finergy

Dated: November 8th, 2018

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

SUBJECT: **LICENSEE PROPOSED MODIFICATION APPLICATION FOR 49.95 MW FINERGY (PRIVATE) LIMITED**

Dear Sir,

I, Mr. Farman Ahmed Khan Lodhi, being the duly authorized representative of 49.95 MW Finergy (Pvt.) Limited by virtue of Board Resolution dated 06-11-2018 hereby apply to the National Electric Power Regulatory Authority for the modification of Generation License No. WPGL/21/2013 dated 22nd August, 2013 pursuant to section to Regulation 10(2) of the National Electric Power Regulatory Authority (Application and Modification Procedure) Regulations, 1999.

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 Pay Order in sum of **PKR 326,272** (Rupees Three Hundred and Twenty Six Thousand Two Hundred and Seventy Two 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.

Farman Ahmed Khan Lodhi
Chief Executive Officer

FINERGY (PVT.) LIMITED

RIAA Barker Gillette Chambers 68, Nazimuddin Road F8/4, Islamabad-44000, Pakistan
T: +92 51 111 529 937

finergy

Dated: November 6th, 2018

RESOLUTIONS OF THE BOARD OF DIRECTORS OF FINERGY (PRIVATE) LIMITED PASSED THROUGH CIRCULATION

RESOLVED THAT Finergy (Private) Limited (the "**Company**") hereby authorizes Mr. Farman Ahmed Khan Lodhi, Chief Executive Officer of the Company, to file an application for Licensee Proposed Modification (the "**Application**") for the Company's proposed 49.95 MW Wind Power Project in Jhimpir, 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 License in respect of the Project and further also for any revisions or modifications to the awarded revised Generation License 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 on 6th November 2018.

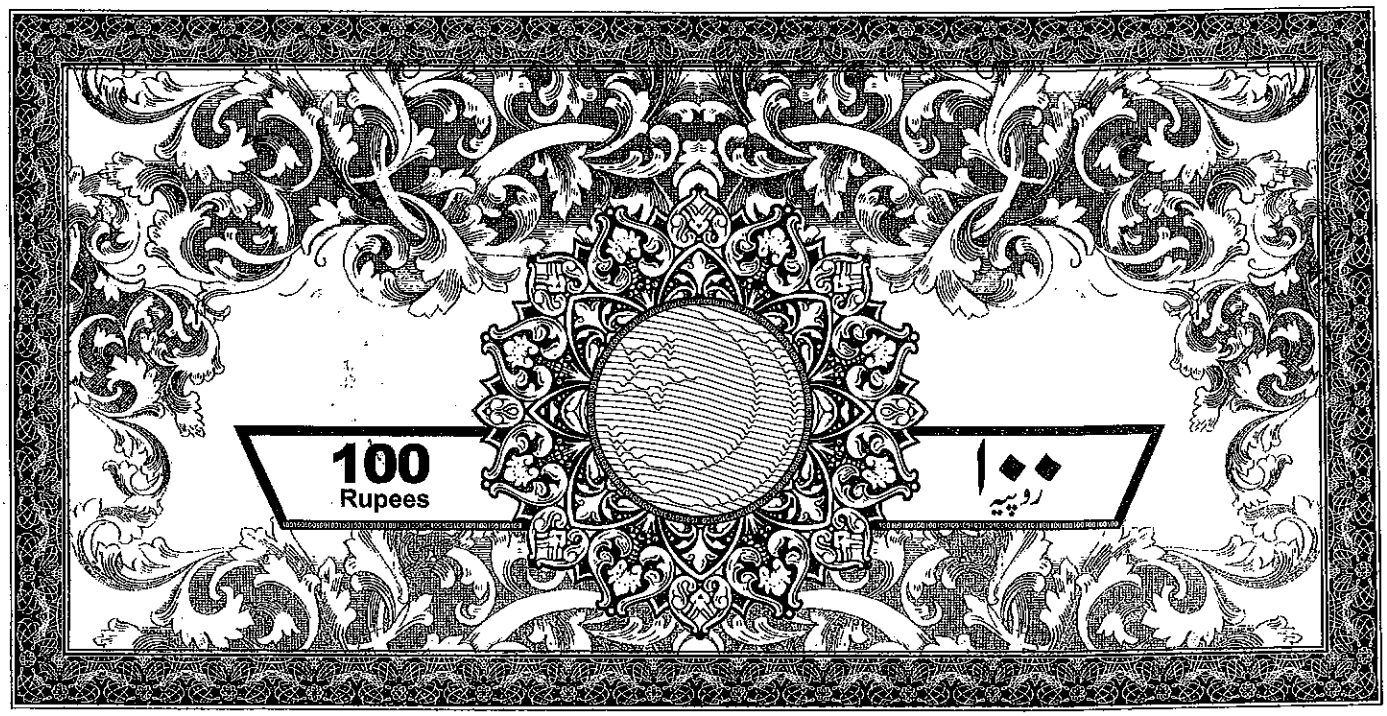
Certified True Copy

Abdul Basit Tola
Director

FINERGY (PVT.) LIMITED

RIAA Barker Gillette Chambers 68, Nazimuddin Road F8/4, Islamabad-44000, Pakistan
T: +92 51 111 529 937

M245302



RUPEES ONE HUNDRED ONLY

MUHAMMAD ASIF STAMP VENDOR
Licence No. 68, Shop No. B-108, Grace Shopping Mall,
Gulshan-e-Iqbal, Karachi
S.NO 893 DATE
ISSUED TO WITH ADDRESS
THROUGH WITH ADDRESS MUHAMMAD NAWAZ
PURPOSE H-C 7493 Advocate
VALUE RS
STAMP VENDOR SIGNATURE

01 AUG 2018

BEFORE

THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

AFFIDAVIT

I, Mr. Farman Ahmed Khan Lodhi, holding CNIC 42101-7436364-3, Chief Executive Officer, Finergy (Private) Limited, C-18, Block – 4, Clifton, Karachi, Pakistan, do hereby solemnly affirm and declare that:

1. The Licensee Proposed Modification Application for 49.95 MW Finergy (Private) Limited 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 Finergy (Private) Limited 49.95 MW wind power project at Jhimpir, District 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

FINERG

BEFORE
THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
(NEPRA)

APPLICATION FOR MODIFICATION IN GENERATION LICENSE NO. WPGL/ 21/2013 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) REGULATION 1999 AND LICENSING (GENERATION) RULES 2000 &
THE FEDERAL GOVERNMENT'S
'POLICY OF RENEWABLE ENERGY FOR POWER GENERATION 2006'

ON BEHALF OF

FINERGY (PVT) LIMITED

FOR NEPRA'S APPROVAL OF MODIFICATIONS IN THE GENERATION LICENSE NO. WPGL/ 21/2013 DATED 22 AUGUST 2013 FOR FINERGY (PVT) LIMITED

FOR A POWER PROJECT OF 49.95 MW

AT

JHIMPIR, DISTRICT THATTA, PROVINCE OF SINDH, PAKISTAN

DATED: 08 November 2018

FINERGY (PVT) LIMITED
ADDRESS : C-18, BLOCK – 4, CLIFTON, KARACHI
PHONE # : (+9221) 3587 6531- 35
FAX # : (+9221) 3587 6621

1. BACKGROUND – GRANT OF GENERATION LICENSE

1.1 NEPRA'S GRANT OF GENERATION LICENSE

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

1.1.2 Pursuant to the Sections 7(2) (a) and 15 of the NEPRA Act read with the other enabling provisions of the NEPRA Act, the National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations 1999 (the **Licensing 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, **FINERGY (PVT) LIMITED** submitted its application (the **Generation License Application**) on August 16, 2012 to NEPRA for grant of a generation license to Finergy (Pvt) Limited for its power generation facility to be located at Jhimpir, District Thatta, Province of Sindh, Pakistan (the **Project**).

Later pursuant to the provisions of sub-regulation (15) and in accordance with sub-regulation (2) of the Regulation 10 of the Licensing Regulation 1999 of NEPRA, **FINERGY (PVT) LIMITED** submitted its application for the Modification Generation License on August 16, 2012.

1.1.3 NEPRA in exercise of the powers conferred upon it under the laws of Pakistan granted a generation license (Ref: WPGL/21/2013) (the **Generation License**) to Finergy (Pvt) Limited on August 22, 2013.

2. APPLICATION FOR MODIFICATION IN THE GENERATION LICENSE

2.1 CHANGES RESULTING IN APPLICATION FOR MODIFICATION II

2.1.1 Finergy (Pvt) Limited, being the licensee under the Generation License, (the **Licensee**), is desirous of modifying the Generation License, to the extent and in the form set out hereunder in Section 3 (*Proposed Modification in the Generation License*), due to certain changes relating to its Project – as set out in this Generation License Modification Application (the **Project Changes**):

Change in Wind Turbine Generator (WTG) Type

The licensee is applying for a Modification Generation License with the aim in mind to have the latest technology available for the project. The previous turbines GE 1.5 xle selected by the Licensee have now been upgraded for improved performance and output. The new upgraded version, which the licensee has now opted for is Acciona Wind (AW) 3.15MW - 125m and AW3.0MW turbines, is the latest and technically the best of its class available in the market and very well suited for our environment.

Because of this change in the individual capacity of the turbines, we propose to change the configuration of the windfarm so that it consists of 13 AW3.15MW - 125 WTGs and 3 AW3.0MW – 125 machine hence the overall installed capacity of the project shall become 49.95 MW still in line with the LOI awarded for the Project i.e., 50MW.

The step to install higher generating capacity turbines was taken keeping in view the power crisis in the country. Though the installed capacity remains in the same range, these machines are more efficient and the extra generation produced by the new turbines would be added to our national grid, resulting in a reduced quantum of load shedding, combating the power crisis and giving a boost to our energy deficient economy.

2.2 LOI APPROVAL OF PROJECT CHANGES

2.2.1 The Project Changes set out in Section 2.1.1 are same as per the LOI issues to us by the Government of Sindh, Energy Department hence no additional review or approval by GoS is required. Similarly no change in the bank guarantees submitted to GoS or modification of LOS is required.

2.3 PROCESS FOR MODIFICATION

2.3.1 Subject to the provisions of sub-regulation (15) and in accordance with sub-regulation (2) of the Regulation 10 of the Licensing Regulation 1999, a licensee may, at any time during the term of its generation license, communicate to NEPRA a licensee proposed modification setting out:

(a) the text of the proposed modification;

(b) a statement of the reasons in support of the modification; and

(c) a statement of the impact on the tariff, quality of service and the performance by the Licensee of its obligations under the generation license.

2.4 APPLICATION FOR MODIFICATION OF LICENSE

2.4.1 **PURSUANT TO** Regulation 10 of the NEPRA Licensing (Application & Modification Procedure) Regulation 1999: **FINERGY (PVT) LIMITED SUBMITS** for NEPRA's kind consideration and approval, the application for modification in its Generation License together with supporting documents (the **Generation License Modification Application**) appended to the Generation License Modification Application at **Annexure A** (*Amended Schedule-I*) **and Annexure B** (*Amended Schedule-II*).

2.6 This Generation License Modification Application is submitted in triplicate, together with Bank Draft No. 00660496 dated 06 November 2018 in the amount of PKR 326,272/- as requisite fee for the Generation License Modification Application, as communicated by NEPRA.

3. PROPOSED MODIFICATION IN THE GENERATION LICENSE

3.1 AMENDMENTS TO SCHEDULE I: PLANT DETAILS – Section entitled "General Information"

i. The proposed modification to section 1 entitled "GENERAL INFORMATION" of "SCHEDULE I – PLANT DETAILS" of the Modification Generation License is attached hereto at **Annexure A (*Modified Schedule-I*)**

3.2 AMENDMENTS TO SCHEDULE I: PLANT DETAILS – Sections entitled "Plant System Description", "Turbine Data", "Generator Data", "Power Performance Curve" and "Single Line Diagram"

i. The proposed modifications to sections entitled "Plant System Description", "Turbine Data", "Generator Data", "Power Performance Curve" and "Single Line Diagram" of "SCHEDULE I – PLANT DETAILS" of the Modification Generation License are attached hereto at **Annexure A (*Modified Schedule-I*)** with "Plant System Description", "Turbine Data", "Generator Data", and "Power Performance Curve" being Modified.

ii. The sections entitled "Plant System Description", "Turbine Data", "Generator Data", "Power Performance Curve" and "Single Line Diagram" of "SCHEDULE I – PLANT DETAILS" of the Modification Generation License are submitted for modification due to the WTG Type Change (as submitted in Section 2.1.1 above). The mentioned sections reflect the information relating to AW 3.15MW - 125m WTGs (as selected for the Project) in addition to AW 3.0MW – 125 WTGs.

iii. Considering that the Licensee has selected the AW 3.15/3.0 MW – 125m WTGs with an aim of achieving high standards in technology for its Project, the output and the performance by the Licensee of its obligations under the Generation License will improve as a result of this selection. And as stated above considering the power crisis of the economy, this shift will increase the power available for the national grid, in turn abating the quantum of load shedding and will ameliorate our energy deficient economy at minimal increased project cost.

3.3 AMENDMENTS TO SCHEDULE I: PLANT DETAILS – Section entitled "Project Commissioning Date (Anticipated)"

i. The proposed modification to the section entitled "Project Commissioning Date (Anticipated)" of "SCHEDULE I – PLANT DETAILS" of the Modification Generation License is attached hereto at **Annexure A (*Modified Schedule-I*)**.

3.4 AMENDMENTS TO SCHEDULE II: NET CAPACITY OF THE LICENSEE'S GENERATION FACILITIES

i. The proposed modification to Schedule II – "Net CAPACITY OF THE LICENSEE'S GENERATION FACILITIES" of the Generation License is attached hereto at **Annexure B (*Modified Schedule-II*)**.

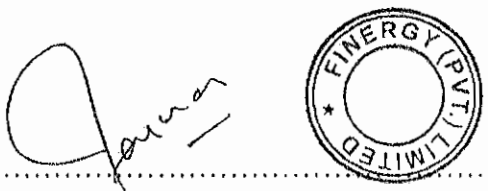
ii. The proposed modifications to Schedule II – "Net CAPACITY OF THE LICENSEE'S GENERATION FACILITIES" of the Modification Generation License are submitted for modification due to the WTG Type Change (as submitted in Section 2.1.1 above). Schedule II reflects the information relating to AW 3.0 – 125 m WTGs (as selected for the Project) in addition to AW 3.0 WTGs (details of which are presently set out in the Modification Generation License). In addition, the table set out the technical parameters for the wind power producers.

iii. The Modification Application submitted to NEPRA by the Licensee takes into account the modifications proposed by the Licensee and does not have any effect on the quality of service and the performance by the Licensee of its obligations under the Generation License. The Modification in fact increases the available generation and adds power to the national grid, abating load shedding and boosting the energy deficient economy in turn amelioration the power crisis for the nation.

4. CONCLUSION

In light of the submissions set out herein and the information attached hereto (together with the Annexures), this Modification Generation License Application is submitted for NEPRA's approval of the proposed modifications in the Generation License granted to Licensee. Given the advance stage of the Project, NEPRA is kindly requested to process the Modification Generation License Application at the earliest, thereby enabling the Licensee to proceed further with the development process.

Respectfully submitted for and on behalf of:
FINERGY (PVT) LIMITED



.....

MR. FARMAN AHMED KHAN LODHI
(CHIEF EXECUTIVE OFFICER AND AUTHORIZED REPRESENTATIVE)

Plant Details - Annexure A (Modified Schedule-I)

"Plant System Description", "Turbine Data", "Generator Data", "Power Performance Curve" and "Single Line Diagram"

1) General Information

1	Name of Applicant/Company	Finergy (Pvt) Limited
2	Registered/Business Office	C-18, Block-4, Clifton, Karachi
3	Plant Location	Jhimpir, District Thatta Sindh
4	Type of Generation	Wind Power

2) "Plant System Description", "Turbine Data", "Generator Data"

Wind Farm Capacity & Configuration

1	**Wind Turbine type, Make & Model**	**Acciona Wind (AW) 3.15 - 125m, Acciona Wind (AW) 3.0 - 125m**
2	Installed Capacity of Wind Farm (MW)	49.95 MW
3	Number of Wind Units/ Size of each unit (kW)	13/3150KW, 03/3000KW

a) Wind Turbine Details – Acciona Wind 3.15MW

a)	**Rotor**	
1	Number of blades	3
2	Rotor speed	7.3 — 14.7 rpm
3	Rotor diameter	125 m
4	Swept area	12305 m2
5	Power regulation	Combination of blade pitch angle adjustment and generator/converter torque control
6	Cut-in wind speed	3 m/s
7	Cut-out wind speed	25 m/s
8	Survival wind speed	40 m/s, 3s average
9	Pitch regulation	Electric motor drives a ring gear mounted to the inner race of the blade pitch bearing
b)	**Blades**	
1	Blade Length	61.2 m
2	Material	Fiberglass polyester resin
c)	**Gearbox**	
1	Type	Multi-stage planetary/parallel gear design
2	Gear ratio	1:92
3	Main Shaft bearing	Double spherical roller bearings
d)	**Generator**	
1	Power	3050 kW (@10% slip)
2	Voltage	12000 V
3	Type	Doubly-fed induction type
4	Enclosure class	IP54
5	Coupling	Flexible coupling
(e)	**Yaw System**	
1	Yaw bearing	Roller bearings

2	Brake	Hydraulic Callipers
3	Yaw drive	Electrical motorgears
4	Slewing gear / yaw drive pinion ratio	11.2:1
(f)	**Control System**	
1	Type	Programmable Logic Controller
2	Interface	SCADA
3	Power Control	Converted Control Unit
(g)	**Parking Brake**	
1	Type	Single disk
2	Location	High speed shaft
(h)	**Tower**	
1	Type	Tubular steel tower
2	Tower height	85.5

b) Wind Turbine Details – Acciona Wind 3.0MW

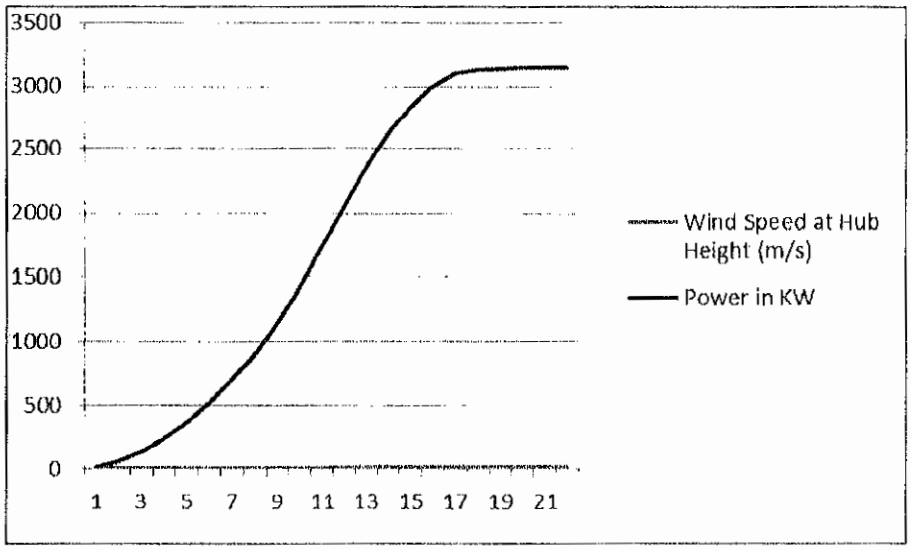
a)	**Rotor**	
1	Number of blades	3
2	Rotor speed	9.2 — 15.6 rpm
3	Rotor diameter	125 m
4	Swept area	12305 m2
5	Power regulation	Combination of blade pitch angle adjustment and generator / converter torque control
6	Cut-in wind speed	3 m/s
7	Cut-out wind speed	25 m/s
8	Survival wind speed	40 m/s, 3s average
9	Pitch regulation	Electric motor drives a ring gear mounted to the inner race of the blade pitch bearing
b)	**Blades**	
1	Blade Length	61.2 m
2	Material	Fiberglass polyester resin
c)	**Gearbox**	
1	Type	Multi-stage planetary/parallel gear design
2	Gear ratio	1:83
3	Main Shaft bearing	Double spherical roller bearings
d)	**Generator**	
1	Power	3050 kW
2	Voltage	2000 V
3	Type	Doubly-fed induction type
4	Enclosure class	IP 54
5	Coupling	Flexible coupling
(e)	**Yaw System**	
1	Yaw bearing	Roller bearing
2	Brake	Hydraulic Callipers
3	Yaw drive	Electrical motorgears
4	Slewing gear / yaw drive pinion	11.2:1

	ratio	
(f) Control System		
1	Type	Programmable Logic Controller
2	Interface	SCADA
3	Power Control	Converted Control Unit
(g) Parking Brake		
1	Type	Single disk
2	Location	High speed shaft
(h) Tower		
1	Type	Tubular steel tower
2	Tower height	85.5

Other Details

1	**Project Commissioning Date (Anticipated)**	1st September 2021
2	Expected Life of the Project from Commercial Operation Date (COD)	25 years

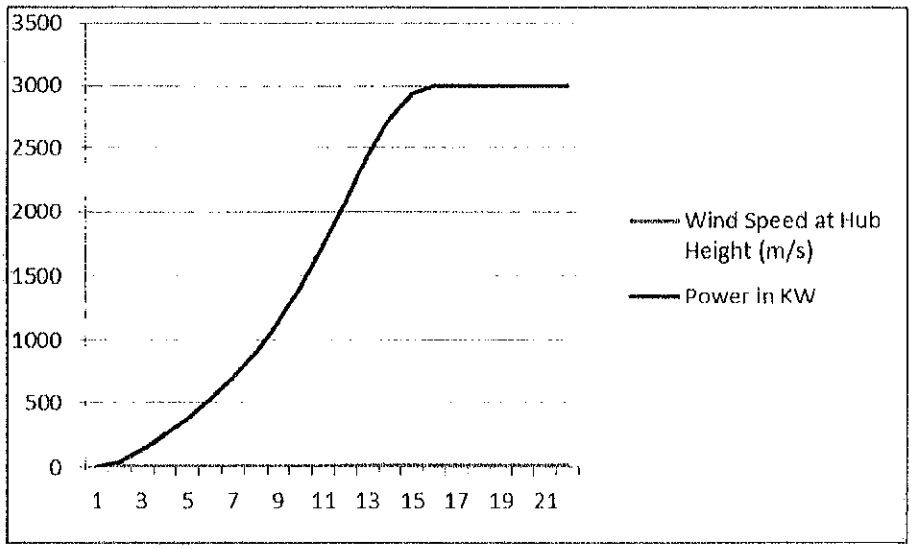
Power Performance Curve
Power Performance of AW3150 - 125 (3.15MW)
(Graphical Representation)



Power Performance of AW3150 - 125 (3.15MW)
(Tabular Representation)

Wind Speed at Hub Height (m/s)	Power in KW		Wind Speed at Hub Height (m/s)	Power in KW
3	14		8.5	2048
3.5	58		9	2359
4	131		9.5	2623
4.5	239		10	2835
5	369		10.5	3003
5.5	518		11	3104
6	696		11.5	3133
6.5	905		12	3146
7	1144		12.5	3150
7.5	1417		13	3150
8	1723		13.5	3150

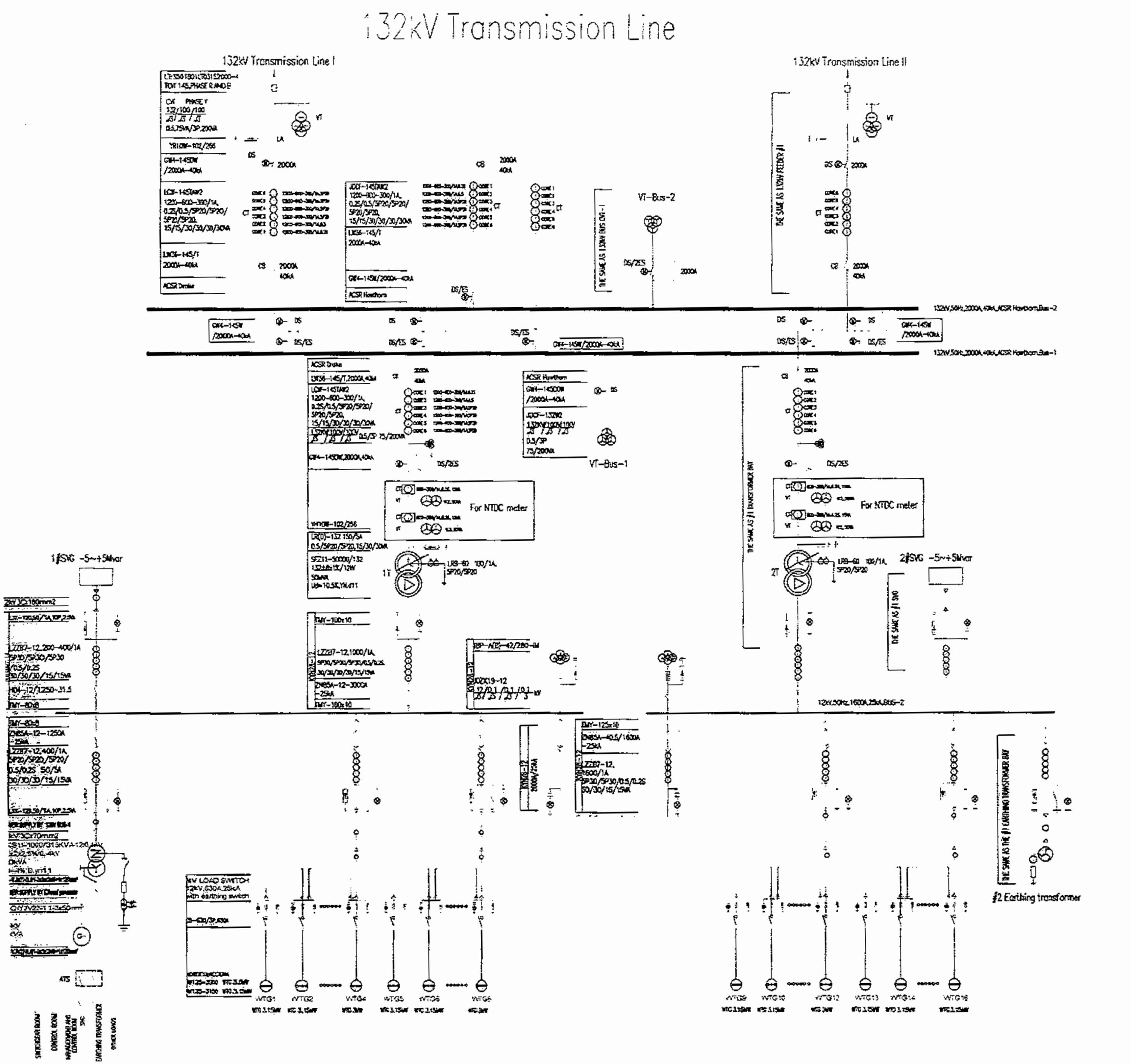
Power Performance Curve
Power Performance of AW3000 - 125 (3.0MW)
(Graphical Representation)



Power Performance of AW3000 - 125 (3.0MW)
(Tabular Representation)

Wind Speed at Hub Height (m/s)	Power in KW		Wind Speed at Hub Height (m/s)	Power in KW
3	0		8.5	2082
3.5	39		9	2440
4	137		9.5	2754
4.5	246		10	2940
5	373		10.5	3000
5.5	524		11	3000
6	699		11.5	3000
6.5	905		12	3000
7	1144		12.5	3000
7.5	1417		13	3000
8	1729		13.5	3000

Single Line Drawing



LEGEND

No	SYMBOL	DESCRIPTION	COMMENT
1		145kV CIRCUIT BREAKER 40kA 50Hz 4000A	
2		145kV DISCONNECTING SWITCH 40kA 50Hz 2000A WITHOUT EARTHING SWITCH	
3		145kV DISCONNECTING SWITCH, 40kA, 50Hz 2000A WITH ONE EARTHING SWITCH	
4		145kV DISCONNECTING SWITCH, 40kA 50Hz 2000A WITH TWO EARTHING SWITCHES	
5		CURRENT TRANSFORMER CORE	
6		145kV COUPLING CAPACITOR VOLTAGE TRANSFORMER 5000pF 50Hz WITH CARRIER ACCESSORIES	
7		CONVENTIONAL SURGE ARRESTER	
8		132/133 kV,50MVA POWER TRANSFORMER,WITH ON-LOAD TAP CHANGER AND NATURE CT	
9		40.5kV SWITCHGEAR	
10		CABLE AND CABLE TERMINATIONS	
11		BOX TYPE STEP UP TRANSFORMER	
12			
13		EARTHING TRANSFORMER AND RESISTANCE	
14		CABLE TERMINAL	
15			
16			
17		ATS	
18		DXN-T / VOLTAGE INDICATOR	
19		AUXILIARY TRANFORMER AUX1:SC-400/33; AUX2:S11-M-400/11	
20			
21		LT: 5501B01LT0315200-4 CCVT 145	

Note:

1. The substation is 50MW wind power step-up station made up of two 50MVA main transformers
2. 12kV system is designed sectionalized single-circuit busbar configuration and 132kV system is designed double-circuit busbar
3. There are 4 incoming lines in 12kV class, and 2 outgoing lines in 132kV system side
4. Outdoor-type AIS is designed in 132kV system side

REV.	DATE	ISSUE PURPOSE	PREPARED / CHECKED / APPROVED

PROJECT: Finergy WIND POWER PROJECT (50MW)

CLIENT: FINERGY (Pvt) LIMITED

EPC: TBEA SUN OASIS Pvt. (Ltd)

CONSULTANT: TBEA SUN OASIS Pvt. (Ltd)

DRAWING TITLE: single line diagram of substation system 系统主接线图

SCALE	PROJECT NO.	DRAWING NO.	SHEET
NTS			1/1

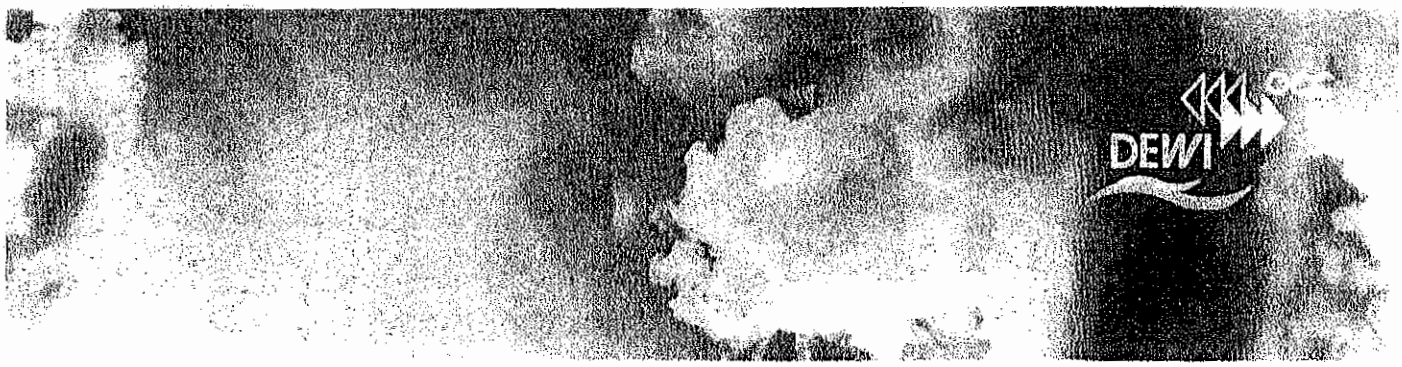
Annexure B Modified SCHEDULE-II

Net Capacity of the Licensee's Generation Facilities

(1)	**Total Installed Gross ISO Capacity of the Generation Facility/Wind Farm (MW/GWh)**	**49.95 MW**
(2)	Total Annual Full Load Hours	3252 Hours
(3)	Auxiliary Consumption	Approximately 3%
(4)	Average WTG Availability	97%
(5)	Net Capacity Factor	Approximately 37.12%
(6)	Annual Energy Generation 20 years Equivalent NET AEP's	162.42 GWh*

Note:

1. The original table was configured for capacity data which is not applicable to Wind Powered IPP's. The technical parameters as per the above table are relevant for wind power generation.
2. All the above figures are indicative as provided by the Licensee. The Net Capacity available to NTDC for dispatch and provision to purchasers will be determined through procedures contained in the Agreements of the Grid code.



A - Type Certificate

TC – 170303, Rev. 0

This certificate is issued to	Acciona Windpower, S.A. Polígono Industrial Barasoain, Parcela 2. 31395 Barasoain (Navarra Spain
for the wind turbine	**AW125/3150 IEC IIb T87.5 AW61.2-2 50Hz**

This certificate attests compliance with

GL 2010	Germanischer Lloyd, "Guideline for the Certification of Wind Turbines", Edition 2010 - WT Class IIB

concerning the design and manufacture. It is based on the following reference documents:

ADA-GL-IV-1-01709-2	A - Design Assessment	DNV GL, Rev. 2, 2017-03-24
STC – 170307	A - IPE	DEWI-OCC, Rev. 0, 2017-03-30
STC – 170303	A - Prototype Testing	DEWI-OCC, Rev. 0, 2017-03-30
R11501636-12b	Final Assessment	DEWI-OCC, Rev. 0, 2017-03-30

The conformity evaluation was carried out according to Germanischer Lloyd, "Guideline for the Certification of Wind Turbines", Edition 2010.

The wind turbine main characteristics are specified in the annex of the following statement of compliance (limited to 50Hz).

ADA-GL-IV-1-01709-2 A - Design Assessment DNV GL, Rev. 2, 2017-03-24

Changes in the system design or the manufacturer's quality system are to be approved by DEWI-OCC. Without approval, this certificate loses its validity.

This type certificate is valid until: 2022-03-29

Cuxhaven, 2017-03-30

Kai Grigutsch, M.Sc.
Head of DEWI-OCC
Certification Body for Wind Turbines

The validity is linked to the mandatory annual surveillance of this type certificate and can be verified on the following link: http://www.dewi-occ.de/

A - Type Certificate
(Platform Certificate)

TC – 170313, Rev. 1

This certificate is issued to

Acciona Windpower, S.A.
Polígono Industrial Barasoain, Parcela 2
31395 Barasoain (Navarra)
Spain

for the wind turbine platform

AW 125/3000 IEC IIb AW61.2-2 50/60Hz for Hub Heights TH120m, TH100m and T87.5m

This certificate attests compliance with

GL 2010 — Germanischer Lloyd, "Guideline for the Certification of Wind Turbines", Edition 2010

- in conjunction with IEC 61400-1:1999 WTGS Class IIB

concerning the design and manufacture. It is based on the following reference documents:

STC – 170325	A - Design Assessment	DEWI-OCC, Rev. 0, 2017-04-27
STC – 170326	A - IPE	DEWI-OCC, Rev. 0, 2017-04-27
STC – 170327	A - Prototype Testing	DEWI-OCC, Rev. 0, 2017-04-27
R11667427-12	Final Assessment	DEWI-OCC, Rev. 0, 2017-04-27

The conformity evaluation was carried out according to Germanischer Lloyd, "Guideline for the Certification of Wind Turbines", Edition 2010.

The main characteristics of the wind turbine configurations are specified in the annex of the following statement of compliance.

STC – 170325	A - Design Assessment	DEWI-OCC, Rev. 0, 2017-04-27

Changes in the system design or the manufacturer's quality system are to be approved by DEWI-OCC. Without approval, this certificate loses its validity.

This type certificate is valid until: 2020-12-18

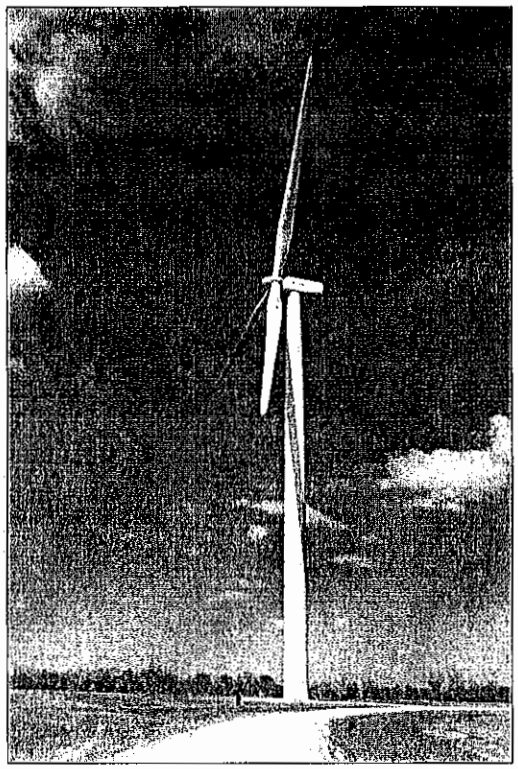
Cuxhaven, 2017-05-04

Jörn Gerlach, M.Eng.
Vice Head of DEWI-OCC
Certification Body for Wind Turbines

The validity is linked to the mandatory annual surveillance of this type certificate and can be verified on the following link: http://www.dewi-occ.de/

DESCRIPCIÓN TÉCNICA AW3000

AW3000 TECHNICAL DESCRIPTION



Rev	Fecha Date	Descripción de la revisión Description of the revision
"A"	23.03.06	Elaboración del documento
"Q"	18.08.16	Incluidos modelos de máquina y condición de altitud máxima de emplazamiento. New wind turbine models added and site maximum altitude specified.
"R"	28.10.16	Incluidos modelos de máquina y actualización general. New wind turbine models added and general update.
"S"	08.06.17	Se añade T112.5 // T112.5 added.
"T"	18.07.17	Se añade AW140 // AW140 added.

Realizado / Done	Revisado / Reviewed	Aprobado / Approved
L.H.	E.S.S.	MJP
18-07-2017	18-07-2017	18-07-2017

En caso de duda prevalecerá la versión en castellano/ In case of doubt, the Spanish version shall prevail.

1. INTRODUCCIÓN

Este documento resume la descripción técnica de los aerogeneradores AW3000 desarrollados y fabricados por ACCIONA WINDPOWER. A partir de este punto, el texto se referirá genéricamente al aerogenerador AW3000, a no ser que se especifique el modelo concreto.

Las cantidades y tipos de componentes pueden variar en función del modelo de aerogenerador.

1. INTRODUCTION

This document summarizes the technical description of the AW3000 wind turbine platform, developed and manufactured by ACCIONA WINDPOWER. From this point onwards, the text will refer generically to the AW3000 wind turbine, unless specific model variants are discussed.

Quantity and type of components may change depending on wind turbine model.

2. GENERALIDADES

El aerogenerador AW3000 es una plataforma de aerogeneradores de velocidad variable, con un rango de potencia nominal con valores comprendidos entre 3000kW y 3300kW (la potencia nominal depende del modelo), tensión nominal de 12kV (están disponibles opcionales para tensiones de red de parque superiores), y disponible para la generación eléctrica en frecuencias de 50 ó 60Hz.

El aerogenerador está diseñado para operación a altitudes por debajo de los 1000m (msnm). Emplazamientos por encima de esta altitud deben ser analizados y podrían requerir adaptaciones o un diseño específico.

Existe también un aerogenerador

2. GENERAL INFORMATION

The AW3000 wind turbine is a range of wind turbines based on a variable speed design, with a nominal power range with values between 3000kW and 3300kW (the nominal power depends on the model), 12kV nominal voltage (optionals are available for higher wind farm grids), and the ability to generate electric power in frequencies of 50 or 60Hz.

The wind turbine is designed for operation at altitudes below 1000m (AMSL). Sites above this altitude must be analyzed and they could require some modifications or a specific design.

An option for a cold weather package is

AW3000 para emplazamientos con Bajas Temperaturas, con temperatura ambiente mínima de funcionamiento -30º y temperatura ambiente mínima de supervivencia de -40ºC.

El aerogenerador estará disponible en seis variantes de rotor, de acuerdo a los requerimientos del proyecto:

- Diámetro 100 metros, clase IEC Ia para emplazamientos con altos vientos.
- Diámetro 109 metros, clase IEC IIa para emplazamientos con medios vientos.
- Diámetro 116 metros, clase IEC IIa para emplazamientos con medios vientos.
- Diámetro 125 metros, clase IEC S/IIb/IIIa/IIIb para emplazamientos con bajos - medios vientos.
- Diámetro 132 metros, clase IEC IIb/S/IIIb para emplazamientos con bajos - medios vientos.
- Diámetro 140 metros, clase IEC S para emplazamientos con bajos - medios vientos.

also available for the AW3000, which allows an operating minimum ambient temperature of -30ºC and a survival minimum ambient temperature of -40ºC.

The wind turbine is available in six rotor variants, depending on the requirements for the project site:

- 100 metre diameter, IEC Class Ia for high wind speed sites.
- 109 metre diameter, IEC Class IIa for medium wind speed sites.
- 116 metre diameter, IEC Class IIa for medium wind speed sites.
- 125 metre diameter, IEC Class S/IIb/IIIa/IIIb for low to medium wind speed sites.
- 132 metre diameter, IEC Class IIb/S/IIIb for low to medium wind speed sites.
- 140 metre diameter, IEC Class S for low to medium wind speed sites.

El suministro del aerogenerador puede realizarse con diferentes alturas de buje:

- 84 metros (torre acero)
- 87.5 metros (torre acero)
- 92 metros (torre acero)
- 95.5 metros (torre acero)
- 112.5 metros (torre acero)
- 80 metros (torre hormigón)
- 100 metros (torre hormigón)
- 120 metros (torre hormigón)
- 137.5 metros (torre hormigón)

The wind turbine can be supplied with different hub heights:

- 84 metres (steel tower)
- 87.5 metres (steel tower)
- 92 metres (steel tower)
- 95.5 metres (steel tower)
- 112.5 metres (steel tower)
- 80 metres (concrete tower)
- 100 metres (concrete tower)
- 120 metres (concrete tower)
- 137.5 metres (concrete tower)

El aerogenerador AW3000 es un aerogenerador de tres palas a barlovento, de eje horizontal. El rotor y la nacelle están montados en lo alto de una torre de hormigón compuesta por cuatro, cinco o seis tramos, o en torre tubular compuesta por tres, cuatro o cinco tramos de acero.

La máquina emplea un sistema de orientación automática (yaw), que permite un perfecto alineamiento del rotor con la dirección del viento y un enclavamiento estable en la posición óptima de producción, garantizado por su robusto sistema de frenado.

La máquina está provista de un sistema de regulación automática de ángulo de paso (pitch), que permite a cada pala

The AW3000 wind turbine is a horizontal axis turbine, with a three bladed rotor placed upwind. The rotor and the nacelle are mounted to a concrete tower composed of four, five or six sections, or to a tubular tower composed of three, four or five steel sections.

The turbine uses an automatic system (yaw) that allows perfect alignment of the rotor with the wind direction and a stable interlocking in the optimal production position, supported by a powerful braking system.

The wind turbine is provided with an automatic regulation system controlling the pitch angle. This allows each blade to

girar, independientemente de las otras dos, sobre su eje longitudinal, comandadas por una misma consigna de posición, a la cual pueden dirigirse las palas con distintas velocidades.

El generador es de tipo asíncrono doblemente alimentado de rotor devanado. Su equipo de potencia permite regular las corrientes rotóricas de manera que la potencia entregada a la red tenga las características de tensión y frecuencia requeridas en cada momento. Con vientos altos se regula potencia en valores entorno a la potencia nominal mediante los lazos de control de pitch y par en el generador eléctrico.

rotate independently from the other two on its longitudinal axis. They are controlled by the same position set point. The blades can reach this position at different speeds.

The generator is a doubly-fed asynchronous wound-rotor generator. The power converter makes it possible to regulate the rotor currents so that the power transmitted to the grid has the required voltage and frequency characteristics at all times. In high winds, power is regulated around nominal power values, using pitch control loops and torque on the electric generator.

3. DESCRIPCIÓN TÉCNICA DEL AEROGENERADOR Y COMPONENTES PRINCIPALES

3. TECHNICAL DESCRIPTION OF THE WIND TURBINE AND ITS PRINCIPAL COMPONENTS

El diseño del aerogenerador AW3000 consta de un tren de potencia distribuido, constituido por el rotor, el eje lento, la multiplicadora, el acoplamiento elástico y el generador.

El rotor se compone de tres palas sujetas a un buje de fundición, recubierto éste por el cono-nariz, de poliéster reforzado con fibra de vidrio.

El resto de componentes del tren de

The design of the AW3000 wind turbine has a distributed mechanical power transmission. It is comprised of the rotor, the low speed shaft, the gearbox, the flexible coupling and the generator.

The rotor consists of three blades joined to a cast-iron hub, covered by a nose cone of fibreglass-reinforced polyester.

The remaining mechanical power

potencia, salvo el generador, descansan sobre el bastidor delantero, situado ya dentro de la nacelle. El generador descansa sobre el bastidor trasero, también dentro de la nacelle.

Sobre el bastidor delantero se asienta también el grupo hidráulico.

Todos los componentes alojados en la nacelle están protegidos por la carcasa exterior de poliéster reforzado con fibra de vidrio.

La nacelle descansa sobre el rodamiento dentado de yaw, que tiene una pista móvil unida al bastidor delantero y una pista fija unida a la torre. La actuación de motorreductoras, instaladas en el bastidor delantero, sobre el rodamiento posibilita la orientación del aerogenerador (yaw).

La torre de la turbina es la encargada de situar la nacelle a una altura determinada.

A continuación se detallan las características de los componentes principales.

transmission components, except the generator, are secured on the main frame, located inside the nacelle. The generator lies on the generator frame, also inside the nacelle.

The hydraulic unit is also joined to the main frame.

The nacelle cover, made of fibreglass-reinforced polyester, protects all the parts inside in the nacelle.

The nacelle rests on a geared yaw bearing that has a moveable ring bolted to the main frame and a fixed ring to the tower. The yaw gears installed in the main frame, on the bearing, change the direction of the wind turbine (yaw).

The turbine tower is responsible for positioning the nacelle at a given height.

The characteristics of the main components are provided below.

3.1. Cimentación

Torre hormigón:

La torre es una estructura con elementos prefabricados de hormigón llamados dovelas. La unión de la torre al terreno se realiza mediante la introducción de las barras que

3.1 Foundation

Concrete tower:

The tower is a structure with prefabricated concrete elements called keystones. The union of the tower to the ground is made by inserting the steel bars of the lower section

sobresalen de las dovelas del tramo inferior en las vainas embebidas en la zapata de hormigón. Posteriormente, se procederá al rellenado de las vainas, y a la realización del anillo de cimentación, ambos con mortero de alta resistencia. La torre entera es postensada, desde la parte superior hasta la cimentación.

keystones into the sheaths embedded in the foundation. Then, the sheaths are filled with high resistance mortar to form a union with the foundation. The entire tower is also post-tensioned from the top of the tower to the foundation.

Torre de acero:

La fijación de la torre al terreno se realiza mediante una corona formada por una doble hilera concéntrica de pernos, embebida en una zapata de hormigón armado. La parte superior de dichas hileras de pernos verticales queda visible tras el fraguado del hormigón y preparada para recibir el tramo inferior de torre que, posteriormente, una vez que ha sido correctamente asentado, se atornilla a dichas hileras. El diámetro exterior en base de torre de acero es 4600mm.

Steel tower:

The tower is fixed to the ground by a concentric double ring of studs, embedded in a base of reinforced concrete. The upper part of these rings of vertical studs remains visible after the concrete sets, prepared to receive the tower lower section that, once properly settled, is secured to these studs. The external diameter of the steel tower base is 4600mm.

Las dimensiones, armadura, etc. de la zapata de hormigón depende del tipo de turbina y de las características geológicas del terreno.

The dimensions, reinforcements, etc. of the foundation depend on the type of turbine and the geological characteristics of the project site.

3.2. Torre

El aerogenerador está situado en una altura determinada por la torre. Existen seis variantes dependiendo del diámetro del rotor:

- T84 metros: AW132/3000, AW132/3300
- T87.5 metros: AW125/3000, AW125/3000 Low Sound, AW125/3150
- T92 metros: AW116/3000
- T95.5 metros: AW109/3000
- T112.5 metros: AW132/3000
- TH80 metros: AW125/3000
- TH100 metros: AW100/3000, AW109/3000, AW116/3000, AW125/3000, AW125/3150
- TH120 metros: AW116/3000, AW125/3000, AW125/3150, AW125/3300, AW132/3000, AW132/3150, AW132/3300, AW140/3000
- TH137.5 metros: AW125/3000 Low Sound

Torre hormigón:

La torre se compone de cuatro, cinco o seis tramos unidos entre sí. Cada tramo está compuesto por dovelas unidas, perfectamente selladas con

3.2. Tower

The wind turbine is positioned at a given height by the tower. There are six different options corresponding to different size rotors:

- T84 metres: AW132/3000, AW132/3300
- T87.5 metres: AW125/3000, AW125/3000 Low Sound, AW125/3150
- T92 metres: AW116/3000
- T95.5 metres: AW109/3000
- T112.5 metres: AW132/3000
- TH80 metres: AW125/3000
- TH100 metres: AW100/3000, AW109/3000, AW116/3000, AW125/3000, AW125/3150
- TH120 metres: AW116/3000, AW125/3000, AW125/3150, AW125/3300, AW132/3000, AW132/3150, AW132/3300, AW140/3000
- TH137.5 metres: AW125/3000 Low Sound

Concrete tower:

The tower is composed of four, five or six sections joined to each other. The sections are composed of joined keystones, with the vertical joints filled

mortero de alta resistencia a través de sus juntas verticales. La unión entre tramos se realiza introduciendo las barras de acero del tramo superior en las vainas del inferior y el posterior sellado mediante mortero de alta resistencia de la junta horizontal.

Torre de acero:

La torre de acero es una estructura troncocónica tubular y se compone de tres, cuatro o cinco tramos. Dichos tramos se atornillan entre sí por las bridas situadas en sus extremos para formar conjuntamente la torre. La brida inferior del primer tramo se atornilla a la hilera de pernos de la cimentación y la brida superior del último tramo al rodamiento de yaw, fijado a la nacelle.

La estructura portante de cada tramo de torre se compone de chapas curvadas soldadas entre sí, denominadas virolas, y de las bridas inferior y superior, también soldadas a las virolas.

El acceso al interior de la torre es posible a través de una puerta metálica situada en la parte inferior.

En el interior de la torre se encuentran una serie de componentes eléctricos y de control. Asimismo, el interior de la

with high resistance mortar. The sections are joined to each other by inserting the steel bars of the upper section into the sheaths of the lower section and the horizontal joint filled with high resistance mortar.

Steel tower:

The steel tower is a tapered tubular structure and is composed of three, four or five sections. These sections are secured with the flanges located at their ends, and together they form the tower. The lower flange of the lower section is secured to the ring of foundation studs described above, and the yaw bearing, fixed to the nacelle, is secured to the upper flange of the upper section.

The structural components of each tower section are composed of curved plates welded together, called ring sections, and of lower and upper flanges, which are also welded to the ring sections.

The inside of the tower can be accessed through a metal door located in the lower section.

Inside the tower there are a number of electrical and monitoring components. Also, the internal part of the tower has

torre está iluminado en los puntos necesarios.

El diseño de la torre permite la instalación (de manera opcional) de un elevador en el interior de la torre, para facilitar el acceso a la nacelle y las labores de mantenimiento. No obstante, en todos los casos existe la posibilidad de acceso por escalera manual hasta lo alto de la torre. Esta escalera está provista de una línea de vida y demás elementos de seguridad.

lighting in the necessary areas.

The design of the tower enables the installation of a lift inside the tower, to facilitate access to the nacelle and maintenance operations. Nevertheless, in all cases it is possible to access the top of the tower using the ladder. The ladder is equipped with a lifeline and other safety elements.

3.3. Nacelle

La góndola o nacelle se sitúa en lo alto de la torre y se orienta según la dirección del viento gracias al sistema de posicionamiento (sistema de yaw). Todos los elementos que se describen a continuación se encuentran en su interior, albergados dentro de la carcasa de protección.

A la nacelle se accede desde el interior de la torre a través de una trampilla y una escalera de acceso. Desde el interior de esta existe también un acceso al buje para poder realizar labores de comprobación y mantenimiento en él sin necesidad de salir al exterior.

3.3. Nacelle

The nacelle is located at the top of the tower and faces the direction of the wind by means of its positioning system (yaw system). All the elements described next are found inside the nacelle, sheltered under the protective cover.

The nacelle is accessed from inside the tower through a hatch and an access ladder. From the inside there is also access to the hub, in order to perform maintenance and verification operations without having to go outside the nacelle cover.

3.3.1. Carcasa de protección

La carcasa de protección de la góndola se fabrica en poliéster reforzado con fibra de vidrio.

En exterior de la carcasa en la parte superior trasera se sitúan el sensor ambiental (velocidad y dirección de viento) y la baliza o luz de gálibo.

La nacelle incorpora en el suelo de la parte trasera una trampilla y una pequeña grúa para permitir la elevación de repuestos o material diverso desde el suelo hasta la nacelle, facilitando las labores de mantenimiento.

Asimismo, existen varias trampillas-claraboyas distribuidas en la parte superior para posibilitar el acceso a los elementos de la parte exterior superior de la nacelle y para iluminación natural.

La carcasa de la nacelle dispone también de tres aberturas para refrigeración, una en la parte trasera para disipación de calor generado por el generador y otras dos en la parte superior para disipación de calor generado por la multiplicadora (intercooler de aceite).

Además de la iluminación natural a

3.3.1. Nacelle protective cover

The nacelle protective cover is made of fibreglass-reinforced polyester.

The environmental sensor (wind speed and wind direction) and the beacon or warning light, are located outside the nacelle cover in the upper rear part.

On the floor of the back of the nacelle there is a hatch and a small hoist to allow spare parts or equipment to be lifted from the ground up to the nacelle, facilitating maintenance operations.

There are also various hatches-windows distributed throughout the upper part that allow access to the elements of the nacelle outer upper part and to provide natural light.

The nacelle cover also has three cooling outlets, one in the back to release heat produced by the generator and another two on the upper part to release heat produced by the gearbox (oil intercooler).

In addition to the natural light provided

través de las claraboyas, el interior de la nacelle está iluminado eléctricamente.

La parte inferior de la carcasa tiene forma de bañera, de manera que cualquier sustancia líquida que se derrame en el interior de la nacelle vaya a un sistema de retención.

Además, la torre en su parte superior tiene un sistema de drenaje para dichas sustancias líquidas, conduciendo estas por una manguera a lo largo de la torre hasta un bidón de 50L situado en la base de la torre.

by the windows, the inside of the nacelle is electrically lit.

The lower part of the nacelle cover has the shape of a basin, so that any liquid spilled inside the nacelle goes to a retention system.

Additionally, there is a drain system at the top of the tower where any liquid flows through a hose along the tower down to a 50L drum located in the tower base.

3.3.2. Bastidor delantero

La turbina AW3000 consta de dos bastidores: uno delantero y otro trasero. El delantero se apoya sobre la torre a través del rodamiento de yaw, y el trasero se encuentra a su vez atornillado al delantero. El bastidor delantero se fabrica en un solo bloque de fundición nodular de gran robustez que le permite soportar las elevadas cargas que el rotor transmite al eje principal y a la multiplicadora.

Directamente sobre él se apoyan sobre el mismo los siguientes componentes:

- Eje lento y rodamientos

3.3.2. Main Frame

The AW3000 turbine consists of two frames: the main frame and the generator frame. The main frame is supported on the tower by means of the yaw bearing, and the generator frame is bolted to it. The main frame is made of one single nodular cast-iron block, which makes it very strong. It can withstand the torque that the rotor transmits to the low speed shaft and the gearbox.

The following parts are supported directly on the main frame:

- Low speed shaft and bearings

- Grupo hidráulico
- Motorreductoras y corona de giro
- Armario superior de control.

- Hydraulic power unit
- Yaw gears and yaw bearing
- Top controller cabinet

3.3.3. Bastidor trasero

El bastidor trasero va atornillado al delantero y sobre él se sitúa el generador.

3.3.3. Generator Frame

The generator frame is bolted to the main frame, and the generator is located on it.

3.3.4. Eje lento y rodamientos

El eje principal de la turbina AW3000 transfiere la energía del viento captada por el rotor en forma de energía cinética angular hasta la multiplicadora.

Con el fin único de evitar que las palas pudieran llegar a tocar la torre, en caso de altas velocidades de viento, el eje principal de la turbina AW3000 se coloca sobre el bastidor con una inclinación respecto de la horizontal de 5º.

Dos soportes que se fijan al bastidor principal y que albergan a los dos rodamientos del eje lento, reciben el peso del eje y los esfuerzos del rotor. A su vez dichos esfuerzos se transmiten desde el bastidor principal hacia la torre.

El armario superior de control (top

3.3.4. Low speed shaft and bearings

The low speed shaft of the AW3000 turbine transfers the wind energy captured by the rotor, in the form of angular kinetic energy, to the gearbox.

To avoid the blades touching the tower, in the event of high wind speeds, the AW3000 turbine's low speed shaft is placed on the frame at an angle of 5º to the horizontal axis.

There are two supporting structures attached to the main frame that house the two low speed shaft bearings. They support the weight of the shaft and the stress of the rotor. In turn, this stress is transferred from the main frame to the tower.

The top controller cabinet is located on

controller) va situado sobre el soporte de rodamiento trasero.

3.3.5. Multiplicadora y acoplamiento elástico

La función de la multiplicadora es transferir el par desde el eje lento hasta el eje rápido del aerogenerador aumentando la velocidad angular. El sistema de transmisión es de dos etapas planetarias y una paralela. El factor de multiplicación depende de la clase del aerogenerador, dado que el rango de velocidades angulares de operación del rotor depende del tamaño del rotor.

El eje rápido es fundamentalmente un acoplamiento elástico que conecta el eje de salida de la multiplicadora con el eje del generador. Este acoplamiento es capaz de transmitir la potencia en forma de par torsor y a la vez absorber desalineaciones de los ejes de la multiplicadora y del generador sin introducir grandes esfuerzos en dichos componentes.

Además, el acoplamiento elástico está dotado de un limitador de par que impide la transmisión de sobrepares a la multiplicadora en caso de huecos de tensión.

the rear bearing housing.

3.3.5. Gearbox and flexible coupling

The gearbox transfers torque from the low speed shaft to the high speed shaft of the wind turbine, increasing the angular speed. The transmission system is composed by two planetary stages and one parallel stage. The gearbox ratio depends on the class of wind turbine because the angular speed range of rotor operation also depends on the rotor size.

The high speed shaft is a flexible coupling design that connects the gearbox output shaft with the generator shaft. It is capable of transmitting power in the form of torque and at the same time absorbing shaft misalignments of the gearbox and of the generator, without putting great stress on these parts.

In addition to this, the elastic coupling is provided with a torque limiter which avoids transmitting over-torque to the gearbox in the case of voltage dips.

La multiplicadora va literalmente colgada del extremo anterior del eje lento, y sus brazos de reacción se apoyan sobre el bastidor delantero en dos puntos.

Esta unión se realiza mediante unos soportes elásticos cuya función es amortiguar las vibraciones y reducir el ruido.

La multiplicadora consta de su propio sistema de lubricación y refrigeración forzada. Con este sistema se lubrican y refrigeran engranajes y rodamientos mediante un circuito cerrado de aceite a presión y temperatura controladas con etapas de refrigeración y filtrado.

Este circuito se compone de:

- Una bomba accionada por un motor trifásico
- Filtros
- Bloque de válvulas
- Intercooler con ventilador
- Resistencia monofásica calefactora

La temperatura del aceite y los actuadores enumerados arriba están monitorizados y gestionados por la unidad de control.

En la parte trasera de la multiplicadora existe un freno de disco hidráulico y un

The gearbox is directly attached to the rear end of the low speed shaft, and its torque reaction arms are attached to the main frame at two points.

This union is made with elastic supports that absorb vibrations and dampen noise emissions.

The gearbox has its own lubrication and forced cooling systems. With this system, the gears and bearings are lubricated and cooled by a closed oil circuit of controlled pressure and temperature with stages of cooling and filtration.

This circuit is composed of:

- A pump activated by a three phase motor
- Filters
- Manifold block
- Intercooler with fan
- Single phase heater resistance

The temperature of the oil and the actuators listed above are monitored and managed by the controller.

At the back of the gearbox there is a hydraulic disc brake and a locking system

sistema de bloqueo del tren de potencia.

3.3.6. Generador

El generador es un generador asíncrono trifásico de inducción, doblemente alimentado, de rotor devanado y excitación por anillos rozantes. El generador tiene 3 pares de polos y, por tanto, una velocidad de sincronismo de 1000rpm (50Hz) ó 1200rpm (60Hz).

La velocidad de giro del rotor es variable y se adapta a la velocidad del viento.

Esto es posible adecuando la excitación rotórica a la velocidad angular del rotor, de manera que la potencia se genera a tensión y frecuencia constantes.

El rango de velocidades del generador viene indicado en la correspondiente Especificación Técnica.

La característica más reseñable de este generador es que la potencia se genera a media tensión (12kV), lo cual ahorra transformadores y reduce pérdidas.

El generador se apoya sobre el bastidor trasero mediante cuatro elementos amortiguadores (Silent-Blocks), cuya función es reducir la amplitud de las vibraciones y el ruido.

La refrigeración se lleva a cabo por ventilación forzada por medio de

for the mechanical power transmission.

3.3.6. Generator

The generator is a three-phase asynchronous induction generator, doubly-fed with winding rotor connected through slip rings. The generator has 3 pole pairs and, consequently, a synchronous speed of 1000rpm (50Hz) or 1200rpm (60Hz).

The rotational speed of the rotor is variable and adapts to the wind speed.

Power is generated at a constant voltage and frequency by adapting the rotor excitation to the angular speed of the rotor.

The generator speed range is indicated in the relevant Technical Specification.

The most notable characteristic of this generator is that power is generated in medium voltage (12kV), which reduces the need for transformers and reduces losses.

The generator is attached to the generator frame through four dampeners (silent blocks), which reduce the amplitude of the vibrations and noise.

Cooling of the system is carried out by forced ventilation through fans in order to

ventiladores para incrementar el intercambio de calor.

increase heat exchange.

La temperatura en los devanados del estator, en el cuerpo de anillos rozantes, y en los rodamientos está monitorizada. La temperatura de dichos puntos se controla con ayuda de resistencias calefactoras y de los ventiladores mencionados anteriormente.

The temperature of the stator windings is monitored, in both the slip ring assembly and in the bearings. The temperature of these parts is controlled with help from the heater resistances and from the fans mentioned earlier.

3.3.7. Sistema de yaw

La orientación de la nacelle con la dirección del viento predominante se lleva a cabo mediante el sistema de yaw. Este consiste en una corona dentada solidaria a la torre y motorreductoras solidarias a la nacelle con sus respectivos piñones engranados en la corona de la torre, que hacen que la nacelle gire en ambos sentidos con respecto a la torre, sobre el rodamiento de yaw.

3.3.7. Yaw system

The positioning of the nacelle towards the dominant wind direction is performed by the yaw system. It consists of a slewing ring attached to the tower and yaw drives attached to the nacelle, with their respective pinions which gear with the tower bearing. These make the nacelle rotate in both directions on the yaw bearing around the tower axis.

Cada una de las motorreductoras se compone de un motor eléctrico trifásico de jaula de ardilla y un tren de engranajes reductores. Los motores constan asimismo de un freno eléctrico que está activado cuando no hay tensión.

Each of the yaw drives is formed by a three-phase cage motor and a gearbox. The motors also include an electric brake which is applied when there is no voltage.

El sistema de yaw se completa con un sistema de freno activo, realizado a través de pinzas de freno hidráulicas, que fijan mecánicamente la nacelle en la

The yaw system is completed by an active brake system, consisting of hydraulic brake callipers that mechanically fix the nacelle in the correct position, and a brake

orientación correcta, y un disco de freno situado entre la torre y el rodamiento.

disc positioned between the tower and the yaw bearing.

3.4. Rotor

La función del rotor es captar la energía del viento y convertirla en energía cinética de rotación.

El rotor del aerogenerador AW3000 se compone de tres palas montadas sobre un buje de fundición de hierro nodular, el cual está cubierto por el cono-nariz, de poliéster reforzado con fibra de vidrio.

Está diseñado para funcionamiento a barlovento.

Tal y como se ha indicado anteriormente, existen seis variantes de rotor según el diámetro de la superficie que barren: 100, 109, 116, 125, 132 y 140 m. El buje es el mismo en el caso de los rotores 100 (pala 48,8 m) y 109 (pala 53,2 m), pero diferente respecto a los de rotor 116 (pala 56,7 m) y 125 (pala 61,2 m) y a los de 132 (pala 64,7 m) and 140 (pala 68,7 m).

El rango de velocidades del rotor depende del diámetro de rotor de la máquina y del tipo de torre, y viene indicado en la correspondiente Especificación Técnica.

La velocidad del rotor se regula con una combinación de control de par resistente del generador (vientos bajos) y de control

3.4. Rotor

The rotor is used to take wind energy and convert it into rotational kinetic energy.

The rotor of the AW3000 wind turbine is made up of three blades mounted on a cast-iron hub which is covered by the nose cone, made of fibreglass-reinforced polyester.

It is designed for upwind operation.

As previously mentioned, there are six types of rotors, with swept area diameters: 100, 109, 116, 125, 132 y 140 m. There are three different hubs, one for rotors 100 (blade length 48,8m) and 109 (blade length 53,2 m), other for rotors 116 (blade length 56,7 m) and 125 (blade length 61,2m) and other for 132 (blade length 64,7m) and 140 (blade length 68,7 m).

The rotor speed range depends on the rotor size and on the tower type and it is indicated in the relevant Technical Specification.

The rotor speed is regulated by a combination of resistant torque control of the generator (low winds) and pitch control

de pitch (vientos altos). El rotor gira en sentido horario mirando la turbina desde el frente.

Para evitar colisiones de la pala con la torre en caso de vientos altos, el rotor tiene una inclinación de 5° (tilt) respecto a la vertical, consecuencia de la inclinación del eje lento respecto a la horizontal. Con el mismo objetivo se dota al rotor de un angulo de *coning*. Adicionalmente algunas palas están diseñadas con *prebending*.

Integrado en el buje está el sistema de orientación de pala (pitch), de accionamiento independiente para cada una de las tres palas, que permite variar el ángulo de paso desde la posición de producción con la mayor superficie de pala expuesta al viento, a la posición de bandera-parada. Este sistema actúa también como freno aerodinámico, llevando las palas a posición de bandera.

(high winds). The rotor rotates clockwise, when looking at the turbine from the front.

To avoid the rotor blade colliding with the tower in the event of high winds, the rotor has a 5° inclination angle (tilt) to the vertical axis, a consequence of the low speed shaft inclination angle to the horizontal axis. With the same purpose the hub is designed with a *coning* angle. Additionally, some blades are designed with *prebending*.

The blade position system (pitch) is integrated in the hub and activates each of the three blades independently. This allows the pitch angle to vary from a position of production with largest blade area exposed to the wind, to feather position. This system also acts as an aerodynamic brake, bringing the blades into the feather position.

3.4.1. Buje

El buje, fabricado en fundición nodular, es el mecanismo que transmite la energía de las tres palas al eje lento. La unión del buje al eje lento es atornillada, con tres bulones adicionales de cortadura.

En el interior de este componente hueco

3.4.1. Hub

The hub, manufactured in nodular cast iron, is the mechanism that transmits energy from the three blades to the low speed shaft. The hub is attached to the low speed shaft by bolts, with three additional C-section shear pins.

se alojan los elementos que componen el sistema de pitch.

El buje dispone de 11 aberturas:

- 3 aberturas laterales para la inserción de rodamientos de pala
- 1 abertura frontal central para acceso al cono-nariz desde el buje.
- 3 aberturas frontales pequeñas para los cilindros de pitch
- 1 abertura trasera central para introducción de tubos de presión y cables para el sistema de pitch (conexión eje lento).
- En buje de la AW100 y 109 tiene 3 aberturas traseras para acceso al buje directamente desde la nacelle.

The pitch system elements are located within the hub casing.

The hub has 11 openings:

- 3 openings on the sides for the insertion of the blade bearings
- 1 opening at the front centre to access the nose cone from the hub
- 3 small openings at the front for the pitch cylinders
- 1 opening at the back centre for the insertion of pressure tubes and pitch system cables (low speed shaft connection).
- AW100 and AW109 hub has 3 rear openings in order to access the hub directly from the nacelle.

3.4.2. Palas

Cada turbina AW3000 tiene tres palas, conectadas al buje mediante sus respectivos rodamientos de pala. Las palas están fabricadas en fibra de vidrio reforzada con poliéster, con un recubrimiento superficial suave destinado a proteger los materiales de la radiación UV y a proporcionar el color a la pala. Cada pala está formada por dos cortezas

3.4.2. Blades

Every AW3000 turbine has three blades, connected to the hub by their respective blade bearings. The blades are manufactured in polyester-reinforced fiberglass, with a smooth superficial coating intended to protect them from UV radiation and to keep their colour. Each blade comprises two joined sections, supported by beams and internal ribs.

unidas y soportadas por vigas y costillas internas.

Correspondiendo con los seis diámetros de rotor disponibles comercialmente, hay seis longitudes de pala: 48,8 m, 53,2 m, 56,7 m, 61,2 m, 64,7 m and 68,7 m.

El perfil aerodinámico de las palas varía a lo largo de su eje longitudinal, tanto en sección y forma como en ángulo de incidencia del borde de ataque.

Unos insertos especiales de acero conectan la pala a la pista móvil del rodamiento de pala.

El rodamiento de pala permite el giro de la pala respecto a su eje longitudinal. Su pista fija está atornillada al buje y la móvil a la pala.

There are six blade lengths corresponding to the six rotor diameters commercially available: 48,8 m, 53,2 m, 56,7 m, 61,2 m, 64,7 m and 68,7 m.

The aerodynamic profile of the blades varies along its longitudinal axis both in the section and shape, such as in the incidence angle of the leading edge.

Special steel inserts connect the blade to the moveable ring of the blade bearing.

The blade bearing allows the rotation of the rotor blade with respect to its axis. Its fixed ring is bolted to the hub and the mobile one to the blade.

3.4.3. Sistema de pitch

El sistema de pitch permite variar el ángulo de paso de cada pala, al girar ésta sobre su eje longitudinal. Este sistema tiene dos objetivos:

- Regular la potencia generada con vientos altos
- Freno aerodinámico en caso de parada controlada o emergencia.

3.4.3. Pitch system

The pitch system allows the pitch angle of each blade to vary, rotating on its axis. This system has two goals:

- To regulate the power generated in high winds.
- To brake aerodynamically in the event of a controlled or emergency stop.

Normalmente se accionan las tres palas simultáneamente. Sin embargo, cada una

Normally the three blades operate simultaneously. However, each of the

de las palas del rotor tiene un sistema independiente de ajuste de ángulo de paso, accionado por un cilindro hidráulico específico para cada pala. Estos cilindros están físicamente ensamblados a las placas pitch, solidarias a la pista móvil de los rodamientos de pala, provocando con su actuación el giro de la misma.

Con el accionamiento independiente de cada pala se consigue un dispositivo de seguridad doblemente redundante, ya que con sólo una pala en bandera, se podría conseguir la detención el rotor.

Cada pala tiene un acumulador de nitrógeno alojado en el buje, en el que hay una reserva permanente de aceite a presión suficiente para garantizar poder llevar la pala a bandera, incluso en el caso de falta de tensión de alimentación del grupo hidráulico (caída de presión en el sistema).

Los componentes del sistema de pitch en el buje son:

- 3 cilindros hidráulicos para accionamiento mecánico del giro de pala
- 6 acumuladores de aceite a presión con cámara de nitrógeno
- 3 bloques de válvulas para el accionamiento de los cilindros
- Sensores de posición de pitch

rotor blades has an independent system for pitch angle setting, activated by a specific hydraulic cylinder for each blade. These cylinders are mounted onto the pitch plates, connected to the mobile ring of the blade bearings, provoking their rotation when they turn.

Independent activation of each blade provides redundancy for the safety system. With only one blade in the feather position, the rotor can be stopped.

Each blade has a nitrogen accumulator located in the hub, where there is sufficient permanent supply of pressurized oil to ensure the blade can enter the feather position, even in the case of insufficient power supply from the hydraulic unit (system pressure drop).

The components of the pitch system in the hub are:

- 3 hydraulic cylinders to mechanically activate the blade rotation
- 6 accumulators of pressurized oil with a nitrogen chamber
- 3 manifold blocks activate the cylinders
- Pitch position sensors (integrated in

(integrados en los cilindros)

- Circuitería hidráulica (latiguillos y/o tubos)
- Circuitería eléctrica y de comunicaciones (cables y cajas de conexiones)

the cylinders)

- Hydraulic circuitry (hoses and/or tubes)
- Electric and communications circuitry (wires and junction boxes)

3.4.4. Cono-nariz

El cono nariz protege el buje de las inclemencias meteorológicas. Está fabricado en poliéster reforzado con fibra de vidrio. El diseño de este cono-nariz junto con el del buje permite un acceso cómodo y seguro al interior del buje, sin necesidad de salir al exterior de la turbina.

El cono-nariz consta de dos partes, una principal con aberturas para las tres palas y la conexión al eje lento y otra que cierra el conjunto por su parte delantera.

3.4.4. Nose cone

The nose cone protects the hub from inclement weather. It is made of fibreglass-reinforced polyester. The design of the nose cone together with the hub allows safe and easy access to the internal part of the hub, without having to exit the turbine.

The nose cone consists of two sections: a main section with holes for the three blades and the connection to the low speed shaft, and another section that closes the assembly at its front.

4. FUNCIONAMIENTO

El control que incorpora la turbina AW3000 funciona básicamente como se describe a continuación (modo automático).

Con vientos bajos, la velocidad de giro del rotor es proporcional a la velocidad del viento. Cuanto mayor es la velocidad del viento, mayor es la velocidad de giro del

4. OPERATION

The AW3000 turbine has a control that operates predominantly as described next (automatic mode).

In low winds, the rotational speed of the rotor is proportional to the speed of the wind. The higher the wind speed, the higher the rotational speed of the rotor.

rotor, controlando ésta mediante el denominado "control de velocidad a través de par". El par resistente del generador es el que mantiene la velocidad del rotor en su valor óptimo (zona de velocidad variable) y en el valor de velocidad nominal una vez alcanzada (zona de codo).

The factor controlling this is called "speed control regarding torque". Due to the resistant torque of the generator the rotor speed is controlled to its optimum value (variable speed zone) and at the nominal speed value once it's been reached (elbow zone).

Este control se utiliza desde el momento en que el aerogenerador entra en producción hasta que la potencia producida por el generador alcanza su valor nominal.

This control is used from the time the wind turbine enters production until the power produced by the generator reaches its nominal value.

Con vientos altos, la velocidad del rotor se mantiene en valores entorno a la velocidad nominal.

In high winds, the rotor is maintained at values around the nominal speed.

Cuando el generador alcanza valores cercanos a la potencia nominal, el control de par se combina con la regulación del ángulo de paso de las tres palas (denominado "control de velocidad a través de pitch") para regular la potencia volcada a la red en valores entorno a la potencia nominal hasta llegar a la velocidad de viento de corte. La potencia entregada en este régimen tendrá valores que fluctuarán alrededor de la potencia nominal.

When the generator reaches values close to the nominal power, the torque control combines together with the three blade pitch angle regulation. (known as "pitch control") To regulate the power supplied to the grid in values around the nominal power until reaching the cut-out speed. The delivered power in this regimen will have fluctuating values around the nominal power.

Abajo se describen más detalladamente diferentes aspectos del funcionamiento de los aerogeneradores AW3000.

Below, various functional aspects of the functioning of the AW3000 wind turbines are described in more detail.

4.1. Red eléctrica

Las condiciones nominales de la red a la que debe conectarse el aerogenerador son 12 kV, 50Hz ó 60Hz.

La red eléctrica debe ser suficientemente estable puesto que variaciones frecuentes de tensión o frecuencia más allá de los límites en operación pueden causar daños en los componentes mecánicos de la máquina.

En caso de pequeñas redes eléctricas independientes, será necesario comprobar las condiciones reales.

En todas las condiciones de operación se puede obtener un factor de potencia unitario a la salida del cuadro de 12kV y una conexión a la red eléctrica muy suave, gracias a su rutina de sincronización a red.

En la cimentación se integra una conexión a tierra de máximo 10Ω, adaptando la topología de la red a las características del terreno.

4.1. Electrical grid

The nominal conditions of the grid that the wind turbine must be connected to are 12kV, 50Hz or 60Hz.

The electrical grid must be sufficiently stable since frequent voltage or frequency variations can damage the mechanical components of the turbine.

In the case of small independent electrical grids, actual conditions must be checked.

In all operational modes, a power factor of 1 is obtained at the output of the 12kV panel and a regulated electrical grid connection because of the grid synchronization routine.

In the foundation there is an integrated earthing connection maximum of 10Ω, adapting the grid topology to the characteristics of the site.

4.2. Sistema de generación

El sistema de generación eléctrica es de velocidad variable, y asegura que la velocidad y el par mecánico del aerogenerador siempre suministren a la red una potencia eléctrica estable. El

4.2. Generation system

The electricity generation system is variable speed, and ensures that the speed and the mechanical torque of the wind turbine always supplies stable electric power to the grid. Its operation is

funcionamiento se explica a continuación.

El estator está directamente conectado a la red. El rotor bobinado se alimenta con una señal controlada en amplitud y frecuencia, producida por el equipo electrónico de potencia. Las corrientes rotóricas se introducen en el rotor mediante anillos rozantes.

La velocidad del giro del rotor se optimiza con relación a la del viento. El equipo de potencia a su vez adecua la magnetización del rotor a la velocidad del mismo, generando en el estator la potencia a la tensión y frecuencia deseadas.

Dado que la excitación del rotor está controlada por el equipo de potencia, el generador puede funcionar por encima y por debajo de la velocidad de sincronismo. En régimen subsíncrono, el rotor consume energía de la red y en régimen hipersíncrono produce energía que es entregada a la red.

En todo caso, el generador es visto como síncrono desde la red. El control de corrientes rotóricas permite también el control del factor de potencia, que se puede imponer como un parámetro definible por el sistema de control.

Otro resultado de la generación síncrona que caracteriza al sistema de generación

explained below.

The stator is directly connected to the grid. The rotor winding is fed with a signal controlled in both amplitude and frequency, produced by the electronic power converter. The rotor currents are introduced into the rotor through slip rings.

The rotational speed of the rotor is optimized in relation to that of the wind. The power converter adapts the magnetization of the rotor to its speed, generating power in the stator to the desired voltage and frequency.

Given the power converter controls the rotor's excitation, the generator can operate within and below the synchronous speed. In subsynchronous operation, the rotor uses energy from the grid and in hypersynchronous operation it supplies energy to the grid.

From the grid, the generator is seen as synchronous in all cases. The control of rotor currents also allows the control of power factor, which can be considered as a parameter defined by the monitoring system.

Another result of the synchronous generation that characterizes the

es la "suave" conexión a la red eléctrica. Estas conexiones suaves se consiguen mediante una rutina de sincronización a la red, en la que se genera una tensión en el estator del generador igual a la de red en magnitud y fase, con lo que se conecta a red con corriente de conexión cero, y con simples contactores, sin ser necesario equipo adicional como tiristores en el caso de grupos asíncronos convencionales.

generation system is the "smooth" connection to the electrical grid. You can achieve these smooth connections by a "grid synchronization" routine. This generates voltage in the generator stator in magnitude and phase equal to that of the grid. This connects the generator to the grid at zero current by means of standard contactors, which makes any additional equipment unnecessary, such as thyristors in the case of conventional asynchronous groups.

Como resultado del control de par mecánico se pueden reducir las cargas en el tren de potencia, permitiendo absorber el exceso de energía de las ráfagas de viento trasformándolo en energía cinética de rotación en el rotor que permite la autoinducción y la entrega de energía a red desde el rotor en régimen hipersíncrono.

As a result of the mechanical torque control, the loads in the mechanical power transmission can be reduced. This allows the excess energy from gusts of wind to be absorbed. It is then transformed into rotational energy in the rotor, which allows the supply of energy to the grid from the rotor in the hyper-synchronous system.

Asimismo se consigue disminuir el nivel de ruido debido a la menor velocidad de giro del rotor en vientos bajos, en los que el aporte de ruido medioambiental del aerogenerador podría ser bien perceptible respecto al nivel de ruido de fondo causado por el propio viento.

Also, noise levels are reduced because of the lower rotational speed of the rotor in low winds. The noise of the wind turbine could be highly perceptible when compared to the background noise caused by the wind.

4.3. Unidad de control y potencia

La unidad de control y potencia,

4.3. Controller and power unit

The controller and power unit, monitors

monitoriza y controla todas las funciones críticas del aerogenerador, para optimizar constantemente el funcionamiento del mismo en todo el rango de velocidades del viento. Se sitúa en la base de la torre, en el interior de un armario eléctrico, comúnmente llamado "Ground".

La unidad de control y potencia puede descomponerse en dos, tal y como indica su nombre:

- La unidad de control, que consta de un PLC (Programmable Logic Controller), y que es la encargada de controlar toda la máquina
- La unidad de potencia, que trabaja en comunicación con el PLC. Consta de una CCU (Converter Control Unit) y de un equipo de potencia al que controla.

El PLC y la CCU se hallan constantemente comunicados y coordinados entre sí. Asimismo, el armario ground está preparado para conectar una pantalla táctil opcional que aporta una interfaz al usuario.

and controls all the critical functions of the wind turbine, to constantly optimize its operation throughout the range of wind speeds. It is located in the base of the tower, inside an electrical cabinet, which is commonly called the "ground controller".

The controller and power unit can be divided into two parts, as their name indicates:

- The controller, that has a PLC (Programmable Logic Controller), and is responsible for controlling the entire turbine
- The power unit, that communicates with the PLC. It has a CCU (Converter Control Unit) and a power converter controlling it.

The PLC and the CCU are constantly communicating and coordinated with each other. Additionally, the ground cabinet is prepared to connect an optional touch screen so that the user can have an interface.

4.3.1. Unidad de control

El PLC junto con sus tarjetas de entrada/salida capta las señales de las diversas funciones del aerogenerador, calcula las acciones de control óptimas

4.3.1. Control unit

The PLC and its input/output cards detect the signals of the wind turbine's various functions, calculate the optimal control actions and give orders to the

y da las órdenes a los actuadores correspondientes (motores, electroválvulas, relés...) para conseguir el funcionamiento seguro y la mejor captación de la energía eólica disponible en el emplazamiento. También es el encargado de activar la parada de emergencia en caso de que la turbina no funcione correctamente.

Las funciones principales de la unidad de control (PLC) son:

- Orientación de la góndola respecto al viento predominante. Supervisión y corrección del estado de torsión de los cables de la torre.
- Gestión del grupo hidráulico que proporciona energía mecánica al sistema del pitch y a los frenos del sistema yaw y de eje rápido.
- Supervisión de los sensores ambiente: viento, dirección predominante de viento, temperaturas.
- Supervisión de la velocidad de giro de los diferentes componentes mecánicos.
- Supervisión y monitorización del estado de vibraciones.
- Supervisión de las funciones del generador y del convertidor.

actuators (motors, electrically operated valves, relays, etc.) to obtain secure operation and the most efficient capture of available energy. It is also in charge of activating the emergency stop in the event of the turbine not working properly.

The main tasks of the controller (PLC) are:

- Positioning the nacelle towards the prevailing wind. Monitoring and correcting the torsion condition of the tower wires.
- Managing the hydraulic unit that provides mechanical energy to the pitch system and to the yaw and high speed shaft brakes.
- Monitoring the environmental sensors: wind, prevailing wind direction, temperatures.
- Monitoring the rotational speed of the various mechanical components.
- Monitoring and testing the state of vibrations.
- Monitoring the generator and converter functions. Connecting to

Conexiones y desconexiones a red.
- Consignas de potencia activa y reactiva.
- Regulación de la velocidad.
- Posicionamiento y control del ángulo de pitch (palas).
- Control de alarmas y modo de operación.
- Intercambio de datos con Telemando.
- Contadores de energía, horas y disponibilidades.
- Gestión de parámetros de la turbina.

and disconnecting from the grid.
- Setting the active and reactive power.
- Regulating speed.
- Positioning and controlling the pitch angle (blades).
- Monitoring alarms and operating mode.
- Exchanging data with the remote control.
- Monitoring power meters, hours and availability.
- Managing the turbine parameters.

4.3.2. Unidad de potencia

La unidad de potencia está compuesta por los siguientes elementos:
- Equipo de potencia (convertidor)
- CCU
- Medida de tensiones y corrientes
- Medida de velocidad (Encoder)
- Protecciones contra sobretensiones en el convertidor
- Sistemas de refrigeración
- Contactores de alimentación
- Contactor de acoplamiento del estator a red

El equipo de potencia consta fundamentalmente de un convertidor rectificador de entrada desde la red, una

4.3.2. Power unit

The power unit consists of the following elements:
- Power converter
- CCU
- Pressure and current monitor
- Speed monitor (Encoder)
- Protection against overvoltage in the converter
- Cooling systems
- Power supply contactors
- Stator to grid contactor

The power converter is basically an input rectifier converter from the grid, a capacitor bank for load storage in the form

batería de condensadores para el almacenamiento de carga en forma de tensión continua y un convertidor inversor de salida hacia el rotor. En régimen hipersíncrono, el flujo de energía a través del equipo de potencia se invierte, aportando el rotor energía a la red.

El convertidor cuenta con active crowbar y/o brake choppers para superar los huecos de tensión.

of continuous voltage and an output inverter converter to the rotor. In hypersynchronous operation, the energy flowing through the power converter is inverted, bringing the rotor energy to the grid.

The converter has active crowbar and/or brake choppers to overcome voltage dips.

4.4. Modos de operación

Los aerogeneradores AW3000 tienen tres modos o sublógicas de operación, que se describen a continuación:

- Modo Automático
- Modo Manual
- Modo de Emergencia

4.4. Operational modes

The AW3000 wind turbines have three modes or operation sublogic, that are described below:

- Automatic mode
- Manual mode
- Emergency mode

4.4.1. Modo automático

El modo automático es el modo normal de funcionamiento (autónomo) de la turbina.

Al reiniciar la máquina en modo automático, la máquina pasa por tres fases:

- Ensayo
- Pausa (una vez completado el ensayo)
- Marcha (cuando las condiciones de viento son propicias)

4.4.1. Automatic mode

Automatic mode is the normal operation mode (autonomic) of the turbine.

To restart the turbine in automatic mode, the turbine goes through three phases:

- Test
- Standby (once the test is complete)
- Run (when the wind conditions are favourable)

En fase de pausa, las palas están en posición de bandera, de tal forma que no recogen la energía del viento.

Cuando la velocidad de viento alcanza la velocidad de necesaria para el arranque (dependiente de la clase de la turbina), la turbina pasa de la fase de pausa a marcha. Esto significa que las palas se mueven a la posición de 0º, recogiendo la mayor cantidad de viento posible.

Cuando las palas se posicionan a 0º, el rotor empieza a acelerarse. Cuando el generador alcanza la velocidad de acoplamiento, comienza a entregar energía a la red, funcionando tal como se explica en la introducción de la presente sección.

Los lazos de control del aerogenerador regulan el funcionamiento hasta que se alcanza la velocidad de corte, valor que depende de la clase de la turbina. En ese momento se vuelve a la fase de pausa, dirigiendo las palas a posición de bandera.

In standby, the blades are in feather position so that they do not capture wind energy.

When the wind speed reaches the cut-in level (depending on the turbine class), the turbine switches from standby to run. This means that the blades move into the 0º position, capturing the largest amount of wind possible.

When the blades are positioned at 0º, the rotor begins accelerating. When the generator reaches the coupling speed, it starts supplying energy to the grid, running as specified on the introduction of this section.

The wind turbine control loops continues adjusting until the cut-out wind speed is reached (this value depends on the turbine class). At this point it returns to standby, moving the blades into feather position.

4.4.2. Modo manual

El modo manual se emplea para realizar pruebas de mantenimiento de la máquina. Trabajando en este modo, el usuario puede manejar manualmente

4.4.2. Manual mode

Manual mode is used when performing turbine maintenance tests. While working in this mode, users can manually manage all the subsystems of the turbine from the

todos los subsistemas de la máquina desde la pantalla táctil de mantenimiento conectada al armario ground. No obstante, en este modo, el PLC continúa supervisando por seguridad todas las operaciones.

maintenance touch screen connected to the ground controller.
Nevertheless, the PLC continues supervising all operations for safety in this mode.

4.4.3. Modo emergencia

El modo emergencia se alcanza cuando se abre la denominada serie de emergencia, que se activa cuando cualquiera de los sensores de los que dispone la máquina detecta algo anómalo (nivel de vibraciones, sobrevelocidad, etc.), o se pulsa alguno de los pulsadores de parada de emergencia.

En modo emergencia, la máquina se encuentra en reposo y segura.

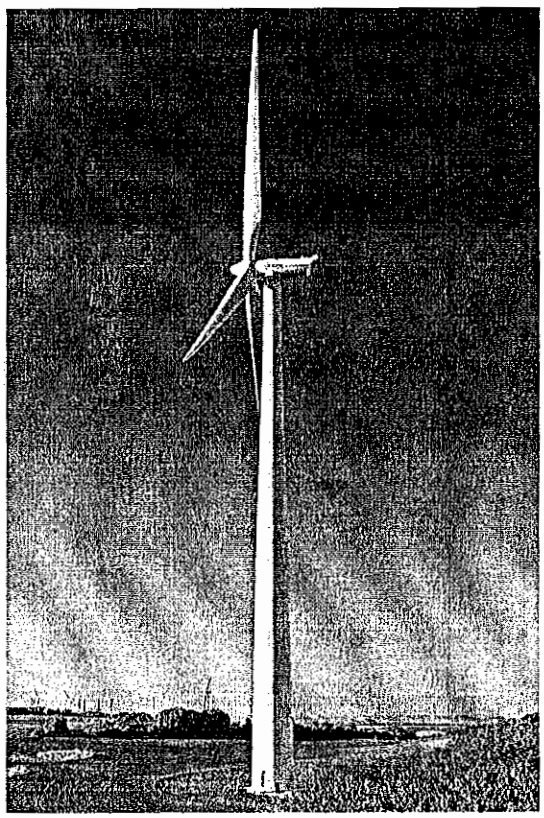
Este modo debe desactivarse imperativamente por medio de accionamiento manual, tras inspeccionar la máquina.

4.4.3. Emergency mode

Emergency mode is reached when the safety system is enabled, when any of the turbine sensors detect an abnormal situation (level of vibrations, overspeed, etc.) or when one or more of the emergency stop buttons is pressed.

In emergency mode the turbine is not operating and secure.

This mode must be disabled by manual activation, after the turbine inspection.



Rev	Fecha Date	Descripción de la revisión Description of the revision
"A"	13/11/13	Elaboración / Elaborated
"B"	27/05/14	Corrección datos / Data corrected
"C"		
"D"		
"E"		

Realizado / Done	Revisado / Reviewed	Aprobado / Approved
EGU	JAL	MNP
27-05-2014	28-05-2014	28-05-2014

acciona Windpower	TECHNICAL SPECIFICATION	DATE: 26/05/2014
		REVISION: B
	AW 125/3000 CLASS IEC IIIb 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	15450 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

Rev	Fecha Date	Descripción de la revisión Description of the revision
"A"	05/05/16	Elaboración / Elaborated
"B"	11/05/16	Hub height corrected
"C"		
"D"		
"E"		

Realizado / Done	Revisado / Reviewed	Aprobado / Approved
EGM 11-05-2016	JAL 19-05-2016	MNP 19-05-2016

En caso de duda prevalecerá la versión en castellano/ In case of doubt, the Spanish version shall prevail.

acciona Windpower	TECHNICAL SPECIFICATION	DATE: 11/05/16
		REVISION: B
	AW 125/3150 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 - 7.3 ... 14.7 rpm
	Hub height	87.5
	Power regulation	Full span blade pitch
	Overspeed control	Full span blade pitch
	Rotor shaft tilt angle	5º
	Nominal tip speed	84.8 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	3465 kW
	Gearbox ratio	1:92 (50 Hz) / 1:110 (60 Hz)
	Input speed	Variable - 7.3 ... 14.7 rpm
	Output speed	Variable - 680 ... 1365 rpm (50 Hz)
		Variable - 816 ... 1638 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 (@10% slip)
	Degree of protection	IP 54
	Frequency	50-60 Hz
	Voltage	12000 V
	Power factor (shortcircuited rotor)	0.93
	Speed range	680 - 1365 rpm (50 Hz)
		816 - 1638 rpm (60 Hz)
	Rated-speed Slip	20%
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	203 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	3150 Kw
	Operation temperature range	-10°C to +40°C
	Survival temperature range	-20°C to +50°C