

Wind energy generation systems - Part 12-6:  
Measurement based nacelle transfer function of  
electricity producing wind turbines

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

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English Version

Wind energy generation systems - Part 12-6: Measurement  
based nacelle transfer function of electricity producing wind  
turbines  
(IEC 61400-12-6:2022)

Systèmes de génération d'énergie éolienne - Partie 12-6:  
Fonction de transfert de la nacelle fondée sur le mesurage  
des éoliennes de production d'électricité  
(IEC 61400-12-6:2022)

Windenergieanlagen - Teil 12-6: Messbasierte  
Gondelübertragungsfunktion von stromerzeugenden  
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## European foreword

The text of document 88/826/CDV, future edition 1 of IEC 61400-12-6, prepared by IEC/TC 88 "Wind energy generation systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61400-12-6:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2023-07-04
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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Wind energy generation systems –  
Part 12-6: Measurement based nacelle transfer function of electricity producing  
wind turbines**

**Systèmes de génération d'énergie éolienne –  
Partie 12-6: Fonction de transfert de la nacelle fondée sur le mesurage des  
éoliennes de production d'électricité**



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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Wind energy generation systems –  
Part 12-6: Measurement based nacelle transfer function of electricity producing  
wind turbines**

**Systèmes de génération d'énergie éolienne –  
Partie 12-6: Fonction de transfert de la nacelle fondée sur le mesurage des  
éoliennes de production d'électricité**

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**WIND ENERGY GENERATION SYSTEMS –****Part 12-6: Measurement based nacelle transfer  
function of electricity producing wind turbines**

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This first edition of IEC 61400-12-6 is part of a structural revision that cancels and replaces the performance standards IEC 61400-12-1:2017 and IEC 61400-12-2:2013. The structural revision contains no technical changes with respect to IEC 61400-12-1:2017 and IEC 61400-12-2:2013, but the parts that relate to wind measurements, measurement of site calibration and assessment of obstacle and terrain have been extracted into separate standards.

The purpose of the re-structure was to allow the future management and revision of the power performance standards to be carried out more efficiently in terms of time and cost and to provide a more logical division of the wind measurement requirements into a series of separate standards which could be referred to by other use case standards in the IEC 61400 series and subsequently maintained and developed by appropriate experts.

The text of this International Standard is based on the following documents:

Draft	Report on voting
88/826/CDV	88/871/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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## INTRODUCTION

The IEC 61400-12 series consists of the following parts, under the general title Wind energy generation systems:

IEC 61400-12:	<i>Power performance measurements of electricity producing wind turbines – Overview</i>
IEC 61400-12-1:	<i>Power performance measurement of electricity producing wind turbines</i>
IEC 61400-12-2:	<i>Power performance of electricity producing wind turbines based on nacelle anemometry</i>
IEC 61400-12-3:	<i>Power performance – Measurement based site calibration</i>
IEC 61400-12-4:	<i>Numerical site calibration</i>
IEC 61400-12-5:	<i>Power performance – Assessment of obstacles and terrain</i>
IEC 61400-12-6:	<i>Measurement based nacelle transfer function of electricity producing wind turbines</i>

The purpose of this document is to provide a uniform methodology of measurement, analysis, and reporting for the determination of a nacelle transfer function of electricity producing wind turbines utilising nacelle-anemometry methods. This document is intended to be applied only to horizontal axis wind turbines of sufficient size that the nacelle-mounted anemometer does not significantly affect the flow through the turbine's rotor and around the nacelle and hence does not affect the wind turbine's performance. The intent of this document is that the methods presented herein be utilised when applying the methodology described in IEC 61400-12-2 to determine the power performance of individual wind turbines. This will ensure that the results are as consistent, accurate, and reproducible as possible within the current state of the art for instrumentation and measurement techniques.

This procedure describes how to characterise a wind turbine's nacelle transfer function in terms of wind speeds measured on a meteorological mast as well as a wind speed measured on the hub or nacelle of a wind turbine. The anemometer that is placed on the turbine is measuring a wind speed that is strongly affected by the test turbine's rotor. This procedure includes methods for determining and applying appropriate corrections for this interference. Such a correction is termed a nacelle transfer function which relates the wind speed measured on the turbine to a free-stream wind speed as measured on a meteorological mast. The procedure also provides guidance on determination of measurement uncertainty including assessment of uncertainty sources and recommendations for combining them into uncertainties.

Even when anemometers are carefully calibrated in a quality wind tunnel, fluctuations in magnitude and direction of the wind vector can cause different anemometers to perform differently in the field. Further, the flow conditions close to a turbine nacelle are complex and variable. Therefore, special care should be taken in the selection and installation of the anemometer. These issues are addressed in this document.

This document will benefit those parties interested in power performance testing of wind turbines using IEC 61400-12-2 as well as parties involved in the installation, planning and execution of such tests. When and where appropriate, the technically accurate measurement and analysis techniques recommended in this document should be applied by all parties to ensure that continuing development and operation of wind turbines is carried out in an atmosphere of consistent and accurate communication relative to environmental concerns. This document presents measurement and reporting procedures expected to provide accurate results that can be replicated by others.

Meanwhile, a user of this document should be aware of differences that arise from large variations in wind shear and turbulence intensity, and from the chosen criteria for data selection. Therefore, a user should consider the influence of these differences and the data selection criteria in relation to the purpose of the test before engaging in nacelle transfer function measurements.

## WIND ENERGY GENERATION SYSTEMS –

### Part 12-6: Measurement based nacelle transfer function of electricity producing wind turbines

#### 1 Scope

This part of IEC 61400-12 specifies a procedure for measuring the nacelle transfer function of a single electricity-producing, horizontal axis wind turbine, which is not considered to be a small wind turbine in accordance with IEC 61400-2. It is expected that this document be used when a valid nacelle transfer function is needed to execute a power performance measurement according to IEC 61400-12-2.

A wind speed measured on the nacelle or hub of a wind turbine is affected by the turbine rotor (i.e. speeded up or slowed down wind speed). In IEC 61400-12-1, an anemometer is located on a meteorological tower that is located between two and four rotor diameters upwind of the test turbine. This location allows direct measurement of the "free" wind with minimum interference from the test turbine's rotor. In the procedure of this document, the anemometer is located on or near the test turbine's nacelle. In this location, the anemometer is measuring a wind speed that is strongly affected by the test turbine's rotor and the nacelle. The procedure in this document includes methods for determining and applying appropriate corrections for this interference. However, note that these corrections inherently increase the measurement uncertainty compared to a properly configured test conducted in accordance with IEC 61400-12-1.

This document specifies how to characterise a wind turbine's nacelle transfer function. The nacelle transfer function is determined by collecting simultaneous measurements of nacelle-measured wind speed and free stream wind speed (as measured on a meteorological mast) for a period that is long enough to establish a statistically significant database over a range of wind speeds and under varying wind and atmospheric conditions. The procedure also provides guidance on determination of measurement uncertainty including assessment of uncertainty sources and recommendations for combining them.

#### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60688, *Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals*

IEC 61400-12-1, *Wind energy generation systems – Part 12-1: Power performance measurement of electricity producing wind turbines*

IEC 61400-12-2:2022, *Wind energy generation systems – Part 12-2: Power performance of electricity producing wind turbines based on nacelle anemometry*

IEC 61400-12-3, *Wind energy generation systems – Part 12-3: Power performance – Measurement based site calibration*

IEC 61400-12-5:2022, *Wind energy generation systems – Part 12-5: Power performance – Assessment of obstacles and terrain*

IEC 61400-50-1, *Wind energy generation systems – Part 50-1: Wind measurement – Application of meteorological mast, nacelle and spinner mounted instruments*

ISO/IEC GUIDE 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
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#### 3.1

##### **accuracy**

closeness of the agreement between the result of a measurement and a true value of the measurand

#### 3.2

##### **complex terrain**

terrain surrounding the test site that features significant variations in topography and terrain obstacles that may cause flow distortion

#### 3.3

##### **data set**

collection of data sampled over a contiguous period

#### 3.4

##### **documentation**

any information regarding the test which is kept in files or data, or both, but which is not necessarily presented in the final report

#### 3.5

##### **flow distortion**

change in air flow caused by obstacles, topographical variations, turbine's rotor, turbine's nacelle or other wind turbines that results in a significant deviation of the measured wind speed from the free stream wind speed

#### 3.6

##### **free stream wind speed**

horizontal wind speed measured upstream of the rotor of the wind turbine generator that is unaffected by rotor aerodynamics

#### 3.7

##### **turbulence intensity**

ratio of the wind speed standard deviation to the mean wind speed, determined from the same set of measured data samples of horizontal wind speed, and taken over a specific period of time

#### 3.8

##### **hub height**

<wind turbine> height of the centre of the swept area of the wind turbine rotor above the ground level at the tower base