



DELTA GENERATION

**PROVEN TECHNOLOGY –  
AT A NEW STAGE OF EVOLUTION**



N100/3300 N131/3600  
N117/3600 N131/3900  
N131/3300



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## TECHNICAL DEVELOPMENT AT NORDEX

### *Experience keeps us one step ahead*

As one of the pioneers in the modern use of wind energy, Nordex has been developing increasingly efficient wind turbines for use onshore since 1985. Since then, we have always remained true to proven principles, using tried-and-tested series engineering and giving top priority to the reliability of all system components.

In 2000, Nordex installed the first 2.5-megawatt series turbine in the world. Since then, the company has connected more than 5,000 machines from this platform to the grid at a wide range of locations around the world. We know what we're talking about when we claim that our wind turbine generators offer quality, mature technology and dependable performance, even in extreme locations.

With the Delta Generation, we are now offering the fourth turbine generation of our proven multimegawatt platform. Thanks to its larger rotors, greater nominal capacity and optimised technical systems, the Delta Generation sets new standards for economic efficiency, reliability and service- and HSE-friendliness.



## MATURE TECHNOLOGY

### *Proven concepts ensure a secure investment*

With the new Delta Generation, Nordex customers benefit from the know-how we have gathered in the multimegawatt range over many years. Mature technical solutions that have proven their worth thousands of times form a sound basis for the new generation.

#### **Continuity: the electrical system**

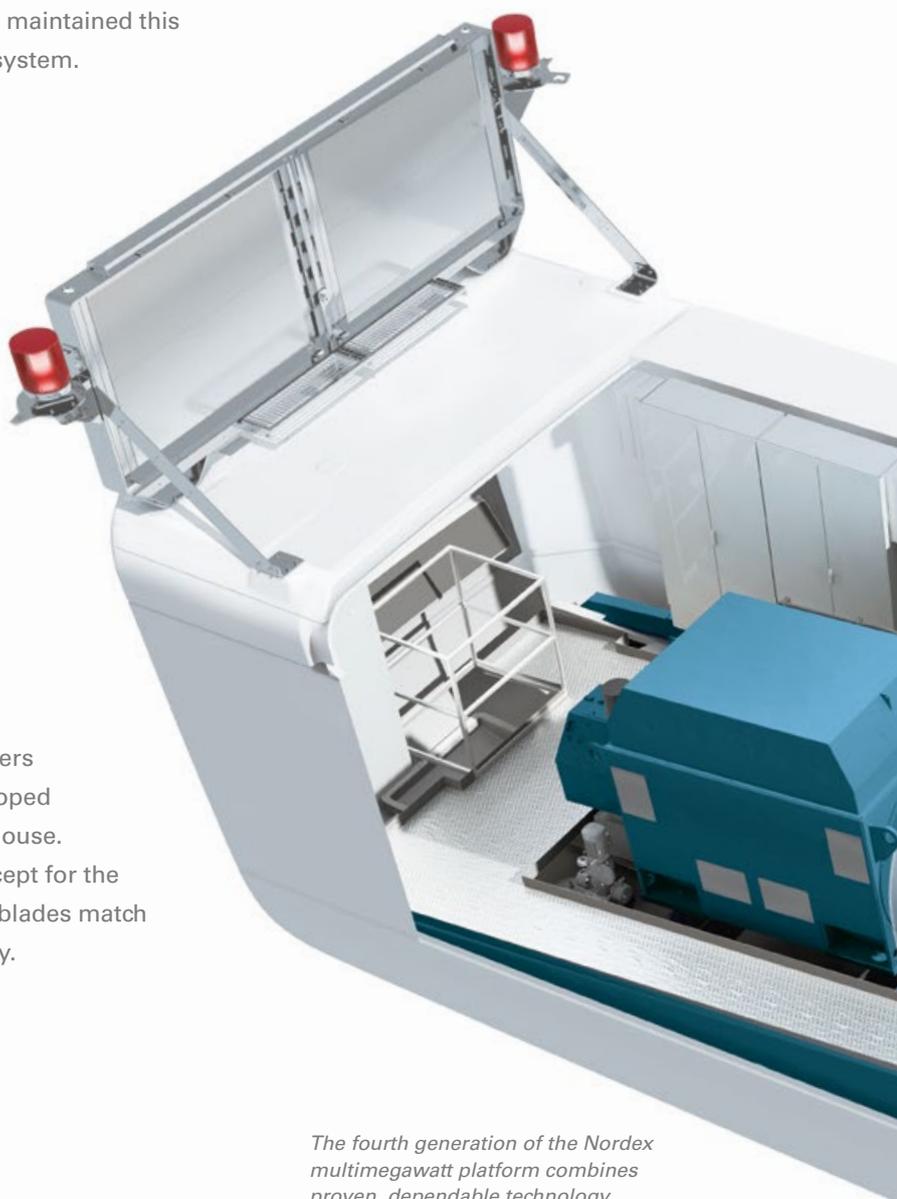
Even the first Nordex multimegawatt turbine was equipped with a doubly fed asynchronous generator and a partial converter. With the Delta Generation, we have maintained this proven and highly economical electrical system.

#### **Tried-and-tested drive train concept**

The drive train system is based on a modular drive train layout with a three-point suspension. We have used this system successfully from the outset. Together with our qualified suppliers, we work on continuously improving our drive train components. This delivers the output required while maintaining availability at a high level.

#### **Proven rotor blade designs**

For the turbines of the new platform generation, Nordex uses proven aerodynamic designs for the rotor diameters of 100, 117, and 131 metres. Nordex developed the NR50, NR58.5, and NR65.5 blades in-house. This allowed us to realise an optimal concept for the overall turbine system. The efficient rotor blades match the respective turbine technology perfectly.



*The fourth generation of the Nordex multimegawatt platform combines proven, dependable technology with targeted improvements for enhanced performance.*

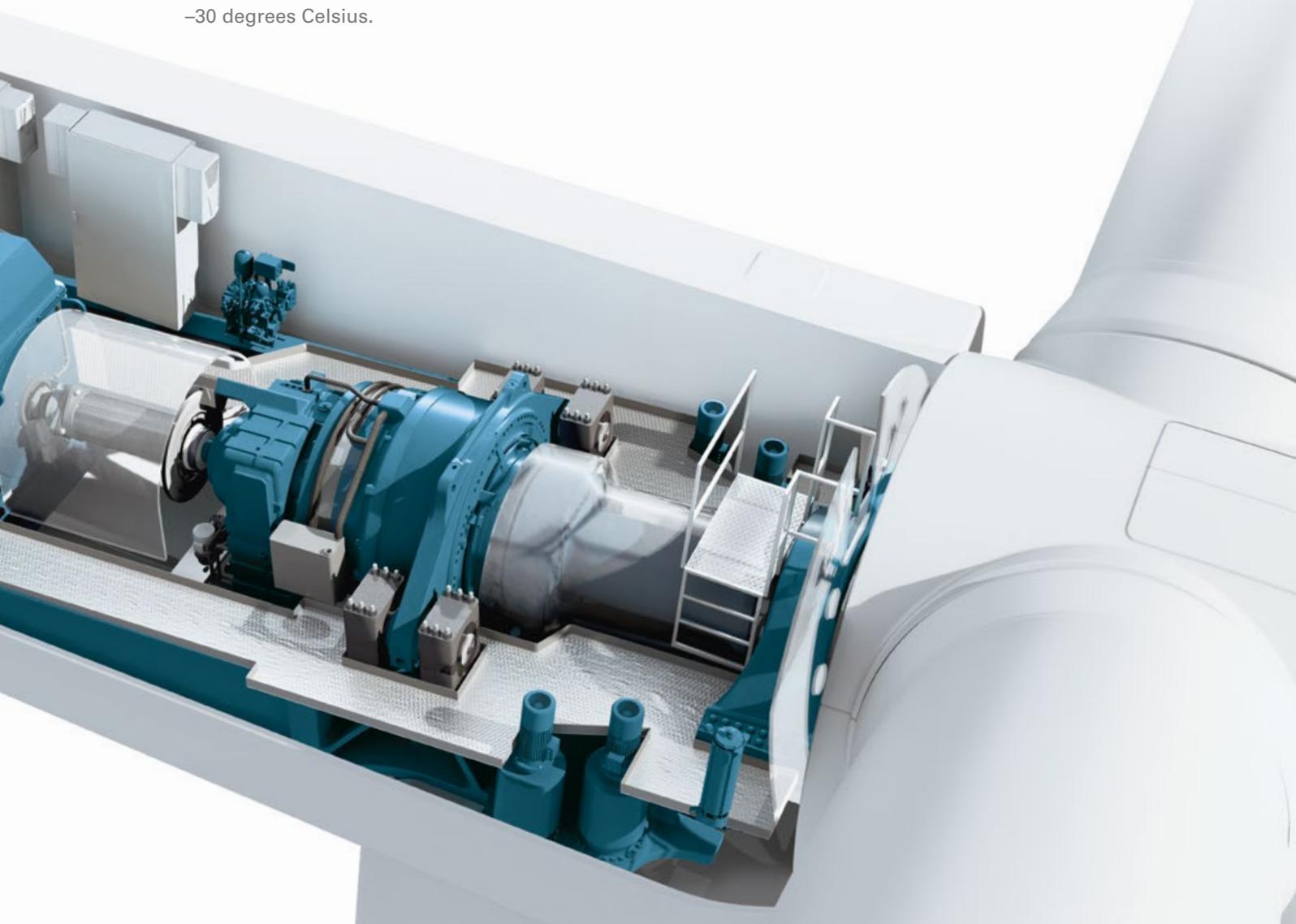
### Grid compatibility ensured

Like the previous generations, the turbines of the Delta Generation meet the grid requirements of international markets. One of the most demanding grid connection directives in Europe is the German SDLWindV (German System Service Ordinance). Thanks to their fault-ride-through capability, our turbines are able to bridge voltage drops easily, thereby meeting all the requirements for the German system service bonus (SDL-Bonus). In addition, the Nordex Wind Farm Management System also allows the grid operator to directly control the active and reactive power of the wind farm in the grid.



### Making the most of cold locations

During the winter, temperatures can be extreme at many sites offering a high wind yield. The tried-and-tested Nordex Cold Climate Package is designed to meet the challenges of these especially cold locations. Turbines in the cold-climate version (CCV) are able to operate down to an outside temperature of  $-30$  degrees Celsius.



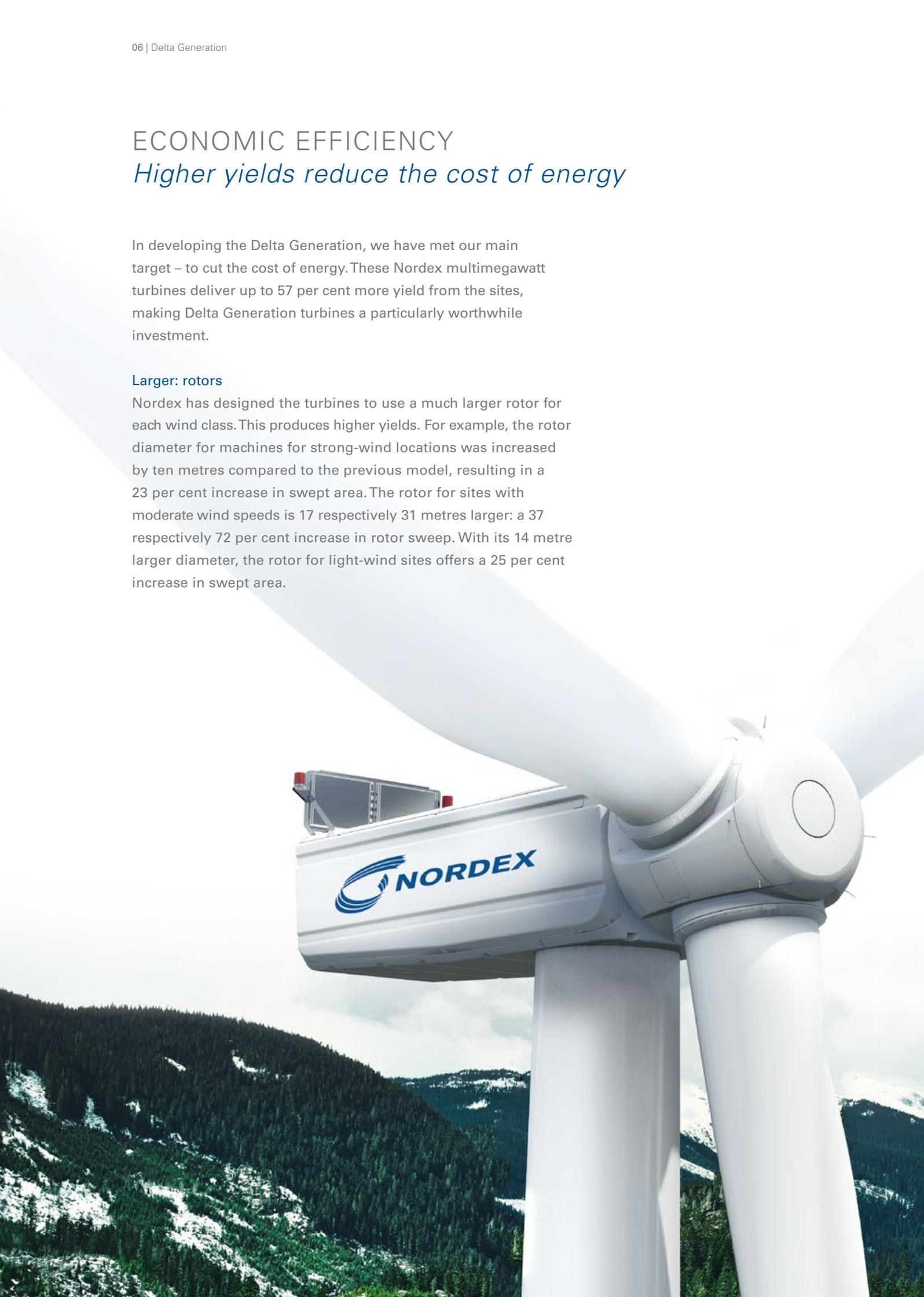
## ECONOMIC EFFICIENCY

### *Higher yields reduce the cost of energy*

In developing the Delta Generation, we have met our main target – to cut the cost of energy. These Nordex multimegawatt turbines deliver up to 57 per cent more yield from the sites, making Delta Generation turbines a particularly worthwhile investment.

#### **Larger: rotors**

Nordex has designed the turbines to use a much larger rotor for each wind class. This produces higher yields. For example, the rotor diameter for machines for strong-wind locations was increased by ten metres compared to the previous model, resulting in a 23 per cent increase in swept area. The rotor for sites with moderate wind speeds is 17 respectively 31 metres larger: a 37 respectively 72 per cent increase in rotor sweep. With its 14 metre larger diameter, the rotor for light-wind sites offers a 25 per cent increase in swept area.



### **Stronger: rated output**

With the N100/3300, Nordex has raised the rated output of the strong-wind turbine by more than 30 per cent. The N117/3600 is designed for moderate wind speeds and has a 20 per cent higher rated output than the previous model. New in this windclass is the N131/3600 with a 25 per cent increase in rotor swept area. In the case of the light-wind turbine N131/3300, the increase in nominal capacity is at least 25 per cent, and with the N131/3900 more than 60 per cent. This has a positive effect on the energy yields of the Delta turbines. In spite of the considerable increase in output, the sound power levels remain low for each class. For the N131/3300, Nordex has further reduced the sound power level of the turbine for light-wind sites, while that of the N131/3900 has been maintained on a reasonable level thanks to the use of serrations.

### **Higher: towers**

New and higher hub heights produce even greater yield increases and make siting possible even in wooded areas or locations with complex topography. Nordex offers towers with hub heights of up to 141 metres for sites with average wind speeds. For light-wind sites, tower heights up to 134 metres are available.



### **Smarter: Anti-icing system**

Particularly in frost regions, ice forms on rotor blades in the winter months. Icing can reduce the efficiency of a wind turbine generator, as well as lowering its availability. The proven Nordex Anti-icing System heats the most aerodynamically important areas of the rotor blades and efficiently reduces icing levels. Nordex customers can rely on their turbines for dependable yields and maximum availability in cold regions.



## QUALITY AND RELIABILITY

### *A focus on high availability*

To ensure that our turbines perform reliably, we conduct exhaustive tests. We certify the quality of all components and manufacture in a modern line production. The average availability of all turbines covered by Nordex Service stands at 98 per cent. We ensure this high level of availability by consistently further developing the vital systems. This contributes to a further reduction in the cost of energy.

#### **Extreme tests for hardware and software**

In the Nordex Test Centre, engineers test the components and systems of the new turbine generation under simulated wind and weather conditions. By subjecting them to strains in excess of the usual specifications, Nordex ensures that the design meets all criteria, delivering a high-quality, mature product for serial production.

#### **Highest industrial standards**

Nordex continues to meet high industrial standards, manufacturing the nacelle and hub modules in a continuous flow process. Many of the steps needed for assembly and commissioning are performed in the protected factory hall before the equipment is shipped to the site.

*In the Nordex Test Centre, engineers ensure the quality of components.*



### Advanced control infrastructure

Nordex has equipped the new turbine generation with the Profinet communication system. Its ethernet-based fieldbus transfers turbine data rapidly, reliably and by priority. All actuators and sensors in the turbine control systems, as well as the different module options, are directly integrated into the network. This ensures improved diagnostics and the reliability of the system.

### Optimised drive train

The drive train design of the Delta Generation reduces the forces acting on the individual components, taking greater strain off the robust rotor bearing. Innovations in the cooling system of the drive train ensure constant temperatures over a wide operating range – with lower internal energy consumption.



## SERVICE AND HSE

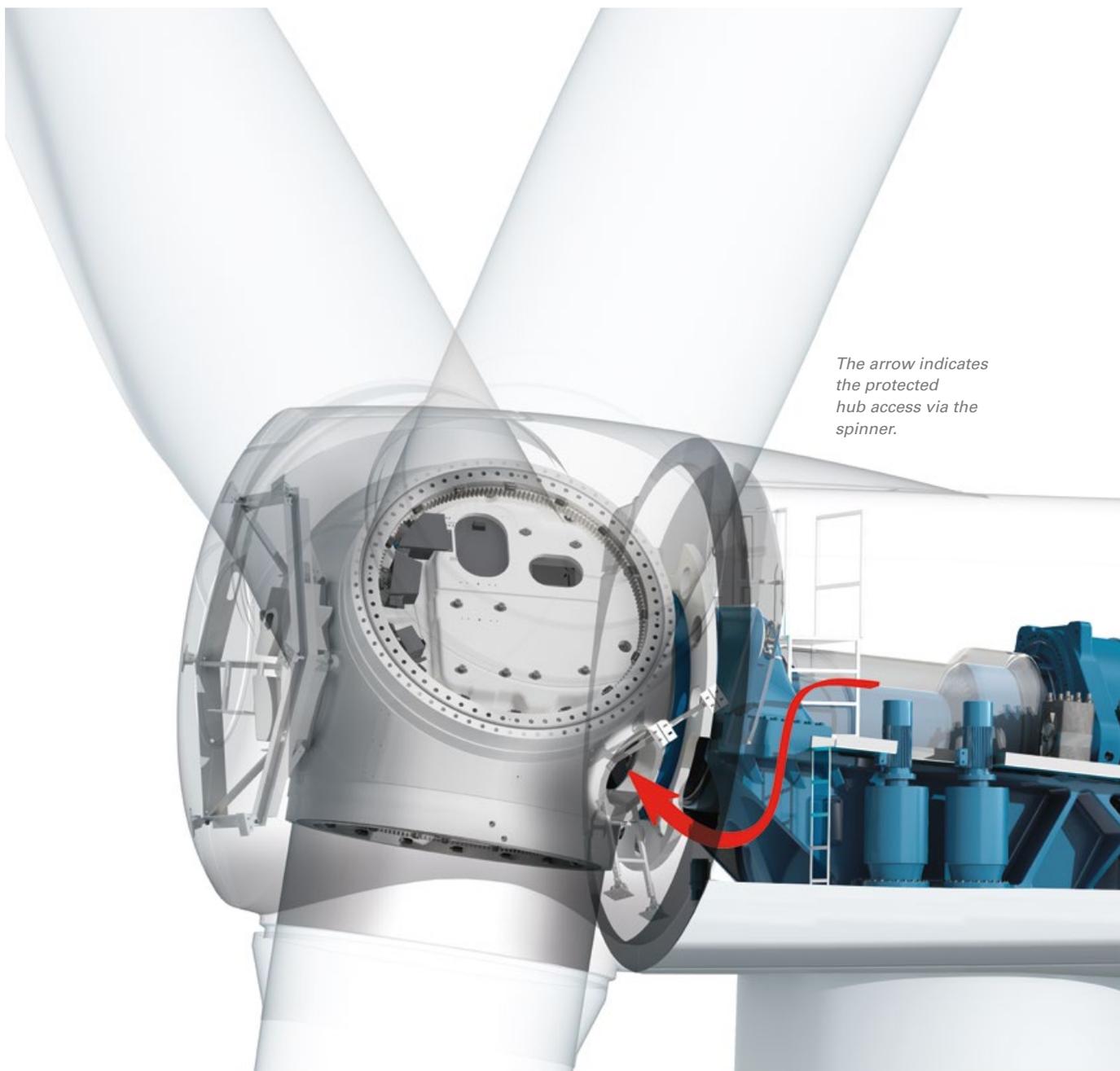
### *Fast and safe turbine O&M*

The Delta Generation is designed so that service operations can be conducted rapidly and safely. This reduces ongoing operational costs. We make no compromise when it comes to HSE – the turbines of the new generation meet the most stringent requirements.



#### Protected hub access

The new spinner, a complete housing for the rotor hub, provides rapid and protected access to the hub. This means that service work can be carried out in a wider range of wind and weather conditions. This is of particular advantage in cold regions – making it possible to reduce downtimes for service purposes.



*The arrow indicates the protected hub access via the spinner.*

### Ergonomics and safety

When we were developing the new multimegawatt generation, we gave high priority to designing the turbines as a particularly safe and spacious workplace. In case of an emergency, the platform also offers extended escape and rescue routes. All systems are easily accessible for maintenance. Nacelle components weighing less than one tonne can be reached with the on-board crane and, if necessary, can be exchanged without additional equipment.

### Annual service interval

The technical design of the Delta Generation allows for an annual service interval. Automatic lubrication of the bearings in the pitch system replaces manual processes. These bearings, as well as the main bearing and the generator bearings, are supplied automatically with lubricant, making them less susceptible to wear. This minimises the service requirements and reduces the O&M expenses.

### Yaw n-1 concept

The yaw system runs with four drives in standard operation. However, should one drive break down, the turbine can continue to run temporarily on three drives, making it possible to plan any needed service work. This concept increases turbine availability and reduces service costs.



## DELTA GENERATION IN THE FIELD

### *Tried-and-tested performance*

In mid-2013 Nordex installed the first two Delta Generation turbines for strong and average wind speeds in the Janneby wind farm in Germany. One year later the N131/3000 light-wind turbine was added to the range. Since then the family has grown further – Nordex has installed and commissioned the N131/3300 turbine in 2015, the N117/3600 in 2016 and the N131/3600 in 2017.

Certification and field validation are right on schedule – the following certificates have been issued for the Delta Generation turbines:

Turbine	Windclass	Certificate
N100/3300	IEC Ia	DIBt, TC
N117/3000	IEC IIa	DIBt, TC
N117/3600	IEC IIa	DIBt, TC
N131/3000	IEC IIIa	DIBt, TC
N131/3300	WZ II	DIBt
N131/3600	IEC S	DIBt, TC

The principal measuring results for the 3 megawatt and 3.3 megawatt types were recorded. One particularly important finding was that both the sound power levels and unit certificates were confirmed by external measurements. The power curves measured for the N100/3300, the N117/3000, the N131/3000 and the N131/3300 are available.





## SOLUTION FOR STRONG WIND

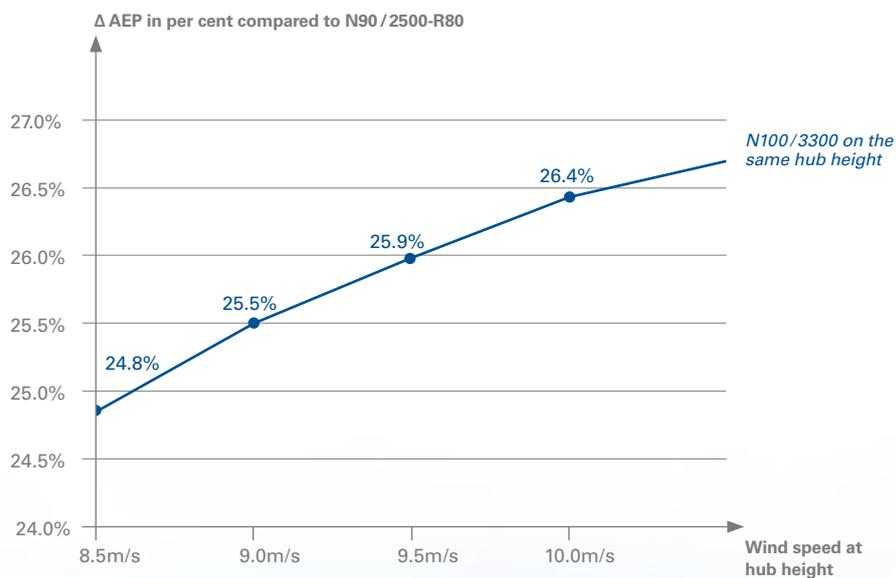
### *High yields in rough climates*

Wind sites with a rough environment call for mature, robust technology. With the turbines of the Delta Generation, Nordex offers the proven 100-metre rotor, now also for IEC-I locations. Thanks to the large rotor diameter and the higher rated output, the N100/3300 obtains much higher energy yields at sites with strong winds compared to the previous model. This turbine is available with hub heights of 75, 85 and 100 metres.

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**The N100/3300 generates up to 26 per cent more AEP compared to the preceding IEC I model**

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*Calculation of AEP based on air density of 1.225 kg/m<sup>3</sup>, wind shear of 0.2 and Weibull shape parameter of  $k = 2.0$*



# TECHNICAL DATA

## N100/3300

### Operating data

Rated power	3,300 kW
Cut-in wind speed	3.5 m/s
Cut-out wind speed	25 m/s

### Rotor

Diameter	99.8 m
Swept area	7,823 m <sup>2</sup>
Operating range rotational speed	9.0–16.1 rpm
Rated rotational speed	14.3 rpm
Tip speed	75 m/s
Speed control	Variable via microprocessor
Overspeed control	Pitch angle

### Gearbox

Type	3-stage gearbox (planetary-planetary-spur gear)
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### Generator

Construction	Doubly fed asynchronous generator
Cooling system	Liquid/air cooling
Voltage	660 V
Grid frequency	50/60 Hz

### Brake system

Main brake	Aerodynamic brake (pitch)
Holding brake	Disc brake

<b>Lightning protection</b>	Fully compliant with IEC 61400-24
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### Hub height

75 m/IEC Ia, DIBt 3
85 m/IEC Ia
100 m/IEC Ia, DIBt 3

*The powerful N100/3300 is the first choice for strong-wind sites.*





## SOLUTION FOR MODERATE WIND *Economical at a wide range of sites*

With the N117/3600 and the N131/3600, Nordex now offers even more economical turbines for IEC-II locations. Thanks to their enlarged rotor sweeps and higher rated output, they obtain much higher yields. The two turbines are available with hub heights of 84 to 141 metres and are thus also ideal for complex locations. The maximum rated power can be adjusted (e.g. 3 MW) to meet also project specific grid requirements.

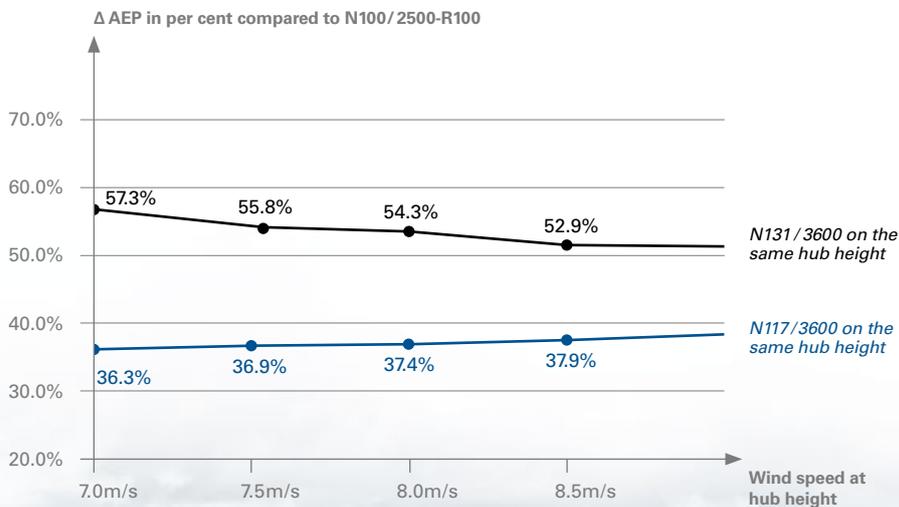
Nordex limits the sound power levels of the N117/3600 to a maximum of 103.5 decibels. The N131/3600 achieves a maximum of 104.9 decibels with serrations each.

In order to ensure high yields even at sites with a cold climate, Nordex fits both the N117/3600 and the N131/3600 with the efficient anti-icing system on request.

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### The N131/3600 generates up to 57 per cent more AEP compared to the N100/2500-R100

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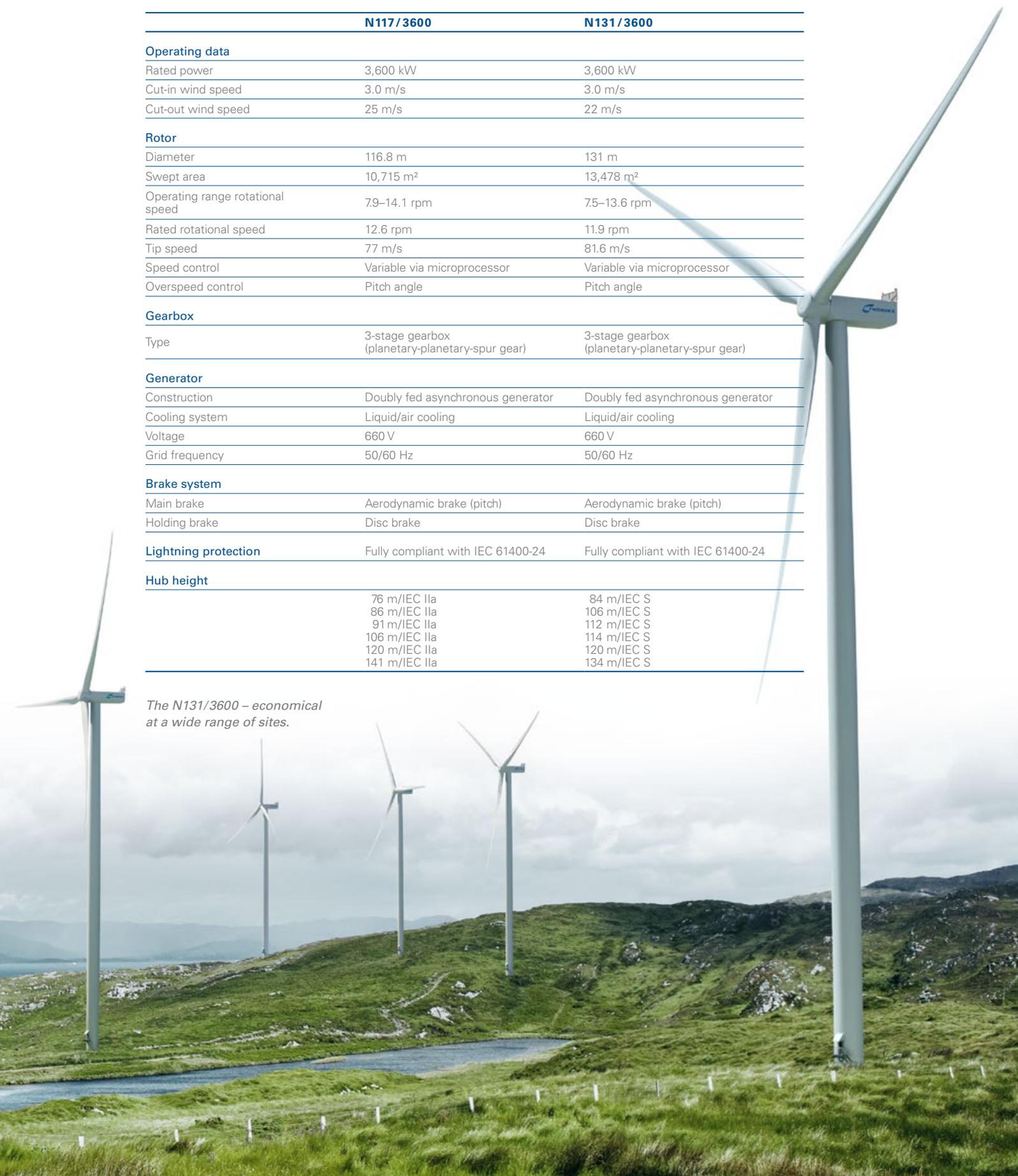
Calculation of AEP based on air density of 1.225 kg/m<sup>3</sup>, wind shear of 0.2 and Weibull shape parameter of  $k = 2.0$



# TECHNICAL DATA

	N117/3600	N131/3600
<b>Operating data</b>		
Rated power	3,600 kW	3,600 kW
Cut-in wind speed	3.0 m/s	3.0 m/s
Cut-out wind speed	25 m/s	22 m/s
<b>Rotor</b>		
Diameter	116.8 m	131 m
Swept area	10,715 m <sup>2</sup>	13,478 m <sup>2</sup>
Operating range rotational speed	7.9–14.1 rpm	7.5–13.6 rpm
Rated rotational speed	12.6 rpm	11.9 rpm
Tip speed	77 m/s	81.6 m/s
Speed control	Variable via microprocessor	Variable via microprocessor
Overspeed control	Pitch angle	Pitch angle
<b>Gearbox</b>		
Type	3-stage gearbox (planetary-planetary-spur gear)	3-stage gearbox (planetary-planetary-spur gear)
<b>Generator</b>		
Construction	Doubly fed asynchronous generator	Doubly fed asynchronous generator
Cooling system	Liquid/air cooling	Liquid/air cooling
Voltage	660 V	660 V
Grid frequency	50/60 Hz	50/60 Hz
<b>Brake system</b>		
Main brake	Aerodynamic brake (pitch)	Aerodynamic brake (pitch)
Holding brake	Disc brake	Disc brake
<b>Lightning protection</b>		
	Fully compliant with IEC 61400-24	Fully compliant with IEC 61400-24
<b>Hub height</b>		
	76 m/IEC IIa	84 m/IEC S
	86 m/IEC IIa	106 m/IEC S
	91 m/IEC IIa	112 m/IEC S
	106 m/IEC IIa	114 m/IEC S
	120 m/IEC IIa	120 m/IEC S
	141 m/IEC IIa	134 m/IEC S

*The N131/3600 – economical at a wide range of sites.*



## SOLUTION FOR LIGHT WIND

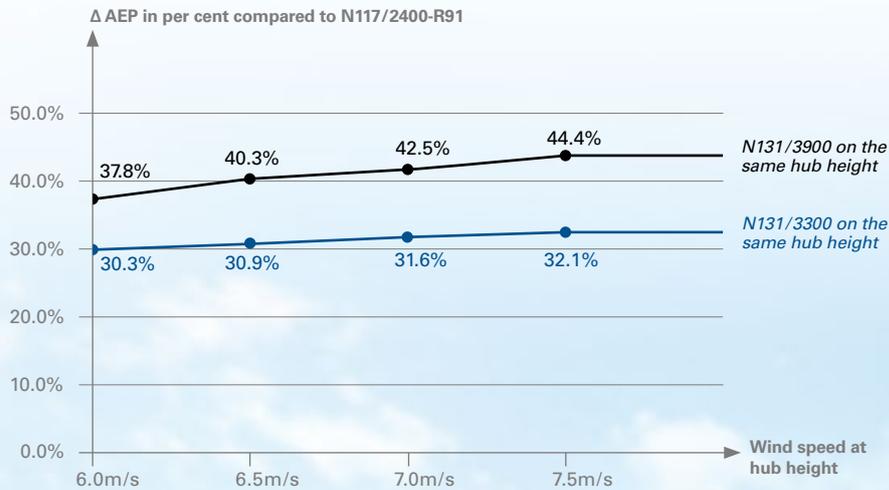
### *Maximum efficiency in the 3 MW segment*

High yield even in regions with light-wind: thanks to their enlarged rotor sweeps and higher rated output, N131/3300 and the N131/3900 generate much higher yields at light-wind locations. Both the N131/3300 IEC IIIa and the N131/3900 IEC S come on towers with hub heights of 84 to 134 metres. The maximum rated power can be adjusted (e.g. 3 MW) to meet also project specific grid requirements.

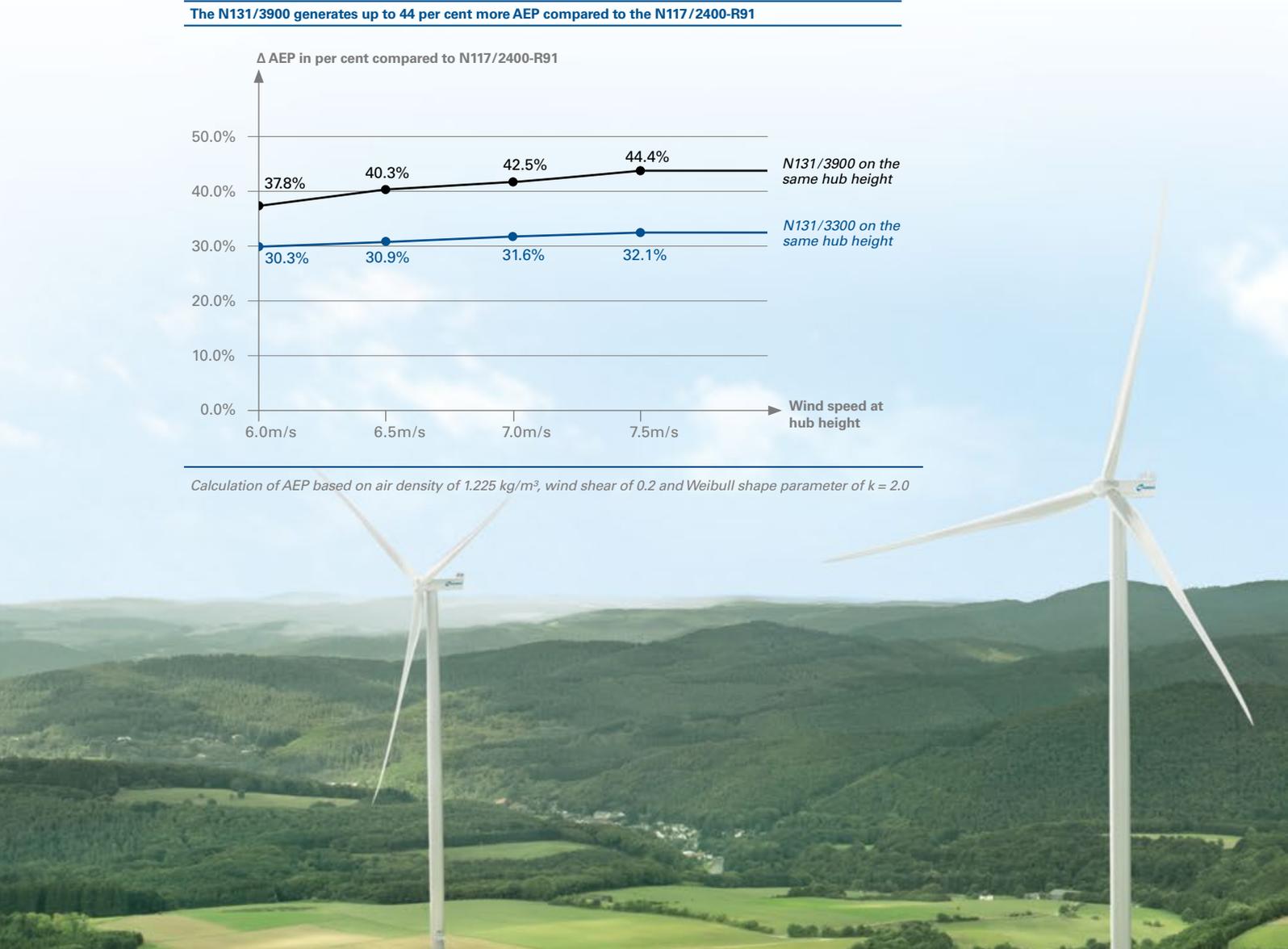
Nordex limits the sound power levels of the N131/3300 IEC IIIa to 103.7 decibels. The N131/3900 produces a maximum of 106.2 decibels with serrations – which is crucial for optimising and obtaining approvals for wind farms.

In order to ensure high yields even at sites with a cold climate, Nordex fits the N131/3900 with the efficient anti-icing system on request.

#### The N131/3900 generates up to 44 per cent more AEP compared to the N117/2400-R91



Calculation of AEP based on air density of 1.225 kg/m<sup>3</sup>, wind shear of 0.2 and Weibull shape parameter of  $k = 2.0$



# TECHNICAL DATA

	<b>*N131/3300 IEC</b>	<b>N131/3900</b>
<b>Operating data</b>		
Rated power	3,300 kW	3,900 kW
Cut-in wind speed	3.0 m/s	3.0 m/s
Cut-out wind speed	20 m/s	20 m/s
<b>Rotor</b>		
Diameter	131.0 m	131.0 m
Swept area	13,478 m <sup>2</sup>	13,478 m <sup>2</sup>
Operating range rotational speed	7.5–13.6 rpm	7.9–14.4 rpm
Rated rotational speed	11.2 rpm	12.6 rpm
Tip speed	76.9 m/s	86.2 m/s
Speed control	Variable via microprocessor	Variable via microprocessor
Overspeed control	Pitch angle	Pitch angle
<b>Gearbox</b>		
Type	3-stage gearbox (planetary-planetary-spur gear)	3-stage gearbox (planetary-planetary-spur gear)
<b>Generator</b>		
Construction	Doubly fed asynchronous generator	Doubly fed asynchronous generator
Cooling system	Liquid/air cooling	Liquid/air cooling
Voltage	660 V	660 V
Grid frequency	50/60 Hz	50/60 Hz
<b>Brake system</b>		
Main brake	Aerodynamic brake (pitch)	Aerodynamic brake (pitch)
Holding brake	Disc brake	Disc brake
<b>Lightning protection</b>		
	Fully compliant with IEC 61400-24	Fully compliant with IEC 61400-24
<b>Hub height</b>		
	84 m/IEC IIIa	84 m/IEC S
	106 m/IEC IIIa	114 m/IEC S
	112 m/IEC IIIa	120 m/IEC S
	120 m/IEC IIIa	134 m/IEC S
	134 m/IEC IIIa	

\* international markets

*Strong, efficient and quiet:  
the N131/3900.*



# WORLDWIDE PRESENCE

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As of: 09/2017



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