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Abstract

This document outlines the technical specifications and conditions of a complete wind power plant for sale, consisting of 41 Nordex Delta4000 N149/4.0-4.5 wind turbines. Every component of the wind farm, from the turbines themselves to the transmission cables, transformers, and control cabinets, is new, never mounted, and stored in optimal conditions in warehouses.

Detailed technical specifications for each unit are available. This includes all information concerning the operational capacities of the turbines, their dimensions, construction materials, and control technologies. Additionally, the technical support structure, such as medium and high voltage cables and fiber optic infrastructure, is detailed in the information provided.

A significant aspect of this offer is that the factory warranty for the turbines and associated components is still active.

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Nomenclature

AC	Alternating Current
AVR	Automatic Voltage Regulator
DC	Direct Current
DCS	Distributed Control System
EPC	Engineering, Procurement and Construction
HMI	Human-Machine Interface
I/O	Input / Output
ISO	International Organization for Standardization
LHV	Lower Heating Value
LV	Low Voltage
MCC	Motor Control Cubicle
MV	Medium Voltage
HV	High Voltage
N/A	not applicable / not available
OEM	Original Equipment Manufacturer
P&ID	Process & Instrumentation Diagram
PC	Personal Computer
PFD	Process Flow Diagram
PLC	Programmable Logic Controller
WTG	Wind Turbine Generator
TBD	To be determined / To be defined

1. Introduction

Complete wind power plant available for relocation, this document describes the various characteristics of the plant and its current status. The subject of the opportunity is as follows:

General Data	
Manufacturer	Nordex
Model	Delta 4000 N149/4.0-4.5
Quantity	41
Power	205 MW
Available from	June 2024
Country	Colombia goods in free trade zone
Grid connection	220 kV

Technical Data	
Condition	New
Year of construction	2021
Nominal power (unit)	Mode a.01 5 MW
Tower height	104.7 m
Rotor diameter	149.1 m

2. Description of Supply

2.1 Wind Turbine Delta4000 N149 4.0-4.5 TS105 Mode 0.a1

The Nordex Delta 4000 N149/4.0-4.5 TS105 Mode0.a1 wind turbine is characterized as a variable-speed model with a rotor diameter of 149 meters. This turbine has a nominal power ranging from 4000 to 4500 kW, with a design capacity to expand up to 5000 kW, adaptable based on the installation site. This model is developed to operate within the requirements of Class S, compliant with the IEC 61400-1 standard or for areas categorized as wind zone S according to DIBt 2012, and is designed to function at 60 Hz. The main components of the Nordex N149/4.0-4.5 wind turbine include:

1. A rotor consisting of a hub, three blades, and a pitch system for adjusting the blade inclination.
2. A nacelle, which houses the drivetrain and generator, along with a yaw system for proper orientation, a medium voltage transformer, and a converter.
3. A support structure that can be either a tubular tower or a hybrid tower, equipped with a control panel for managing medium voltage.

The Nordex N149/4.0-4.5 wind turbine is mounted on a tubular steel tower, securely anchored to a foundation cage. The tower's surface is treated with an anti-corrosion coating system compliant with ISO 12944 standards. Access to the nacelle is facilitated by a service elevator and a vertical ladder with fall protection, along with work and rest platforms to ensure a safe and sheltered ascent.

The rotor of the Nordex N149/4.0-4.5 wind turbine includes a rotor hub with three slewing bearings, a pitch system for blade adjustment, and three rotor blades. The hub consists of a rigid cast structure

on which the pitch bearings and rotor blades are mounted. A spinner cover allows direct access from the nacelle to the rotor hub.

The blades are made from high-quality fiberglass and carbon-fiber reinforced plastic, tested in accordance with IEC 61400-23 and DNVGL-ST-0376 (2015) standards.

The pitch system adjusts the angle of the rotor blades using an electromechanical drive that includes a rotary current motor, a planetary gear, and a drive pinion, controlled by a unit with a frequency converter and emergency power supply. Power supply and signal transmission are managed through a slip ring located in the nacelle.

The nacelle of the Nordex N149/4.0-4.5 wind turbine houses essential mechanical and electrical components and can pivot on the tower. The transformer converts the low voltage from the generator/converter system to medium voltage. All components necessary for the control and supply of the turbine are located inside the electrical cabinet.

A mechanical rotor brake locks the rotor during maintenance, generating the necessary oil pressure through a hydraulic pump. The converter connects the electrical grid to the generator, allowing operation at variable speeds. The gearbox increases the rotor speed to the required level for the generator.

Bearings and gearings are continuously lubricated with oil, facilitated by a two-stage pump that circulates the oil. A combination filter traps solid particles, and the control system monitors filter contamination. The gear oil, which lubricates and cools, is continuously temperature-monitored; a thermal bypass redirects it back to the gearbox if not yet at optimum temperature or cools it if it exceeds the desired level.

Gearbox cooling is achieved with an oil/water cooler mounted directly on the gearbox. The cooling water is recirculated along with that from other major components in a passive cooler on the nacelle roof. The rotor shaft is supported by the rotor bearing inside the nacelle, where a rotor lock is integrated for reliable mechanical locking. All nacelle assemblies are protected from weather conditions by a housing. The coupling provides a force-transmitting connection between the gearbox and the generator. The generator is a 6-pole doubly-fed induction machine with an air/water heat exchanger mounted on it. The yaw drives optimize the nacelle's orientation relative to the wind, with drive pinions meshing with the external teeth of the yaw bearing. In the aligned position, the nacelle is locked by the yaw drives.

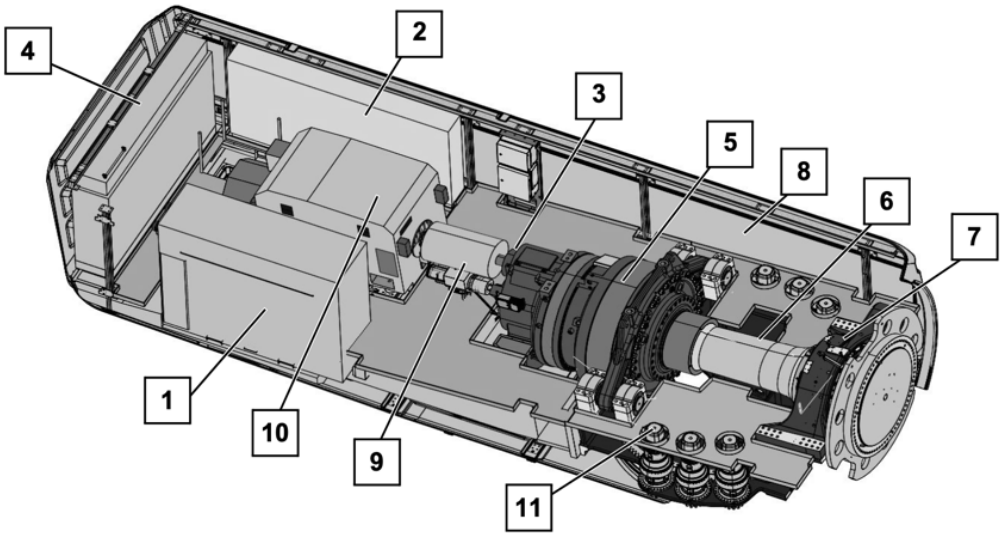

Fig. 3 Schematic diagram of the nacelle, example

1	Transformer	2	Cabinet	3	Rotor brake
4	Converter	5	Gearbox	6	Rotor shaft
7	Rotor bearing	8	Nacelle housing	9	Coupling
10	Generator	11	Yaw drives		

The medium-voltage components are used to connect a wind turbine (WT) to the electrical grid of the wind farm or to the local grid operator. The MV switchgear is located at the base of the tower. It includes a transformer field with circuit breakers and at least one ring cable field as the standard configuration, with the option to add up to three ring cable fields depending on the wind farm configuration. The transformer panel is equipped with a vacuum circuit breaker and a disconnector with a ground switch. The ring cable panel includes a switch disconnector with a ground switch. The entire MV switchgear is mounted on a support/adapter frame.

The WT wind turbine operates automatically through a Programmable Logic Controller (PLC) that monitors operating parameters using sensors, comparing actual values to setpoints and managing the WT's components. When there is no wind, the WT remains idle with only auxiliary systems like heating and lubrication active. With sufficient wind, the WT activates, aligns the nacelle and rotor blades towards the wind, and begins generating energy once a certain speed is reached.

At low wind speeds, the WT operates under partial load and switches to full load when the nominal wind speed is achieved, adjusting the rotor blade angle to keep the rotor speed constant. The yaw system ensures the nacelle is always optimally aligned with the wind.

Wind energy is converted into electrical energy by a doubly-fed induction machine with a low-loss system, connected to the grid through a medium-voltage transformer. Only a portion of the power passes through the converter, reducing electrical system losses.

2.2 Control system

The Wind Farm Portal® Nordex Control 2 (NC2) connects the optimal operation control of a wind turbine (WT) to the clear and simple visualization of the control system and its data management.

NC2 ensures the reliable information exchange between the modules for control, monitoring, visualization and data storage either for a single wind turbine or for a complete wind farm (incl. meteorological system and substation). NC2 is a software that has been developed especially for operating and monitoring wind turbines. It is continuously updated and optimized in accordance with the market requirements, such as grid codes. NC2 is the result of the continuous development of the NC1 software, in use since 1999. It is therefore based on the experience from this development, extended by an internet based communication.

The connection to a wind farm or to a single wind turbine is realized via a dial-up connection or the Internet. Independent of the location, dialing up to the wind turbine is possible 24 hours a day.

To establish the communication, only a telephone or Internet connection and the Internet Explorer® are required. The access authorization to a wind farm is determined by means of a password and a log-in name. This prevents unauthorized access and establishes safe data exchange between user and wind turbine.

Within a wind farm, the communication is ensured by an Ethernet network via fiber optic cables. This network can be expanded as required with regard to the number of wind turbines, meteorological systems and substations.

The concept of the wind turbine control system is based on Profinet, an open standard for Industrial Ethernet. This system is continuously enhanced, thus offering a long-term perspective for the automation tasks.

The control system consists of the following components:

- Controller hardware
- Automation software
- Profinet peripheral
- components Configuration tools

2.3 Technical data

2.3.1 Design

Design temperature:	-20°C to +45°C
Operating temperature range :	-20°C to + 40°C
Stop :	Standard -20°C restart -18°C
Max. height above MSL	2000 m
Certificate:	In accordance with IEC 61400-1 and DIBt 2012
Type :	3-blade rotor with horizontal axis Up-wind turbine
Output control :	Active single blade adjustment
Nominal power :	mode 0.a1 5000kW
Nominal power starting at wind speeds of (at air density of 1.225 kg/m3):	Approx. 11.5 m/s
Operating speed range of the rotor :	6.4 min-1 to 12.3 min-1
Nominal speed	11.0 min-1
Cut-in wind speed	3 m/s
Cut-out wind speed	26 m/s
Cut-back-in wind speed	25.5 m/s
Calculated service life	≥ 20 years

2.3.2 Power curves – Nordex N149/4.0-4.5 TS105 Mode 0.a1

Wind speed	Power P_{el} [kW] at air density ρ [kg/m³]								
vhub [m/s]	0.900	0.925	0.950	0.975	1.000	1.025	1.050	1.075	1.100
3.0	13	15	17	18	20	22	23	25	26
3.5	81	84	88	91	95	98	102	105	109
4.0	172	178	184	191	197	203	209	215	221
4.5	286	295	304	313	322	332	341	350	359
5.0	421	434	447	460	473	486	499	512	525
5.5	581	599	616	633	650	668	685	702	719
6.0	769	791	814	836	858	881	903	926	948
6.5	988	1016	1045	1073	1101	1130	1158	1186	1214
7.0	1242	1277	1312	1347	1382	1418	1453	1488	1523
7.5	1533	1576	1619	1662	1705	1748	1791	1834	1877
8.0	1863	1915	1967	2019	2071	2122	2174	2226	2277
8.5	2235	2297	2359	2420	2482	2543	2605	2666	2727
9.0	2640	2713	2785	2857	2930	3001	3073	3145	3214
9.5	3058	3142	3225	3308	3391	3474	3558	3638	3707
10.0	3473	3568	3663	3756	3844	3933	4020	4090	4146
10.5	3879	3976	4072	4164	4237	4310	4383	4439	4484
11.0	4238	4319	4399	4474	4533	4592	4651	4694	4725
11.5	4509	4575	4640	4700	4745	4789	4834	4863	4882
12.0	4709	4760	4809	4854	4884	4915	4945	4960	4967
12.5	4850	4885	4919	4949	4965	4980	4996	4998	4999
13.0	4941	4961	4980	4995	4997	4999	5000	5000	5000
13.5	4990	4995	4999	5000	5000	5000	5000	5000	5000
14.0	5000	5000	5000	5000	5000	5000	5000	5000	5000
14.5	5000	5000	5000	5000	5000	5000	5000	5000	5000
15.0	5000	5000	5000	5000	5000	5000	5000	5000	5000
15.5	5000	5000	5000	5000	5000	5000	5000	5000	5000
16.0	5000	5000	5000	5000	5000	5000	5000	5000	5000
16.5	5000	5000	5000	5000	5000	5000	5000	5000	5000
17.0	5000	5000	5000	5000	5000	5000	5000	5000	5000
17.5	5000	5000	5000	5000	5000	5000	5000	5000	5000
18.0	5000	5000	5000	5000	5000	5000	5000	5000	5000
18.5	5000	5000	5000	5000	5000	5000	5000	5000	5000
19.0	4953	4953	4953	4953	4953	4953	4953	4953	4953
19.5	4833	4833	4833	4833	4833	4833	4833	4833	4833
20.0	4658	4658	4658	4658	4658	4658	4658	4658	4658
20.5	4482	4482	4482	4482	4482	4482	4482	4482	4482
21.0	4307	4307	4307	4307	4307	4307	4307	4307	4307
21.5	4131	4131	4131	4131	4131	4131	4131	4131	4131
22.0	3951	3951	3951	3951	3951	3951	3951	3951	3951
22.5	3776	3776	3776	3776	3776	3776	3776	3776	3776
23.0	3600	3600	3600	3600	3600	3600	3600	3600	3600
23.5	3420	3420	3420	3420	3420	3420	3420	3420	3420
24.0	3245	3245	3245	3245	3245	3245	3245	3245	3245
24.5	3065	3065	3065	3065	3065	3065	3065	3065	3065
25.0	2885	2885	2885	2885	2885	2885	2885	2885	2885
25.5	2705	2705	2705	2705	2705	2705	2705	2705	2705
26.0	2529	2529	2529	2529	2529	2529	2529	2529	2529

Wind speed	Power P_{el} [kW] at air density ρ [kg/m³]							
v_{hub} [m/s]	1.125	1.150	1.175	1.200	1.225	1.250	1.275	1.300
3.0	28	30	31	33	34	36	38	39
3.5	112	116	119	123	126	130	133	137
4.0	227	233	239	245	251	257	263	269
4.5	368	377	386	396	405	414	423	432
5.0	537	550	563	576	589	602	615	628
5.5	737	754	771	788	806	823	840	857
6.0	970	993	1015	1037	1059	1082	1104	1126
6.5	1243	1271	1299	1327	1355	1384	1412	1440
7.0	1558	1593	1628	1663	1698	1733	1768	1803
7.5	1919	1962	2005	2047	2090	2132	2175	2218
8.0	2329	2380	2431	2483	2534	2586	2636	2686
8.5	2788	2848	2906	2963	3019	3074	3127	3178
9.0	3279	3342	3402	3459	3515	3569	3620	3668
9.5	3770	3830	3887	3940	3992	4041	4087	4125
10.0	4198	4245	4290	4332	4372	4410	4444	4472
10.5	4523	4558	4591	4621	4649	4675	4698	4715
11.0	4751	4775	4796	4815	4833	4849	4864	4873
11.5	4896	4910	4922	4933	4943	4953	4962	4965
12.0	4973	4979	4984	4989	4993	4997	5000	5000
12.5	5000	5000	5000	5000	5000	5000	5000	5000
13.0	5000	5000	5000	5000	5000	5000	5000	5000
13.5	5000	5000	5000	5000	5000	5000	5000	5000
14.0	5000	5000	5000	5000	5000	5000	5000	5000
14.5	5000	5000	5000	5000	5000	5000	5000	5000
15.0	5000	5000	5000	5000	5000	5000	5000	5000
15.5	5000	5000	5000	5000	5000	5000	5000	5000
16.0	5000	5000	5000	5000	5000	5000	5000	5000
16.5	5000	5000	5000	5000	5000	5000	5000	5000
17.0	5000	5000	5000	5000	5000	5000	5000	5000
17.5	5000	5000	5000	5000	5000	5000	5000	5000
18.0	5000	5000	5000	5000	5000	5000	5000	5000
18.5	5000	5000	5000	5000	5000	5000	5000	5000
19.0	4953	4953	4953	4953	4953	4953	4953	4953
19.5	4833	4833	4833	4833	4833	4833	4833	4833
20.0	4658	4658	4658	4658	4658	4658	4658	4658
20.5	4482	4482	4482	4482	4482	4482	4482	4482
21.0	4307	4307	4307	4307	4307	4307	4307	4307
21.5	4131	4131	4131	4131	4131	4131	4131	4131
22.0	3951	3951	3951	3951	3951	3951	3951	3951
22.5	3776	3776	3776	3776	3776	3776	3776	3776
23.0	3600	3600	3600	3600	3600	3600	3600	3600
23.5	3420	3420	3420	3420	3420	3420	3420	3420
24.0	3245	3245	3245	3245	3245	3245	3245	3245
24.5	3065	3065	3065	3065	3065	3065	3065	3065
25.0	2885	2885	2885	2885	2885	2885	2885	2885
25.5	2705	2705	2705	2705	2705	2705	2705	2705
26.0	2529	2529	2529	2529	2529	2529	2529	2529

2.3.3 Tower

Hub height:	105 m
Wind class:	DIBt S/ IEC S
Number of tower sections	4

2.3.4 Rotor

Diameter:	149.1 m
Swept area:	17460 m^2
Angle of inclination:	5º
Blade cone angle:	3.5º

2.3.5 Rotor blade

Material:	fiber glass and carbon fiber reinforced plastic
Length:	72.40 m

2.3.6 Rotor shaft/rotor bearing

Type:	Forged hollow shaft
Material:	42CrMo4 or 34CrNiMo6
Bearing type	Spherical roller bearing
Lubrication	Regularly using lubricating grease

2.3.7 Mechanical brake

Type:	Friction plain bearing system
Material Slewing ring bearing:	EN-GJS-500-7Uby EN 1503
Material Plain bearing:	PETP
Orientation speed:	less than 0.5 º/s; 1 turn every 12 min. approx.
Mechanism:	Planetary / 2-stage helical gear combination Planetary / 1 Helical self-locking
Motor:	Asynchronous 1.5 kW 6 poles

2.3.8 Tower

Type:	Actively actuated disk brake
Location:	On the high-speed shaft
Number of brake calipers:	1
Brake pad material:	Organic pad material

2.3.9 Gearbox

Type:	Multi-stage planetary gear + spur gear stage
Gear ratio:	60 Hz: i = 136.2
Lubrication:	Forced-feed lubrication
Oil quantity including cooling circuit:	Max. 650 l
Oil type:	VG 320
Max. oil temperature:	Approx. 77 °C

2.3.10 Electrical installation (690 V AC) - wind turbines with a power of up to 5000 kW

Nominal power PnG:	Up to 5000* kW
Nominal voltage:	3 x AC 690 V ± 10 % (specific to grid code)
Nominal current during full reactive current feed-in InG at SnG:	4571 A
Nominal apparent power SnG at PnG:	5463 kVA
Power factor at PnG:	1.00 as default setting
	0.8785 underexcited (inductive) up to 0.8785 overexcited (capacitive) possible
Frequency:	60 Hz

*)All data are maximum values. The values may deviate depending on the rated voltage, rated apparent power and WT active power.

2.3.11 Three-phase- Oil transformer

Description

Three-phase- Oil transformer acc. to IEC60076-16 hermetic sealed, designed for ambient temperature of -25°Cup to 55°C and max. altitude for installation of 2.000 m, suitable for indoor installation with aluminium winding Routine test acc. to DINEN60076-1 corresponds to Normal Climate Version /(NCV) according and where applicable to Nordex Specification E0004486644:

Type:	DST 5350 H/30
Nominal Capacity:	5.350 kVA
Nominal Voltage:	33.000 V /690 V
Nominal Current HV:	93,6 A
Nominal Current LV:	4.477 A
Tappings HV:	±2x2,5%
ACHV / LV:	70,0 kV /3,0 kV
BIL HV /LV:	170 kV
Insulated for:	36,0 kV /1,1 kV
Cooling method:	KFWF
Operating Mode:	Continuous
Frequency:	60.00 Hz
Type:	LT
Insulation Class:	120
Degree of protection transform:	IP54
Degree of protection bushings:	IP54/IP00
Vectorgroup:	Dy5
Neutral point:	not brought out
Water inlet temperature:	max 55°C
Water flow rate:	160l/min
Losses	
No-load losses:	4500 W
impedance losses:	59000 W
Total Losses:	63500 W
Impedance voltage:	9.00%
Reference Temp. uk /Pk:	75°C
Sound power:	80 db

2.3.12 Technical data of the switchgear 8DJH36

Voltages

Rated voltage	36.0 kV
Test voltage	36.0 kV
Rated short-duration power-frequency withstand voltage	70.0 kV
Rated lightning impulse withstand voltage	170.0 kV
Rated frequency	60 Hz

Short-circuit ratings

Rated short-time withstand current Ik	25 kA
Rated duration of short circuit	1 s
Rated peak withstand current Ip	63 kA

Current ratings

Rated normal current of the busbar	630 A

2.3.13 Generator

Degree of protection:	IP 54 (slip ring box IP 23)
Nominal voltage:	690 V
Frequency:	60 Hz
Speed range:	60 Hz: 1230 min-1
Poles:	6
Weight:	approx. 10.6 t

2.3.14 Generator and convert cooling

Type:	1. Cooling circuit: Oil circuit with oil/water heat exchanger and thermal bypass 2. Cooling circuit: Water/air combined with generator, main converter and transformer
Filters:	Coarse filter 50 µm / fine filter 10 µm / ultrafine filter <5 µm
Flow rate:	Stage 1: Approx. 100 l/min / Stage 2: Approx. 200 l/min

2.3.15 Pitch system

Pitch bearing:	Double-row four-point contact bearing
Gearing/raceway lubrication:	Regular lubrication with grease
Drive:	Electric motors incl. spring-loaded brake and multi- stage planetary gear
Emergency power supply:	Gel batteries

2.3.16 Yaw system

Yaw bearing:	Double-row four-point contact bearing
Gearing/raceway lubrication:	Regular lubrication with grease
Drive:	Electric motors incl. spring-loaded brake and four-stage planetary gear
Number of drives:	5
Yaw speed Approx. :	0.5 °/s

3. Substation

The electrical substation forming part of the wind farm ready for sale consists of:

Description	Quantity	Technical documentation
220 kV system		
Current Transformer 245 kV	1	Available
Potential transformer 245 kV	6	Available
Disconnector or disconnector 245 kV	1	Available
Lightning arrester 240 kV	3	Available
Power circuit breaker 245 kV	3	Available
Pedestal Isolator	6	Available
CT's and PT's Grouping Boxes	2	Available
33 kV system		
Capacitor Bank 12 MVAR	2	Available
33 kV/208V SSAA Transformer	2	Available
Zig-Zag Transformer 33 kV	2	Available
Medium voltage switchgear 33 kV	22	Available
Step up Transformer		
Step up transformer model chint sffz-220000/220, class 220/33/33 kv, 180/90/90 mva (onan), 220/110/110 mva (onaf) and 60 hz.	1	Available

Substation control and protection		
Transformer protection enclosure	1	Available
Line protection cabinet	1	Available
Control panel	1	Available
SSAA Controller Board	1	Available
DC board	2	Available
AC Board	2	Available
Essential Services Board	1	Available
Non-Essential Services Board	1	Available
Cuestecitas ICT Board	1	Available
ICT SCADA Board	1	Available
The facility includes substation structures, power cable towers, medium voltage cables, communication cables (fiber optics), and grounding cables.		
Auxiliaries		
Battery banks	1	Available
Battery charger	1	Available
Generator unit	1	Available

4. Storage status

4.1 WTGs

4.1.1 Blades

Figure 1: Blades storage status 1

Figure 2: Blades storage status 2

4.1.2 Drive train

Figure 3: Drive train storage status 1

Figure 4: Drive train storage status 2

4.1.3 Hub

Figure 5: Hub storage status

4.1.4 Nacelle

Figure 6: Nacelle storage status

4.1.5 Towers

Figure 7: Towers storage status 1

Figure 8: Towers storage status 2

4.2 Cables

Figure 9: cables storage status 1

Figure 10: cables storage status 2

Figure 11: cables storage status 3

4.3 Substation

Figure 12: Substation parts storage status 1

Figure 13: Substation parts storage status 2

Figure 14: Substation parts storage status 3

Figure 15: Substation parts storage status 4

4.4 Scope of Supply

Position	Quantity	Description
1000		**Wind power plant**
1001	41	**Wind turbine** • *Manufacturer: Nordex* • *Model: Delta 4000 N149/4.0-4.5*
1002	1	**Step up transformer** • *Manufacturer: Chint* • *220 KV*
1003	1	**Substation, structure and cables**

Table 1: scope of supply.

4.5 Exclusions

Scope not explicitly listed in the Scope of Supply (Table 1) is excluded.

The following items are explicitly excluded:

Mechanical
Modification of any existing systems not explicitly cited.
Missing parts and components.
Electrical
Modification of existing systems not explicitly cited.
Civil
Land and land preparation and permits
Temporary accesses and final accessing roads
Security plan and hardware
Temporary accommodation
Finishing and fencing
Waste disposal facility

Table 2: exclusions from the Scope of Supply.

Project Management
Attainability of installation, commissioning and operation permits, or any other permit.
Assessment and acceptance of safety relevant issues.
Any study, engineering, documentation, or other service.
Additional works resulting from changes in laws or any other reasons.
Building of Site Facilities of any kind (lights, water supply and treatment, heating, power supply, etc.).
Custom duties and taxes.
Engineering
Feasibility studies, basic, design and detailed engineering of existing equipment.

Table 3: exclusions from scope of Services.

4.6 Technical documentation

Following documents are part of the technical documentation (list is preliminary):

Pos.	Document	Available
1	**General**	
1.1	Document & drawing list	yes
1.2	Technical data sheet	yes
1.3	Component manuals	yes
1.4	Quality documentation	yes

Table 4: technical documentation.

5. Attachments

General documentation

Technical description

Wind turbine class Nordex Delta4000
N149/4.0-4.5

E0004109668

Revision 09 / 2020-02-04

- Translation of the original document (E0004051131, rev. 09) -

This is a translation from German. In case of doubt, the German text shall prevail.

Document will be distributed electronically.

Original document at Nordex Energy GmbH, Engineering.

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Turbine generation	Product series	Product
Delta	Delta4000	N149/4.0-4.5

1. Structure

The Nordex N149/4.0-4.5 wind turbine (WT) is a speed-variable wind turbine with a rotor diameter of 149 m and a nominal power between 4000 and 4500 kW (project-specific up to 4800 kW) which can be adapted dependent on location. In Germany, information on the nominal power of the WT always relates to the demonstrated reference amount of 4500 kW.

The wind turbine is designed for class S in accordance with IEC 61400-1 or wind zone S in accordance with DIBt 2012 and is available in 50 Hz and 60 Hz variants.

A Nordex N149/4.0-4.5 wind turbine consists of the following main components:

- Rotor, with rotor hub, three rotor blades and pitch system.
- Nacelle with drive train, generator, yaw system, medium voltage transformer and converter.
- Tubular tower or hybrid tower with MV switchgear.

1.1 Tower

A N149/4.0-4.5 class wind turbine can be erected on a tubular steel tower or on a hybrid tower. The steel tower is cylindrical and consists of several sections. This tower is bolted to the anchor cage embedded in the foundation. The bottom part of the hybrid tower consists of a concrete tower and the top part of a tubular steel tower with two sections.

Corrosion protection is guaranteed by a coating system of the surface according to ISO 12944. A service lift, the vertical ladder with fall protection system as well as resting and working platforms inside the tower allow for a weather-protected ascent to the nacelle.

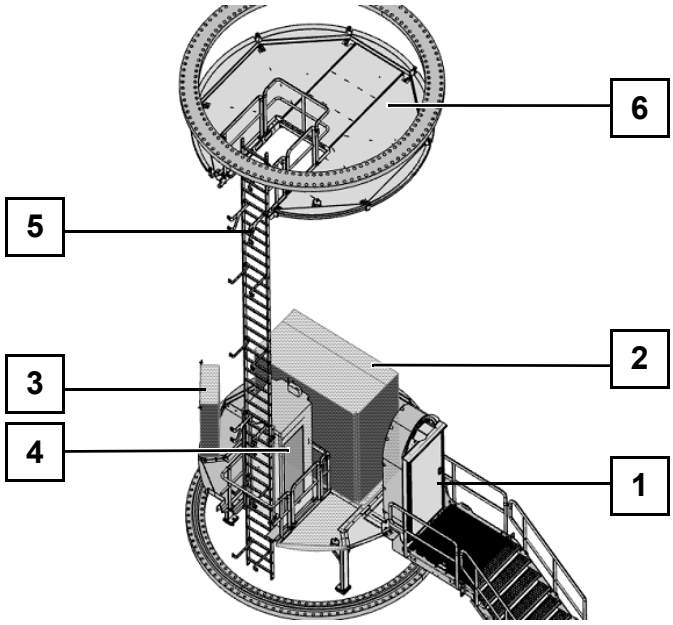

Fig. 1 Overview of the bottom section in a tubular steel tower, tower plates not shown

1	Tower access	2	MV switchgear	3	Control cabinet
4	Tower service lift	5	Ladder path	6	Flange platform

The foundation structure of all towers depends on the soil conditions at the intended location.

1.2 Rotor

The rotor consists of the rotor hub with three slewing bearings, the pitch system for blade adjustment and three rotor blades.

The **rotor hub** consists of a base element with support system and spinner. The base element consists of a stiff cast structure, on which the pitch bearings and the rotor blades are assembled. The rotor hub is covered with the spinner which enables the direct access from the nacelle into the rotor hub.

The **rotor blades** are made from high quality fiber glass- and carbon-fiber reinforced plastic. The rotor blade is tested statically and dynamically in accordance with the guidelines IEC 61400-23 and DNVGL-ST-0376 (2015). Optionally the blades can be equipped with serrations to optimize the noise level. The serrations consist of several serrated light-gray components made from glass fiber laminate, with a length of approx. 0.3 m to approx. 0.7 m, which are attached to the trailing edge of the rotor blades.

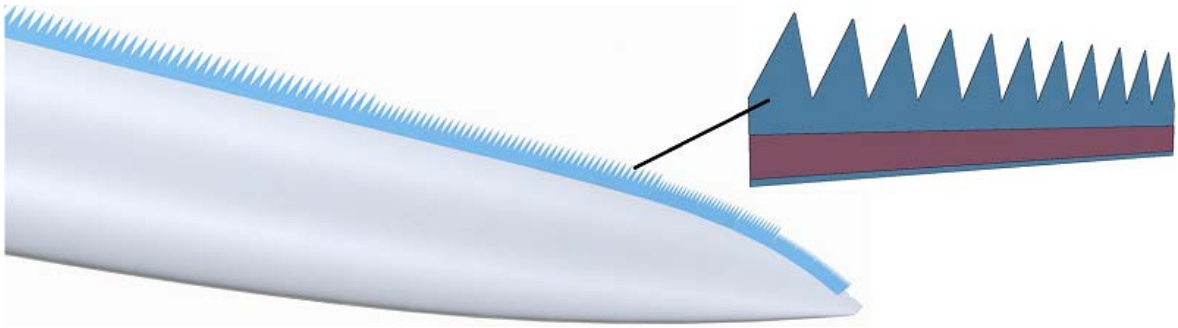

Fig. 2 Serrations on a rotor blade's trailing edge

The **pitch system** serves to adjust the pitch angle of the rotor blades set by the control system. For each individual rotor blade the pitch system comprises an electromechanical drive with rotary current motor, planetary gear and drive pinion, as well as a control unit with frequency converter and emergency power supply. Power supply and signal transfer are realized through a slip ring in the nacelle.

1.3 Nacelle

The nacelle contains essential mechanical and electric components of the wind turbine. The nacelle can be pivoted on the tower.

The **transformer** converts the generator/converter system's low voltage to the medium voltage defined by the point of supply.

In the **switch cabinet**, all electrical components required for the control and supply of the turbine are located.

With the mechanical **rotor brake** the rotor is locked during maintenance work. For this, a sufficient oil pressure is generated by the hydraulic pump.

The **converter** connects the electrical grid to the generator which means the generator can be operated with variable rotational speeds.

The **gearbox** increases the rotor speed until it reaches the speed required for the generator.

The bearings and gearings are continuously lubricated with oil. A 2-stage pump enables the oil circulation. A combination filter element with coarse, fine and ultrafine filter retains solid particles. The control system monitors the contamination of the filter element.

The gear oil used for lubrication also cools the gearbox. The temperatures of the gearbox bearings and the oil are continuously monitored. If the optimum operating temperature is not yet reached, a thermal bypass directs the gear oil directly back to the gearbox. If the operating temperature of the gear oil is exceeded it is cooled down.

The gearbox cooling is realized with an oil/water cooler that is installed directly at the gearbox. The cooling water is re-cooled together with the cooling water

from the generator, converter and transformer in a passive cooler on the roof of the nacelle.

The **rotor shaft** is supported in the **rotor bearing** inside the nacelle. A rotor lock is integrated in the rotor bearing, with which the rotor can be reliably locked in place mechanically.

All nacelle assemblies are protected against wind and weather conditions by means of a **nacelle housing**.

The **coupling** acts as force-transmitting connection between the gearbox and the generator.

The **generator** is a 6-pole doubly-fed induction machine. An air/water heat exchanger is mounted on the generator. The cooling water is re-cooled together with the cooling water of the other major components in a passive cooler on the roof of the nacelle.

The **yaw drives** optimally rotate the nacelle into the wind. The yaw drives are located on the machine frame in the nacelle. A yaw drive consists of an electric motor, multi-stage planetary gear, and a drive pinion. The drive pinions mesh with the external teeth of the yaw bearing. In the aligned position the nacelle is locked with the yaw drives.

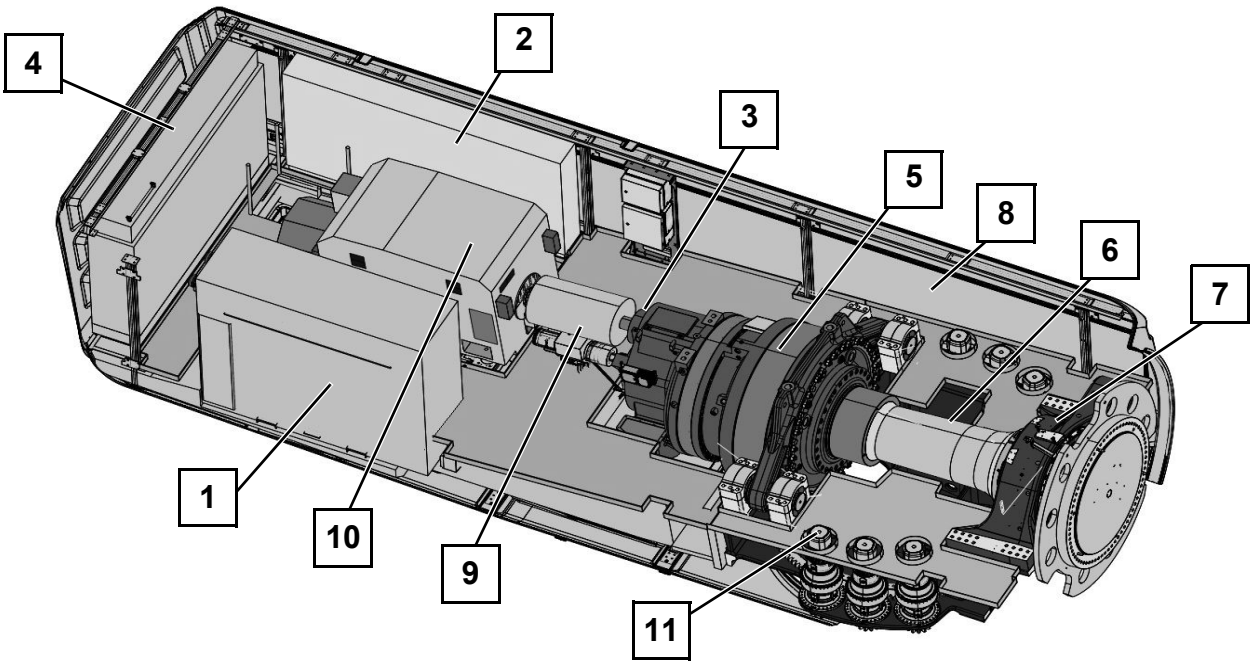

Fig. 3 Schematic diagram of the nacelle, example

1	Transformer	2	Cabinet	3	Rotor brake
4	Converter	5	Gearbox	6	Rotor shaft
7	Rotor bearing	8	Nacelle housing	9	Coupling
10	Generator	11	Yaw drives		

1.4 Auxiliary systems

Generator bearing, gearing of the pitch bearings, rotor shaft and gearing of the yaw bearing are each equipped with an **automatic lubrication system**. An

automatic lubrication of the raceways of the pitch bearing can be offered as an option.

Gearbox, generator, cooling circuit and all relevant switch cabinets are equipped with **heaters**.

An electric **chain hoist** is installed in the nacelle which is used for lifting tools, components and other work materials from the ground into the nacelle. A second movable **overhead crane** together with a manual chain hoist is used to move materials within the nacelle. The manual chain hoist is not included in the standard scope of delivery of the WT, but can be offered as an option.

Various options of additional equipment are available for the wind turbine.

Cooling system

Gearbox, generator, converter and transformer are cooled via a coupled air/ water heat exchanger. A pump conveys the mixture through the heat exchanger. At startup the lightly heated gear oil is directly fed back into the gearbox via a thermal bypass and only directed into the plate-type heat exchanger after reaching operating temperature.

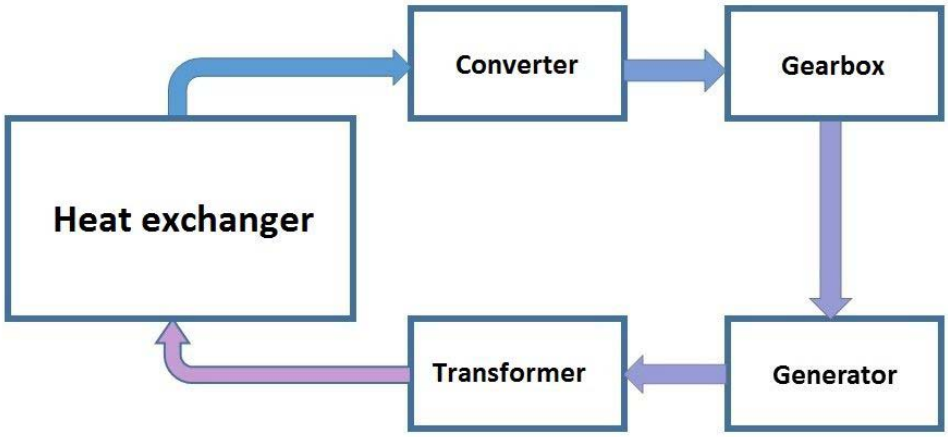

Fig. 4 Diagram of the cooling of major components in the nacelle

Heat exchange takes place via two passive coolers on the nacelle roof.

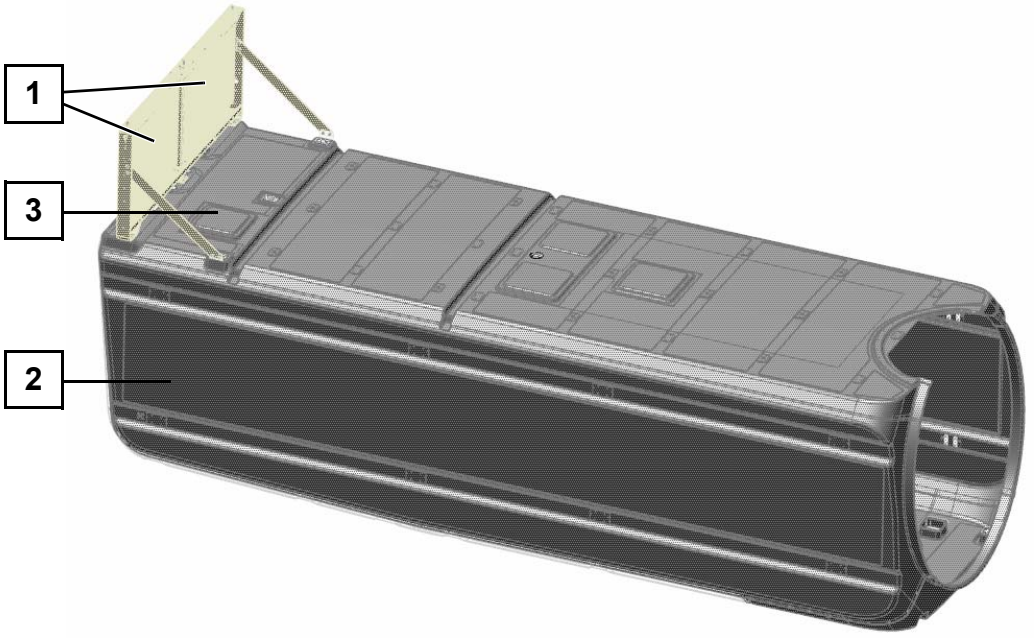

Fig. 5 Passive coolers in a frame on the roof

1 Passive cooler 2 Nacelle 3 Rear roof

2. Medium-voltage switchgear

The medium voltage components are used to connect a WT to the wind farm medium-voltage grid or the local grid operator. The tower base contains the **MV switchgear**. It consists of a transformer field with circuit breakers and at least one ring cable field as default and up to three ring cable fields as an option (dependent on the wind farm configuration). The transformer panel consists of a vacuum circuit breaker and the disconnector with ground switch. The ring cable panel consist of a switch disconnector with a ground switch. The entire MV switchgear is assembled on a support/adapter frame.

Further characteristics of the MV switchgear:

- Routine tests of each switchgear in compliance with IEC 62271-200
- Type tested, SF6 insulation
- Internal switchgear for self-contained electrical systems (min. IP2X)
- SF6 tank: metal-clad, metal-enclosed (min. IP65), independent of environmental influences
- Switch positions shown "On - Off - Grounded"
- Test terminal strip for secondary test
- Low-maintenance in accordance with class E2 (IEC 62271-100)

The system protection of the MV switchgear is achieved by the following items:

- Pressure relief by pressure absorber duct in case of arcing
- Improved personal safety and system protection in case of arcing by type testing in compliance with IEC 62271-200
- Protection device supplied with converter current and stabilized for activation current as overcurrent-time protection relay (independent maximum current protection)
- Actuating openings for switchgear are interlocked to preclude operation of more than one simultaneously, and can be locked as an option
- Corrosion protection of the switchgear cells through hot-dip galvanization and painted surfaces

Transformer and converter are located in the nacelle. The transformer has been specified in accordance with IEC 60076-16 and meets the eco-design requirements of 548/2014/EC.

The steel components at the transformer are dimensioned for corrosion protection class C3 (H).

Additional protection measures:

- Grounded housing (dry-type transformer) or grounded tank (ester transformer)
- Overtemperature protection with temperature sensor and relay
- Hermetic protection (leakage) and overpressure protection for ester transformer

3. Control and electrical system

The WT operates automatically. A programmable logic controller (PLC) continuously monitors the operating parameters using various sensors, compares the actual values with the corresponding setpoints and issues the required control signals to the WT components. The operating parameters are specified by Nordex and are adapted to the individual location.

When there is no wind the WT remains in idle mode. Only various auxiliary systems are operational or activated as required: e.g., heaters, gear lubrication or PLC, which monitors the data from the wind measuring system. All other systems are switched off and do not use any energy. The rotor idles. When the optional STATCOM function has been enabled, the converter remains in operation and enables reactive power supply to the grid. When the cut-in wind speed is reached, the WT changes to the “ready for operation” condition. Now all systems are tested, the nacelle turns into the wind and the rotor blades turn into the wind. When a certain speed is reached, the generator is connected to the grid and the WT produces energy.

At low wind speeds the WT operates at part load. The rotor blade remain turned into wind to the maximum extent. The power produced by the WT depends on the wind speed.

When the nominal wind speed is reached, the WT switches over to the nominal load range. If the wind speed continues to increase, the speed control changes the rotor blade angle so that the rotor speed and thus the power output of the WT remain constant.

The yaw system ensures that the nacelle is always optimally aligned to the wind. To this end two separate wind measuring systems on the nacelle measure the wind direction. Only one wind measuring system is used for the control system, while the second system monitors the first and takes over in case the first system fails. If the wind direction measured deviates too much from the nacelle alignment, the nacelle is yawed into the wind.

The wind energy absorbed from the rotor is converted into electrical energy using a doubly-fed induction machine with slip ring rotor. Its stator is connected directly, and the rotor via a specially controlled frequency converter, to the MV transformer which connects the turbine to the grid. Only part of the power needs to be routed via the converter, permitting low electrical system losses.

3.1 Safety systems

Nordex wind turbines are equipped with extensive equipment and accessories to provide for personal and turbine safety and ensure continuous operation. The entire turbine is designed in accordance with the Machinery Directive 2006/42/EC and certified as per IEC 61400.

If certain parameters concerning turbine safety are exceeded, the WT will cut out immediately and is put into a safe state. Depending on the cut-out cause, different brake programs are triggered. In event of external causes, such as excessive wind speeds or below operating temperatures, the wind turbine is gently braked by means of rotor blade adjustment.

3.2 Lightning/overvoltage protection, electromagnetic compatibility (EMC)

The lightning/surge protection of the wind turbine is based on the EMC-compliant lightning protection zone concept, which comprises the implementation of internal and external lightning/surge protection measures under consideration of the standard IEC 61400-24.

The wind turbine falls into lightning protection level I. All components of the internal and external lightning/surge protection are designed in accordance with lightning protection level I.

The wind turbine with the electrical equipment, consumers, the measurement, control, protection, information and telecommunication technology meets the EMC requirements according to IEC 61400-1, item 10.11.

3.3 Low-voltage grid types

The **660 V / 690 V low-voltage grid** as an IT grid configuration and three phase rotary current grid is insulated against ground and is the primary low voltage energy system of the wind turbine. The elements of the electrical operating and measuring devices of this network are grounded directly or via separate protective equipotential bonding cables. As a further protection measure for personal and turbine protection in the 660 V / 690 V IT grid a central insulation monitor has been installed.

The **400 V/230 V low-voltage grid** has its neutral point grounded directly in the supplying grid transformers as a TN system and three-phase system. The equipment grounding conductor PE and the neutral conductor are available separately. The bodies of electrical equipment and consumers, including the additional protective equipotential bonding, are connected directly, through protective earthing conductor connections, straight to the neutral points of the supply grid transformers. The 400 V/230 V low voltage grid is the auxiliary wind turbine low voltage system.

3.4 Auxiliary power of the wind turbine

The auxiliary low voltage required by the wind turbine in stand-by mode and feed-in mode is requested by the following consumers:

- System control including main converter control
- 400 V/230 V auxiliary power of the main converter
- 230 V AC UPS supply including 24 V DC supply
- Yaw system
- Pitch system
- Auxiliary drives such as pumps, fans and lubrication units
- Heating and lighting
- Auxiliary systems such as service lift, obstacle lights

Long-term measurements show that the average base load (average active power) of the auxiliary low voltage system during WT feed-in operation mode is approx. 15 kW, based on one year. These values are already included in the power curves.

For locations with an average annual speed of 6.5 m/s approx. 10 MWh auxiliary consumption arise, however, this value is greatly dependent on location. Auxiliary consumption is defines as the energy consumption of the WT from the grid for a period during which the WT does not supply current to the grid.

3.5 Wind turbine ratings exceeding 4500 kW

The N149/4.0-4.5 can be operated project-specifically with up to 4800 kW. For power outputs above 4500 kW, operation of an IT low-voltage grid with 690 V is required.

4. Technical data

Design	
Design temperature	Standard -20 °C to +45°C CCV -40 °C to +45 °C
Operating temperature range	-20 °C to +40 °C[1)]
Operating temperature range CCV	-30 °C to +40 °C[1)]
Stop	Standard -20 °C, restart at -18 °C CCV -30 °C, restart at -28 °C
Max. height above MSL	2000 m[1)]
Certificate	In accordance with IEC 61400-1 and DIBt 2012
Type	3-blade rotor with horizontal axis Up-wind turbine
Output control	Active single blade adjustment
Nominal power	variable 4000 - 4500 kW[1)]
Nominal power starting at wind speeds of (at air density of 1.225 kg/m^3)	Approx. 11.5 m/s
Operating speed range of the rotor	6.4 min^{-1} to 12.3 min^{-1}
Nominal speed	11.0 min^{-1}
Cut-in wind speed	3 m/s
Cut-out wind speed	26 m/s[2)]
Cut-back-in wind speed	25.5 m/s[2)]
Calculated service life	≥ 20 years

[1)] Nominal power is achieved up to defined temperature ranges depending on the power factor. The N149/4.0-4.5 can be operated project-specifically with up to 4800 kW.

[2)] Depending on the project, the cut-out wind speed can be decreased to safeguard the structural stability.

Power adjustment depending on reactive power, temperature and altitudes ≤ 1000 m above MSL

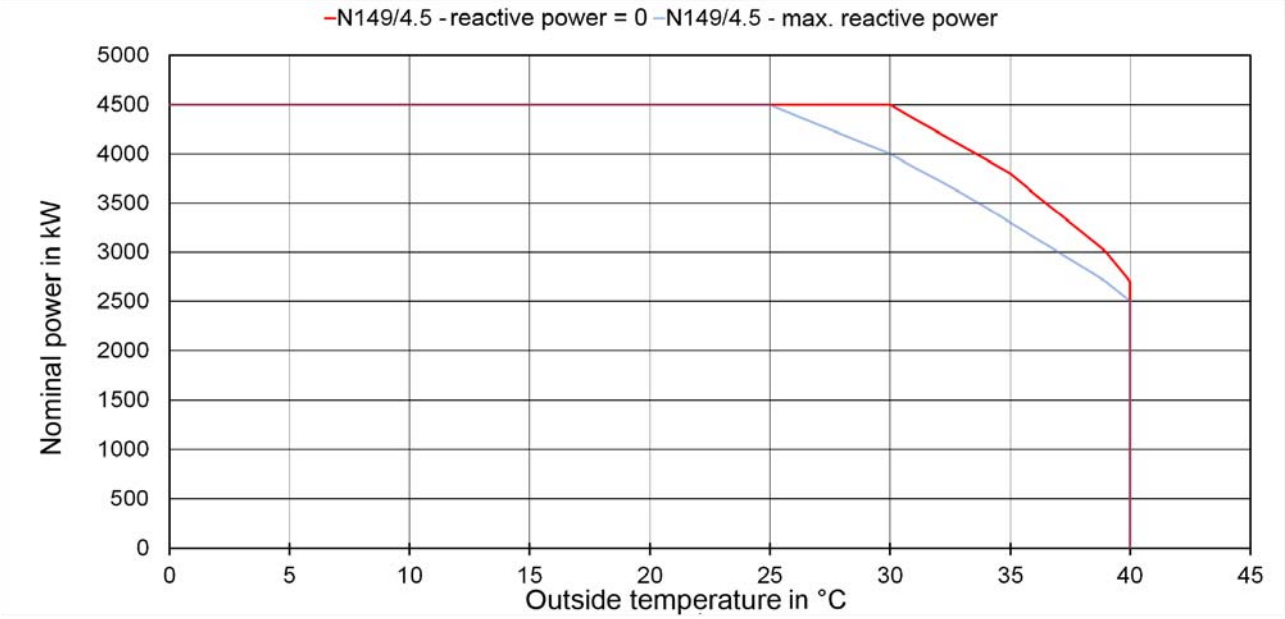

Fig. 6 Power adjustment for Nordex N149 wind turbines with a power of up to 4500 kW

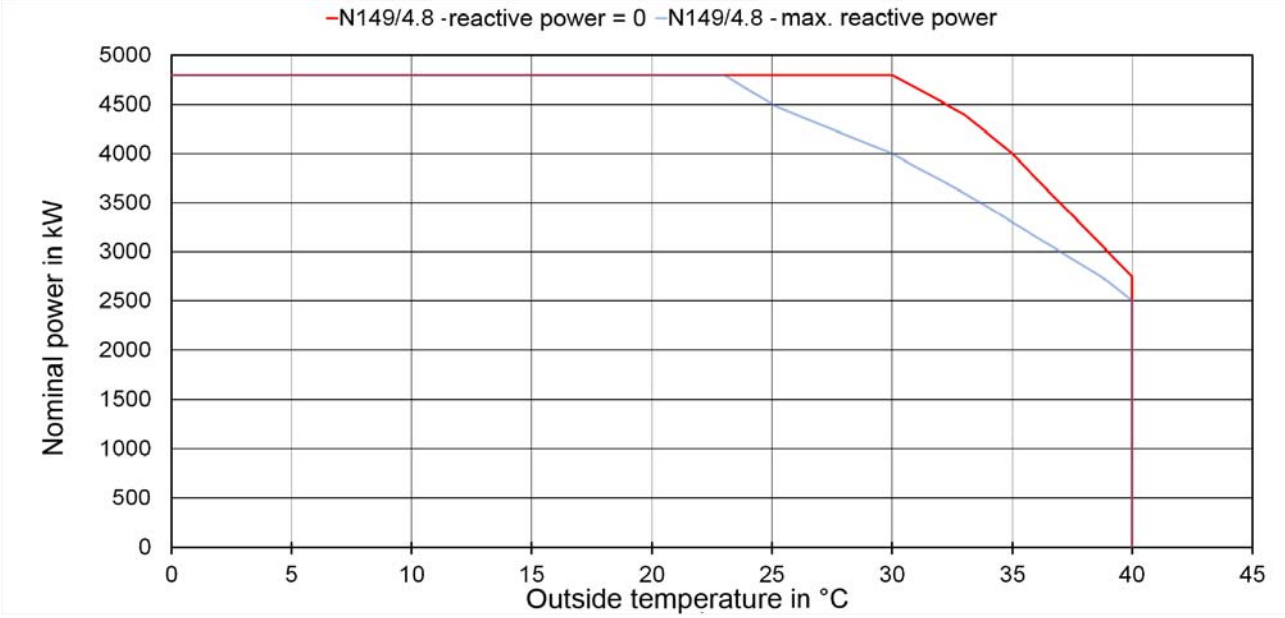

Fig. 7 Power adjustment for Nordex N149 wind turbines with a power of up to 4800 kW

Towers	TS105	TS108	TS125-01	TS135
Hub height	105 m	108 m	125 m	135 m
Wind class	DIBt S/ IEC S	IEC S	DIBt S/ IEC S	IEC S
Number of tower sections	4	5	6	5

Towers	TS145-01	TS155		
Hub height	145 m	155 m		
Wind class	IEC S	IEC S		
Number of tower sections	5	6		

Towers	TCS164 NV05	TCS164 NV06		
Hub height	164 m	164 m		
Wind class	DIBt S/ IEC S	DIBt S/ IEC S		
Number of tower sections	2 steel sections 1 concrete part			

Rotor	
Rotor diameter	149.1 m
Swept area	17460 m2
Nominal power/area	257.7 W/m2
Rotor shaft inclination angle	5 °
Blade cone angle	3.5 °

Rotor blade	
Material	fiber glass and carbon fiber reinforced plastic
Total length	72.40 m

Rotor shaft/rotor bearing	
Type	Forged hollow shaft
Material	42CrMo4 or 34CrNiMo6
Bearing type	Spherical roller bearing
Lubrication	Regularly using lubricating grease

Mechanical brake	
Type	Actively actuated disk brake
Location	On the high-speed shaft
Number of brake calipers	1
Brake pad material	Organic pad material

Gearbox	
Type	Multi-stage planetary gear + spur gear stage
Gear ratio	50 Hz: i = 113.5 60 Hz: i = 136.2
Lubrication	Forced-feed lubrication
Oil quantity including cooling circuit	Max. 650 l
Oil type	VG 320
Max. oil temperature	Approx. 77 °C
Oil change	Change, if required

Electrical installation (660 V AC) - wind turbines with a power of up to 4500 kW	
Nominal power P_{nG}	up to 4500* kW
Nominal voltage	3 x AC 660 V ± 10 % (specific to grid code)
Nominal current during full reactive current feed-in I_{nG} at S_{nG}	4503 A
Nominal apparent power S_{nG} at P_{nG}	5148 kVA
Power factor at P_{nG}	1.00 as default setting 0.869 underexcited (inductive) up to 0.885 overexcited (capacitive) possible
Frequency	50 and 60 Hz

*) All data are maximum values. The values may deviate depending on the rated voltage, rated apparent power and WT active power.

Electrical installation (690 V AC) - wind turbines with a power of up to 4800 kW	
Nominal power P_{nG}	Up to 4800* kW
Nominal voltage	3 x AC 690 V ± 10 % (specific to grid code)
Nominal current during full reactive current feed-in I_{nG} at S_{nG}	4571 A
Nominal apparent power S_{nG} at P_{nG}	5463 kVA
Power factor at P_{nG}	1.00 as default setting 0.8785 underexcited (inductive) up to 0.8785 overexcited (capacitive) possible
Frequency	50 and 60 Hz

*)All data are maximum values. The values may deviate depending on the rated voltage, rated apparent power and WT active power.

20 kV ester transformer*	660 V grid voltage	690 V grid voltage
Total weight	max. 9 t	
Rated voltage OV, U_r	0.66 kV	0.69 kV
Maximum rated voltage OV, dependent on MV grid, U_r	20 kV	
Taps, overvoltage side	+ 4 x 2.5%	
Grid voltage OV	20 kV; 20.5 kV; 21 kV; 21.5 kV; 22 kV	
Rated frequency, f_r	50 / 60 Hz	
Vector group	Dy5	
Installation altitude (above MSL)	Up to 2000 m	
Rated apparent power, S_r	5000 kVA	5350 kVA
Impedance voltage, u_z	8 to 9 % ± 10 % tolerance	
Minimum peak efficiency index, η	99.483 %	99.490 %
Activation current	≤ 5.5 x I_N (peak value)	
Verlustleistung1) Idle losses Short circuit losses	 2800 W 57000 W	 3000 W 60000 W

*)The values are (if not specified otherwise) maximum values. The values may deviate depending on the rated voltage, rated apparent power and WT active power.

1) Guide values

20 kV resin transformer*	
Total weight	max. 9 t
Rated voltage OV, U_r	0.66 kV
Maximum rated voltage OV, dependent on MV grid, U_r	20 kV
Taps, overvoltage side	+ 4 x 2.5%
Grid voltage OV	20 kV; 20.5 kV; 21 kV; 21.5 kV; 22 kV
Rated frequency, f_r	50 / 60 Hz
Vector group	Dy5
Installation altitude (above MSL)	Up to 1000 m
Rated apparent power, S_r	5000 kVA
Impedance voltage, u_z	8 to 9 % ± 10 % tolerance
Minimum peak efficiency index, η	99.354%
Activation current	≤ 12.5 x I_N (peak value).
Verlustleistung1) Idle losses Short circuit losses	 6000 W 42000 W

30 kV transformer*	660 V grid voltage	690 V grid voltage
Total weight	max. 9 t	
Insulation medium	Ester	
Rated voltage OV, U_r	0.66 kV	0.69 kV
Maximum rated voltage OV, dependent on MV grid, U_r	30 kV / 34 kV	
Taps, overvoltage side	+ 4 x 2.5% / + 4 x 0.5 kV	
Grid voltage OV	30; 30.75; 31.5; 32.25; 33 kV / 34; 34.5; 35; 35.5; 36 kV	
Rated frequency, f_r	50 / 60 Hz	
Vector group	Dy5	
Installation altitude (above MSL)	Up to 2000 m	
Rated apparent power, S_r	5000 kVA	5350 kVA
Impedance voltage, u_z	8 to 9 % ± 10 % tolerance	
Minimum peak efficiency index, η	99.483 %	99.490 %
Activation current	≤ 5.5 x I_N (peak value)	
Power loss[1)] Idle losses Short circuit losses	 2800 W 57000 W	 3000 W 60000 W

*)The values are (if not specified otherwise) maximum values. The values may deviate depending on the rated voltage, rated apparent power and WT active power.

1) Guide values

MV switchgear	
Rated voltage (depending on MV network)	24, 36 or 40.5 kV
Rated current	630 A (>630 A optional)
Rated short-circuit duration	1 s
Rated short circuit current	24 kV: 16 kA (20 kA optional) 36 / 40.5 kV: 20 kA (25 kA optional)
Minimum/maximum ambient temperature during operation	NCV: -25 °C to +40 °C
	CCV -30 °C to +40 °C
Connection type	External cone type C according to EN 50181
Circuit breaker	
Number of switching cycles with rated current	E2
Number of switching cycles with short-circuit breaking current	E2

MV switchgear	
Number of mechanical switching cycles	M1
Switching of capacitive currents	Min. C1 - low
Switch disconnector	
Number of switching cycles with rated current	E3
Number of switching cycles with short-circuit breaking current	E3
Number of mechanical switching cycles	M1
Disconnector	
Number of mechanical switching cycles	M0
Ground switch	
Number of switching cycles with rated short-circuit breaking current	E2
Number of mechanical switching cycles	≥ 1000

Generator	
Degree of protection	IP 54 (slip ring box IP 23)
Nominal voltage	660 V / 690 V
Frequency	50 and 60 Hz
Speed range	50 Hz: 730 to 1390 min^{-1} 60 Hz: 876 to 1668 min^{-1}
Poles	6
Weight	approx. 10.6 t

Gearbox cooling and filtration	
Type	1. Cooling circuit: Oil circuit with oil/water heat exchanger and thermal bypass 2. Cooling circuit: Water/air combined with generator, main converter and transformer
Filters	Coarse filter 50 µm / fine filter 10 µm / ultrafine filter <5 µm
Flow rate	Stage 1: Approx. 100 l/min / Stage 2: Approx. 200 l/min

Generator and converter cooling	
Type	Water circuit with water/air heat exchanger and thermal bypass
Flow rate	approx. 160 l/min
Coolant	Water/glycol-based coolant

Transformer cooling	
1. Cooling circuit	Variant 1: Ester circuit with ester/water heat exchanger Variant 2: Sealed air circuit with air/water heat exchanger
2. Cooling circuit	Water/air combined with generator, converter and gearbox

Pitch system	
Pitch bearing	Double-row four-point contact bearing
Gearing/raceway lubrication	Regular lubrication with grease
Drive	Electric motors incl. spring-loaded brake and multi-stage planetary gear
Emergency power supply	Gel batteries

Yaw system	
Yaw bearing	Double-row four-point contact bearing
Gearing/raceway lubrication	Regular lubrication with grease
Drive	Electric motors incl. spring-loaded brake and four-stage planetary gear
Number of drives	5*
Yaw speed	Approx. 0.5 °/s

*) 6 drives may be installed, dependent on the project.

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