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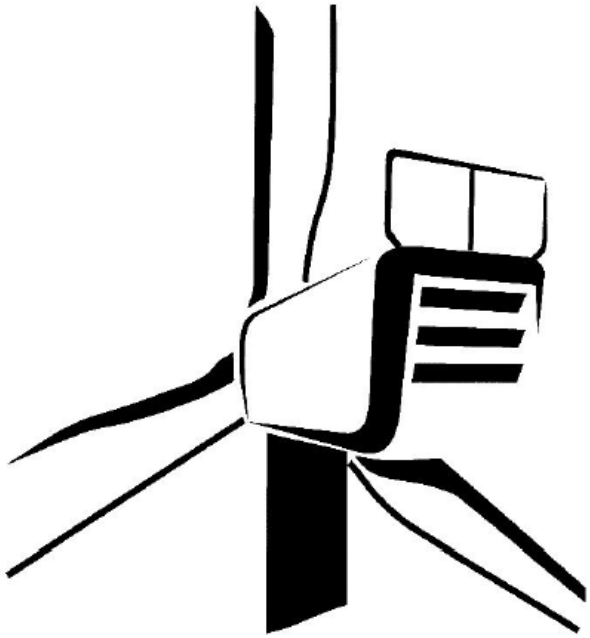
NORDEX REQUIREMENTS ON LIDAR TI FOR SITE SUITABILITY ASSESSMENT		Page: **1 / 11**



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Validity

Product series / Turbine type	**Product**
K08 Delta	N117/3000 N117/3600 N131/3000 N131/3300 N131/3600 N131/3900
Delta4000	N133/4.X N149/4.X N149/5.X N163/5.X N163/6.X N175/6.X

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1 General

1.1 Purpose and Content

This report provides a consolidated statement on Nordex's approach to the use of light detecting and ranging (LiDAR) data in the context of site suitability assessments for wind projects. It outlines the principles, quality requirements, and validation steps Nordex applies when evaluating LiDAR measurements, with a focus on ensuring data integrity, traceability, and compliance with industry standards. Furthermore, the document defines the specific information, documentation, and measurement conditions Nordex requires in order to conduct a robust site assessment based on stand-alone LiDAR data. The aim is to provide transparency on Nordex's methodology, establish clear expectations regarding LiDAR data deliveries, and ensure consistent, high-quality inputs for subsequent wind resource and turbine suitability analyses.

1.2 Target group

This document is intended for project developers, LiDAR suppliers and other customers.

1.3 Signs and symbols used

Sign/ symbol	Meaning
✓	Prerequisite
➢	Action with no specific order
1 2	Action with multiple steps Pay attention to the specific order!
↳	Result of the actions
•	List with no specific order
–	Subitem to actions or lists
	Additional information, notes and hints
	Reference to information in other documents
	Cybersecurity risk note

1.4 Abbreviations

Abbreviation	Designation	Description
-	Collocated measurements	Measurements of wind data with LiDAR and mast at the same site and same period.
LiDAR	Light detecting and ranging	-
MT	Maintenance teams	-
RSD	Remote sensing device (here LiDAR only)	-
TI	Turbulence intensity	-

1.5 Referenced documents

Title
IEC61400-1 Ed 4.1, Wind energy generation systems – Part 1: Design requirements
IEC61400-15-1 Ed 1, Wind energy generation systems - Part 15-1: Site suitability input conditions for wind power plants
IEC61400-50-2, Wind energy generation systems - Part 50-2: Wind measurement - Application of ground-mounted remote sensing technology

2 Sufficient data for a site assessment

2.1 Data availability

2.1.1 Basic requirements

IEC61400-1 Ed 4.1, Wind energy generation systems – Part 1: Design requirements

The requirements regarding measurement setup and data evaluation as stated in IEC61400-1 Ed. 4, sections 11.3.3 and 11.3.4, need to be fulfilled.

2.1.2 Measurement of data quality

The LiDAR specific requirements for ensuring sufficient quality of the measurements need to be fulfilled. These requirements are issued by the LiDAR manufacturer.

2.1.3 Availability

At least one complete year (12 consecutive months) with a minimum data availability of 85 % is required.

2.2 Terrain

Terrain complexity impacts the correction of the LiDAR signals. In complex terrain, a meaningful correction might not be possible. Therefore, site complexity needs to be assessed by Nordex and use of LiDAR data at such sites might not be feasible.

2.3 Reporting

IEC61400-15-1 Ed 1, Wind energy generation systems - Part 15-1: Site suitability input conditions for wind power plants

In general, the reporting should fulfil the requirements listed in IEC61400-15 Annex B: Turbine suitability input reporting.

2.3.1 Installation report

The installation report for the LiDAR measurement campaign needs to be provided to Nordex. It must at least contain the following information:

- Specific type of installed and used remote sensing device (RSD)
  - including serial number
- Measurement period
- Coordinates of the RSD
- Northing set up and height offset

2.3.2 Reports according to IEC61400-50-2

IEC61400-50-2, Wind energy generation systems - Part 50-2: Wind measurement - Application of ground-mounted remote sensing technology

- Calibration report
- Verification report
- Classification report

2.3.3 Additional mandatory information

- Data availability
- Data quality check
- Uncertainties

3 Pros and cons of LiDAR versus mast

A stand-alone LiDAR measurement campaign inherently carries higher uncertainty than a conventional met mast solution. This is primarily driven by differences in measured turbulence intensity (TI) between LiDAR and mast-based instruments. While established correction methods significantly reduce these differences, a small residual deviation typically remains.

To account for this conservatively, an additional margin on the measured TI may be required in some cases. In other situations, LiDAR tends to report higher TI values than cup anemometers. As a result, LiDAR-based TI inputs can lead to higher calculated loads and reduced lifetime estimates in site suitability assessments compared with mast-based measurements.

This effect should be viewed in the context of the overall project benefits: LiDAR offers lower installation effort, faster deployment, and greater flexibility. The potential conservatism in results therefore can be seen a reasonable trade-off for the efficiency and cost advantages of a mast-free measurement approach.

3.1 LiDAR in addition to a mast

Advantages compared to mast only:

- Measuring up to the upper tip height allows for a significantly more accurate shear estimate
- Mast-based calibration enables a significant reduction in LiDAR TI uncertainty

Disadvantages compared to mast only:

- More effort
- Higher cost

3.2 Stand-alone LiDAR

Advantages compared to mast only:

- Measuring up to the upper tip height allows for a significantly more accurate shear estimate
- No anemometer icing issues
- Less effort
- Lower cost

Disadvantages compared to mast only:

- Uncertainty in turbulence intensity is supposed to negatively impact turbine lifetime or require curtailments
- Sometimes lower availability due to clean air or other LiDAR specific issues

4 Standardization committees

4.1 IEA Task 52

Nordex participates in this IEA Task with a leading role in WP 1 LiDAR TI. Nordex contributed by providing suitable KPIs and acceptance criteria for checking the quality of LiDAR TI. The final report of the current phase will be issued at the end of May 2026 and will contain all relevant details.

4.2 IEC61400

Nordex participates in the maintenance teams (MT) of the relevant parts of this series, which are -1, -12, -15 and -50.

4.3 KPIs and acceptance criteria

Nordex collaborates closely with Vaisala and ZX on the development of their correction algorithms [1; 2]. In the context of these collaborations Nordex performed extensive checks of ZX and Windcube corrections to collocated measurements by applying their KPIs and acceptance criteria. These criteria are part of Nordex contributions to IEA Task 52, and they will most likely be entered into the IEC61400 series. This is the basis for the correction of LiDAR data from new sites.

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[1] "Repeatability, reproducibility, and uncertainty estimation of a new lidar turbulence algorithm in varying wind conditions around the world", Poster to be published at WindEurope workshop Madrid, June 11th – 12th 2026, Nordex, Pavana GmbH, RWE, Vaisala

[2] "Lidar for site suitability assessment", Presentation at Wind Lidar Masterclass hosted by ZX Lidars, Berlin, 5.2.2026, Nordex Energy

5 Accepted devices

Nordex can only accept the devices which have been tested by Nordex including corresponding correction algorithms. They are listed in the following.

5.1 Windcube

Vaisala developed their own correction algorithm called Pure-TI [3]. It is only applicable to Windcube V2.0, 2.1, and 2.1 XP. Currently 1 s data in RTD format is needed for the application. For this reason, Nordex can only accept LiDAR data from these specific versions.

The algorithm was not yet tested in very complex terrain. Nordex needs to decide if the terrain is too complex, see section 2.2.

5.2 ZX LiDARs

ZX developed their own correction algorithm called Metice [4]. Currently Wind10 files are necessary for its application.

It has been checked by Nordex, and it is applicable to flat, hilly and slightly complex terrain. Nordex needs to decide if the terrain is too complex, see section 2.2.

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[3] "Untangling turbulence profiles with new lidar algorithms", October 30, 2025, Andrew Black, Hazem Rabhi, ACP Peak conference, Austin Texas

[4] "Introducing METICE - Multi-Site Ensemble Turbulence Intensity Cup Equivalent", 07/11/2025, ZX Lidars