WPPs in integration with the already planned WPPs and other upcoming WPPs in its vicinity.
- Out of these 15 WPPs, 9 plants which lie in the southern part of Jhimpir namely Indus, Lakeside, DHA City, Noor, Metro-2, Iran Pak, Nasda, Uni-energy and Shafi Energy WPPs, are proposed to be connected to the newly proposed Jhimpir-2 220/132kV Grid station. Since the site of Jhimpir-2 220/132kV grid station has recently been finalized hence a site visit was carried out on 25th January 2017 along with NTDC official to verify the distances of the upcoming 220kV circuits emanating from this grid station. Moreover sites of the above mentioned 9 WPPs were also visited to develop technically correct as well as least cost scheme for evacuation of power from these WPPs. Based on the location of the WPPs, two loops (each having 8 WPPs) were proposed at Jhimpir-2 grid station. The configuration of the new loops is shown in Appendix-4 and the list of WPPs in each loop is provided below:

First Loop: Lakeside, Nasda, Trans-Atlantic, Uni-Energy, Iran Pak, Artistic, Act-2 and Cacho WPPs

Second Loop: Indus, Gul Ahmed, Metro-2, Zulaikha, Din Energy, Noor, Shafi Energy and DHA-City WPPs

- Sites of 3 plants out of these 15 WPPs which lie in the northern part of Jhimpir namely Sinowell, Sinowell and Tricom WPPs were also visited and they are proposed to be connected via loop in-loop out of upcoming Jhimpir-1 - T.M Khan 132kV single circuit. Similarly Burj WPP is proposed to be connected via loop in-loop out of Thatta – FWEL-I 132kV S/C and Master Green WPP which is located in Jamshoro district is proposed to be connected by loop in-loop out configuration of the newly proposed Nooriabad - Jamshoro old 132kV single circuit. Lastly, Sinowell Energy WPP is proposed to be connected via loop in-loop out of upcoming T.M.Khan – Tricom 132kV S/C
- Sinowell WPP which is the plant under study, has been placed in the loop at 220/132kV Jhimpir-1 grid station. Sinowell Wind Power Plant would be connected by a double circuit of 132 kV by looping in-out configuration of the one circuit of Jhimpir-1 – T.M.Khan along with Tricom WPP and Norinco-2 WPP. It should be noted that the length of circuits used for the simulations are confirmed from site visit and agreed with NTDC official. They may change slightly during the implementation of the project. In addition, the connectivity of Sinowell WPP with neighboring wind power plants may change, depending upon the COD of the project.
- The scheme of interconnection of these 15 new WPPs including Sinowell WPP proposes the following reinforcements in place at Jhimpir cluster.
  - 220 kV D/C transmission line approx. 5km long on twin bundled Greeley conductor looping In/out of second circuit of existing Jamshoro – KDA-33 D/C transmission line at the proposed Jhimpir-2 220/132 kV substation
  - Addition of 4th 220/132 kV transformer at the newly proposed Jhimpir-2 220/132 kV substation.

- 132kV double circuit transmission line approx. 135 km long on twin bundled Greeley conductor for connecting 8 WPPs in the first loop to Jhimpir-2 220/132 newly proposed substation.
- 132kV double circuit transmission line approx. 168 km long on twin bundled Greeley conductor for connecting 8 WPPs in the second loop to Jhimpir-2 220/132 newly proposed substation.
- In this Integrated study, the interconnection of Sinowell WPP includes 132 kV D/C transmission line approx. 5.5 km long, on Greeley conductor for looping in/out on the 132kV single circuit from T.M.Khan to TRICOM WPP grid station.

➢ The existing grid system of HESCO and NTDC in the vicinity of Sinowell WPP has been studied in detail by performing load flow, short circuit and dynamic analysis for the conditions prior to commissioning of Sinowell WPP and no bottlenecks or constraints have been found in the grid system.

➢ Wind Farm of Sino Well has been modeled considering Type-3 WTGs. They are Doubly Fed Induction Generators which are designated as Type-3 WTG. The terminal voltage is 0.7 kV. The medium voltage level of wind farm has been selected as 35 kV for unit step-up transformers, for collector circuits and step-up from MV to HV (132 kV) at Farm substation to connect to the Jhimpir-1 220/132 kV grid station of NTDC.

➢ The design of scheme of 132/35 kV substation of Sinowell Wind Farm has been provided by the Client and is attached in Appendix – 2.

➢ Load flow analysis has been carried out for peak and Off Peak scenarios of August/September 2019 considering the COD targeted by Sinowell WPP and a future scenario of 2022, for the dispersal of power from Sinowell WPP into NTDC system using the latest load forecast, generation and transmission expansion plans of NTDC and HESCO. The above mentioned interconnection scheme has been evolved by performing the load flow studies testing the steady state performance for normal as well as N-1 contingency conditions fulfilling the Grid Code criteria of Wind Power Plants. The reactive power requirement at point of

common coupling to meet PF of ± 0.95, voltage and line loading criteria are fulfilled by these studies. All the scenarios have been studied by considering maximum dispatch from all the existing/planned WPPs in the Jhimpir and Gharo Clusters.

- For the base case of summer 2019, capacity constraint was observed in 500kV network emanating from Jamshoro and upwards in case of some critical outages of 500kV circuits. Due to this capacity constraint, partial curtailment in the output of all WPPs under study was proposed to bring the loading on the 500kV network within limit. Hence output of Sinowell WPP is curtailed to 7 MW in case of some contingency events. For the future scenario of 2022, this issue of capacity constraint is resolved due to the following major reinforcements:
    - 660kV HVDC from Matiari to Lahore
    - 660kV HVDC from Port Qasim to Faisalabad West
- With the proposed reinforcements highlighted earlier and the curtailment process for the base year of 2019 under special circumstances, the load flow results for peak and Off Peak scenarios establish that the proposed scheme of interconnection of Sinowell WPP shows no bottlenecks or capacity constraints in the adjoining 500 kV, 220 kV and 132 kV network in terms of absorbing all the output of Sinowell WPP and other proposed WPPs under normal as well as the contingency conditions.
- Maximum and minimum short circuit levels for three-phase faults and single-phase faults have been evaluated. The maximum SC levels have been evaluated for the year 2022 and minimum short circuit level for the year 2019 for the most stringent conditions. The fault levels of Sinowell 132 kV are 8.35 kA and 7.58 kA for 3-phase and single phase faults respectively for 2022. This is much less than the switchgear rating of 40 kA recommended for Sinowell Farm Substation as per NTDC requirements for 132 kV. The fault levels for Sinowell MV 35 kV are 15.01 kA and 16.37 kA for 3-phase and single-phase faults respectively for year 2022.

Therefore the short circuit rating for 35 kV switchgear is recommended as 25 kA. It has been found that the proposed scheme provides maximum SC strength for the evacuation of Sinowell WPP power to the grid.

The switchgear ratings for Sinowell WPP substation are as follows:

132 kV:

Short circuit rating = 40 kA (3 sec.)

Continuous rating = 2500 A

35 kV:

Short circuit rating = 25 kA (3 sec.)

Continuous rating = 2500 A

- Transient Stability analysis has been carried out for Sino Well WPP based on their selection of Type-3 WTGs, with connectivity of proposed scheme. Different disturbances have been simulated to apply stresses from the system faults on the wind farm and vice versa and it was found that Sino Well WTG unit's dynamic characteristics and the grid connectivity is strong enough to maintain stability under all disturbances. In turn, any disturbance from Sino Well WPP side did not cause any stress on the main grid or the power plants nearby and in the HESCO area such that the whole system remained stable under all events.
- The LVRT requirements have been tested to fulfill 100 ms (5 cycles) under normal clearing time and 180 ms (9 cycles) for contingency condition of delayed fault clearing due to stuck-breaker (breaker failure) reason. The simulations have proved that the proposed machine fulfills the LVRT criteria as required in the Grid Code for Wind IPPs.
- The issues of power quality like flicker, unbalance and harmonic resonance have been studied in detail. The results have indicated that the levels of flicker and unbalance are within the permissible limits of IEC and other International Standards.
- There are no technical constraints whatsoever in the way of bringing in the 50 MW of Sinowell Wind Power Plant at the proposed site and scheduled time of

commissioning, in any respect of steady state (load flow) or short circuit or dynamic performance (stability) or power quality issues related to this plant.

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1. Introduction

1.1 Background

There exists a huge wind corridor in coastal Sindh, starting from Gharo-Ketti Bandar up to Jhimpir and upward, that has been identified by AEDB with an actual potential of about 50,000 MW. There are many entrepreneurs coming forward to tap this huge natural resource of power.

Study of 10 WPPs was recently carried out by NTDCL Planning Department after cancellation of LOIs of NBT-II and NBT-III. New Jhimpir-2 220/132 kV substation was proposed to evacuate power from these WPPs. For further evacuation of power from Jhimpir area, an integrated study was required depicting optimal utilization of resources. Hence a study of 15 new WPPs was carried out in integration with the already planned / existing WPPs. Sinowell (Pvt) limited is amongst those entrepreneurs who have come forward with a Wind Power Plant within this cluster at Jhimpir.

The proposed wind farm shall have the installed capacity of about 50 MW of electricity. The project is being developed in the private sector and the electricity generated from this project would be supplied to power grid of NTDC. The services of Power Planners International have been engaged to perform the impact studies of penetration of this wind power in the national grid to evolve the most feasible interconnection scheme for this plant.

1.2 Objectives

The overall objectives of this study are:

1. Impact of Sinowell Wind Power Plant on the System
2. Impact of the System on Sinowell Wind Power Plant

These impacts are to be studied for different operating conditions of Plant as well as the System. The operating condition of the plant may vary from its 100 % output to 0 % i.e. no output at all. The system conditions would be peak load, off-

peak load for the spot year of study i.e. 2019. A future scenario of 2022 is also studied.

The impacts are required to be studied for steady state as well as the dynamic and disturbed conditions of the system. The specific objectives are:

1. To develop a feasible scheme of interconnections of Sinowell Wind Power Plant (WPP) with HESCO/NTDC network at 132 kV for which right of way (ROW) and space at the terminal substations would be required to be made available.
2. To check the load-ability of lines and transformers to be within their rated limits satisfying the clauses OC 4.8, OC 4.9, and OC 4.10 of NEPRA Grid Code regarding the criteria of operation of frequency, voltage and stability under normal and contingency conditions for peak and off-peak load conditions of grid as well as the plant.
3. To check the voltage profile of the bus bars of the neighboring interconnected network under different operating conditions
4. To check the reactive power limitations of the wind turbines and the neighboring generators of the system; and evaluate the size of switched shunt capacitor banks at Medium Voltage level of substation of collector system of Sinowell Wind Farm to regulate the voltage under steady state and contingency conditions to fulfill the Grid Code criteria of ± 0.95 Power Factor at the point of common coupling (interface point) interconnecting Wind Farm and the Grid i.e. 132 kV gantries of outgoing circuits.
5. To check if the contribution of fault current from this new plant increases the fault levels at the adjoining substations at 220 kV and 132 kV voltage levels to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the Medium Voltage substation of collector system of Sinowell Wind Farm and the NTDC/HESCO substations of 132 kV connecting with the Sinowell Wind Farm.

6. To check the minimum short circuit strength of the system to handle large variation of generation of wind turbine
7. To check if the interconnection with the grid withstands transient stability criteria of post fault recovery with good damping satisfying the NEPRA Grid Code.
8. Transient stability to see the dynamic performance of Sinowell WPP in response to Grid disturbances and vice versa the dynamic impact of disturbances in Sinowell WPP on the Grid.
9. To check the ability of the wind turbine generators of Sinowell WPP to remain connected following major disturbances and grid disruptions i.e. the Low Voltage Ride Through (LVRT) capability to satisfy the Grid Code requirement of LVRT for 180 ms.
10. Analysis of power quality issues such as flicker, voltage-unbalance, harmonics and resonance of the system.

1.3 Planning Criteria

The planning criteria required to be fulfilled by the proposed interconnection as enunciated in NEPRA Grid Code including Addendum No.1 for WPPs are as follows:

Voltage	± 5 %, Normal Operating Condition
	± 10 %, Contingency Conditions
Frequency	50 Hz, Continuous, ± 1% variation steady state
	49.4 - 50.5 Hz, Under Contingency

Short Circuit:

132 kV Substation Equipment Rating 40kA

Dynamic/Transient and Low Voltage Ride through (LVRT):

The WTGs should remain connected during voltage dip upto 30 % level, under fault conditions by ride through capability for the following sequence of disturbance

1. Total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker

interruption time to isolate the faulted element, is equal to 100 ms (5 cycles) for the systems of 132 kV and above.

2. In case of failure of primary protection (stuck breaker case), the total fault clearing time from the instant of initiation of fault current to the complete interruption of current to isolate the faulted element, including the primary protection plus the backup protection to operate and isolate the fault, is equal to 180 ms (9 cycles) for 132 kV and higher voltage levels.

3. LVRT of 100 ms for normal fault clearing and 180 ms for the case of failure of primary protection (stuck breaker case).

Reactive Power and Power factor:

Reactive Power Control to maintain the power factor within the range of 0.95 lagging to 0.95 leading, over full range of plant operation, according to Dispatch Instructions/manual voltage adjustment requirements.

Power Quality Requirements:

As per IEC61400-21standards

1.4 Operating Criteria

The operating requirements to be fulfilled by the proposed Sinowell WPP as enunciated in NEPRA Grid Code for WPPs (Addendum No.1) are as follows:

Black Start and Islanded Operation:

Exempted

Active Power and Frequency Control:

Exempted from precise frequency control responsibility

Synchronization / De-Synchronization:

(i) The Wind Power Plant will manage for

  (a) Smooth Synchronization

  (b) Smooth De-Synchronization

(ii) The above operations, achieved through appropriate equipment, will be without jerk(s), felt on the grid system

Power Generation Capability Forecasting Requirement:

(i) Power Generation Capability Forecasting, of average power on hourly basis, will be managed by the Wind Power Plant as required from conventional power plants, except provisions of clause (ii) & (iii) below.

(ii) The forecasting, as required in (i), will be estimated by Wind Power Plant through

  (a) Expected availability of plant during the period of forecast.

  (b) Predicted value of wind speed at site based upon analysis of historic wind data available.

(iii) The forecasting, as required in (i), will be on the basis of total Wind Power Plant and break-up for each WTG will not be required.

(iv) The forecasted values will not be a binding upon the wind power plant as actual wind speeds may differ significantly from predicted values over short durations.

1.5 Input Data

The input data of HESCO / NTDC has been used in this study as per letter no. GMPP/CEMP/TRP-380/5240-45 dated 06-12-2016. The load forecast and the generation expansion plan of NTDC provided vide this letter has been used as shown in Appendix 2.

The input data regarding Sino Well Wind Farm has been provided by the client who has indicated to use 2 MW CSIC-(Chongqing) Haizhuang Windpower Equipment Co., Ltd. Type-3 WTG. The main parameters of the WTGs have been attached in Appendix-2.

2. Description of Problem & Study Approach

2.1 Description of the Problem

In Pakistan, there is big wind power generation potential in the Southern parts of Sindh province, which is untapped as yet. However now with the establishment of Alternative Energy Development Board, this sector of power generation has taken an unprecedented stride and many entrepreneurs have come forward to build small and big Wind farms in this area.

The peculiar nature of wind power turbine is such that its output fluctuates in terms of MW and MVAR, being dependent on the wind speed and its direction. So long as the capacity of wind farm is less significant compared to the size of the power grid it is connected, these fluctuations are absorbable without compromising the power quality. But as the penetration of wind power in the power grid increases, the capability of the power grid may not be as strong as may be required to absorb constant variations of MW, MVAR and hence rapid deviation in voltage and frequency from the system's normal operating set point.

The existing power plants nearest to the vast wind farm areas of Jhimpir in the existing power grid are Kotri and Jamshoro Power Plants. Next to them is Hub with 1200 MW and Lakhra with 150 MW installed capacities respectively. Apparently this amount of generation in Southern grid seems strong enough to absorb the penetration of wind power. But there are other variables that necessitate detailed studies like strengths of nodes of connectivity, loading capacity of the transmission lines to evacuate power from Wind Farm area and dynamic response of wind turbine generators and neighboring conventional synchronous generators.

The dynamic response of power plants in the neighborhood may not be uniform; as some of them are gas turbines and some are steam turbines i.e. Kotri has gas turbines whereas Jamshoro, Lakhra and Hub have steam turbines. Normally gas turbines are faster than the steam turbines to respond to changes in the system. The dynamic studies will determine how they respond to dynamic behavior of Sinowell WPP.

The above-mentioned thermal power plants do not run at their full capacity all along the whole year. During high water months when cheaper hydel power is abundantly available in the Northern grid of NTDC, many generating units of these plants are shut down for the sake of economic dispatch. Therefore in high hydel season, which is low thermal season by default, the southern power grid would get weaker in terms of system strength, especially during off-peak hours. The dynamics of this season is different than that of high thermal season.

There are different models of different sizes and make available in the market viz. GE, Vestas, Nordex, Gamesa, Siemens, Goldwind and Vensys etc. The dynamics of each model may be different with respect to grid's dynamics Sino Well Wind Energy is considering using 2 MW CSIC (Chongqing) Haizhuang Windpower Equipment Co., Ltd. Type-3 WTGs which are Doubly Fed Induction Generators.

2.2 Approach to the problem

We will apply the following approaches to the problem:

- According to the COD of Sinowell WPP as provided by the Client Client Sinowell Wind Power (Pvt.) Limited, we have decided to perform our analysis for the scenario of August/September 2019 to judge the maximum impact of the plant after the COD of the plant when the 220/132 kV Substation of Jhimpir-2 is commissioned.
- The base case for the year 2019 comprising all 500kV, 220kV and 132 kV, and 66kV system would be prepared envisaging the load forecast, the generation additions and transmission expansions for each year particularly in the Southern parts of the country. The case would include all the proposed and existing Wind Power Plants which have been developed or are going to be developed on a fast track basis and are expected to be commissioned by 2019 as per the latest schedule of AEDB.
- Interconnection scheme without any physical constraints, like right of way or availability of space in the terminal substations, would be identified.

- Perform technical system studies for peak load conditions of high wind seasons' power dispatches, to confirm technical feasibility of the interconnections.
- The proposed interconnection scheme will be subjected to steady state analysis (load flow), short circuit and transient stability to test the robustness of the scheme under normal and contingency conditions by checking steady state and transient/dynamic behavior under all events.
- Determine the relevant equipment for the proposed technically feasible scheme of interconnection
- Perform sensitivity studies considering adjacent wind farms to check their impact on HESCO/NTDC Grid. This sensitivity check can be performed for the ultimate planned number of Wind Power Plants in the neighborhood of Sinowell Wind Power (Pvt.) Limited.

3. Analysis of Network Prior to Sinowell WPP Interconnection

3.1 Description of the Network

The electrical grid, which is relevant for interconnection of Sinowell Wind PP, is the 500, 220 and 132 kV network that stretches through South of Hyderabad and Jamshoro up to coastal areas of Southern Sindh. The sketch of this network for the spot year 2019 after the addition of reinforcements in the area is shown in Appendix-4.

In this sketch, all the existing and proposed WPPs in the Jhimpir and Gharo clusters are modeled. Newly proposed 220/132kV substation of Jhimpir-2 is shown connected in loop In-out of the 220 kV Jamshoro – KDA double circuit and Jhimpir-1 – Gharo-New 220 kV single circuit. On 25th January 2017 a site visit was carried out to develop technically correct as well as least cost scheme for evacuation of power from these WPPs. Based on the location of the WPPs, two loops (each having 8 WPPs) were proposed at Jhimpir-2 grid station. The list of WPPs in each loop is provided below:

First Loop:

- Lakeside (50 MW)
- Nasda (50 MW)
- Trans-Atlantic (50 MW)
- Uni-Energy (50 MW)
- Iran Pak (50 MW)
- Artistic (50 MW)
- Act-2 (50 MW)
- Cacho (50 MW)

Second Loop:

- Indus (50 MW)
- Gul Ahmed (50 MW)
- Metro-2 (60 MW)
- Zulaikha (50 MW)

- Din Energy (50 MW)
- Noor (50 MW)
- Shafi Energy (50 MW)
- DHA-City (50 MW)

The details of the other 6 newly proposed WPPs is provided below:

- 14 MW Burj WPP connected via loop In-Out of 132 kV Thatta – FWEL-I single circuit
- Sinowell (50 MW), Norinco-2 (50 MW) and Tricom (50 MW) connected via loop In-out of the 132kV Jhimpir-1 – T.M.Khan 132kV single circuit
- Master Green (50 MW) connected via loop In-out of the proposed Nooriabad – Jamshoro Old 132kV single circuit
- Sinowell Energy (50 MW) connected via loop In-out of the upcoming Jhimpir-1 – Tricom 132kV single circuit

We have carried out the studies of the case "without" Sinowell WPP but including all the other planned and existing WPPs which have COD by 2019 to ascertain if there are any constraints in the system prior to Sinowell WPP's commissioning.

3.1.1 Load Forecast

The load forecast of NTDC attached in Appendix-2 has been used for the preparation of all the study scenarios.

3.1.2 Generation and Transmission Expansion Plan

There is a sizable addition of generation in the Southern part of the country. The latest generation and transmission expansion plan provided by NTDCL has been used and is attached in Appendix-2.

3.2 Load Flow Analysis

Load flow analysis has been carried out for the NTDC / HESCO network including all the existing and planned wind power plants at Jhimpir and Gharo clusters but without including Sinowell WPP to see if the network was adequate for dispersal of wind power without it. The case has been studied for the system conditions of

August/September 2019. The month has been selected so that the Jhimpir-2 220/132 kV substation is completed before the commissioning of the said WPPs. In order to ensure proper economic dispatch in the southern area for this High Wind High Water Season, it was essential to have a reasonable energy mix with contributions from both thermal and wind power plants. We kept the dispatch of the nearby power plants such as Thatta, Nooriabad and Kotri-Site at its maximum. Kotri GTPS was operated at 50% capacity. Output from all the existing/ under construction/ planned Wind Plants was kept at maximum. The results are shown plotted in Exhibit 3.0 in Appendix-3 which indicates that no circuit is loaded more than its rated power carrying capacity and the voltage profile at all the bus bars of 132 kV, 220 kV and 500 kV is within the permissible range. All power plants are running at lagging power factor within their rated range.

The N-1 contingency check has also been applied and the results are attached in Appendix-3 as below:

Exhibit 3.1	Tricom to T.M.Khan 132 kV Single Circuit Out
Exhibit 3.2	Norinco-2 to Tricom132 kV Single Circuit Out
Exhibit 3.3	Norinco-2 to Jhimpir-1 132 kV Single Circuit Out
Exhibit 3.4	Jhimpir-1 220/132 kV Single Transformer Out
Exhibit 3.5	Jhimpir-1 to T.M. Khan 132 kV Single Circuit Out
Exhibit 3.6	Jhimpir to Kotri GTPS 132 kV Single Circuit Out
Exhibit 3.7	Kotri GTPS to Jamshoro Old 132 kV Single Circuit Out
Exhibit 3.8	Jhimpir-1 to TM Khan Road 220 kV Single Circuit Out
Exhibit 3.9	Jhimpir-1 to Jhimpir-2 220 kV Single Circuit Out
Exhibit 3.10	Jhimpir-2 to KDA-33 220 kV Single Circuit Out
Exhibit 3.11	Jhimpir-2 to Jamshoro 220 kV Single Circuit Out
Exhibit 3.12	Jamshoro 500/220 kV Single Transformer Out
Exhibit 3.13	Matiari to Dadu 500 kV Single Circuit Out
Exhibit 3.13a	Matiari to Dadu 500 kV Single Circuit Out - Curtailment of Wind Generation by 600 MW

Exhibit 3.14 Jamshoro to Dadu 500 kV Single Circuit Out

Exhibit 3.14a Jamshoro to Dadu 500 kV Single Circuit Out - Curtailment of Wind Generation by 600 MW

The load flow results of the network in the close vicinity of Sinowell WPP shown plotted in Exhibits 3.1 to 3.12 indicate that all the power flows on the lines are within the rated limits of this network.

For some critical outages of 500kV circuits shown in Exhibit 3.13 and 3.14, capacity constraint was observed in 500kV network emanating from Jamshoro and upwards. Due to this capacity constraint, partial curtailment in the output of all WPPs under study was proposed to bring the loading on the 500kV network within limit. Results are shown in Exhibit 3.13(a) and 3.14(a). The details of the curtailment of WPPs are provided below:

Plant Name	Gross output	Curtailed Output
Nasda	50 MW	7 MW
Uni-Energy	50 MW	7 MW
Indus	50 MW	7 MW
Noor	50 MW	7 MW
Sino Well	50 MW	7 MW
Sinowell	50 MW	7 MW
Shafi Energy	50 MW	7 MW
Master Green	50 MW	7 MW
Iran Pak	50 MW	7 MW
Metro-2	60 MW	9 MW
Sinowell	50 MW	7 MW
DHA City	50 MW	7 MW
Tricom	50 MW	7 MW

With the curtailment process described above, it is established with Load flow results that the network existing before Sinowell WPP in the same vicinity in Jhimpir cluster including the Jhimpir-2 220/132 kV collector substation is enough to absorb their power, and has no limitations in terms of power transfer capacity under normal as well as N-1 contingency, prior to connection of Sinowell WPP. We will check the adequacy of network after adding Sinowell WPP in Chapter 6.

4. Development of Interconnection Scheme

4.1 Interconnection of Sinowell 50 MW WPP

To connect the wind farms to the main grid of NTDC / HESCO, one may think of connecting each Farm with any nearby available 132 kV substation by laying a direct 132 kV circuit from the gantry of each Farm's substation. But it is important to first see if the nearby substation has enough short circuit strength to connect to a Wind farm having characteristics of time-varying output because flicker and harmonics' resonance are a function of short circuit MVA of that node where this variation would be occurring.

In case there is a potential of developing of several Wind Farms in the same area, then a better interface or common coupling point may be a collector substation where each Wind Farm is connected and then this collector substation is connected to suitable node or nodes of the main national grid system. From suitable node or nodes we mean the nodes (bus bars) having relatively higher short circuit levels to mitigate the impact of time-variant generation from WTG.

In case of Sinowell WPP, the nearest substation is the collector substation of Jhimpir-1 220/132 kV for evacuation of power from said power plant.

4.2 Proposed Interconnection Scheme

The scheme of interconnection of these 15 new WPPs including Sinowell WPP proposes the following reinforcements in place at Jhimpir cluster.

- 220 kV D/C transmission line approx. 5km long on twin bundled Greeley conductor looping In/out of second circuit of existing Jamshoro – KDA-33 D/C transmission line at the proposed Jhimpir-2 220/132 kV substation
- Addition of 4th 220/132 kV transformer at the newly proposed Jhimpir-2 220/132 kV substation.
- 132kV double circuit transmission line approx. 135 km long on twin bundled Greeley conductor for connecting 8 WPPs in the first loop to Jhimpir-2 220/132 newly proposed substation.

- 132kV double circuit transmission line approx. 168 km long on twin bundled Greeley conductor for connecting 8 WPPs in the second loop to Jhimpir-2 220/132 newly proposed substation.
- In this Integrated study, the interconnection of Sinowell WPP includes 132 kV D/C transmission line approx. 5.5 km long, on Greeley conductor for looping in/out on the 132kV single circuit from T.M.Khan to TRICOM WPP grid station.

The connection scheme of Sinowell WPP for the scenario of August/September 2019 as shown in Appendix - 4 is by interconnecting Sinowell in the double circuit going from Jhmipir-1 to T.M.Khan Road placed along with Tricom and Norinco-2 WPP. It should be noted that the length of circuits used for the simulations are confirmed from site visit and agreed with NTDC official. They may change slightly during the implementation of the project. In addition, the connectivity of Sinowell WPP with neighboring wind power plants may change, depending upon the COD of the project.

5. Modeling of Sinowell Wind Farm

5.1 Electrical Layout of Wind Farm

5.1.1 Sinowell WPP Energy Selection

Sino Well has selected Type-3 CSIC (Chongqing) Haizhuang Windpower Equipment Co., Ltd. WTGs which they are considering to install on their Wind Farm. It is a Doubly Fed Induction Generator. Each WTG would step up from its terminal LV voltage of 0.7 kV to a medium voltage (MV) that will be 35 kV.

5.1.2 Electrical Layout

The WTGs would be connected to MV collector cables of 35 kV laid down in the Farm connecting each line (row) of the WTGs to the Farm substation. The layout is shown in **Sketch – 3** (Appendix-5), briefly described as follows;

Line – 1	WTGs 1-6	(6 x 2 = 12 MW)
Line – 2	WTGs 7-12	(6 x 2 = 12 MW)
Line – 3	WTGs 13-18	(6 x 2 = 12 MW)
Line – 4	WTGs 19-25	(7 x 2 = 14 MW)

The average length of cable between the two WTGs has to be enough to completely outdo the wake effect from the adjoining WTG based on thumb rule to leave 4xD (rotor diameter) between the WTGs to take care of wake effect. In actual micro-siting the distances between WTGs might be slightly different due to many other factors. We have taken about 400 meters distances between the WTGs.

The Farm Substation has been assumed to be located somewhere in the middle of the Farm.

The three collector circuits of 35 kV would thus be laid as shown in Sketch-3 and explained as follows;

Collector Line-1	from WTG-1 to Farm Substation
Collector Line-2	from WTG-7 to Farm Substation
Collector Line-3	from WTG-13 to Farm Substation
Collector Line-4	from WTG-19 to Farm Substation

Since each collector would carry a max of approximately 14 MW at normal rating, the 35 kV collector circuits loading capacity should be in the range of 16 MVA each, giving some margin for reactive power at 0.95 Power Factor and some losses in the circuits with certain overload capacity as well.

5.1.3 35 kV Collector Circuits

The MV voltage level selected by Sinowell for interconnection of collector groups of WTGs in the Farm is 35 kV. Underground cables will be used with length of approx. 4.5 km, 2.3 km, 6.66 km and 6.7 km for two different collector Cables as shown in sketch-3 of Appendix - 5. Further details regarding the type of cable is provided in Appendix - 2.

5.2 Wind Farm Substation 132/35 kV

A substation would be built in the middle of the Farm to collect all the power from the WTGs, spread out in the Farm, at medium voltage (MV) level of 35 kV and step-up this power to high voltage (HV) level of 132 kV so that the Farm's output may be evacuated to the main grid of NTDC. The single line diagrams of the substation are briefly shown in Sketch-1 and 2 in Appendix-5 for 35 kV and 132 kV respectively.

Keeping in view the data provided by the Client, the bus bar scheme for 132 kV level is double bus with a coupler i.e. double bus-single-breaker scheme. Keeping in view the NTDC/DISCOs practice, we propose to provide good reliability to a power plant as follows:

- Single bus scheme with a sectionalizer to enable to have two bus sections at 35 kV.
- Double-bus single-breaker scheme with a Bus Coupler at 132 kV

The schemes are shown in Sketch-1 and 2 respectively and described as follows.

5.2.1 Conceptual Design of 35 kV

The single line diagram SLD–1 in Appendix-5 shows the conceptual design of 35 kV (MV) bus bar of the Farm substation. It comprises of

- Two single bus-sections of 35 kV with a bus sectionalizer
- Four breaker bays to connect four collector double circuits of WTG Lines 1-2
- Two breaker bays to connect two transformers of 132/35 kV
- Two breaker bays for connecting two auxiliary transformers of 35/0.4 kV
- Two breaker bays to connect SVCs

Rating of all the breakers and bus bar equipment would be

Short circuit rupturing capacity = 25 kA

Normal continuous current = 1250 A for line breakers

= 2500A for Bus Sectionalizer and Power TF

5.2.2 Conceptual Design of 132 kV

Single-line-diagram SLD–2 (Appendix–5) shows 132 kV bus bars of the Farm substation, which would comprise as follows:

- Double bus bars with a Bus Coupler
- Two breaker bays to connect two transformers 132/35 kV
- Two breaker bays to connect two circuits of 132 kV i.e. double circuit on single tower overhead line to connect to the grid system.

Rating of all the breakers and bus bar equipment would be

Short circuit rupturing capacity = 40 kA

Normal continuous current = 1250 A for line and TF breakers

= 2500 A for Bus Sectionalizer

The other equipment of the substation consists of:

- Two 132/35 kV, 31.5/40/50 MVA ONAN/ONAF1/ONAF2 OLTC transformers, 132±8×1%/35kV, to fulfill N-1 criteria of Grid Code
- Two station auxiliary transformers 35/0.4 kV
- Two static VAR generator each of the size of 10 MVAR with contactors and PLC (Programmable Logic Controller).
- Energy meters would be installed on HV side (132 kV) of the 132/35 kV transformers.

6. Load Flow Analysis

Load flow analysis has been carried out for the proposed scheme of interconnection of Sinowell WPP with NTDC grid for the base scenario of September 2019.

6.1 Modeling of Wind Farm in Load Flow

Representation of all the individual machines in a large Wind Farm is inappropriate in most grid impact studies [1]. There is a provision in the model structure of PSS/E to allow single equivalent WTG machine model to represent multiple WTGs. However there are limitations. Disturbances within the local collector grid cannot be analyzed, and there is some potentially significant variation in the equivalent impedance for the connection to each machine. A single machine equivalent requires the approximation that the power output of all the machines will be the same at a given instant of time. For grid system impact studies, simulations are typically performed with the initial wind of sufficient speed to produce the rated output on all the machines. Under this condition, the assumption that all the machines are initially at the same (rated) output is not an approximation [2]. Otherwise this assumption presumes that the geographic dispersion is small enough that the wind over the farm is uniform. Though simulations of bulk system dynamics using a single machine equivalent are adequate for most planning studies, we have adopted a rather more detailed level of modeling by using an equivalent machine just for one group of WTGs connected to one collector feeder. Since we have two collector feeders connecting to two groups of WTGs, therefore there are two equivalent WTGs assumed for each collector group in this study report.

The Farm Substation is represented by two bus bars as Sinowell medium voltage bus named Sinowell -MV 35 kV and Sinowell 132 kV, with two inter-bus transformers of 31.5/40/50 MVA each. These transformers have an overload capacity of 50 MVA for a limited time to cover N-1 contingency criteria of Grid Code i.e. in case of outage of one transformer, the other can take up the full output of Farm i.e. 50 MVA.

6.2 Reactive Power Requirements

Sino Well is considering using 2 MW CSIC (Chongqing) Haizhuang Windpower Equipment Co., Ltd. Type-3 WTGs, which are doubly fed induction generators, in their WPP. Its power factor is 0.95 lagging (capacitive/generating) and 0.95 leading (inductive/absorbing). The maximum reactive power output that can be available at the 0.7 kV terminal is 0.66 MVAR for each WTG. Part of this reactive power will be consumed by the 0.7/35 kV step-up (GSU) transformer and the rest may be consumed in the MV collector cables of the wind farm. However some reactive power might reach the MV bus bar of Farm substation. That means each WTG is self sufficient to meet VAR absorption requirement of its step-up transformer with some contribution of VARs to the Farm MV network.

The Grid Code Addendum No.1 requires to meet the criteria of ± 0.95 power factor at the point of interconnection with the NTDC/HESCO grid at 132 kV (point of common coupling). Therefore a Farm of 50 MW generating capacity is required to pump 16.4 MVAR to the grid at full output of 50 MW. The VAR generating capability of WTG at 0.95 PF will not be able to fully meet this VAR demand of the system because of VAR loss in step-up transformers, collector cables and the HV/MV i.e. 132/35 kV transformers at the Farm substation. In order to meet the Grid Code criteria, we need to install SVC at 35 kV bus of the Farm substation of sufficient size capable of delivering approx. 16.4 MVAR at 132 kV bus after VAR loss across 132/35 kV transformers.

6.3 Load Flow Analysis for Peak Load Scenario of August/September 2019

Load flow analysis has been carried out for the NTDC / HESCO network to see the steady state impact of adding the generation of Sinowell WPP on the network including the existing/under-construction/planned WPPs in the Jhimpir and Gharo Cluster. The network configuration is same for Jhimpir and Gharo clusters as indicated in Appendix-4 and discussed in Ch. 3.

The integrated case has been studied for the system conditions of summer 2019, the time line associated with the COD of Sinowell WPP and after the commissioning of the newly proposed 220/132 kV substation in the southern part of Jhimpir. In order to ensure proper economic dispatch in the southern area for this High Wind High Water Season, it was essential to have a reasonable energy mix with contributions from both thermal and wind power plants. We kept the dispatch of the nearby power plants such as Thatta, Nooriabad and Kotri-Site at its maximum. Kotri GTPS was operated at 50% capacity. Output from all the existing/ under construction/ planned Wind Plants was kept at maximum.

Load flow simulations have been run for normal and contingency conditions. The results are shown plotted in Appendix-6.

6.3.1 Normal Case

Exhibit 6.1.0 shows the normal case under the system conditions of summer 2019. All the wind farms in Jhimpir and Gharo clusters with installed capacity of 50 MW or 49.5 MW have been assumed after deducting Farm losses and given some diversity in the maximum output of all the Wind Power Plants at one time. For Sinowell WPP, 48.11 MW is assumed to be delivered at the point of delivery to grid at 132 kV.

All these loadings are within the rated limits of these circuits. The bus voltages on all the substations in Southern HESCO grid are within the normal limits of operation.

We see that all the WTGs are running at a power factor above its rated value of 0.90 not using full reactive power capability leaving enough margin to cover contingencies. The SVC of 20 MVAR at 35 kV bus bar is supplying 18.11 MVAR at (35.49 kV) voltage and, after VAR loss across 132/35 kV transformers, supplying about 14.88 MVAR (nearly 0.95 PF) at 132 kV bus i.e. fulfilling the Grid Code criteria at the point of interconnection. The voltage profile on all the bus bars of 132 kV of HESCO grid are well within the normal operating criteria of ± 5 % off the nominal.

6.3.2 Contingency cases and evolving of reliable scheme

The N-1 contingency cases have been run and the results have been shown plotted as under:

Exhibit 6.1.1	Sinowell 132/35 kV Single Transformer Out
Exhibit 6.1.2	Sinowell to T.M.Khan 132 kV Single Circuit Out
Exhibit 6.1.3	Tricom to Sinowell 132 kV Single Circuit Out
Exhibit 6.1.4	Norinco-2 to Jhimpir-1 132 kV Single Circuit Out
Exhibit 6.1.5	Jhimpir-1 220/132 kV Single Transformer Out
Exhibit 6.1.6	Jhimpir-1 to T.M. Khan 132 kV Single Circuit Out
Exhibit 6.1.7	Jhimpir to Kotri GTPS 132 kV Single Circuit Out
Exhibit 6.1.8	Kotri GTPS to Jamshoro Old 132 kV Single Circuit Out
Exhibit 6.1.9	Jhimpir-1 to TM Khan Road 220 kV Single Circuit Out
Exhibit 6.1.10	Jhimpir-1 to Jhimpir-2 220 kV Single Circuit Out
Exhibit 6.1.11	Jhimpir-2 to KDA-33 220 kV Single Circuit Out
Exhibit 6.1.12	Jhimpir-2 to Jamshoro 220 kV Single Circuit Out
Exhibit 6.1.13	Jamshoro 500/220 kV Single Transformer
Exhibit 6.1.14	Matiari to Dadu 500 kV Single Circuit Out
Exhibit 6.1.14a	Matiari to Dadu 500 kV Single Circuit Out - Curtailment of Wind Generation by 600 MW
Exhibit 6.1.15	Jamshoro to Dadu 500 kV Single Circuit Out
Exhibit 6.1.15a	Jamshoro to Dadu 500 kV Single Circuit Out - Curtailment of Wind Generation by 600 MW

The load flow results of the network in the close vicinity of Sinowell WPP shown plotted in Exhibits 6.1.1 to 6.1.13 indicate that all the power flows on the lines are within the rated limits of this network.

For some critical outages of 500kV circuits shown in Exhibit 6.1.14 and 6.1.15, capacity constraint was observed in 500kV network emanating from Jamshoro and

upwards. Due to this capacity constraint, partial curtailment in the output of all WPPs under study was proposed to bring the loading on the 500kV network within limit. Hence output of Sinowell WPP is curtailed to 7MW in case of these contingency events. Results are shown in Exhibit 6.1.14(a) and 6.1.15(a). The details of the curtailment of WPPs are provided below:

Plant Name	Gross output	Curtailed Output
Lake Side	50 MW	7 MW
Nasda	50 MW	7 MW
Uni-Energy	50 MW	7 MW
Indus	50 MW	7 MW
Noor	50 MW	7 MW
Sino Well	50 MW	7 MW
Sinowell	50 MW	7 MW
Shafi Energy	50 MW	7 MW
Master Green	50 MW	7 MW
Iran Pak	50 MW	7 MW
Metro-2	60 MW	9 MW
Sinowell	50 MW	7 MW
DHA City	50 MW	7 MW
Tricom	50 MW	7 MW

Total Wind Capacity: 724 MW
Wind Capacity after curtailment: 113 MW

The results also show that under all events of outages the switched shunt capacitor banks at 35 kV bus regulates the voltage under all events. The reactive power being supplied by the 20 MVAR SVC as proposed by the client connected at 35 kV bus, maintains the supply of VARS to the grid under all contingencies adjusting its output according to the system requirement.

In addition, Greeley conductor (184 MVA) is used for the interconnection of Sinowell WPP. In the load flow simulation, however, the MVA capacity is assumed to be 202 MVA taking into account the increase in MVA capacity of the conductors at high wind speed during high wind season. This is true for all the conductors in the area, whether lynx or rail, a 10% increase in the thermal rating is assumed.

6.4 Load Flow Analysis for Off-Peak Load Scenario of August/September 2019

Load flow analysis has been carried out for the off-peak conditions of August/September 2019 for the NTDC / HESCO network to see the steady state impact of reduced loads and generations as a higher loading on the circuits is expected during the off-peak conditions.

Load flow simulations have been run for normal and contingency conditions. The results are shown plotted in Appendix-6.

Exhibit 6.2.0 shows the normal case under the off-peak system conditions of August/September 2019. All these loadings are within the rated limits of these circuits. The bus voltages on all the substations in Southern HESCO grid are within the normal limits of operation.

The N-1 contingency cases have been run and the results have been shown plotted as under:

Exhibit 6.2.1	Sinowell 132/35 kV Single Transformer Out
Exhibit 6.2.2	Sinowell to T.M.Khan 132 kV Single Circuit Out
Exhibit 6.2.3	Tricom to Sinowell 132 kV Single Circuit Out
Exhibit 6.2.4	Norinco-2 to Jhimpir-1 132 kV Single Circuit Out
Exhibit 6.2.5	Jhimpir-1 220/132 kV Single Transformer Out
Exhibit 6.2.6	Jhimpir-1 to T.M. Khan 132 kV Single Circuit Out
Exhibit 6.2.7	Jhimpir to Kotri GTPS 132 kV Single Circuit Out
Exhibit 6.2.8	Kotri GTPS to Jamshoro Old 132 kV Single Circuit Out
Exhibit 6.2.9	Jhimpir-1 to TM Khan Road 220 kV Single Circuit Out

Exhibit 6.2.10	Jhimpir-1 to Jhimpir-2 220 kV Single Circuit Out
Exhibit 6.2.11	Jhimpir-2 to KDA-33 220 kV Single Circuit Out
Exhibit 6.2.12	Jhimpir-2 to Jamshoro 220 kV Single Circuit Out
Exhibit 6.2.13	Jamshoro 500/220 kV Single Transformer
Exhibit 6.2.14	Matiari to Dadu 500 kV Single Circuit Out
Exhibit 6.2.14a	Matiari to Dadu 500 kV Single Circuit Out - Curtailment of Wind Generation by 600 MW
Exhibit 6.2.15	Jamshoro to Dadu 500 kV Single Circuit Out
Exhibit 6.2.15a	Jamshoro to Dadu 500 kV Single Circuit Out - Curtailment of Wind Generation by 600 MW

The load flow results of the network in the close vicinity of Sinowell WPP shown plotted in Exhibits 6.2.1 to 6.2.13 indicate that all the power flows on the lines are within the rated limits of this network.

For some critical outages of 500kV circuits shown in Exhibit 6.2.14 and 6.2.15, capacity constraint was observed in 500kV network similar to the peak scenario discussed above. Hence curtailment of WPPs as discussed above was carried out in this off-peak scenario as well. Results after curtailment are shown in Exhibit 6.2.14(a) and 6.2.15(a).

6.5 Load Flow Analysis for Future Scenario of 2022

Load flow analysis has been carried out for the peak conditions for future scenario of 2022 for the NTDC / HESCO network. All the future reinforcements that were proposed till 2022 are modeled in the case.

Load flow simulations have been run for normal and contingency conditions. The results are shown plotted in Appendix-6.

Exhibit 6.3.0 shows the normal case under the peak system conditions of future year 2022. All these loadings are within the rated limits of these circuits. The bus voltages

on all the substations in Southern HESCO grid are within the normal limits of operation.

The N-1 contingency cases have been run and the results have been shown plotted as under:

Exhibit 6.3.1	Norinco 2 132/35 kV Single Transformer Out
Exhibit 6.3.2	Norinco 2 to Tricom 132 kV Single Circuit Out
Exhibit 6.3.3	Norinco 2 to Jhimpir-1 132 kV Single Circuit Out
Exhibit 6.3.4	Lake Side to Jhimpir-2 132 kV Single Circuit Out
Exhibit 6.3.5	Gul Ahmed-E to Jhimpir-2 132 kV Single Circuit Out
Exhibit 6.3.6	Jhimpir-2 220/132 kV Single Transformer Out
Exhibit 6.3.7	Jhimpir-1 to T.M. Khan 132 kV Single Circuit Out
Exhibit 6.3.8	Jhimpir to Kotri GTPS 132 kV Single Circuit Out
Exhibit 6.3.9	Kotri GTPS to Jamshoro Old 132 kV Single Circuit Out
Exhibit 6.3.10	Jhimpir-1 to TM Khan Road 220 kV Single Circuit Out
Exhibit 6.3.11	Jhimpir-1 to Jhimpir-2 220 kV Single Circuit Out
Exhibit 6.3.12	Jhimpir-2 to KDA-33 220 kV Single Circuit Out
Exhibit 6.3.13	Jhimpir-2 to Jamshoro 220 kV Single Circuit Out
Exhibit 6.3.14	Jamshoro 500/220 kV Single Transformer Out
Exhibit 6.3.15	Matiari to Dadu 500 kV Single Circuit Out
Exhibit 6.3.16	Jamshoro to Dadu 500 kV Single Circuit Out

The results show that power flows on intact 132 kV circuits remain within their rated limits. For this future scenario of 2022, the issue of capacity constraint that was observed in the base case of 2019 is resolved due to the following major reinforcements in the system:

- 660kV HVDC from Matiari to Lahore
- 660kV HVDC from Port Qasim to Faisalabad West

6.6 Conclusion of Load Flow Results

With the proposed reinforcements and the curtailment process for the base year of 2019 under special circumstances, the load flow results of the proposed scheme of interconnection of Sinowell WPP shows no bottlenecks or capacity constraints in the adjoining 500 kV, 220 kV and 132 kV network in terms of absorbing all the output of Sinowell WPP under normal as well as the contingency conditions for all the scenarios studied.

Sinowell Wind Power Plant would be connected by a double circuit of 132 kV by looping in-out configuration of the Jhimpir-1 to T.M.Khan 132kV single circuit. Greeley conductor with the capacity of 184 MVA per circuit is assumed to have a thermal limit of 202 MVA taking into account the increase in MVA capacity of the conductors at high wind speed during high wind season.

7. Short Circuit Analysis

7.1 Methodology and Assumptions

The methodology of IEC 909 has been applied in all short circuit analyses in this report for which provision is available in the PSS/E software used for these studies. For calculations of maximum fault levels the bus voltage has been assumed as 1.1 PU i.e. 10 % above the nominal as per IEC909. For calculations of minimum fault levels the bus voltage has been assumed as 0.9 PU i.e. 10 below the nominal. That covers the entire ± 10 % range of the ratings of the equipment.

7.1.1 Assumptions for maximum and minimum short circuit levels

7.1.1.1 Assumptions-Maximum short circuit levels

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the future year of 2022 to assess the maximum impact of Sinowell WPP.

The maximum fault currents have been calculated with the following assumptions under IEC909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence

Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition

However tabular results of some significant bus bars of 220 kV and 132 kV in the electrical vicinity of Sinowell WPP have also been produced and placed in Appendix-7.

7.1.1.2 Assumptions-Minimum Short Circuit Levels

The minimum fault currents are important for the evaluation of power quality issues such as flicker, unbalance, sudden voltage dip and harmonics.

To assess the minimum short circuit levels we have considered conditions of 2019 to simulate the minimum short circuit strength of southern grid. For Sinowell WPP we have assumed a smaller percentage of dispatch of its capacity for the minimum short circuit calculations i.e. just one collector group with partial output of approx. 25 MW is on bar.

For minimum fault currents we have applied the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence

Desired voltage magnitude at bus bars set equal to 0.9 P.U. i.e. 10 % lower than nominal, which is the minimum permissible voltage under contingency condition.

7.2 Fault Currents Calculations

7.2.1 Maximum Short Circuit Levels for the Year 2022

The short circuit levels have been calculated and plotted on the bus bars of 500 kV, 220 kV and 132 kV of substations lying in the electrical vicinity of our area of interest i.e. Jhimpir, T.M.Khan Road, Jamshoro and Gharo area, and are shown plotted in the Exhibit 7.2 for the scenario of 2022 and attached in Appendix-7. Both 3-phase and 1-phase fault currents are indicated in the Exhibit which are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault currents are shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-7 for the 500 kV, 220 kV and 132 kV bus bars of our interest i.e. the substations connecting in the three branches of 132 kV running South of Hyderabad up to Southern Sind coast line. The tabular output is the detailed output showing the contribution to the fault current from the adjoining sources i.e. the lines and transformers connected to that bus. The phase currents, the sequence currents and the sequence impedances are shown in detail for each faulted bus bar.

The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 7.1. We see that the maximum fault currents do not exceed the short circuit ratings of the equipment at these 132 kV substations which normally are 25 kA or 31.5 kA for older substations and 40 kA for new substations. For Jamshoro 220kV substation whose fault level exceed 40kA, this is due to the reinforcements in the NTDC system hence NTDC should take mitigation measures to reduce these fault levels.

The fault levels of Sinowell 132 kV are 8.36 kA and 7.58 kA for 3-phase and single phase faults respectively for 2022. This is much less than the switchgear rating of 40 kA recommended for Sinowell Farm Substation as per NTDC requirements for 132 kV.

The fault levels for Sinowell 35 kV are 15.01 kA and 16.37 kA for 3-phase and single-phase faults respectively for 2022. Therefore the short circuit rating recommended for 35 kV switchgear is recommended as 25 kA.

Table-7.1

Maximum Short Circuit Levels with Sinowell WPP – 2022

Substation	3-Phase Fault Current (kA)	1-Phase Fault Current (kA)
Sinowell 132 kV	8.36	7.58
Sinowell MV 35 kV	15.01	16.37
Nooriabad 132 kV	11.92	13.16
Thatta 132 kV	6.62	6.50
Jamshoro Old 132 kV	23.84	22.88
Jamshoro New 132 kV	25.25	24.90
Kotri GTPS 132 kV	19.73	19.01
Hala Road 132 kV	22.36	21.44
T.M.KHAN 132 kV	14.80	14.24
Jhimpir 132 kV	11.45	10.49
Jhimpir-1 132 kV	30.36	26.69
Jhimpir-2 132 kV	24.21	22.22
Gharo-New 132 kV	10.37	9.81
Gharo-New 220 kV	10.17	8.00
Jhimpir-1 220 kV	23.18	18.06
Jhmipir-2 220 kV	29.86	21.96
Hala Road 220 kV	29.68	22.90
TM.KH.RD 220 kV	22.56	18.46

7.2.2 Minimum short circuit levels

The minimum fault levels have been calculated for minimum dispatch of power in the grid system. The plotted results of short circuit analysis are attached as Exhibit 7.1. Both 3-phase and 1-phase fault currents are indicated in the Exhibit which are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault currents are shown below the faulted bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-7 for the 132 kV bus bars of our interest.

The total minimum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 7.2.

Table-7.2

Minimum Short Circuit Levels with Sinowell WPP 2019

Substation	3-Phase Fault Current (kA)	1-Phase Fault Current (kA)
Sinowell 132 kV	5.77	4.91
Sinowell MV 35 kV	9.96	9.76
Nooriabad 132 kV	7.88	8.41
Thatta 132 kV	4.74	4.70
Jamshoro Old 132 kV	15.93	15.60
Jamshoro New 132 kV	16.89	16.89
Kotri GTPS 132 kV	13.25	12.28
Hala Road 132 kV	15.58	15.18
T.M.KHAN 132 kV	10.91	10.58
Jhimpir 132 kV	7.31	6.88
Jhimpir-1 132 kV	18.25	18.90
Jhimpir-2 132 kV	16.98	16.26
Gharo-New 132 kV	7.44	7.52
Gharo-New 220 kV	7.42	6.30
Jhimpir-1 220 kV	14.88	13.40
Jhmipir-2 220 kV	19.00	15.65
Jamshoro 220 kV	23.86	23.59
Hala Road 220 kV	18.13	14.89
TM.KH.RD 220 kV	14.89	12.89
Jamshoro 500 kV	13.12	11.17
Matiari 500 kV	12.75	10.52

7.3 Conclusions of Short Circuit Analysis

As a whole for the peak scenario of 2022, the fault levels at all the 132 kV bus bars are well below the short circuit rating of the equipment at these substations.

The fault levels of Sinowell 132 kV are 8.36 kA and 7.58 kA for 3-phase and single phase faults respectively for 2022. This is much less than the switchgear rating of 40 kA recommended for Sinowell Farm Substation as per NTDC requirements for 132 kV.

The fault levels for Sinowell 35 kV are 15.01 kA and 16.37 kA for 3-phase and single-phase faults respectively for 2022. Therefore the short circuit rating recommended for 35 kV switchgear is 25 kA.

Similarly for minimum short circuit case for the year 2019, the fault levels are also well below the short circuit rating of the equipment at these substations.

The short circuit strength is very important for Power Quality issues like flicker, harmonics and voltage unbalance. Exhibit 7.1.1 and 7.1.2 show the results of minimum fault levels in MVA to be used in Power Quality analysis carried out in Ch.9.

The fault levels indicate that there are no constraints in terms of short circuit ratings of the equipment of the adjoining substations and there is improvement in minimum fault levels. The proposed interconnection scheme holds well on the basis of short circuit analysis as well.

8. Transient Stability Analysis

The objective of transient stability study is to see:

1. Dynamic impact of Sinowell Wind Power Plant on the System
2. Dynamic impact of the System on Sinowell Wind Power Plant

8.1 Assumptions & Methodology

8.1.1 Type-3 WTG Dynamic Model

Sino Well is considering using Doubly Fed Induction Generator which is designated as Type-3 WTG in their Wind Power Plant. We have used the generic Type-3 wind turbine-generator model, which has been developed and has been made available by Siemens–PTI to their users of PSS/E software. Only the main parameters have been incorporated in this model, whereas other details and minute control parameters have been based on assumptions in the controllers of generic model of Siemens-PTI software PSS/E.

8.2 Dynamic Impact of System Disturbances

8.2.1

Fault Type: 3-Phase			
Fault Location: Sinowell 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Sinowell to Tricom 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Sinowell 132 kV 2. Sinowell MV 35 kV 3. Tricom 132 kV 4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	The voltages of all the bus bars recover after fault clearance	8.1.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.1.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.1.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.1.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.1.5

• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.1.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.1.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.1.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell to T.M.Khan132 kV intact single circuit	Attains steady state value after damping of oscillations	8.1.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.1.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.1.11

8.2.2

Fault Type: 1-Phase			
Fault Location: Sinowell 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Sinowell to Tricom 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Sinowell 132 kV 2. Sinowell MV 35 kV 3. Tricom 132 kV 4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	The voltages of all the bus bars recover after fault clearance	8.2.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.2.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.2.3

• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.2.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.2.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.2.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.2.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.2.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell to T.M.Khan132 kV intact single circuit	Attains steady state value after damping of oscillations	8.2.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.2.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.2.11

8.2.3

Fault Type: 3-Phase			
Fault Location: Sinowell 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Sinowell to T.M.Khan 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Sinowell 132 kV 2. Sinowell MV 35 kV 3. Tricom 132 kV 4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	The voltages of all the bus bars recover after fault clearance	8.3.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.3.2

• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.3.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.3.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.3.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.3.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.3.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.3.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell to Tricom 132 kV Intact circuit	Attains steady state value after damping of oscillations	8.3.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.3.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.3.11

8.2.4

Fault Type: 1-Phase			
Fault Location: Sinowell 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Sinowell to T.M.Khan 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Sinowell 132 kV 2. Sinowell MV 35 kV 3. Tricom 132 kV	The voltages of all the bus bars recover after	8.4.1

	4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	fault clearance	
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.4.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.4.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.4.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.4.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.4.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.4.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.4.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell to Tricom 132 kV Intact circuit	Attains steady state value after damping of oscillations	8.4.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.4.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.4.11

8.2.5

Fault Type: 3-Phase			
Fault Location: Sinowell MV 22 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Sinowell 132/22 kV Single Transformer			
Variable	**Bus/Line**	**Response**	**Figure No.**

Voltage	1. Sinowell 132 kV 2. Sinowell MV 35 kV 3. Tricom 132 kV 4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	The voltages of all the bus bars recover after fault clearance	8.5.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.5.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.5.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.5.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.5.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.5.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.5.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.5.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell 132/22 kV Single Transformer	Attains steady state value after damping of oscillations	8.5.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.5.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.5.11

8.2.6

Fault Type: 3-Phase

Fault Location: Sinowell MV 22 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: One Collector Group of 12 MW			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Sinowell 132 kV 2. Sinowell MV 35 kV 3. Tricom 132 kV 4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	The voltages of all the bus bars recover after fault clearance	8.6.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.6.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.6.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.6.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.6.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.6.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.6.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.6.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell 132/22 kV Single Transformer	Attains steady state value after damping of oscillations	8.6.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.6.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.6.11

8.2.7

Fault Type: 3-Phase			
Fault Location: Tricom 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Tricom to Sinowell 132kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Tricom 132 kV 2. Sinowell 132 kV 3. Sinowell MV 22 kV 4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	The voltages of all the bus bars recover after fault clearance	8.7.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.7.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.7.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.7.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.7.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.7.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.7.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.7.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell to T.M.Khan 132 kV intact single circuit	Attains steady state value after damping of oscillations	8.7.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.7.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV	Damps down quickly and attain a steady state value	8.7.11

	5. Hub 220 kV 6. Guddu-New (Reference)		

8.2.8

Fault Type: 1-Phase			
Fault Location: Tricom 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Tricom to Sinowell 132kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Tricom 132 kV 2. Sinowell 132 kV 3. Sinowell MV 22 kV 4. T.M.Khan 132 kV 5. Jhimpir-1 132 kV 6. Jhimpir-1 220kV	The voltages of all the bus bars recover after fault clearance	8.8.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.8.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.8.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.8.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.8.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.8.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.8.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.8.8
• **MW Line Flow** • **MVAR Line Flow**	Sinowell to T.M.Khan 132 kV intact single circuit	Attains steady state value after damping of oscillations	8.8.9
• **MW Output**	Tricom 132 kV	Recovers after damping down	8.8.10

• **MVAR Output**		oscillations	
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.8.11

8.2.9

Fault Type: 3-Phase			
Fault Location: T.M.Khan 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: T.M.Khan to Sinowell 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. T.M.Khan 132 kV 2. Sinowell 132 kV 3. Tricom 132 kV 4. Jhimpir-1 132 kV 5. Jhimpir-1 220 kV 6. T.M.Khan 220 kV	The voltages of all the bus bars recover after fault clearance	8.9.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.9.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.9.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.9.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.9.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.9.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.9.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.9.8

• **MW Line Flow** • **MVAR Line Flow**	T.M.Khan to Jhimpir-1 132 kV intact single circuit	Attains steady state value after damping of oscillations	8.9.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.9.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.9.11

8.2.10

Fault Type: 1-Phase			
Fault Location: T.M.Khan 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: T.M.Khan to Sinowell 132kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. T.M.Khan 132 kV 2. Sinowell 132 kV 3. Tricom 132 kV 4. Jhimpir-1 132 kV 5. Jhimpir-1 220 kV 6. T.M.Khan 220 kV	The voltages of all the bus bars recover after fault clearance	8.10.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.10.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.10.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.10.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.10.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.10.6

• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.10.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.10.8
• **MW Line Flow** • **MVAR Line Flow**	T.M.Khan to Jhimpir-1 132 kV intact single circuit	Attains steady state value after damping of oscillations	8.10.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.10.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.10.11

8.2.11

Fault Type: 3-Phase			
Fault Location: Jhimpir-1 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Jhimpir-1 to T.M.Khan 132kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Jhimpir-1132 kV 2. T.M.Khan 132 kV 3. Sinowell 132 kV 4. Jhimpir-1 220 kV 5. T.M.Khan 220 kV 6. Gharo-New 220 kV	The voltages of all the bus bars recover after fault clearance	8.11.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.11.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.11.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.11.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.11.5

• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.11.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.11.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.11.8
• **MW Line Flow** • **MVAR Line Flow**	T.M.Khan to Sinowell 132 kV intact single circuit	Attains steady state value after damping of oscillations	8.11.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.11.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.11.11

8.2.12

Fault Type: 1-Phase			
Fault Location: Jhimpir-1 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Jhimpir-1 to T.M.Khan 132kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Jhimpir-1132 kV 2. T.M.Khan 132 kV 3. Sinowell 132 kV 4. Jhimpir-1 220 kV 5. T.M.Khan 220 kV 6. Gharo-New 220 kV	The voltages of all the bus bars recover after fault clearance	8.12.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.12.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.12.3

• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.12.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.12.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.12.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.12.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.12.8
• **MW Line Flow** • **MVAR Line Flow**	T.M.Khan to Sinowell 132 kV intact single circuit	Attains steady state value after damping of oscillations	8.12.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.12.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 220 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.12.11

8.2.13

Fault Type: 3-Phase			
Fault Location: Jhimpir-1 220 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Jhimpir-1 to T.M.Khan Road 220 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Jhimpir-1 220 kV 2. T.M.Khan Road 220 kV 3. Jhimpir-2 220 kV 4. Sinowell 20 kV 5. Jhimpir-1132 kV 6. T.M.khan 132 kV	The voltages of all the bus bars recover after fault clearance	8.13.1

Frequency	Sinowell 132 kV	Recovers after fault clearance	8.13.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.13.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.13.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.13.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.13.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.13.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.13.8
• **MW Line Flow** • **MVAR Line Flow**	Jhimpir-1 to T.M.Khan Road 220 kV Single Circuit	Attains steady state value after damping of oscillations	8.13.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.13.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 500 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.13.11

8.2.14

Fault Type: 1-Phase			
Fault Location: Jhimpir-1 220 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Jhimpir-1 to T.M.Khan Road 220 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Jhimpir-1 220 kV	The voltages of	8.14.1

	2. T.M.Khan Road 220 kV 3. Jhimpir-2 220 kV 4. Sinowell 20 kV 5. Jhimpir-1132 kV 6. T.M.khan 132 kV	all the bus bars recover after fault clearance	
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.14.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.14.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.14.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.14.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.14.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.14.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.14.8
• **MW Line Flow** • **MVAR Line Flow**	Jhimpir-1 to T.M.Khan Road 220 kV Single Circuit	Attains steady state value after damping of oscillations	8.14.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.14.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 500 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.14.11

8.2.15

Fault Type: 3-Phase
Fault Location: T.M.Khan 220 kV bus bar
Fault Duration: 5 cycles (100 ms)
Line Tripping: T.M.Khan to Jamshoro 220 kV Single Circuit

Variable	Bus/Line	Response	Figure No.
Voltage	1. T.M.Khan 220 kV 2. Jamshoro 132 kV 3. Jhimpir-1 220 kV 4. Jhimpir-2 220 kV 5. T.M.Khan 132 kV 6. Sinowell 132 kV	The voltages of all the bus bars recover after fault clearance	8.15.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.15.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.15.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.15.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.15.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.15.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.15.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.15.8
• **MW Line Flow** • **MVAR Line Flow**	Jhimpir-1 to T.M.Khan 220 kV Single Circuit	Attains steady state value after damping of oscillations	8.15.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.15.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 500 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.15.11

8.2.16

Fault Type: 1-Phase			
Fault Location: Jhimpir-2 220 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Jhimpir-1 to KDA-33 220 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. T.M.Khan 220 kV 2. Jamshoro 132 kV 3. Jhimpir-1 220 kV 4. Jhimpir-2 220 kV 5. T.M.Khan 132 kV 6. Sinowell 132 kV	The voltages of all the bus bars recover after fault clearance	8.16.1
Frequency	Sinowell 132 kV	Recovers after fault clearance	8.16.2
• **Plant MW Output** • **Plant MVAR Output**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.16.3
• **Speed** • **Pmechanical**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.16.4
• **Torque** • **Pitch Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.16.5
• **Paero** • **Shaft Twist Angle**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.16.6
• **Turbine Rotor Speed Deviation** • **Generator Speed Deviation**	Sinowell Collector Group-1 0.7 kV	Recovers	8.16.7
• **Pitch control** • **Pitch compensation**	Sinowell Collector Group-1 0.7 kV	Recovers after damping down oscillations	8.16.8
• **MW Line Flow** • **MVAR Line Flow**	Jhimpir-1 to T.M.Khan 220 kV Single Circuit	Attains steady state value after damping of oscillations	8.16.9
• **MW Output** • **MVAR Output**	Tricom 132 kV	Recovers after damping down oscillations	8.16.10
Rotor Angles	1. Kotri GTPS 132 kV 2. Thatta132 kV 3. Lakhra 132 kV 4. Nooriabad 132 kV 5. Hub 500 kV 6. Guddu-New (Reference)	Damps down quickly and attain a steady state value	8.16.11

8.5 Conclusion of Stability Study

The transient stability analysis performed as discussed above indicates that the NTDC system connecting to Sinowell WPP through the proposed scheme of interconnection is strong enough to absorb the worst disturbances on either side i.e. on Sinowell WPP side or the Grid side.

There are no constraints of connecting Sinowell WPP with the NTDC grid in terms of transients or dynamic behavior of system under the disturbed conditions either on the Farm side or on the Grid side.

9- Power Quality

The issues of power quality are of particular importance to wind turbines that may cause flicker and distortions in the power supply due to harmonics and unbalance. These issues are more significant for weak systems of low short circuit strength. Therefore we have investigated these issues for the case of minimum short circuit of 2019 for the proposed scheme of interconnection. The same case has been re-

evaluated with per unit MVA values and plotted for 3-phase faults in Exhibits 7.1.1 and 7.1.2 in Appendix-7

9.1 Flicker

We have used IEC61400-21 for the calculations of flicker levels for steady-state continuous operation and for switching conditions [1].

9.1.1 Continuous Operation

The probability of 99th percentile flicker emission from a single wind turbine during continuous operation for short time $P_{st\Sigma}$ and longer time flicker levels $P_{lt\Sigma}$ are assumed same and calculated by the following formula

$$P_{st\Sigma} = P_{lt\Sigma} = \frac{1}{S_k} \cdot \sqrt{\sum_{i=1}^{N_{wt}} (c_i(\psi_k, v_a) \cdot S_{n,i})^2}$$

where

$c(\psi_k, v_a)$ is the flicker coefficient of the wind turbine for the given network impedance phase angle, ψ_k at the PCC, and for the given annual average wind speed, v_a at hub-height of the wind turbine at the site;

S_n is the rated apparent power of the wind turbine;

S_k is the short-circuit apparent power at the PCC.

N_{wt} is the number of wind turbines connected to the PCC.

PCC is the point of common coupling of WTGs that is MV bus of Sinowell Farm substation.

For minimum short circuit case we have assumed the same case as discussed in paragraph 7.1.1.2 of Chapter 7 in which output of Sinowell Wind farm reduced from full rated capacity. Therefore taking one collector group as one equivalent generator of 6 x 2 = 12 MW we have calculated as follows;

S_n= 2.22MVA at 0.90 PF (For 1 WTG)

N_{WT} = 6

S_k for MV bus = 600 MVA

The value of c (ψ_k) at 10 minute average speed (v_a) is supplied by the manufacturer after filed measurements of $P_{St,\ fic}$ for different operating conditions using the following formula.

$$c(\psi_k) = P_{st,fic} \cdot \frac{S_{k,fic}}{S_n}$$

where

S_n is the rated apparent power of the wind turbine;

$S_{k,fic}$ is the short-circuit apparent power of the fictitious grid.

The value of c (ψ_k) may not be greater than 1, therefore for the present analysis we may assume it as 1 for the worst case.

Putting this data in the above Equation, we find

$P_{St\Sigma} = P_{It\Sigma} = 0.009063 = 0.9063\ \%$

Whereas the acceptable value is 4 % as mentioned in Ref. [2]. Therefore we are much less than the maximum permissible level and the WTGs at Sinowell Wind farm would not cause any flicker problem during steady state operation even in the weakest system conditions of minimum short circuit level.

9.1.2 Switching Operation

The most common switching operations would be as follows;

a. Wind turbine start-up at cut-in speed
b. Wind turbine start-up at rated wind speed
c. The worst case of switching between the WTGs

The flicker emission from the wind farm of many machines can be calculated by the following equation as per IEC61400-21 (Section 8.3.2)

$$P_{st\Sigma} = \frac{18}{S_k} \cdot \left(\sum_{i=1}^{N_{wt}} N_{10,i} \cdot \left(k_{f,i}(\psi_k) \cdot S_{n,i} \right)^{3,2} \right)^{0,31}$$

$$P_{lt\Sigma} = \frac{8}{S_k} \cdot \left(\sum_{i=1}^{N_{wt}} N_{120,i} \cdot \left(k_{f,i}(\psi_k) \cdot S_{n,i} \right)^{3,2} \right)^{0,31}$$

where

$N_{10,i}$ and $N_{120,i}$	are the number of switching operations of the individual wind turbine within a 10 min and 2 h period respectively;
$k_{f,i}(\psi_k)$	is the flicker step factor of the individual wind turbine;
$S_{n,i}$	is the rated power of the individual wind turbine.

The values of N_{10} and N_{120} are usually provided by the manufacturers based on field measurements, but if these are not available then IEC61400-21 proposes in section 7.6.3 to use as follows;

For switching conditions of (a) and (b)

$N_{10} = 10$

$N_{120} = 120$

For switching conditions of (c)

$N_{10} = 1$

$N_{120} = 12$

The value of flicker step factor $k_{f,i}$ (ψk) is also provided by the manufacturer after the field and factory measurements; but for the present analysis we assume it to be equal to 1.

Substituting the numbers in the above equations, we find for switching conditions of (a) and (b) as follows;

$P_{St\Sigma} = 0.210829$

$P_{lt\Sigma} = 0.202439$

For switching conditions of (c) these values would be less as the frequency of occurrence assumed i.e. N_{10} and N_{120} are 10 times less.

Engineering Recommendation P28 (Electricity Association, 1989) specifies an absolute maximum of P_{St} on a network from all sources to be 1.0 with a 2 hour P_{St} value of 0.6. However, extreme caution is advised if these limits are approached as the risk of complaints increases when the limits are reached, therefore, an assessment method proposed in the same document is based on P_{St} not exceeding 0.5. British Standard (1995) is less stringent specifying that over a one week period

P_{lt} must be less than 1 for 95 % of the time. Gardner (1996) describes P_{st} limits from a number of utilities in the range of 0.25 to 0.5 [2].

The values evaluated above are less than the values recommended in the references of above standards.

9.2 Voltage Unbalance

9.2.1 Voltage Step-Change

The voltage step change would occur when a WTG will be energized, assuming just one WTG in the collector for the minimum No. of units in the collector being energized.

The limit on the voltage change is based on the impedance of the circuit between the point of connection and the MV transformer bus bar together with the apparent power of the wind turbine generators. The following equation needs to be satisfied [2];

$$\Delta V = \sum S_{WKA} [(1/S_{KE}) - (1/S_{KSS})] \leq 1/33 \text{ or } 3\ \%$$

Where

S_{WKA} = MVA rating of the WTG

S_{KE} = Short circuit MVA at connection point

S_{KSS} = Short circuit MVA at MV bus of the wind farm substation

For the minimum short circuit case, we have calculated minimum fault levels in MVA as shown in Exhibit 7.1.2

S_{WKA} = 2.22MVA for the equivalent WTG of a collector group for the minimum case

S_{KE1} for one WTG in collector group = 390 MVA (Exhibit 7.1.2)

S_{KSS} = 570 MVA (Exhibit 7.1.2)

Substituting these values we get

$$\Delta V = 0.001797571 = 0.1797571\ \%$$

Which is much less than the limit of 3 %

9.2.2 Voltage Fluctuation

For the limits of voltage fluctuation, we need to satisfy the following equation [2].

$$\sqrt{\sum} (P_{WKA} / S_{KE})^2 \leq 1/25 \text{ or } 4\ \%$$

Where

P_{WKA} = MW rating of the WTG

S_{KE} = Short circuit MVA at connection point

Punching all the numbers in this equation, we get

Voltage Fluctuation = 0.008064516 = 0.80645 %

Which is less than the maximum permissible specified as 4 %.

10- Conclusions & Recommendations

- Interconnection Study has been carried out for 50 MW Sinowell WPP which is proposed to be placed in the loop at Jhimpir-1 220/132 kV collector substation. The scheme of interconnection of these 15 new WPPs including Sinowell WPP proposes the following reinforcements in place at Jhimpir cluster.
  - 220 kV D/C transmission line approx. 5km long on twin bundled Greeley conductor looping In/out of second circuit of existing Jamshoro – KDA-33 D/C transmission line at the proposed Jhimpir-2 220/132 kV substation
  - Addition of 4th 220/132 kV transformer at the newly proposed Jhimpir-2 220/132 kV substation.
  - 132kV double circuit transmission line approx. 135 km long on twin bundled Greeley conductor for connecting 8 WPPs in the first loop to Jhimpir-2 220/132 newly proposed substation.
  - 132kV double circuit transmission line approx. 168 km long on twin bundled Greeley conductor for connecting 8 WPPs in the second loop to Jhimpir-2 220/132 newly proposed substation.
  - In this Integrated study, the interconnection of Sinowell WPP includes 132 kV D/C transmission line approx. 5.5 km long, on Greeley conductor for looping in/out on the 132kV single circuit from T.M.Khan to TRICOM WPP grid station.
- The existing grid system of HESCO and NTDC in the vicinity of Sinowell WPP has been studied in detail by performing load flow, short circuit and dynamic analysis for the conditions prior to commissioning of Sinowell WPP and no bottlenecks or constraints have been found in the grid system.
- Wind Farm of Sinowell has been modeled considering Type-4 WTGs. The terminal voltage is 0.7 kV. The medium voltage level of wind farm has been selected as 35 kV for unit step-up transformers, for collector circuits and step-up from MV to HV (132 kV) at Farm substation to connect to the Jhimpir-1 220/132 kV grid station of NTDC.

- The design of scheme of 132/35 kV substation of Sinowell Wind Farm has been provided by the Client and is attached in Appendix – 2.
- Load flow analysis has been carried out for peak and Off Peak scenarios of August/September 2019 considering the COD targeted by Sinowell WPP and a future scenario of 2022, for the dispersal of power from Sinowell WPP into NTDC system using the latest load forecast, generation and transmission expansion plans of NTDC and HESCO. The above mentioned interconnection scheme has been evolved by performing the load flow studies testing the steady state performance for normal as well as N-1 contingency conditions fulfilling the Grid Code criteria of Wind Power Plants. The reactive power requirement at point of common coupling to meet PF of ± 0.95, voltage and line loading criteria are fulfilled by these studies. All the scenarios have been studied by considering maximum dispatch from all the existing/planned WPPs in the Jhimpir and Gharo Clusters.
- For the base case of summer 2019, capacity constraint was observed in 500kV network emanating from Jamshoro and upwards in case of some critical outages of 500kV circuits. Due to this capacity constraint, partial curtailment in the output of all WPPs under study was proposed to bring the loading on the 500kV network within limit. Hence output of Sinowell WPP is curtailed to 7MW in case of some contingency events. For the future scenario of 2022, this issue of capacity constraint is resolved due to the following major reinforcements:
    - 660kV HVDC from Matiari to Lahore
    - 660kV HVDC from Port Qasim to Faisalabad West
- With the proposed reinforcements highlighted earlier and the curtailment process for the base year of 2019 under special circumstances, the load flow results for peak and Off Peak scenarios establish that the proposed scheme of interconnection of Sinowell WPP shows no bottlenecks or capacity constraints in the adjoining 500 kV, 220 kV and 132 kV network in terms of absorbing all the output of Sinowell WPP and other proposed WPPs under normal as well as the contingency conditions.

- Maximum and minimum short circuit levels for three-phase faults and single-phase faults have been evaluated. The maximum SC levels have been evaluated for the year 2022 and minimum short circuit level for the year 2019 for the most stringent conditions. The fault levels of Sinowell 132 kV are 8.36 kA and 7.58 kA for 3-phase and single phase faults respectively for 2022. This is much less than the switchgear rating of 40 kA recommended for Sinowell Farm Substation as per NTDC requirements for 132 kV. The fault levels for Sinowell 35 kV are 15.01 kA and 16.37 kA for 3-phase and single-phase faults respectively for year 2022. Therefore the short circuit rating for 35 kV switchgear is recommended as 25 kA. It has been found that the proposed scheme provides maximum SC strength for the evacuation of Sinowell WPP power to the grid.

  The switchgear ratings for Sinowell WPP substation are as follows:

  132 kV:

  Short circuit rating = 40 kA (3 sec.)

  Continuous rating = 2500 A

  35 kV:

  Short circuit rating = 25 kA (3 sec.)

  Continuous rating = 2500 A

- Transient Stability analysis has been carried out for Sino Well WPP based on their selection of Type-3 WTGs, with connectivity of proposed scheme. Different disturbances have been simulated to apply stresses from the system faults on the wind farm and vice versa and it was found that Sino Well WTG unit's dynamic characteristics and the grid connectivity is strong enough to maintain stability under all disturbances. In turn, any disturbance from Sino Well WPP side did not cause any stress on the main grid or the power plants nearby and in the HESCO area such that the whole system remained stable under all events.
- The LVRT requirements have been tested to fulfill 100 ms (5 cycles) under normal clearing time and 180 ms (9 cycles) for contingency condition of delayed fault clearing due to stuck-breaker (breaker failure) reason. The simulations have

proved that the proposed machine fulfills the LVRT criteria as required in the Grid Code for Wind IPPs.

- The issues of power quality like flicker, unbalance and harmonic resonance have been studied in detail. The results have indicated that the levels of flicker and unbalance are within the permissible limits of IEC and other International Standards.
- There are no technical constraints whatsoever in the way of bringing in the 50 MW of Sinowell Wind Power Plant at the proposed site and scheduled time of commissioning, in any respect of steady state (load flow) or short circuit or dynamic performance (stability) or power quality issues related to this plant.

THE COMPANIES ORDINANCE, 1984

(A Company Limited by Shares)

MEMORANDUM

OF

ASSOCIATION

SINO WELL (PRIVATE) LIMITED

THE COMPANIES ORDINANCE, 1984

(A Company Limited by Shares)

MEMORANDUM OF ASSOCIATION

OF

SINO WELL (PRIVATE) LIMITED

I. The name of the company is SINO WELL (PRIVATE) LIMITED.

II. The Registered office of the company will be situated in the province of Sindh.

III. The main and exclusive object for which the company is established is to set up an industrial undertaking in power sector to carry on the business of electric power generation, accumulation, transmission and distribution thereof in all its branches and aspects by the use of such forms of energy and in such manner as may be deemed feasible for that purpose. To achieve the main and exclusive object the Company shall be authorized:

1. To market, sell, transmit and deliver the electric power generated by the Company any where in Pakistan.

2. To arrange for buying all kinds of plant and machinery, equipments, tools and other raw material, whether local or imported, on cash, loan, deferred credit, pay-as-earn or non-repatriable investment basis.

To acquire by purchase, exchange, hire, assignment or otherwise, tenements, buildings, easements, rights, advantages, moveable and immoveable property of any kind whatsoever, machinery, trade marks, patents or inventions, or other properties, plants and stock-in-trade and to employ, sell, exchange, mortgage, get on lease, license to use or otherwise.

4. To purchase, or acquire by some other means, any land or lands and build, erect, construct, furnish, equip, maintain or improve any building, structure and edifice and to carry on construction thereof for the purposes of the Company.

5. To arrange electricity, water, gas, sewerage and other utilities required for efficient running of the project.

6. To appoint agents, sub-agents, attorneys, consultants, brokers and contractors in connection with the business of the Company but not to act as managing agents.

7. To adopt such means of making known the product of the Company as may seem expedient, and in particular by advertising in the press and electronic media, by circulars, by purchase and exhibition of works of art or interest, by publication of books and periodicals, and by rewards, stipends and donations.

8. To enter into any arrangement with any governments or authorities (Federal, Provincial, Municipal, Local or otherwise), or any corporations, companies, firms or persons that may seem conducive to the Company's exclusive object, and to obtain from any such government, authority, corporation, company, firm or person any charters, contracts, decrees, rights, privileges and concessions which the Company may think desirable, and to carry out, exercise and comply with any such charters, contracts, decrees, rights, privileges and concessions.

9. To sell or otherwise dispose off all goods, materials, articles and things belonging to the Company either on cash or on credit and either for immediate or future delivery and to send the same for sale or export to any place that may be deemed necessary or expedient, in the event of winding up of the Company.

10. To get insured against losses, damages, risks, accidents and liabilities of all kinds which may affect the company whether in respect of its contracts, agreements, advances or securities or in respect of servants or employees of the company, or in respect of property belonging to or leased to or hired by the company, either by setting apart funds of the company or by effecting such insurance.

11. To open, close and operate bank accounts with scheduled banks or financial institutions and to draw, make, accept, endorse, discount, execute and issue promissory notes, bills of exchange, cheques, bills of lading, warrants, debentures and other negotiable or transferable instruments, concerning the business of this Company.

12. To borrow or procure on mark-up, profit or return in any form, money or finances, in local or any foreign currency from any bank or financial institution and to receive money on mark-up by issuing debentures, and on security of any such money so borrowed or received to mortgage, pledge, charge or hypothecate whole or any part of property, assets or revenue of the Company (both present and future) including its capital by special assignment or otherwise, to transfer or convey the same conditionally, absolutely or in trust and to give, tender power to sell and other powers as may seem expedient, and to purchase or redeem such securities and pay for such borrowing and loans for the purpose of achieving the main and exclusive object.

13. To procure or arrange finances from scheduled banks and financial institutions under any mode of Islamic financing scheme like, redeemable capital including modaraba and musharaka and to procure, raise or secure the money in such manner as the company may deem fit and particularly by mortgage of its property in full or in part on both the present and future assets in accordance with the Islamic Laws and/or by the issue of shares, bonds, debentures, participation term certificates, Term Finance Certificates, or redeemable capital or any other securities charged or based upon the undertaking of the company, on any part of its property, both present and in future and generally to borrow money for achievement of the main and exclusive object of the company in such manner as the company shall deem fit. To issue debentures or participation term certificates, term finance certificates, redeemable capital, either permanent or redeemable or repayable or convertible into shares and to secure any securities of the company by a trust or other assurances.

14. To distribute any of the property of the Company amongst the members in specie or kind and in particular any shares, debentures or securities of other companies belonging to this Company, or of which this Company may have the power of dispose of, in the event of winding up of the Company.

15. To create any depreciation fund, provident fund, reserve fund, sinking fund, insurance fund, or any other special fund conducive to the interest of the company.

16. To establish and maintain branches, receiving offices and distribution centers and to enter into contracts or agency agreements (other than managing agency) with any other persons or firms or companies or for the distributing centers for achievement of the main and exclusive object of the company.

To undertake and execute any trusts which the Company may think fit and expedient to undertake for the benefit of the employees.

18. To apply for, purchase, or other wise acquire, and protect and renew any patents, patent rights, trade marks, designs, licenses, concessions and the like, conferring any exclusive or non-exclusive or limited right to their use.

19. To train personnel and workers, in Pakistan and/or abroad, to obtain technical proficiency in various specialties connected with the business of the Company.

20. To give any indemnity, guarantee or security or enter into any bond and, without restricting the generality of the foregoing, to indemnify any person or company, and guarantee or otherwise become liable for the performance by any person or company of any obligation, contract or undertaking as may be required in connection with the business.

21. To carry on any other business or activity and do any act or thing which in the opinion of the Company is or may be capable of being conveniently carried on or done in connection with the objects of the Company and or any of the above powers, or likely directly or indirectly to enhance the value of or render more profitable all or any part of the Company's property or assets or otherwise to advance the interests of the Company or its members.

22. To carry out joint venture agreements with other companies or countries within the scope of the objects of the Company.

23. To amalgamate, merge with, absorb, reconstruct, de-merge, acquire or take over any other company or the whole or part of any undertaking having objectives altogether or in part similar to those of the Company or carrying on any business capable of being conducted so as directly or indirectly to benefit this Company, whether by sale or purchase of the assets, property or undertaking, or divestiture of the whole or part of the undertaking of the company or by partnership or any arrangement in the nature of partnership or in any other manner or to enter into and carry into effect any arrangement, or for sharing of profits, with any partnership undertaking or person carrying on business within the objects of this Company.

24. To do and perform all other acts and things as are incidental or conducive to the attainment of the above objects or any of them.

25. It is hereby, undertaken that the Company shall not engaged in banking business or Forex, illegal brokerage, or any business of investment company or non-banking finance company or insurance or leasing or business of managing agency or in any unlawful business and that nothing contained in the object clauses shall be so construed to entitle it to engaged in such business directly or indirectly and the Company shall not launch multi-level marketing (MLM), pyramid and Ponzi schemes.

26. Notwithstanding anything stated in any object clause, the Company shall obtain such other approval or licence from the competent authority, as may be required under any law for the time being in force, to undertake a particular business.

IV. The liability of the Members is limited.

V. The authorized share capital of the Company is Rs. 100,000 (Rupees One Hundred thousand only) divided into 10,000 (Ten Thousand) ordinary shares of Rs. 10 (Rupees Ten) each with powers to increase and reduce the capital of the Company in such manner as may be consistent with the provisions of the Companies Ordinance, 1984.

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

Name and surname (present and former in full and block letters)	Father's/Husband's name in full	Nationality with any former Nationality if any	Occupation	Residential address	Number of shares taken by each subscriber	Signature
MR. TABISH TAPAL CNIC No. 42301-2385059-9	Mr. Moiz Ali Tapal	Pakistani	Business	33-B, 3rd Gizri Street, Phase IV, D.H.A., Karachi	500 (Five Hundred)	
MR. MUHAMMAD SADIQ TAPAL CNIC No. 35201-2785819-5	Mr. Tajwar Tapal	Pakistani	Business	73/6A, Munir Road, Lahore, Pakistan	499 (Four Hundred Ninety Nine)	
MR. MUSTAFA LAKDAWALA CNIC No. 42201-3140375-9	Mr. Abid Hussain Lakdawala	Pakistan	Service	House No. 14/A Overseas Cooperative Housing Society, Block-7 & 8, Off Amir Khusroo Road, Karachi	1 (One)	
Total					1000 (One Thousand)	

Dated this 2nd day of June 2016

Witness to the above Signatures:

Name

National Institutional Facilitation Technologies (Pvt) Ltd

Full Address

5th Floor AWT Plaza I. I. Chundrigar Road
Karachi

Certified to be True Copy
29/10/2018
Deputy Registrar of Companies

Securities and Exchange Commission of Pakistan * Company Registration Office Karachi *

THE COMPANIES ORDINANCE, 1984

(A Company Limited by Shares)

ARTICLES

OF

ASSOCIATION

SINO WELL (PRIVATE) LIMITED

THE COMPANIES ORDINANCE, 1984

(COMPANY LIMITED BY SHARES)

ARTICLES OF ASSOCIATION

OF

SINO WELL (PRIVATE) LIMITED

PRELIMINARY

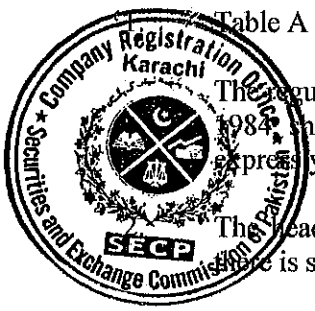


Table A not to apply

The regulations contained in the Table 'A' in the First Schedule to the Companies Ordinance 1984 shall not apply to the Company except so far as the same are repeated, contained or expressly made applicable in these Articles or by the Ordinance.

The headings hereto shall not affect the construction hereof and in these presents, unless there is something in the subject of context for the time being in force.

i) '*The Ordinance*' means the Companies Ordinance, 1984 or any statutory modification or re-enactment thereof for the time being in force;

ii) '*The Articles*' means the Articles of Association as originally framed or as from time to time altered by Special Resolution;

iii) '*The Company*' means SINO WELL (PRIVATE) LIMITED;

iv) '*Special Resolution*' has the same meaning as assigned thereto by Section 2(1)(36) of the Ordinance;

v) '*Member*' means member of the Company in accordance with the provisions of

Section 2(1)(21) of the Ordinance.

vi) '*The Directors*' means the Directors, including alternate director for the time being of the Company.

vii) '*The Chief Executive*' means the Managing Director of the Company, by whatever name called, appointed pursuant to Section 198 of the Ordinance.

viii) '*The Board*' means the Board of Directors for the time being.

ix) '*The Secretary*' means the Secretary for the time being of the Company.

x) '*The Register*' means the Register of Members to be kept pursuant to Section 147 of the Ordinance.

xi) '*The Office*' means the Registered Office for the time being of the Company.

xii) '*Dividend*' includes bonus shares.

xiii) '*Seal*' in relation to a Company means the Common Seal of the Company.

xiv) '*Month*' means calendar month.

xv) '*Proxy*' includes an attorney duly constituted under a power of attorney.

xvi) '*The Registrar*' means a Registrar, an Additional Registrar, a Joint Registrar, a Deputy Registrar or an Assistant Registrar of Companies.

xvii) '*In Writing and Written*' includes printing, lithography, typewriting and other modes of representing or reproducing words in a visible form.

xviii) Words importing the singular number shall include the plural number and vice versa.

xix) Words importing the masculine gender shall include the feminine gender.

xix) '*Person*' includes Corporations.

xxi) '*Family Members*' mean and include Parents, Husband, Wife, Sons and Daughters.

3. Unless the context otherwise requires or unless expressly defined words or expressions contained in these Articles shall bear the same meaning as in the Ordinance or any statutory modification thereof in force at the date at which these present are binding on the Company.

BUSINESS

4. The business of the Company shall be the main and exclusive object provided in the Memorandum of Association.

CAPITAL

5. The authorized share capital of the Company is Rs. 100,000 (Rupees One Hundred Thousand only) divided into 10,000 (Ten Thousand) ordinary shares of the nominal value of Rs. 10 (Rupees Ten) each.

The share capital of the Company may comprise of different classes of shares, issued from time to time, including ordinary shares, cumulative and non-cumulative preference share, and shares having different rights and privileges attached to them, subject to requirement and conditions mentioned in Companies Share Capital (Variation in Rights and Privileges) Rules, 2000. Subject to the aforesaid, shares of different classes and kinds may have different rights and privileges attached to them, however all shares of a particular class shall have same rights and privileges attached to them.

SHARES

6. The Company shall not issue partly paid shares.

7. Except to the extent and in the manner allowed by Section 95 of the Ordinance, no part of the funds of the Company shall be employed in the purchase of, or in loans upon the security of, the Company's shares.

8. The Directors may increase the share capital by such sum as they think fit, to be divided into shares of such amount as the resolution may prescribe, subject, nevertheless, to the provisions of Section 92 of the Ordinance.

9. Where the Directors decide to increase the Issued Capital of the Company by the issue of ordinary or preference shares, either at a premium or at par, such shares, shall be offered on such terms and conditions and for such consideration, and at such times as the directors deem fit, to the members in proportion to the existing shares held by each member and such offer shall be made by notice specifying the number of shares to which the member is entitled and limiting a time within which the offer, if not accepted, will be deemed to be declined; and after the expiration of such time or on receipt of an intimation from the member to whom such notice is given that he declines to accept the shares offered, the directors may dispose of the same in such manner as they think most beneficial to the Company.

10. The Company may at any time pay commission to any person for subscribing or agreeing to subscribe (whether absolutely or conditionally) for any shares, debentures or debenture stock of the Company, or procuring or agreeing to procure subscriptions (whether absolutely

or conditionally), for any shares, debentures, debenture stock of the Company, but if the commission in respect of shares shall be paid or payable out of capital, the conditions and requirements laid-down in Section 82 of the Ordinance shall be observed. The amount or rate of commission shall not exceed any statutory limit thereon. The commission may be paid or satisfied in cash or in shares, debentures or debenture-stock of the Company.

11. Any capital raised by the creation of new shares, subject to the capital structure stipulated in these present shall be considered part of the original capital and shall be subject to the provisions herein contained with reference to the payment, transfer and transmission, surrender, voting and otherwise.

12. The Company may from time to time by Special Resolution reduce its share capital in any way and in particular (without prejudice to the generality of the power) by paying off capital or canceling capital which has been lost or is unrepresented by available assets or reducing the liability on the share or otherwise as may seem expedient and capital may be paid off which is in excess of the needs of the Company or otherwise, and paid up capital may be cancelled as aforesaid without reducing the nominal amount of the shares by the like amount to the extent that the capital shall be increased by the like amount.

13. Save as herein otherwise provided, the Company shall be entitled to treat the registered holder of any share as the absolute owner thereof and accordingly shall not, except as ordered by a court of competent jurisdiction, be bound to recognize any equitable, contingent or partial interest in or any other right in respect of such share on the part of any other person.

14. Shares may be registered in the name of any limited Company or other corporate body but not in the name of a firm. Not more than four persons shall be registered as joint holders of any shares.

15. If any share stands in the name of two or more persons, the person first named in the Register shall, as regards receipt of dividend or bonus or service of notice, and all or any other matters connected with the Company except voting at the meeting and the transfer of shares, be deemed the sole holder.

16. In the case of the death of any one or more of the persons named in the Register as the joint-holder of any share, the survivor or survivors shall be the only person or persons recognized by the company as having any title to or interest in such share, but nothing herein contained shall be taken to release the estate of a joint holder from any liability.

17. Every shareholder shall name to the Company a place in Pakistan to be registered as his address and such address shall for all purposes be deemed to be his place of residence.

18. Subject to the provisions of Section 92 of the Ordinance the Company may by Special Resolution:

    a) consolidate and divide the whole or any part of its share capital into shares of larger amount than its existing shares;

b) sub-divide its shares or any of them into shares of smaller amount than is fixed by the Memorandum of Association;

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

The Resolution by which any share is sub-divided or consolidated may determine that as between holders of shares resulting from sub-division or consolidation, rights of profits, votes and other benefit attaching to them will be proportionate to their paid up value and where shares issued as sub-divided or consolidated shares are of same class as those previously issued that rights attaching to them, subject as aforesaid, shall be the same as those attaching to the shares previously held.

19. Subject to the provisions of the Ordinance and these Articles, the Directors may allot and issue shares in the capital of the Company as payment or part payment of any property, sold or transferred, discharge of any indebtedness or obligations of the company, goods or machinery supplied or for services rendered to the Company in or about the formation or promotion of the Company or conduct of its business, and any shares which may be sold or allotted may be issued as fully paid-up shares, and, if so issued, shall be deemed to be fully paid up shares

CERTIFICATE

20. Every person whose name is entered as Member in the Register shall without payment be entitled to receive, after allotment or registration of transfer, one certificate for all his shares or several certificates each for one or more of his shares and upon payment of such charges, if any, as the Directors may determine for every certificate after the first.

21. The certificates of title of share and duplicates thereof when necessary shall be issued under the seal of the Company and signed by two Directors, or by one Director and the Secretary.

22. The Company shall not be bound to issue more than one share certificate in respect of a share or shares held jointly by two or more persons, and delivery of a certificate for a share to any one of joint holders shall be sufficient delivery to all.

23. The Company shall, within ninety days, after the allotment of any of its shares, and within 45 days after the date on which the instrument of transfer has been lodged, complete and have ready for delivery the certificates of all shares, allotted or transferred, unless the conditions of issue of the shares otherwise provide.

24. If any certificate be worn out, defaced, destroyed or if there is no further space on the back thereof for endorsement of transfer, it may be renewed or replaced on payment of such sum, not exceeding five Rupees, as the Directors may from time to time prescribe; provided, however, that such new certificate shall not be granted except upon delivery of the worn out or defaced or used up certificate for the purpose of cancellation or upon proof of destruction or loss to the satisfaction of the Directors and on such indemnity as the Directors may deem

adequate in case of certificate having been lost or destroyed. Any renewed certificates shall be marked as such.

TRANSFER AND TRANSMISSION OF SHARES

25. In the event of sale or transfer of shares as permitted under the Ordinance, the transferee of shares shall, if not already a member become a member and shall be bound by the terms of the Articles in the same manner and to the same extent as the transferor of shares.

26. A share may, subject to the provisions of Section 76 of the Ordinance, at any time be transferred, by a Member or other person entitled to transfer, provided it is approved by the Board in accordance with the provisions contained in these present

27. If the Directors refuse to register the transfer of any shares they shall within one month from the date on which the transfer was lodged with the Company send to the transferee and the transferor notice of such refusal indicating the defect or invalidity to the transferee, who shall, after removal of such defect or invalidity, be entitled to re-lodge the transfer deed with the Company. No transfer of shares in any case be made to an insolvent or person of unsound mind.

28. The transfer of shares shall be effected by an instrument in writing in the usual common form modified so as to suit the circumstances of the parties and shall be executed both by the transferor and the transferee and duly stamped according to law, whose execution be attested by at least one witness, who shall add his address and occupation, and the transferor shall be deemed to remain the holder of such shares until the name of transferee shall have been entered in the Register of members in respect hereof.

29. Every instrument of transfer shall be left at the office for registration, duly stamped and accompanied by the certificate of the shares to be transferred and such other evidence as the Company may require to prove the title of the transferor or his right to `transfer the shares'. All instruments of transfer which will be registered shall be retained by the Company, but any instrument of transfer which the Directors may decline to register shall, on demand, be returned to the person depositing the same.

30. Where it is proved to the satisfaction of the Directors that an instrument of transfer signed by the transferor and the transferee has been lost, the Company may, if the Directors shall think fit, by an application in writing made by the transferee and bearing the stamp required by an instrument of transfer, register the transfer on such terms as to indemnity as the Directors may think fit.

31. Nothing contained in Articles 26 and 29 shall prejudice any power of the Company to register as shareholder any person to whom the right to any shares of the Company has been transmitted by operation of law.

32. No fee will be charged for registering transfer of shares.

33. The transfer books and register of members may be closed for any time or times not exceeding in the whole forty five days in each year, but not exceeding thirty days at a time, in accordance with the manner specified in Section 151 of the Ordinance.

34. The nominees of a deceased member as specified in Section 80 of the Ordinance, or executors or administrators of a deceased member shall be the only persons recognized by the Company as having title to his share except in case of joint holders in which case the surviving holders or the executors or administrators of the last surviving holder shall be the only person entitled to be so recognized; but nothing herein contained shall release the estate of a deceased joint holder from any liability in respect of any share jointly held by him. The Company shall not be bound to nominee of deceased member or executor or administrator unless he shall have obtained probate or letters of administration or other legal representation, as the case may be, from a duly constituted court in Pakistan or from any court or authority authorized by any Act of the legislature or by any order or notification of the Federal or Provincial Government, to grant such probate or letters of administration. Provided nevertheless that in special cases, and in such cases only, it shall be lawful for the Directors to dispense with the production of probate or letters of administration or such other legal representation upon such terms as to indemnity or otherwise as the Directors may deem fit.

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

36. Neither the Company nor its Directors shall incur any liability or responsibility whatsoever in consequence of their registering or giving effect to any transfer of shares made or purporting to be made by an apparent legal owner thereof to the prejudice of persons having or claiming any equitable right, title or interest to or in the same, notwithstanding that the Company may have had notice of such equitable right, title or interest, or notice prohibiting registration of such transfer, and may have entered such notice or referred thereto in any book of the Company and shall not be bound or required to attend or give effect to any notice which may be given to them of any equitable right, title or interest or be under any liability whatsoever for refusing or neglecting so to do, though it may have been entered or referred to in some book of the Company; but the Company shall nevertheless be at liberty to regard and attend to any such notice and give effect thereto if the Directors shall so think fit.

GENERAL MEETINGS

37. A general meeting, to be called Annual General Meeting, shall be held within eighteen months from the date of incorporation and thereafter once at least in each calendar year within a period of four (4) months following the close of its financial year at such time and place as the Directors may determine, provided, however, that no greater interval than

fifteen months shall be allowed to elapse between two Annual General Meetings. All general meetings of the Company other than Annual General Meeting shall be called Extraordinary General Meetings.

38. The Directors may, whenever they think fit, call an Extraordinary General Meeting and Extraordinary General Meeting shall also be called on the requisition of the holders of not less than 10% of the issued capital of the Company on the date of deposit of requisition, the directors shall forthwith proceed to convene an Extraordinary General Meeting of the Company and in case of such requisition, the provisions of Section 159 of the Ordinance shall apply.

39. If at any time sufficient number of directors capable of acting to form a quorum are not present in Pakistan, the directors may convene an extra ordinary general meeting in the same manner as nearly as possible in the manner in which the Meeting may be convened by the Directors

NOTICE OF MEETING

40. Subject to the provisions of Sections 158 and 159 of the Ordinance twenty-one days' notice at least (exclusive of the day on which the notice is served or deemed to be served, but inclusive of the day for which notice is given) specifying the place, the day the hour of meeting and, in case of special business the general nature of that business, shall be given in the manner provided by the Ordinance for the general meeting, to such persons as are under the Ordinance or the regulations of the Company, entitled to receive such notice from the Company. With the consent in writing of all the members entitled to receive notice of some particular meeting, that meeting may be convened by such shorter notice and in such manner as those members may deem fit.

41. The accidental omission to give notice of a meeting to or the non-receipt of notice of a meeting by, any member or person entitled to receive notice shall not invalidate the proceedings at any general meeting.

PROCEEDINGS AT GENERAL MEETINGS

42. The business of the Annual General Meeting shall be to receive and consider the balance sheet and profit and loss account, the reports of the Directors and of the Auditors, to elect Directors, to declare dividends and to appoint Auditors, and fix their remunerations. All other business transacted at an Annual General Meeting and all business transacted at Extraordinary General Meetings, shall be deemed special.

43. No business shall be transacted at any General Meeting unless a quorum of members is present at the time when the meeting proceeds to business. Subject to the provisions of the Ordinance, two (2) members present personally who represent more than [illegible] percent of the total voting power, either of their own account or as proxies shall be a quorum.

44. If within half an hour from the time appointed for the meeting, a quorum is not present, the meeting if called upon requisition of members shall be dissolved; in any other case it shall stand adjourned to the same day in the next week at the same time and place, and, at the adjourned meeting the quorum shall be two (2) members present in person.

45. The Chairman, if any, of the Board shall preside as Chairman at every General Meeting of the Company, but if there is no such Chairman, or if he shall not be present within fifteen minutes after the time appointed for the holding of the meeting or is unwilling to act, the Directors present shall elect one of the members present to be Chairman of the meeting, or if no Directors be present or if Directors present decline to take the chair, the members present shall choose one of their member to be Chairman of the meeting.

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

47. At a General Meeting a resolution put to the vote of the meeting shall be decided on a show of hands, unless a poll is (before or on the declaration of the show of hands) demanded in accordance with provisions of Section 167 of the Ordinance:

a) by the Chairman of the meeting of his own motion; or

(b) by one Member having the right to vote on the resolution and present in person or by proxy if not more than seven such members are personally present, and by two such Members present in person or by proxy if more than seven such Members are personally present; or

(c) by any Member or Members present in persons or by proxy and having not less than one-tenth of the total voting power in respect of the resolution; or

(d) by any Member or Members present in person or by proxy and holding shares in the company conferring a right to vote on the resolution, being shares on which an aggregate sum has been paid up which is not less than one-tenth of the total sum paid up on all the shares conferring that right.

48. Unless a poll is so demanded, a declaration by the Chairman of the meeting that a resolution has on a show of hands been carried or carried unanimously or by a particular majority, or lost, and an entry to that effect in the book containing the minutes of the proceedings of the Company shall be conclusive evidence of the fact without proof of the number or proportion of the votes recorded in favour of or against that resolution.

Any poll duly demanded on the election of a Chairman of a meeting or on any question of adjournment shall be taken at the meeting and without adjournment.

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

50. The demand of a poll shall not prevent the continuance of the meeting for the transaction of any business other than the question on which the poll has been demanded. The demand for a poll may be withdrawn at any time by the person or persons who made demand.

51. The Chairman of any meeting shall be the sole judge of the validity of every vote tendered at such meetings. The Chairman present at the time taking of a poll shall be the sole judge of the validity of every vote tendered at such poll.

52. The following matters shall be resolved only by Special Resolution of the Company in General Meeting.

a) Increase or reduction in the Authorized Share Capital;

b) Issue of debentures;

c) Sale or disposal or leasing out of a substantial part of the undertaking of the Company;

d) Sale of the whole of the undertaking of the Company;

e) Amendment to the Memorandum and Article of Association; and

f) the redemption or repurchase by the Company of outstanding shares of the Company to the extent so authorized by law.

VOTES OF MEMBERS

53. Subject to any rights or restrictions for the time being attached to any class or classes of shares, on a show of hands every member present in person or by proxy and every corporation present by proxy or by a representative duly appointed pursuant to Article 64 shall have one vote except for election of Directors in which case the provisions of Section 178 of the Ordinance shall apply. On a poll every member shall have voting rights as laid down in Section 160 of the Ordinance.

54. In the case of joint holders the vote of the senior member present whether in person or by proxy shall be accepted to the exclusion of the votes of the other joint holders; and for this purpose seniority shall be determined by the order in which their names stand in the Register.

55. A member of unsound mind, or in respect of whom an order has been made by any court having jurisdiction in lunacy, may vote, whether on a show of hands or on a poll, by his

committee or other legal guardian and any such committee or guardian may, on a poll, vote by proxy.

56. No member shall be entitled to vote at any General Meeting unless all sums presently payable by him in respect of shares in the Company have been paid.

57. No objection shall be raised to the qualification of any voter except at the meeting or adjourned meeting at which the vote objected to is given or tendered, and every vote not disallowed at such meeting shall be valid for all purposes. Any such objection made in due time shall be referred to the Chairman of the Meeting, whose decision shall be final and conclusive.

58. On a poll votes may be given either personally or by proxy or in the case of a corporation by a representative duly authorized in accordance with Article 64.

59. The instrument appointing a proxy shall be in writing under the hand of the appointer or of his attorney duly authorized in writing, or if the appointer is a corporation, under its common seal or the hand of an officer or attorney so authorized and in default the instrument of proxy shall not be duly authorized. A proxy need not be a member of the Company.

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

61. An instrument appointing a proxy may be in the following form:-

> I, the undersigned ..... of ..... being a member of Sino Well (Private) Limited hereby appoint Mr./Mrs./Miss .... of ..... or failing him/her .... of ..... as my proxy to vote for me and on my behalf at the Annual or Extraordinary (as the case may be) General Meeting of the Company to be held on the ..... day of ..... and at every adjournment thereof (or at every general meeting of the Company to be held before the ..... day of ..... and at every adjournment of any such meeting).
>
> **Signed this ..... day of.....**

The instrument appointing a proxy shall be deemed to confer authority to demand or join in demanding a poll.

A vote given in accordance with the terms of an instrument or proxy shall be valid notwithstanding the previous death or insanity of the principal or revocation of the proxy or of the authority under which the proxy was executed, or the transfer of the shares in respect

of which the proxy is given, provided that no intimation in writing of such death, insanity, revocation or transfer as aforesaid shall have been received by the Company at the office before the commencement of the meeting or adjourned meeting at which the proxy is used.

64. Subject to the provisions of Section 162 of the Ordinance, a company or other body corporate which is a member of the Company may by resolution of its Directors or other governing body authorize such person as it thinks fit, to act as its representative at any meeting of the Company or of any class of members of the Company, and the person so authorized shall be entitled to exercise the same power on behalf of the company which he represents as that company could exercise if it were an individual member of the Company present in person. A corporation or company attending a meeting through such representative shall be deemed to be present at the meeting in person.

DIRECTORS

65. The number of Directors to be elected shall be fixed, according to the provisions of Section 178 of the Ordinance, from time to time by the Board, subject to the condition that there shall not be less than two (2) directors nor more than ten (10) directors, and until otherwise determined by the Company by a Special Resolution in a general meeting, the number of Directors including the Directors nominated by the Company's creditors or other special interest by virtue of contractual obligation in accordance with the provisions of the Ordinance, shall not be more than ten (10), including the Chief Executive of the Company.

66. The following shall be the first Directors of the Company:

1. Mr. Tabish Tapal
2. Mr. Muhammad Sadiq Tapal
3. Mr. Mustafa Lakdawala

67. Except in the manner and to the extent provided for nomination in Article 65 hereof, the appointment, election, tenure of office and removal of directors shall be made and/or carried out in accordance with provisions of the Ordinance.

68. Save as provided in Section 187 of the Ordinance and Article 65 hereof, no person shall be appointed as a director unless he is a member of the Company.

69. The first directors shall stand retired at the first annual general meeting, and directors shall be nominated in accordance with Article 65 hereof, be elected in their place in accordance with Article 72 hereof.

70. Any person who seeks to contest an election to the office of Director shall, whether he is a retiring Director or otherwise, file with the Company, not later than fourteen days before the date of the meeting at which elections are to be held, a notice of his intention to offer

himself for election as a Director. Provided that any such person may, at any time, before the holding of elections withdraw such notice.

71. Retiring Directors shall be eligible for re-election.

72. The Directors shall be elected in accordance with the provisions of the Ordinance by the Members in General Meeting from amongst the candidates eligible for election in the following manner:

a) every member present in person or by proxy or by representative shall have such number of votes as is equal to the product of the number of voting shares held by him and the number of Directors to be elected;

b) the number of votes calculated in accordance with the preceding clause (a) may be given to a single candidate or may be divided between any two or more candidates in such manner as the person voting may choose; and

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

73. The Company in General Meeting may remove a Director from office by a resolution passed with the requisite number of votes determined in accordance with the provisions of Section 181 of the Ordinance.

74. Retiring directors shall continue to perform their functions until their successors are elected.

75. A Director elected by the members in General Meeting shall hold office for a period of three years following the date from which his election is effective unless he earlier resigns, becomes disqualified from being a Director or otherwise ceases to hold office.

76. A casual vacancy occurring among the elected Directors may be filled up by the directors, but a person so appointed in lieu of an elected Directors shall hold office for the remainder of term of the Director in whose place he is appointed.

77. When any director intends to be, or is absent for a period of not less than three (3) months from Pakistan, he may with the approval of the directors appoint any person to be his alternate director, and such alternate director during the absence of the appointer from Pakistan, shall be entitled to receive notice of and to attend and vote at meeting of directors and shall be subject to and entitled to the benefit of the provisions contained in these Articles with reference to directors and may exercise and perform all such powers, directions and duties as his appointer could have exercised or performed including the power of appointing another alternate director. An alternate director so appointed shall not be entitled to receive any remuneration from the Company nor be required to hold any qualification. Such appointment shall be recorded in the directors' minute book. A director may at any time by notice in writing to the Company remove an alternate director appointed

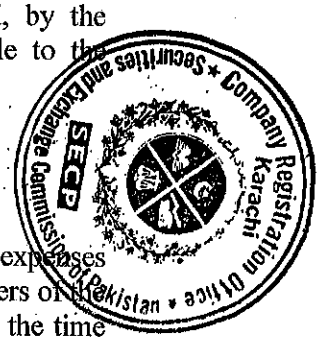
by him upon the return of the appointer to Pakistan, or the death of, or the retirement or resignation as director of the appointer, the alternate director shall cease to be such provided that if any director retires but is re-elected at the meeting at which such retirement took effect any appointment made by him pursuant to this Article which was in force immediately prior to this retirement and re-election and which has not otherwise ceased to be effective shall continue to operate after his re-election as if he had not so retired. An alternate director shall not be deemed to be the agent of the director appointing him but shall be reckoned as one with his appointer. All appointments and removals of alternate directors shall be effected by writing under the hand of the director making or revoking such appointment and left at the office. For the purpose of assessing a quorum in accordance with the provisions of Article 94 hereof an alternate director shall be deemed to be director. Any director may act an alternate director for any one or more directors, as well as being able to act as a director in his own right. An alternate director may resign as such upon giving thirty (30) days prior notice to the Board to this effect. An alternate director need not be a member of the Company.

78. The remuneration to be paid to any Director for attending meetings of the Board shall, from time to time, be determined by the Board of Directors. It shall not exceed Rs. 500 per meeting. The directors shall be paid such traveling expenses as may be fixed by the directors from time to time or in or about the performance of their duties as directors or if a director has to come to attend the Board meeting from outstation.

79. Any Director appointed to any executive office, including for purpose of this Article, the office of chief executive or chairman, who serves on any committee or who devotes special attention to the business of the Company or who otherwise performs extra services which in the opinion of the Board are outside the scope of the ordinary duties of a Director, may be paid such extra remuneration whether by way of salary, fees, percentage of profits or otherwise, as the Board may determine, which shall be charged as part of the Company's ordinary working expenses; subject to the provision of any law for the time being in force.

80. The Directors shall elect one of their number as the Chairman of the Board.

81. The Directors may from time to time delegate any of their powers to a committee or committees consisting of two (2) or more members of their body as they think fit. Any committee so formed shall conform to any regulations that may by imposed upon it by the Directors and shall be governed, in the exercise of the powers so delegated, by the provisions herein contained for regulating meetings and proceedings applicable to the Directors.



POWERS AND DUTIES OF DIRECTORS

82. The business of the Company shall be managed by the Directors, who may pay all expenses incurred in setting up and registering the Company, and may exercise all such powers of the Company as are not by the Ordinance or any Statutory modification thereof for the time being in force, or by any other law or these Articles, required to be exercised by the Company in General Meeting subject, never-the-less, to any regulations of these Articles, to

the provisions of the Ordinance, and to such regulations being not inconsistent with the aforesaid regulations or provisions, as may be prescribed by the Company in General Meetings, but no regulation made by the Company in General Meeting shall invalidate any prior act of the Directors which would have been valid if that regulation had not been made.

83. The Directors may exercise all the powers of the Company to borrow money and to mortgage its undertaking, property and capital or any part thereof, and to issue securities and debentures, Participation or Term Finance Certificates or any other instrument, whether outright or as security for any debt, liability or obligation of the Company or of any third party.

84. The Directors may from time to time and at any time by power of attorney appoint any company, firm or person or body of persons, whether nominated directly or indirectly by the Directors, to be the attorney or attorneys of the company for such purposes and with such powers, authorities and discretion (not exceeding those vested in or exercisable by the Directors under these Articles) for such period subject to such conditions, if any, as they may think fit, and any such powers of attorney may contain such provisions for the protection and convenience of persons dealing with any such attorney to delegate all or any of the powers, authorities, and discretion vested in him.

85. A Director of the Company or a firm of which such Director is a partner or private company of which such Director is a Director may with the consent of the Company in General Meeting hold any office of profit in the Company.

86. Subject to the provisions of Section 195 and 196 of the Ordinance, the Directors shall not be disqualified from contracting with the Company either as vendor, purchaser, or otherwise, nor shall any such contract or agreement entered into by or on behalf of the company or partnership of or in which any Director of the Company shall be a member or otherwise interested be avoided nor shall any such Director so contracting or being such member or so interested be liable to account to the Company for any profit realized by any such contract or arrangement by reason of such Director holding that office or of the fiduciary relation thereby established, but the nature of his interest must be disclosed by him at the meeting of the Directors at which the contract or arrangement is determined on, if the interest then exists, or in any other case at the first meeting of the Directors after the acquisition of the interest. A General Notice that any Director of the Company is a Director or a member of any other company or is a member of any named firm and is to be regarded as interested in any subsequent transaction with such company or firm shall, as regards any such transaction, be sufficient disclosure under this Article and after any such general notice it shall not be necessary to give any special notice relating to any particular transaction with such firm or company. In the case of a contract for the appointment of a manager of the company, the provisions of Section 218 of the Ordinance shall be observed and performed.

87. In accordance with the provisions of Section 219 of the Ordinance a Register shall be kept by the Directors in which shall be entered particulars of all contracts or arrangements and which shall be open for inspection by any member at the office during business hours.

88. All cheques, promissory notes, drafts, bills of exchange and other negotiable instruments, and all receipts for moneys paid to the Company, shall be signed, drawn, accepted, endorsed, or otherwise executed, as the case may be, in such manner as the Directors shall from time to time by resolution determine.

89. The Directors shall duly comply with the provisions of the Ordinance or any statutory modification thereof for the time being in force, and in particular with the provisions in regard to the registration of the particulars of mortgages and charges affecting the property of the Company or created by it, and to keep a Register of the Directors and Managers, and to send to the Registrar an annual list of members and a summary of particulars relating thereto and notice of any consolidation or increase of share capital and copies of special resolutions and a copy of the Register of Directors and notification of any changes therein.

90. The Directors shall cause minutes to be made in books provided for the purpose:

a) of all appointments of officers made by the Directors;

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

c) of all resolutions and proceedings of all meetings of the Company, and of the Directors and of committee of Directors; and every Director present at any meeting of Directors or committee of Directors shall sign his name in a book to be kept for the purpose and any such minute of such a meeting if purporting to be signed by the Chairman thereof, or by the Chairman of the next succeeding meeting of the same body, shall be sufficient evidence without any further proof of the facts therein stated.

DISQUALIFICATION OF DIRECTORS

91. The Office of Director shall be vacated if:

a) he is found to be of unsound mind by a court of competent jurisdiction, or

b) he is adjudged an insolvent, or

c) he ceases to be a member of the Company; as specified in section 187 of the Ordinance, or

d) he or any firm of which he is a partner or any private company of which he is a director without the sanction of the company in general meeting accepts or holds any office of profit under the Company, or

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

f) he acts in contravention of Section 195 of the Ordinance, or

g) he resigns his office by notice in writing to the Company, or

h) he suffers from any of the disabilities or disqualifications mentioned in Section 187 of the Ordinance, or

i) he has been convicted by a Court of competent jurisdiction for an offence involving moral turpitude, or

j) he has betrayed lack of fiduciary behavior and a declaration to this effect has been made by the Court under Section 217 of the Ordinance.

k) If the nomination of the relevant Director by the Shareholder whose interest is being represented by such Director has been revoked or withdrawn in writing.

PROCEEDINGS OF DIRECTORS

92. The Directors may meet together for the despatch of business, adjourn and otherwise regulate their meetings, as they think fit. Questions arising at any meeting shall be decided by a majority of votes. A Director may, and the Secretary on the requisition of Director shall, at any time, summon a meeting of Directors. It shall not be necessary to give notice of a meeting of directors to any director for the time being absent from Pakistan unless such Director has appointed alternate director.

93. The quorum necessary for the transaction of the business of the Directors shall not be less one third of their number or two Directors whichever is greater, actually present in person or by an alternate director. For the purposes of this Article, an Alternate appointed by a Director shall be counted in a quorum at a meeting at which the Director appointing him is not present.

94. All questions arising at any meeting of Directors shall be decided by a simple majority of votes.

95. The continuing Directors may act notwithstanding any vacancy in their body, but if and so long as their number is reduced below the number fixed by or pursuant to the regulations of the Company as the necessary quorum of Directors, the continuing Directors may act for the purpose of filling vacancies in their body or summoning a General Meeting of the Company, but for no other purpose.

96. All acts done at any meeting of the Directors or by any person acting as a Director shall notwithstanding that it shall afterwards be discovered that there was some defect in the appointment or continuance in office of any such Director or person acting as aforesaid, or that they or any of them were disqualified or had vacated office, or were not entitled to vote, be as valid as if every such person had been duly appointed or had duly continued in office and qualified and had continued to be a Director and had been entitled to be a Director.

97. Except as otherwise provided in the Ordinance, any action which may be taken at a meeting of the Board of Directors shall be validly taken without such meeting if a resolution in writing approving such action is executed by the Directors. For this purpose, it shall be permissible to circulate the text of the proposed resolution duly signed by the Chief Executive or any Director and obtain the signatures of all the other Directors thereon separately by fax and such resolution shall be effective as soon as the text of the resolution signed by each of the other Directors shall have been faxed to and received by the Company.

98. If at any meeting the Chairman is absent, the Directors may elect any Director to act as the Chairman for the meeting.

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

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

101. A committee may meet and adjourn, as it thinks proper.

CHIEF EXECUTIVE

102. The Directors shall within fourteen days after the constitution of the Board or from the date of election of Directors or the office of the Chief Executive falling vacant, as the case may be, appoint, subject to the provisions of Section 198 of the Ordinance, a person to be the Chief Executive of the Company who may be a Director or not. The period for which a Chief Executive shall be appointed shall not exceed three years from the date of appointment unless he earlier resigns or his services as Chief Executive have been terminated by the Board in accordance with the provisions of the Ordinance. On the expiry of his term of office, a Chief Executive shall be eligible for reappointment if nominated in the manner provided in this Article. The terms and conditions of appointment of a Chief Executive including his powers and remuneration shall be determined by the Directors, subject to the provisions of the Ordinance.

103. The Chief Executive shall, if not already a Director, be deemed to be a member of the Board and shall be entitled to such remuneration, benefits and allowances as the Board may specify from time to time. Subject to supervision of the Board, the Chief Executive shall be responsible, and hold the powers and authorities, for the implementation of policies, decisions, guidelines and directive of the Board for achievement of the objectives of the Company and shall have, full powers to execute the same, including powers for conducting day to day management and business of the Company, appointment and termination of personnel , he will inform the Board subsequently at the earliest possible opportunity and

the Board may review it if it considers necessary, powers to carry out sale, production and distribution, import, export and operation of bank account and to make payment and powers to appoint distributors, authorized sub-contractors, dealers or agents. The Chief Executive may further delegate any of his powers to any other persons or committee as he may think fit subject to the overall approval of the Board.

104. The Chief Executive shall devote a substantial part of his time exclusively to the management of the Company except that he may, with the prior consent of the Board, devote lesser time to the Company or become a Director of such company or companies as are not engaged in any business in direct competition with that of the Company.

105. The Chief Executive and/or other personnel appointed by the Company shall be entitled to remuneration and benefits comparable to the best performance Companies in Pakistan which determination shall be done by the Board.

SECRETARY

106. The Secretary shall be appointed by the Directors for such term, at such remuneration and upon such conditions as they may think fit, and any Secretary so appointed may be removed by them. Where there is no Secretary capable of acting, the Directors may appoint an Assistant or Deputy Secretary or any other officer of the Company to perform the duties of the Secretary.

THE SEAL

107. The Directors shall provide for the safe custody of the Seal which shall only be used by the authority of the Directors; and every instrument to which the Seal shall be affixed shall either be signed by two Directors and countersigned by Secretary or only by two Directors.

DIVIDENDS AND RESERVES

108. The Company in General Meeting may declare dividends, but no dividend shall exceed the amount recommended by the Directors. No dividend shall be paid by the company otherwise than out of the profits of the company or in contravention of Section 248 (2) of the Ordinance.

109. The Directors may from time to time pay to the members such interim dividend as appear to the Directors to be justified by the profits of the Company.

110. The Directors may, before recommending any dividends, set aside out of the profits of the Company, such sums as they think proper as a reserve or reserves, which shall, at the discretion of the Directors, be applicable for meeting contingencies, or for equalizing dividends, or for any other purpose to which the profits of the Company may be properly applied, and pending such application may, at the like discretion, either be employed in the

business of the Company or be invested in such investments (other than shares of the Company) as the Directors may from time to time think fit.

111. When any shareholder is indebted to the Company, all dividends payable to him, or a sufficient part thereof, may be retained and applied by the Directors in or towards satisfaction of the debt.

112. Any dividend, interest or other moneys payable in cash in respect of shares may be paid by cheque or warrant sent through the post direct to the registered address of the holder or, in the case of joint holders, to the registered address of that one of the joint holders who is first named on the Register or to such persons and to such address as the holder or joint holders may in writing direct. Every such cheque or warrant shall be made payable to the order of the person to whom it is sent. Any of two or more joint holders may give effectual receipts for any dividends, bonuses, or other moneys payable in respect of the shares held by them as joint holders. The dividend shall be paid within the period laid down in the Ordinance.

113. Unpaid dividends shall not bear interest as against the Company.

CAPITALIZATION OF PROFITS

114. The Company in General Meeting may upon the recommendation of the Directors resolve that it is desirable to capitalize any part of the amount for the time being standing at the credit of any of the Company's reserve accounts or to the credit of the profit and loss accounts or otherwise available for distribution and accordingly that such sum be set free for distribution amongst the members who would be entitled thereto if distributed by way of dividend and in the same proportion on condition that the same be not paid in cash but be applied either in or towards paying up any amounts for the time being unpaid on any shares held by such members respectively or paying up in full un-issued shares of the Company to be allotted and distributed/credited as fully paid up to and amongst such members in the proportion aforesaid, or partly in the other, and the Directors shall give effect to such resolution.

ACCOUNTS

115. The Directors shall cause to keep proper books of account as required under section [illegible] the Ordinance.

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

117. The Directors shall from time to time determine whether and to what extent and at what time and places and under what conditions or on regulations that accounts and books or papers of the Company or any of them shall be open to the inspection of members not being directors, and no member (not being a director) shall have any right of inspecting any

account and book or papers of the Company except as conferred by law or authorized by the Directors or by the Company in General meeting.

118. The Directors shall as required by sections 233 and 236 of the Ordinance cause to be prepared and to be laid before the Company in general meeting such profit and loss account and balance sheets duly audited and reports as are referred to in those sections.

119. The balance sheet, profit and loss account, and other reports referred to in Article 116 shall be made out in every year and laid before the Company in annual general meeting made up to a date not more than four months before such meeting. The balance sheet and profit and loss account shall be accompanied by a report of the auditors' of the Company and the report of directors.

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

121. The Directors shall in all respect comply with the provisions of section 230 to 236 of the Ordinance.

AUDIT

122. Auditors shall be appointed and their duties regulated in accordance with sections 252 to 255 of the Ordinance or any statutory modifications thereof for the time being in force.

NOTICES

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

Where a notice is sent by post, service of the notice shall be deemed to be effected by properly addressing, prepaying, and posting a letter containing the notice and, unless the contrary is proved, to have been effected at the time at which the letter would be delivered in the ordinary course of post.

124. A notice may be given by the Company to the joint holders of a share by giving the notice to the joint holder named first in the Register in respect of the share and a notice so given shall be sufficient notice to all the holders of such shares.

125. A notice may be given by the Company to the persons entitled to a share in consequence of the death or insolvency of a member through the post in a prepaid letter addressed to them by name or by the title or representatives of the deceased, or assignee of the insolvent or by any like description, at the address (if any) in Pakistan supplied for the purpose by the

persons claiming to be entitled, or (until such an address has been so supplied) by giving the notice in any manner in which the same might have been given if the death or insolvency had not occurred.

126. Notice of every General Meeting shall be given in the manner hereinbefore authorized to (a) every member of the Company, except those members who have no registered address or have not supplied to the Company an address for the giving of notice to them, and also (b) every person entitled to a share in consequence of the death or insolvency of a member, who but for his death or insolvency would be entitled to receive notice of the meeting, and (c) to the auditors of the company for the time being.

DISPUTE SETTLEMENT

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

WINDING UP

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

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

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

SECRECY

129. Save as otherwise provided in the Ordinance no member or other person (not being a Director) shall be entitled to visit and inspect any of the Company's premises or properties of the Company without the permission of the Directors of the Company for the time being

or any person authorized in this behalf by the Directors or to require discovery of or information respecting any detail of the Company's trading or any matter which is or may be in the nature of a trade secret, mystery of trade or secret process or of any matter whatsoever

which may relate to the conduct of the business of the Company and which in the opinion of the Directors will be inexpedient in the interest of the members of the Company to communicate to the public.

INDEMNITY

130. Every Director or officer of the Company and every person employed by the Company as auditor shall be indemnified out of the funds of the Company against all liability incurred by him as such Director, officer or auditor in defending any proceeding, whether civil or criminal, in which judgment is given in his favour, or in which he is acquitted, or in connection with any application under section 488 of the Ordinance in which relief is granted to him by the court.

RECONSTRUCTION

131. On any sale of the undertaking of the Company, the Directors or the Liquidator on a winding-up may, if authorized by Special Resolution, accept fully paid or party paid-up shares, debentures or securities of any other company, whether incorporated in Pakistan or not either then existing or to be formed for the purchase in whole or in part of the property of the Company, and the Directors (if the profits of the Company permit) or the Liquidator (in a winding-up) may distribute such shares, or any other property of the Company amongst the members without realization, or vest the same in trustees for them, and any special Resolution may provide for the distribution or appropriation of the cash, shares, or other securities, benefits or property, otherwise than in accordance with the strict legal rights of the members or contributories of the Company, and for the valuation of any such securities or property at such price and in such manner as the meeting may approve, and all holders of shares shall be bound by any valuation or distribution so authorized, and waive all rights in relation thereto, save only in case the Company is proposed to be or is in the course of being wound up, such statutory rights if any, under section 367 of the Ordinance as are incapable of being varied or excluded by these Articles.

ARBITRATION

132. Whenever any difference arises between the Company on the one hand, and any of the members, their executors, administrators, or assigns on the other hand, touching the true intent or construction, or the incidents or consequences of these presents, or of the statutes, or touching anything then or thereafter done, executed, omitted or suffered in pursuance of these presents, or of the statutes or touching any breach or alleged breach of these presents, or any claim on account of any such breach or alleged breach, or otherwise relating to the premises, or to these presents, or to any statute affecting the Company, or to any of the affairs of the Company, every such difference shall be referred under the Arbitration, Act, 1940, to the decision of an arbitrator to be appointed by the parties in differences, or if they cannot agree upon a single arbitrator, to the decision of two arbitrators, of whom one shall be appointed by each of the parties in difference, or an umpire to be appointed by the two arbitrators. The cost of, and incident to, any such reference and award shall be in the discretion of the arbitrators, or umpire respectively, who may determine the amount thereof,

or direct the same to be taxed as between attorney and client or otherwise, and may award by whom, and to whom, and in what manner the same shall be borne and paid.

MISCELLANEOUS

133. If the provisions of these Articles are in any way inconsistent with the provisions of the Ordinance or any other law for the time being in force, the provisions of that Ordinance or other law shall prevail, and these Articles shall be read subject to that Ordinance or that other Law.

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

Name and surname (present and former in full and block letters)	Father's/Husband's name in full	Nationality with any former Nationality if any	Occupation	Residential address	Number of shares taken by each subscriber	Signature
MR. TABISH TAPAL CNIC No. 42301-2385059-9	Mr. Moiz Ali Tapal	Pakistani	Business	33-B, 3rd Gizri Street, Phase IV, D.H.A., Karachi, Pakistan	500 (Five Hundred)	
MR. MUHAMMAD SADIQ TAPAL CNIC No. 35201-2785819-5	Mr. Tajwar Tapal	Pakistani	Business	73/6A, Munir Road, Lahore, Pakistan	499 (Four Hundred Ninety Nine)	
MR. MUSTAFA LAKDAWALA CNIC No. 42201-3140375-9	Mr. Abid Hussain Lakdawala	Pakistan	Service	House No. 14/A Overseas Cooperative Housing Society, Block-7 & 8, Off Amir Khusroo Road, Karachi	1 (One)	
Total					1000 (One Thousand)	

Dated this 2nd day of June 2016

Witness to the above Signatures:

Name

National Institutional Facilitation Technologies (Pvt) Ltd

Full Address

5th Floor AWT Plaza I. I. Chundrigar Road Karachi

Securities and Exchange Commission of Pakistan * Company Registration Office Karachi SECP

Certified to be True Copy
29/10/25
Deputy Registrar of Companies

Annexure F – Certificate of Incorporation of the Project Company

A020957

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

SECP

COMPANY REGISTRATION OFFICE, KARACHI

CERTIFICATE OF INCORPORATION

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

Corporate Universal Identification No. **0100200**

I hereby certify that **SINO WELL (PVT.) LIMITED** is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is **limited by shares.**

Given under my hand at **Karachi** this **Fourteenth** day of **June,** Two Thousand and **Sixteen.**

Incorporation fee Rs. **1000/=** only

(Zia-ul-Rasheed Abbasi)
Joint Registrar
Karachi

Registrar

Securities and Exchange Commission of Pakistan

SECP

Certified to be True Copy
Dep. Registrar of Companies
29/10/2018