Nordex Group

Colombia Wind Power 2020

November 2020

AGENDA

1 **INTRODUCTION**
Nordex in the Region

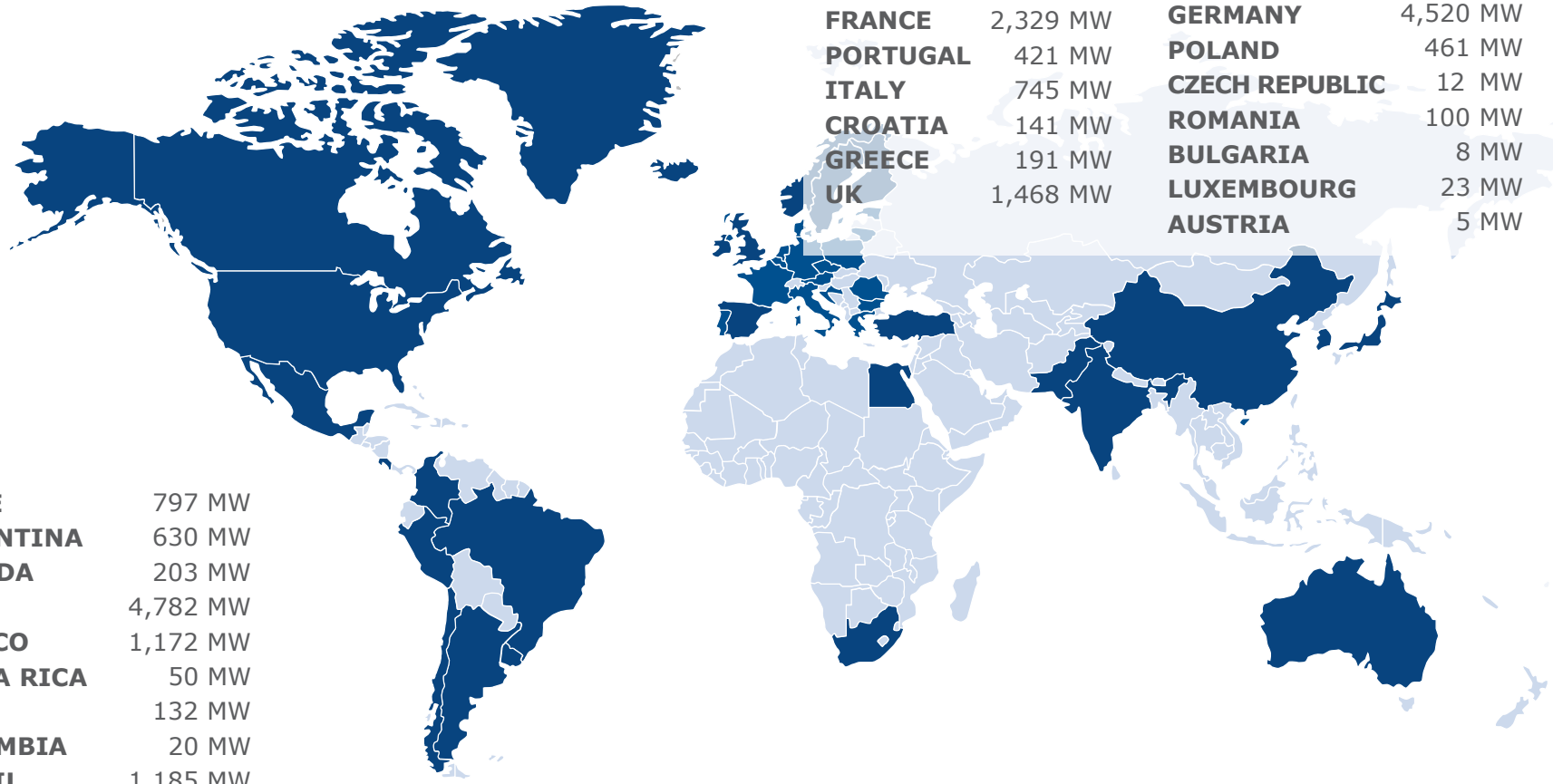
2 **CONSTRUCTION AND O&M**
Construction Experience and O&M Services

3 **PRODUCT DEVELOPMENT**
N149/163 – N155 Platform, Project Optimization Program

4 **TECHNICAL REVIEW**
Nordex Technology Revision by DNV, Seismic Evaluation

Where We Are – Track Record

MORE THAN 28,877 MW INSTALLED WORLDWIDE



SPAIN	2,043 MW
FRANCE	2,329 MW
PORTUGAL	421 MW
ITALY	745 MW
CROATIA	141 MW
GREECE	191 MW
UK	1,468 MW

IRELAND	937 MW
GERMANY	4,520 MW
POLAND	461 MW
CZECH REPUBLIC	12 MW
ROMANIA	100 MW
BULGARIA	8 MW
LUXEMBOURG	23 MW
AUSTRIA	5 MW

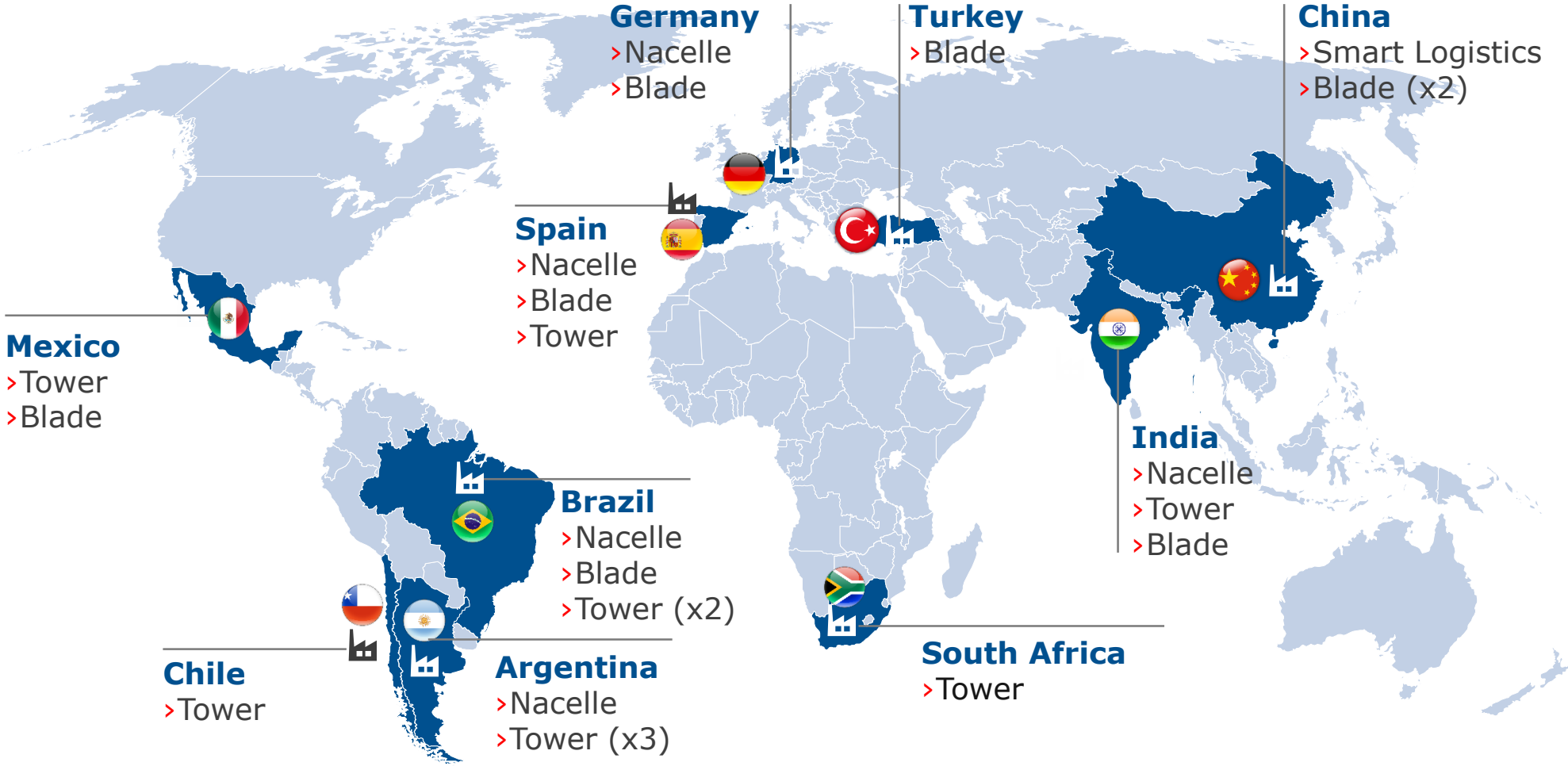
NORWAY	190 MW
SWEDEN	537 MW
FINLAND	593 MW
DENMARK	152 MW
BELGIUM	80 MW
NETHERLANDS	328 MW
ESTONIA	18 MW
LITHUANIA	70 MW

CHILE	797 MW
ARGENTINA	630 MW
CANADA	203 MW
USA	4,782 MW
MEXICO	1,172 MW
COSTA RICA	50 MW
PERU	132 MW
COLOMBIA	20 MW
BRAZIL	1,185 MW
URUGUAY	309 MW

TURKEY	2,112 MW
PAKISTAN	300 MW
INDIA	78 MW
CHINA	1,053 MW
JAPAN	73 MW
SOUTH KOREA	65 MW
AUSTRALIA	371 MW
EGYPT	63 MW
SOUTH AFRICA	563 MW
OTHERS (ROW)	330 MW

Where We Are – The Nordex Group's Production Footprint

A TRULY GLOBAL SUPPLY CHAIN SET UP TO DELIVER, WITH THE LOWEST TOTAL LANDED COSTS, TO EVERY MAJOR MARKET



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Construction

Assembly

- Main Components unloading
- Cranes stategy design in accordance with Project needs
- Highly specialized and trained team of key personnel
- Commissioning and supervisión meeting all industry standards.
- Multi functional team management experience

Service - LATAM South Cone

1. More than 5 years with O&M "Full" Contracts
2. Operations in 4 countries – 2 Technologies
3. 13 WF with dedicated staff assigned in 2020, and 17 WF for 2021
4. Country / Regional / Global Approach
5. NO LDs in the region since the beginning of the service operations

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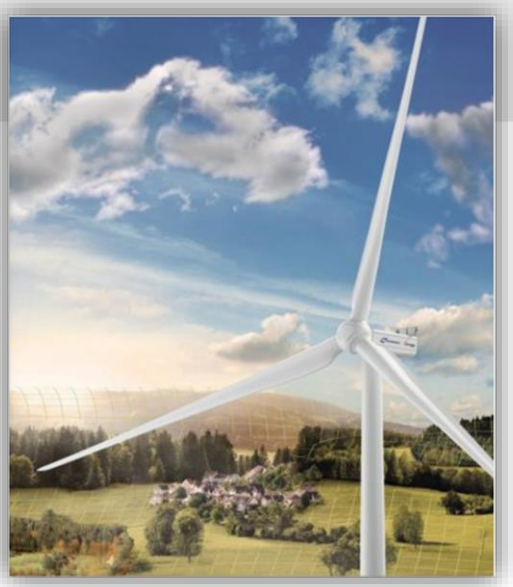
Delta4000 Platform - success based on multiple variants serving different market segments and requirements around the globe best

N133/4.8

N149/4.x *
N149/5.x

N155/4.x
N155/5.x



N163/5.x

*) official name N149/4.0-4.5

Delta4000
Design parameters and conditions

Basic design parameter

	N133/4.8	N149/4.0-4.5	N149/5.X	N155/4.X	N163/5.X
Rotor diameter	133.2 m	149.1 m	149.1 m	155 m	163 m
Rated power	Up to 4.8 MW	Up to 4.8 MW	Up to 5.9 MW	Up to 4.8 MW	Up to 5.7 MW
Swept area	13,935 m²	17,460 m²	17,460 m²	18,869 m²	20,867 m²
Turbulence level	IEC S	IEC S	IEC S	IEC S	IEC S
Tip speed	79.5 m/s	86.0 m/s	83.5 m/s	87.7 m/s	88.8 m/s
Rated rotor speed	11.4 rpm	11.0 rpm	10.7 rpm	10.8 rpm	10.4 rpm
Gear ratio (@50 Hz)	107.6	113.5	117.3	113.5	121.5
Gear ratio (@60 Hz)	129.1	136.2	140.7	136.2	145.8
Nominal torque	~4.3 MNm	~4.8 MNm	~5.5 MNm	~4.6 MNm	~5.7 MNm
Max. sound power level L_{WA} (incl. STE) acc. IEC 61400-11/-14	104.5 dB(A)	106.1 dB(A)	105.6 dB(A)	110.2 dB(A) w/o serrated trailing edge	107.2 dB(A)

Agenda

- **N149/4.x/5.x**
- N163/5.x
- N155/4.x
- PRO Update

N149/5.X
One nacelle – Two 5.X turbine variants

Basis:
- *Certified and proven Delta4000 technology*

Upgrade:
- *One nacelle – Two 5.X turbine variants*

Delta4000 – Service optimized turbine design

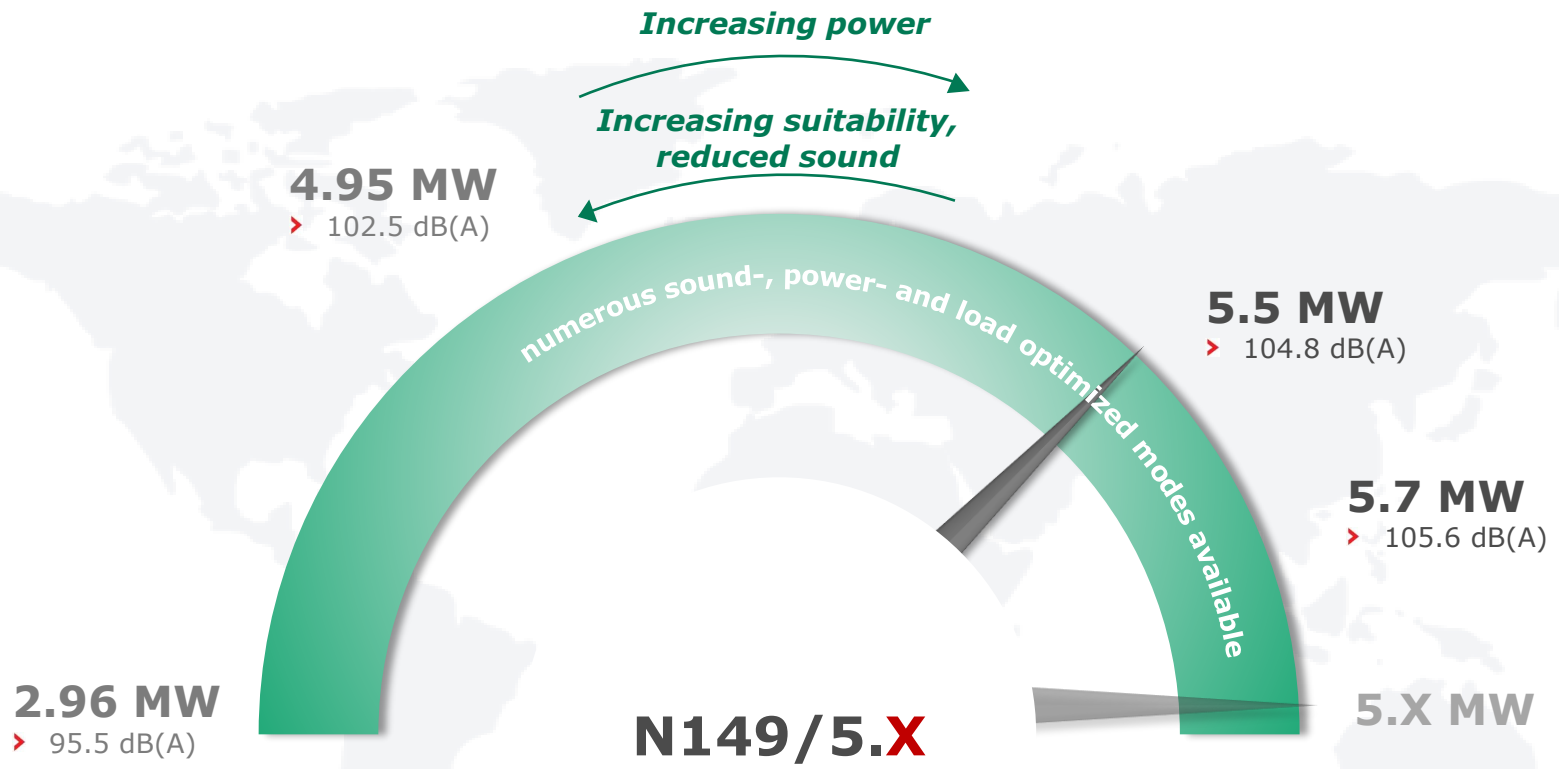
- Up tower repair options for drivetrain
- Turbine prepared for usage of Self-Hoisting Crane
- Smart repair concepts for several components
- Improved yaw and hydraulic system
- Predict-to-Prevent Monitors
- Improved maintenance concept

LT1200 exchanging a gearbox on a Nordex Delta4000 turbine

LT1200 during installation on a Nordex Delta4000 turb

Lowest O&M costs and maintenance effort of all NX platforms

N149/5.X
Flexible rating



- N149/5.X with its flexible design philosophy ensures maximum performance under various site conditions

N149/5.X
Sales release 5.9 MW power mode

N149/5.X
Mode 0 (5.7 MW)

Max. sound (STE):
105.6 dB(A)

Rated Power: *+3.5%*

Rated Torque: *+3.5%*

Rated Speed: *±0%*

N149/5.X
Mode 0.a (5.9 MW) TOM*

Max. sound (STE):
105.6 dB(A)

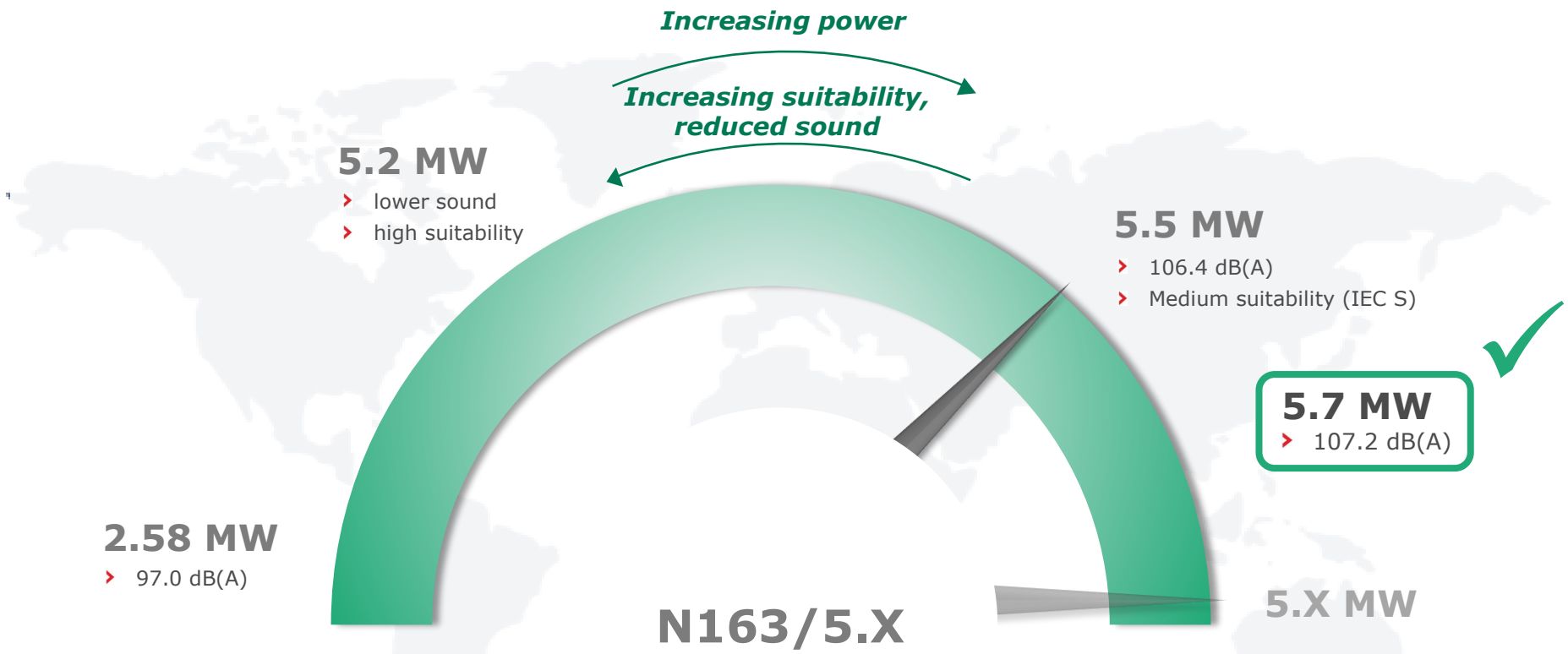
- No hardware change
- Slightly reduced electrical capabilities (WTG OLTC could be required in specific project cases)

*TOM = Torque Optimized Mode

Agenda

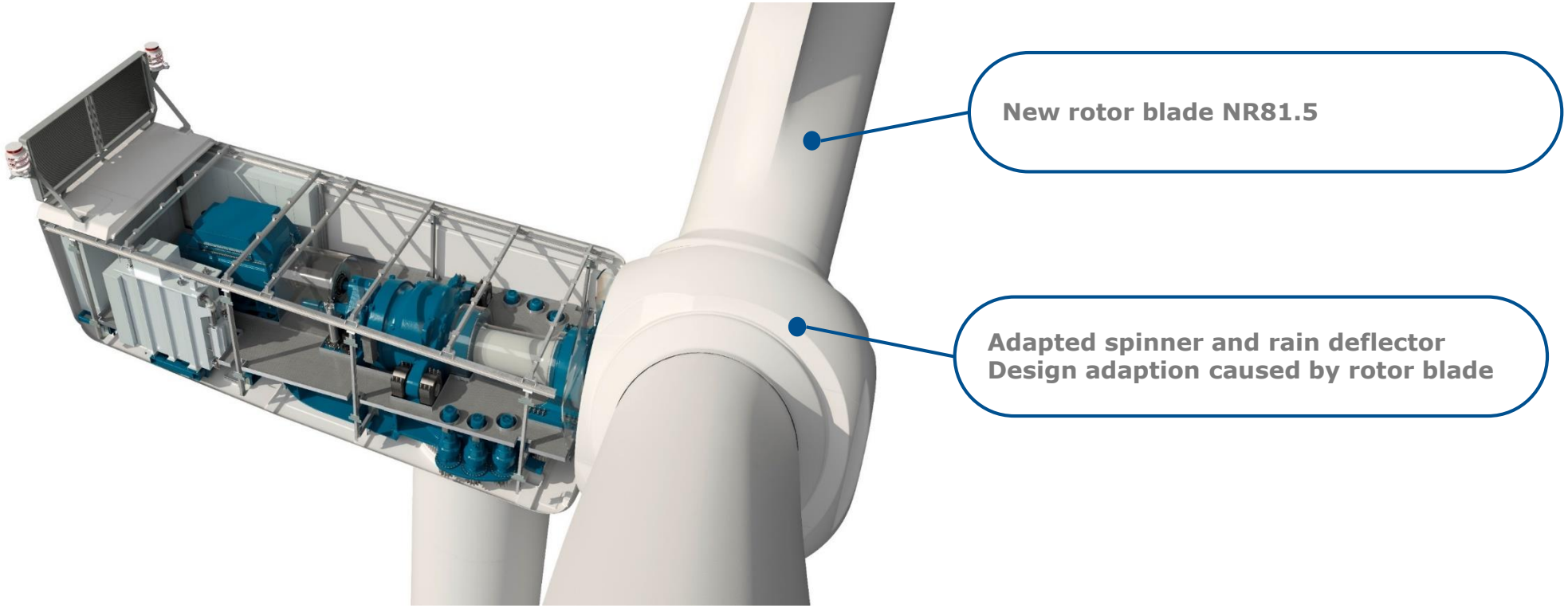
- N149/4.x/5.x
- **N163/5.x**
- N155/4.x
- PRO Update

N163/5.X - Flexible rating



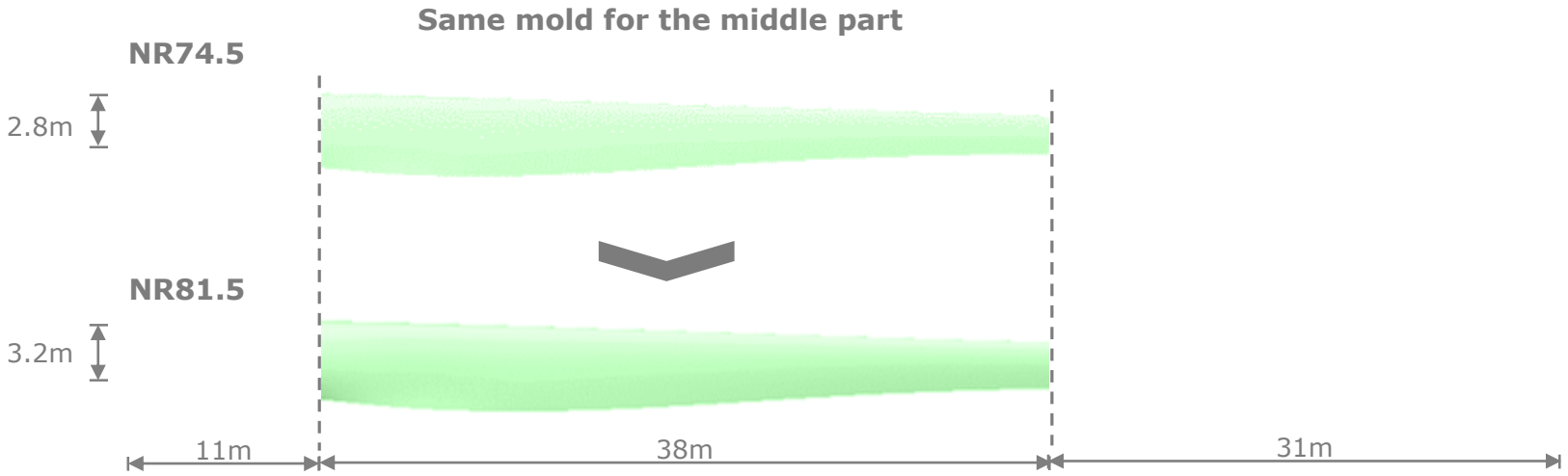
- N163/5.X with its flexible design philosophy ensures maximum performance under various site conditions

N163/5.X - Overview technical changes compared to N149/5.X



N163/5.X - New Single-Piece Blade NR81.5

New blade



- NR81.5 is a single-piece blade
- N149/5.X blade shares the same middle part of the mold with N163/5.X

Note: Blade drawings are illustrative only

Agenda

- N149/4.x/5.x
- N163/5.x
- **N155/4.x**
- PRO Update

N155/4.X - Overview technical changes

Utilized Delta4000 components

NACELLE:
- Drive train, electrical system, yaw, etc. from N149/4.0-4.5

NACELLE:
- Selected components from 5.x generation (cooling, main bearing housing, cover)

Modified Delta4000 components

Blade:
- Rotor diameter 155m, BCD of 3.2m
- Glass blade based on AW148 blade

New hub: Increased cone-angle to 5.0°

Hydraulic pitch (upscale of AW3000 design)

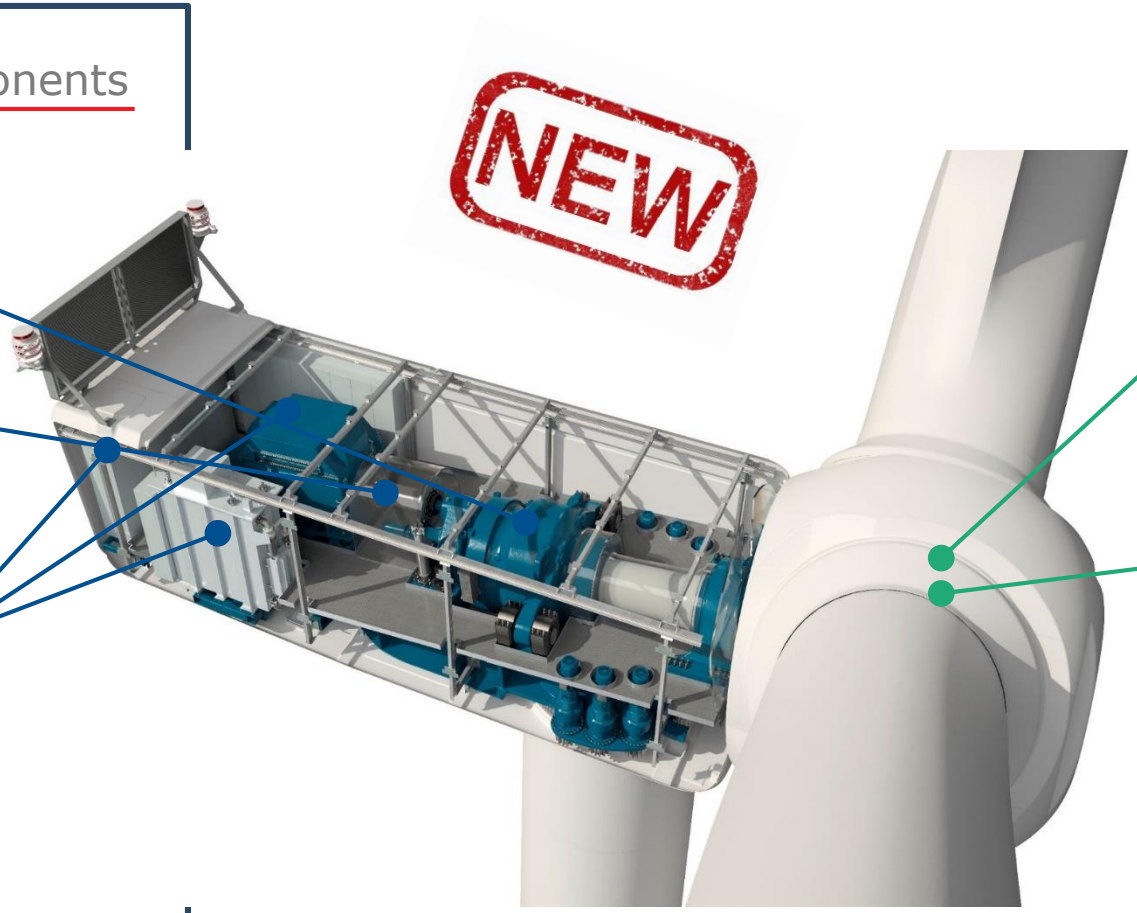
N155/5.X

Utilized Delta4000 Components

New gearbox & shrink disc
- Higher nominal torque

Adapted coupling
- Higher nominal torque

Upgraded power transmission system
- Higher rating 5.7 MW
- Increased grid voltage 750V



Modified Components

Reinforced pitch plate & hub minor changes

Site-specific: reinforced pitch bearing

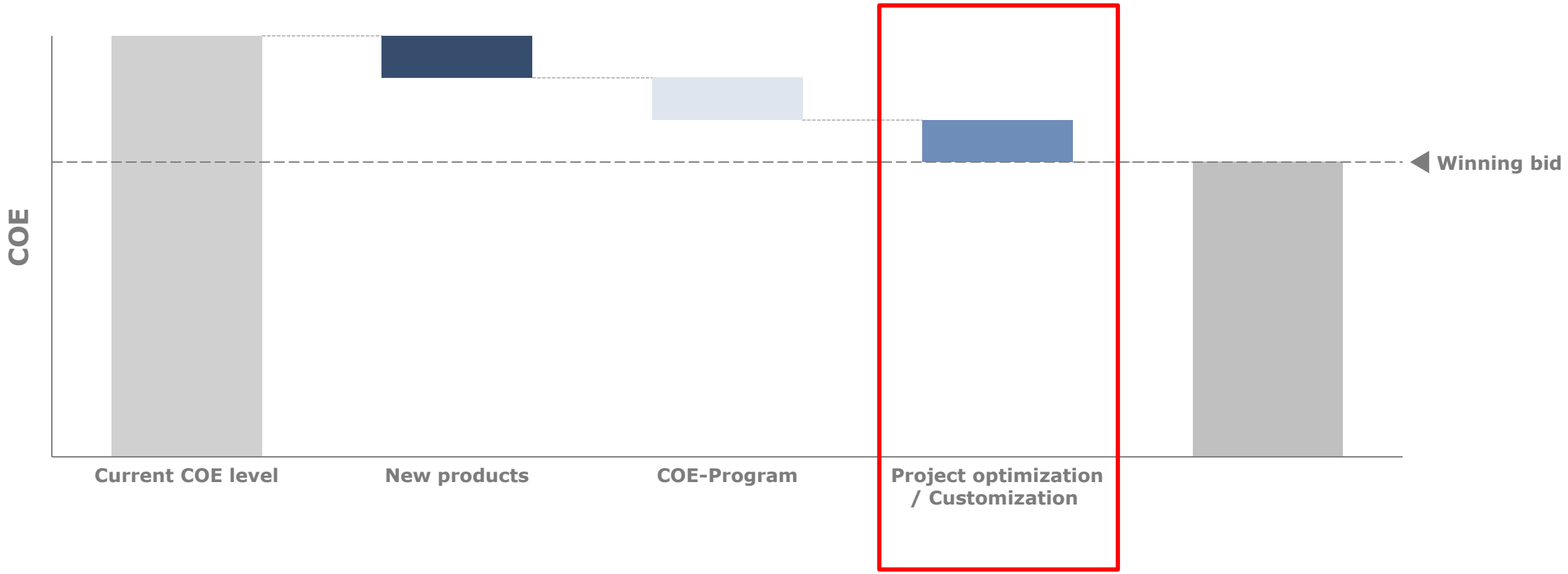
N149/5.X & N163/5.X components

* Key aspects highlighted—additional details in Initial Turbine Design Data form

Agenda

- N149/4.x/5.x
- N163/5.x
- N155/4.x
- **Project Optimization**

3-pillar product strategy to optimize COE



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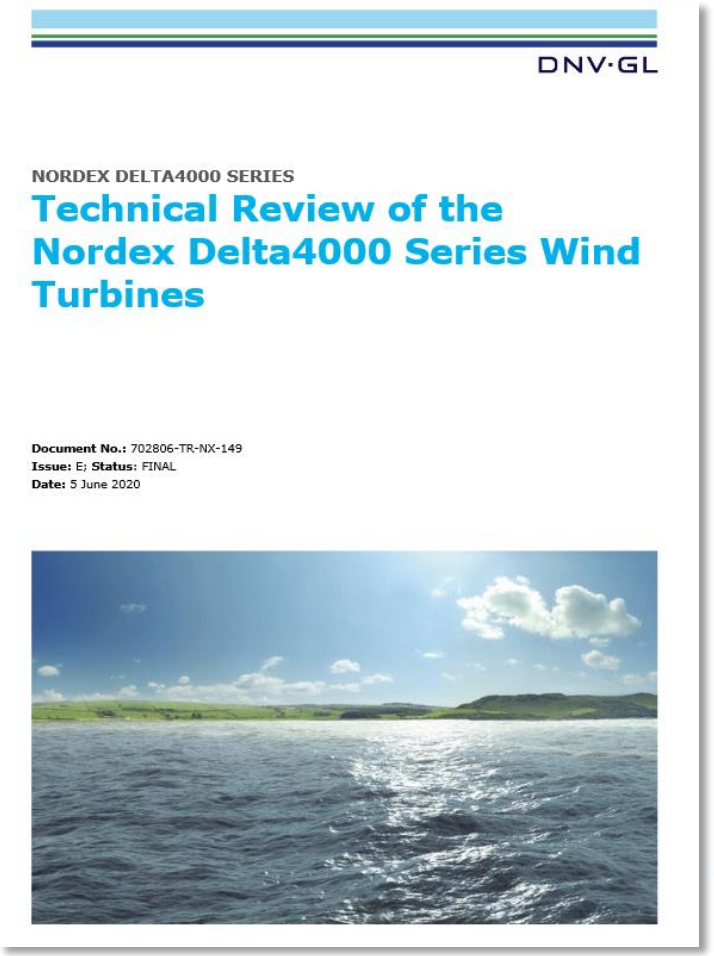
Nordex Technology Revision - IE Engagement in the US



- Up to date Technical Review covering N149/4.X, N149/5.X, and N155/4.X (N163 details pending)
- Provided to main lenders

- Early engagement with Delta4000 including prototype climb and engineering deep dive in Hamburg
- Currently working on Technical Review report based on further due diligence
- Nordex undertaking Power Curve Prediction Method Verification (PCPMV) study to improve power curve loss factor assumption—nearly complete

Wind Turbine Assessment Experience

Reference Standards

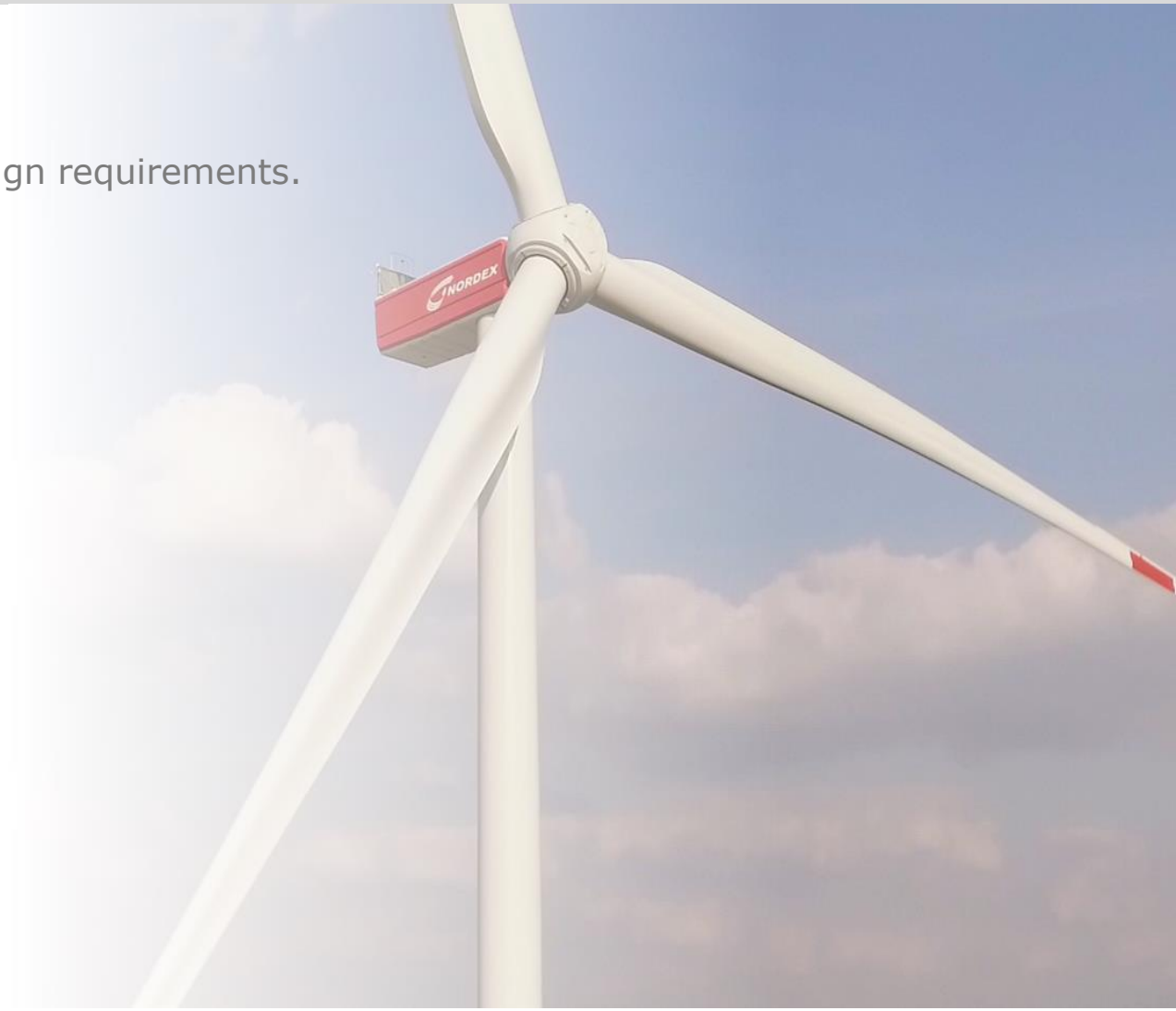
- Ref. 61400-1: Wind energy generation systems - Part 1: Design requirements.
- Steel Tower Structural Verification:

  61400-1.

  Eurocode 3: Design of steel structures.
- Concrete Tower Structural Verification:

  61400-1.

  Eurocode 2: Design of concrete structures.



Grid Code

Reference Standard

CREG 060 de 2019: Código de Red y Código de Conexión

Verification Approach

Requirements verified at WTG LV terminals.
Requirements at WF POI/PCC verified as a total.

Grid Code Tests

Defined in CREG 060 de 2019 and its associated Agreements (“Acuerdos”):

- Acuerdo 1223: verification of voltage control functions.
- Acuerdo 1224: verification of active power/frequency control.
- Acuerdo 1225: verification of PQ curve.

Seismic Assessment

Reference Standard

NSR-10: Reglamento Colombiano de Construcción Sismo Resistente

Calculation Approach

Modal Superposition Method calculation approach for a given design spectrum.

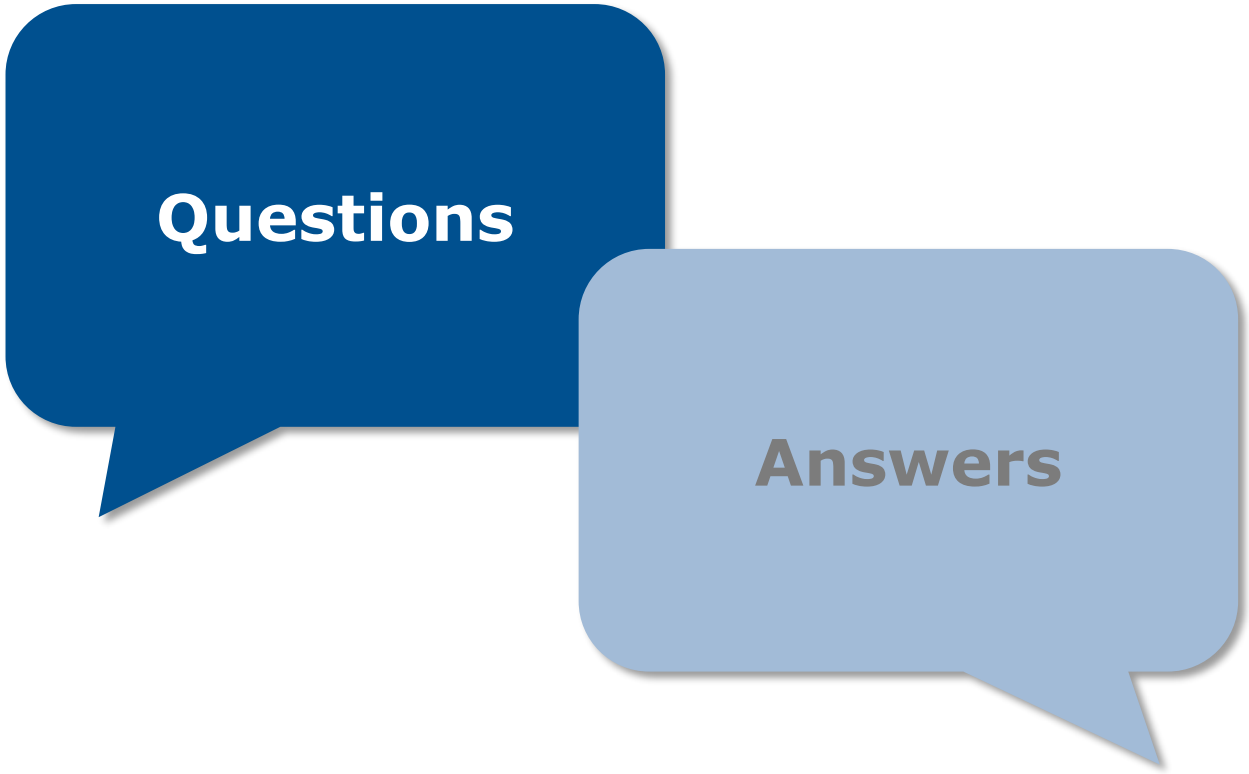
Aeroelastic calculation approach (Alaska Wind, Bladed depending on the platform) for a given operational conditions (idling, normal operation, emergency stop).

Seismic Certification Scope

Main Structural components are included in the certification:

- Tower
- Anchor Cage

Your questions



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