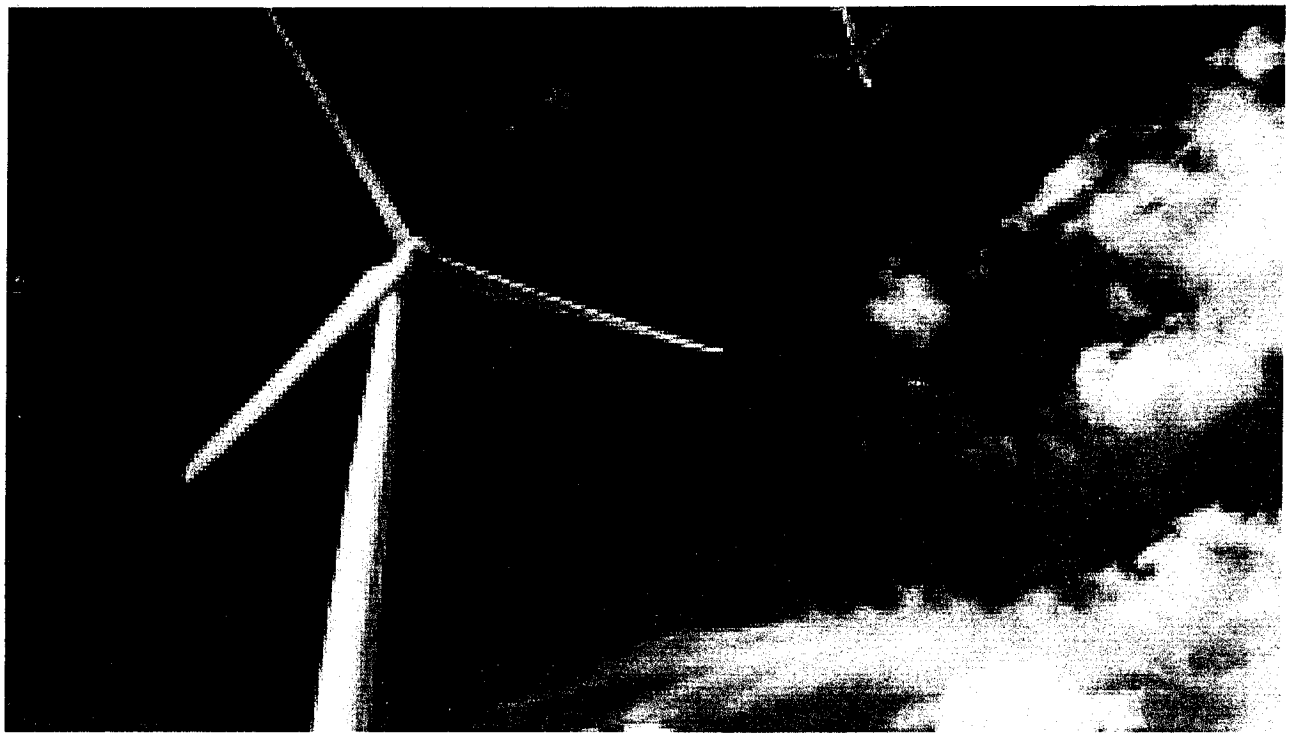
LICENSEE PROPOSED MODIFICATION

APPLICATION

FOR

51 MW SHAHEEN RENEWABLE ENERGY 1,

WIND POWER PROJECT AT BHOLARI, SINDH



PROJECT COMPANY:

SHAHEEN RENEWABLE ENERGY 1 (PRIVATE) LIMITED.

PROJECT TECHNICAL CONSULTANT:

RENEWABLE RESOURCES (PVT) LIMITED.

SHAHEEN RENEWABLE ENERGY 1 (PVT) LTD
A company of Shaheen Foundation Pakistan Air Force

Date: 09-10-2017

The Registrar
National Electric Power Regulatory Authority
NEPRA Tower
Ataturk Avenue (East)
G-5/1, Islamabad

Subject: Licensee Proposed Modification Application for 51 MW Shaheen Renewable Energy – 1 (Private) Limited (SRE-1)

Dear Sir,

I, Brig Dr. Gulfam Alam (Retd), being the duly authorized representative of 51MW Shaheen Renewable Energy –1 (Pvt.) Limited (SRE-1) by virtue of Board Resolution dated 06-10-2017 hereby apply to the National Electric Power Regulatory Authority for the modification of Generation License No. WPGL/44/2017 dated 7th June, 2017 pursuant to section to Regulation 10(2) of the National Electric Power Regulatory Authority (Application and Modification Procedure) Regulations, 1999 (the "AMPR").

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 (Application and Modification Procedure) Regulations, 1999 and undertake to abide by the terms and provisions of the above-said regulations. I further undertake and confirm that the information provided in the attached documents-in-support is true and correct to the best of my knowledge in belief.

A BANK DRAFT in sum of **PKR 378,340** (Rupees Three Hundred and Seventy Eight Thousand Three Hundred and Forty Only) being the non-refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

The application is filed in triplicate with all annexure appended with each set of the application.

(DR. GULFAM ALAM)
Brigadier (Retd)
C.E.O

Shaheen Renewable Energy-1 (Pvt) Limited
SRE-1

DOCUMENT STRUCTURE

This document is the Licensee Proposed Modification Application (the "**Application**") for a Wind Power Project having a capacity of 51 MW at Bholari, Sindh to be set up by Shaheen Renewable Energy 1 (Private) Limited, (the "**Applicant**").

The document comprises of the Application and all required Annexure.

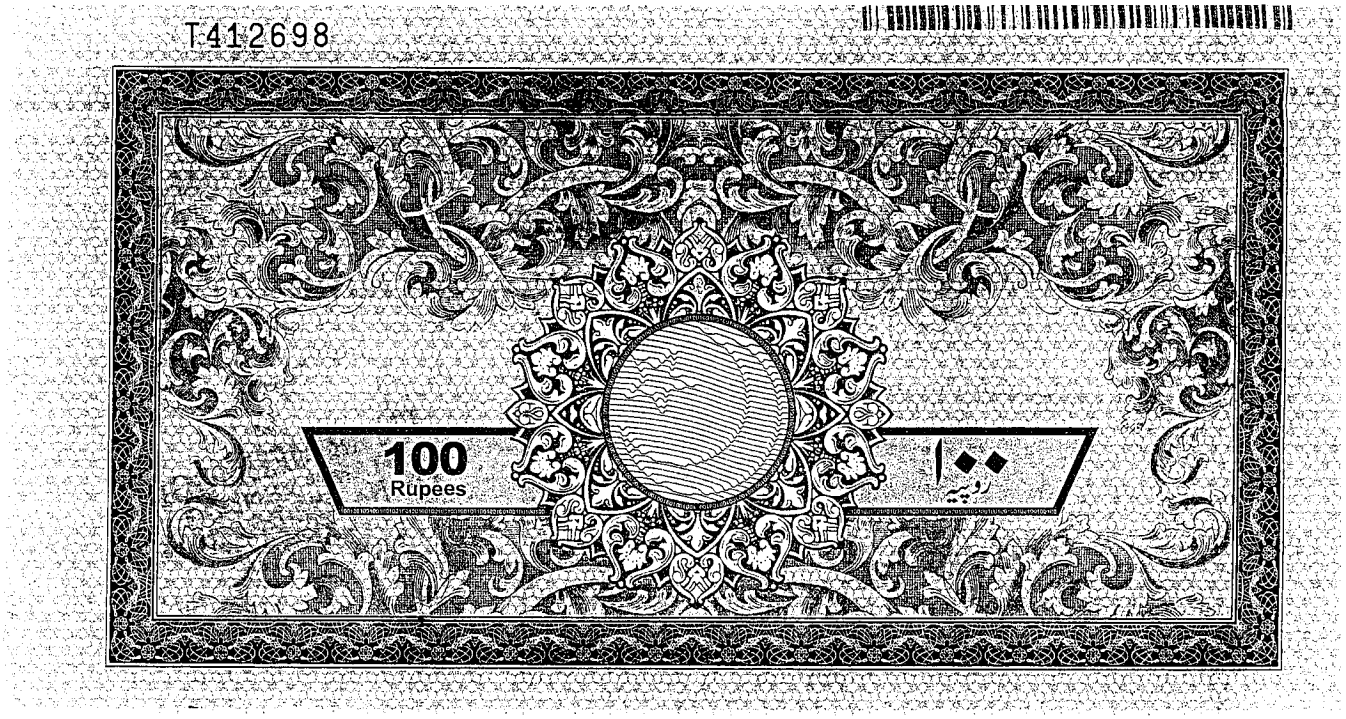
The following Project documents are annexed to this Application in pursuant to Section - 5 of Article -3 of NEPRA Licensing (Application & Modification Procedure) Regulation, 1999;

Required Information/Documents	Annex
Cover Letter	1
Affidavit Of The Person Authorized For Filing Application	2
Board Resolution In Name Of Person Authorized For Filing Application	3
Bank Draft For Application Fee (Nonrefundable)	4
Text Of The Proposed Modification	5
Statements Of Reasons In Support Of Modifications	6
Statement Of Impact On Tariff	7
Revised Schedule-I Of Lpm	8
Revised Schedule-Ii Of Lpm	8-a
Technology, Size And No. Of Units	9
Grid Interconnection Details	10
Project Cost, Debt/Equity	11
Project Commencement And Completion Schedule	12
Grid Study And Approval	13
Expected Life Of Generation Facility	14
Feasibility Study And Approval	15

Annexure-2:

Affidavit

T 412698



BEFORE

THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

AFFIDAVIT

I, Brig Dr. Gulfam Alam, CNIC 37405-1261883-9, Chief Executive Officer, Shaheen Renewable Energy 1 (Private) Limited , Shaheen Foundation, PAF, Sector E-9/1, PAF Complex Islamabad, Pakistan, do hereby solemnly affirm and declare that:

1. The Licensee Proposed Modification Application for 51 MW Shaheen Renewable Energy–1 (Private) Limited (SRE-1) has been filed before the National Electric Power Regulatory Authority ("NEPRA) and the contents of the same may kindly be read as an integral part of this affidavit.

2. The contents of the accompanying application for Licensee Proposed Modification for Shaheen Renewable Energy 1 (Private) Limited 51MW wind power project at Bholari, Distt Thatta, Sindh, Pakistan including all supporting documents are true and correct to the best of my knowledge and belief, and nothing material or relevant thereto has been concealed or withheld therefrom.

3. I also affirm that all further documentation and information to be provided by me is connection with the aforesaid request shall be true and correct to the best of my knowledge and belief.

DEPONENT

Brig Dr. Gulfam Alam (Retd)
C.E.O
Shaheen Renewable Energy 1 (Pvt) Limited
Shaheen Foundation, PAF

Dated: 09 Oct, 2017

ATTESTED

MUHAMMAD RUSTAM MALIK
NOTARY PUBLIC
Islamabad
Advocate High Court

09 OCT 2017

Annexure-3:

Board Resolution

Date: 06-10-2017

RESOLUTIONS OF THE BOARD OF DIRECTORS OF SHAHEEN RENEWABLE ENERGY-1 (PRIVATE) LIMITED BY CIRCULATION

RESOLVED THAT:

Shaheen Renewable Energy 1 (Private) Limited ("**Company**") hereby authorizes Brig Dr. Gulfam Alam (Retd), Chief Executive Officer of the Company, to file an application for Licensee Proposed Modification (the "**Application**") for the Company's proposed 51MW Wind Power Project (WPP) in Bholari, District Thatta, Province of Sindh, Pakistan (the "**Project**") and to do all actions and take all measures as may be necessary or appropriate in connection with the filing, presentation and pursuit of the Application, including, without limitation:

i. to sign, file, amend or withdraw the Application, affidavits, Powers-of-Attorney, statements forms, applications, deeds, certificates, interrogatories, correspondence or any other documents and instruments as may be necessary or appropriate;

ii. make all filings and pay all applicable fees in connection with the Application;

iii. to appoint and remove consultants, attorneys and advisors;

iv. represent the Company in person or through attorneys, advocates or representatives in all negotiations, representations, presentations, hearings, conferences or meetings of any nature whatsoever with any entity (including, but not limited to NEPRA, private parties, companies, partnerships, individuals, governmental or statutory authorities and agencies, ministries, boards and departments, regulatory authorities or any other entity of any nature whatsoever); and

v. do all acts, matters, things and take all actions as may be required in connection with the Application until the award of the revised Generation Licence in respect of the Project and further also for any revisions or modifications to the awarded revised Generation Licence by NEPRA at any stage whatsoever as may be considered fit and appropriate by him in his estimation.

The above resolution was duly passed by circulation by the Board of Directors in accordance with the Articles of Association of the Company.

Directors and person Authorized to sign Name in full	Official position	Specimen Signature
Air Marshal Muhammad Jamshed Khan (Retd)	Chairman/Director	
Brig Dr. Gulfam Alam (Retd)	C.E.O/Director	
Mr. Aamir Shahzad Mughal	Director	
Air Commodore Sikander Niaz (Retd)	Director	

We further certify that the specimen signatures recorded above are correct.

Shaheen Renewable Energy-1 (Pvt) Limited

(Umar Sadiq)
Company Secretary

Annexure-5:

TEXT OF THE PROPOSED MODIFICATION

TEXT OF THE PROPOSED MODIFICATION

Shaheen Renewable Energy - 1 (Pvt.) Ltd (the "Company") has selected Acciona WTG Model AW125/v3000 kW each with hub height of 87.5m for its 51 MW Wind Power Plant located in Bholari, Distt Thatta, Sindh. The Company has finalized the equipment for the Project. The Company desires to modify its Generation Licence by changing the followings:-

a) Net Power Output of Wind Power Plant from **49.735 MW to 51 MW**.
b) Number of WTGs and Power Rating from **29 x 1,715 kW to 17 x 3,000 kW**.

The Letter of Intent (LOI) from AEDB has also been revised from 50 MW to 51 MW and is enclosed with this annexure. Also, please find the revised Schedule-I **(Annexture-8)** and Schedule-II **(Annexture-8a)** of the Generation Licence.

Government of Pakistan
Alternative Energy Development Board (AEDB)

B/3/1/SF/15 29 August 2017

Chief Executive Officer
Shaheen Renewable Energy 1 (Pvt.) Limited
E 9/1, PAF Complex
Islamabad.

Subject: **CAPACITY ENHAMCEMENT IN LETTER OF INTENT (LOI) # B/3/16/2007-143 DATED APRIL 14, 2016**

This is with reference to Shaheen Renewable Energy (Pvt.) Limited (SRE1) letter No.SF(PAF)/0224/SRE1 dated August 02, 2017 on the subject matter wherein SRE1 requested AEDB for LOI capacity enhancement from 50MW to 51MW.

2. AEDB acknowledges the receipt of additional Project Facilitation Fee of USD. 10,000/- and amendment in Bank Guarantee (BG) # IGT227300101016 dated April 15, 2016 amounting USD 25,500/- submitted by SRE1. In view of the request made by SRE1 vide reference letter, it is informed that the capacity of the project stated in the LOI # B/3/16/2007-142 dated April 14, 2016 issued to Shaheen Foundation, PAF for the development of 50MW wind power project will now be read as 51 MW. All other terms and conditions of the LOI shall remain the same.

(Naeem Memon)
Director (Wind-II)

Copy to:

a. Chairman, National Electric Power Regulatory Authority (NEPRA), Islamabad.
b. Chief Executive Officer, CPPA-G Limited, Islamabad.
c. Secretary Energy, Energy Department, Government of Sindh.
d. Director (F), AEDB, Islamabad.
e. PS to CEO, AEDB (for information).

2nd Floor, OPF Building, Shahrah-e-Jumhuriat, Sector G-5/2, Islamabad.
Ph: 051-9202081 / Fax: 051-9222364

Annexure-6:

STATEMENTS OF REASONS IN SUPPORT OF MODIFICATIONS

STATEMENTS OF REASONS IN SUPPORT OF MODIFICATIONS

The Company has selected Acciona AW125/3000 WTG of 3,000 kW each with hub height of 87.5m. The Company found that by using 17 WTGs of Acciona model AW 125/3000, the construction time will be decreased. Since Acciona Wind Power has been merged with Nordex SE of Germany after takeover by the latter, the new entity Nordex-Acciona Wind Power has emerged as a leader in providing sustainable solutions for infrastructure and renewable energy projects across the world.

Further to above, the proposed modification in Generation Licence shall not affect net capacity factor of the Project.

In view of the foregoing, the Company hereby requests NEPRA to approve the proposed modification to Generation Licence so that the company can proceed further with the project.

Annexure-7:

STATEMENT OF IMPACT ON TARIFF

STATEMENT OF IMPACT ON TARIFF

As energy yield or capacity factor of Wind Power Plant shall remain the same and there will be no change in EPC price or O&M price, so there will be no impact on Tariff due to proposed modification.

Annexure-8:

REVISED SCHEDULE-I OF LPM

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 Facilities of the Licensee are described in this Schedule.

Location of Generation Facility/ Wind Farm

Shaheen Renewable Energy-1 (Private) Limited is the Project Company for a 51 MW Wind Power Project to be in Bholari District Thatta, Sindh that is towards the East of Karachi. The National Highway and Superhighway are the major connecting roads to the Project site, having approximately 120-125 km from Port Qasim. The wind farm Project is in Bholari, which is located approximately 130 km from Karachi, Pakistan's commercial hub and main coastal/port city. The Project Site consists of approximately 1600 acres of land, which is owned by the project company. The Jhimpir wind corridor is identified as a potential area for the development of wind power projects. The overview of the project site is shown in Figure below:

The Project site is exposed to strong south westerly winds; wind data analysis of the area suggests that 80% wind blows from the south west direction. The terrain of the area is flat with small change in altitude. The proposed site lies under roughness class 1.5 as there is low vegetation. The site is easily accessible through metallic roads. The ground is hard and rocky; the subsurface soil also includes clay and silt.

The proposed wind farms lie on a flat inland area with hard and rocky ground conditions. The site would be categorized as inland wind development as opposed to offshore/coastal wind project development (which is more difficult to develop due to tides and soft subsoil clay). The general terrain at the site can be described as simple and flat terrain. Internal access roads are the roads connecting the single wind turbine locations with each other and the external access roads and grid station would be constructed during the civil works of the wind farm.

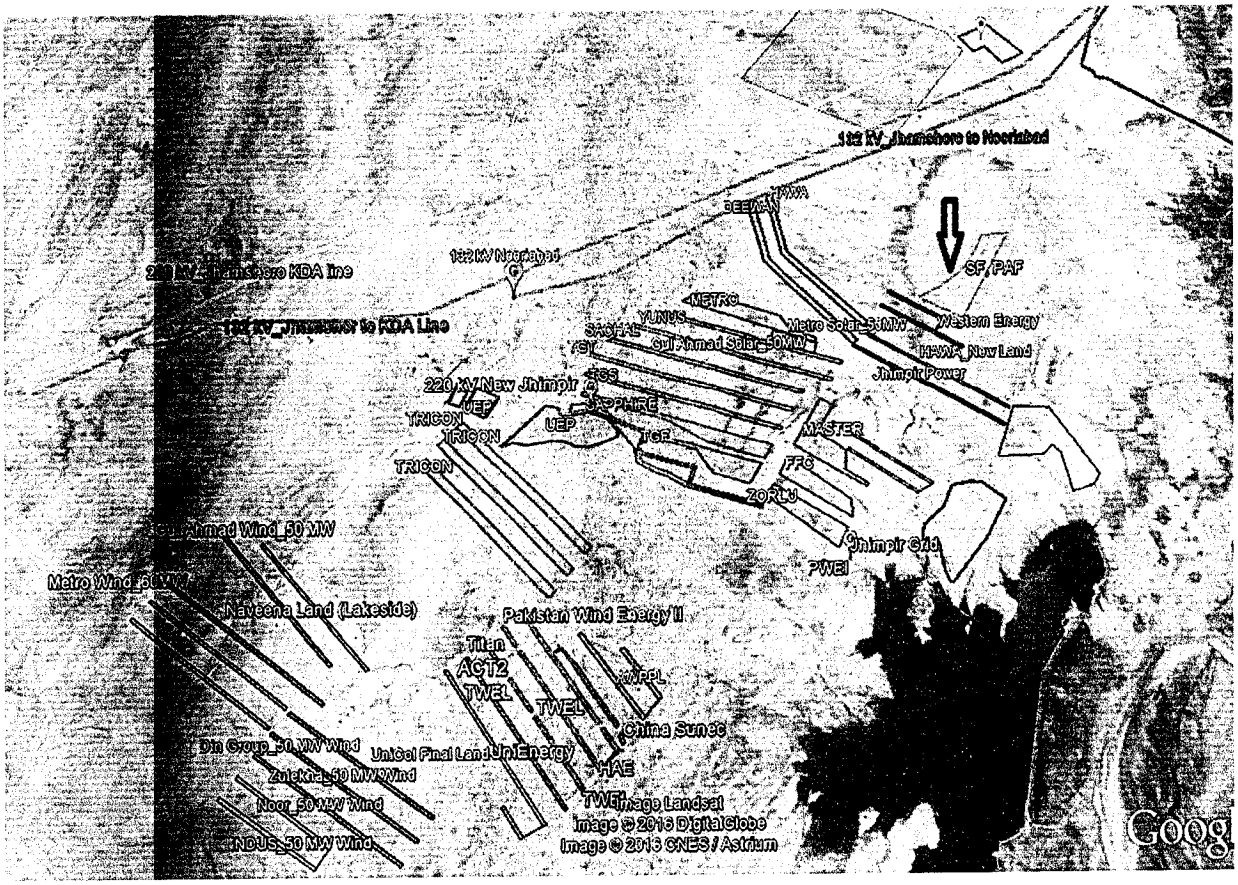
The proposed site area lies in an arid zone with very little annual precipitation. The result is that there is sparse vegetation in the area. Some hardy tree species are visible scattered far and wide in the area. The area is rocky with some rock outcrops towards the Super Highway. The terrain at the site and surrounding area is generally flat with elevations varying between 55 m in the southwest corner of the site to 100 m in the northeast corner.

The proposed site is located about 120-125 km from Port Qasim, Karachi. Karachi borders on the Arabian Sea and the weather belongs to tropical monsoon climate. Rainfall is scarce with about 200 mm for a whole year and most of this is concentrated in July and August. The temperature in winter from November to February is temperate, but it is hot with high temperature in summer from April to August as the highest temperature has reached 44.02°C. The coordinates of Wind farm are given in Table below:

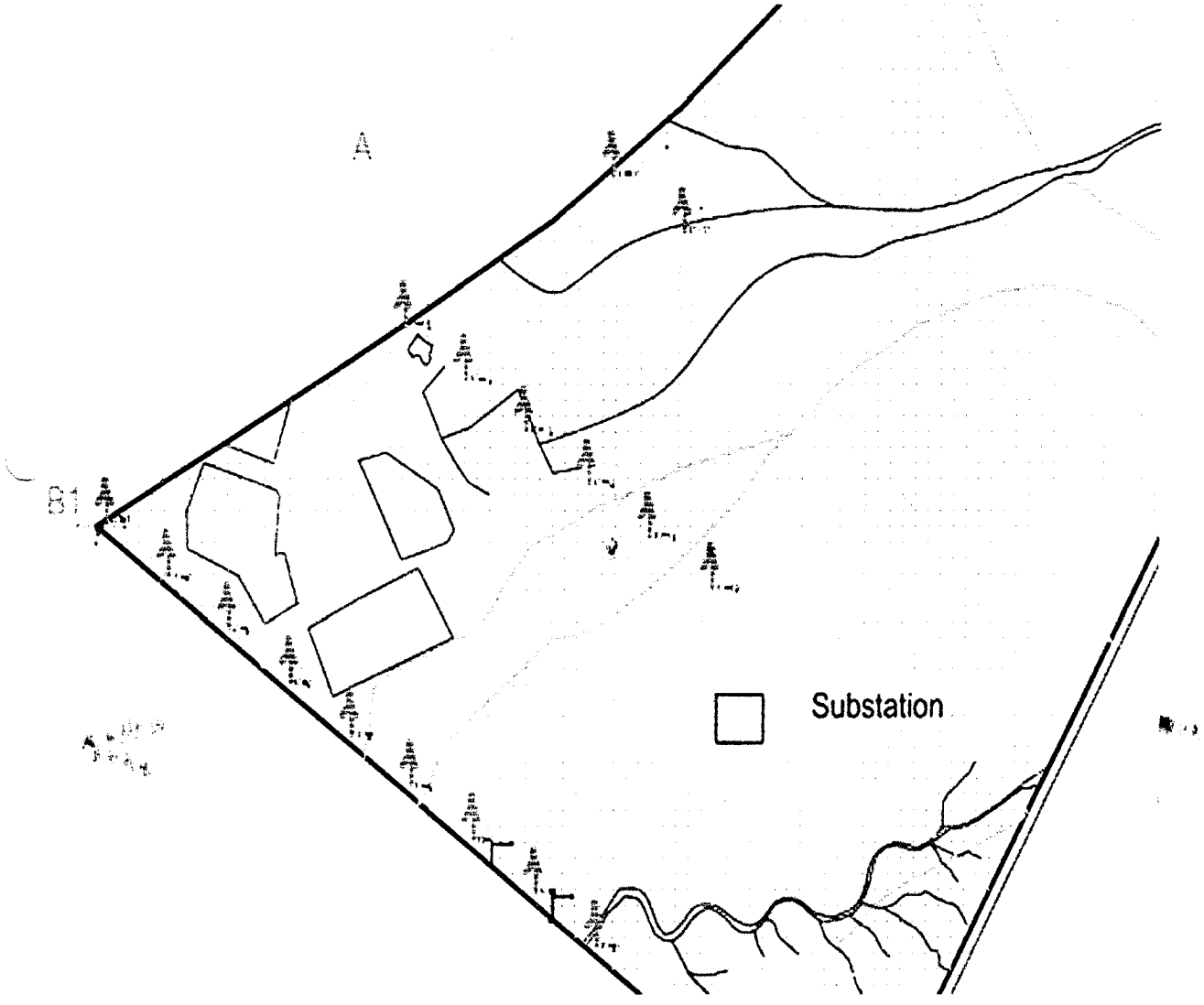
S. No.	Latitude	Longitude
1	25°10'55.80"N	68° 3'48.00"E
2	25° 13'26.40"N	68° 6'28.80"E
3	25° 13'29.19"N	68° 7'28.97"E
4	25° 10'2.80"N	68° 5'15.10"E

Wind Farms Layout at Project Site

The overview of wind farm of Shaheen Renewable Energy 1 (Private) Limited and neighboring wind farms are shown in Figure below:



The micro sitting of the Shaheen Renewable Energy 1 (Private) Limited Project with 17 Turbines is shown in Figure below:



The coordinates of WTGs are given in Table below:

The coordinates of wind turbines about 3.0MW			
number	turbine number	latitude(X)	longitude(Y)
1	TWT-1	405645	2785452
2	WT-2	405845	2785318
3	WT-3	406039	2785186
4	WT-4	406237	2785052
5	WT-5	406433	2784919
6	WT-6	406630	2784785
7	WT-7	406827	2784651
8	WT-8	407024	2784517
9	WT-9	407219	2784382
10	WT-10	406594	2785952
11	WT -11	406790	2785817
12	WT-12	406986	2785684
13	WT-13	407183	2785551
14	WT-14	407380	2785417
15	WT-15	407581	2785286
16	WT-16	407256	2786334
17	WT-17	407486	2786189

Topographical and Geological Conditions at Project Site

Topographical conditions

The Project site is on a plain area at an elevation of 55-100 m, which is generally flat, but a bit higher on the east and lower on the west. The landform at wind farm sites is mainly of pediment and the vegetation there is less developed.

Geological conditions

The planned wind farm sites are covered mainly by marine alluvium of Holocene and recent weathered deposit, and underlain mainly by Tertiary limestone. The bedrock in the site is generally outcropped. As the WTG is a high-rise structure, it has a high gravity center and should sustain high loads, large horizontal wind force and overturning moments. WTGs are designed to withstand these forces.

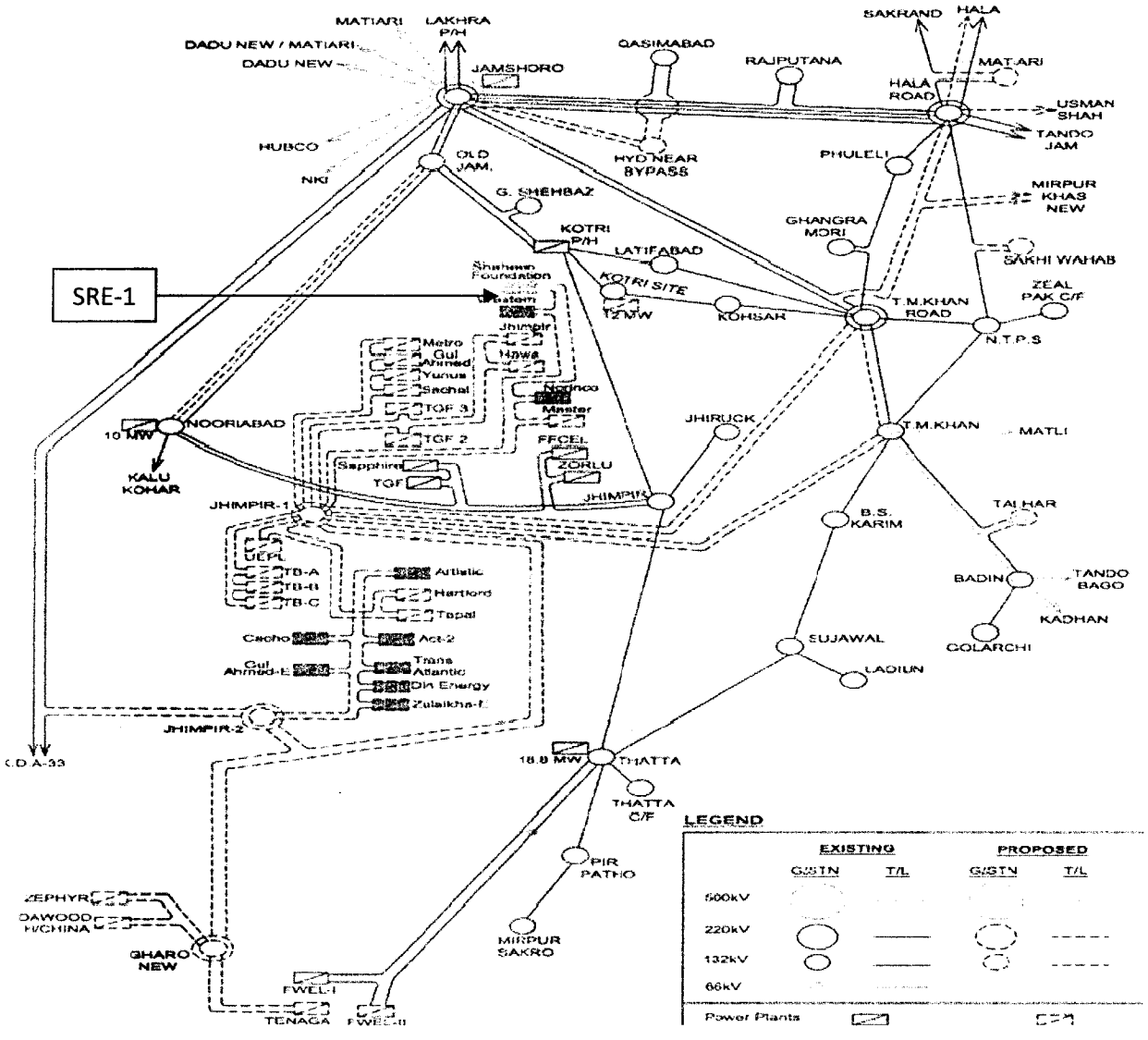
Hydrology

According to the regional hydrological data available, the Project site is in a dry area, where the water table is deeply underground, and the surface water and water in the shallow surface layers is weakly to slightly corrosive to the concrete and is corrosive to the rebars in the concrete which has been submerged in water for a long-time or alternatively in wet and dry conditions. Corrosion prevention measures will be adopted in the design and implementation of the wind farm.

Project Size

The Project shall have an installed capacity of 51 MW. The number of WTGs is 17 with capacity of 3,000 kW each.

Schematic Diagram for Interconnection Arrangement/Transmission Facilities for Dispersal of Power from SRE-1



Details of Generation Facility/Power Plant/Wind Farm

(A). General Information

(i).	Name of Applicant/Company	Shaheen Renewable Energy – 1 (Pvt.) Ltd
(ii).	Registered/Business Office	Shaheen Foundation, Shaheen Complex, Sector E-9 Islamabad.
(iii).	Plant Location	Bholari, District Thatta, Sindh
(iv).	Type of Generation Facility	Wind Power

(B). Wind Farm Capacity & Configuration

(i).	Wind Turbine Type, Make & Model	Acciona AW 125/3000
(ii).	Installed Capacity of Wind Farm (MW)	51 MW
(iii).	Number of Wind Turbine Units/Size of each Unit (kW)	17 x 3000 kW

(C). Wind Turbine Details

(a).	**Rotor**	
(i).	Number of blades	3
(ii).	Rotor diameter	125 m
(iii).	Swept area	10305 m^2
(iv).	Power regulation	Full span blade pitch
(v).	Cut-in wind speed	3 m/s
(vi).	Cut-out wind speed	25 m/s
(viii)	Pitch	Full span

(b).	**Blades**	
(i).	Blade length	61.2 m
(ii).	Material	GRE
(c).	**Gearbox**	
(i).	Type	Planetary
(ii).	Gear ratio	1:1430
(d).	**Generator**	
(i).	Rated Power	3050 (kW)
(ii).	Voltage	12000 V
(iii).	Type	6 poles, double feeding
(iv).	Degree of Protection	IP54 Turbine
(v).	Frequency	50-60 Hz
(vi).	Power factor	0.93
(e).	**Control System**	
(i).	Power Control	Convertor control unit
(ii).	Master Processor	Programable Logic Controller
(iii).	Interface	SCADA
(f).	**Brake**	
(i).	Design	Single Disk
(ii).	Location	High speed shaft

(g).	**Tower**	
(i).	Type	Tubular steel
(ii).	Hub Height	87.5 m

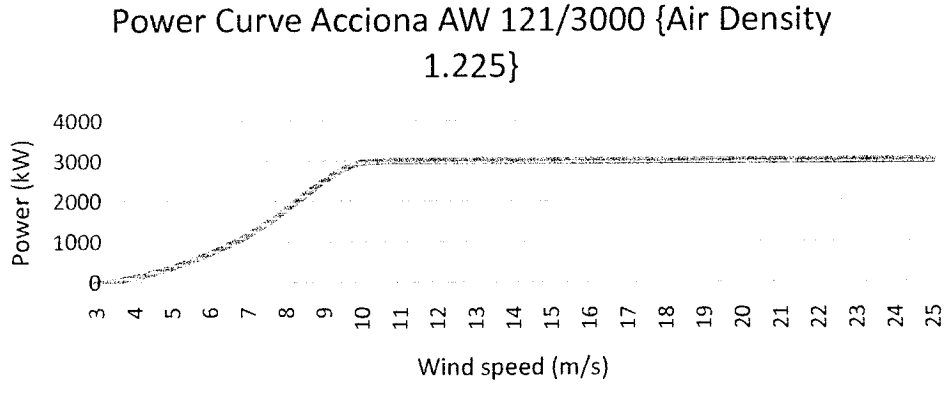
(D). Other Details

(i).	Project Commissioning Date (Anticipated)	2019-2020
(ii).	Expected Life of the Project from Commercial Operation Date (COD)	25 Years

Power Curve of Acciona AW125/3000 Wind Turbine Generator at Air Density 1.225 kg/m^3

The tabular and graphical values of Power curve are shown below:

3	0
3.5	40
4	142
4.5	257
5	388
5.5	545
6	726
6.5	941
7	1189
7.5	1472
8	1797
8.5	2159
9	2521
9.5	2814
10	2980
10.5	3000
11	3000
11.5	3000
12	3000
12.5	3000
13	3000
13.5	3000
14	3000
14.5	3000
15	3000



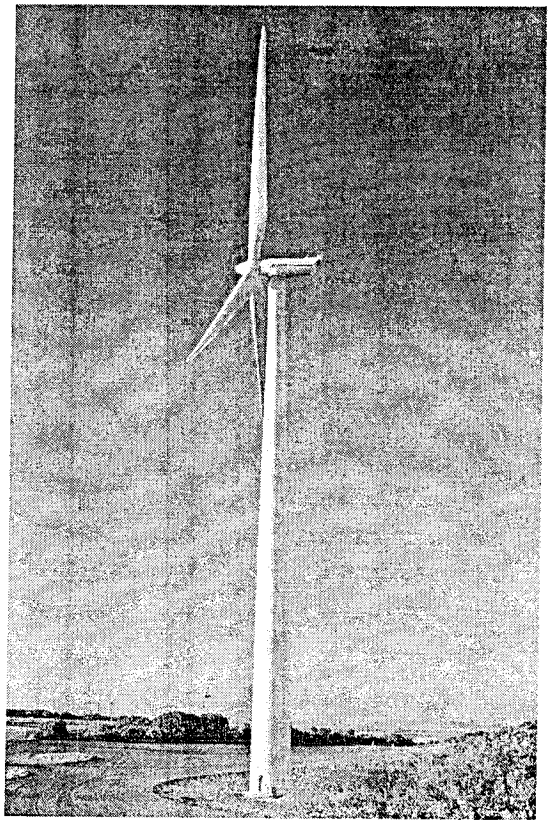
The EPC Contractor–[Nordex/Acciona/TBEA]

With the acquisition of M/s Acciona Wind Power of Spain by Nordex SE, Germany, the new entity, M/s Nordex-Acciona holds more than 30 years of experience in designing, constructing and operating wind turbines, delivering more than 21 GW of sustainable energy worldwide. M/s Nordex-Acciona shall install 17 x AW125/3000 87.5m tower height WTGs for the Project. These turbines are the member of Nordex Acciona multi-megawatt wind turbine platform which are type certified for IEC class IIb sites. AW125/3000 turbine is designed for medium wind sites with low turbulence intensity and belongs to the platform of which 6000 MW have been installed globally.

TBEA Xinjiang Sunoasis Co., Ltd. (TBEA Sunoasis Co., Ltd.), founded in 2000, is the world leading green and smart energy service provider with business in more than 20 countries and areas all over the world to devote to the sustainable development of human society with the drive of smart, efficient and green energy. The company focuses on PV, wind power, power electronics, energy internet and other fields to provide clients with integrated solution including clean energy project development, investment financing, design, construction, debugging and O&M to build the company into a global excellent green and smart energy service provider. TBEA Xinjiang Sunoasis Co., Ltd. tops the lists of global wind power/PV EPC, inverter and other fields, and ranks No. 32 in The Clean 200 List 2017.

The Company actively practices the national strategy of "the Belt and Road initiative" and is devoted to sharing the advanced electricity construction experience of China with the world. The Company has provided green technology and smart environment-friendly, stable and efficient energy equipment to more than 60 countries, including the United States, Russia, Brazil, Mongolia, Tajikistan, Kyrgyzstan, Pakistan, etc. and supplied the turnkey project and systematic solutions from survey to design, construction, installation and debugging and to training, operation and maintenance to promote the construction of green and efficient power supply and grid, benefit the people of various countries and promoted the economic development of local areas.

In Pakistan, TBEA first commissioned project as Lead EPC is the 100MW Quaid-e-Azam solar project. TBEA is also the EPC contractor for the 500Kv sub-station project being constructed in Yamishier area of Pakistan. In china alone, TBEA has been the EPC contractor for more than 1300MW wind/solar projects.



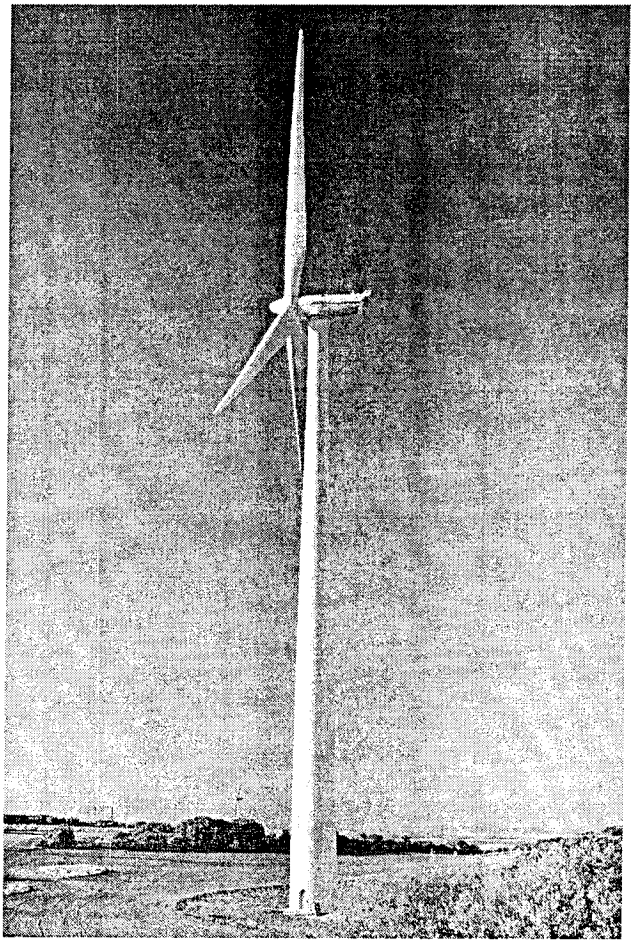
Rev	Fecha Date	Descripción de la revisión Description of the revision
"A"	12/09/14	Elaboración / Elaborated
"B"	24/10/14	Dato corregido / Data corrected
"C"		
"D"		
"E"		

Realizado / Done	Revisado / Reviewed	Aprobado / Approved
FGM 24-10-2014	JAL 24-10-2014	MNP 24-10-2014

acciona Windpower	TECHNICAL SPECIFICATION	DATE: 24/10/14
		REVISION: B
	AW 125/3000 CLASS IEC IIb T87.5 WIND TURBINE	AUTHOR: EGM
		CHECKED: JAL
		APPROVED: MNP

ROTOR	Number of blades	3
	Orientation	Upwind
	Diameter	125 m
	Swept area	12305 m^2
	Rotational direction	Clockwise
	Rotational speed	Variable - 9.2 ... 15.6 rpm
	Hub height	87.5 m
	Power regulation	Full span blade pitch
	Overspeed control	Full span blade pitch
	Rotor shaft tilt angle	5º
	Nominal tip speed	86.5 m/s
	Cone angle	5º
BLADES	Material	GRE
	Total length	61.2 m
	Weight range	15600 kg ± 3% / blade
	Pitch	Full span
	Aerodynamic Brake	Full feathering
HUB	Hub type	Cast iron
	Protection	Epoxy
PITCH SYSTEM	Pitch bearings	Double row four point contact bearing
	Actuation	Hydraulic
	Linkage	Through hydraulic cylinders
	Failsafes	Accumulators on hub
DRIVE TRAIN	Gearbox	3 stages, 2 planetary / 1 paralel
	Gearbox nominal power	3300 kW
	Gearbox ratio	1:83 (50 Hz) / 1:100 (60 Hz)
	Input speed	Variable - 9.2 ... 15.6 rpm
	Output speed	Variable - 770 - 1300 rpm (50 Hz)
		Variable - 920 ... 1560 rpm (60 Hz)
	Lubrication	Pressure and splash with oil cooler / oil filter
ROTOR SHAFT	Type	Forged hollow shaft
	Supporting	2 bearings
DRIVETRAIN BEARINGS	Type	Double spherical roller bearings
PARKING BRAKE	Type	Single disk
	Location	High speed shaft
YAW SYSTEM	Type	Double row four point contact bearing
	Slewing gear	external
	Slewing gear / yaw drive pinion ratio	11.2:1
	Braking system	Hydraulic Callipers
	Yaw drives system	Electrical motorgears

YAW GEARS AND MOTORS	Type	Planetary 4-5 stages
	Ratio	1:1430
	Yaw rate	0.09 rpm
	Motor types	Asyncronous 4 poles
	Voltage / Frequency	230/400 V - 50-60 Hz.
	Power rating	2.2 kW
HYDRAULIC POWER UNIT	Oil pump capacity	90 l/min
	Motor type	37 kW
	Voltage/frequency	380 V / 50-60 Hz
	Blade accumulator	2 x 20 l
	Principal accumulator	20 l
GENERATOR	Type	6 poles, double feeding
	Insulation Classes (stator/rotor)	H / H
	Rated Power	3050 kW
	Degree of protection	IP 54
	Frequency	50-60 Hz
	Voltage	12000 V
	Power factor (shortcircuited rotor)	0.93
	Speed range	770 - 1300 rpm (50 Hz) 920 - 1560 rpm (60 Hz)
CONTROL SYSTEM	Power control	Converter Control Unit
	Master processor	Programmable Logical Controller
	Interface	Scada
	Power factor correction	Programmable by software
TOWER	Type	Tubular Steel
	Tower height	85.5 m
	Material	S355 J2
	Access to the tower	Door with lock system
	Access to nacelle cabin	Ladder or elevator
	Weight	211 T
	Foundation connection	Two stud races embedded in concrete
OPERATING DATA	Cut-in wind speed	3 m/s
	Cut-out wind speed	25 m/s
	Nominal power	3000 kW
	Operation temperature range	-10°C to +40°C
	Survival temperature range	-20°C to +50°C



AW3000

Rev	Fecha Date	Descripción de la revisión Description of the revision
"A"	08/03/07	Elaboración
"E"	08/02/10	Actualización caracteristicas / Performance update
"F"	20/04/11	Cambio formato documento / Document format change
"G"	08/02/12	Actualización circuito generador. Apdo 6.4 trasladado a DG200311 / Generator circuit update. Setion 6.4 moved to DG200311
"H"	16/11/15	Actualización general / General update
"I"	22/08/16	Actualización punto 4.2.1 / Point 4.2.1 update

Realizado / Done	*Revisado / Reviewed*	*Aprobado / Approved*
22-08-2016	22-08-2016	22-08-2016

1. ALCANCE / SCOPE

Este documento aplica a las turbinas AW3000 con cualquier altura de torre y diámetro de rotor. En primer lugar se describen las características funcionales y prestaciones que ofrece la turbina. En segundo lugar se detallan todos los aspectos que deben considerarse para su correcta conexión, operación y servicio en red.

Certificación de turbina de acuerdo a la norma "Guideline for certification of Wind Turbines", Ed. 2010, Germanicher Lloyd and IEC 61400-1, "Wind turbine generator systems. Part 1: Safety requirements" 2nd Ed. 1999-02.

2. DESCRIPCIÓN GENERAL

La figura 2.1 muestra el esquema de potencia general simplificado del aerogenerador AW3000. La generación eléctrica utiliza la máquina de inducción doblemente alimentada controlada electrónicamente por rotor. La tensión nominal de estator es 12 kV (línea) y la potencia de generación (activa y reactiva) se controla por medio de las corrientes de rotor. Estas corrientes son producidas mediante un convertidor electrónico de conmutación forzada formado por interruptores de potencia de tipo IGBT. Tal como se muestra en la figura 2.1, el equipo de potencia se alimenta a 690V y los servicios auxiliares a 400V utilizando un transformador 12kV/690V/400V.

Para redes de parque diferentes de 12 kV, están disponibles opciones formadas un conjunto de trasformador y celdas de maniobra y protección integrable dentro de las torres de hormigón.

1. SCOPE

This document applies to all AW3000 wind turbines with any tower height or rotor diameter. First, all turbine functional characteristics and features of the turbines are described in detail. Second, all necessary aspects to be considered for correct connection, operation and grid service are also explained.

The wind turbine certification is according to "Guideline for certification of Wind Turbines", Ed. 2010, Germanicher Lloyd and IEC 61400-1, "Wind turbine generator systems. Part 1: Safety requirements" 2nd Ed. 1999-02.

2. GENERAL DESCRIPTION

Figure 2.1 shows a simplified electrical power circuit of the AW3000 wind turbine generator. The electrical generation is based on a doubly fed induction generator that is electronically controlled. Rated stator line voltage is 12 kV while the generation power (active and reactive) is controlled through the rotor currents. Those currents are produced by means of a hard switching electronic power converter based on IGBTs. As observed in figure 2.1, power converter supply is 690V while auxiliary services require 400V, thus requiring a step-down transformer 12kV/690V/400V.

For field bus voltages higher than 12 kV, options are available consisting on a set of transformer and high voltage cabinets (operation and protection) to be placed inside the turbine concrete towers.

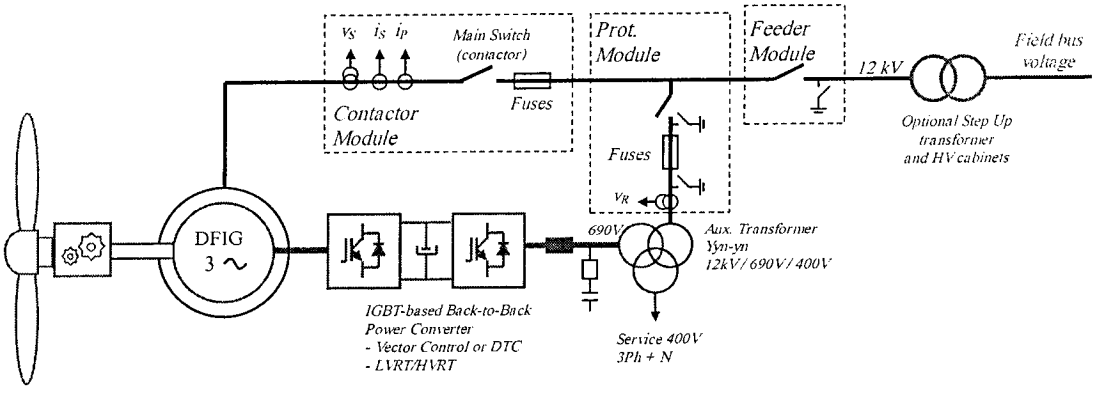


Figura 2.1 Esquema de generación AW3000 / ***Figure 2.1*** *AW3000 generation schematic*

3. CARACTERÍSTICAS NOMINALES PRINCIPALES

3. MAIN RATED VALUES

Característica / *Feature*	Nominal / *Rated*
Tensión de línea / *Line Voltage*	12000 VAC
Frecuencia de red / *Grid Frequency*	50/60 Hz
Potencia activa / *Active Power* [1]	3000 kW
Potencia Reactiva / *Reactive power* [1][2][3]	1200 kVAr

Tabla. 3.1.- Características nominales principales / ***Table 3.1*** *Rated values of Main characteristics*

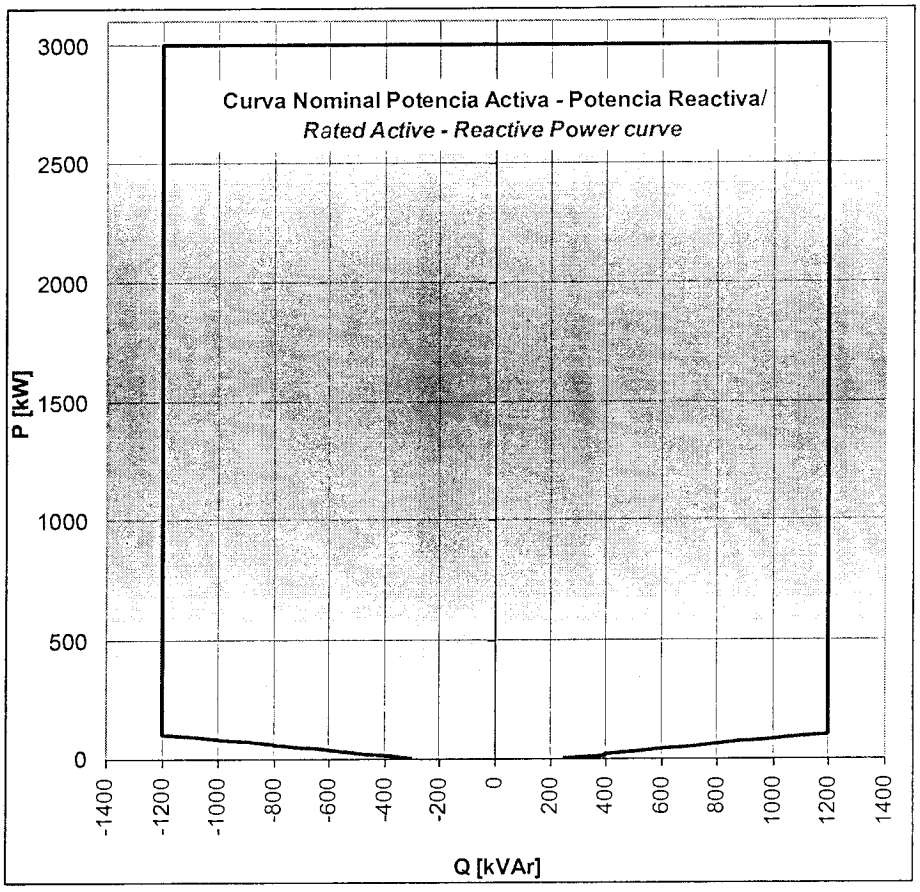


Figura. 3.1 .- Característica nominal Potencia Activa- Potencia reactiva [1][2][4]
Figure. 3.1 .- *Rated Active Power – Reactive power curve* [1][2][4]

(1) No aplicable a modos de reducción de ruido.
(2) La capacidad de potencia reactiva está disponible en el rango de tensión local del +/- 5% respecto a la nominal.
(3) Para la zona de baja potencia, se aplica una reducción lineal de esta capacidad de manera que desde aproximadamente 60kW hasta 0kW la potencia reactiva disponible pasa de ±1200kVAr a -300kVAr en la zona inductiva y 250kVAr en la zona capacitiva con el objeto de suavizar la transición.

(1) Not applicable in noise reduction modes.
(2) Reactive power capability is available when local voltage is within +/- 5% of the rated power.
(3) Lineal de-rating is introduced in the low power range such that the reactive power capability is reduced from ±1200kVAr to -300kVAr in the inductive region and to 250kVAr in the capacitive region from approx.60kW to 0kW respectively with the aim to make a soft transition.

4. OPERACIÓN FUERA DEL RANGO NOMINAL

4.1 Límites de operación en régimen permanente

El aerogenerador AW3000 puede operar fuera de los márgenes nominales definidos en el apartado 3. En la siguiente tabla se muestran los valores máximos y mínimos de tensión y frecuencia en los que la turbina puede operar de manera permanente.

4. OPERATION OUTSIDE RATED RANGE

4.1 Steady state operation limits

The AW3000 wind turbine can operate outside the nominal range defined in section 3. The table below shows the maximum and minimum voltage and frequency steady-state operation limits for a normal operation of the wind turbine.

	Valor / *Value*
Máxima tensión de línea / *Line maximum voltage*	Un+10% (13200V)
Mínima tensión de línea / *Line minimim voltage*	Un - 10% (10800V)
Frecuencia máxima de red / *Maximum grid frequency* - Versión 50 Hz / *50 Hz version* - Versión 60 Hz / *60 Hz version*	 53 63
Frecuencia mínima de red / *Minimum grid frequency* - Versión 50 Hz / *50 Hz version* - Versión 60 Hz / *60 Hz version*	 47 57

Tabla 4.1 Límites de operación de tensión y frecuencia de la AW3000 / ***Table 4.1*** *AW3000 frequency and voltage operation limits*

La figura 4.1 muestra el rango de potencia reactiva disponible en función de la tensión local y a potencia nominal. Por debajo del 95% de la tensión nominal o por encima del 105% existe una reducción de capacidades no lineal. Esta capacidad fuera del rango Un±5% puede extenderse en el caso de temperatura ambiente exterior igual o inferior a 30°C.

Figure 4.1. shows the range of reactive power available as a function of the local voltage at rated power. Below 95% of rated voltage or above 105% there is a non-linear reduction of capabilities. This capability out of the range Un±5% can be extended in the case of external ambient temperature equal or lower than 30°C.

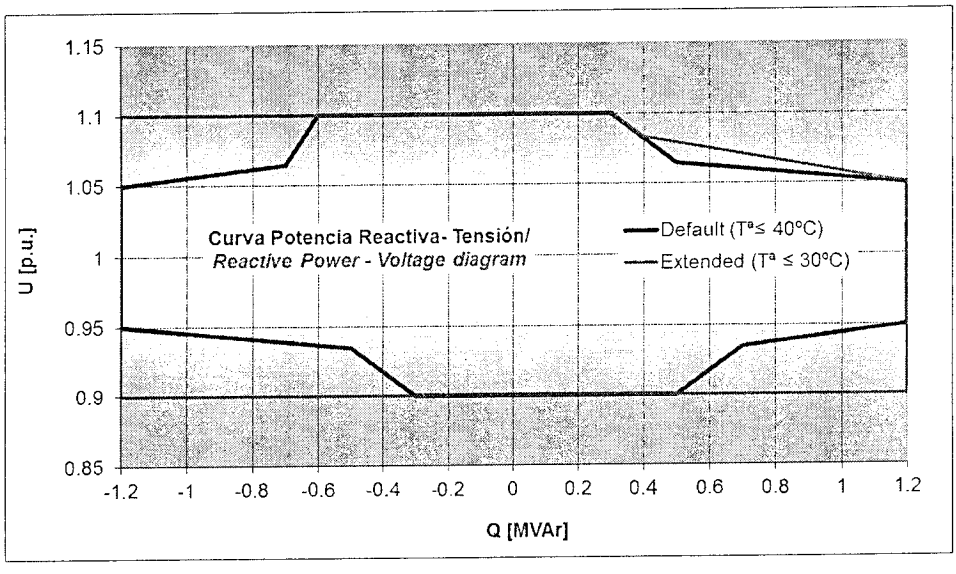


Figura. 4.1 .- Característica Potencia reactiva – Tensión
Figure. 4.1 .- *Reactive Power – Voltage characteristic*

4.2 Límites de operación en régimen transitorio

4.2.1 Perturbaciones transitorias de tensión

La turbina AW3000 incluye de manera estándar diversos dispositivos específicos para poder soportar huecos de tensión o sobretensiones de la red eléctrica. Opcionalmente, se pueden añadir componentes hardware específicos que permiten extender la capacidad del aerogenerador para superar perturbaciones de tensión. El sistema está diseñado para adaptarse y poder cumplir con los requerimientos del operador eléctrico local de la mayoría de países. La opción de capacidad extendida es dependiente de la configuración de la red del parque y por lo tanto solo está disponible tras un análisis caso a caso mediante estudios de simulación.

Después de la falta, el control establece operación normal en unos pocos segundos después de haber estado ayudando a equilibrar la tensión.

La turbina AW3000 está diseñada para poder trabajar en condiciones estacionarias con una sobretensión del 10% respecto a la nominal. Por encima de este límite, el valor de sobretensión admitido depende de la duración del mismo.

La figura 4.2.1 indica la región de tensión-tiempo máxima donde puede trabajar la turbina, tanto para la versión estándar como para la opción de capacidad extendida. Fuera de estos límites la turbina se desconectará de la red.

4.2 Transient operation limits

4.2.1 Voltage transients

The AW3000 includes specific devices in order to ride through voltage dips or swells in the electric grid. Optionally, specific hardware components can be added in order to extend the windturbine capacity to operate during voltage disturbances. Those systems have been designed to be easily configurable and therefore fulfill the electric requirements of local grid operators in most countries. The extended capacity option is dependent on the configuration of the wind farm grid and is therefore only available on case-by-case basis after simulation studies.

After the fault clearance, the control reaches normal operation after a few seconds during which several helpful LVRT and HVRT techniques have been balancing the local machine voltage.

The AW3000 turbine has been designed to operate normally up to 10% over rated voltage. Above this limit, the maximum over-voltage allowed depends on the duration.

The figure 4.2.1 shows the maximum allowable voltage-time region where the turbine operates, not only for the standard version but also for the extended capacity option. Outside that region the turbine is disconnected from the grid.

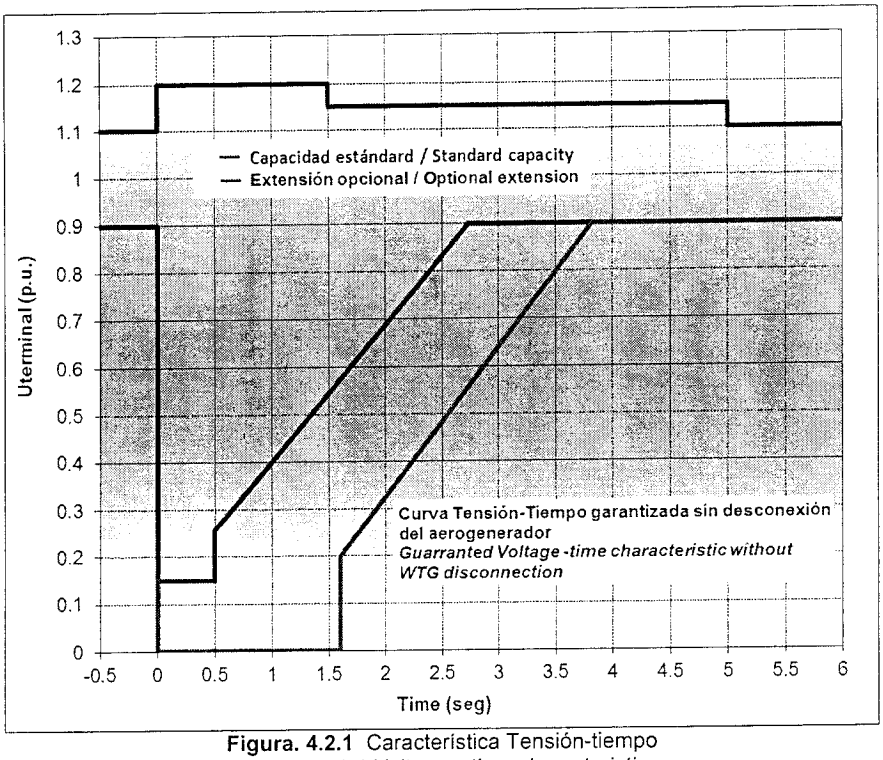


Figura. 4.2.1 Característica Tensión-tiempo
Figure. 4.2.1 *Voltage – time characteristic*

4.2.1.1 Inyección de potencia activa y reactiva en transitorios de tensión

La capacidad de inyección de corriente reactiva para el soporte de la tensión durante transitorios de la misma depende de los siguientes factores:

- Nivel de tensión remanente.
- Tipo de falta y su asimetría.
- Tiempo de control requerido.

Dicha inyección de corriente reactiva en falta es parametrizable y puede ser ajustada dependiendo de las condiciones exigidas en cada emplazamiento.

4.2.2. Perturbaciones transitorias de frecuencia

Los límites de frecuencia en operación se han definido en el apartado 4.1. Dentro de este rango, el tiempo en que el aerogenerador puede mantener su operación depende de la tensión de red. Para cada caso, se deberá confirmar con Acciona Windpower la capacidad de operación en tensión-frecuencia.

4.2.1.1 Active and reactive power supply in voltage transients

The supply of active and reactive power for the voltage support during its transients depend on the following factors:

- Remaining voltage level.
- Fault type and unbalance level
- Required settling time.

The mentioned reactive current supply during faults can be adjustable through parameter setting according to the required features in each project.

4.2.2 Transient frequency disturbances

The frequency limits in operation have been defined in section 4.1. Within this range, the time in which the windturbine can operate depends on the grid voltage. In each case, the voltage-frequency operation capability should be confirmed by Acciona Windpower.

5. MODOS DE CONTROL DE POTENCIA REACTIVA

La potencia reactiva intercambiada con la red puede ser controlada en tiempo real mediante el convertidor de frecuencia dentro de los límites definidos en los apartados anteriores. Este control puede ser local (consigna fija de tensión, potencia reactiva o factor de potencia para el aerogenerador) o remoto. El control remoto exige la instalación del armario de control de subestación AW SGCS, y permite implementar a nivel de subestación distintos controles de reactiva, los más comunes son:

- Control de la tensión de parque en el punto de medida del SGCS.
- Control de factor de potencia en parque en el punto de medida del SGCS.
- Control de potencia reactiva en parque en el punto de medida del SGCS.

El DG200112 describe con mayor detalle el armario de control de subestación AW SGCS y las funcionalidades disponibles a nivel de parque.

5. REACTIVE POWER CONTROL MODES

The reactive power exchanged with the grid can be controlled in real time by means of the power converter within the limits defined in previous sections. This control may be local (for constant voltage, reactive power or power factor setpoint for the windturbine) or remote. The remote control requires the installation of the AW SGCS substation controller cabinet, and allows the implementation at substation level of different reactive controls, most commonly:

- Windfarm voltage control in the measurement point of SGCS.
- Windfarm power factor control in the measurement point of SGCS.
- Windfarm reactive power control in the measurement point of SGCS.

DG200112 document describes in detail the AW SGCS substation controller cabinet and the functionalities available at windfarm level.

6. MODOS DE CONTROL DE POTENCIA ACTIVA Y POTENCIA/FRECUENCIA

Dentro del rango nominal de frecuencia definido en el punto 4.1, se dispone de controles de potencia activa y frecuencia a nivel de parque. Estos controles deben ser solicitados y acordados con AW para cada proyecto y exigen la instalación del armario de control de subestación AW SGCS. Dichos controles son configurables y pueden ser utilizados para cumplir con las necesidades de soporte de la red que requieren los operadores de red: controles de frecuencia, de limitación de potencia y rampa, etc.

La descripción técnica del funcionamiento de estos controles de potencia activa y frecuencia está recogida en el DG200428.

6. ACTIVE POWER AND POWER/FREQUENCY CONTROL MODES

Inside the rated frequency range defined in the point 4.1, active power and frequency controls are available at windfarm level. These controls should be demanded and agreed with AW for each project and require the installation of the AW SGCS substation controller cabinet. Such controls are configurable and can be adapted to meet grid operator requirements regarding grid support: frequency control, power limiting, ramp up/down limiting, etc.

The technical description of the performance of these active power and frequency controls is contained in the DG200428.

7. INSTALACION

7.1 Puesta a tierra

Su concepción general ha sido realizada siguiendo las indicaciones del estándar Germanischer Lloyd. No obstante, para el correcto funcionamiento de todos estos sistemas es necesario asegurar una puesta a tierra local cuya resistencia sea menor de 10 Ω incluso con la red de tierras de parque desconectada de la máquina.
El sistema de alimentación trifásica en 12kV debe estar rígidamente referenciado respecto a la tierra del aerogenerador. Para ello, el sistema de conexión que se recomienda es estrella con neutro conectado a la puesta a tierra del aerogenerador dentro de la torre. En el caso de que no sea posible disponer de esta conexión en estrella con neutro a tierra en el secundario del transformador de subestación, el aerogenerador podrá operar normalmente excepto en los casos de faltas monofásicas a tierra en dicho circuito secundario del transformador de subestación. En este tipo de faltas monofásicas, las fases sanas sufrirán una sobretensión 1,73 veces la tensión de fase, provocando la desconexión de todos los aerogeneradores conectados al secundario del transformador de subestación.

7.2 Coordinación de protecciones

7.2.1 Protecciones de turbina

El circuito de potencia de 12 kV de las turbinas AW3000 tiene dos líneas principales: línea de alimentación del transformador de auxiliares y línea de estator, figuras 7.2.1.1 y 7.2.1.2.

La celda del contactor de estator incluye una doble protección: fusibles y relé de sobrecorriente. La combinación de fusibles y relé proporciona una protección completa de tipo térmico, magnético y homopolar.

Los valores de ajuste de la protección de sobrecorriente en los aerogeneradores de cada parque eólico dependerán del modelo de celda empleado y de las normativas locales que sean de aplicación en cada caso.

A modo de ejemplo, la figura 7.2.1.1 muestra la curva resultante de protección teniendo en cuenta la solución combinada. El valor nominal de corriente es 148 A.

El circuito del transformador de auxiliares se protege por medio de fusibles de 63 A nominales. La curva de protección correspondiente corriente-tiempo se muestra en la figura 7.2.1.2.

7. INSTALATION

7.1 Grounding

The whole concept has been performed following the requirements of the Germanischer Lloyd rules. However, good performance of these systems is dependent on a local grounding system with resistance lower than 10 Ω, even when the ground network is disconnected from the turbine.

The 12kV three-phase supply system must be totally referenced with respect to the turbine ground. Therefore, the recommended connection system is star with neutral directly connected to the grounding couplings available inside the tower. In case this star connection with neutral connected to ground is not available in the secondary winding of the substation transformer, the windturbine will operate normally except for the case of single phase faults direct to ground in the mentioned secondary circuit of the substation transformer. In this type of single phase faults, the phases without fault will suffer from an overvoltage 1,73 times the phase voltage, causing the disconnection of all the windturbines connected to the secondary winding of the substation transformer.

7.2 Protection system coordination

7.2.1 Turbine protection

The 12kV power circuit of the AW3000 turbine has two main lines: auxiliary transformer supply line and the stator line, figures 7.2.1.1 and 7.2.1.2.

The stator contactor cabinet includes a double protection: fuses and overcurrent relay. The combination of these elements establishes a complete thermal, magnetic and single phase protection.

The parameter values of the overcurrent protection of the wind turbines, for each wind project, will depend on the switchgear model installed in each WTG and the local regulations that may be applicable in each case.

As an example, the figure 7.2.1.1 shows the resulting protection curve taking into consideration the combination of protection. The rated value for this curve is 148 A.

The transformer line is protected against short circuit and overloads by means of fuses rated at 63 A. The resulting current-time protection curve is shown on figure 7.2.1.2.

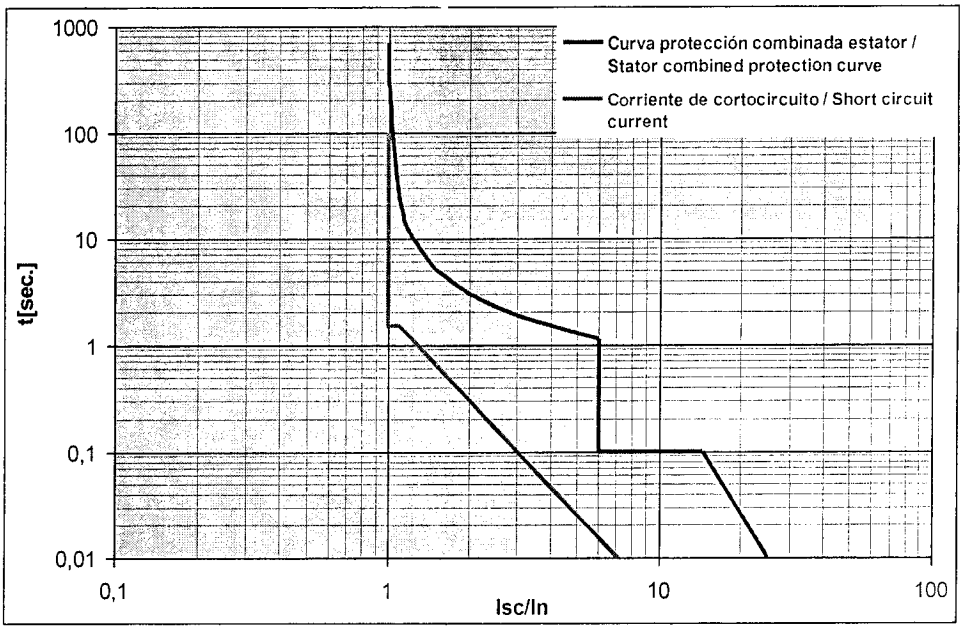


Figura 7.2.1.1 Curva de protección circuito estator
Figure 7.2.1.1 *Stator circuit protection curve*

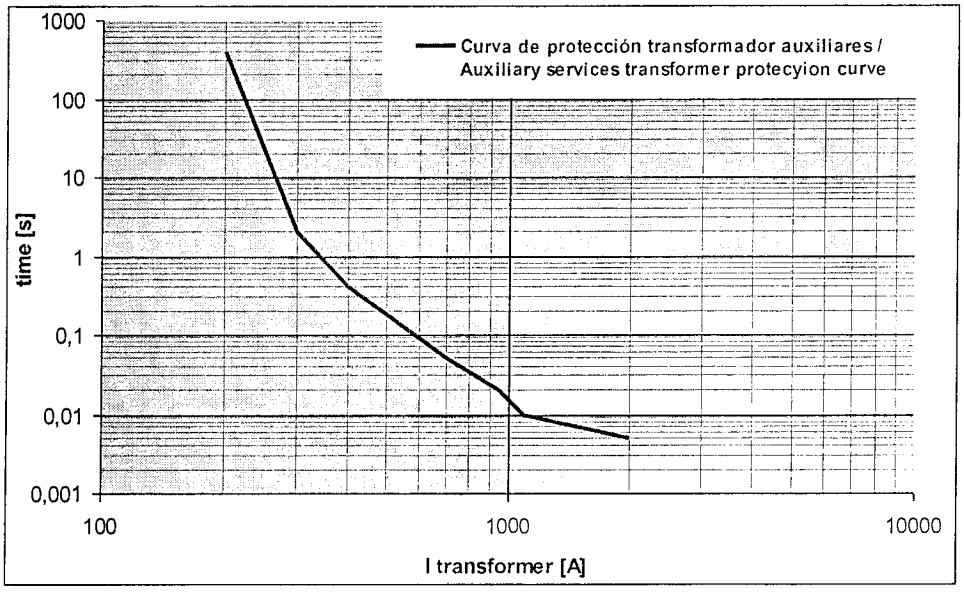


Figura 7.2.1.2 Curva de protección circuito transformador auxiliares
Figure 7.2.1.2 *Auxiliary services transformer circuit protection curve*

7.2.2 Protecciones de subestación

A continuación se indican una serie de recomendaciones y aspectos a tener en cuenta para la correcta configuración y taraje del conjunto de protecciones de línea en subestación.

- Las curvas de protección magneto-térmica de las alineaciones deben programarse con margen suficiente y teniendo en cuenta las curvas I-t de las figuras 6.2.1 y 6.2.2 y el número de máquinas total conectadas en cada alineación.

- Las máquinas incluyen protección por sobre/baja frecuencia de acuerdo a las normativas de red. Por ello, y siempre que sea posible, el margen de frecuencia a nivel de subestación deberá ser mayor y permitir de este modo operar a las turbinas.

- Las máquinas incluyen protección por sobre/baja tensión e incluyen también técnicas de respuesta de acuerdo a las normativas de red. A nivel de subestación el taraje de los relés correspondientes deberá dejar margen de reacción suficiente para que las turbinas realicen su trabajo.

- El estator del generador (12kV) está conectado en estrella con neutro aislado. Por ello, fallos homopolares fuera de la turbina únicamente se detectarán en subestación.

Acciona Windpower dispone de información y procedimientos detallados para ayudar en el proceso de ajuste y coordinación de las protecciones de subestación. Esta documentación debe solicitarse a personal responsable de Acciona Windpower en cada país.

7.3 Potencia consumida por servicios auxiliares

La potencia consumida por servicios auxiliares en el aerogenerador AW3000 depende de las condiciones de operación de la turbina, como el viento o la temperatura ambiente. El documento DG200404 desglosa la potencia nominal de los servicios auxiliares y detalla las variables que intervienen en la activación de los diferentes subsistemas.

7.2.2 Substation protection

The following indications and recommendations should be taken into consideration during the configuration and setting of all protection relays at the substation:

- Instantaneous and delayed protection relay settings of every circuit must be defined with enough margin considering the I-t curves, in figure 6.2.1 and 6.2.2, and the number of machines installed on every circuit.

- All turbines include over/under frequency protection mechanisms according to grid operator grid codes or standards. Therefore, and if it is possible, the frequency margin of the substation relays should be higher to allow the turbines operation.

- Turbines also include protective means for over/under voltage together with grid supporting techniques according to grid codes. Substation relays settings should have enough margin in order to allow the operation of the turbines according to the grid requirements.

- Generator stator (12kV) is star-connected with isolated neutral. Therefore, single phase faults outside the turbine can only be detected at substation level.

Acciona Windpower offers detailed information and procedures to help during the definition and coordination of protection relays at the substation. To request this documentation please contact local Acciona Windpower staff.

7.3 Auxiliary services power demand

The power demanded by the auxiliary services within AW3000 windturbine depends on the operating conditions of the turbine, like the wind or the ambient temperature. The document DG200404 breaks down the rated power of the auxiliary services and details the variables that take part in the activation of the different subsystems.

8. INTEGRACIÓN EN LA RED

8.1 Generalidades

En este documento, se utiliza un factor para caracterizar la debilidad de la red de un proyecto cualquiera. Este factor se define SCR (ratio de corriente de cortocircuito) y debe calcularse como el cociente entre la potencia de cortocircuito presente en el lado de baja tensión del transformador de la subestación y la potencia total de parque instalada.

8.2 Calidad de energía

Todas las versiones de turbina AW3000 se ensayan en campo conforme a la CEI 61400-21. Los informes correspondientes a dichos ensayos están disponibles en versión documento general.

8.3 Estudios de conexión a red

8.3.1 Modelos de simulación

Hay disponibles modelos de simulación actualizados de la turbina AW3000 en las plataformas PSS/E (Siemens PTI) y Power Factory (DigSilent). Con estos modelos se puede analizar la integración en red de la máquina a partir de estudios de flujos de carga, dinámicos, huecos de tensión, sobretensiones, etc. En ambos casos los modelos están disponibles para usuarios registrados en los sitios web correspondientes a cada plataforma de simulación:

- PSS/E: http://www.pti-us.com
- Power Factory: http://www.digsilent.de/

Para la descarga de los modelos es necesario disponer de permisos o contraseñas que serán suministradas por personal acreditado de Acciona Windpower en cada país. Los modelos de simulación se sirven con el siguiente contenido:

- Modelo compilado de la turbina eólica. Capaz de simular parques agregados.
- Modelo de controlador de tensión de subestación
- Manual de configuración y uso del modelo

8. GRID INTEGRATION

8.1 Overview

In this document a specific factor is used to characterize the weakness or strength of the grid for any Project. This factor is defined as SCR, Short Circuit Ratio, and must be calculated considering the short circuit power remaining on the low voltage side of the substation transformer with respect to the rated wind farm power.

8.2 Power quality

All AW3000 turbines models are tested in the field to obtain the correspondent power quality report according to IEC 61400-21. Actual reports are available as generic documents.

8.3 Estudios de conexión a red

8.3.1 Simulation models

Acciona Windpower offers updated simulation models for the AW3000 turbine on PSS/E (Siemens PTI) and Power Factory (DigSilent) platforms. These models were designed for grid integration analysis based on different studies such as load flux, dynamic, LVRT, HVRT or swells, etc. In both cases the models are available only for registered users at the web sites of the corresponding simulation platforms:

- PSS/E: http://www.pti-us.com
- Power Factory: http://www.digsilent.de/

To download the model it is necessary to obtain specific permission or password from authorised Local Acciona Windpower personnel. All simulation models are supplied with the following content:

- Wind turbine model. Compiled code. Valid for lumped simulation of big wind farms.
- Substation Voltage Controller model.
- User manual for correct use or configuration.

8.3.2 Recomendaciones y estudios necesarios

La tabla 8.2.1 resume todas las recomendaciones y condiciones necesarias para la correcta instalación y operación de las turbinas AW3000 en función del ratio de cortocircuito, SCR.

8.3.2 Recommendations and necessary analysis

Table 8.2.1 summarises all recommendations and conditions necessary for a safe and correct operation of AW3000 wind turbines as a function of the SCR factor.

SCR at turbine terminals	Recomendaciones / Acciones *Recommendations / Actions*		
	Estabilidad *Stability*	Flujo cargas *Load flow*	
> 10	-	-	No se recomienda especialmente ningún estudio particular. *No special recommendations or particular studies are required.*
≥ 5	○	●	Se recomienda un estudio de flujo de cargas y quizá también de estabilidad para comprobar el correcto funcionamiento de los ajustes estándar de la respuesta del aerogenerador.
< 5	●	●	Se recomienda realizar estudios completos de estabilidad de red y de flujo de cargas de cara a encontrar los ajustes de la respuesta del aerogenerador que aseguren la integración del parque en la red.

Tabla 8.3.2.- Análisis y acciones necesarias y recomendadas
Table 8.3.2.- *Necessary and recommended analysis and actions to be taken*

8.3.3 Constantes mecánicas

Las principales constantes mecánicas se han tenido en cuenta en el desarrollo de los modelos de simulación de Acciona Windpower (PSS/E, Digsilent). Estas constantes no deben utilizarse en modelos simplificados de generadores eólicos. Las múltiples etapas de control activo así como la rápida gestión de potencia electrónica modifican sustancialmente la respuesta respecto de la que se obtiene en los modelos de simulación clásicos.

8.3.3 Mechanical constants

The most important mechanical constants have taken into account during the development o simulation models of Acciona Windpower (PSS/E Digsilent). Such constants must not be used to simplified simulation models of wind turbines. multiple stages with active controls together witl fast response electronic control modify substar the turbine behavior with respect to the resp obtained through classic simulation models.

8.3.4 Valores del circuito equivalente del generador en régimen permanente

Los valores del circuito equivalente del generador en régimen permanente pueden variar ligeramente de un modelo de generador a otro. A modo de ejemplo, se muestran a continuación unos valores tipo.

8.3.4 Steady state generator equivalent circuit parameters

The values of the equivalent circuit of the generator may be slightly different from each generator model.
Following table is an example of type values.

	Generador inductivo doblemente alimentado *Double feed induction generator (DFIG)*	
	Version 50 Hz ***50 Hz version***	***Version 60 Hz*** ***60 Hz version***
Circuito equivalente (estrella) referido a estator / *Equivalent circuit (star) referred to stator side* Resistencia **estator** /*stator resistance* Resistencia **rotor** / *rotor resistance* Reactancia **stator** / *stator reactance* Reactancia **rotor** / *rotor reactance* Reactancia **magnetización** / *magnetizing reactance*	 0.465 Ω @ 165°C 0.338 Ω @ 165°C 3.32 Ω 4.91 Ω (s=0) 122 Ω	 0.372 Ω @ 95°C 0.249 Ω @ 95°C 3.88 Ω 5.86 Ω (s=0) 171 Ω
Tensión de **rotor** bloqueado en circuito abierto (tensión de línea) / *Locked rotor voltage with rotor terminals opened (phase-to-phase)*	1848 V	1850 V
Momento de **inercia** / *Moment-of-inertia*	404 kgm^2 / 9587 $lbft^2$	404 kgm^2 / 9587 $lbft^2$
Numero polos / *Pole Lumber*	6	6
Deslizamiento y velocidad nominal / *Rated slip and speed*	10% / 1100 rpm	10% / 1320 rpm

Tabla. 8.3.4.- Características del generador
Table 8.3.4.- Generator parameters

8.3.5 Resumen de características dinámicas

La tabla 8.3.5 muestra los valores por unidad de impedancias transitorias establecidas para el circuito de generación de la AW3000. Puesto que este sistema trabaja controlado activamente por un convertidor de potencia la respuesta es difícilmente representable únicamente con impedancias.

Los valores se han calculado para una potencia base de 3000kVA y una tensión de línea base de 12000V.

8.3.5 Dynamic characteristics summary

Table 8.3.5 shows the transient impedances (per unit) established to represent the generation circuit response of the AW3000 turbine. This system is controlled by power electronic converters. Consequently, the final response produced during grid events is difficult to represent considering only impedance equivalent circuits.

Values have been calculated using 3000kVA base and 12000V base

	Version 50 Hz *50 Hz version*	*Version 60 Hz* *60 Hz version*
Reactancia síncrona directa Xd(i)/*Direct Synchronous reactance Xd(i)* (pu)	2.589	3.832
Reactancia transitoria directa X'd(i)/*Direct transient reactance X'd(i)* (pu)	0.170	0.211
Reactancia subtransitoria directa X"d(i)/ *Direct sub-transient reactance X"d(i)* (pu)	0.170	0.211
Reactancia sincronía de cuadratura Xq(i)/*Quadrature synchronous reactance Xq(i)* (pu)	2.589	3.832
Reactancia transitoria de cuadratura X'q(i)/*Quadrature transient reactance X'q(i)* (pu)	0.170	0.211
Reactancia subtransitoria de cuadratura X"q(i)/*Quadrature sub transient reactance X"q(i)* (pu)	0.170	0.211
Reactancia de fugas de estator X1/ *Stator leakage reactance, X1* (pu)	0.0683	0.0821
Resistencia estator / *Armature winding resistance (pu)*	0.00765 @95°C	0.00758 @95°C
Constante de tiempo transitoria / *transient time constant, Td,q'* (ms)	71 ms	74 ms
Constante de tiempo subtransitoria / *subtransient time constant, Td,q" (ms)*	92 ms	94 ms
Constante de tiempo de circuito abierto / *open circuit time constant Td,q0'* (ms)	1394 ms	1699 ms

Tabla 8.3.5.- Impedancias transitorias
Table 8.3.5.- *Transient Impedances*

Annexure-8a:

REVISED SCHEDULE-II OF LPM

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 Power Plant/Wind Farm (MW/GWh)	51MW
(2).	Total Annual Full Load Hours	3066
(3).	Average Wind Turbine Generator (WTG)Availability	97%
(4).	Total Gross Generation of the Generation Facility/Wind Farm (in GWh)	196,193 GWh
(5).	Array & Miscellaneous Losses GWh	29.036 Gwh
(6).	Availability Losses GWh	5.885 Gwh
(7).	Balance of Plant Losses GWh	4.829 Gwh
(8)	Annual Energy Generation (25 year equivalent Net AEP) GWh	156,443 Gwh
(9).	Net Capacity Factor	35%

Note

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

Annexure 9

Technology, Size and No. of Units

Technology	Wind Power
Size	51MW
No. of Units	**17**

Annexure 10

Grid Interconnection Details

Name of Grid	Jhimpir-1
Distance from Nearest Grid	30KM
Grid Voltage	132KV

Annexure 11

Project Cost, Debt/Equity

Project Cost

The estimated project cost is **91.31 Million USD**.

Debt to Equity Ratio
73.048 Million USD (80%) : 18.262 Million USD (20%)

Annexure 12

Project Commencement and Completion Schedule

Award of Tariff	Dec 30, 2017
Financial Close	Dec 30, 2018
Commercial Operation Date	Mar 30, 2020

Annexure 13

Grid Study and Approval

Central Power Purchasing Agency (Guarantee) Limited

A Company of Government of Pakistan

OFFICE OF THE CHIEF TECHNICAL OFFICER

No. Tech/DGMT-II/MT-V/SRE1PL/ 35290-92 Dated: 09/10/2017

M/s Shaheen Renewable Energy 1 (Pvt) Limited,
P.O Box 2225, E-9, PAF Complex, Islamabad

Project: 51 MW Wind Power Plant, Shaheen Renewable Energy 1 (Pvt) Limited

Subject: Approval of Grid Interconnection Studies for 1.7 MW Increase in Gross Capacity.

Reference: [1] General Manager Power System Planning, NTDC office letter No. GMPP/CEMP/TRP-380/5862-63 dated 04-10-2017
[2] This office letter No. Tech/DGMT-II/MT-V/SRE1PL/33401-03 dated 12-09-2017

General Manager Power System Planning vide [1] have intimated that 1.7 MW enhanced capacity with total gross capacity of 51 MW of the subject wind power plant can be dispersed from the proposed location to the national Grid System. So there is no need to modify and resubmit the grid Interconnection study of M/s Shaheen WPP in respect of its increased capacity of 1.7 MW.

The same is being forwarded for necessary action, please.

Manager (Tech)-V
CPPA-G, Islamabad
9/10

Copy to:

1. Chief Technical Officer, CPPA-G Islamabad.
2. General Manager Power System Planning NTDC, 4F PIA Tower, Egerton Road, Lahore.
3. Master File.

9A

NATIONAL TRANSMISSION & DESPATCH CO. LTD (NTDC)

General Manager Power System Planning, NTDC

No. GMPP/CEMP/TRP-380/5862-63 Dated: 4-10-2017

Chief Technical Officer CPPA(G) Ltd.
Ground Floor, ENERCON Building,
G-5/2, Islamabad.
Fax#:051-9216949

Sub: Approval of Grid Interconnection Studies for 1.7 MW Increase in Gross Capacity of Shaheen Renewable Energy-1 (Private) Limited 51 MW Wind Power Project Located at Bholari, District Thatta, Province of Sindh

Ref: CPPA-G Letter No. Tech/DGMT-II/MT-V/SREIPL/33401-03 dated 12-09-2017.

With reference to the above letter, it is to intimate that 1.7 MW enhanced capacity with total gross capacity of 51 MW of the subject wind power plant can be dispersed from the proposed location to the national grid system. Therefore, there is no need to modify and resubmit the grid interconnection study of Shaheen WPP in respect of its increased capacity of 1.7 MW.

(Maqsood Ahmad Qureshi) 4/10/17
General Manager Power System Planning

cc:
- M/s Shaheen Renewable Energy-1 (Private) Limited, P.O. Box 2225, E-9, PAF Complex, Islamabad. MD SF — For info, pl 4/6/x
- *Master File (MP)*

SRE - 1		
Seen by	Action	Info
Proj. Director	4/6/x	
G.M.		
Manager (Tech)		
Manager (Fin)		
H/Clk		
PA / Office Asstt.		
Diary No.	206	

12 Grid study

21A

NATIONAL TRANSMISSION & DESPATCH COMPANY LTD

No. 8800 /GM/GSC/NTDC

GENERAL MANAGER (GSC)

Date: 01/12/2016

CERTIFICATE

Subject: **APPROVAL OF SYSTEM STUDIES OF 50 MW OF M/S SHAHEEN RENEWABLE ENERGY 1 (PVT) LTD (SHAHEEN FOUNDATION) WIND POWER PROJECT.**

NTDC hereby accords its approval in respect of system studies submitted by M/s Shaheen Renewable Energy 1 (Pvt) Ltd (Shaheen Foundation) in respect of 50 MW Wind Power Project at Jhimpir Sindh. NTDC further certifies that the power to be generated by M/s Shaheen Renewable Energy 1 (Pvt) Ltd (Shaheen Foundation) will be evacuated by July, 2019 and the power injected through the above mentioned project will not have any adverse affect on the National Grid as required under the Grid Code.

Signature:

Name: WAJAHAT SAEED RANA

Designation: General Manager (GSC)
413-WAPDA House, Lahore.

413-WAPDA House, Lahore, Pakistan Tel: +92 42 99202699, Fax: +92 42 99202150, gmgsc@nldc.com.pk

Annexure 14

Expected Life of Generation Facility

Expected Life of Generation Facility is 25 years

Annexure 15

Feasibility Study and Approval

Government of Pakistan
Alternative Energy Development Board (AEDB)

AEDB

B/3/1/SF/15

October 03, 2017

Subject: **PANEL OF EXPERTS (POE) MEETING TO REVIEW THE FEASIBILITY STUDY SUBMITTED BY SHAHEEN RENEWABLE ENERGY 1 (PVT.) LIMITED FOR APPROVAL**

This is with reference to the project feasibility study submitted by Shaheen Renewable Energy 1 (Pvt.) Limited (SRE-1) to AEDB for approval under RE Policy 2006.

2. It is apprised that SRE-1 is developing a 51MW wind power project at Bholari, District Thatta, Sindh under Letter of Intent (LOI) issued by AEDB. The Project Company has completed the project feasibility study and is now completing formalities to file for negotiated tariff under Cost-Plus regime to NEPRA.

3. As per Section 8.7.1.3 of the RE Policy 2006 "The Feasibility Study will be reviewed by a Panel of Expert (POE) appointed by AEDB". The POE will evaluate the feasibility study submitted by project sponsor and shall submit its recommendations (either approval or rejection of request) to CEO, AEDB for endorsement. CEO, AEDB is pleased to constitute the POE committee comprising of representatives from following departments:

i. Alternative Energy Development Board (AEDB)
ii. Central Power Purchasing Agency (Guarantee) Limited (CPPA-G)
iii. National Transmission & Dispatch Company Limited (NTDCL)
iv. Sindh Environmental Protection Agency (SEPA)

4. The POE meeting is scheduled on **October 12, 2017 at 1100hrs** in the conference room of AEDB Head Office Islamabad. It is requested to kindly nominate a representative from your organization to attend the above requested POE meeting. Further enclosed please find the copy of the feasibility study submitted by SRE-1 for your kind review please.

(Naeem Momon)
Director (Wind-II)

Distribution:
i. Chief Executive Officer, CPPA (G), Islamabad
ii. Managing Director, NTDCL, Lahore
iii. Director General, SEPA, Karachi

Copy to:
a. Chief Executive Officer, SRE-1, Islamabad (with a request to attend and give presentation on Feasibility Study to POE)
b. Director (Policy), AEDB
c. Director (Wind-I), AEDB
d. PS to CEO, AEDB (for information please)

2nd Floor, OPF Building, Shahrah-e-Jumhuriat, Sector G-5/2, Islamabad.
Ph: 051-9202082 / Fax: 051-9222364