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BSI Standards Publication

Wind turbines

Part 26-1: Time-based availability for wind turbine generating systems

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National foreword

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Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than three years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of Update Standards.

According to the replies received by the end of the review period, BSI Committee PEL/88 will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of BSI Technical Committee PEL/88 at British Standards House, 389 Chiswick High Road, London W4 4AL.

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 secretary.

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TECHNICAL SPECIFICATION

colour inside

Wind turbines –
Part 26-1: Time-based availability for wind turbine generating systems

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINES –

Part 26-1: Time-based availability for wind turbine generating systems

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 61400-26-1, which is a technical specification, has been prepared by IEC technical committee 88: Wind turbines.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
88/387/DTS	88/415/RVC

Full information on the voting for the approval of this technical specification 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 of the IEC 61400 series, 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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual edition of this document may be issued at a later date.

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INTRODUCTION

The intention of this technical specification is to define a common basis for exchange of information on performance indicators between owners, utilities, lenders, operators, manufacturers, consultants, regulatory bodies, certification bodies, insurance companies and other stakeholders in the wind power generation business. This is achieved by providing an information model specifying how time designations shall be split into information categories. The information model forms the basis for allocation of time for reporting availability and reliability indicators.

The technical specification defines generic terms of wind turbine systems and environmental constraints in describing system and component availability, lifetime expectancy, repairs and criteria for determining overhaul intervals. The specification defines terminology and generic terms for reporting wind power based generating unit availability measurement. A generating unit includes all equipment up to the termination point defined in the distribution code (grid code) agreed between the generation party and the distribution / transmission party. Availability measurements are concerned with fractions of time a unit is capable of providing service, taking environmental aspects into account. Environmental aspects will be wind and other weather conditions, as well as grid and substation conditions. The specification furthermore defines terminology and terms for reporting performance indicators based on power production or capacity. Mandatory information categories defined in the technical specification are written in capital letters; optional information categories defined in the technical specification are written in bold letters.

The project scope is accomplished by separating the technical specification into two parts:

- IEC/TS 61400-26-1 specifies terms for time based availability of a wind turbine generating system;
- IEC/TS 61400-26-2 specifies terms for production based availability of a wind turbine generating system.

WIND TURBINES –

Part 26-1: Time-based availability for wind turbine generating systems

1 Scope

This part of IEC 61400 defines generic information categories to which fractions of time can be assigned for a wind turbine generating system (WTGS) considering internal and external conditions based on fraction of time and specifying the following:

- generic information categories of a WTGS considering availability and other performance indicators;
- information category priority in order to discriminate between concurrent categories;
- entry and exit point for each information category in order to allocate designation of time
- informative annexes including:
  - examples of optional information categories,
  - examples of algorithms for reporting availability and performance indicators,
  - examples of application scenarios.

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 60050-415:1999, *International Electrotechnical Vocabulary – Part 415: Wind turbine generator systems* Available from: http://www.electropedia.org/

IEC 61400-1, *Wind turbines – Design requirements*

3 Terms, definitions and abbreviations

For the purposes of the present document, the following terms, definitions and abbreviations apply, as well as the relevant terms and definitions contained in IEC 60050-415.

3.1 Terms and definitions

3.1.1
availability
fraction of a given operating period in which a WTGS is performing its intended services within the design specification

3.1.2
design specifications
collection of precise and explicit information about requirements for a product design

It provides in-depth details about the functional and non-functional design requirements including assumptions, constraints, performance, dimensions, weights, reliability and standards. For example, specifications and design considerations given in IEC 61400-1 define the process for producing design specifications for WTGS.

3.1.3
external conditions
conditions outside of the WTGS that affect the operation of the WTGS, for example (i) out of environmental specification and (ii) out of electrical specification

3.1.4
permanent storage
type of computer storage that keeps the data or its contents regardless of whether the power is turned off or if the storage device is moved to another computer

The most commonly used permanent storage is the computer hard disk drive.

3.1.5
reliability
probability that a component part, equipment, or system will satisfactorily perform its intended function under given circumstances for a specified period of time

3.1.6
repair
activity whereby components of a system are restored to a safe operating condition following an unpredicted or unforeseen failure

3.1.7
retrofit
incorporation of new technology or new design parts resulting from an approved engineering change to an already supplied item

3.1.8
total time
the total calendar time of the period selected

3.2 Abbreviations

IA	Information available category
IAO	Information available operative category
IAOG	Information available operative generating category
IAOGFP	Information available operative generating with full performance category
IAOGPP	Information available operative generating with partial performance category
IAONG	Information available operative non generating category
IAONGTS	Information available operative non generating technical standby category
IAONGEN	Information available operative non generating out of environmental specification category
IAONGENC	Information available operative non generating out of environmental specification optional category calm winds
IAONGENO	Information available operative non generating out of environmental specification optional category other environmental
IAONGEL	Information available operative non generating out of electrical specification category
IAONGRS	Information available operative non generating requested shutdown category
IAN	Information available non operative category
IANSM	Information available non operative scheduled maintenance category
IANPCA	Information available non operative planned corrective action category
IANFO	Information available non operative forced outage category
IANS	Information available non operative suspended category

IAFM	Information available force majeure category
IU	Information unavailable category
SCADA	Supervisory control and data acquisition
WTGS	Wind turbine generating system
TT	Total time

4 Information model

4.1 General

The information model is comprised of different information categories. All calendar time shall be distributed into these information categories.

Each information category has an associated entry point and exit point. The entry point describes the criteria that have to be fulfilled to allocate time into a specific information category. The exit point describes the criteria to be fulfilled to end time allocation to a specific information category.

The information model is split into five levels and the hierarchy shall be understood from level one to level five i.e. all attributes of overlaying information categories are inherited by underlying information categories. The time designations are allocated at the lowest mandatory level. Overlaying information categories shall contain the sum of the related information categories on the underlying level. The information categories are introduced in 4.2.

In case entry conditions are fulfilled concurrently for two or more information categories, time shall be assigned into the information category with the highest priority only. Information category priorities are described in more details in 4.4.

4.2 Information categories

Information categories are counters for accumulation of time periods with specified attributes defined for a WTGS for the purpose of exchange of information on availability.

Figure 1 is an overview of the information categories defined in this technical specification. The information model includes four mandatory categories. The model also allows for additional optional levels of information categories to provide the user with more detailed data.

Compliance with this technical specification requires designation of time periods into the mandatory information categories defined in level 1 to level 4, as shown in Figure 1.

The optional information categories defined in level 5 are not required to be compliant with this specification; they are included to allow users to customize reporting details to meet their specific requirements. This specification imposes no limits on the number of optional information categories or levels added by the individual users. The optional information categories shown in Figure 1 are for illustrative purposes only and are described in Annex A. All optional information categories shall be located on level 5 or higher in order to be compliant with this technical specification.

Abbreviations for the various information categories are indicated in brackets with bold letters. The abbreviations are defined in Clause 3.

4.3 Limitations

It is not in the scope of this technical specification to determine the method of information acquisition.

<table>
<tr><th colspan="5">Information categories</th></tr>
<tr><td>Mandatory
Level 1</td><td>Mandatory
Level 2</td><td>Mandatory
Level 3</td><td>Mandatory
Level 4</td><td>Optional - description see Annex A
Level 5</td></tr>
<tr><td rowspan="11">INFORMATION AVAILABLE
(IA)</td><td rowspan="6">OPERATIVE
(IAO)</td><td rowspan="3">GENERATING
(IAOG)</td><td>FULL PERFORMANCE
(IAOGFP)</td><td></td></tr>
<tr><td rowspan="2">PARTIAL PERFORMANCE
(IAOGPP)</td><td>Derated</td></tr>
<tr><td>Degraded</td></tr>
<tr><td rowspan="3">NON-GENERATING
(IAONG)</td><td>TECHNICAL STANDBY
(IAONGTS)</td><td></td></tr>
<tr><td rowspan="2">OUT OF ENVIRONMENTAL SPECIFICATION
(IAONGEN)</td><td>Calm winds</td></tr>
<tr><td>Other environmental</td></tr>
<tr><td>REQUESTED SHUTDOWN
(IAONGRS)</td><td></td></tr>
<tr><td>OUT OF ELECTRICAL SPECIFICATION
(IAONGEL)</td><td></td></tr>
<tr><td rowspan="4">NON-OPERATIVE
(IANO)</td><td colspan="2">SCHEDULED MAINTENANCE
(IANOSM)</td><td></td></tr>
<tr><td colspan="2">PLANNED CORRECTIVE ACTION
(IANOPCA)</td><td>Retrofit
Upgrade
Other corrective action</td></tr>
<tr><td colspan="2">FORCED OUTAGE
(IANOFO)</td><td>Response
Diagnostic
Logistic
Failure repair</td></tr>
<tr><td colspan="2">SUSPENDED
(IANOS)</td><td>Scheduled maintenance
Planned corrective action
Forced outage</td></tr>
<tr><td colspan="2">FORCE MAJEURE
(IAFM)</td><td></td></tr>
<tr><td colspan="3">INFORMATION UNAVAILABLE
(IU)</td><td></td></tr>
</table>

Figure 1 – Information category overview

The information categories are described in further details in Clause 5, Clause 6 and Annex A.

4.4 Information category priority

Time present in the information categories shall be exclusive and continuous. In case the conditions for allocating a time period to more than one information category are fulfilled at the same time, the information category priorities determine which category takes precedence for the allocation of the time period being considered. Assignment of priorities to the information categories provides a uniform and transparent method for designation of time.

The order of priorities as specified in Figure 2 is mandatory for compliance with this model. The priorities are ranked from one to twelve with one as the lowest and twelve as the highest priority. Priorities for optional information categories can be introduced for specific purposes. In such cases, the mandatory priorities can be extended with a priority for the optional information category.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**
		NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**
	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**
		FORCED OUTAGE (**IANOFO**)		**9**
		SUSPENDED (**IANOS**)		**10**
	FORCE MAJEURE (**IAFM**)			**11**
INFORMATION UNAVAILABLE (**IU**)				**12**

Figure 2 – Information category priority

5 INFORMATION AVAILABLE

Definition – The category INFORMATION AVAILABLE covers all time periods during which information on the WTGS and external conditions is retrieved, logged and stored manually or automatically.

It is recognised that there may be circumstances where information is partially available. Qualification for INFORMATION AVAILABLE category requires enough information to confirm if the exit and entry points for all mandatory categories are met.

This category covers all mandatory information categories as depicted in Figure 3.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**
		NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**
	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**
		FORCED OUTAGE (**IANOFO**)		**9**
		SUSPENDED (**IANOS**)		**10**
	FORCE MAJEURE (**IAFM**)			**11**

Figure 3 – INFORMATION AVAILABLE category

Entry point – The WTGS operating status data is available and can be logged and stored.

Exit point – The WTGS operating status data is not available and/or cannot be logged or stored.

5.1 OPERATIVE

Definition – The WTGS is in the category OPERATIVE when capable of performing generation function, regardless of whether it is actually generating and regardless of the capacity level that can be provided.

The OPERATIVE category is underlying the INFORMATION AVAILABLE category and has two underlying information categories as listed below and depicted in Figure 4.

- GENERATING – as defined in 5.1.1;
- NON-GENERATING – as defined in 5.1.2.

The OPERATIVE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVILABLE (**IA**)	**OPERATIVE** (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**
		NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**

Figure 4 – OPERATIVE category

Entry point – The WTGS is able to perform the generation function, regardless of whether it is actually generating and regardless of the capacity level that can be provided. For example internal faults or alarms are resolved, maintenance is completed and other events such as force majeure are cleared.

Exit point – One or more turbine-internal faults, alarms or other constraints occur, preventing the turbine from providing its intended service.

5.1.1 GENERATING

Definition – The WTGS is converting wind energy into electrical energy and/or providing reactive compensation.

The GENERATING category is an underlying category of the OPERATIVE category and has two underlying mandatory information categories as listed below and depicted in Figure 5.

- FULL PERFORMANCE – as defined in 5.1.1.1;
- PARTIAL PERFORMANCE – as defined in 5.1.1.2.

The GENERATING information category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	**GENERATING** (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**

Figure 5 – GENERATING category

Entry point – The WTGS starts generating.

Exit point – The WTGS stops generating.

5.1.1.1 FULL PERFORMANCE

Definition – The WTGS is operative and generating according to design specifications with no technical restrictions or limitations which affect generation.

The FULL PERFORMANCE category is an underlying category of GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 6.

The FULL PERFORMANCE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	**FULL PERFORMANCE** (**IAOGFP**)	**1**
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**

Figure 6 – FULL PERFORMANCE category

Entry point – The WTGS starts generating with full performance.

Exit point – The WTGS stops generating with full performance.

5.1.1.2 PARTIAL PERFORMANCE

Definition – This category is obtained when the WTGS is operative and generating with technical restrictions or other limitations which affect generation.

The PARTIAL PERFORMANCE category is an underlying category of GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 7.

The PARTIAL PERFORMANCE category is mandatory. This includes, but is not limited to, curtailment.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**

Figure 7 – PARTIAL PERFORMANCE category

Entry point – The WTGS starts generating with partial performance. An external or internal conditions exists which prohibits the WTGS from operating at specified active or reactive power levels.

Exit point – The WTGS stops generating with partial performance. All external and internal conditions which prohibit the WTGS from operating at a specified active and reactive power levels are cleared.

5.1.2 NON-GENERATING

Definition – The category NON-GENERATING is obtained when the WTGS is operative but not generating because one of the underlying information categories is active.

The NON-GENERATING category is an underlying category of OPERATIVE and has four predefined underlying mandatory information categories as listed below and depicted in Figure 8.

- TECHNICAL STANDBY – as defined in 5.1.2.1;
- OUT OF ENVIRONMENTAL SPECIFICATION – as defined in 5.1.2.2;
- REQUESTED SHUTDOWN – as defined in 5.1.2.3;
- OUT OF ELECTRICAL SPECIFICATION – as defined in 5.1.2.4.

The NON-GENERATING category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	**NON-GENERATING** (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**

Figure 8 – NON GENERATING category

Entry point – The WTGS is not generating or it stops generating due to one of the circumstances described in the underlying information categories.

Exit point – All circumstances in all underlying categories are cleared.

5.1.2.1 TECHNICAL STANDBY

Definition – The category TECHNICAL STANDBY is defined as the periods where a WTGS is actively performing tasks required for generation.

This may include, but is not limited to, the following aspects:

- safety loop test;
- component and system self- testing;
- cable unwinding / untwisting;
- heating up or cooling down after a period of “out of environmental specification” on temperature;
- de-icing after a period of “out of environmental specification” on ice build-up;
- ramp-up time – from a command to completion of command;
- dry out time after WTGS stop/pause with high humidity.

The TECHNICAL STANDBY category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 9.

The TECHNICAL STANDBY category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	NON-GENERATING (**IAONG**)	**TECHNICAL STANDBY** (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**

Figure 9 – TECHNICAL STANDBY category

Entry point – The WTGS determines or receives a command that technical standby tasks have to be executed and subsequently executes one or more technical standby tasks.

Exit point – The WTGS has completed all active technical standby tasks.

5.1.2.2 OUT OF ENVIRONMENTAL SPECIFICATION

Definition – The category OUT OF ENVIRONMENTAL SPECIFICATION is obtained when the WTGS is operative but not generating as the conditions of the natural environment are outside the design specifications.

Natural environmental conditions could include ambient temperature, wind speed, humidity, atmosphere acidity, dust, turbulence, air density, etc.

The OUT OF ENVIRONMENTAL SPECIFICATION category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 10.

The OUT OF ENVIRONMENTAL SPECIFICATION category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**

Figure 10 – OUT OF ENVIRONMENTAL SPECIFICATION category

Entry point – One or more of the natural environment conditions change to be outside the WTGS design specification, prohibiting the WTGS from generating.

Exit point – All the natural environment conditions change to be within the WTGS design specification.

5.1.2.3 REQUESTED SHUTDOWN

Definition – The category REQUESTED SHUTDOWN is obtained when the WTGS is operative but not generating as it has been stopped by an external demand, which could be either local or remote.

This may include, but is not limited to, the following aspects:

- safety related events (such as icing on blades);
- manual stop;
- training;
- visits / demonstrations;
- bird / bat protection;
- sector management;
- thunderstorms;
- full curtailment;
- nuisance – noise;
- operator requested upgrades or improvements.

REQUESTED SHUTDOWN category is mandatory.

The REQUESTED SHUTDOWN category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 11.

The REQUESTED SHUTDOWN category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**

Figure 11 – REQUESTED SHUTDOWN category

Entry point – The WTGS is requested to shut down by an external demand.

Exit point – All active external requests to shut down are cleared.

5.1.2.4 OUT OF ELECTRICAL SPECIFICATION

Definition – The category OUT OF ELECTRICAL SPECIFICATION is obtained when the WTGS is operative but not generating as the electrical conditions at the WTGS terminals are outside design specifications.

This may include, but is not limited to, the following aspects:

- voltage;
- frequency;
- phase imbalance.

The OUT OF ELECTRICAL SPECIFICATION category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 12.

The OUT OF ELECTRICAL SPECIFICATION category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**

Figure 12 – OUT OF ELECTRICAL SPECIFICATION category

Entry point – One or more of the electrical conditions at the WTGS terminals change to be outside the design specifications, prohibiting the WTGS from generating.

Exit point – All the electrical conditions at the WTGS terminals change to be within the design specifications.

5.2 NON-OPERATIVE

Definition – The NON-OPERATIVE category covers all the situations when a WTGS is not capable of performing the generation function.

The NON-OPERATIVE category is an underlying category of the INFORMATION AVAILABLE and has four underlying mandatory information categories as listed below and depicted in Figure 13.

- SCHEDULED MAINTENANCE – as defined in 5.2.1;
- PLANNED CORRECTIVE ACTION – as defined in 5.2.2;
- FORCED OUTAGE – as defined in 5.2.3;
- SUSPENDED – as defined in 5.2.4.

The NON-OPERATIVE category is mandatory.

<table>
<tr><th colspan="5">Information categories</th></tr>
<tr><td>Mandatory
Level 1</td><td>Mandatory
Level 2</td><td colspan="2">Mandatory
Level 3</td><td>Mandatory
Priority</td></tr>
<tr><td rowspan="5">INFORMATION AVAILABLE
(IA)</td><td rowspan="4">NON-OPERATIVE
(IANO)</td><td colspan="2">SCHEDULED MAINTENANCE
(IANOSM)</td><td>7</td></tr>
<tr><td colspan="2">PLANNED CORRECTIVE ACTION
(IANOPCA)</td><td>8</td></tr>
<tr><td colspan="2">FORCED OUTAGE
(IANOFO)</td><td>9</td></tr>
<tr><td colspan="2">SUSPENDED
(IANOS)</td><td>10</td></tr>
<tr><td colspan="3">FORCE MAJEURE
(IAFM)</td><td>11</td></tr>
</table>

Figure 13 – NON-OPERATIVE category

Entry point – Maintenance or repair work is required or one or more WTGS faults or alarms occur, prohibiting the WTGS from performing the generating function.

Exit point – Any maintenance or repair work is completed and all WTGS faults or alarms are cleared and the WTGS is able to perform the generating function.

5.2.1 SCHEDULED MAINTENANCE

Definition – The category SCHEDULED MAINTENANCE is obtained during scheduled maintenance actions according to the WTGS manufacturer's maintenance specification.

Conditions identified during the performance of scheduled maintenance shall be prioritised and categorised according to 4.4.

The SCHEDULED MAINTENANCE category is an underlying category of the NON-OPERATIVE and has no predefined underlying mandatory information categories as depicted in Figure 14.

The SCHEDULED MAINTENANCE category is mandatory.

<table>
<tr><th colspan="5">Information categories</th></tr>
<tr><td>Mandatory
Level 1</td><td>Mandatory
Level 2</td><td colspan="2">Mandatory
Level 3</td><td>Mandatory
Priority</td></tr>
<tr><td rowspan="5">INFORMATION AVAILABLE
(IA)</td><td rowspan="4">NON-OPERATIVE
(IANO)</td><td colspan="2">SCHEDULED MAINTENANCE
(IANOSM)</td><td>7</td></tr>
<tr><td colspan="2">PLANNED CORRECTIVE ACTION
(IANOPCA)</td><td>8</td></tr>
<tr><td colspan="2">FORCED OUTAGE
(IANOFO)</td><td>9</td></tr>
<tr><td colspan="2">SUSPENDED
(IANOS)</td><td>10</td></tr>
<tr><td colspan="3">FORCE MAJEURE
(IAFM)</td><td>11</td></tr>
</table>

Figure 14 – SCHEDULED MAINTENANCE category

Entry point – The WTGS is stopped or prohibited from being operative with the intention of performing scheduled maintenance.

Exit point – The WTGS exits this category by manual intervention confirming that the scheduled maintenance has been interrupted or completed.

5.2.2 PLANNED CORRECTIVE ACTION

Definition – The category PLANNED CORRECTIVE ACTION is obtained during actions required to retain, restore, or improve the generating function of a WTGS when these actions are not part of normal scheduled maintenance.

PLANNED CORRECTIVE ACTION may include retrofits and upgrades, or required corrective actions identified through condition-based maintenance, inspections, investigations etc., and is intended to account for corrective actions where the need is identified prior to any actual failure and early enough to be planned and completed before resulting in a possible forced outage.

The PLANNED CORRECTIVE ACTION category is an underlying category of the NON-OPERATIVE category and has no predefined underlying mandatory information categories as depicted in Figure 15.

The PLANNED CORRECTIVE ACTION category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**
		FORCED OUTAGE (**IANOFO**)		**9**
		SUSPENDED (**IANOS**)		**10**
	FORCE MAJEURE (**IAFM**)			**11**

Figure 15 – PLANNED CORRECTIVE ACTION category

Entry point – The WTGS is stopped or prohibited from being operative with the intention of performing planned corrective actions.

Exit point – The WTGS exits this category by manual intervention confirming the planned corrective actions are interrupted or completed.

5.2.3 FORCED OUTAGE

Definition – The category FORCED OUTAGE is obtained when an immediate action to disable the generating function of the WTGS is required as unforeseen damage, faults, failures or alarms are detected. This can be detected manually or automatically.

The FORCED OUTAGE category is an underlying category of the NON-OPERATIVE and has no underlying mandatory information categories as depicted in Figure 16.

The FORCED OUTAGE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**
		FORCED OUTAGE (**IANOFO**)		**9**
		SUSPENDED (**IANOS**)		**10**
	FORCE MAJEURE (**IAFM**)			**11**

Figure 16 – FORCED OUTAGE category

Entry point – The WTGS is disabled from generating because of damage, faults, or failures or an alarm.

Exit point – The WTGS exits this category when causes for outage are cleared.

5.2.4 SUSPENDED

Definition – The category SUSPENDED covers all situations when activities in SCHEDULED MAINTENANCE, PLANNED CORRECTIVE ACTION and FORCED OUTAGE have to be interrupted or cannot be initiated due to conditions which compromise personal safety or equipment integrity.

The SUSPENDED category includes, but is not limited to:

- access limitations because of e.g. high waves, ice, snow, storm;
- severe weather conditions, like lightning, tornados, hail;
- reduction of risks initiated by the activities like bush fire;
- public authorities' orders for suspension of the work because of personal safety;
- site working conditions are not met.

The SUSPENDED category is an underlying category of the NON-OPERATIVE and has no underlying mandatory information categories as depicted in Figure 17.

The SUSPENDED category is mandatory.

<table>
<tr><th colspan="5">Information categories</th></tr>
<tr><th>Mandatory Level 1</th><th>Mandatory Level 2</th><th colspan="2">Mandatory Level 3</th><th>Mandatory Priority</th></tr>
<tr><td rowspan="5">INFORMATION AVAILABLE (IA)</td><td rowspan="4">NON-OPERATIVE (IANO)</td><td colspan="2">SCHEDULED MAINTENANCE (IANOSM)</td><td>7</td></tr>
<tr><td colspan="2">PLANNED CORRECTIVE ACTION (IANOPCA)</td><td>8</td></tr>
<tr><td colspan="2">FORCED OUTAGE (IANOFO)</td><td>9</td></tr>
<tr><td colspan="2">SUSPENDED (IANOS)</td><td>10</td></tr>
<tr><td colspan="3">FORCE MAJEURE (IAFM)</td><td>11</td></tr>
</table>

Figure 17 – SUSPENDED category

Entry point – This category is entered by manual intervention when work is suspended according to conditions defined.

Exit point – This category is terminated by manual intervention when the conditions suspending the work have been cleared.

5.3 FORCE MAJEURE

Definition – The category FORCE MAJEURE covers all situations where an extraordinary event or circumstance beyond the control of the parties involved prevents the parties from fulfilling their obligations.

FORCE MAJEURE is a common clause in contracts which essentially frees concerned parties from their liability or obligation when an extraordinary event or circumstance beyond the control of the parties occurs.

FORCE MAJEURE is not intended to excuse negligence or other malfeasance of a party, as where non-performance is caused by the usual and natural consequences of external forces or where the intervening circumstances are specifically contemplated.

The FORCE MAJEURE information category is underlying the INFORMATION AVAILABLE information category on level 2 and has no underlying mandatory information categories as depicted in Figure 18.

The FORCE MAJEURE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**
		FORCED OUTAGE (**IANOFO**)		**9**
		SUSPENDED (**IANOS**)		**10**
	FORCE MAJEURE (**IAFM**)			**11**

Figure 18 – FORCE MAJEURE category

Entry point – This category is entered by manual intervention when a force majeure situation is detected according to contract text.

Exit point – This category is terminated by manual intervention when a force majeure situation has been cleared according to contract text.

6 INFORMATION UNAVAILABLE

Definition – The category INFORMATION UNAVAILABLE covers all time periods when the category INFORMATION AVAILABLE is not applicable.

The INFORMATION UNAVAILABLE information category is on level 1 and as such has no overlying information category. In addition, this information category has no underlying mandatory information categories as depicted in Figure 19.

The INFORMATION UNAVAILABLE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**
		NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**
	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**
		FORCED OUTAGE (**IANOFO**)		**9**
		SUSPENDED (**IANOS**)		**10**
	FORCE MAJEURE (**IAFM**)			**11**
INFORMATION UNAVAILABLE (**IU**)				**12**

Figure 19 – INFORMATION UNAVAILABLE category

Entry point – A WTGS becomes unable to detect WTGS operating data or unable to log to permanent local storage or communicate data to other storage.

Exit point – A WTGS becomes able to detect WTGS operating data and to log to permanent local storage or communicate data to other storage.

Annex A
(informative)

Optional information categories – examples

A.1 General

This annex describes examples of optional information categories proposed to be applied when more detailed information is required in order to address specific information needs. An overview of some possible information categories is depicted in Figure A.1.

If further detail is required, more optional information categories can be added as underlying categories to the mandatory level 4 and/or to the proposed level 5 categories. All optional information categories shall be located on level 5 or higher in order to be compliant with this technical specification. Priority of optional categories must be assigned as depicted in the example in Figure A.1. Priorities of optional categories only apply within its parent information category.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**		
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**	Derated	**2.1**
					Degraded	**2.2**
		NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**		
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**	Calm winds IAONGENC	**4.1**
					Other environmental IAONGENO	**4.2**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**		
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**		
	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**		
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**	Retrofit Upgrade Other corrective action	**8.1** **8.2** **8.3**
		FORCED OUTAGE (**IANOFO**)		**9**	Response Diagnostic Logistic Failure repair	**9.1** **9.2** **9.3** **9.4**
		SUSPENDED (**IANOS**)		**10**	Scheduled maintenance Planned corrective action Forced outage	**10.1** **10.2** **10.3**
	FORCE MAJEURE (**IAFM**)			**11**		
INFORMATION UNAVAILABLE (**IU**)				**12**		

Figure A.1 – Information category overview – mandatory and optional

A.2 PARTIAL PERFORMANCE – optional categories

The optional information categories are introduced to further detail the mandatory information category PARTIAL PERFORMANCE as listed below and depicted in Figure A.2.

- **Derated** – as defined in A.2.1;
- **Degraded** – as defined in A.2.2.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**		
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**	**Derated**	**2.1**
					Degraded	**2.2**

Figure A.2 – Optional categories for PARTIAL PERFORMANCE

In following subclauses are the optional information category further specified.

A.2.1 Derated

Definition – The optional information category **Derated** can be used to accumulate time periods when a WTGS is operative and generating at reduced power because of external commands or external constraints.

External constraints would typically include, but are not limited to, power curtailment, grid stability support modes, ancillary services, environmental conditions (temperature, dust, turbulence, etc.) or other external factors (noise, shadow, flicker, wake, turbulence, etc.).

The **Derated** category is an underlying category of PARTIAL PERFORMANCE and has no predefined underlying optional information categories as depicted in Figure A.3.

The **Derated** category is optional.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**		
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**	**Derated**	**2.1**
					Degraded	**2.2**

Figure A.3 – Derated category

Entry point – An external event or manual intervention prohibits a WTGS from operating at specified active or reactive power level.

Exit point – All external constraints which prohibit a WTGS from operating at a specified active and reactive power level are cleared.

A.2.2 Degraded

Definition – The information category **Degraded** can be used to accumulate time periods when a WTGS is operative and generating power with a reduced performance because of internal constraints.

Internal constraints could result from component damage or the need to prevent component damage, e.g. component overheating, vibration levels, bearing failure, converter cooling system failure, etc.

The **Degraded** optional information category is an underlying category of PARTIAL PERFORMANCE and has no predefined underlying information categories as depicted in Figure A.4.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	GENERATING (**IAOG**)	FULL PERFORMANCE (**IAOGFP**)	**1**		
			PARTIAL PERFORMANCE (**IAOGPP**)	**2**	Derated	**2.1**
					Degraded	**2.2**

Figure A.4 – Degraded category

Entry point – An internal event or manual intervention prohibits a WTGS from operating at a specified active or reactive power level.

Exit point – All internal constraints which prohibit a WTGS from operating at a specified active and reactive power level are cleared.

A.3 OUT OF ENVIRONMENTAL SPECIFICATION – optional categories

The optional information categories are introduced to further detail the mandatory information category OUT OF ENVIRONMENTAL SPECIFICATION as listed below and depicted in Figure A.5.

- **calm winds** – as defined in A.3.1;
- **other environmental** – as defined in A.3.2.

The optional information categories are defined in the following subclauses.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**		
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**	**Calm winds** IAONGENC	**4.1**
					Other environmental IAONGENO	**4.2**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**		
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**		

Figure A.5 – Optional categories for OUT OF ENVIRONMENTAL SPECIFICATION

A.3.1 Calm winds

Definition – The optional information category **Calm winds** can be used to accumulate time periods when a WTGS is operative but not generating because the wind speed is under the design specification for the minimum wind speed of the turbine.

The **Calm winds** category is an underlying category of OUT OF ENVIRONMENTAL SPECIFICATION and has no predefined underlying information categories as depicted in Figure A.6.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE **(IA)**	OPERATIVE **(IAO)**	NON-GENERATING **(IAONG)**	TECHNICAL STANDBY (**IAONGTS**)	**3**		
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	**4**	**Calm winds** **IAONGENC**	**4.1**
					Other Environmental IAONGENO	**4.2**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**		
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**		

Figure A.6 – Calm winds category

Entry point – The wind speed in the natural environment changes to be below the WTGS design specification for minimum wind speed, prohibiting the WTGS from generating.

Exit point – The wind speed in the natural environment rises above the WTGS design specification for minimum wind speed.

A.3.2 Other environmental

Definition – The optional information category **Other environmental** is obtained when the WTGS is operative but not generating as one or more conditions of the natural environment are outside the design specifications, other than wind speed being below the design specification for minimum wind speed.

The **Other environmental** optional information category is an underlying category of OUT OF ENVIRONMENTAL SPECIFICATION and has no predefined underlying information categories as depicted in Figure A.7.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	OPERATIVE (**IAO**)	NON-GENERATING (**IAONG**)	TECHNICAL STANDBY (**IAONGTS**)	**3**		
			OUT OF ENVIRONMENTAL SPECIFICATION (**IAONGEN**)	4	Calm winds IAONGENC	**4.1**
					Other Environmental IAONGENO	**4.2**
			REQUESTED SHUTDOWN (**IAONGRS**)	**5**		
			OUT OF ELECTRICAL SPECIFICATION (**IAONGEL**)	**6**		

Figure A.7 – Other environmental category

Entry point – One or more conditions in the natural environment changes to be outside the WTGS design specification, other than the wind speed falling below the design specification for minimum wind speed, prohibiting the WTGS from generating.

Exit point – All conditions in the natural environment are within the design specification of the WTGS, other than the wind speed in the natural environment being above the WTGS design specification for minimum wind speed.

A.4 NON-OPERATIVE – optional categories

The optional information categories are introduced to further detail the mandatory information category NON-OPERATIVE as listed below and depicted in Figure A.8.

Optional information categories applicable for PLANNED CORRECTIVE ACTION:

- **Retrofit** – as defined in A.4.1.1;
- **Upgrade** – as defined in A.4.1.2;
- **Other corrective action** – as defined in A.4.1.3.

Optional information categories applicable for FORCED OUTAGE:

- **Response time** – as defined in A.4.2.2;
- **Diagnostic time** – as defined in A.4.2.3;
- **Logistic** – as defined in A.4.2.4;
- **Failure repair** – as defined in A.4.2.5.

Optional information categories applicable for SUSPENDED:

- **Scheduled maintenance** – as defined in A.4.3.1;
- **Planned corrective action** – as defined in A.4.3.2;
- **Forced outage** – as defined in A.4.3.3.

An overview of the optional information categories is depicted in Figure A.8.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**		
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**	**Retrofit**	**8.1**
					Upgrade	**8.2**
					Other corrective action	**8.3**
		FORCED OUTAGE (**IANOFO**)		**9**	**Response**	**9.1**
					Diagnostic	**9.2**
					Logistic	**9.3**
					Failure repair	**9.4**
		SUSPENDED (**IANOS**)		**10**	**Scheduled maintenance**	**10.1**
					Planned corrective action	**10.2**
					Forced outage	**10.3**

Figure A.8 – Optional categories for NON-OPERATIVE

A.4.1 PLANNED CORRECTIVE ACTION – optional categories

The following optional information categories can be applied to add details in the mandatory information in the category PLANNED CORRECTIVE ACTION. The main purpose for these optional information categories is to provide generic terms for assigning responsibility in case planned corrective actions are performed.

A.4.1.1 Retrofit

Definition – This optional information category will identify the planned corrective actions to incorporate any modification recommended by the manufacturer to achieve the wind turbine specification.

Entry point – The retrofit activity begins. The operator has already prepared support needed such as parts, repair team, equipments, etc. A **Retrofit** category can only be entered by manual intervention.

Exit point – This optional information category is terminated by manual intervention when the retrofit activity is completed.

A.4.1.2 Upgrade

Definition – This optional information category will identify the planned corrective actions to incorporate any modification recommended by the manufacturer to improve the wind turbine performances beyond the specification. These upgrades are user's choice to implement.

Entry point – The upgrade activity begins. The operator has already prepared support needed such as parts, repair team, equipments, etc. The **Upgrade** category can only be entered by manual intervention.

Exit point – This optional information category is terminated by manual intervention when the upgrade activity is completed.

A.4.1.3 Other planned corrective action

Definition – This optional information category will identify planned corrective actions that are not retrofits or upgrades. An example would be to replace a generator bearing that was found damaged in an earlier inspection, but could continue operating while parts and logistics were prepared for the repair.

Entry point – The **Other planned corrective action** activity begins. The operator has already prepared support needed such as parts, repair team, equipments, etc. This information category can only be entered by manual intervention.

Exit point – This optional information category is terminated by manual intervention when the other planned corrective action activity is completed.

A.4.2 FORCED OUTAGE – optional category

The following optional information categories can be applied to increase the detail of the following mandatory information categories FORCED OUTAGE. The main purpose for these optional information categories is to provide generic terms for assigning responsibility for various stages of an outage workflow.

An overview of the optional information categories is depicted in Figure A.9.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**		
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**	Retrofit	**8.1**
					Upgrade	**8.2**
					Other corrective action	**8.3**
		FORCED OUTAGE (**IANOFO**)		**9**	**Response**	**9.1**
					Diagnostic	**9.2**
					Logistic	**9.3**
					Failure repair	**9.4**
		SUSPENDED (**IANOS**)		**10**	Scheduled maintenance	**10.1**
					Planned corrective action	**10.2**
					Forced outage	**10.3**

Figure A.9 – Optional categories for forced outage

A.4.2.1 FORCED OUTAGE workflow

When a FORCED OUTAGE category is encountered, a breakdown of the outage workflow can be interesting for monitoring the performance of the various parties involved.

The time terms to be observed can be as specified in this subclause. The overall workflow can be separated into the optional information categories as depicted in Figure A.10.

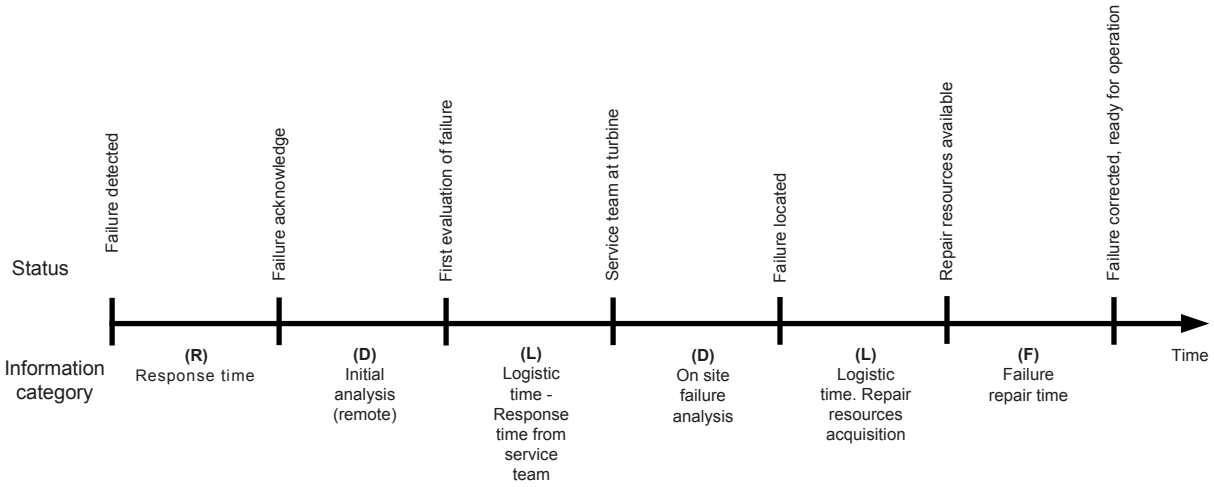

Figure A.10 – Workflow breakdown structure

As seen from the schematic workflow, the time period from when a fault in a WTGS is detected to when the failure is repaired and all alarms / events are cleared can be divided into four underlying optional information categories as listed below.

- **Response time (R)** – as defined in A.4.2.2;
- **Diagnostic time (D)** – as defined in A.4.2.3;
- **Logistic time (L)** – as defined in A.4.2.4;
- **Repair time (F)** – as defined in A.4.2.5.

The optional information categories defined are described in further detail in the following sublauses.

A.4.2.2 Response time (R)

Definition – This optional information category can be used to accumulate time periods from notification of any event until an action on the event has been initiated.

In the workflow breakdown, this category could cover but is not limited to:

- failure acknowledge;
- service partner response time for a repair request;
- service team setup;
- waiting time for acceptance to initiate a corrective action.

Entry point – An internal fault or external command is received and the WTGS does not automatically return to the operative category.

Exit point – The operator detects and logs fault or status. A WTGS can only exit this category by manual intervention.

A.4.2.3 Diagnostic time (D)

Definition – This optional information category can be used to accumulate time periods spend to analyse a fault symptom, related measurements and findings indicating a failure and planning corrective action. In the workflow breakdown, it covers but is not limited to:

- initial analysis;
- remote detailed analysis;
- additional analysis;
- additional clarifications required;
- planning corrective actions;
- approval of corrective actions.

Entry point – The operator detects and logs fault or status. The turbine can only enter this mode by manual intervention.

Exit point – The operator has completed analysis and determined required action. A WTGS can only exit this category by manual intervention.

A.4.2.4 Logistic time (L)

Definition – This optional information category can be used to accumulate time periods used for logistic activities such as, but not limited to:

- transportation of tools;
- crane lead time;
- service team set-up;
- ordering support tools;
- ordering spare parts;
- waiting time for resource allocation;
- lead time for tools required;
- lead time for spare parts required;
- waiting time resource allocation.

Entry point – The operator has completed analysis and determined required action and has initiated actions such as: ordering parts, calling out repair team, etc. A WTGS can only enter this category by manual intervention.

Exit point – All the required actors and equipment are in place for the activities called for by the current diagnostics. A WTGS can only exit this category by manual intervention.

A.4.2.5 Repair time (F)

Definition – This optional information category can be used to accumulate time periods used for implementation of repair activities such as, but not limited to:

- change of a defective sensor;
- change of control software version;
- verification of replaced damage parts;
- inspection or audit related to repairing activity;
- run-in test after finalizing repair activity.

Entry point – The repair activity begins either local or remote. A **Repair time** information category can only be entered by manual intervention.

Exit point – This optional information category is terminated by manual intervention when the repair activity is completed.

A.4.3 SUSPENDED – optional categories

The following optional information categories can be applied to increase details in the mandatory information category SUSPENDED. The main purpose for the optional information categories focusing on the suspended situation is to provide generic terms for exchange of information on availability and reliability for suspended periods.

An overview of the optional information categories is depicted in Figure A.11.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (**IA**)	NON-OPERATIVE (**IANO**)	SCHEDULED MAINTENANCE (**IANOSM**)		**7**		
		PLANNED CORRECTIVE ACTION (**IANOPCA**)		**8**	Retrofit	**8.1**
					Upgrade	**8.2**
					Other corrective action	**8.3**
		FORCED OUTAGE (**IANOFO**)		**9**	Response	**9.1**
					Diagnostic	**9.2**
					Logistic	**9.3**
					Failure repair	**9.4**
		SUSPENDED (**IANOS**)		**10**	**Scheduled maintenance**	**10.1**
					Planned corrective action	**10.2**
					Forced outage	**10.3**

Figure A.11 – Optional categories for SUSPENDED

A.4.3.1 Scheduled maintenance

Definition – The optional information category **Scheduled maintenance** covers all situations where a suspension is initiated during a scheduled maintenance activity.

Entry point – This optional information category is entered by manual intervention when a scheduled maintenance task is suspended according to defined conditions.

Exit point – This optional information category is terminated by manual intervention when the conditions suspending the work have been cleared.

A.4.3.2 Planned corrective action

Definition – The optional information category **Planned corrective action** covers all situations where a suspension is initiated during a planned corrective activation period.

Entry point – This optional information category is entered by manual intervention when a planned corrective action is suspended according to conditions defined.

Exit point – This optional information category is terminated by manual intervention when the conditions for suspending the work have been cleared.

A.4.3.3 Forced outage

Definition – The optional information category **Forced outage** covers all situations were a suspension is initiated during a forced outage.

Entry point – This optional information category is entered by manual intervention when a forced outage situation has occurred.

Exit point – This optional information category is terminated by manual intervention when the conditions for suspending the work have been cleared.

Annex B
(informative)

Time based availability indicators – examples

B.1 General

This annex describes examples of how to calculate various measures of availability of a WTGS, based on the information categories defined in this document. Each example of availability is defined in terms of three types of information categories:

a) information categories considered as available time;

b) information categories considered as unavailable time; and

c) information categories not to be considered in the availability calculation.

The constituents of each of the three types of information categories specified above are defined for each measure of availability in its respective clause. Below are three examples using mandatory and optional categories. Users may find other arrangements of the categories to calculate availability specific for their need.

When calculating the measure of availability, the following formula shall be applied:

$$\text{Availability} = 1 - \frac{\text{Unavailable time}}{\text{Available time} + \text{Unavailable time}} \quad \text{(B.1)}$$

Available time + Unavailable time is equal to Total time.

B.2 Operational availability (“WTGS user’s view”)

B.2.1 General

Definition – System operational availability is the fraction of a given period of time in which a WTGS is actually generating. Lost operating hours due to any reason are included as unavailability.

B.2.2 Operational availability algorithm based on mandatory states only

In this definition, time considered as available includes:

- GENERATING – FULL PERFORMANCE;
- GENERATING – PARTIAL PERFORMANCE.

Time considered as unavailable includes:

- TECHNICAL STANDBY;
- OUT OF ENVIRONMENTAL SPECIFICATION;
- REQUESTED SHUTDOWN;
- OUT OF ELECTRICAL SPECIFICATION;
- SCHEDULED MAINTENANCE;
- PLANNED CORRECTIVE ACTION;
- FORCED OUTAGE;

- SUSPENDED;
- FORCE MAJEURE.

Time not included in the calculation includes:

- Information not available.

$$\text{System operational availability} = 1 - \frac{\text{IAONGTS+ IAONGEN+ IAONGRS + IAONGEL + IANOSM + IANOPCA + IANOFO + IANOS+ IAFM}}{\text{(IAOGFP + IAONPP)+ (IAONGTS+ IAONGEN+ IAONGRS + IAONGEL + IANOSM + IANOPCA + IANOFO+ IANOS+ IAFM)}} \quad \text{(B.2)}$$

Note that since no information about the turbine is known in the INFORMATION UNAVAILABLE category, these periods are not included as available or unavailable, and are excluded entirely from the calculation. This is the equivalent of assuming availability during those hours is the same as that during the period for which information is available.

B.2.3 Operational availability algorithm – including optional states

In this definition, hours considered as available include:

- GENERATING – FULL PERFORMANCE;
- GENERATING – PARTIAL PERFORMANCE;
- OUT OF ENVIRONMENTAL SPECIFICATION – **calm**.

Hours considered as unavailable include:

- TECHNICAL STANDBY;
- OUT OF ENVIRONMENTAL SPECIFICATION – **other**;
- REQUESTED SHUTDOWN;
- OUT OF ELECTRICAL SPECIFICATION;
- SCHEDULED MAINTENANCE;
- PLANNED CORRECTIVE ACTION;
- FORCED OUTAGE;
- SUSPENDED;
- FORCE MAJEURE.

Hours not included in the calculation include:

- INFORMATION UNAVAILABLE.

$$\text{System operational availability (optional)} = 1 - \frac{\text{IAONGTS+ IAONGENO+ IAONGRS + IAONGEL + IANOSM + IANOPCA + IANOFO + IANOS+ IAFM}}{\text{(IAOGFP + IAONPP + IAONGENC)+ (IAONGTS+ IAONGENO+ IAONGRS + IAONGEL + IANOSM + IANOPCA + IANOFO + IANOS + IAFM)}} \quad \text{(B.3)}$$

The use of the optional states **Calm winds** and **Other environmental** allows for a distinction to be made between lost operating hours due to unavailable wind resource, and those hours lost due to other operating conditions being beyond the design specifications of the turbine. This performance metric is not penalized by low winds.

B.2.4 Turbine operational availability algorithm – including optional states

In this definition, hours considered as available include:

- GENERATING – FULL PERFORMANCE;
- GENERATING – PARTIAL PERFORMANCE;
- OUT OF ENVIRONMENTAL SPECIFICATION – **calm**.

Hours considered as unavailable include:

- TECHNICAL STANDBY;
- OUT OF ENVIRONMENTAL SPECIFICATION – **other**;
- SCHEDULED MAINTENANCE;
- PLANNED CORRECTIVE ACTION;
- FORCED OUTAGE;
- SUSPENDED.

Hours not included in the calculation include:

- REQUESTED SHUTDOWN;
- OUT OF ELECTRICAL SPECIFICATION;
- FORCE MAJEURE;
- INFORMATION UNAVAILABLE.

$$\text{Turbine operational availability (optional)} = 1 - \frac{\text{IAONGTS+ IAONGENO+ IANOSM + IANOPCA + IANOFO + IANOS}}{\text{(IAOGFP + IAONPP + IAONGENC)+ (IAONGTS+ IAONGENO+ IANOSM + IANOPCA + IANOFO + IANOS)}} \quad \text{(B.4)}$$

Turbine operational availability differs from operational availability in that categories generally beyond the control of the turbine are excluded from consideration. Turbine performance is not being evaluated during hours where the operator has requested a shutdown, an electrical connection is not available, or a force majeure event has occurred.

B.3 Technical availability (“WTGS manufacturer’s view”)

B.3.1 General

Definition – Technical availability is the fraction of a given period of time in which a WTGS is operating according to its design specifications.

B.3.2 Technical availability – mandatory states only

In this definition, time considered as available includes:

- GENERATING – FULL PERFORMANCE;
- GENERATING – PARTIAL PERFORMANCE;
- TECHNICAL STANDBY;
- OUT OF ENVIRONMENTAL SPECIFICATION;
- REQUESTED SHUTDOWN;
- OUT OF ELECTRICAL SPECIFICATION.

Time considered as unavailable includes:

- PLANNED CORRECTIVE ACTION;
- FORCED OUTAGE.

Time not included in the calculation includes:

- SCHEDULED MAINTENANCE;
- SUSPENDED;
- FORCE MAJEURE;
- INFORMATION UNAVAILABLE.

$$\text{Turbine technical availability} = 1 - \frac{(IANOPCA + IANOFO)}{(IAOGFP + IAONPP + IAONGTS + IAONGEN + IAONGRS + IAONGEL) + (IANOPCA + IANOFO)} \quad \text{(B.5)}$$

Annex C
(informative)

Verification scenarios – examples

This annex is intended to illustrate the application of the indicators shown in Annex B to the information model described in the main body of this technical specification.

Each scenario consists of a time line covering one calendar week of events that may typically occur at a WTGS. The scenarios are described in the following clauses.

For each scenario, time is distributed into the mandatory information categories depicted in graphical form in Figure C.1 according to each verification scenario. Colour indicates how the individual mandatory information categories are included in the availability calculations, with green indicating that time is included in the period hours as available, red indicating that time is included in the period hours as unavailable and grey indicating those hours are excluded from the period hours and are not included in the calculation of the performance metric.

	Mandatory – Information categories													Availability = 1 – unavailability/ (availability + unavailability)	
MEANING OF COLORS: **GREEN** = included in period hours as available **RED** = included in period hours as unavailable **GREY** = excluded from period hours	Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Rut of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
Operational availability														X	
Technical availability															X

Figure C.1 – Verification scenarios – time allocation to information categories

The availability for the period is then calculated in general as follows:

$$\text{Availability} = 1 - \text{Unavailability} = 1 - \frac{\text{Unavailable hours}}{\text{Available hours} + \text{Unavailable hours}}$$

For each scenario, these availability performance metrics are calculated, according to the definitions in Annex B, each with a different perspective on availability performance measurement, as summarized below.

Operational availability: This is primarily an operator's or user's view of a wind turbine system as a whole and measures how often the asset was actually generating power and revenue. The reasons for allocation of the lost operating hours are less important than the overall view that operation and production have been lost. This is calculated as specified in Clause B.2.

Technical availability: This is primarily the manufacturer's view of a wind turbine and measures how often a wind turbine operated as it was intended to operate. Lost production due to maintenance as specified, environmental conditions outside the specifications, standby for internal checks, etc. are not considered as unavailable in the definition. This is calculated as specified in Clause B.3.

Scenario 1 – communication aspects

MEANING OF COLOURS: GREEN = included in period hours as available; RED = included in period hours as unavailable; GREY = excluded from period hours			Mandatory — Information categories														
			Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Out of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
	Operational availability															X	
	Technical availability																X
1. Information category		Comments															
1.1	Turbine produces power all week	Distribution of time (weekly hours) across information states	168	0	0	0	0	0	0	0	0	0	0	0		100,0 %	100,0 %
1.2	Turbine has 10 h before all communication is lost	Turbine is 100 % available during the 10 known hours	10											158		100,0 %	100,0 %
1.3	Turbine runs 5 h, has 1 h fault and then runs again 4 h before all communication is lost	If the Information unavailable state were included in the period time, availability would be 99,4 %, an assumption that the turbine was available all those hours	9								1			158		90,0 %	90,0 %
1.4	An earlier gearbox fire has destroyed all communication to the unit. There is no on-line information available	A forced outage, the state is known, but manual entry needed	0								168					0,0 %	0,0 %

Figure C.2 – Verification scenarios – communication aspects

In scenario 1.1 in Figure C.2 where the wind turbine has operated at full power for a continuous week of 168 h, these metrics are each 100 %, as expected.

The communications scenarios illustrate the importance of excluding from the calculation time where information about the turbine state is unknown. In scenario 1.3, if the 158 h of unknown state were included in the period time, the operational and technical availability would increase to 99,4 %. However, it is not known whether the turbine was available or unavailable during this time period, and these hours must be excluded from the calculation. This essentially extrapolates the measured availability metric throughout the period when information is unavailable.

Note that the loss of electronic or on-line communication does not necessarily imply information is unavailable. As shown in scenario 1.4, the status of a turbine may in some instances need to be manually entered, or data corrected when a state becomes later known.

Wind turbines with local information storage could have a higher availability than wind turbines without local information storage. In addition, local information storage in a wind turbine might facilitate a more correct picture of the availability metrics.

Scenario 2 – partial operational aspects

			Mandatory – Information categories														
MEANING OF COLOURS: **GREEN** = included in period hours as available **RED** = included in period hours as unavailable **GREY** = excluded from period hours			Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Out of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	Information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
	Operational availability															X	
	Technical availability																X
2. Partial operation		**Comments**															
2.1	Output is curtailed to 50 % power for 40 h due to grid constraints	Time-based performance indicators not affected by partial operation	128	40												100,0 %	100,0 %
2.2	Due to a generator bearing problem, output is limited to 50 % load for 2 days	Time-based performance indicators not affected by partial operation	120	48												100,0 %	100,0 %
2.3	Turbine mechanical failure prevents active power production for 50 h, but the unit is able to produce reactive power	100 % available if reactive power alone is considered generation. 70,2 % if not	118								50					100,0 %	100,0 %

Figure C.3 – Verification scenarios – partial operational aspects

The scenarios depicted in Figure C.3 demonstrate that for time-based availability measurements, generating at partial capacity does not affect the availability calculation, and that generating reactive power only, per the defined information category, is also considered partial generation.

Scenario 3 – maintenance aspects

MEANING OF COLOURS: GREEN = included in period hours as available; RED = included in period hours as unavailable; GREY = excluded from period hours			Mandatory — Information categories															
			Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Out of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	Information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
	Operational availability															X	
	Technical availability																X
3. Maintenance		Comments															
3.1	8 h of scheduled maintenance, within specification for expected maintenance duration	Technical availability is not affected by maintenance since it is per design, but operational availability will increase with reducing maintenance needs	160						8							95,2 %	100,0 %
3.2	8 h of scheduled maintenance must be extended 4 h to replace a bearing found to be near failure	Manual entry needed for excess time, which is considered a forced outage	156						8		4					92,9 %	97,5%

Figure C.4 – Verification scenarios – maintenance aspects

In scenarios depicted in Figure C.4 it is clear that maintenance affects operational availability, but not technical availability, as it is planned and scheduled. Wind turbine designs which require less maintenance will have higher measured operational availabilities. According to the definitions and priorities established in this technical specification, planned corrective actions have a higher priority than maintenance, and a manual data entry may be needed to allocate time to planned corrective action after the scheduled maintenance is completed in scenario 3.2.

Scenario 4 – operational aspects

MEANING OF COLOURS: GREEN = included in period hours as available RED = included in period hours as unavailable GREY = excluded from period hours			Mandatory — Information categories														
			Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Out of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	Information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
	Operational availability															X	
	Technical availability																X
4. Operations		**Comments**															
4.1	Gusty high winds exceed cut out speed for 5 h	Turbines with higher cut out speeds will report higher operational availability, same technical availability	163			5										97,0 %	100,0 %
4.2	Turbine has a failed part in a lightning storm and the unit could not be entered for 20 h, before the 4-h repair is completed. The week also includes a 40-h grid outage	Definitions handle each point of view	104					40			4	20				61,9 %	96,3 %
4.3	Unit has to untwist 6 times at 10 min each time		167		1											99,4 %	100,0 %
4.4	A gearbox pump failure causes 10 h of down time and while the crew is there they do a planned retro on a control card in the top box for 2 h more	Repair switch and manual entry needed	156							2	10					92,9 %	92,9 %
4.5	A lightning strike over the specification causes the turbine to come off line half way through the week	Manual entry needed. The unit will see this as a fault. Reporting 100 % available seems odd. The turbine could be more tolerant of lightning	84										84			50,0 %	100,0 %
4.6	A unit is down all week due to a gearbox failure. 20 h of regular scheduled maintenance is done during this time	Down time is a higher priority and you cannot enter maintenance from this state	0								168					0,0 %	0,0 %
4.7	Blade icing is detected and unit shuts down for 10 h. During this time, cable untwist and other system checks are performed for	Out of environmental specification is higher priority. Cannot go to standby from there	158			10										94,0 %	100,0 %

MEANING OF COLOURS: **GREEN** = included in period hours as available **RED** = included in period hours as unavailable **GREY** = excluded from period hours			**Mandatory — Information categories**														
			Full performance (IAOGFP)	**Partial performance (IAOGPP)**	**Technical standby (IAONGTS)**	**Out of environ spec (IAONGEN)**	**Requested shutdown (IAONGRS)**	**Out of electrical spec (IAONGEL)**	**Maintenance (IANOSM)**	**Plan corrective action (IANOPCA)**	**Forced outage (IANOFO)**	**Suspended (IANOS)**	**Force majeure (IAFM)**	**Information unavailable (IU)**		**Operational availability (B.2)**	**Technical availability (B.3)**
	Operational availability															**X**	
	Technical availability																**X**
	2 h.																
4.8	There is a 2 day grid outage. During this time, 4 h of maintenance are performed, winds exceed specs for 8 h, and a planned repair is done for 2 h	Out of electrical specification is higher priority than out of environmental, lower than maintenance and repair	120					42	4	2						71,4 %	98,8 %
4.9	On an offshore unit, a generator fails just 5 h into the week, but rough seas prevent access the entire rest of the week	Technical availability is reported at 100 %	5									163				3,0 %	100,0 %
4.10	Bat diurnal patterns cause the unit to be shut down for 2 h each day		154				14									91,7 %	100,0 %
4.11	Turbine faults offline for an overtemp. pitch motor and restarts after a 2-h cooling period. This happens 10 times.	Cooling is recovery from a design issue - forced outage time	148								20					88,1 %	88,1 %
4.12	2 h into a repair of a failed part, lightning and high winds stop all work for 16 h then it resumes and is completed in 2 more hours	Suspend is higher priority than forced outage. Manual entry needed. The unit will see this as a fault	148								4	16				88,1 %	97,4 %

Figure C.5 – Verification scenarios – operational aspects

The operational scenarios depicted in Figure C.5 more fully illustrate the distinction between operational availability and technical availability to the specifications, and the usefulness of these metrics in assessing overall availability performance. In scenario 4.1, for example, the wind turbine shuts down as expected for winds which exceed the maximum design limit. Although this is per design, from the operator's viewpoint of the wind turbine and system, the

unit is unavailable, causing lost operating hours. Units with lower cut-out speeds will have comparable technical availability, but lower operational availability.

Scenario 4.2 illustrates the use of priorities and definitions to handle complicated combinations of events. Note that in scenario 4.6, performing planned maintenance during a forced outage is a part of effective operations, but the forced outage is a higher priority and the unit remains unavailable.

Scenario 4.9 highlights the difficultly in accounting for safety suspension hours. From the operator's system view, the unit is clearly unavailable, and while the lost hours contribute to wind turbine unavailability since the cause of the initial forced outage was a part failure, the safety suspension prevents this condition from being corrected, extending the forced outage. The technical availability metric is not charged with this lost operating time. However, to report the unit as 100 % technically available during this time period is an apparent contradiction to the low operational availability.

Scenario 5 – grid / electrical network aspects

			Mandatory □ Information categories														
MEANING OF COLOURS: **GREEN** = included in period hours as available **RED** = included in period hours as unavailable **GREY** = excluded from period hours			Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Out of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	Information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
		Operational availability														X	
		Technical availability															X
5. Electrical		**Comments**															
5.1	A unit operates for 80 h then is in forced outage for 4 h. There is a grid outage later in the week	Out of electrical specification hours are included as available in turbine availability since the unit is operable	80					84			4					47,6 %	97,6 %

Figure C.6 – Verification scenarios – grid / electrical network aspects

As shown in Figure C.6, scenario 5.1, hours when the system is outside of its electrical design specifications are considered unavailable from the operator's system perspective but not from the wind turbine perspective since this is clearly beyond the control of the wind turbine.

A forced outage, however, is a higher priority, and a unit which is in the forced outage state at the beginning of a grid outage would remain in a forced outage, despite the fact that it is unlikely the unit can be returned to service before the electrical system is brought back in to specification.

Scenario 6 – Environmental aspects

			Mandatory □ Information categories															
MEANING OF COLOURS: GREEN = included in period hours as available RED = included in period hours as unavailable GREY = excluded from period hours			Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Out of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	Information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
	Operational availability															X	
	Technical availability																X
6. Environment		**Comments**															
6.1	Winds are below the cut in speed for 68 h in a week	100 % technically available, but lost operating hours due to low winds	100			68										59,5 %	100,0 %
6.1a	Same as 6.1, but uses optional state "out of environment - calm"	*100 % operational availability if the optional state – out of environmental calm winds is included as available. No lost operation due to WTGS														100,0 %*	100,0 %
6.2	Winds are only above the cut in speed for 8 h in the week, the turbine is faulted for 4 h and runs for 4 h	Lost hours due to wind speeds outside specification affect operational availability, not technical availability	4			160					4					2,4%	97,6 %
6.2a	Same as 6.2, but uses optional state "out of environment - calm"	*97,6 % operational availability if the optional state – out of environmental calm winds is included as available														97,6 %*	97,6 %
6.3	Good winds, but temperatures are below operating minimum for 68 h	Low operational availability ties to lost production due to cold. All out of environmental specification hours could be excluded from availability calculation and availability would be 100 %, but this does not reflect lost potential operating hours	100			68										59,5 %	100,0 %
6.4	A unit operates for 80 h then is in forced outage for 4 h and then temperatures drop to -30 °C and all units stop	Forced outage and out of environment specification affect operational availability same, but not technical availability	80			84					4					47,6 %	97,6 %

			Mandatory □ Information categories															
MEANING OF COLOURS: **GREEN** = included in period hours as available **RED** = included in period hours as unavailable **GREY** = excluded from period hours			Full performance (IAOGFP)	Partial performance (IAOGPP)	Technical standby (IAONGTS)	Out of environ spec (IAONGEN)	Requested shutdown (IAONGRS)	Out of electrical spec (IAONGEL)	Maintenance (IANOSM)	Plan corrective action (IANOPCA)	Forced outage (IANOFO)	Suspended (IANOS)	Force majeure (IAFM)	Information unavailable (IU)		Operational availability (B.2)	Technical availability (B.3)
	Operational availability															X	
	Technical availability																X
	operation																
6.5	A turbine rated for 30 °C operation stops operation for 20 h due to temperatures rising to 35 °C	Turbines designed for higher temperatures will have higher operational availability, but technical availability is 100 % per design	148			20										88,1 %	100,0 %
6.6	A turbine rated for 40 °C operation continues to operate for 20 h as temperatures rise to 35 °C	Operational availability of the better turbine is higher, as expected	168			0										100,0 %	100,0 %

Figure C.7 – Verification scenarios – environmental aspects

The scenarios depicted in Figure C.7 review environmental scenarios, primarily the impact on calculated availability metrics of ambient temperatures and wind speed above or below the design specification of the turbine.

Scenario 6.1, for example, illustrates the loss of availability due to low wind speed. Although there is little potential for production, the unit cannot operate outside its design limits and is therefore unavailable to the operator, but is fully available technically. This apparent contradiction is resolved through the use of the optional state for out of environmental specification – calm. Similarly, when the ambient temperature is above or below the design limit, the wind turbine is also operationally unavailable, but technically available.

Wind turbines which through better design have broader operating ranges of wind speed and ambient temperature will have higher operational availability, as expected since they will likely actually operate for more hours, though both might have the same technical availability according to their respective designs. This is shown in scenarios 6.5 and 6.6.

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