



**NSAI**  
Standards

Irish Standard  
I.S. EN 61400-12-2:2013

Wind turbines -- Part 12-2: Power performance of electricity-producing wind turbines based on nacelle anemometry (IEC 61400-12-2:2013 (EQV))

## I.S. EN 61400-12-2:2013

*Incorporating amendments/corrigenda issued since publication:*

The National Standards Authority of Ireland (NSAI) produces the following categories of formal documents:

I.S. xxx: Irish Standard – national specification based on the consensus of an expert panel and subject to public consultation.

S.R. xxx: Standard Recommendation - recommendation based on the consensus of an expert panel and subject to public consultation.

SWiFT xxx: A rapidly developed recommendatory document based on the consensus of the participants of an NSAI workshop.

<i>This document replaces:</i>	<i>This document is based on:</i> EN 61400-12-2:2013	<i>Published:</i> 19 July, 2013
This document was published under the authority of the NSAI and comes into effect on:  31 July, 2013		ICS number: 27.180
<b>NSAI</b> 1 Swift Square, Northwood, Santry Dublin 9	T +353 1 807 3800 F +353 1 807 3838 E standards@nsai.ie  W NSAI.ie	<b>Sales:</b> T +353 1 857 6730 F +353 1 857 6729 W standards.ie
Údarás um Chaighdeáin Náisiúnta na hÉireann		

EUROPEAN STANDARD

**EN 61400-12-2**

NORME EUROPÉENNE

EUROPÄISCHE NORM

July 2013

---

ICS 27.180

English version

**Wind turbines -  
Part 12-2: Power performance of electricity-producing wind turbines  
based on nacelle anemometry  
(IEC 61400-12-2:2013)**

Eoliennes -  
Partie 12-2: Performance de puissance  
des éoliennes de production d'électricité  
basée sur l'anémométrie de nacelle  
(CEI 61400-12-2:2013)

Windenergieanlagen -  
Teil 12-2: Messung des  
Leistungsverhaltens von Elektrizität  
erzeugenden Windturbinen basierend auf  
Gondelanemometrie  
(IEC 61400-12-2:2013)

This European Standard was approved by CENELEC on 2013-05-02. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

**CENELEC**

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Management Centre: Avenue Marnix 17, B - 1000 Brussels**

---

## **Foreword**

The text of document 88/442/FDIS, future edition 1 of IEC 61400-12-2, prepared by IEC/TC 88 "Wind turbines" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61400-12-2:2013.

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) 2014-02-02
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2016-05-02

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

## **Endorsement notice**

The text of the International Standard IEC 61400-12-2:2013 was approved by CENELEC as a European Standard without any modification.

## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60688 + A1 (mod) + A2	1992 1997 2001	Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals	EN 60688 + A1 + A2	1992 1999 2001
IEC 61400-12-1	2005	Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines	EN 61400-12-1	2006
IEC 61869-2	-	Instrument transformers - Part 2: Additional requirements for current transformers	EN 61869-2	-
IEC 61869-3	-	Instrument transformers - Part 3: Additional requirements for inductive voltage transformers	EN 61869-3	-
ISO/IEC 17025	-	General requirements for the competence of testing and calibration laboratories	EN ISO/IEC 17025	-
ISO/IEC Guide 98-3	-	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-
ISO 2533	-	Standard atmosphere	-	-

*This page is intentionally left BLANK.*

## CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references .....	8
3 Terms and definitions .....	9
4 Symbols and units .....	13
5 Overview of test method .....	16
6 Preparation for performance test .....	19
6.1 General .....	19
6.2 Wind turbine.....	19
6.3 Test site .....	19
6.3.1 Terrain classification.....	20
6.3.2 RIX indices .....	20
6.3.3 Average slope .....	21
6.3.4 Determine terrain class.....	21
6.3.5 Ridge formations .....	22
6.4 Nacelle wind speed transfer function .....	23
6.5 Test plan .....	23
7 Test equipment.....	23
7.1 Electric power .....	23
7.2 Wind speed .....	24
7.3 Wind direction .....	24
7.3.1 Nacelle yaw position sensor .....	24
7.3.2 Nacelle wind direction sensor .....	25
7.3.3 Wind direction .....	25
7.4 Air density .....	25
7.5 Rotor speed .....	26
7.6 Pitch angle .....	26
7.7 Wind turbine status .....	26
7.8 Data acquisition.....	26
8 Measurement procedure.....	27
8.1 General .....	27
8.2 Wind turbine operation .....	27
8.3 Data system(s) synchronisation.....	27
8.4 Data collection .....	28
8.5 Data quality check.....	28
8.6 Data rejection.....	29
8.7 Data correction.....	30
8.8 Database.....	30
9 Derived results .....	31
9.1 Data normalisation .....	31
9.1.1 Density correction.....	31
9.2 Determination of measured power curve.....	32
9.3 Annual energy production (AEP).....	32
9.4 Power coefficient.....	33
9.5 Uncertainty analysis .....	34

10 Reporting format.....	34
Annex A (informative) Nacelle instrument mounting .....	42
Annex B (normative) Measurement sector procedure .....	44
Annex C (normative) Nacelle wind speed transfer function validity procedure .....	49
Annex D (normative) Nacelle wind speed transfer function measurement procedure .....	51
Annex E (normative) Evaluation of uncertainty in measurement .....	58
Annex F (normative) Theoretical basis for determining the uncertainty of measurement using the method of bins .....	62
Annex G (normative) NTF/NPC uncertainty estimates and calculation.....	70
Annex H (normative) Allowable anemometry instrument types .....	83
Annex I (informative) Results and uncertainty considerations.....	85
Annex J (informative) Example multi-turbine NTF/NPC uncertainty calculation.....	90
Annex K (informative) Organisation of test, safety and communication.....	98
Annex L (informative) NPC and NTF flowchart .....	100
Figure 1 – Procedural overview.....	18
Figure 2 – Presentation of example data: transfer function resulting from Annex D .....	37
Figure 3 – Presentation of example data: nacelle power performance test scatter plots .....	38
Figure 4 – Presentation of example data: binned power curve with uncertainty bands.....	38
Figure 5 – Presentation of example data: measured power curve and $C_p$ curve .....	39
Figure A.1 – Mounting of anemometer on top of nacelle.....	43
Figure B.1 – Sectors to exclude due to wakes of neighbouring and operating wind turbines and significant obstacles .....	46
Figure B.2 – Example of the result of a sector self-consistency check.....	48
Figure D.1 – Nacelle transfer function for wind speed .....	56
Figure J.1 – Impact of multiple turbine testing on measurement uncertainty.....	97
Figure J.2 – Impact of multiple turbine testing on sampling uncertainty .....	97
Figure L.1 – NPC flowchart .....	100
Figure L.2 – NTF flowchart.....	101
Table 1 – Slope terrain classification .....	21
Table 2 – RIX terrain classification.....	22
Table 3 – Final terrain class.....	22
Table 4 – Maximum ridge step effects on terrain class .....	22
Table 5 – Example of a measured power curve.....	40
Table 6 – Example of estimated annual energy production.....	41
Table B.1 – Obstacle requirements: relevance of obstacles .....	45
Table D.1 – Example of presentation of a measured power curve based on data from the meteorological mast, for consistency check .....	57
Table E.1 – Uncertainty components in nacelle transfer function evaluation.....	59
Table E.2 – Uncertainty components in nacelle power curve evaluation .....	60
Table E.3 – Uncertainty components in nacelle based absolute wind direction .....	61
Table F.1 – Example cancellation sources .....	64
Table F.2 – List of category A and B uncertainties for NTF .....	64



Table F.3 – List of category A and B uncertainties for NPC .....	66
Table F.4 – Expanded uncertainties .....	69
Table G.1 – Estimates for uncertainty components from site calibration .....	70
Table G.2 – Estimates for uncertainty components from NTF measurement .....	72
Table G.3 – Estimates for uncertainty components from NPC measurement .....	74
Table G.4 – Estimates for $u_{V5,i}$ for NPC terrain class .....	76
Table G.5 – Estimates for uncertainty components for wind direction .....	77
Table G.6 – Estimates for contribution factors for site calibration .....	78
Table G.7 – Estimates for contribution factors for NTF .....	79
Table G.8 – Estimates for contribution factors for NPC .....	80
Table J.1 – List of correlated uncertainty components .....	91
Table J.2 – Sample AEP and uncertainty data from 3 turbines .....	93
Table J.3 – Component uncertainty contribution to AEP uncertainty on turbine 1 .....	93
Table J.4 – Combination of uncertainty components across turbines .....	95

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## WIND TURBINES –

**Part 12-2: Power performance of electricity-producing  
wind turbines based on nacelle anemometry**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61400-12-2 has been prepared by IEC technical committee 88: Wind turbines.

The text of this standard is based on the following documents:

FDIS	Report on voting
88/442/FDIS	88/445/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61400 series, published under the general title *Wind turbines*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## INTRODUCTION

The purpose of this part of IEC 61400-12 is to provide a uniform methodology of measurement, analysis, and reporting of power performance characteristics for individual electricity-producing wind turbines utilising nacelle-anemometry methods. This standard 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 standard is that the methods presented herein be utilised when the requirements set forth in IEC 61400-12-1:2005 are not feasible. 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 power performance characteristics in terms of a measured power curve and the estimated annual energy production (AEP) based on nacelle-anemometry. In this procedure, the anemometer is located on or near the test turbine's nacelle. In this location, the anemometer is measuring 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. However, it must be noted that these corrections inherently increase the measurement uncertainty compared to a properly-configured test conducted in accordance with IEC 61400-12-1:2005. The procedure also provides guidance on determination of measurement uncertainty including assessment of uncertainty sources and recommendations for combining them into uncertainties in reported power and AEP.

A key element of power performance testing is the measurement of wind speed. 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 standard.

The standard will benefit those parties involved in the manufacture, installation, planning and permitting, operation, utilisation and regulation of wind turbines. When appropriate, the technically accurate measurement and analysis techniques recommended in this standard 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 standard presents measurement and reporting procedures expected to provide accurate results that can be replicated by others.

Meanwhile, a user of the standard 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 contracting power performance measurements.

## WIND TURBINES –

### Part 12-2: Power performance of electricity-producing wind turbines based on nacelle anemometry

#### 1 Scope

This part of IEC 61400-12 specifies a procedure for verifying the power performance characteristics of a single electricity-producing, horizontal axis wind turbine, which is not considered to be a small wind turbine per IEC 61400-2. It is expected that this standard will be used when the specific operational or contractual specifications may not comply with the requirements set forth in IEC 61400-12-1:2005. The procedure can be used for power performance evaluation of specific turbines at specific locations, but equally the methodology can be used to make generic comparisons between different turbine models or different turbine settings.

The wind turbine power performance characterised by the measured power curve and the estimated AEP based on nacelle-measured wind speed will be affected by the turbine rotor (i.e. speeded up or slowed down wind speed). The nacelle-measured wind speed shall be corrected for this flow distortion effect. Procedures for determining that correction will be included in the methodology. In IEC 61400-12-1:2005, 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 this IEC 61400-12-2 procedure, the anemometer is located on or near the test turbine's nacelle. In this location, the anemometer is measuring wind speed that is strongly affected by the test turbine's rotor and the nacelle. This procedure includes methods for determining and applying appropriate corrections for this interference. However, it should be noted that these corrections inherently increase the measurement uncertainty compared to a properly-configured test conducted in accordance with IEC 61400-12-1:2005.

This IEC 61400-12-2 standard describes how to characterise a wind turbine's power performance in terms of a measured power curve and the estimated AEP. The measured power curve is determined by collecting simultaneous measurements of nacelle-measured wind speed and power output 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. In order to accurately measure the power curve, the nacelle-measured wind speed is adjusted using a transfer function to estimate the free stream wind speed. The procedure to measure and validate such a transfer function is presented herein. The AEP is calculated by applying the measured power curve to the reference wind speed frequency distributions, assuming 100 % availability. The procedure also provides guidance on determination of measurement uncertainty including assessment of uncertainty sources and recommendations for combining them into uncertainties in reported power and AEP.

#### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC/TR 60688, *Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals*

Amendment 1 (1997)

Amendment 2 (2001)

This is a free preview. Purchase the entire publication at the link below:

[Product Page](#)

- 
- [Looking for additional Standards? Visit Intertek Inform Infostore](#)
  - [Learn about LexConnect, All Jurisdictions, Standards referenced in Australian legislation](#)
-