



BSI Standards Publication

Wind energy generation systems

Part 31: Siting risk assessment

National foreword

This Published Document is the UK implementation of IEC TS 61400-31:2023.

The UK participation in its preparation was entrusted to Technical Committee PEL/88, Wind turbines.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

This publication is not to be regarded as a British Standard.

© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 539 16535 7

ICS 27.180

Compliance with a Published Document cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2023.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------



IEC TS 61400-31

Edition 1.0 2023-11

TECHNICAL SPECIFICATION



Wind energy generation systems – Part 31: Siting risk assessment

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.180

ISBN 978-2-8322-7744-7

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	8
3 Terms, definitions and symbols.....	8
3.1 Terms and definitions.....	8
3.2 Symbols used in this document.....	12
3.3 Abbreviated terms.....	13
4 Risk assessment process	13
4.1 Overview.....	13
4.2 Documentation requirements in the risk assessment process.....	14
4.3 Involvement of stakeholders.....	14
5 Risk management throughout service life	15
5.1 Overview.....	15
5.2 Reviewing, documenting and reporting of the risk management process	15
6 Harm to people	16
6.1 Overview.....	16
6.2 Direct harm	16
6.3 Indirect harm.....	16
6.4 Domino effect	17
6.5 Consequences of impacts of objects	17
7 Risk assessment approaches and associated acceptance criteria.....	17
7.1 Risk assessment approaches.....	17
7.2 Risk acceptance criteria.....	19
7.3 Risk regions.....	20
7.4 Types of risk criteria	21
7.5 Prescriptive risk acceptance criteria.....	21
7.6 Qualitative risk acceptance criteria	22
7.7 Semi-quantitative risk acceptance criteria	22
7.8 Quantitative risk acceptance criteria	23
7.8.1 General	23
7.8.2 Quantitative risk criteria for individuals	24
7.8.3 Quantitative societal risk criteria	26
8 Hazard identification.....	30
8.1 General.....	30
8.2 General principles of hazard identification.....	30
8.3 Wind turbine failure modes	30
8.3.1 General	30
8.3.2 Tower collapse	30
8.3.3 Shedding of hub or nacelle	30
8.3.4 Rotor blade failure	31
8.4 Ice fall and ice throw	31
8.5 Fire.....	32
8.6 Occupancy.....	32
8.7 Project relevant hazards	33
9 Estimation of the risk.....	33
9.1 General.....	33

9.2	Wind turbine failures – tower collapse, shedding of hub or nacelle and rotor blade failure	33
9.2.1	General	33
9.2.2	Input information.....	34
9.2.3	Additional assumptions/models.....	34
9.2.4	Tower collapse	35
9.2.5	Shedding of hub or nacelle	35
9.2.6	Blade breakage	35
9.2.7	Summation of impact probabilities and risks	36
9.3	Ice fall and ice throw	36
9.3.1	Input information.....	36
9.3.2	Additional assumptions/models.....	37
9.3.3	Calculation of trajectories of ice pieces.....	37
9.4	Wind turbine fire	38
9.5	Calculation of the risk	38
9.5.1	General	38
9.5.2	Effective cross-section for people and cars.....	39
9.6	Analysis of domino effects	39
10	Risk evaluation	40
11	Risk treatment	40
11.1	General.....	40
11.2	Selection of risk reduction measures.....	40
11.3	Examples of risk reduction measures	40
11.4	Ice detection systems and rotor blade heating systems	41
12	Uncertainties in risk assessments.....	42
	Annex A (informative) Summary of failure frequencies published by the Dutch RIVM	44
	Annex B (informative) Overview of used risk criteria in different countries.....	45
	Annex C (informative) Introduction to trajectory models for blades and blade fragments	49
	Bibliography.....	54
	Figure 1 – Flow chart of the risk assessment process (Modified from ISO/IEC Guide 51 [3])	13
	Figure 2 – The risk assessment process	14
	Figure 3 – Flow chart of the selection of risk assessment methods with different levels of fidelity.....	19
	Figure 4 – Risk regions	20
	Figure 5 – Example tables for a semi-quantitative risk assessment	23
	Figure 6 – Combination of hazards and impacted persons.	27
	Figure 7 – Example of an f-N plot.....	28
	Figure 8 – Example of societal risk criteria.....	29
	Figure C.1 – Blade-fixed and inertial reference frames.....	50

Table 1 – Examples of risk acceptance criteria for different risk assessment approaches.....	21
Table 2 – Policy factor according to [11]	26
Table 3 – Examples for hazardous installations that could be affected by domino effects triggered by wind turbine failures.....	39
Table A.1 – Failure frequencies from [13] in units of failures per turbine and year.....	44
Table B.1 – Overview of used risk criteria in different countries	45

INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ENERGY GENERATION SYSTEMS –**Part 31: Siting risk assessment**

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC [had/had not] received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch> [and/or] www.iso.org/patents. [IEC/IEC and ISO] shall not be held responsible for identifying any or all such patent rights.

IEC TS 61400-31 has been prepared by subcommittee PT 61400-31: Wind energy generation systems – Part 31: Siting Risk Assessment, of IEC technical committee 88: Wind energy generation systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
88/936/DTS	88/956/RVDTS

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

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

The language used for the development of this Technical Specification 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. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

WIND ENERGY GENERATION SYSTEMS –

Part 31: Siting risk assessment

1 Scope

This part of IEC 61400, which is a Technical Specification, establishes a guideline for the assessment of the risks which a wind turbine may pose to the general public.

Incidents in wind farms causing harm to the general public are very rare events. However, there are requirements to cover this topic in the permitting procedures of several countries. This document aims to facilitate a uniform scope and a uniform use of methods in wind turbine risk assessments.

This document covers harm to the general public. It does not cover occupational exposure, e.g. of personnel involved in the operation and maintenance of the turbine, since occupational risks are usually dealt with in occupational health and safety regulations. The risk of damage to structures or other objects is also not part of this document unless such damage in turn poses a risk to the public.

Harm according to this document can be direct harm or indirect harm via damage to buildings or infrastructure, e.g. gas pipelines, nuclear facilities, dykes, rail infrastructure or roads.

This document covers risk due to internal or external causes, such as technical failures, human errors, extreme wind conditions, turbine icing, lightning strikes, earthquakes, flooding, landslides or fire. However, the specific cause of an incident (e.g. an incident such as a turbine collapse) is irrelevant to the assessment of the consequences. The only relevant factor is the expected probability of occurrence for the incident considered.

In terms of transmission of the hazard to the people affected, this document describes tower collapses, shedding of the nacelle, blade failures, falling or throwing of ice pieces and fire spread.

This document does not cover risks from visual distraction and environmental risk such as noise or shadow flicker.

Wind turbines may pose a hazard to aviation through incidents such as collisions with aircrafts or disturbance of air traffic control radar. These hazards are not covered in this document. In order to mitigate the hazard of aircrafts colliding with wind turbines, aviation lights are installed on wind turbines as covered in IEC 61400-29[1]¹.

Risks connected to terrorist attacks and other malicious actions are not covered by this document.

¹ Numbers in square brackets refer to the Bibliography.

This document covers only onshore wind turbines with a horizontal axis and a swept area greater than 200 m². Substations and other external structures are excluded. Other tall structures associated with a wind farm or wind turbine (e.g. temporary or permanent meteorological masts) also introduce risks related to their possible collapse or failure. Such structures are not covered by this document. Guidance on the risks can be inferred from the reliability classes of the tall structure as determined with reference to EN 1993 Eurocode 3: Design of steel structures [2], including the national annexes where local design requirements are specified.

As to the extent of the harm, this document is limited to the immediate, potentially lethal, physical harm. Non-lethal harm is indirectly covered as described in Clause 6.

This document describes risks during operation of the wind turbine including maintenance, idling and standstill. It does not describe risks during construction, civil works, crane operations, assembly or decommissioning.

Risks according to this document are assessed by prescriptive and/or risk-based methods.

In evaluating risk, the risk is first expressed as a localized risk. Along with the probability of people being present at the location, a risk of lethal harm per year will be used to quantify the risk of harm to people.

This document covers risk reduction measures that might be necessary to reduce risk to a tolerable level.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and symbols

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

risk

combination of the probability of occurrence of harm and the severity of that harm

[SOURCE: IEC 60050-903:2013, 903-01-07]

3.1.2

harm

physical injury or damage to persons, property, and livestock

Note 1 to entry: Harm to property and to livestock is excluded from the scope of this document.

[SOURCE: IEC 60050-903:2013, 903-01-01, modified – addition of Note 1 to entry]