Sales document

Deconstruction effort for wind turbines

Product series K08 Delta



K0801_041841_EN

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

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Turbine generation	Product series	Product
Delta	K08 Delta	N100/3300
		N117/3000
		N117/3600
		N131/3000
		N131/3300
		N131/3600
		N131/3900

1. Introduction

Due to the necessity for reducing the greenhouse gas CO_2, the number of wind turbines has greatly increased during recent decades.

Every wind turbine (WT) has been designed for a limited service life. After expiry of this time it must be disassembled, disposed of and the site returned to its original condition – the condition prior to the erection of the wind turbine. The operator of the wind turbine must save up provisions for this purpose. Nordex provides disassembly instructions for the wind turbine and this compilation of the deconstruction effort. The estimated costs for the deconstruction are already saved up and put aside for financial security while the WT is still operating.

However, it has become apparent that the old wind turbines above approx. 150 kW power capacity are not normally scrapped but disassembled and exported abroad. If the WT is sold, careful planning, execution and documentation of the following steps is important for dismantling: Disconnection through the grid operator, disassembly of the WT (backwards – in line with the erection), packing and transport. Selling the WT or parts of the WT is always more favorable than scrapping.

Individual components, especially motors or transformers, can be overhauled and reused. They will then no longer be classified as electronic scrap and can continue yielding revenue. Partial or complete reuse, however, cannot be considered here as the market for old turbines and spare parts always changes and any sales return is a matter of negotiation.

The deconstruction is completed with the deconstruction of the foundation, of all ancillary buildings, the cabling to the supply grid, and the access roads.

2. Factors affecting the costs of WT deconstruction

2.1 Site-specific factors

The costs for the dismantling of wind turbines depend on the site-specific conditions, such as landscape, costs for access roads and crane costs. Therefore, the figures calculated here for access roads can only represent guide values for the actual costs in Germany. Another guide value are the originally incurred costs during the erection of the wind farm. These, however, are often not known to Nordex.

In interconnected wind farms there are additional costs, e.g., for a substation, separate met mast or buildings. On the other hand, fixed costs, such as planning and mobilization costs for the cranes, are allocated to the entire wind farm.

2.2 Regional factors

The disposal costs and sales returns depend on the individual disposal companies and the region. For a particular project, i.e., a specific location, the current regionally applicable costs and prices must in each case be obtained and applied afresh.

For the transport costs arising, a distance of max. 50 km has been applied.

2.3 Additional factors

The disposal costs and the sales returns for scrap metal and electronic scrap depend to a large extent on the economy. In addition, changed legal requirements might have an effect on disposal and its costs.

The costs for planning, documenting and monitoring the deconstruction may differ greatly and cannot be considered here. Legal concerns, e.g., lease agreements, can also not be considered. The economies of scale in the deconstruction of several wind turbines are also not considered.

3. Wind turbine data

The values refer to Nordex K08 generation delta wind turbines on a steel or hybrid tower and a standard shallow foundation. They should be considered only an example as all foundations are designed for the specific project.

Masses/volumes of the wind turbine components

WT type		**N100**	
Performance class [kW]		3300	
Rotor masses Blade - GRP - Copper - Electrical components Hub - Steel - Electrical components - GRP (spinner)	[t]	 approx. 32 0.9 approx. 0.2 30.2 1.6 0.5	
Nacelle masses - GRP - Steel - Electrical components - Copper (from cables)	[t]	 3.5 100.3* 12.5 1.0	
Hub heights/designation	[m]	75/ R75	100/ R100
Tower masses - Steel as per tower drawing - Aluminum - Volumes of concrete - Mass of reinforcement - Mass of tendons	 [t] [t] [m³] [t] [t]	 161 0.4	 311 0.5
Foundation - Volumes of concrete - Mass of reinforcement (incl. anchor cage)	[m³] [t]	 519 67	 630/806[3)] 94/111[3)]
Cabling[1)]	[t]	2.7	3.2
Electrical components (transformer, MV switchgear, switch cabinet in the tower base etc.)	[t]	approx. 13.5 external transformer substation: approx. 13	
Hazardous waste (oils, greases, transformer oil, coolant, etc.)[2)]	[t]	approx. 2.8 approx. 2.8	

WT type		N117								
Performance class [kW]		3000			3600					
Rotor masses Blade - GRP - Copper - Electrical components Hub - Steel - Electrical components - GRP (spinner)	[t]	approx. 31 0.9 approx. 0.2 30.2 1.3 0.5								
Nacelle masses - GRP - Steel - Electrical components - Copper (from cables)	[t]	3.5 100.3* 12.5 1.0								
Hub heights/designation	[m]	91/ R91	120/ R120	141/ PH141	76/ TS76	91/ TS91	99/ TS99	106/ TS106	106/ TS106-01	120/ TS120
Tower masses - Steel as per tower drawing - Aluminum - Volumes of concrete - Mass of reinforcement - Mass of tendons	[t] [t] [m³] [t] [t]	217 0.4	470 0.5	99 0.9 413 40 41	134 0.4	191 0.4	221.5 0.4	293 0.5	264 0.5	337 0.5
Foundation - Volumes of concrete	[m³]	515/ 623[3)]	616/ 726[3)]	611	-	500/ 650[3)]	-	476/ 535[3)]	476/ 535[3)]	554/ 672[3)]
- Mass of reinforcement (incl. anchor cage)	[t]	70/76[3)]	101/ 114[3)]	95	-	70/75[3)]	-	74/84[3)]	74/84[3)]	71/82[3)]
Cabling[1)]	[t]	2.7	3.2	4.2	2.4	2.7	4.9	3.2	3.2	3.2
Electrical components (transformer, MV switchgear, switch cabinet in the tower base etc.)	[t]	approx. 13.5 external transformer substation: approx. 13								
Hazardous waste (oils, greases, transformer oil, coolant, etc.)[2)]	[t]	approx. 2.8 approx. 2.8								

WT type		N117
Performance class [kW]		3600
Rotor masses Blade - GRP - Copper - Electrical components Hub - Steel - Electrical components - GRP (spinner)	[t]	 approx. 31 0.9 approx. 0.2 30.2 1.3 0.5
Nacelle masses - GRP - Steel - Electrical components - Copper (from cables)	[t]	 3.5 100.3* 12.5 1.0
Hub heights/designation	[m]	134/TS134
Tower masses - Steel as per tower drawing - Aluminum - Volumes of concrete - Mass of reinforcement - Mass of tendons	[t] [t] [m³] [t] [t]	 337 0.9
Foundation - Volumes of concrete - Mass of reinforcement (incl. anchor cage)	[m³] [t]	 542/664[4)] 86-104[6]
Cabling[1)]	[t]	4.2
Electrical components (transformer, MV switchgear, switch cabinet in the tower base etc.)	[t]	approx. 13.5 external transformer substation: approx. 13
Hazardous waste (oils, greases, transformer oil, coolant, etc.)[2)]	[t]	approx. 2.8 approx. 2.8

WT type		**N131**			
Performance class [kW]		3000		3000/3300	3300
Rotor masses Blade - GRP and CRP - Copper* - Electrical components Hub - Steel - Electrical components - GRP (spinner)	[t]	approx. 42 0.9 approx. 0.2 39.5 1.3 0.5			
Nacelle masses - GRP - Steel - Electrical components - Copper (from cables)	[t]	3.5 106.2** 12.5 1.0			
Hub height/designation	[m]	99 / R99	114 / R114	134 / PH134	164 / PH164
Tower masses - Steel as per tower drawing - Aluminum - Volumes of concrete - Mass of reinforcement - Mass of tendons	 [t] [t] [m³] [t] [t]	 221.5 0.4	 291.9 0.5	 84.6 0.9 393 35 34	 106.1 0.9 518 47 53
Foundation - Volumes of concrete - Mass of reinforcement (incl. anchor cage)	[m³] [t]	500-650[3)] 70-78	660-760[3)] 78-86	611 72	611 / 702[4)] 72/ 99.1[3)]
Cabling[1)]	[t]	2.7	3.2	4.2	4.2
Electrical components (transformer, MV switchgear, switch cabinet in the tower base etc.)	[t]	approx. 13.5 external transformer substation: 13			
Hazardous waste (oils, greases, transformer oil, coolant, etc.)[2)]	[kg]	approx. 2800 (greases: 120; coolant: 200; oils: 750; transformer oil: 1300)			

WT type		N131						
Performance class [kW]		3600/3900	3600			3600/3900		
Rotor masses Blade - GRP and CRP - Copper* - Electrical components Hub - Steel - Electrical components - GRP (spinner)	t	approx. 42 0.9 approx. 0.2 39.5 1.3 0.5						
Nacelle masses - GRP - Steel - Electrical components - Copper (from cables)	t	3.5 106.2** 12.5 1.0						
Hub height/designation	m	84 / TS84	106 / TS106	106/ TS106-01	112 / TS112	114 / TS114	120 / TS120	134 / TS134
Tower masses - Steel as per tower drawing - Aluminum - Volumes of concrete - Mass of reinforcement - Mass of tendons	t t m³ t t	174 0.4 - - -	293 0.4 - - -	252 0.4 - - -	360 0.5 - - -	303*** 0.5 - - -	337 0.5 - - -	377 0.9 - - -
Foundation - Volumes of concrete - Mass of reinforcement (incl. anchor cage)	m³ t	380/450[3)] 60/70	476/535[3)] 79-89	476/535[3)] 79-89	approx. 778[5)] 86.7-100.7[5)]	553/608[3)] 82-92[3)]	553/608[3)] 82-92[3)]	542/664[4)] 86-104[6)]
Cabling[1)]	t	2.7	2.7	2.7	3.2	3.2	3.2	4.2
Electrical components (transformer, MV switchgear, switch cabinet in the tower base etc.)	t	approx. 13.5 external transformer substation: 13						
Hazardous waste (oils, greases, transformer oil, coolant, etc.)[2)]	kg	approx. 2800 (greases: 120; coolant: 200; oils: 750; transformer oil: 1300)						

1) Transformer in tower means approx. 0.1 t less cable; HCV means approx. 0.1 t more

2) Transformer oil for external transformer substations; synthetic esters possible for internal transformers

3) Values depend on variant with or without buoyancy

4) Small or large foundation, selection depends on location

5) Values for exemplary foundation, foundation is not designed by Nordex

6) Project-specific selection (foundation size, certification specifications)

*) only for variant with anti-icing

**) Additional 1.1 t of steel if a rolling mass damper is installed

**) Additional 5 t of steel if a vibration damper is installed

Further explanations on the tables:

- GRP = glass-fiber reinforced plastics, material of the rotor blade and the nacelle cover
- CRP = carbon-fiber reinforced plastics, additional rotor blade material
- The quantities of plastics other than GRP are negligible
- Additional options are not taken into account
- The tower is a hybrid tower with approx. 80 m/100 m concrete tower and approx. 51 m/61 m tubular steel tower. No anchor cage is required in the foundation

4. Applied costs and returns

The most important cost factors are: rotor (with rotor hub), nacelle, tower (incl. cabling), switchgear, transformer with feed-in station and the crane hard standing areas as well as the crane, transport and personnel costs. All disassembly costs are considered in Chapter 4.9. The transport costs are considered in the respective prices/returns.

Only the materials steel, aluminum, copper and GRP are listed separately. The quantities of other materials are negligible. Electronic scrap and hazardous waste must be disposed of separately by law. Returns from cast iron are a little higher than those from steel. All prices stated in this document are net prices rounded to whole numbers. Since raw material costs may fluctuate greatly, the actual daily prices may differ significantly.

- Sale of steel: approx. € 260.00 per t
- Returns of copper with insulation: approx. €1,600.00 per t
- Sale of aluminum: approx. € 900.00 per t
- Sale of electronic scrap: approx € 100.00 per t
- Costs for hazardous waste: approx. € 360.00 per t*
- Costs for GRP material, crushing and disposal: approx. € 268.00 per t*
- Costs for foundation breakup, transport, disposal and backfilling: from € 50.00 per m^3
- Costs for earth work, crane hard standing areas and access roads: from € 15.00 per m^2
- Crane costs: € 8.000.00 per day
  + one-time cost of EUR 25,000 - 80,000.00
- Personnel costs € 4,000.00 per day

* Depends greatly on the region

The individual items are further explained in the following chapters.

4.1 Rotor and rotor hub

The rotor must be dismantled with the aid of a crane. The rotor blades are crushed on site, picked up and passed to thermal or material recycling. Metal parts, such as lightning protection, are neglected here. Already the crushing of waste places high demands due to the size of the rotor blades and for reasons of dust protection and may account for approx. 30 % of the costs.

4.2 Nacelle

The nacelle must be disassembled using a crane. The nacelle can be disassembled into the individual parts drive train (rotor shaft and gearbox), generator and the support frame construction, then transported away and recycled.

4.3 Tower

The tubular steel tower of the wind turbine must be disassembled using a crane. The aluminum installations and copper cables are removed. The tower is disassembled on site and transported away. A concrete tower is blown up. The concrete is broken up, the reinforcement scrapped.

4.4 Electronic scrap

The electrical components present in the wind turbine and in the compact transformer substation must be disposed of separately as they are subject to the regulations on electronic waste. This affects particularly switch cabinets, transformer and medium-voltage switchgear. The electronic scrap is sorted and recycled by specialist companies. Depending on the degree of sorting, the recycling company and the raw material prices, the returns or costs may differ greatly.

4.5 Foundation

The foundation in accordance with DIBt (Deutsches Institut für Bautechnik [German Institute for Civil Engineering]) is a steel-reinforced round, shallow foundation. The foundation must be broken up partially or completely in accordance with the specifications of the building permits or other regulations. Blowing up the foundation might be the most effective method. The concrete must be disposed of and the reinforcement scrapped. Depending on authority directives or the technology used it may be cheaper to break up and dispose of the entire foundation; this case was applied here.

4.6 Transformer / feed-in station

The feed-in station (1 per wind farm) and the transformer (1 per WT) must be disassembled and transported away. This results in transport and disposal costs and sale returns. There is no foundation.

4.7 Cabling/underground cable

During wind turbine disassembly a significant amount of copper and aluminum cables is recovered. These run from the generator through the tower via the switch cabinet to the transformer. The "transformer in tower" version requires a lot less cabling than a transformer in a separate transformer substation. Here, the separate transformer substation is considered.

The cabling between the wind turbines within the wind farm is not considered here, because the number of wind turbines and distances differ between projects.

4.8 Crane hard standing areas and access roads

In accordance with the Nordex sales documentation crane hard standing areas and access roads are necessary for the wind turbine and exist since its erection.

These areas must be deconstructed again after completion of the dismantling work (excavation and backfill with soil). A minimized crane hard standing area is assumed.

The access roads between the wind turbines within the wind farm are not considered here, because the number of wind turbines and distances differ between projects.

4.9 Cranes and disassembly costs

An 800 t crane and a 120 t auxiliary crane are required for deconstruction work. One-time “mobilization costs” of €25,000 to 80,000 are incurred for crane deployment. The large margin can be explained by the unpredictable local conditions. Additional crane costs arise for each working day – in wind farms also for the additional logistics requirements for the cranes.

4 days were estimated for the dismantling of the wind turbine and transport of the turbine components.

The figures given here as an example assume a 100 m tower. The crane costs depend greatly on tower height and maximum required hook load (degree of disassembly of the WT).

4.10 Hazardous waste

The hazardous waste materials arising from a wind turbine must be collected separately and recycled or disposed of by special companies. This includes batteries, coolants and lubricants. A list of used coolants and lubricants including quantities will be provided by Nordex.

Batteries are present in the rotor hub, switch cabinet in the tower base and – where applicable – in switch cabinets for obstacle lights and any other installed options.

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