

Operating manual

Description and operation

ENERCON E-138 EP3 E3 wind energy converter

Publisher

ENERCON GmbH ▪ Dreekamp 5 ▪ 26605 Aurich ▪ Germany
Phone: +49 4941 927-0 ▪ Fax: +49 4941 927-109
E-mail: info@enercon.de ▪ Internet: <http://www.enercon.de>
Managing Directors: Dr. Jürgen Zeschky, Dr. Martin Prillmann, Dr. Michael Jaxy
Local court: Aurich ▪ Company registration number: HRB 411
VAT ID no.: DE 181 977 360

Copyright notice

The entire content of this document is protected by copyright and – with regard to other intellectual property rights – international laws and treaties. ENERCON GmbH holds the rights in the content of this document unless another rights holder is expressly identified or obviously recognisable.

ENERCON GmbH grants the user the right to make copies and duplicates of this document for informational purposes for its own intra-corporate use; making this document available does not grant the user any further right of use. Any other duplication, modification, dissemination, publication, circulation, surrender to third parties and/or utilisation of the contents of this document – also in part – shall require the express prior written consent of ENERCON GmbH unless any of the above is permitted by mandatory legislation.

The user is prohibited from registering any industrial property rights in the know-how reproduced in this document, or for parts thereof.

If and to the extent that ENERCON GmbH does not hold the rights in the content of this document, the user shall adhere to the relevant rights holder's terms of use.

Registered trademarks

Any trademarks mentioned in this document are intellectual property of the respective registered trademark holders; the stipulations of the applicable trademark law are valid without restriction.

Reservation of right of modification

ENERCON GmbH reserves the right to change, improve and expand this document and the subject matter described herein at any time without prior notice, unless contractual agreements or legal requirements provide otherwise.

Document details

Document ID	D02468862/3.3-en		
Note	Original instructions. Source document of this translation: D02468862/3.2-de/2022-07-06		
Date	Language	DCC	Plant/department
2022-07-28	en	DC	WRD Wobben Research and Development GmbH / Documentation Department

Applicable documents

The titles of the documents listed are the titles of the original language versions, with translations of these titles in brackets where applicable. The titles of superordinate standards and guidelines are indicated in the original language or as an English translation. Document IDs always refer to the original language versions. If the document ID does not contain a revision, the most recent revision of the document applies. This list contains documents concerning optional components if necessary.

Higher-level standards and guidelines

Document ID	Document
DIBt 2012	Guideline on wind energy converters, influences and stability analyses for tower and foundation, Deutsches Institut für Bautechnik (DIBt), Berlin, October 2012 version
DIN EN ISO 13849-1:2018	Safety of machinery – Safety-related parts of control systems
EN 50110-1:2013	Operation of electrical installations – Part 1: General requirements
IEC 60204-1:2016	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
IEC 61400-1:2005+A1:2010	Wind turbines – Part 1: Design requirements

Associated documents

Document ID	Document
D0154407	Technische Beschreibung ENERCON Eisansatzerkennung (Technical description ENERCON ice detection system)
D0226958	Gebrauchsanleitung Steigschutzsystem Bornack Railstop RS-S05 CSA (Operating manual Bornack Railstop RS-S05 CSA fall arrest system)
D02298629	Technische Beschreibung Wassergefährdende Stoffe E-138 EP3 E3 (Technical description for substances hazardous to the aquatic environment E-138 EP3 E3)
D02344880	Montage-, Gebrauchs- und Instandhaltungsanleitung Zweiholmleiter LMB (Assembly, operating and maintenance instructions for LMB dual-rail ladders)
D02382286	Technische Beschreibung Beschilderung E-138 EP3 E3 (Technical description of signage E-138 EP3 E3)
D0245140	Gebrauchsanleitung Steigschutzsystem Bornack Railstop RS-S05 (Operating manual Bornack Railstop RS-S05 fall arrest system)
D02467708	Betriebsanleitung TOPlift L+ edition (Operating manual TOPlift L+ edition)
D02548550	Gebrauchsanleitung Steigschutzsystem Climbttec CT-02 (Operating manual Climbttec CT-02 fall arrest system)
D02584682	Technische Beschreibung Anschlagpunkte zur Personensicherung E-115 EP3 E4, E-138 EP3 E3 (Technical description of anchorage points E-115 EP3 E4, E-138 EP3 E3)

Document ID	Document
D0314266	Betriebsanleitung PLANETA EME Kettenzug EM50/1SFS (Operating manual PLANETA EME EM50/1SFS chain hoist)
D0340045	Technische Beschreibung Automatische Löschesysteme für Windenergieanlagen (Technical description automatic extinguishing systems for wind energy converters)
D0360464	Betriebsanleitung LIFTKET Kettenzug Star (Operating manual LIFTKET Star chain hoist)
D0376121	EG-/EU-Konformitätserklärung für die Windenergieanlage (EC/EU declaration of conformity for the wind energy converter)
D0464436	Verfahrensanleitung Aufstellung von Warnschildern bei Eiswurf (Procedure instructions for putting up warning signs in case of ice throw)
D0648865	Technisches Datenblatt Installationsorte der Feuerlöscher (Technical data sheet – Installation locations of fire extinguishers)
D0701831	Technisches Datenblatt Installationsorte der Rauchschalter (Technical data sheet – Installation locations of smoke detectors)
D0734076	Technische Beschreibung Wölfel-Eisansatzerkennung (Technical description of the Wölfel ice detection system)
D0754506	Bedienungsanleitung G-servicelift GWB-300-L (Operating instructions for GWB-300-L G-service hoist)
D0788324	Wartungsplan ENERCON Windenergieanlagen (Maintenance plan – ENERCON wind energy converters)
D0819725	Gebrauchsanleitung Steigschutzsystem Bornack Railstop RS-S06 (Operating manual Bornack Railstop RS-S06 fall arrest system)
D0969220	Montage- und Betriebsanleitung Hailo Aluminiumsteigleiter 72x25 60x25 (Assembly and operating manual Hailo aluminium safety ladder 72x25 60x25)
D0974730	Gebrauchsanleitung Steigschutzsystem Bornack Railstop RS-S06 CSA (Operating manual Bornack Railstop RS-S06 CSA fall arrest system)
D0976141	Betriebsanleitung Demag Kettenzug DC-Wind (Operating manual Demag DC-Wind chain hoist)
D0998452	Produktbeschreibung LMB-Fangschiene Tr280 mit HAILO-Leiter 72x25 (Product description LMB Tr280 safety rail with HAILO ladder 72x25)

Table of contents

1	About this document	11
1.1	Target groups and purpose	11
1.2	Text and layout conventions	12
1.3	Contact details	12
2	Product overview	14
3	Safety	15
3.1	Safety information	15
3.1.1	Risk levels in safety warnings	15
3.1.2	Pictograms in safety warnings	16
3.2	Intended use	16
3.3	Operator responsibilities	17
3.4	Danger zone	20
3.5	Personnel requirements	21
3.5.1	Permitted persons	21
3.5.2	Persons not permitted	21
3.5.3	Qualification levels	22
3.5.4	Required training	23
3.6	Personal protection equipment	23
3.6.1	Responsibilities of the operator	23
3.6.2	Personal protection equipment required at all times	23
3.6.3	Personal protection equipment required for particular situations	24
3.6.4	Example of a personal fall protection system	24
3.7	Dangers in and on the wind energy converter	25
3.7.1	Dangers in the wind energy converter overall	25
3.7.2	Danger from exceptional weather conditions	28
3.7.3	Danger from ice shedding and ice throw	29
3.7.4	Dangers from consumables and auxiliary materials	30
3.7.5	Dangers in the tower, tower base and foundation	32
3.7.6	Dangers when using the safety ladder	32
3.7.7	Dangers when using the service hoist	35
3.7.8	Dangers in the machine house	36
3.7.9	Dangers when using the nacelle crane	37
3.7.10	Dangers associated with the rotor lock	39
3.7.11	Dangers in the rotor head	40
3.7.12	Dangers in the generator	41
3.7.13	Dangers on the nacelle roof	42
3.8	Anchorage points	43
3.9	Safety signs	43

3.10	Safe conduct	43
3.10.1	Basic rules	43
3.10.2	Conduct in the event of accidents	44
3.10.3	Conduct in the event of fire	44
3.10.4	Conduct during storms and thunderstorms	44
3.10.5	Conduct in the event of rotor overspeed	45
3.11	Safety equipment	45
3.11.1	Main switch	45
3.11.2	Emergency stop buttons	46
3.11.3	Transformer emergency switching off button	47
3.11.4	Nacelle light and presence switch	48
3.11.5	Tower door safety lock	48
3.11.6	Transformer enclosure	48
3.11.7	Electric locking system	49
3.11.8	Emergency shutdown of medium-voltage switchgear	49
3.11.9	Medium-voltage switchgear explosion protection	50
3.11.10	Automatic extinguishing system	50
3.11.11	Fire extinguishers	51
3.11.12	Smoke detectors	51
3.11.13	First aid kit	51
3.11.14	Rescue equipment	51
3.11.15	Warning signals	52
3.11.15.1	Overview	53
3.11.15.2	Warning device self-test	54
4	Assemblies	55
4.1	Overview	55
4.2	Rotor blade	56
4.2.1	Components in the rotor blade	57
4.3	Nacelle	58
4.3.1	Components in the rotor head (1)	59
4.3.2	Components in the rotor head (2)	60
4.3.3	Components in the rotor head (3)	61
4.3.4	Components in the generator	62
4.3.5	Components on the roof module	63
4.3.6	Components in the machine house (1)	64
4.3.7	Components in the machine house (2)	65
4.3.8	Components in the machine house (3)	66
4.3.9	Components in the machine house (4)	68
4.3.10	Components in the machine house (5)	69
4.3.11	Components of the rotor lock	70
4.4	Tower	71

4.4.1	Components in the tower base	72
4.4.2	Components on the lower level in the tower base	73
4.4.3	Components in the upper tower area	74
5	Operating controls and indicators	76
5.1	Wind energy converter control console	76
5.2	Nacelle control cabinet	78
5.3	Stator control cabinet	80
5.4	Transformer control cabinet	82
5.5	Nacelle lighting control centre	84
5.6	Generator rotor main distribution system	85
5.7	Pitch control cabinet	86
5.8	Wind energy converter display	87
5.8.1	Login	87
5.8.2	Start page	88
5.8.3	Active state	90
5.8.4	Menu	92
5.8.4.1	Overview	92
5.8.4.2	Manual pitching	92
5.8.5	Notifications	94
6	Operation and functions	96
6.1	Power generation and conditioning	96
6.2	Power supply for on-site power consumption	96
6.3	Operating modes	97
6.4	Electrical configuration with FACTS properties	98
6.5	Wind energy converter monitoring	99
6.6	Remote monitoring	101
6.7	Pitch control	101
6.8	Yawing	103
6.9	Cable untwisting	103
6.10	Lighting	103
6.11	Heating of electrical components	104
6.12	Ice detection	104
6.13	Nacelle positioning with ice-build up	104
6.14	Extreme climate equipment	105
6.15	Cooling of the medium-voltage components and the power electronics	106
6.16	Generator cooling	107
6.17	Fire protection system	107
6.17.1	Technical fire safety	107
6.17.2	Organisational fire safety	108
6.17.3	Fire-fighting by the fire brigade	109

6.18	Lightning protection system	109
6.19	Storm control	110
6.20	Noise optimisation	110
6.21	Beacon system components and coloured marking	110
6.21.1	Beacon system components	110
6.21.2	Coloured markings	111
6.22	Sector management	111
6.23	Shadow shutdown	112
7	Operation	113
7.1	Preparing for operation	113
7.2	Operating the yaw system	115
7.3	Starting the wind energy converter	117
7.4	Stopping the wind energy converter	118
7.5	Operating rotor blades manually	118
7.6	Clearing a fault message	120
7.6.1	Clearing a non-safety-relevant fault message	120
7.6.2	Clearing a safety-related fault message	121
7.7	Setting the rotor lock and enabling access to the rotor head and to the generator	122
7.8	Blocking access to the rotor head and to the generator	129
7.9	Releasing the rotor lock	130
7.10	Operating the nacelle crane	132
7.10.1	Transporting materials and tools up to the nacelle	133
7.10.2	Transporting materials and tools down from the nacelle	134
7.11	Concluding operation	135
8	Moving about the wind energy converter	137
8.1	Entering the wind energy converter and making preparations	137
8.2	Using the service hoist	139
8.3	Using the safety ladder	140
8.4	Entering and exiting the nacelle	142
8.5	Entering and exiting the rotor head	145
8.6	Entering and exiting the nacelle roof	146
8.7	Performing final steps and exiting the wind energy converter	148
9	Maintenance	150
10	Repair, retrofitting and replacement of parts	151
11	Malfunctions and troubleshooting	152
12	Decommissioning, dismantlement and disposal	153

13	Technical specifications	154
13.1	General data	154
13.2	Operating data	155
13.3	Nacelle data	156
13.4	Rotor and pitch control data	156
13.5	Generator data	157
13.6	Tower data	158
13.7	Design requirements	159
13.8	Type plate	161

List of abbreviations

EPK	ENERCON PartnerKonzept
FACTS	Flexible Alternating Current Transmission System
FRT	Fault Ride Through
FT	FACTS Transmission (electrical configuration with FACTS properties)
FTQ	FACTS Transmission with Q+ option (electrical configuration with extended reactive power range)
FTQS	FACTS Transmission with Q+ option and STATCOM option (electrical configuration with extended reactive power range and STATCOM option)
FTS	FACTS Transmission with STATCOM option (electrical configuration with STATCOM option)
HST	Hybrid steel tower
HT	Hybrid tower
IEC	International Electrotechnical Commission
SIP	Service Info Portal
STATCOM	Static compensator
TES	Trailing edge serration
UPS	Uninterruptible power supply

1 About this document

This document forms a part of the wind energy converter. It must be stored inside the wind energy converter and be accessible at all times. When the wind energy converter is handed over to the operator, the document is in the wind energy converter folder. This is located in the tower base.

Other documents This manufacturer's document forms part of a complex collection of information. In certain situations, important information may be required from other documents, such as operator documents or legal regulations.

Applicable documents The *Applicable documents* list is situated above the table of contents. This lists documents that must be consulted in conjunction with this document in the manufacturer's opinion. These include *Higher-level standards and guidelines* and *Associated documents* that supplement the contents of this document or explain them in more detail. *Associated documents* form part of this document.

EC/EU declaration of conformity The EC/EU declaration of conformity in the *Applicable documents* list is a model. The legally valid copy of the EC/EU declaration of conformity that contains the serial number of the wind energy converter and the manufacturer's signature is delivered to the operator when the wind energy converter is handed over.

Description of different versions This document also describes optional components. The actual scope of supply may differ from the explanations and illustrations in this document as a result of customisations, the omission of optional components or the latest engineering changes.

Abstract illustrations The illustrations serve as an aid to understanding and may differ slightly from the actual design of the wind energy converter. Some illustrations have been simplified to improve clarity.

Technical service provider This document mentions only ENERCON Service as a technical service provider. If the operator has commissioned another service provider to perform maintenance or other work, replace 'ENERCON Service' with the name of that service provider.

1.1 Target groups and purpose

Target groups The target groups for this document are:

- Owner of the wind energy converter
- Operator of the wind energy converter who has overall responsibility for safe operation
- Persons authorised by the operator/owner to enter the wind energy converter, access the different areas and operate the wind energy converter

- Purpose** This document serves the following purposes:
- Understanding the basic functions of the wind energy converter
 - Understanding and preventing dangers
 - Identifying components and their installation locations in the wind energy converter
 - Accessing different areas of the wind energy converter, as far as this is described in this document
 - Performing operator actions described in this document
 - Looking up technical specifications

1.2 Text and layout conventions

Representation of additional notes



Additional notes for better understanding have a background with grey lines and are identified by this symbol.

- ✓ Identifies a prerequisite for the subsequent work steps.
- 1. (Numbering) indicates lists or work steps, depending on context.
- ⇒ Identifies instructions in safety instructions.
- ↪ Identifies the expected result of an action.

Italics Identifies names of objects and messages where a literal reproduction is required, as well as quoted headings.

‘Quotation marks’ These identify text portions that are meant to stand out from the body text, such as quotations, special technical terms and document titles.

Code typeface Denotes textual messages on displays generated by the software; example:

- The status message `Turbine operational` is displayed.

1.3 Contact details

Manufacturer ENERCON GmbH
 Dreekamp 5
 26605 Aurich
 Germany
 Phone: +49 4941 927-0
 Fax: +49 4941 927-109
info@enercon.de
www.enercon.de

Points of contact

You can reach ENERCON Service around the clock by calling the telephone number of the relevant service station.

The telephone number and other information can be found in the ENERCON SIP on the internet at <https://sip.enercon.de>.

ENERCON is always interested in new information and experience gained from using its products that could contribute to their continuous improvement.

2 Product overview

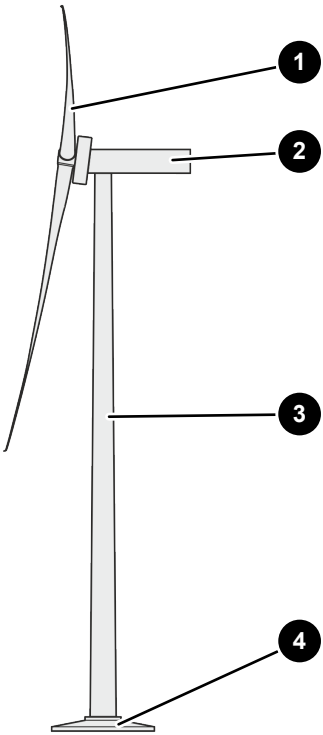


Fig. 1: Wind energy converter

1	Rotor blade	2	Nacelle
3	Tower	4	Foundation

The wind energy converter generates electrical energy from the wind. Wind flowing towards the wind energy converter causes the rotor to rotate clockwise. This rotational movement is converted into electrical energy. The wind energy converter operates automatically.

The wind energy converter essentially consists of the tower, the rotating nacelle with adjustable rotor blades and electrical components for generating and conditioning the electrical energy.

3 Safety





3.1 Safety information

Safety information is organised as follows:

- Safety instructions** All content in ch. 3, p. 15 is understood to be safety instructions. Safety instructions serve as a guide and as preliminary information. They enable basic actions to be taken and safety-oriented conduct to be maintained in order to prevent injury or damage.
- Safety warnings** Safety warnings warn of dangers in specific action situations. Accordingly, safety warnings are situated at the relevant points in this document. By prescribing specific actions, they make it possible to put safety-oriented conduct into practice directly, i.e. to prevent injury or damage.
- Safety signs** Signs are mounted on the wind energy converter that warn of dangers and indicate the correct conduct or action.
Further information is available in document D02382286 'Technische Beschreibung Beschilderung E-138 EP3 E3' (Technical description of signage E-138 EP3 E3).

3.1.1 Risk levels in safety warnings

Safety warnings are preceded by signal words that identify the degree of risk.

	<p>⚠ DANGER</p> <p>... points out an imminently hazardous situation which, if not avoided, will result in death or serious injury.</p>
	<p>⚠ WARNING</p> <p>... points out a potentially hazardous situation which, if not avoided, may result in death or serious injury.</p>
	<p>⚠ CAUTION</p> <p>... points out a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.</p>
	<p>NOTICE</p> <p>... points out a potentially hazardous situation which, if not avoided, may result in damage to property or the environment.</p>

3.1.2 Pictograms in safety warnings

Safety warnings contain pictograms that designate the type of danger involved.



General warning sign



Risk of falling



Risk of danger from electric voltage



Risk of floor-level obstacles



Risk of hand injuries



Risk of crushing

3.2 Intended use

The wind energy converter is exclusively intended for the following:

- Generating electrical energy from wind energy
- Feeding the electrical energy into the power grid

Depending on its configuration, the wind energy converter can also help stabilise the grid, for example by providing reactive-power compensation.

Intended use also includes:

- Making use of the operating manual and applying its contents
- All necessary maintenance work

The wind energy converter is a walk-in machine and an enclosed electrical operating area according to IEC 60204-1:2016.

Misuse

Misuse of the wind energy converter is prohibited. Misuse can result in severe injury and serious property damage. In the event of misuse, claims against ENERCON are excluded.

The following are considered misuse:

- Any use that does not conform to the intended use

- Manipulation of safety equipment such that it is rendered ineffective
- Incorrect handling of safety equipment such that it is rendered ineffective
- Unauthorised installations and modifications that negatively affect safety
- Use of non-approved auxiliary materials, consumables or lubricants
- Use of components as steps or as storage spaces

Specific examples of misuse include:

- Working in the rotor head with the rotor lock not set
- Jamming or clamping buttons on the nacelle crane control console
- Storing materials inside the wind energy converter
- Using the wind energy converter as a jumping platform for extreme sports
- Holding events in the wind energy converter
- Using the wind energy converter as a recreation room
- Using the wind energy converter as a flying ground for hobby model flying, e.g. for drone races

Manipulating safety equipment or performing unauthorised installation and conversion tasks can result in a loss of conformity in accordance with the declaration of conformity.

3.3 Operator responsibilities

The operator in the context of this document has overall responsibility for safe operation of the wind energy converter. This overall responsibility entails obligations for the operator that are explained in this section. ENERCON can support the operator in fulfilling these obligations.

Guaranteeing occupational safety

If the wind energy converter is used for commercial purposes, the operator in their role as employer must comply with the applicable occupational health and safety protection regulations to ensure occupational health and safety.

Providing and understanding the operating manual

The operator must ensure that all personnel operating the wind energy converter or performing any other work in or around the wind energy converter have read and understood this operating manual and the applicable documents.

When the wind energy converter is handed over to the operator, the operating manual is in the wind energy converter folder. This is located in the tower base. The operator is responsible for ensuring that the wind energy converter folder with the operating manual is available in a complete and legible form in the wind energy converter at all times. The operating manual must be stored in plain view or at an agreed place that is easily accessible.

If the operating manual is damaged, illegible or missing, the operator must replace it. A replacement copy can be obtained from ENERCON.

Creating instructions for safe use

The operator must familiarise themselves with the occupational health and safety protection regulations applicable at the installation site of the wind energy converter in order to ensure occupational health and safety. The operator must also carry out a risk assessment at work to determine any dangers that may arise from the particular working conditions prevailing at the installation site of the wind energy converter. The findings from this must then be converted into instructions for safe use for the operation of the wind energy converter.

The operator must clearly specify the responsibilities, e.g. for operation, maintenance, repair and cleaning. They must also establish rules concerning permanently available contingency personnel.

Provision of training sessions

In accordance with the laws and accident prevention regulations applicable at the installation site of the wind energy converter, the operator must provide training on a regular basis to all persons that enter the wind energy converter who are not employees of ENERCON or any other specialised company.

This training must include the handling of components described in separate documents. One example is documentation from suppliers.

The training must also cover proper conduct in the event of accidents and hazardous situations. This includes first aid, the use of fire extinguishers and life-saving equipment and how to raise the alarm in the event of an accident or fire.

The operator must provide the above-mentioned persons with the necessary personal protection equipment and train them in its use.

The operator must document the delivery of training and instruction measures.

Ensuring proper condition

The operator is responsible for keeping the wind energy converter in proper condition at all times. ENERCON would be pleased to assist the operator with this task.

Non-conformity with the target state must be assessed by experts. The operator is responsible for deciding on the course of action if irregularities, problems or damage occur. This might include, for example, reporting chains and action plans.

The operator must immediately notify ENERCON of any irregularities, problems or damage they observe on the wind energy converter. This applies in particular if components relevant to safety are affected or if the operator is unable to assess the consequences of the damage.

Implementing protective measures against potential ice throw/ice shedding

As a protective measure against potential ice throw/ice shedding, the operator/owner must determine the site-specific danger zone and must demarcate this zone using warning signs if necessary. Procedure instructions for setting up the warning signs can be found in the wind energy converter folder and are listed under *Applicable documents*.

Checking safety equipment	<p>The operator must check the functionality and completeness of all safety equipment on a regular basis or have this checked by ENERCON Service.</p> <p>The operator must ensure that the electrical components of the safety equipment are overhauled after 20 years so that they will last for the remaining service life of the wind energy converter. This can be ensured by means of a proof test (cf. DIN EN ISO 13849-1:2018) or by replacing the components.</p> <p>If electrical components of the safety equipment are replaced before this time, this must be permanently documented (up until the end of the service life of the wind energy converter).</p>
Carrying out and recording of maintenance activities	<p>The operator must ensure that the planned maintenance is performed according to the schedule. The operator must ensure that all work performed on the wind energy converter is recorded. The following information must be included:</p> <p>Data specific to the wind energy converter</p> <ul style="list-style-type: none"> ■ Site and operator ■ Manufacturer, type and serial number ■ Serial numbers of rotor blades, generator and tower ■ Total operating hours and energy generated <p>Details specific to the activity</p> <ul style="list-style-type: none"> ■ Names of persons performing the activity and, if applicable, names of other persons present ■ Date, time and duration ■ Description of scope of activities ■ Parts replaced (where applicable) ■ Wind speed and temperature during activities ■ Resulting information, e.g. inspection results, necessary actions
Inspection of personal protection equipment	<p>The operator must regularly check and maintain the personal protection equipment of the personnel according to current regulations. Defective parts must be replaced.</p>
Compliance with requirements of building permit	<p>The operator must comply with the requirements from the type testing and building permit of the wind energy converter. This could take the form, for example, of prescribed recurring inspections of the wind energy converter by an expert inspector contracted for this purpose by the operator.</p>
Observe reporting obligation in the event of a beacon system failure	<p>The operator must report any failure of the obstruction or hazard beacons to the relevant aviation authority (e.g. Deutsche Flugsicherung) without delay.</p>
Checking of fire extinguishers	<p>The operator must have the fire extinguishers in the wind energy converter inspected at regular intervals to ensure that they are operable. All applicable local regulations must be observed.</p>

- Replacement of signs**
- The operator must immediately replace any signs or stickers that have become illegible or are missing. This applies in particular to safety signs.
- Keeping work areas and rescue routes clear**
- The operator must keep all work areas and rescue routes clear, unobstructed and in proper condition.

3.4 Danger zone

Outside the wind energy converter

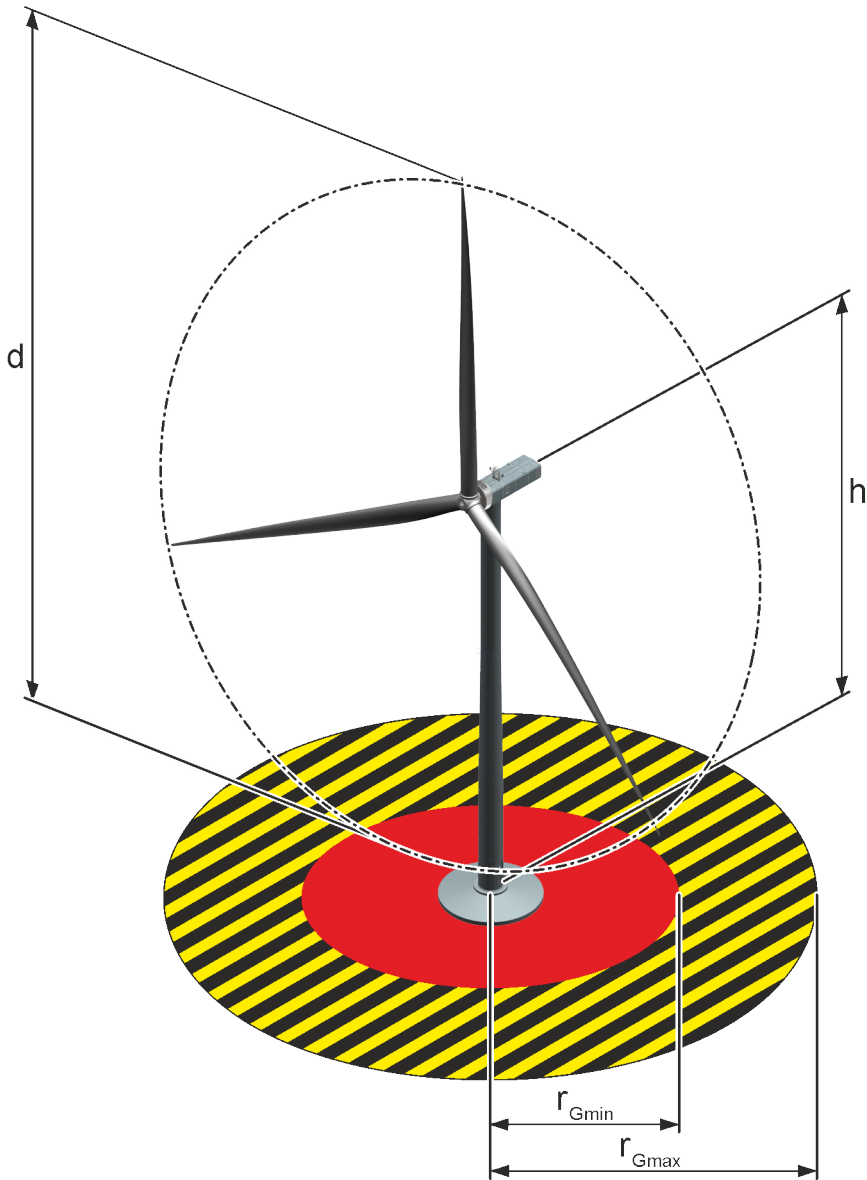


Fig. 2: Danger zone outside the wind energy converter

h	Hub height
d	Rotor diameter
r_{Gmin}	Minimum danger zone radius = $0.5 \times d$
r_{Gmax}	Maximum danger zone radius = $1.5 \times (h + d)$

The danger zone outside the wind energy converter depends on various factors, including wind speed and rotor speed. For this reason, the size of the danger zone varies from case to case.

- The minimum danger zone G_{\min} of the wind energy converter lies within a horizontal circle with the tower at its centre. The radius of this circle is calculated from the rotor diameter using the following formula:

$$r_{G_{\min}} = 0.5 \times d.$$
- The maximum danger zone G_{\max} of the wind energy converter lies within a horizontal circle with the tower at its centre. The radius of this circle is calculated from the rotor diameter and hub height using the formula given below. This formula is derived from empirical values for how far objects (e.g. chunks of ice) can possibly be thrown:

$$r_{G_{\max}} = 1.5 \times (h + d).$$

In order to determine the site-specific danger zone, the operator must carry out a site-specific risk assessment. This applies in particular where there is a potential risk of ice throw. Local official directives in particular may require that warning signs be erected.

Inside the wind energy converter

The danger zone within the wind energy converter is the entire wind energy converter, i.e. the internal areas of the foundation, tower, nacelle and rotor blades. The wind energy converter is locked by means of a lockable door. The door can be opened from the inside at any time by means of a panic lock. The wind energy converter constitutes an enclosed electrical operating area.

The information concerning the danger zone within the wind energy converter applies to the technical equipment provided by ENERCON. If the technical equipment is changed or supplemented, the danger zone must be redetermined in a new risk assessment.

3.5 Personnel requirements

3.5.1 Permitted persons

Persons who enter the wind energy converter must meet the following basic requirements:

- These persons must be in possession of the qualifications required for the activities to be performed. Local and occupation-specific regulations must be taken into account. In Germany, persons who ascend within the tower must, for example, have passed the occupational preventive medical check-up in accordance with guideline G41 of the liability insurance association, 'Arbeiten mit Absturzgefahr (Working with risk of falling)'.
- These persons must be authorised by their supervisor.
- These persons must be in good health and physically fit.

3.5.2 Persons not permitted

The following persons may not enter the wind energy converter:

- Persons who do not meet the basic requirements

- Persons whose ability to act has been impaired through medication, alcohol or other drugs
- Persons with active medical devices, such as an artificial pace-maker or an insulin pump

3.5.3 Qualification levels

The 3 qualification levels – A, B and C – are based on the basic requirements for permitted persons:

Qualification level A These are persons who have little or no knowledge about the wind energy converter and possible dangers. These are ordinary persons. They may only enter the wind energy converter and the danger zone outside it under constant supervision by a person with qualification level B or C. The operator must inform these persons about risks and safe conduct beforehand.

Qualification level B These are persons who have all the knowledge and skills required to enter the wind energy converter, access its different areas and operate it safely to the extent described in this document.

Qualification level C These are qualified persons who are capable of safely performing specialised work on the wind energy converter such as maintenance work, repairs or troubleshooting. These persons must have all the necessary skills, knowledge and authorisation. The activities that can be performed by persons with qualification level C are beyond the scope of this document.

The following table summarises the qualification levels by assigning specific characteristics to each level.

Tab. 1: Qualification level characteristics

Characteristic	A	B	C
Person has been informed of risks and proper conduct.	X	X	X
Person is accompanied and supervised by a person with qualification level B or C.	X		
Person has been briefed by the operator about potential dangers and how to avoid them. They can prevent dangers caused by electricity. In Europe, a minimum qualification as an (electrically) instructed person according to EN 50110-1:2013 is required.		X	X
Person can enter the wind energy converter, access the different areas and operate it safely thanks to their technical vocational training, knowledge and experience. They are capable of independently detecting and preventing potential dangers.		X	X

Characteristic	A	B	C
Person can perform the activities assigned to them safely thanks to their technical vocational training, knowledge and experience. Person has in-depth specialist knowledge concerning the activities to be performed and can independently detect and avoid potential dangers.			X

3.5.4 Required training

For a person to reach qualification levels B or C, various elements of training are required, for example in the use of personal fall protection systems, the safety ladder or the service hoist. ENERCON is happy to provide advice on this matter and offers an extensive training programme that can be found at www.enercon.de.

3.6 Personal protection equipment

3.6.1 Responsibilities of the operator

- The operator must evaluate the hazards and provide the appropriate personal protection equipment on this basis. The operator must ensure that sufficient rescue equipment is available on site.
- The operator must take into account the relevant applicable regulations.
- The operator must ensure that the personal protection equipment is used safely and correctly. This includes:
 - Providing regular training for the users.
 - Instructing the users to give the personal protection equipment a visual and functional check prior to each use and only to use personal protection equipment that is in proper working condition.
 - Having the personal protection equipment checked by an expert inspector at specified intervals.

3.6.2 Personal protection equipment required at all times

The following personal protection equipment is required at all times in the danger zone of the wind energy converter:



Head protection

To protect the head from falling objects and from impact when falling or when working in cramped conditions.



Foot protection

Protection against foot injuries caused by objects or contact with hot or chemical materials.

3.6.3 Personal protection equipment required for particular situations

The following personal protection equipment is required in the danger zone of the wind energy converter in certain situations:



Protective workwear

Close-fitting work clothes with low tear resistance, tight sleeves and no protruding parts.



Hand protection

Protection against hand injuries caused by objects or contact with hot or chemical materials.



Ear protection

Protection against hearing damage caused by loud noise.



Safety goggles

To protect eyes from small falling objects, dirt particles and flying sparks.



Personal fall protection system

For protection from falling from height.



Rescue equipment

To enable injured persons to be abseiled down or the wind energy converter to be evacuated.

3.6.4 Example of a personal fall protection system

The following personal fall protection system is an example. The choice of an appropriate personal fall protection system is the responsibility of the operator.

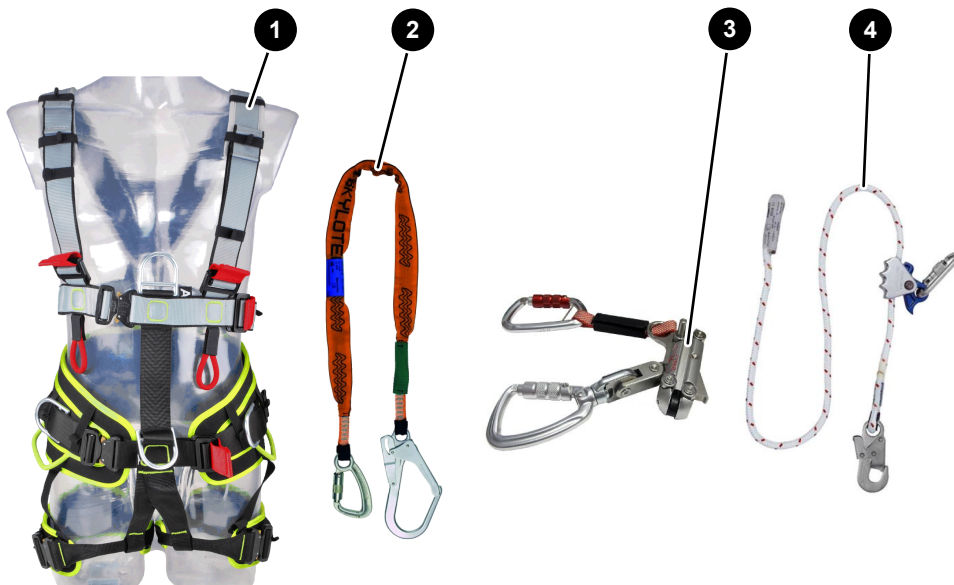


Fig. 3: Example of a personal fall protection system

1	Safety harness	2	Shock-absorbing lanyard
3	Guided-type fall arrester	4	Fall restraint lanyard

Safety harness The safety harness is worn on the body and distributes the forces that occur in a fall. After the fall, the safety harness holds the wearer in an upright position.

Shock-absorbing lanyard Two shock-absorbing lanyards reduce the forces that occur in a fall.

Guided-type fall arrester The guided-type fall arrester moves along the safety ladder together with the wearer to ensure a rigid anchor line.

Fall restraint lanyard The fall restraint lanyard acts as a support for safe positioning for work.

3.7 Dangers in and on the wind energy converter

The wind energy converter is designed such that dangers to persons are reduced to a minimum. Some dangers remain, however, despite the fact that the manufacturer has taken all appropriate and necessary protective measures in the design of the system.

3.7.1 Dangers in the wind energy converter overall

The dangers listed in this chapter affect multiple areas or all areas of the wind energy converter.

Fall from height

There is a risk of falling inside or from the wind energy converter. A fall from height normally results in severe injury or death.

- ⇒ Always use a personal fall protection system if there is a risk of falling. This applies when using the service hoist, for example.
- ⇒ Only attach the personal fall protection system to defined anchorage points. With the exception of the safety ladder, all anchorage points are marked in yellow.
- ⇒ When ascending or descending inside the tower, use both hands to hold on to the safety ladder whenever possible. Do not carry anything in your hands.

Confined spaces

Hazards such as forced postures and collisions can occur in confined spaces. Confined spaces can also result in increased physical strain and increased electrical hazards.

- ⇒ Do not remain in confined spaces longer than necessary.
- ⇒ Do not remain in confined spaces without supervision.
- ⇒ Ensure that possibilities are in place for rescuing casualties.
- ⇒ Ensure that a system of communication is established with the person acting as guard, so that rescue measures can be initiated at any time.

Falling objects

Materials and other objects can fall in an uncontrolled manner and cause serious injury or death.

- ⇒ Wear head protection when inside or near the wind energy converter.
- ⇒ Use tear-resistant, body-hugging sling bags to carry tools, materials, keys and other loose items, and secure them against falling out.
- ⇒ Close the hatches after you have climbed through.
- ⇒ Transport larger tools and materials using the nacelle crane or service hoist.
- ⇒ Use a guide rope to secure loads when transporting them with the nacelle crane. While doing so, keep a safe distance from the tower.
- ⇒ If several persons are using the safety ladder, keep close to one another so that any accidentally falling objects do not have time to pick up speed.
- ⇒ Alternatively, wait until accidentally falling objects no longer pose a hazard to persons below.
- ⇒ Do not remain in the area of the safety ladder when people are climbing up or down.

Objects left lying about

Objects left lying about such as tools, containers and materials can cause people to trip or slip. If people fall into or over them, this can result in severe injury from hitting edges, for example.

Objects left lying about can also block escape routes or make them harder to use.

- ⇒ Keep the work environment clean and tidy. Remove any waste materials.
- ⇒ Keep escape routes clear.

Dirt

Oil and grease spills or dirt brought in from outside, for example, can make the work environment dirty. Dirt on walkways, steps, ladder rungs and grab handles can cause people to slip and fall. A fall can result in severe injury from hitting edges, for example.

- ⇒ Remove any dirt and waste materials.

Corners and edges

Structural elements and fixtures in the wind energy converter may have pointed corners and sharp edges. These areas may cause injuries if grasped or bumped into.

- ⇒ Wear protective gloves if there is any chance of coming into contact with pointed corners and sharp edges.
- ⇒ Be particularly careful and avoid sudden movements when near pointed corners and sharp edges.
- ⇒ Wear protective gloves when on the safety ladder.
- ⇒ Generally wear protective gloves as the situation requires.

Electric current

Touching live components can cause severe injury and even death.

- ⇒ Keep electrical cabinets closed. Electrical cabinets may only be opened by authorised specialist personnel.
- ⇒ Keep moisture away from live parts.

Damaged safety equipment

Damaged safety equipment poses a threat of severe and even fatal injury. Safety can only be ensured if all safety equipment is fully functional.

- ⇒ Do not disable the safety equipment.
- ⇒ Ensure that safety equipment, such as emergency stop buttons, is accessible.
- ⇒ Check that safety guards have been properly installed.
- ⇒ Before starting work, check the safety equipment and replace safety equipment that is obviously defective or have it repaired.
- ⇒ Have the safety equipment inspected in accordance with the maintenance instructions.

Failure of the warning signals

The failure of warning signals can result in persons not being warned in the event of a dangerous situation and not being able to move to safety in good time.

- ⇒ Check the warning signals each time the wind energy converter is entered.

Missing documentation

This operating manual and the documentation of additional components such as the service hoist, safety ladder and nacelle crane must be accessible to personnel and must be read and understood by all personnel before entering the wind energy converter. Missing documentation leads to lack of information and thus to dangers to persons.

- ⇒ Keep the documentation in an accessible place.
- ⇒ Read the documentation before entering the wind energy converter or before using the respective components.
- ⇒ Add any documentation that is missing.

Hot surfaces

Various components of the wind energy converter, such as the generator, can heat up during operation. Touching these parts can result in skin burns.

- ⇒ Do not touch hot surfaces without protection.

Noise

The operation of the wind energy converter, in particular at high wind speeds, causes high noise levels inside the wind energy converter. Prolonged exposure to noise or sudden noise peaks can cause permanent damage to hearing.

- ⇒ When personnel enter, stop the wind energy converter.
- ⇒ Wear ear protection if there is noise.

3.7.2 Danger from exceptional weather conditions

Maintenance wind speed exceeded

If the maintenance wind speed is exceeded, the nacelle can oscillate, which can cause persons to trip and fall.

An alarm is triggered if the maintenance wind speed of 23 m/s is exceeded over a 10-minute mean.

- ⇒ Leave the nacelle and descend through the tower.
- ⇒ Do not use the service hoist.
- ⇒ Switch the wind energy converter to automatic mode and leave.

High temperatures

Under certain climatic conditions, the temperature inside the wind energy converter can rise to approx. 50 °C. High fluid loss from perspiration can impair a person's health and ability to concentrate.

- ⇒ Avoid staying inside the wind energy converter during high temperatures.
- ⇒ When inside the wind energy converter for extended periods, take appropriate measures for the situation, such as wearing light clothing and carrying plenty of potable water.

Thunderstorms

A lightning strike can set the wind energy converter on fire and may directly or indirectly cause severe injury or death.

- ⇒ If a thunderstorm is approaching, descend from the nacelle immediately. Descending in the service hoist is allowed. It is safe to stay in the tower base, provided that the wind energy converter is not on fire.
- ⇒ Do not touch any components that serve as lightning conductors or provide equipotential bonding between parts of the wind energy converter.
- ⇒ Notify ENERCON Service if the wind energy converter shows damage from lightning strikes.

Flooding and extreme wind conditions

Flooding or extreme wind conditions can damage the wind energy converter. Under certain circumstances the stability of the wind energy converter can no longer be ensured. Electrical dangers and fire risk may be caused by short circuits.

- ⇒ In the event of flooding, switch off the wind energy converter.
- ⇒ Have all relevant components tested before restarting the wind energy converter.

3.7.3 Danger from ice shedding and ice throw

Ice shedding and ice throw

With the wind energy converter stopped, ice can fall from the wind energy converter in chunks of different sizes (ice shedding); when the wind energy converter is running, it can be flung off by the rotating rotor (ice throw). Ice throw or ice shedding can cause serious injury or even death.

- ⇒ If there is a danger of ice throw, keep out of the maximum danger zone.
- ⇒ If there is a danger of ice shedding in combination with very high wind speeds, keep out of the maximum danger zone.
- ⇒ If there is a danger of ice shedding in combination with low wind speeds or calm conditions, keep out of the minimum danger zone.
- ⇒ Pay attention to any ice warning signs or ice warning lights in the vicinity of the wind energy converter.
- ⇒ Exercise extreme caution when entering the danger zone where this is unavoidable. Wear head protection throughout the danger zone.

Ice shedding and ice throw during the detection and de-icing period

There is a danger of ice throw during the detection period for ice build-up and also in the event of a manual restart while the wind energy converter is de-icing. There is a danger of ice shedding while the wind energy converter is stationary. Ice throw or ice shedding can cause serious injury or even death.

- ⇒ Refrain from performing a manual restart during the de-icing period if at all possible.

Ice throw with activated blade heating system

If the blade heating system is activated following ice detection and the wind energy converter is in operation, the formation of ice cannot be ruled out. Ice that has been thawed by the blade heating system may be thrown off (ice throw). Ice throw can result in severe injury or death.

- ⇒ Only ever use the blade heating system after ensuring that ice throw cannot injure anyone or cause damage to property.

3.7.4 Dangers from consumables and auxiliary materials

Oil and grease

Defects in certain components of the wind energy converter may result in leakage of oil or grease. This can impair the function of the wind energy converter and increases the fire hazard.

Oils and greases may contain toxic substances. They pose an environmental hazard and can be harmful to human health on contact with skin.

Oils and greases make objects slippery and can cause slips and falls.

- ⇒ Avoid physical contact with leaked oil or grease. Keep oil and grease away from food items.
- ⇒ Wipe up and completely remove any leaked or spilled oil or grease immediately using liquid-binding material (sand, sawdust, etc.) and/or an absorbent cloth. Use a suitable solvent, if necessary. Where walkways and working areas, ladder rungs and grab handles are affected in particular, ensure that all oil and grease residue is removed completely.
- ⇒ Wipe up or catch any leakage.
- ⇒ Properly dispose of oil and grease together with any cleaning agents and materials that have come into contact with these substances.
- ⇒ Notify ENERCON Service if there is a risk that the proper working condition of the wind energy converter has been compromised.

Further information is available in document D02298629 'Technische Beschreibung Wassergefährdende Stoffe E-138 EP3 E3' (Technical description for substances hazardous to the aquatic environment E-138 EP3 E3).

Fire extinguishers

The use of fire extinguishers poses the risk of injury from the effects of cold and from an increased CO₂ concentration. There is an additional danger of electric shock where fire extinguishers are used near electrical systems such as electrical cabinets.

- ⇒ Do not touch the quenching gas or cooled surfaces.
- ⇒ Warn persons in the vicinity.
- ⇒ Keep as much distance as possible from electrical systems.

- ⇒ Train personnel in the use of CO₂ fire extinguishers and in working in an oxygen-reduced environment.

Extinguishing agent used by the automatic extinguishing system

The automatic extinguishing system can be inadvertently triggered when electrical cabinets are opened. The extinguishing agent is electrically conductive and can come into contact with live parts. Touching the extinguishing agent can carry a risk of death from electric shock. There is a danger of damage to health from skin contact, eye contact, inhalation or swallowing.

- ⇒ Electrical cabinets may only be opened by authorised specialist personnel after the automatic extinguishing system has been deactivated.

Further information is available in document D02298629 'Technische Beschreibung Wassergefährdende Stoffe E-138 EP3 E3' (Technical description for substances hazardous to the aquatic environment E-138 EP3 E3).

Flammable materials

Storing and keeping combustible or easily flammable materials within the wind energy converter increases the risk of fire.

- ⇒ Do not store or keep combustible or easily flammable materials in the wind energy converter.

Coolant of the cooling system for the power electronics components

Leaks can result in cooling liquid escaping from the cooling system for the power electronics components. This may compromise the functionality of the wind energy converter.

The cooling liquid is mildly hazardous to the aquatic environment and can pollute the environment. The cooling liquid makes objects slippery and may cause falls. The cooling liquid can lead to poisoning if swallowed.

- ⇒ Wipe up and completely remove any leaked or spilled cooling liquid immediately using an absorbent cloth and, where necessary, a suitable binder. It is particularly important to clean up spills from walkways, working areas, ladder rungs and grab handles.
- ⇒ Notify ENERCON Service if there is a risk that the proper working condition of the wind energy converter has been compromised.

Further information is available in document D02298629 'Technische Beschreibung Wassergefährdende Stoffe E-138 EP3 E3' (Technical description for substances hazardous to the aquatic environment E-138 EP3 E3).

3.7.5 Dangers in the tower, tower base and foundation

Foundation basement in hybrid towers

Hybrid towers have a circular void inside the foundation. Depending on the tower type, this basement is used for tensioning and anchoring the prestressing tendons of the tower. This is also where cables from the power grid run to the medium-voltage switchgear. A hatch leads to the foundation basement.

Various dangers are present in and around the foundation basement. When the hatch is open there is a risk of falling. Toxic gases can become concentrated in the foundation basement and can put persons entering the basement at risk of suffocation. There are additional difficulties associated with rescuing a person from the foundation basement. Water may accumulate in the foundation basement. This results in a risk of slipping.

Because of the dangers present in the foundation basement, only authorised specialist personnel may enter it, observing the appropriate safety measures.

- ⇒ Keep the hatch to the foundation basement closed.
- ⇒ Do not enter the foundation basement.

Lower level in the tower base

The safety ladder leads from the tower entrance level to the lower level in the tower base. It is not possible to rescue people from the lower level without rescue equipment.

- ⇒ When a person descends to the lower level in the tower base, stand ready for deployment with rescue equipment at the tower entrance level.

Overloading the tower floors

The maximum load on the tower floors is 300 kg/m². Overloading the tower floor poses a risk of collapse.

- ⇒ Observe the maximum load of the tower floors.

3.7.6 Dangers when using the safety ladder

Fall from height

There is a risk of falling when using the safety ladder. A fall from height normally results in severe injury or death.

- ⇒ Use a personal fall protection system when ascending or descending in the tower.
- ⇒ Use both hands to hold on to the safety ladder wherever possible. Do not carry anything in your hands.

Tower floor hatches

Fingers can be trapped and crushed when closing the hatches of the tower floors. This applies particularly to winged hatches. Hatches can also make a loud bang if allowed to fall, which could damage hearing.

- ⇒ Open and close the hatches carefully. Only take hold of the hatches through the finger holes.
- ⇒ With winged hatches, keep fingers away from the joint between the halves of the hatch.

Physical overexertion

Only persons who are in good health and physically fit may enter the wind energy converter and use the safety ladder. However, ascending the safety ladder can still result in physical overexertion.

- ⇒ Use the service hoist where possible.
- ⇒ Keep the weight you are carrying with you to a minimum.
- ⇒ Take adequate breaks.

Falling objects

Materials and other objects can fall in an uncontrolled manner and cause serious injury or death.

- ⇒ Wear head protection when inside or near the wind energy converter.
- ⇒ Use tear-resistant, body-hugging sling bags to carry tools, materials, keys and other loose items, and secure them against falling out.
- ⇒ Close the hatches after you have climbed through.
- ⇒ Transport larger tools and materials using the nacelle crane or service hoist.
- ⇒ If several persons are using the safety ladder, keep close to one another so that any accidentally falling objects do not have time to pick up speed.
- ⇒ Alternatively, wait until accidentally falling objects no longer pose a hazard to persons below.
- ⇒ Do not remain in the area of the safety ladder when people are climbing up or down.

Simultaneous use of service hoist and safety ladder

If the service hoist and the safety ladder are used simultaneously, there is a risk of injury on the safety ladder. It is, therefore, forbidden to use both items of equipment simultaneously.

- ⇒ Only ever use the service hoist when nobody is on the safety ladder.
- ⇒ Only ever use the safety ladder when the service hoist is not in use.

Corners and edges

The safety ladder may have pointed corners and sharp edges. These areas may cause injuries if grasped or bumped into.

- ⇒ Wear protective gloves when on the safety ladder.
- ⇒ Be particularly careful and avoid sudden movements when near pointed corners and sharp edges.

Attaching rescue equipment to the safety ladder

If rescue equipment is attached anywhere that is not intended for use as an anchorage point, there is a risk of falling.

- ⇒ Only use the permitted anchorage points.
- ⇒ The safety ladder may only be used by trained personnel. Ensure that ladder rescue is covered during training.

Further information is available in document D02584682 'Technische Beschreibung Anschlagpunkte zur Personensicherung E-115 EP3 E4, E-138 EP3 E3' (Technical description of anchorage points E-115 EP3 E4, E-138 EP3 E3).

Using the safety ladder without a guided-type fall arrester

There is a risk of falling if the safety ladder is used without a guided-type fall arrester. This may be necessary when exiting the service hoist in an emergency, for example.

- ⇒ When leaving the service hoist in an emergency, secure yourself to the safety ladder by alternating the shock-absorbing lanyards.
- ⇒ Secure yourself with a guided-type fall arrester as soon as possible.

Blocked escape route

The service hoist can block the first escape route (down the safety ladder) in a dangerous situation. This happens if persons are present above the service hoist. According to the manufacturer's documentation, the access hatches in the roof and floor of the service hoist can be opened to allow persons to climb through. This will make the escape take longer.

- ⇒ The service hoist and the safety ladder may only be used by trained personnel.
- ⇒ Plan an escape and emergency response system for the service hoist and safety ladder and train personnel appropriately. The plan must cover all conceivable emergencies including, for example, rescuing unconscious persons.
- ⇒ Read the service hoist manufacturer's documentation.
- ⇒ Use a personal fall protection system.
- ⇒ Keep a mobile telephone or two-way radio with you.

Small tread depth on safety ladder

At certain points in the tower the tread depth on the safety ladder is small, as there is not much space behind the rungs. In places with small tread depth there is a danger of slipping from the rung.

- ⇒ Use both hands when climbing up or down.
- ⇒ Look out for obstacles.

Moving from the safety ladder to a tower floor

There is a risk of falling when moving from the safety ladder to a tower floor or vice versa if the person is not secured.

- ⇒ Use the service hoist instead of the safety ladder whenever possible.

- ⇒ Always secure yourself against falling.

3.7.7 Dangers when using the service hoist

Observe the information given in the service hoist operating manual in addition to the dangers listed in this section. The manual is kept in the document pouch inside the service hoist and is listed under *Applicable documents*.

Defects

A defective service hoist poses dangers for the user. There is a risk of death if a defect causes the service hoist to fall from a height.

- ⇒ Inspect the service hoist as per the manufacturer's documentation prior to use.
- ⇒ If the service hoist appears defective, take it out of service. Attach a clear sign and arrange for repair.
- ⇒ Perform maintenance on the service hoist according to the manufacturer's documentation.

Simultaneous use of service hoist and safety ladder

If the service hoist and the safety ladder are used simultaneously, there is a risk of injury on the safety ladder. It is, therefore, forbidden to use both items of equipment simultaneously.

- ⇒ Only ever use the service hoist when nobody is on the safety ladder.
- ⇒ Only ever use the safety ladder when the service hoist is not in use.

Fire

Various dangers are present if the service hoist is used in the event of a fire, e.g. interruption of the power supply, damage to the suspension or secondary ropes and damage to the rope suspension. Persons could be trapped inside the service hoist.

- ⇒ If there is a fire in the nacelle, leave the nacelle via the safety ladder towards the tower base. Depending on the hazard situation, the service hoist can also be used to descend.
- ⇒ If there is a fire in the tower base or tower, climb up into the nacelle using the safety ladder and leave the nacelle using the rescue equipment via the crane hatch.
- ⇒ If a fire breaks out in the tower base while the service hoist is in use, climb up into the nacelle using the safety ladder and leave the nacelle using the rescue equipment via the crane hatch.

Enclosure door

There is a risk of limbs becoming trapped or severed when opening or closing the enclosure door.

- ⇒ Open and close the enclosure door with caution.

Travel path

There is a crushing and collision hazard along the travel path and on the landing of the service hoist.

- ⇒ Do not place any limbs in the travel path of the service hoist.
- ⇒ Keep a safe distance from the guardrail.
- ⇒ Do not reach into the service hoist rope guides, rope rollers or areas which are not visible.
- ⇒ Do not remove protective covers.
- ⇒ Keep out of the floor area on which the hoist cage touches down for boarding.

Low temperatures

When the temperature inside the tower is very low, the functioning of some components of the service hoist can be restricted. The service hoist may fall.

- ⇒ Do not use the service hoist when the temperature inside the tower is very low. For more information, see the service hoist operating manual. The manual is kept in the document pouch inside the service hoist.

Blocked escape route

The service hoist can block the first escape route (down the safety ladder) in a dangerous situation. This happens if persons are present above the service hoist. According to the manufacturer's documentation, the access hatches in the roof and floor of the service hoist can be opened to allow persons to climb through. This will make the escape take longer.

- ⇒ The service hoist and the safety ladder may only be used by trained personnel.
- ⇒ Plan an escape and emergency response system for the service hoist and safety ladder and train personnel appropriately. The plan must cover all conceivable emergencies including, for example, rescuing unconscious persons.
- ⇒ Read the service hoist manufacturer's documentation.
- ⇒ Use a personal fall protection system.
- ⇒ Keep a mobile telephone or two-way radio with you.

3.7.8 Dangers in the machine house

Machine house hatch

When the machine house hatch is open, there is a risk of falling.

- ⇒ Close the machine house hatch after climbing through.

Passing by the yaw motors

The passage width at the yaw motors is narrow. There is a tripping hazard.

- ⇒ To move past the yaw motors, make short sideways steps while keeping the body upright.

Extinguishing agent used by the automatic extinguishing system

The automatic extinguishing system can be inadvertently triggered when electrical cabinets are opened. The extinguishing agent is electrically conductive and can come into contact with live parts. Touching the extinguishing agent can carry a risk of death from electric shock. There is a danger of damage to health from skin contact, eye contact, inhalation or swallowing.

- ⇒ Electrical cabinets may only be opened by authorised specialist personnel after the automatic extinguishing system has been deactivated.

Further information is available in document D02298629 'Technische Beschreibung Wassergefährdende Stoffe E-138 EP3 E3' (Technical description for substances hazardous to the aquatic environment E-138 EP3 E3).

Coolant of the cooling system for the power electronics components

Leaks can result in cooling liquid escaping from the cooling system for the power electronics components. This may compromise the functionality of the wind energy converter.

The cooling liquid is mildly hazardous to the aquatic environment and can pollute the environment. The cooling liquid makes objects slippery and may cause falls. The cooling liquid can lead to poisoning if swallowed.

- ⇒ Wipe up and completely remove any leaked or spilled cooling liquid immediately using an absorbent cloth and, where necessary, a suitable binder. It is particularly important to clean up spills from walkways, working areas, ladder rungs and grab handles.
- ⇒ Notify ENERCON Service if there is a risk that the proper working condition of the wind energy converter has been compromised.

Transformer

The transformer is located inside a closed enclosure. The inside of this enclosure poses a danger of electric shock. This may lead to severe or fatal injury.

- ⇒ The transformer enclosure may only be opened by authorised specialist personnel with additional medium voltage switching authorisation.

3.7.9 Dangers when using the nacelle crane**Crane hatch**

The crane hatch is open during operation of the nacelle crane. There is a risk of falling for persons near the crane hatch.

- ⇒ Wear a personal fall protection system and secure yourself to an anchorage point using a shock-absorbing lanyard.
- ⇒ Before opening the crane hatch, ensure that all persons in the danger zone are secured by the personal fall protection system.
- ⇒ Close the crane hatch after use.

Damaged nacelle crane

If the nacelle crane is damaged, there is a risk of injury to persons.

- ⇒ Check the stability of the crane pillar before use.
- ⇒ Inspect the operational limit switch that stops the upward travel of the chain on every day that the nacelle crane is used.
- ⇒ Visually inspect the chain when lowering and winding.
- ⇒ Make sure that the chain runs correctly into the chain locker.

Failure to observe the operating conditions

The following conditions must be taken into consideration to ensure safe use of the nacelle crane.

- ⇒ Do not exceed the maximum load of the nacelle crane. The maximum load is stated on a sign on the nacelle crane.
- ⇒ Only use the nacelle crane when at least the rotor holding brake is activated.
- ⇒ Do not use the crane to transport persons.
- ⇒ Do not operate the nacelle crane in inching mode (i.e. constantly switching on and off). It should be operated continuously at a low lifting speed.
- ⇒ Do not bypass or jam any of the buttons. Use the other hand to operate the control console if one hand becomes tired.
- ⇒ Do not hoist loads at an angle. Do not exceed an angle of 1.5°.
- ⇒ Approach the end position of the nacelle crane slowly.

Use of the nacelle crane

When using the nacelle crane, there is a risk of crushing for the feet when lowering the load onto the nacelle floor or the ground and also a risk of crushing for the fingers in the rollers of the trolley. Touching the chain can also result in crushing or abrasions.

- ⇒ Only authorised specialist personnel may operate the nacelle crane.
- ⇒ Do not touch the chain.

Insufficient securing of the load

There is a risk of injury to persons from loads that are not sufficiently secured.

- ⇒ Use a guide rope to guide the load.
- ⇒ Ensure that the guide rope secured to the crane hook cannot come loose by itself.
- ⇒ Secure the load firmly. Place small parts in secured containers.

Suspended loads

When using the nacelle crane, there is a risk of injury to persons from suspended loads.

- ⇒ When using the nacelle crane, ensure that the crane hatch is not situated above the tower entrance area. Only start to operate the crane once the crane hatch has been rotated at least $\pm 30^\circ$ away from the tower entrance area.

- ⇒ Ensure that no persons are present in the danger zone (e.g. between the load and the ground). During the lifting procedure, pay attention to the danger zone.
- ⇒ Keep clear of suspended loads.

Lack of communication equipment

For safe operation of the nacelle crane, there must be communication between the nacelle crane operator and the employee on the ground.

- ⇒ Use a two-way radio or clear visual signs. Agree on the signals in advance so that all participants know clearly what is meant.
- ⇒ Only start the lifting procedure once an employee on the ground has given a clear signal to do so.
- ⇒ If the nacelle crane operator does not have a clear view of the danger zone (e.g. due to darkness), an employee on the ground is responsible for giving instructions.

Overhead lines

At wind speeds above 8 m/s, the nacelle crane chain may swing and come into contact with overhead lines near the wind energy converter. The chain can then become a live part and pose a risk of electric shock to persons in the nacelle. In addition, the loads can fall and cause severe or fatal injuries.

- ⇒ Do not use the nacelle crane in the vicinity of an overhead line at wind speeds above 8 m/s.
- ⇒ When using the nacelle crane, rotate the nacelle so that the nacelle crane is as far as possible from the overhead line.

3.7.10 Dangers associated with the rotor lock

Generator rotor not locked

The generator rotor can start to move if the rotor is not locked or not completely locked or if the rotor lock is defective. This may result in persons being crushed between the stationary and the rotating parts of the generator. This can result in severe injury or death.

- ⇒ Do not remove the covers from the access openings in the generator stator and do not climb, lean or reach into the rotor head through the openings of the generator stator unless the rotor is locked.
- ⇒ If the rotor lock or the electric locking system is defective, cancel the rotor locking, do not enter the rotor head and arrange for a repair.
- ⇒ Only enter the rotor head or the generator if the rotor is locked.
- ⇒ Ensure that all rotor lock bolts are fully engaged.
- ⇒ Ensure that the 3 rotor lock indicator lights are on green.
- ⇒ Before releasing the rotor lock, ensure that no-one is present in the rotor head, the rotor blades, the generator or outside on the nacelle.

Exceeding the locking wind speed

The rotor lock may be damaged if the locking wind speed is exceeded. This reduces the reliability of the rotor lock and of the protection from unexpected rotation of the rotor while persons are present in the generator or the rotor head. If the locking wind speed of 16 m/s is exceeded over a 10-minute mean value, an alarm is triggered.

- ⇒ Use the rotor lock only at wind speeds with a 10-minute mean value of up to 16 m/s.
- ⇒ At wind speeds of > 16 m/s over a 10-minute mean value, exit the rotor head and release the rotor lock.

Hydraulic unit hand pump

There is little space near the hydraulic unit for the hand pump to be used. There is a danger of crushing and abrasions.

- ⇒ Wear gloves when operating the hydraulic unit.
- ⇒ Take care when operating the hydraulic unit hand pump.

Incorrect operation

Safe use of the rotor lock system requires expert technical knowledge. Actuating the rotor lock with the rotor spinning can damage the rotor lock and will trigger the immediate emergency pitching of the rotor blades and activation of the rotor holding brake (similar to an emergency stop).

- ⇒ The rotor lock may only be operated by authorised specialist personnel.

Hydraulic hose lines

The hydraulic hose lines for the rotor lock and the rotor holding brake must be replaced regularly. If the hydraulic system fails spontaneously, the rotor lock and rotor holding brake will not be available. Oil can be dispersed in the machine house in the form of mist and pose the danger of injury to the skin and eyes.

- ⇒ Perform a visual inspection of the hydraulic system before operating the hydraulic unit.
- ⇒ Wear safety glasses when operating the hydraulic unit.
- ⇒ Have the hydraulic hose lines replaced regularly.

3.7.11 Dangers in the rotor head

The dangers listed below arise if there are people inside the hub.

Rotor not locked

The rotor can start to move if the rotor is not locked or not completely locked or if the rotor lock is defective. This can cause people to be spun around in the rotor head. These persons can be crushed or thrown around. This can result in severe injury or death.

- ⇒ Do not enter the rotor head unless the rotor is locked.
- ⇒ Ensure that there are no persons in the rotor head before releasing the rotor lock.

Escape and rescue

Casualties are difficult to reach in the rotor head. Rescue equipment can be used only to a limited extent. The confined space makes rescue even more difficult.

- ⇒ Only enter the rotor head if strictly necessary.
- ⇒ Devise a concept for rescuing persons from the rotor head and provide appropriate training.
- ⇒ If necessary, deploy persons as guards or supervisors.
- ⇒ Ensure clear communication between all persons present.
- ⇒ When rescuing others, take care to ensure your own safety.

Slip ring unit

There is a danger of electric shock when opening the slip ring unit. The slip ring unit also contains carbon dust that can cause damage to health if inhaled.

- ⇒ Keep the slip ring unit closed.
- ⇒ Only authorised specialist personnel may open the slip ring unit after disconnecting the slip ring unit and wearing suitable respiratory protection.

3.7.12 Dangers in the generator

Rotor not locked

If the rotor is not locked or not completely locked, or if the rotor lock is defective, the rotor may start to move. This may result in persons being crushed between the stationary and the rotating parts of the generator. This can result in serious injury or death.

- ⇒ Do not enter the generator unless the rotor is locked.

Hot surfaces

During operation the generator can become hot. Touching the generator can result in skin burns.

- ⇒ Do not touch the generator without wearing protection while it is hot.

Slipping

There is a danger of slipping and falling.

- ⇒ Move slowly and with caution. Use the ladders in the generator.
- ⇒ Clean surfaces that are dirty.

Sharp edges

When ascending to the roof module through the generator, there is a danger of sustaining injury or damaging the personal fall protection system on sharp edges.

- ⇒ Move slowly and with caution. Use the ladder to the roof module.
- ⇒ Ensure that the personal fall protection system does not come into contact with the sharp edges.

3.7.13 Dangers on the nacelle roof

There are 2 accessible areas on the nacelle roof:

- The roof module is located on the generator. Access is through the generator when the generator is locked. A ladder that is permanently installed in the generator leads to the roof module.
- The roof of the machine house is accessed via a hook-on ladder.

Generator rotor not locked

Persons who want to access the roof module enter the generator from the machine house by passing through the access door to the generator. The access door to the generator can only be opened when the rotor lock is set.

The rotor lock must remain set whenever persons are in the generator or on the roof module. If the generator rotor is not locked, persons in the generator may be crushed. This can result in severe injury or death.

- ⇒ Do not enter the generator or the roof module unless the rotor is locked.
- ⇒ Ensure that no-one is present in the generator or on the roof module before releasing the rotor lock.

Fall from height

There is a risk of falling when outside on the nacelle. It is highly likely that falling from height off the nacelle roof would result in death.

- ⇒ Secure yourself with the personal fall protection system when on the nacelle roof.

Dazzle from beacon lights

The beacon lights on the nacelle roof are a powerful light source. Looking into the light can damage the eyes.

- ⇒ Do not look into the light from the beacon lights.

Overloading

If the nacelle roof is overloaded, this can result in injury and property damage.

- ⇒ A maximum of 2 persons may enter the accessible areas on the nacelle roof.
- ⇒ Only stand on the central catwalk on the roof of the machine house.

Slippery surfaces due to snow and ice

Wintry weather conditions present a risk of slipping. This may cause injuries.

- ⇒ Remove any snow and ice.

3.8 Anchorage points

Anchorage points are specifically designed and tested connection points to which persons with a personal fall protection system can attach themselves.

Further information is available in document D02584682 'Technische Beschreibung Anschlagpunkte zur Personensicherung E-115 EP3 E4, E-138 EP3 E3' (Technical description of anchorage points E-115 EP3 E4, E-138 EP3 E3).

3.9 Safety signs

Signs are mounted on the wind energy converter that warn of dangers and indicate the correct conduct or action.

Further information is available in document D02382286 'Technische Beschreibung Beschilderung E-138 EP3 E3' (Technical description of signage E-138 EP3 E3).

3.10 Safe conduct

3.10.1 Basic rules

To prevent injury to persons or property damage, observe the following basic rules for safe conduct in and on the wind energy converter:

- Always use the appropriate personal protection equipment.
- Keep enough rescue equipment to hand when working with a risk of falling.
- Always carry a mobile telephone so that an emergency call can be made.
- Ensure that a person is available within range to initiate first-aid and rescue measures in an emergency. Use suitable means of communication to communicate with others on site, e.g. two-way radios.
- Ensure that first-aid materials (first aid kits, blankets, etc.) are always available on site.
- Observe the escape and rescue plan and the emergency chart. They can be found right next to the wind energy converter control console in the tower base. In the nacelle, they are right next to the nacelle control cabinet.
- Before ascending the tower, stop the wind energy converter and switch it to manual mode.
- Do not smoke and do not consume alcohol or other drugs.
- Do not use any naked source of ignition and do not start a fire.
- If only the emergency lights are working, exit the wind energy converter immediately.
- Keep access roads to the wind energy converter clear for emergency vehicles.
- Keep escape routes clear.

- Close the entrance door to prevent unauthorised persons from entering.
- Check the local weather forecast in advance.

3.10.2 Conduct in the event of accidents

1. Press either an emergency stop button or the transformer emergency switching off button, depending on the situation.
2. Rescue persons from the danger zone.
3. Initiate (immediate) first aid measures, e.g. stem severe bleeding.
4. Make an emergency call.
5. Continue first aid measures.
6. Notify the responsible person at the site.

3.10.3 Conduct in the event of fire

1. Notify any other persons present in the wind energy converter.
2. Press either an emergency stop button or the transformer emergency switching off button, depending on the situation.
3. If necessary, rescue injured persons from the danger zone and initiate (immediate) first aid measures, e.g. stem severe bleeding.
4. Make an emergency call.
5. If your own safety is not at risk and a safe escape route is ensured, fight the fire using a fire extinguisher.

Additional measures if the fire cannot be extinguished immediately:

6. Leave the wind energy converter by the most suitable escape route. If possible, press a transformer emergency switching off button as you escape.
 - If there is a fire in the nacelle, leave the nacelle via the safety ladder towards the tower base. Depending on the hazard situation, the service hoist can also be used to descend.
 - If there is a fire in the tower base or tower, climb up into the nacelle using the safety ladder and leave the nacelle using the rescue equipment via the crane hatch.
 - If a fire breaks out in the tower base while the service hoist is in use, climb up into the nacelle using the safety ladder and leave the nacelle using the rescue equipment via the crane hatch.
7. Notify the technical manager of the utility in charge.
8. Secure the danger zone outside the wind energy converter against access.
9. Notify ENERCON Service.

3.10.4 Conduct during storms and thunderstorms

Measures to take if the wind speed increases to above 16 m/s:

1. Leave the rotor head, the nacelle roof and the generator.
2. Release the rotor lock.

3. Do not use the service hoist.

Additional measures to take if the wind speed increases above 23 m/s, the wind energy converter is oscillating heavily from gusts of wind, or a thunderstorm is approaching:

4. Stop all work above the tower base.
5. Descend to the tower base via the safety ladder.
6. Switch the wind energy converter to automatic mode and start it.
7. Wait in the tower base for the weather to become calmer.
8. Do not resume work until the weather has improved.

3.10.5 Conduct in the event of rotor overspeed

Measures to be taken if the rotor speed significantly exceeds the nominal speed and the safety equipment is obviously failing:

1. Press an emergency stop button.
2. When the rotor slows down, leave the wind energy converter without starting and arrange for the fault to be remedied.

Additional measures if the rotor does not slow down:

3. Reset the emergency stop button.
4. Clear the fault on the wind energy converter control console.
5. Set the *Maintenance* switch on the wind energy converter control console to *Off*.
6. Leave the wind energy converter and the danger zone outside the wind energy converter as quickly as possible.
7. Secure the danger zone outside the wind energy converter against access.
8. Notify ENERCON Service.

3.11 Safety equipment

3.11.1 Main switch



Fig. 4: Main switch

Type The main switches are rotary switches.

Installation location The main switches can be found at the following installation locations:

- On the control system UPS
- On the nacelle main distribution system
- On the stator control cabinet

- On the nacelle crane

Function The main switch on the stator control cabinet switches the stator control cabinet on and off.

The main switch on the nacelle main distribution system switches off the nacelle fans, the fans on the liquid cooling system chiller, the power supply to the yaw and pitch drives, and the lubrication pumps in the machine house.

The main switch on the control system UPS switches the power supply to the control system UPS from the internal DC link on and off.

The main switch on the nacelle crane switches the chain hoist on and off.

3.11.2 Emergency stop buttons

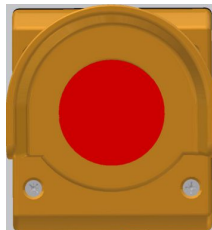


Fig. 5: Emergency stop button

Type The emergency stop buttons are push buttons with a mechanical latching function.

Installation location The emergency stop buttons in the tower base can be found at the following installation locations:

- On the wind energy converter control console

The emergency stop buttons in the nacelle can be found at the following installation locations:

- On the control panel of the nacelle control cabinet
- On the generator rotor main distribution system

The emergency stop button on the service hoist is located on the hoist cage.

Other emergency stop buttons may be present at other installation locations depending on the versions of the wind energy converter and service hoist.

Function When an emergency stop button is actuated in the tower base, the wind energy converter is brought into a safe state as follows:

- Emergency pitching of the rotor blades is triggered.
- The energy supply to the yaw motors for yawing is interrupted.
- The fans within the wind energy converter are switched off.
- The chiller is switched off.
- The blade heating system is switched off.

Once an emergency stop button is reset in the tower base, the emergency stop must be cleared on the wind energy converter control console.

When an emergency stop button is actuated on the control panel of the nacelle control cabinet, the wind energy converter is brought into a safe state as follows:

- Emergency pitching of the rotor blades is triggered.
- The rotor holding brake is activated once the rotor speed falls below a defined value.
- The energy supply to the yaw motors for yawing is interrupted.
- The nacelle fans are switched off.
- The blade heating system is switched off.
- The power units for the pitch unit are switched off.

Once an emergency stop button is reset on the control panel of the nacelle control cabinet, the emergency stop must be cleared at the nacelle control cabinet.

When the emergency stop button is actuated on the generator rotor main distribution system, this triggers an emergency stop of the pitch unit in service mode.

When an emergency stop button is actuated on the service hoist, the service hoist is stopped.

3.11.3 Transformer emergency switching off button

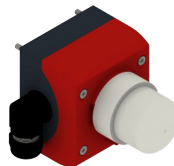


Fig. 6: Transformer emergency switching off button

Type The transformer emergency switching off buttons are red emergency switching off buttons that each have a lead seal cap and a housing cover. When actuated, the transformer emergency switching off buttons lock by means of an automatic latching function. The lead seal cap must be replaced when a transformer emergency switching off button is reset.

Installation location The transformer emergency switching off buttons can be found in the following installation locations:

- On the wind energy converter control console in the tower base
- On the transformer low-voltage distribution system in the machine house

Function When a transformer emergency switching off button is actuated, all power is isolated. An acoustic warning signal is also sounded. The wind energy converter is brought into a safe state as follows:

- Emergency pitching of the rotor blades is triggered.
- The load break switch in the transformer bay of the medium-voltage switchgear is switched off.
- The control voltage is switched off.
- Automatic restarting of the wind energy converter is prevented by a reset lock in the control system of the wind energy converter.

The protection functions are maintained even after the transformer emergency switching off button is unlocked, until they are reset manually. After the protection function is triggered, the medium-voltage switchgear must be reconnected manually.

3.11.4 Nacelle light and presence switch

Type The nacelle light and presence switch is a rotary switch.

Installation location The nacelle light and presence switch is situated near the entrance to the nacelle.

Function The nacelle light and presence switch is used to switch the light on and off in the nacelle. In its 'on' state, the nacelle light and presence switch signals to the control system of the wind energy converter that persons are present in the nacelle.

When the nacelle light and presence switch is on, the wind energy converter cannot be started up. Persons in the nacelle are warned by visual and acoustic signals in the following dangerous situations:

- If the locking wind speed is exceeded
- If the maintenance wind speed is exceeded
- If a fire is detected

3.11.5 Tower door safety lock

Type The tower door safety lock is a panic lock.

Installation location The safety lock is situated on the tower door.

Function The tower door safety lock enables quick and simple evacuation from the wind energy converter in an emergency or a dangerous situation, even if the tower door is locked.

3.11.6 Transformer enclosure

Type The transformer is fitted with an enclosure. This is made of individual plates that are installed around the transformer. The transformer enclosure cannot be walked upon. The plates can be partially or entirely removed for maintenance purposes.

Installation location	The transformer and its enclosure are located in the rear part of the machine house.
Function	The transformer enclosure acts as a contact guard to prevent electric shock and shields people present inside the machine house against electromagnetic radiation immissions.

3.11.7 Electric locking system

Type	The electric locking system is an electro-mechanical locking system.
Installation location	The electric locking system is used in the nacelle on the access door to the rotor head and on the access door to the generator.
Function	<p>The electric locking system is used to ensure safe access to the rotor head and to the generator. The electro-mechanical door lock on the access doors to the rotor head and to the generator is only released when the generator rotor is locked, the nacelle fans are switched off and when the manual valve of the rotor lock is in the <i>Set</i> position. As long as one of the two access doors is open, the manual valve of the rotor lock remains in the <i>Set</i> position.</p> <p>In an emergency or a dangerous situation, the electro-mechanical door lock can be released from the rotor head.</p>

3.11.8 Emergency shutdown of medium-voltage switchgear

Type	The emergency shutdown of the medium-voltage switchgear occurs automatically via a system on the transformer control cabinet.
Installation location	The emergency shutdown system of the medium-voltage switchgear is located on the transformer control cabinet in the machine house.
Function	<p>The transformer control cabinet switches the medium-voltage switchgear off in the following situations:</p> <ul style="list-style-type: none"> ■ If the transformer emergency switching off button is pressed ■ If a fire is detected ■ If an automatic fire extinguisher system is triggered ■ If an earth fault or fault current is detected in the wind energy converter ■ If increased oil pressure is detected in the transformer ■ If an insufficient oil level is detected in the transformer <p>All components connected to the transformer control cabinet are monitored by means of quiescent current. If an error is detected, the load break switch in the transformer bay of the medium-voltage switchgear is switched off. The reason for the shutdown is indicated by indicator lights on the transformer control cabinet and a display in the transformer control cabinet.</p>

3.11.9 Medium-voltage switchgear explosion protection

Type The switching elements of the medium-voltage switchgear are installed inside a gastight container filled with a highly effective insulating gas. The container is designed with a predetermined breaking point and linked to an overflow channel.

Installation location The medium-voltage switchgear explosion protection components are located on the medium-voltage switchgear at the lower level in the tower base.

Function The medium-voltage switchgear explosion protection system prevents injury to persons caused by explosions in the medium-voltage switchgear. Switching operations in the medium-voltage switchgear can result in electric arcs in the switching elements. These electric arcs cause the insulating gas in the container to heat up abruptly, thus increasing the pressure in the container. If the predetermined breaking point is reached, the container breaks and the gas is guided in a controlled manner into the overflow channel, where it can cool and escape safely.

3.11.10 Automatic extinguishing system

Type The automatic extinguishing system consists of fire detection elements and fine spray nozzles which are connected to an extinguishing agent reservoir via a pipe system.

Installation location The automatic extinguishing system is fitted in certain electrical cabinets in the nacelle.

Function The automatic extinguishing system extinguishes any fires that break out immediately at the seat of the fire, therefore preventing them from spreading.

The fire detection elements trigger when a defined temperature is exceeded. The pressure starts to rise and the extinguishing agent is pressed into the piping system and the fine spray nozzles.

When the automatic extinguishing system is triggered, the wind energy converter is disconnected from the power grid and is stopped.

Prior to maintenance work, the automatic extinguishing system must be disabled via the fire extinguishing system maintenance unit to prevent the automatic extinguishing system being triggered inadvertently.

Further information is available in document D0340045 'Technische Beschreibung Automatische Löschesysteme für Windenergieanlagen' (Technical description automatic extinguishing systems for wind energy converters).

3.11.11 Fire extinguishers

Type	The fire extinguishers in the wind energy converter are hand-held CO ₂ fire extinguishers.
Installation location	Fire extinguishers are located in the nacelle and the tower base of the wind energy converter. Further information is available in document D0648865 'Technisches Datenblatt Installationsorte der Feuerlöscher' (Technical data sheet – Installation locations of fire extinguishers).
Function	The fire extinguishers are used by persons present in the wind energy converter to fight incipient fires.

3.11.12 Smoke detectors

Type	The smoke detectors in the wind energy converter feature visual smoke detection and an additional temperature sensor.
Installation location	Smoke detectors can be found at the following installation locations: <ul style="list-style-type: none">■ In the tower base, above the medium-voltage switchgear■ In the nacelle, at the bottom on the main carrier■ In the machine house, above the transformer
Function	Smoke detectors are used to detect a fire in the wind energy converter. If smoke is detected, the wind energy converter is stopped.

3.11.13 First aid kit

Type	The first aid kits in the wind energy converter are first aid kits for workplaces with a maximum of 10 persons in compliance with nationally applicable standards and directives.
Installation location	First aid kits can be found at the following installation locations: <ul style="list-style-type: none">■ In the tower base, on the control console next to the tower door■ In the nacelle, on the control system UPS
Function	The first aid kits provide dressing material, adhesive plasters, etc. to render first aid to injured persons.

3.11.14 Rescue equipment

Type	The rescue equipment in the wind energy converter consists of an ab-seiling device.
-------------	---

Installation location The rescue equipment is situated in the machine house, close to the nacelle crane.

Function The rescue equipment is used for rescuing and evacuating persons from the nacelle in emergencies or dangerous situations if the first rescue route (descent inside the tower) is blocked. The rescue equipment enables persons to abseil from the machine house.

3.11.15 Warning signals

Type Warning signals are issued by means of visual and acoustic warning devices, visual warning devices or on the wind energy converter display start page.

Installation location Visual and acoustic warning devices are found at the following installation locations in the wind energy converter:

- In the tower base
- In the machine house
- In the rotor head

Visual warning devices are found at the following installation locations in the wind energy converter:

- In the service hoist
- On the operating control of the rotor lock

Wind energy converter displays are found at the following installation locations in the wind energy converter:

- On the wind energy converter control console in the tower base
- On the nacelle control cabinet in the machine house

Function The warning signals are used to warn persons if the wind energy converter is in an unsafe operating state. The visual warning signals of the warning devices are always active. The acoustic warning signals of the warning devices are only active when persons are present inside the wind energy converter. Switching the maintenance switch on the control cabinet on/off activates/deactivates the acoustic warning signals of the warning devices in the tower base. Switching the nacelle light and presence switch on/off activates/deactivates the acoustic warning signals of the warning devices in the machine house and in the rotor head. After activation, the warning devices perform an automatic self-test. The self-test is omitted if a warning is already pending. The warning signals for the unsafe operating states that are being monitored have different priorities. If several warning signals occur simultaneously, the warning signal with the highest priority is issued. A warning message appears on the wind energy converter display start page when ascent in the wind energy converter or use of the service hoist is not permitted.

3.11.15.1 Overview

Tab. 2: Warning signals in the wind energy converter

	Fire, smoke		Failure of the monitoring function		Maintenance wind speed exceeded		Locking wind speed exceeded when rotor holding brake or rotor lock actuated		Permissible wind speed for using the service hoist exceeded or temperature below the operating temperature of the service hoist	
	Warning light	Warning tone	Warning light	Warning tone	Warning light	Warning tone	Warning light	Warning tone	Warning light	Warning tone
Rotor head	Strobe lights ¹ continuously on	Siren ² continuously on	Strobe lights ¹ continuously on	Repeated continuously: 1 s continuous tone ³ on, 60 s off	Strobe lights ¹ continuously on	Repeated 3x every 2 min: 1 s continuous tone ³ on, 1 s off	Repeated continuously: 6 s strobe lights ⁴ on, 6 s off	Repeated 3x every 2 min: 1 s continuous tone ³ on, 1 s off	-	-
Machine house							-	-	-	-
Tower base							-	-	-	-
Service hoist⁵	Flashing	-	Flashing	-	Flashing	-	-	-	Flashing	-
Rotor lock operating control	Continuously on	-	-	-	Continuously on	-	Repeated continuously: 6 s on, 6 s off	-	-	-
Prioritisation	1		2		3		4		Independent	
Reset	Manual		Manual		Automatic		Automatic		Automatic	

¹ Standard-compliant strobe lights

² Tone changing in pitch. Pitch falling cyclically from 1200 Hz to 500 Hz, then jumping back to 1200 Hz.

³ Tone with constant pitch. Fixed frequency of 2700 Hz.

⁴ Standard-compliant strobe lights.

⁵ If the warning against use of the service hoist is activated because the temperature inside the tower is too low, the signal transmitter in the service hoist flashes continuously with 0.7 s on and 0.7 s off with the lowest priority.

3.11.15.2 Warning device self-test

Nacelle

If there is no prevailing warning, a self-test of the warning devices is started for a total of 60 s when the nacelle lights are switched on:

- The warning tone sounds in the machine house in this sequence: 1 s siren⁶, 1 s pause, 1 s continuous tone⁷
- The warning light in the machine house is switched on for 60 s.
- During the last 3 s of these 60 s, the warning light comes on and the warning tone sounds in the rotor head in this sequence: 1 s siren⁶, 1 s pause, 1 s continuous tone⁷

Tower

If there is no prevailing warning, a self-test of the warning devices is started for a total of 60 s when the maintenance switch is switched on:

- The warning tone sounds in the tower base in this sequence: 1 s siren⁶, 1 s pause, 1 s continuous tone⁷
- The warning light in the service hoist flashes for 60 s (0.7 s on, 0.7 s off).
- The warning light in the tower base is switched on for 60 s.

⁶ Tone changing in pitch. Pitch falling cyclically from 1200 Hz to 500 Hz, then jumping back to 1200 Hz.

⁷ Tone with constant pitch. Fixed frequency of 2700 Hz.

4 Assemblies

4.1 Overview

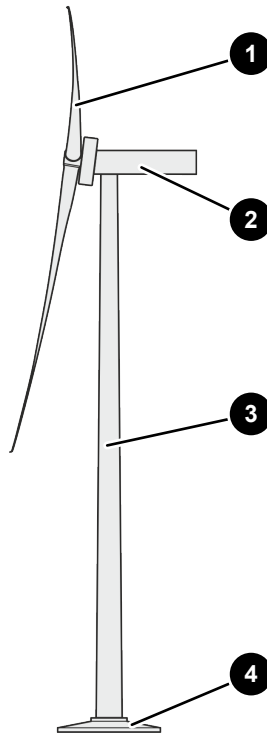


Fig. 7: Wind energy converter

1	Rotor blade	2	Nacelle
3	Tower	4	Foundation

- Rotor blade** Wind flows over the rotor blades, generating lift in the process. This lift causes the rotor of the wind energy converter to turn.
- Nacelle** The nacelle contains the drive train and various electrical and mechanical components and is situated on top of the tower of the wind energy converter.
- Tower** The tower supports the nacelle and the rotor blades of the wind energy converter and contains various electrical and mechanical components.
- Foundation** The foundation forms part of the support structure of the wind energy converter and transfers the loads that occur to the ground. Depending on the external conditions and the tower type, the foundation may be constructed as either a shallow or a deep foundation.

4.2 Rotor blade

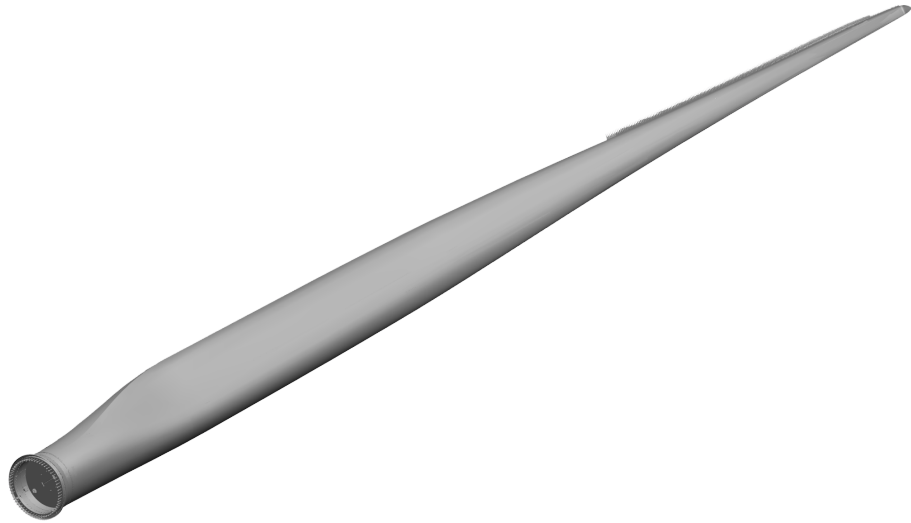


Fig. 8: Rotor blade

The rotor blades are elastic and bend slightly backwards when exposed to wind loads. The rotor blades are hollow and reinforced from the inside by webs.

The rotor blade surface is coated. The coating protects the surface from dirt and other environmental influences. Various components are attached to the surface that optimise the airflow and thus increase power and reduce noise.

The rotor blade has low radar reflectivity. This minimises the electromagnetic waves that are reflected by the lightning protection system and that cause unwanted additional signals in the radar systems of civilian air traffic control authorities, military installations and weather services.

4.2.1 Components in the rotor blade

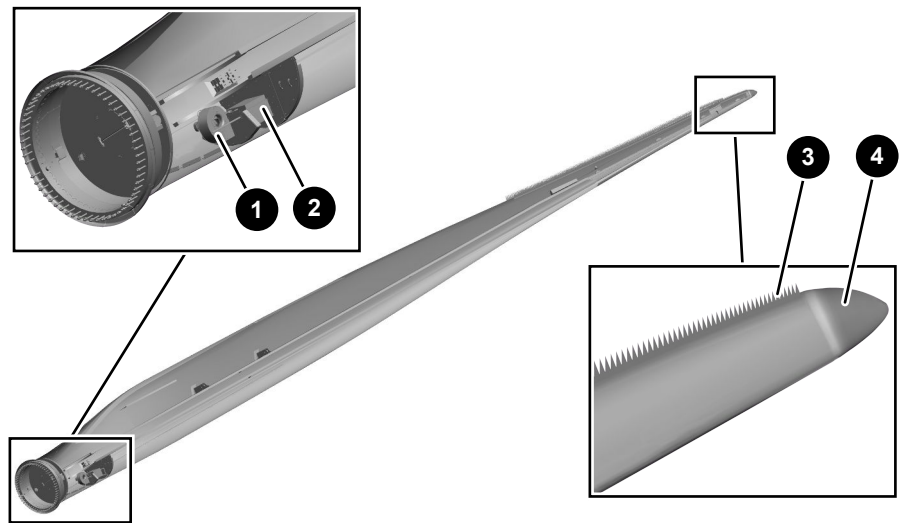


Fig. 9: Components in the rotor blade

1	Radial fan	2	Heating element
3	Trailing edge serration	4	Tip bow

Radial fan The radial fan is part of the blade heating system. The radial fan moves the air heated by the heating element into the rotor blade.

Heating element The heating element is part of the blade heating system. The heating element heats the air that is passed by the radial fan into the rotor blade.

Trailing edge serration The trailing edge serration (TES) is a serrated profile strip on the trailing edge of the rotor blade. It serves to ensure lower noise emissions.

Tip bow The tip bow is the part of the blade tip curved in a right angle. The tip bow optimises airflow and acts as a receptor for the lightning protection system.

4.3 Nacelle

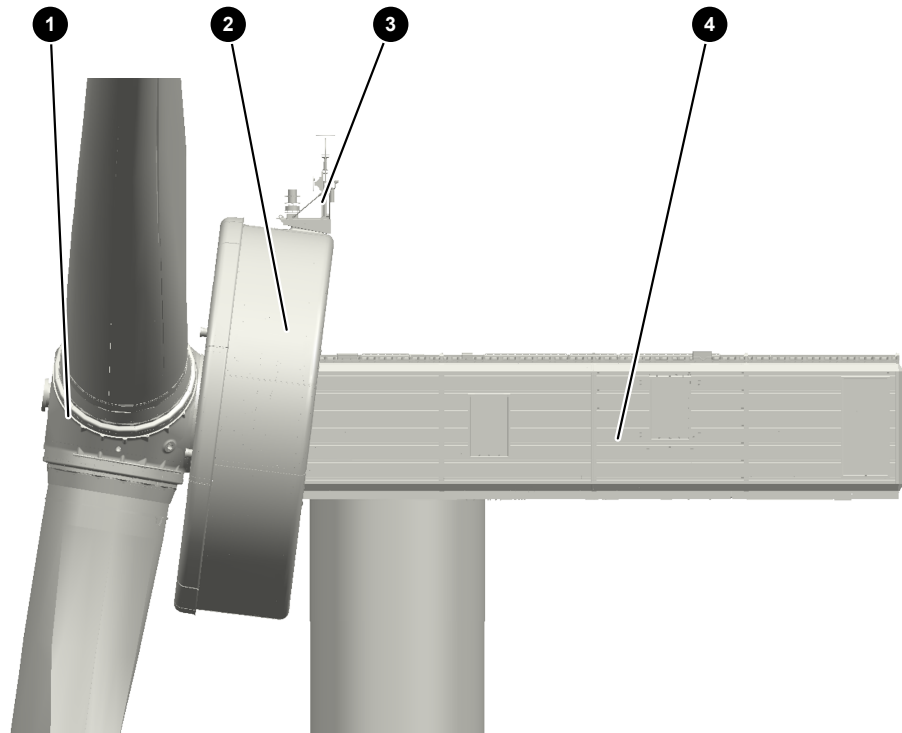


Fig. 10: Nacelle

1	Rotor head	2	Generator
3	Roof module	4	Machine house

Rotor head The rotor head is the rotating part of the wind energy converter without the rotor blades and generator rotor.

Generator The generator is a multi-polar, externally excited synchronous generator. The energy of the wind is converted into electrical energy inside the generator. The generator consists of the generator stator and the generator rotor.

Roof module The roof module serves as a standing area and as a carrier for components mounted on the nacelle roof, such as the beacon lights, the visibility meter and the wind measuring units.

Machine house The machine house contains many of the fixed components of the nacelle.

4.3.1 Components in the rotor head (1)

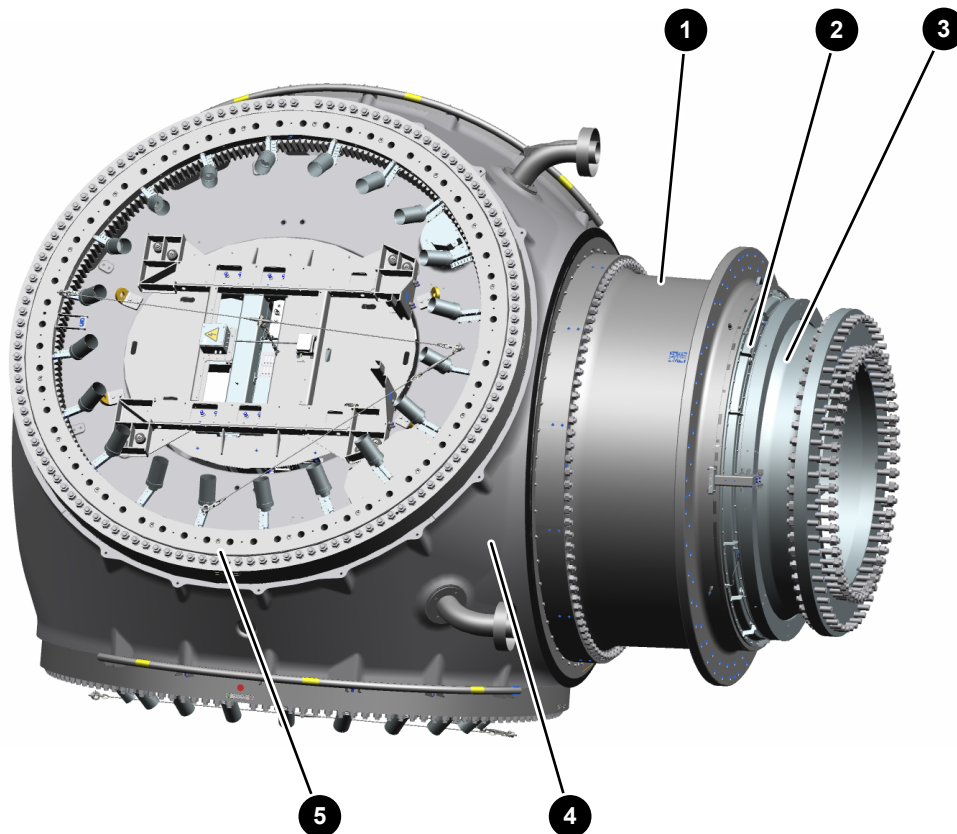


Fig. 11: Components in the rotor head, view from the outside

1	Rotor carrier	2	Rotor bearing
3	Axle pin	4	Hub
5	Blade flange bearing		

Rotor carrier The rotor carrier joins the hub to the generator rotor. The rotor carrier rotates about the axle pin on the rotor bearings.

Rotor bearing The rotating part of the wind energy converter rotates about the axle pin on the rotor bearings.

Axle pin The axle pin is fixed and carries the entire rotating part of the wind energy converter. The rotating part rotates about the axle pin.

Hub The hub rotates about the rotor axis. The rotor blades are attached to the hub.

Blade flange bearing The blade flange bearings connect the rotor blades and the hub and allow the blades to rotate around their longitudinal axis.

4.3.2 Components in the rotor head (2)

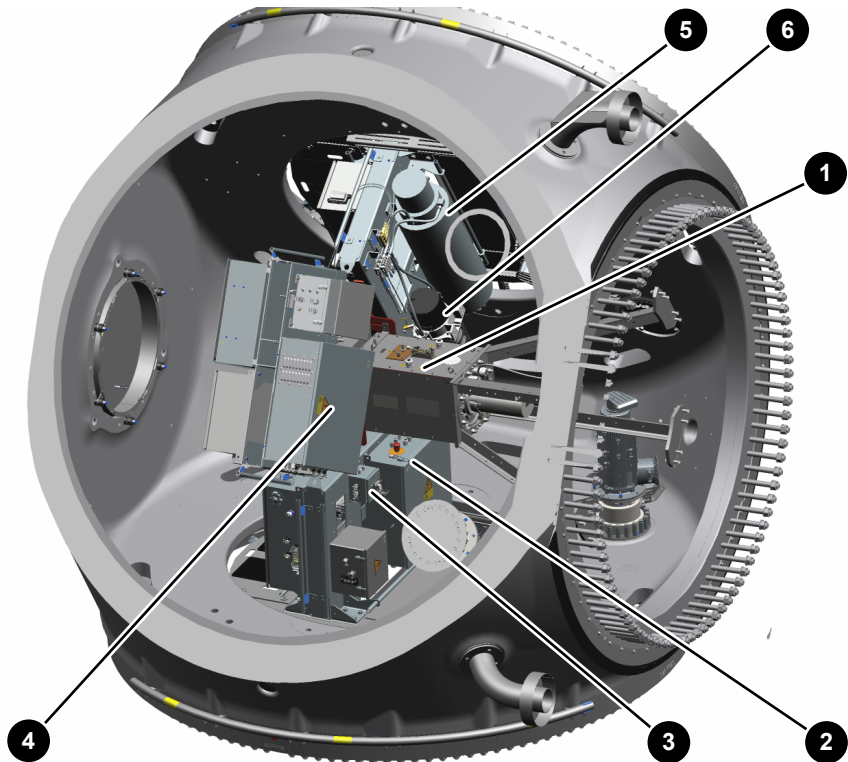


Fig. 12: Components in the rotor head, view from the rear inside

1	Slip ring unit	2	Rotor main distribution system
3	Rotor lighting sub-distribution system	4	Blade heating system control cabinet
5	Rotor bearing central lubrication system	6	Blade flange bearing gear rim central lubrication system

Slip ring unit The slip ring unit transmits electrical energy and data between the stationary and rotating parts of the nacelle via sliding contacts.

Generator rotor main distribution system The generator rotor main distribution system distributes power from a slip ring unit to the pitch control cabinets and acts as a surge protection device.

Rotor lighting sub-distribution system The rotor lighting sub-distribution system acts as a sub-distribution system for the lighting in the vicinity of the rotor head, the rotor blades and the generator rotor.

Blade heating system control cabinet The blade heating system control cabinet contains the components required to control and supply power to the blade heating system.

Rotor bearing central lubrication system The rotor bearing central lubrication system supplies the rotor bearing lubrication points and the blade flange bearing raceways with the required quantities of lubricant.

Blade flange bearing gear rim central lubrication system

The blade flange bearing gear rim central lubrication system supplies the blade flange bearing gear rims with the required quantities of lubricant through lubricating pinions.

4.3.3 Components in the rotor head (3)

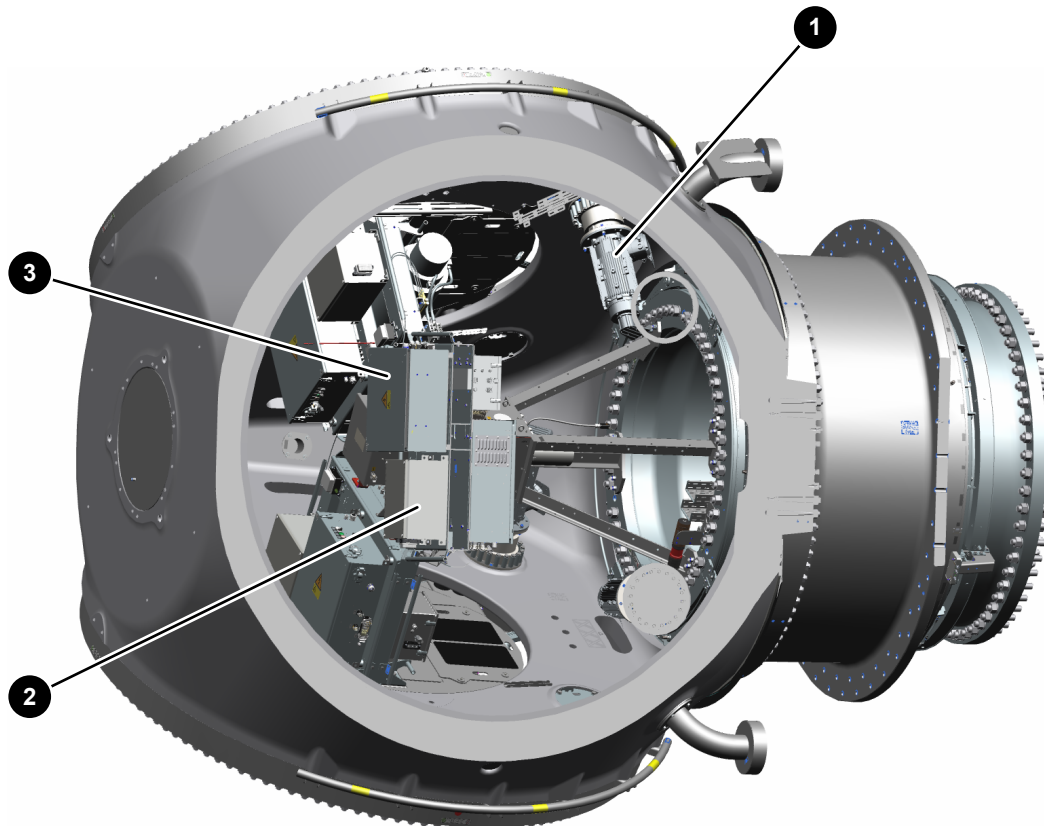


Fig. 13: Components in the rotor head, view from the front inside

1	Pitch drive	2	Capacitor box
3	Pitch unit cabinet		

Pitch drive

The pitch drives consist of a pitch motor and a pitch gear. The pitch drives turn the rotor blades to adjust the blade angle.

Capacitor box

The capacitor boxes provide an emergency power supply to the pitch unit.

Pitch control cabinet

The pitch control cabinets contain the converter for the assigned pitch drive and are used for data acquisition and for monitoring the sensors for pitch control.

4.3.4 Components in the generator

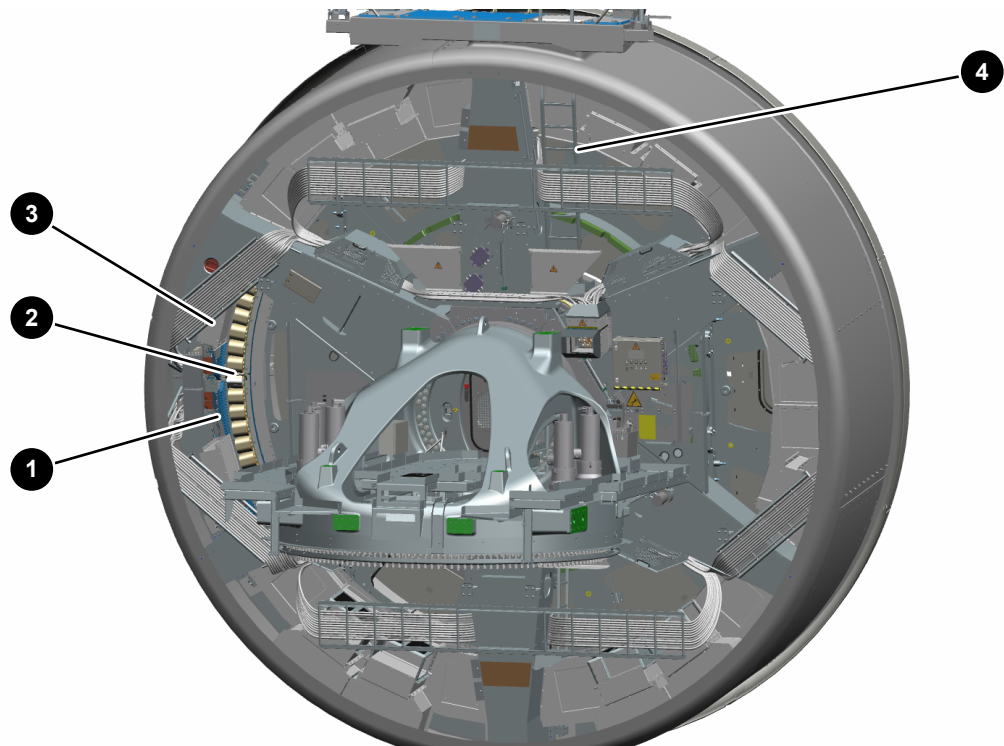


Fig. 14: Components on the generator

1	Generator stator	2	Generator rotor
3	Nacelle fan	4	Roof module ladder

Generator stator The generator stator is the stationary part of the generator. The electrical voltage is induced in the generator stator. The generator stator is mounted on the main carrier by the stator support with stator jibs and by the stator support star. The stator jibs also act as carriers for other components.

Generator rotor The generator rotor is the rotating part of the generator. The magnetic field required for power generation is created in the generator rotor.

Nacelle fan The nacelle fans are used for cooling the components in the nacelle, in particular the generator.

Roof module ladder The roof module ladder is used to access the roof module.

4.3.5 Components on the roof module

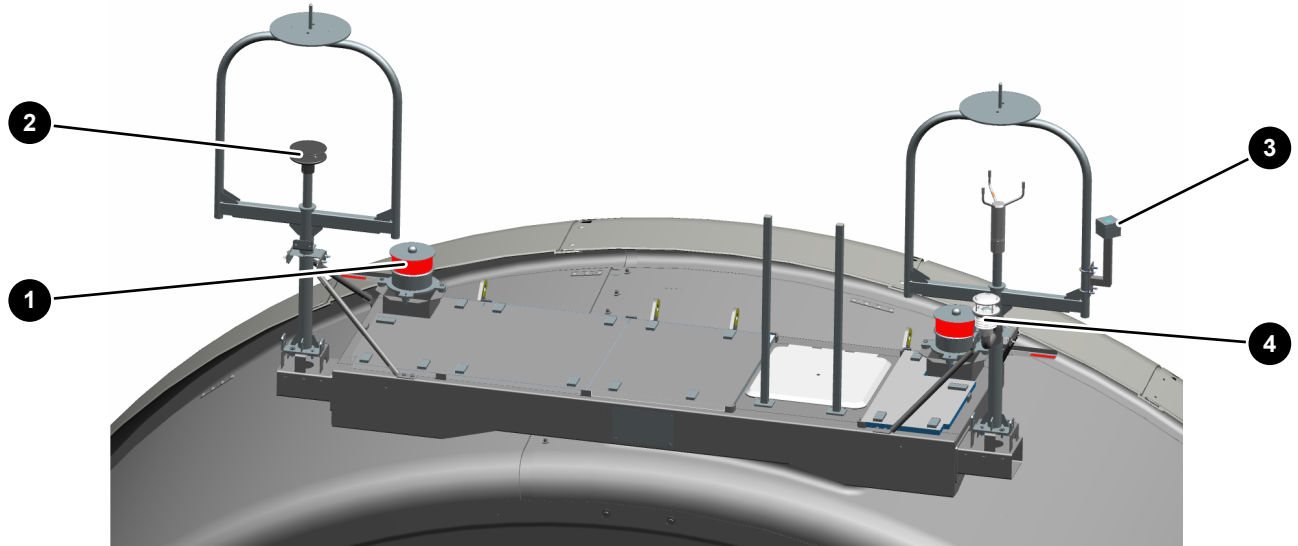


Fig. 15: Components on the roof module

1	Beacon light	2	Wind measuring unit
3	Shadow shutdown light sensor	4	Climate sensor

Beacon light The beacon lights mark the wind energy converter as an obstacle to aviation.

Wind measuring unit The wind measuring units are ultrasonic anemometers. These ultrasonic anemometers measure the wind speed and wind direction continuously and compare their measuring results with one another.

Shadow shutdown light sensor The shadow shutdown light sensor detects light conditions for an optional shadow shutdown function.

Climate sensor The climate sensor detects a range of climate data such as temperature, air humidity and atmospheric pressure.

4.3.6 Components in the machine house (1)

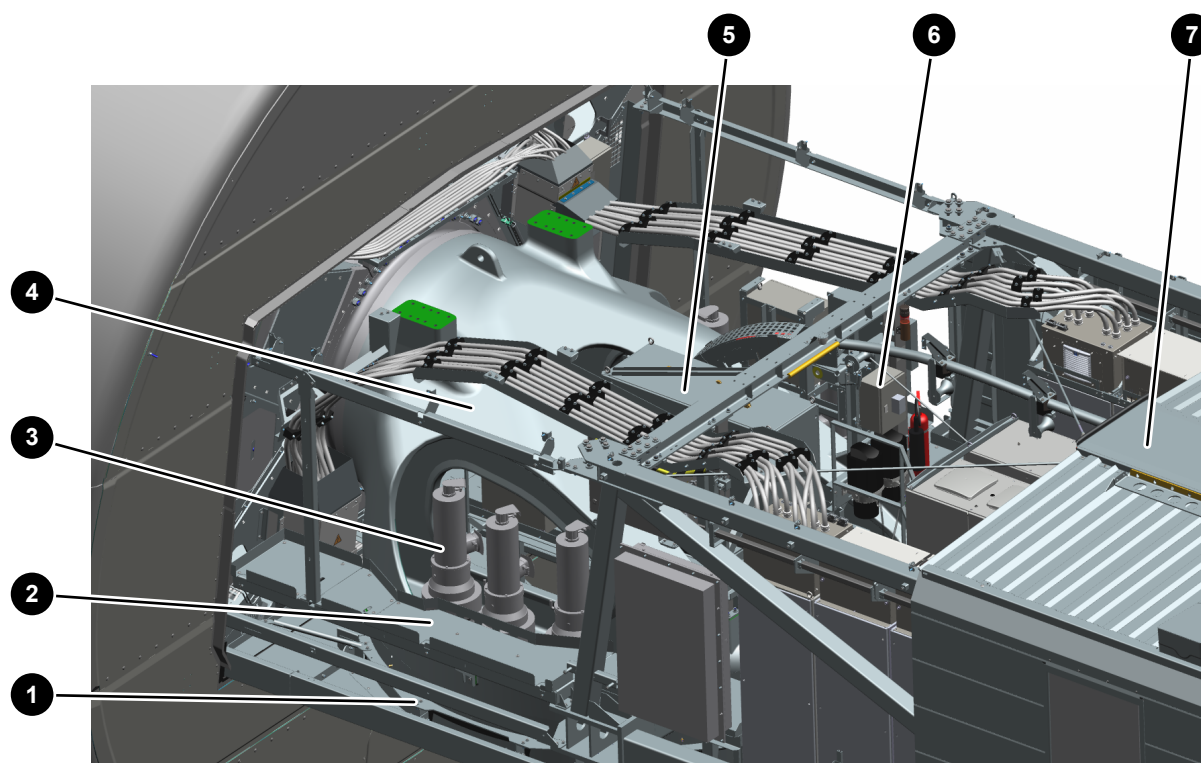


Fig. 16: Components in the machine house, view from front left

1	Yaw bearing	2	Nacelle floor
3	Yaw drive	4	Main carrier
5	Nacelle main distribution system	6	110 V socket power supply
7	Nacelle casing		

Yaw bearing The yaw bearing supports the entire nacelle and enables the nacelle to rotate on the tower.

Nacelle floor The nacelle floor provides the assembly or installation surface for electrical cabinets and other components in the nacelle. The nacelle floor also forms the access and working area for personnel.

Yaw drive The yaw drives are attached to the main carrier. The yaw drives consist of a yaw motor and a yaw gear. The downward-facing drive shaft ends in a gearwheel that engages with the fixed yaw gear rim situated on the top edge of the tower. When the yaw drives are switched on, they rotate the main carrier and thus the entire nacelle.

Main carrier The main carrier rotates on the tower by means of the yaw bearing. All components of the nacelle are mounted directly or indirectly on the main carrier, so that when the main carrier rotates on the yaw bearing, the entire nacelle is rotated.

Nacelle main distribution system	Amongst other items, the nacelle main distribution system contains the back-up fuses and power distribution for the loads in the nacelle.
110 V socket power supply system	The 110 V socket power supply system acts as a sub-distributor with protective circuit breakers for the sockets in the nacelle.
Nacelle casing	The nacelle casing comprises multiple parts and protects the components installed in the nacelle from exposure to the weather.

4.3.7 Components in the machine house (2)

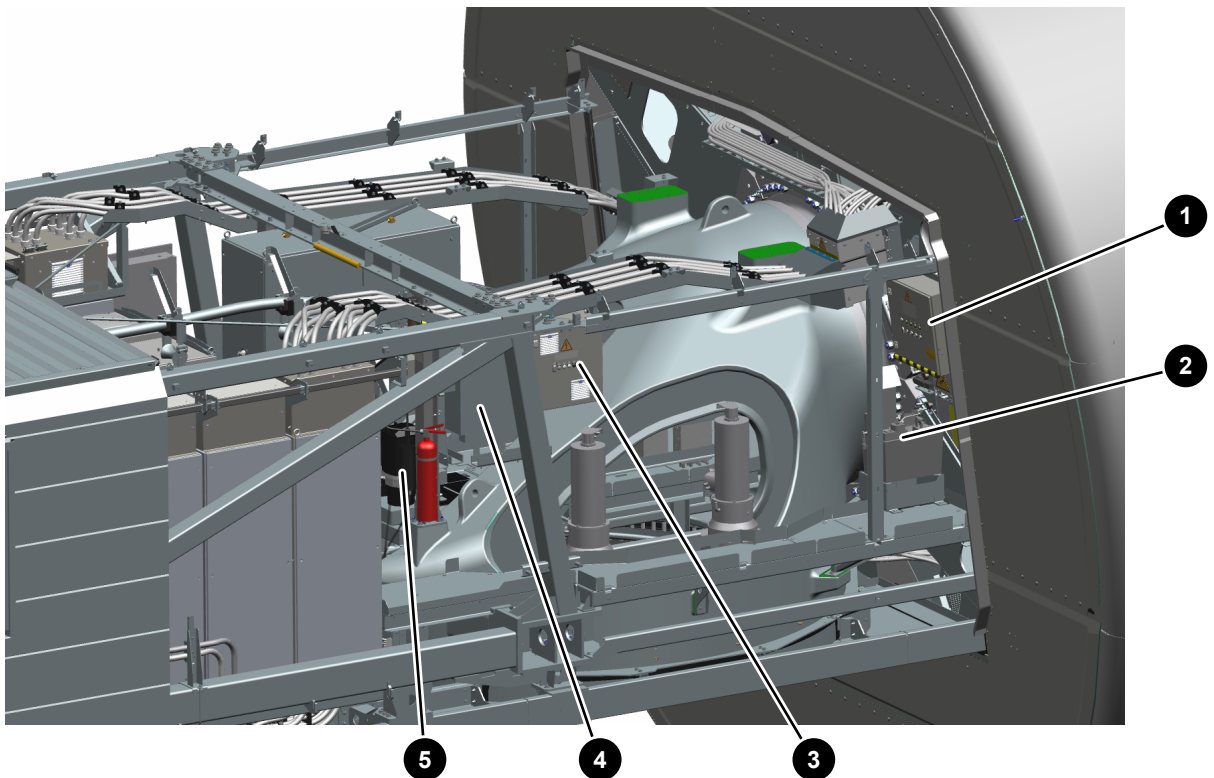


Fig. 17: Components in the machine house, view from front right

1 Stator control cabinet	2 Hydraulic unit
3 Nacelle lighting control centre	4 Nacelle basic power supply electrical cabinet
5 Yaw bearing central lubrication system	

Stator control cabinet	The stator control cabinet acquires sensor signals from the area of the generator stator and exchanges data with the nacelle control cabinet. The stator control cabinet has operating controls for operating the rotor holding brake and the rotor lock.
Hydraulic unit	The hydraulic unit is a combination of a hand pump and an electric pump and generates the hydraulic pressure required for actuating the rotor lock or the rotor holding brake. The hydraulic unit also features

an electric locking system which ensures that the rotor lock can only be released if the access door to the rotor head and the access door to the generator are closed.

Nacelle lighting control centre

The nacelle lighting control centre is the power supply and control unit for the nacelle lighting and the exterior tower lighting. The nacelle lighting control centre also includes the emergency power supply for the nacelle lighting.

Nacelle basic power supply electrical cabinet

The nacelle basic power supply electrical cabinet provides power to various components in the nacelle, e.g. the sockets, the nacelle lighting, the nacelle crane and the beacon system components. Some of these components are also protected by the nacelle basic power supply electrical cabinet via protective circuit breakers.

Yaw bearing central lubrication system

The yaw bearing central lubrication system supplies the yaw bearing with the required quantities of lubricant.

4.3.8 Components in the machine house (3)

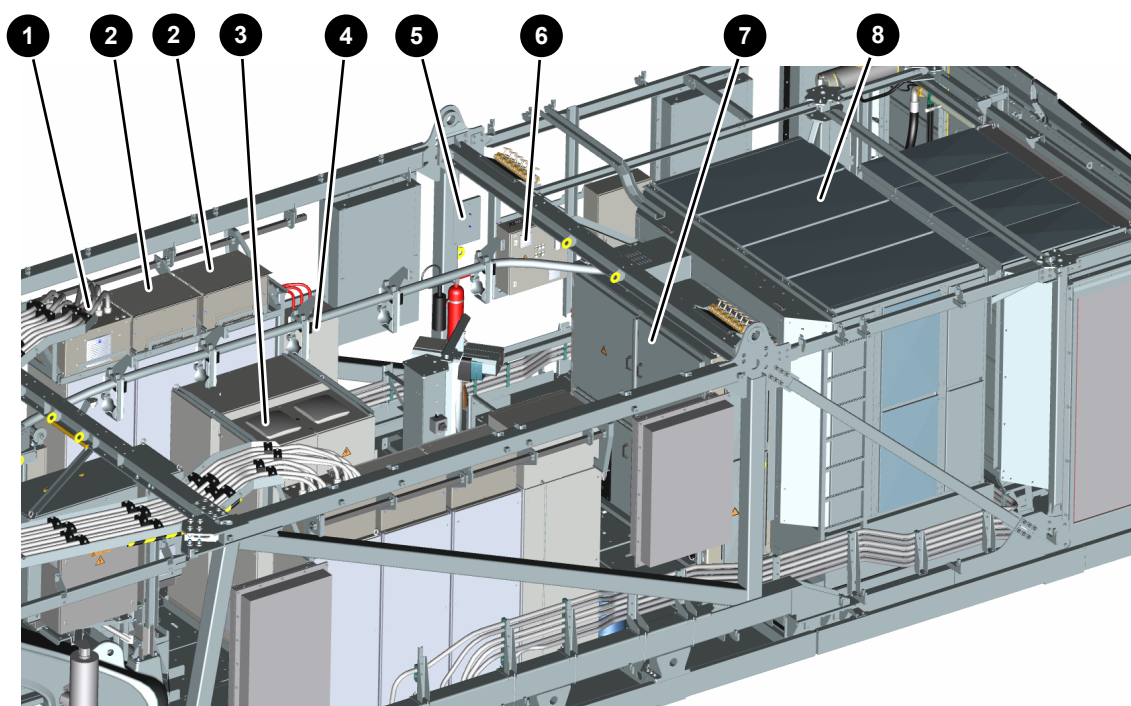


Fig. 18: Components in the machine house, view from middle left

1	Generator low-voltage distribution system	2	Converter cabinet
3	Control system UPS	4	Blade heating system disconnection box
5	Maintenance unit for the automatic extinguishing system	6	Transformer control cabinet
7	Transformer low-voltage distribution system	8	Transformer enclosure

Generator low-voltage distribution system	The generator low-voltage distribution system connects the generator to the converters. There are circuit breakers in the generator low-voltage distribution system that can be used to isolate the converters on the generator side.
Converter cabinet	In the converter cabinets, the alternating current coming from the generator with variable frequency is rectified and fed to the inverter. The inverter converts the direct current into 3-phase alternating current that matches that of the power grid. The converters are cooled by a liquid cooling system.
Control system UPS	The control system UPS is used to supply power to the wind energy converter during operation. The control system UPS is fed from the internal DC link, so that the supply to the wind energy converter can be decoupled from the power grid. This ensures that the supply to the wind energy converter is not affected by any grid fault.
Blade heating system disconnection box	The blade heating system disconnection box can be used to interrupt the energy supply to the blade heating system.
Maintenance unit for the automatic extinguishing system	The maintenance unit for the automatic extinguishing system consists of a maintenance valve for deactivating the automatic extinguishing system and an indicator display.
Transformer control cabinet	The transformer control cabinet is used to control the power supply to the transformer and to protect the transformer. If a fault or other pre-defined event occurs, e.g. if the oil pressure in the transformer increases or if a fire or earth fault is detected, the transformer control cabinet shuts down the medium-voltage switchgear. The transformer control cabinet can connect and disconnect the medium voltage present in the medium-voltage switchgear.
Transformer low-voltage distribution system	The transformer low-voltage distribution system connects the converters to the transformer. There are vertical fuse-switch disconnectors in the transformer low-voltage distribution system that can be used to disconnect the converters from the mains.
Transformer enclosure	The transformer enclosure surrounds the transformer, acts as a contact guard to prevent electric shock and shields persons present inside the machine house against electromagnetic radiation immisions.

4.3.9 Components in the machine house (4)

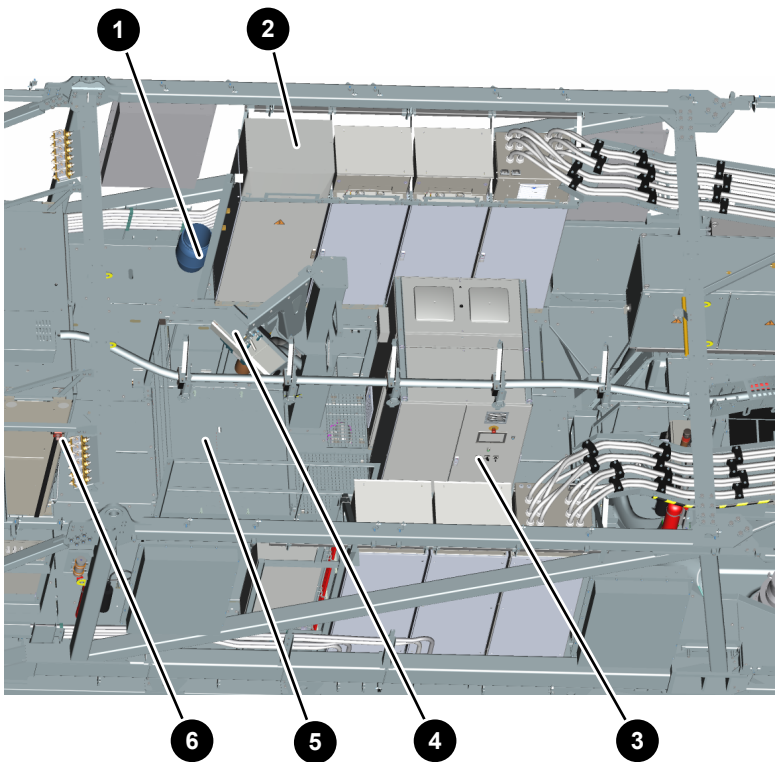


Fig. 19: Components in the machine house, view from middle right

1	Abseiling device	2	Yaw control cabinet
3	Nacelle control cabinet	4	Nacelle crane
5	Crane hatch	6	Transformer emergency switching off button

Abseiling device The abseiling device is used for emergency evacuation of the wind energy converter via the crane hatch.

Yaw control cabinet The yaw control cabinet contains the control system and the converter for the yaw drives.

Nacelle control cabinet The nacelle control cabinet records and analyses the input from all sensors in the nacelle. It controls the yawing and records the rotor speed. Certain functions and systems can also be operated manually via a control panel on the nacelle control cabinet.

Nacelle crane The nacelle crane is used to transport tools and materials between the ground and the nacelle.

Crane hatch The crane hatch is an opening in the nacelle floor and nacelle casing that is covered with hinged doors. The crane hatch is secured by the crane hatch guardrail.

Transformer emergency switching off button

The transformer emergency switching off button is a piece of safety equipment that isolates all power in the event of an emergency. When actuated, the transformer emergency switching off button locks by means of an automatic latching function.

4.3.10 Components in the machine house (5)

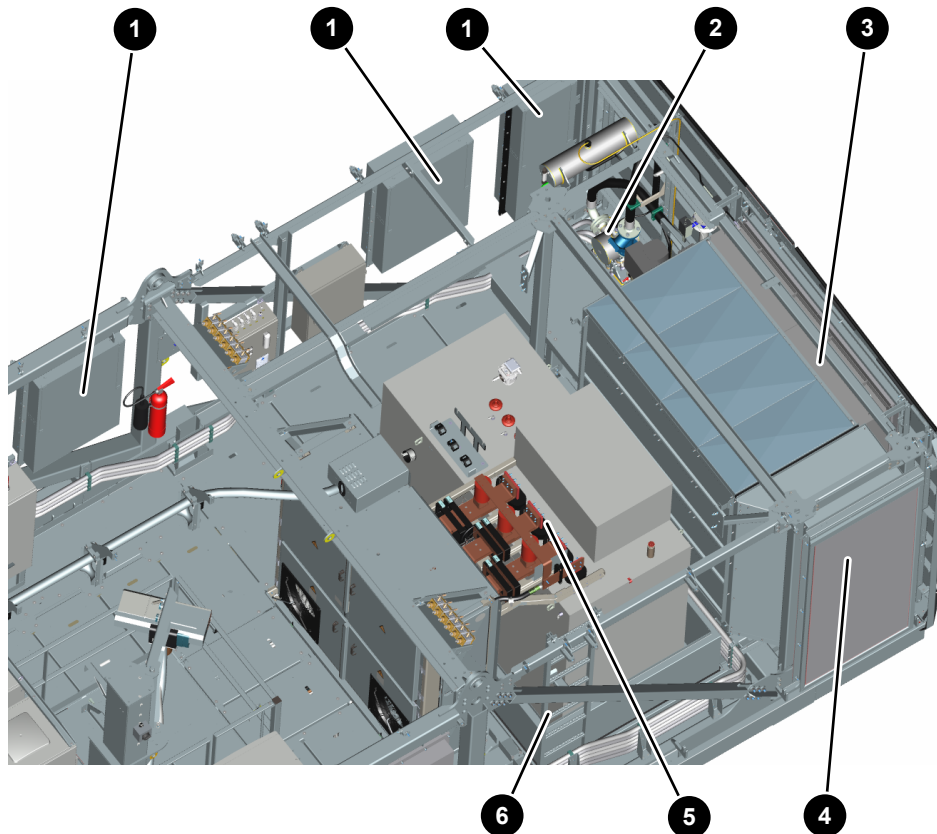


Fig. 20: Components in the machine house, view from rear

1	Machine house air intake	2	Liquid cooling system pump
3	Liquid cooling system chiller	4	Liquid cooling system air intake
5	Transformer	6	Ladder to machine house roof

Machine house air intake

Outside air is drawn in through the machine house air intakes to chill the generator and cool components in the machine house. Separators for drying the outside air are integrated in the machine house air intakes.

Liquid cooling system pump

The liquid cooling system pump is used to transport the cooling liquid in the liquid cooling system. If the wind energy converter is at a standstill and the outside temperature is low, the coolant can also be heated.

Liquid cooling system chiller

The liquid cooling system chiller uses outside air to chill the cooling liquid in the liquid cooling system.

Liquid cooling system air intake	Outside air is drawn in through the liquid cooling system air intake to chill the cooling liquid.
Transformer	The transformer converts the voltage generated in the wind energy converter to the level of the power grid into which the current is fed.
Ladder to machine house roof	The machine house roof can be reached via the ladder to the machine house roof and the nacelle hatch above the main carrier.

4.3.11 Components of the rotor lock

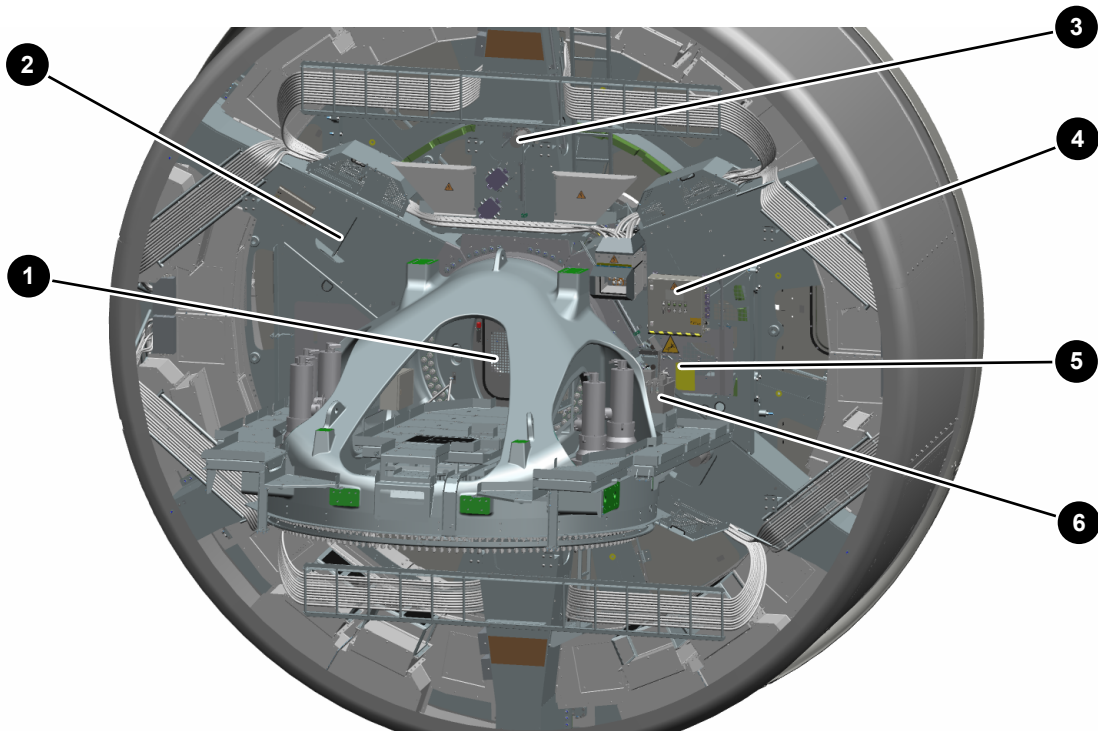


Fig. 21: Components of the rotor lock

1	Access door to rotor head	2	Rotor holding brake
3	Rotor lock bolts	4	Stator control cabinet
5	Access door to generator	6	Hydraulic unit

Rotor lock bolts The rotor lock bolts are part of the rotor lock. The rotor lock is used to immobilise the rotor so that it cannot rotate any further and so that it is safe for persons to enter the rotor head and the generator.

Rotor holding brake The rotor holding brake holds the rotor in place in certain situations so that it cannot rotate further, e.g. before the rotor lock is applied.

Stator control cabinet The stator control cabinet acquires sensor signals from the area of the generator stator and exchanges data with the nacelle control cabinet. The stator control cabinet has operating controls for operating the rotor holding brake and the rotor lock.

Access door to generator	The access door to the generator is secured by an electric locking system and securely locks the access route to the generator. The access door can only be opened when the rotor is locked, the nacelle fans are switched off and when the manual valve of the rotor lock is in the <i>Set</i> position.
Hydraulic unit	The hydraulic unit is a combination of a hand pump and an electric pump and generates the hydraulic pressure required for actuating the rotor lock or the rotor holding brake. The hydraulic unit also features an electric locking system which ensures that the rotor lock can only be released if the access door to the rotor head and the access door to the generator are closed.
Access door to rotor head	The access door to the rotor head is secured by an electric locking system and securely locks the access route to the rotor head. The access door can only be opened when the rotor is locked, the nacelle fans are switched off and when the manual valve of the rotor lock is in the <i>Set</i> position.

4.4 Tower

The wind energy converter can be supplied with a hybrid tower or hybrid steel tower. The hybrid tower consists of concrete segments and steel sections. The hybrid steel tower consists of bevelled steel section plates plus tubular steel sections.

4.4.1 Components in the tower base

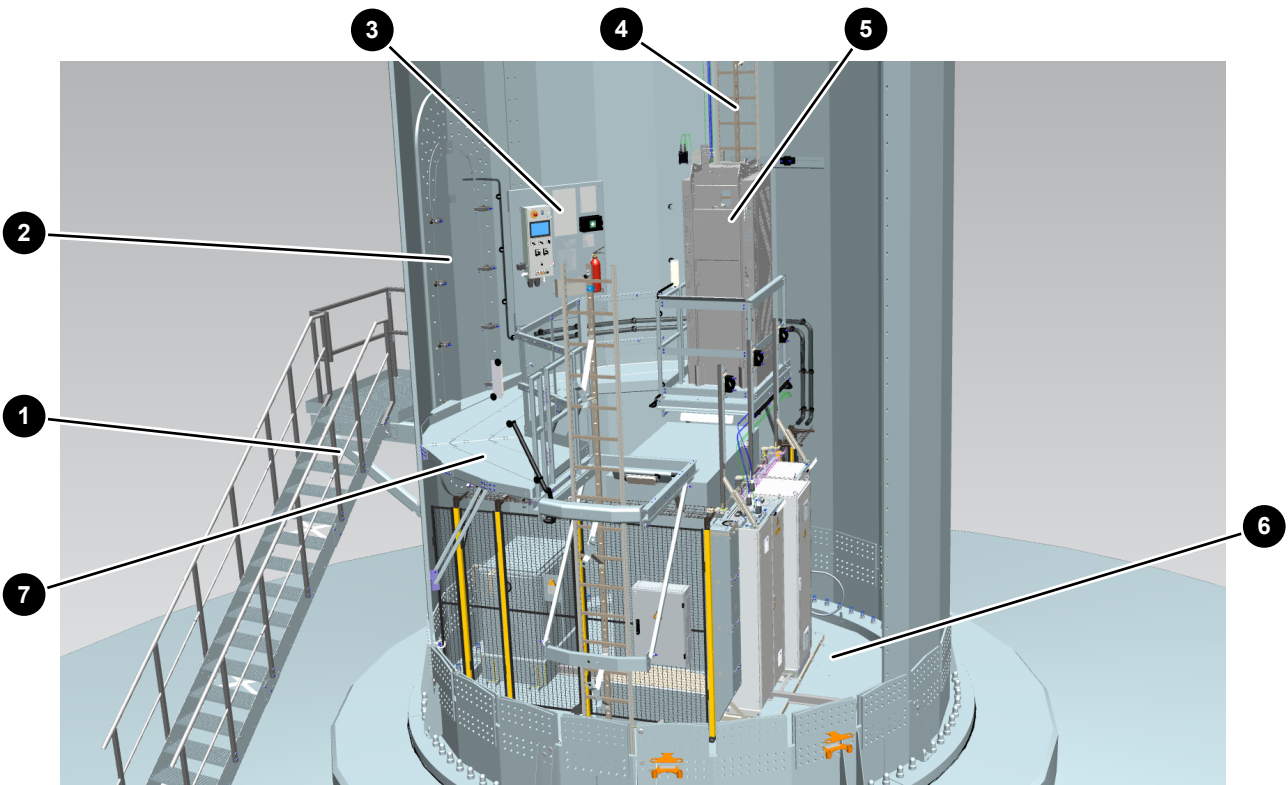


Fig. 22: Components in the tower base

1	Entrance stairs	2	Tower door
3	Control console next to the tower door	4	Safety ladder
5	Service hoist	6	Lower level in tower base
7	Tower entrance level		

Entrance stairs	The entrance stairs lead from ground level on the outside of the tower to the entrance level of the wind energy converter.
Tower door	The tower door provides access to the wind energy converter.
Control console next to the tower door	The control console next to the tower door includes the wind energy converter control console and some safety signs.
Safety ladder	The safety ladder is used for ascending and descending in the tower. The safety ladder runs from the tower base up to the last tower floor before the access to the nacelle.
Service hoist	The service hoist is ladder-guided and is used for transporting persons and materials between the tower base and the machine house. The service hoist is mounted on a tensioned steel wire rope and is raised and lowered by a winch between the tower base and the penultimate tower floor before the access to the nacelle.
Tower entrance level	The tower entrance level is the starting point for ascending the tower.

4.4.2 Components on the lower level in the tower base

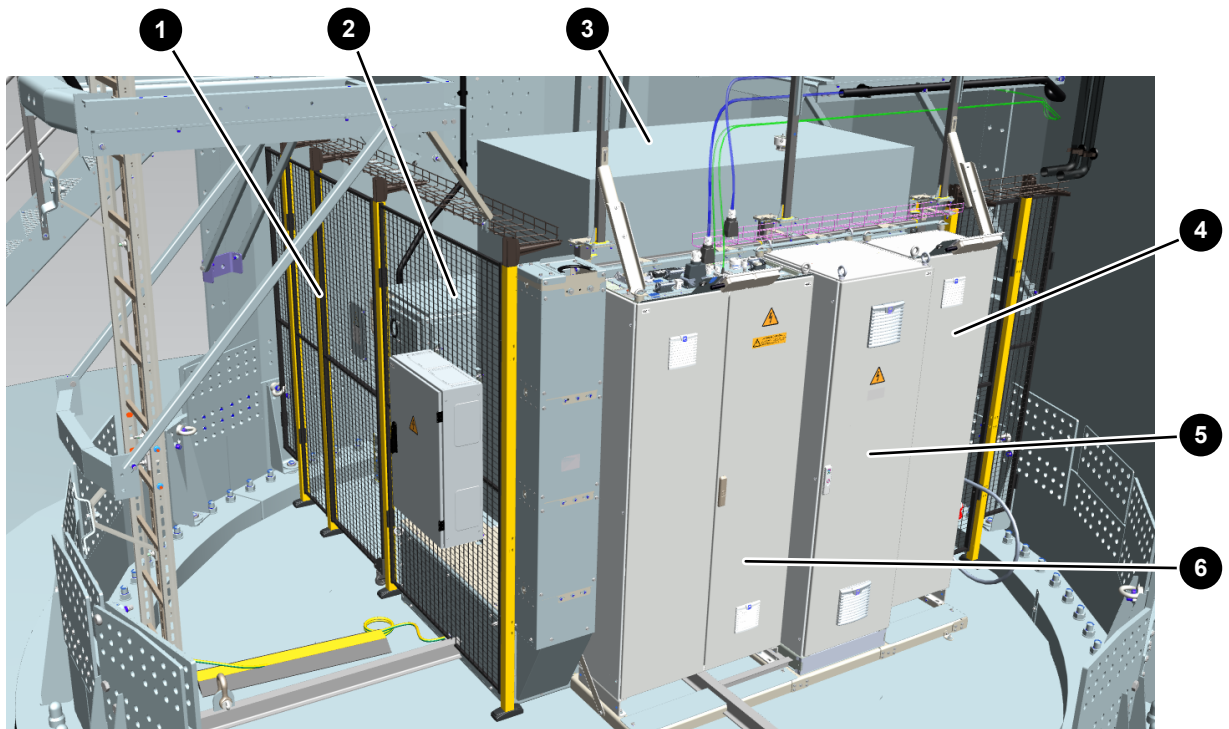


Fig. 23: Components on the lower level in the tower base

1	Protective fence	2	Basic power supply transformer
3	Medium-voltage switchgear	4	Combination cabinet
5	Communication cabinet	6	Control cabinet

Protective fence The lockable protective fence prevents unauthorised persons from accessing the medium-voltage area in the tower base.

Basic power supply transformer The basic power supply transformer supplies various components of the wind energy converter with current. These components include the service hoist, the lighting and the sockets.

Medium-voltage switchgear The medium-voltage switchgear connects the transformer to the utility's power grid so that the power generated can be fed into the grid and power for the wind energy converter's own consumption can be drawn from the grid.

Combination cabinet Among other things, the combination cabinet contains the tower base lighting control centre with the emergency power supply for the tower lighting. Furthermore, the power supplies for various door components such as the sockets and service hoist are integrated in the combination cabinet. Some of these components are also protected by protective circuit breakers in the combination cabinet.

Communication cabinet The communication cabinet contains various interfaces for transmitting data between the wind energy converters in the wind farm as well as between the wind energy converters and the operator.

Control cabinet The control cabinet contains components for controlling the wind energy converter. The sensor data for the tower of the wind energy converter is recorded and evaluated in the control cabinet.

4.4.3 Components in the upper tower area

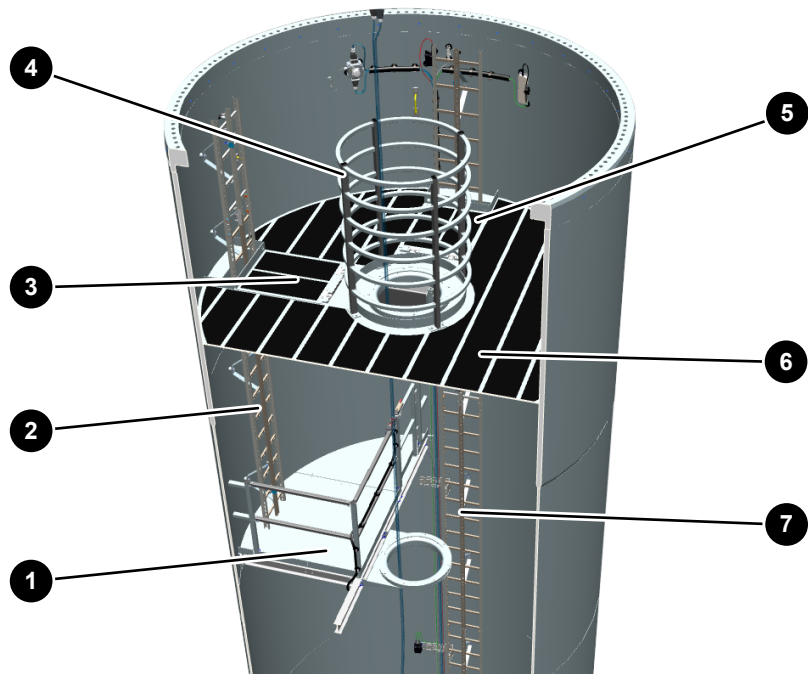


Fig. 24: Components in the upper tower area

1	Service hoist exit platform	2	Safety ladder to the service hoist exit platform
3	Hatch to the service hoist	4	Nacelle access ladder
5	Hatch to the tower base	6	Topmost tower floor
7	Safety ladder to the tower base		

- Service hoist exit platform** The service hoist exit platform is a landing platform via which the service hoist can be accessed and exited.
- Safety ladder to the service hoist exit platform** The safety ladder to the service hoist exit platform leads from the service hoist exit platform to the topmost tower floor.
- Hatch to the service hoist** The hatch to the service hoist closes the access hatch in the topmost tower floor automatically.
- Nacelle access ladder** The machine house can be reached via the nacelle access ladder and the main carrier.
- Hatch to the tower base** The hatch to the tower base closes the access hatch in the topmost tower floor automatically.

- Topmost tower floor** The topmost tower floor is the first tower floor below the nacelle.
- Safety ladder to the tower base** The safety ladder to the tower base leads from the entrance level in the tower base to the topmost tower floor. The safety ladder to the tower base also acts as a guide for the service hoist.

5 Operating controls and indicators

5.1 Wind energy converter control console

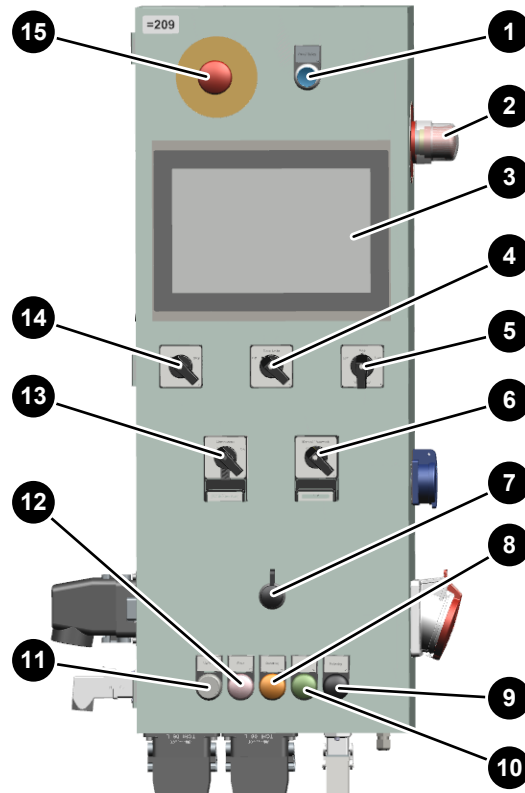


Fig. 25: Operating controls and display elements on the wind energy converter control console

1	Confirmation button	2	Transformer emergency switching off button with cover
3	Wind energy converter display	4	Rotor brake switch
5	Yaw control rotary switch	6	Manual/Automatic switch (lockable)
7	USB connection	8	Buffering indicator light
9	Buzzer	10	Operation indicator light
11	Lighting button	12	Error indicator light
13	Maintenance switch (lockable)	14	Start/Stop switch
15	Emergency stop button		

Tab. 3: Operating controls and display elements on the wind energy converter control console

Element	Function/meaning
<i>Confirmation</i> button	Clears safety-related fault messages for components in the tower base.
Transformer emergency switching off button with cover	Switches the control voltage off and triggers emergency pitching of the rotor blades.
Wind energy converter display	<ul style="list-style-type: none"> ■ Provides information about the current operating state of the wind energy converter. ■ Used to enter or change operating parameters and the operation of components.
<i>Rotor brake</i> switch	Activates or deactivates the rotor holding brake.
<i>Yaw control</i> switch	Rotates the nacelle clockwise or anti-clockwise in manual mode or stops it in its current position.
<i>Start/Stop</i> switch	Starts or stops the wind energy converter (does not perform emergency pitching of the rotor blades).
<i>Manual/Automatic</i> switch (lockable)	Switches the wind energy converter from manual mode into automatic mode or vice versa.
<i>Maintenance</i> switch (lockable)	Signals to the remote monitoring system that maintenance work is in progress. Operation of the wind energy converter via the remote monitoring system is blocked. An active status cannot be assigned remotely.
USB connection	Connection for a USB stick.
<i>Buffering</i> indicator light	<ul style="list-style-type: none"> ■ Lights up green when there is no fault in the UPS or the insulation monitoring system. ■ Lights up yellow if there is a fault in the insulation monitoring system.
Buzzer	Emits an acoustic signal when there is no grid voltage and the emergency lights are activated.
<i>Operation</i> indicator light	Lights up when emergency power operation is switched on.
<i>Lighting</i> button	Switches the lighting in the tower and in the tower base on or off.
<i>Error</i> indicator light	Lights up if there is a fault supplying power to the lighting components.
Emergency stop button	Triggers an emergency stop of the wind energy converter by emergency pitching of the rotor blades.

5.2 Nacelle control cabinet

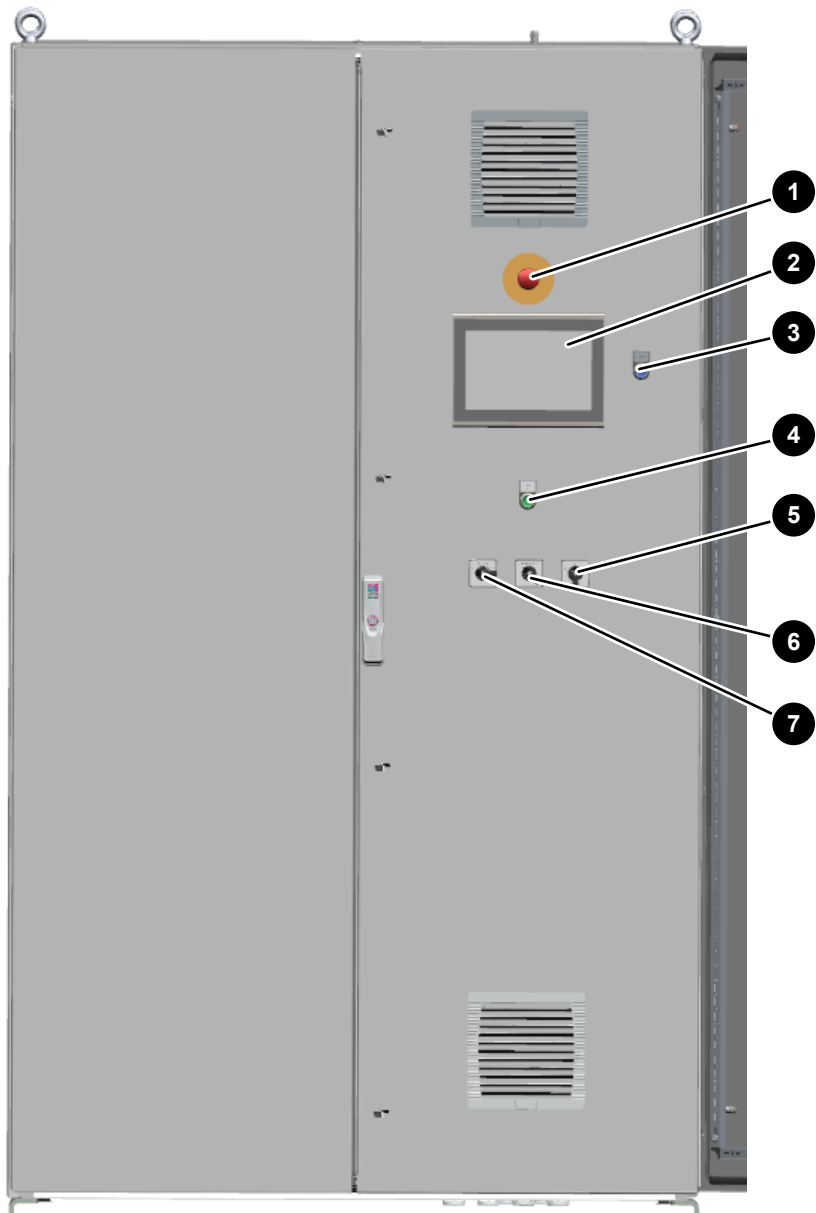


Fig. 26: Operating controls and display elements on the nacelle control cabinet

1	Emergency stop button	2	Wind energy converter display
3	<i>Confirmation</i> button	4	<i>Test run</i> button
5	<i>Yaw control</i> switch	6	<i>Manual/Automatic</i> switch
7	<i>Rotor brake</i> switch		

Tab. 4: Operating controls and display elements on the nacelle control cabinet

Element	Function/meaning
Emergency stop button	<ul style="list-style-type: none"> ■ Triggers an emergency stop of the wind energy converter by emergency pitching of the rotor blades. ■ Stops yawing and the nacelle fans. ■ Activates the rotor holding brake.
Wind energy converter display	<ul style="list-style-type: none"> ■ Provides information about the current operating state of the wind energy converter. ■ Used to enter or change operating parameters and the operation of components.
<i>Confirmation</i> button	Clears safety-related fault messages for components in the nacelle.
<i>Test run</i> button	Starts a time-limited test run of the wind energy converter.
<i>Yaw control</i> switch	Rotates the nacelle clockwise or anti-clockwise in manual mode or stops it in its current position.
<i>Manual/Automatic</i> switch	Switches the wind energy converter from manual mode into automatic mode or vice versa.
<i>Rotor brake</i> switch	Activates or deactivates the rotor holding brake.

5.3 Stator control cabinet

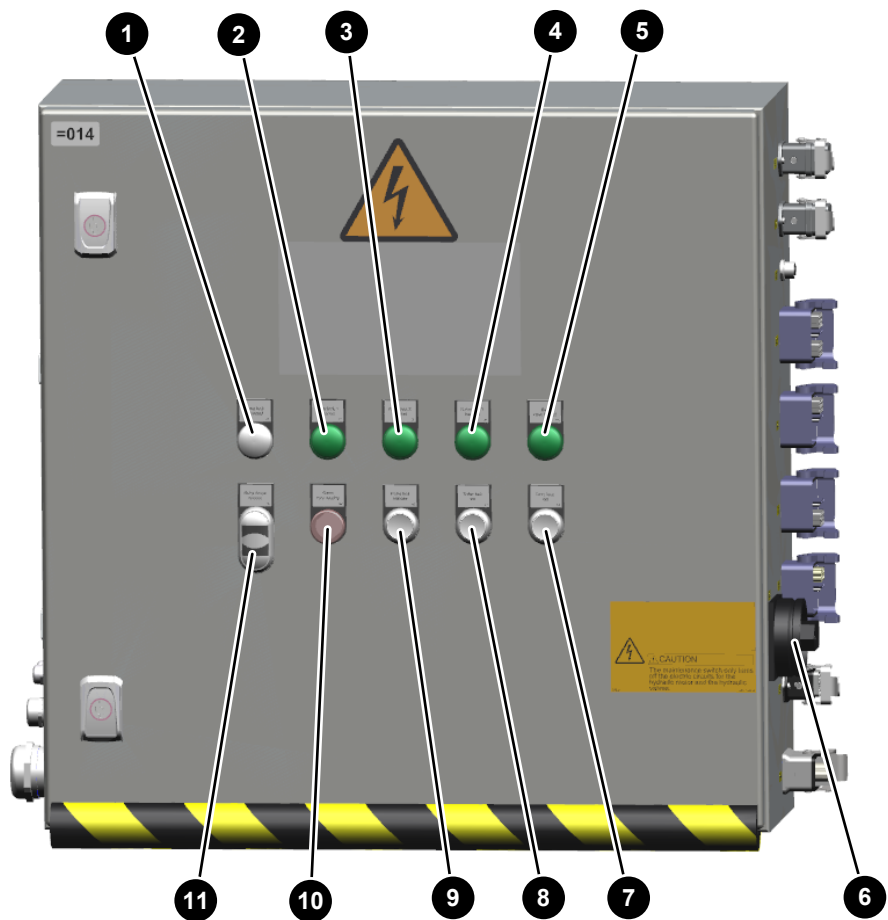


Fig. 27: Operating controls and display elements on the stator control cabinet

1	<i>Rotor lock retracted</i> indicator light	2	<i>Rotor lock 1 inserted</i> indicator light
3	<i>Rotor lock 2 inserted</i> indicator light	4	<i>Rotor lock 3 inserted</i> indicator light
5	<i>Ball valve locked</i> indicator light	6	Main switch
7	<i>Set door lock</i> illuminated button	8	<i>Rotor lock set</i> illuminated button
9	<i>Rotor lock release</i> illuminated button	10	<i>Alarm rotor locking</i> indicator light
11	<i>Rotor holding brake release</i> double pushbutton		

Tab. 5: Operating controls and display elements on the stator control cabinet

Element	Function/meaning
<i>Rotor lock retracted</i> indicator light	Lights up when the rotor is not locked.
<i>Rotor lock 1 inserted</i> indicator light	Lights up when the first rotor lock bolt is fully extended into the groove in the rotor rim.
<i>Rotor lock 2 inserted</i> indicator light	Lights up when the second rotor lock bolt is fully extended into the groove in the rotor rim.
<i>Rotor lock 3 inserted</i> indicator light	Lights up when the third rotor lock bolt is fully extended into the groove in the rotor rim.
<i>Ball valve locked</i> indicator light	Lights up when the <i>Rotor Lock</i> valve is in the <i>Set</i> position.
Main switch	Switches the stator control cabinet on or off.
<i>Set door lock</i> illuminated button	<ul style="list-style-type: none"> ■ Lights up if the access door to the rotor head or the access door to the generator is not locked. ■ Locks the access door to the rotor head and the access door to the generator.
<i>Rotor lock set</i> illuminated button	<ul style="list-style-type: none"> ■ When the <i>Rotor lock set</i> and <i>Rotor lock release</i> illuminated buttons are lit up, the hydraulic unit can be actuated for extending or retracting the rotor lock bolts. ■ Extends the rotor lock bolts into the groove in the rotor rim.
<i>Rotor lock release</i> illuminated button	<ul style="list-style-type: none"> ■ When the <i>Rotor lock set</i> and <i>Rotor lock release</i> illuminated buttons are lit up, the hydraulic unit can be actuated for extending or retracting the rotor lock bolts. ■ Retracts the rotor lock bolts out of the groove in the rotor rim.
<i>Alarm rotor locking</i> indicator light	Flashes if the wind speed is too high for the rotor to be locked. In this case it is not permitted to continue with the locking process. Any existing rotor lock must be released.
<i>Rotor holding brake release</i> double pushbutton	Allows the rotor holding brake to be temporarily released.

Rotor lock status display

The rotor lock status is displayed by the indicator lights on the stator control cabinet as follows:

Tab. 6: Indicator lights on the stator control cabinet

Green indicator lights	White indicator light	Rotor lock status
All on	Off	Fully locked
All off	On	Not locked
None, one or two on	Off	Not fully locked

Rotor holding brake release double pushbutton

The *Rotor holding brake release* double pushbutton is used to release the rotor holding brake briefly to make it easier to position the rotor before locking. The rotor holding brake on the nacelle control cabinet

is active in the initial position. The rotor holding brake can be released by pressing and holding the upper button, *Release*. Pressing and holding the lower button, *STOP*, as well stops the release of the rotor holding brake. The rotor holding brake remains in the currently open position. This way, the rotor can spin very slowly, making it easier to find the locking position using the rotor lock guide plate. The rotor holding brake is re-activated when both buttons of the *Rotor holding brake release* double pushbutton are released.

5.4 Transformer control cabinet

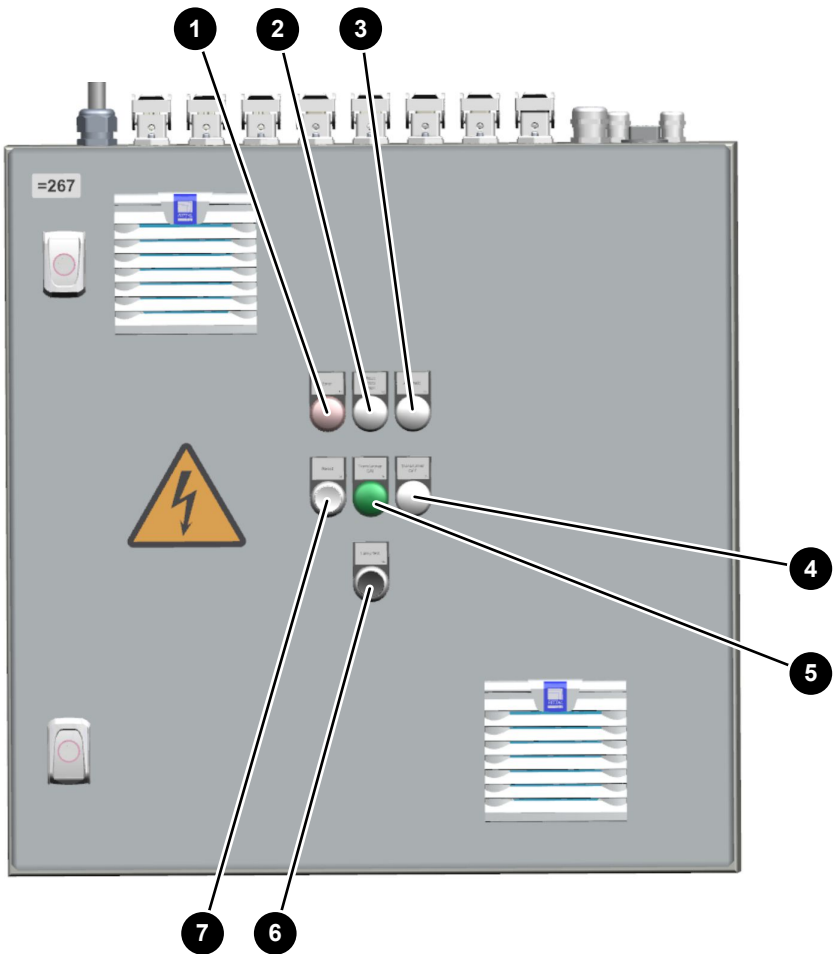


Fig. 28: Operating controls and display elements on the transformer control cabinet

1	Error indicator light	2	Status Control system indicator light
3	Automatic indicator light	4	Transformer Off indicator light
5	Transformer On indicator light	6	Lamp test button
7	Reset button		

Tab. 7: Operating controls and display elements on the transformer control cabinet

Element	Function/meaning
<i>Error indicator light</i>	Lights up if there is a fault in the transformer control system.
<i>Status Control system indicator light</i>	Indicates the status of the transformer control system. <ul style="list-style-type: none"> ■ Green, illuminated: There is no fault. The UPS is in grid mode. ■ Yellow, illuminated: There is no fault. The supply voltage has been interrupted. The UPS is supplying the transformer control system with voltage. ■ Yellow, flashing: The transformer control system is starting or has been switched off by the safety shutdown function for a relay test and is restarting. ■ Red, flashing: There is an internal fault message due to a tripped fuse, a tripped surge protection device or a defective Modbus RTU connection, for example. The fault message appears on the control relay displays.
<i>Automatic indicator light</i>	Lights up when the wind energy converter is in automatic mode.
<i>Transformer Off indicator light</i>	Lights up when the transformer is switched off.
<i>Transformer On indicator light</i>	Lights up when the transformer is switched on.
<i>Lamp test button</i>	Switches on the lamp test in the nacelle.
<i>Reset button</i>	Resets fault messages in the transformer control system.

5.5 Nacelle lighting control centre

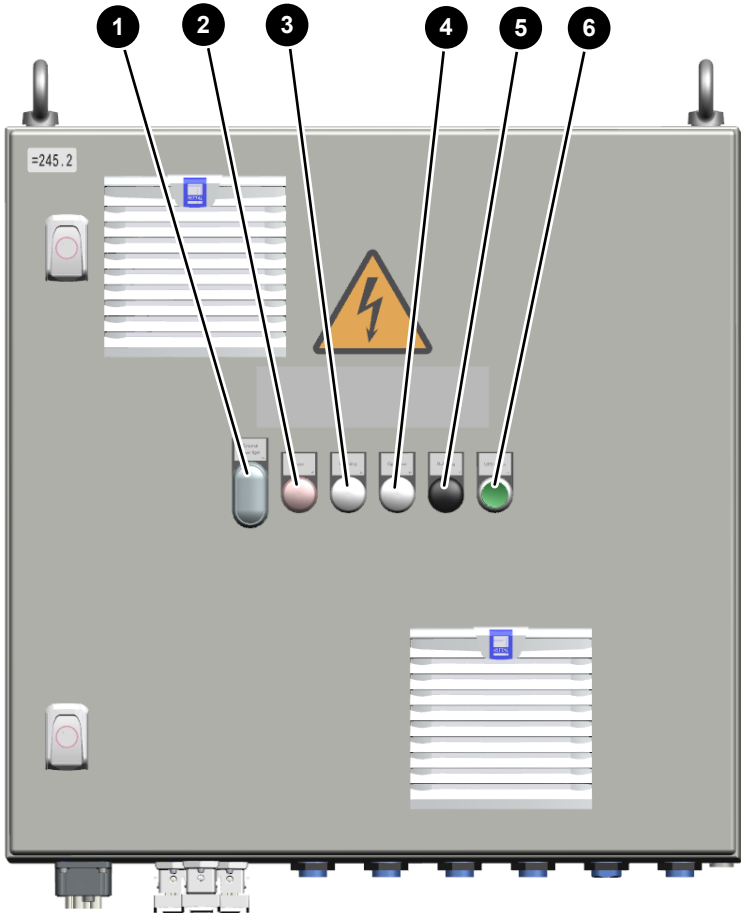


Fig. 29: Operating controls and display elements on the nacelle lighting control centre

1	Exterior tower lighting switch	2	Error indicator light
3	Buffering orange indicator light	4	Operation indicator light
5	Buzzer	6	UPS check button

Tab. 8: Operating controls and display elements on the nacelle lighting control centre

Element	Function/meaning
Exterior tower lighting switch	Switches the exterior tower lighting on or off.
Error indicator light	Lights up when there is a fault in supplying power to the lighting components.
Buffering indicator light	<ul style="list-style-type: none">■ Lights up green when there is no fault in the UPS or the insulation monitoring system.■ Lights up yellow if there is a fault in the insulation monitoring system.
Operation indicator light	Lights up when emergency power operation is switched on.
Buzzer	Emits an acoustic signal when there is no grid voltage and the emergency lights are activated.
UPS check button	For testing the emergency power supply for the nacelle.

5.6 Generator rotor main distribution system



Fig. 30: Operating controls and display elements on the generator rotor main distribution system

1	Heater on indicator light	2	Emergency stop button
---	---------------------------	---	-----------------------

Tab. 9: Operating controls and display elements on the generator rotor main distribution system

Element	Function/meaning
Heater on indicator light	Lights up when the cabinet heating is in operation.
Emergency stop button	Triggers an emergency stop of the pitch unit in service mode.

5.7 Pitch control cabinet

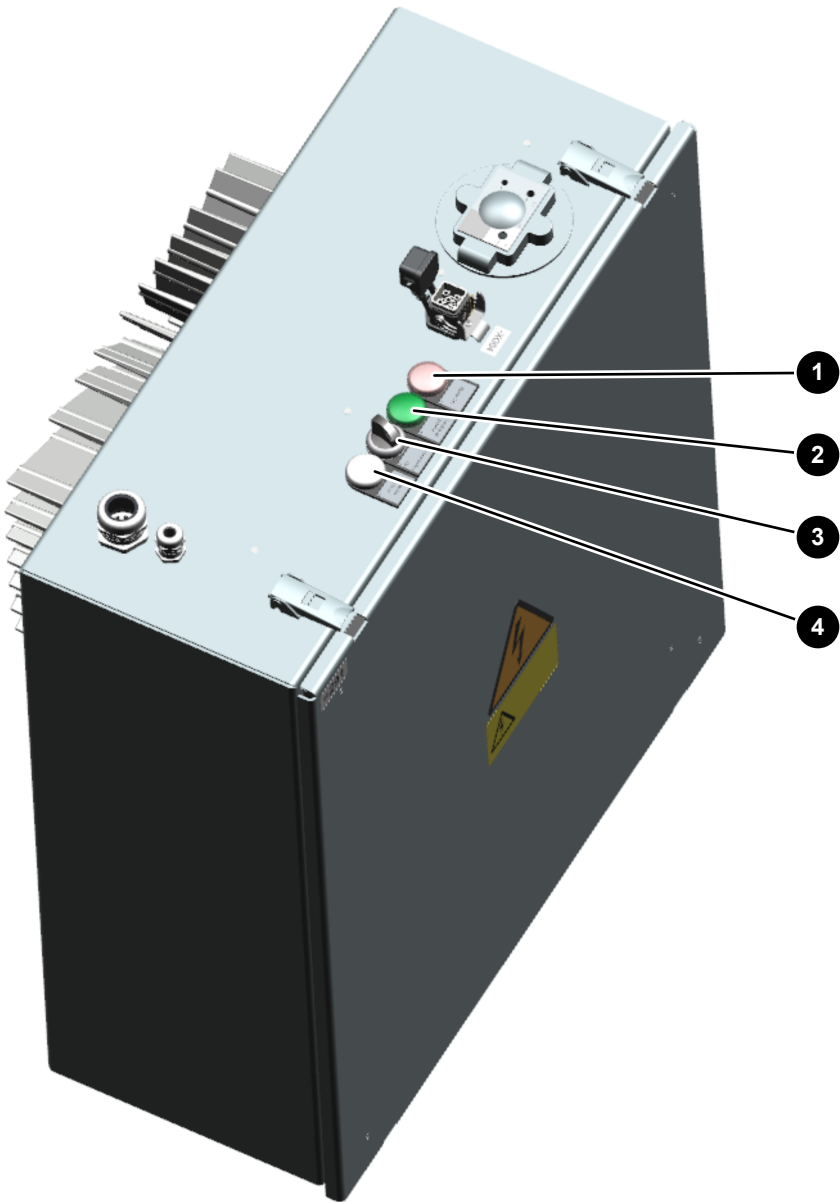


Fig. 31: Operating controls and display elements on the pitch control cabinet

1	Heater on indicator light	2	Feathered position indicator light
3	Service switch rotary switch	4	Service mode on indicator light

Tab. 10: Operating controls and display elements on the pitch control cabinet

Element	Function/meaning
Heater on indicator light	Lights up when the cabinet heating is in operation.
Feathered position indicator light	Lights up when the rotor blade is in the feathered position.
Service switch rotary switch	Requests service mode.

Element	Function/meaning
<i>Service mode on</i> indicator light	Lights up when service mode is active on the pitch control cabinet.

5.8 Wind energy converter display

5.8.1 Login

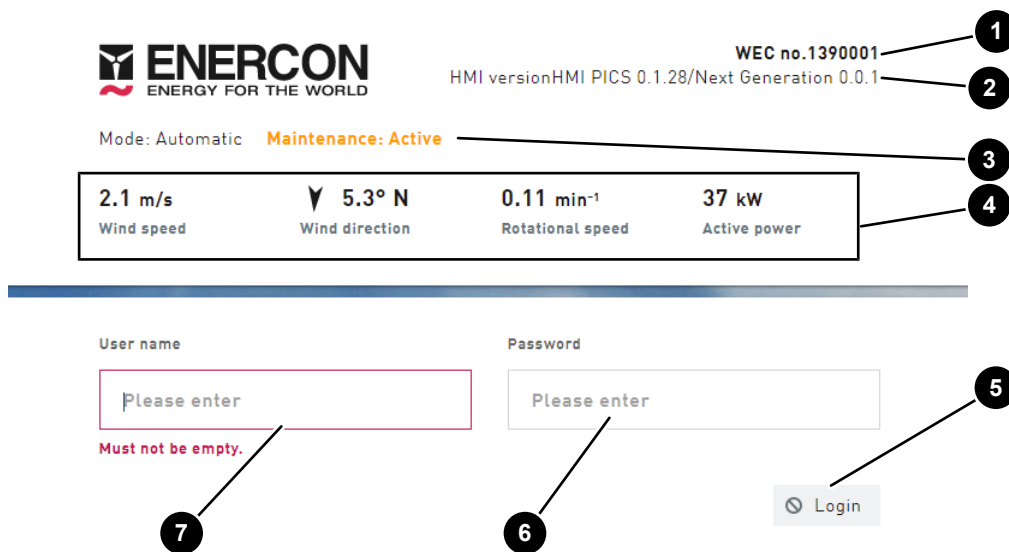


Fig. 32: Login

1	Wind energy converter number	2	HMI and software version
3	Information on mode and maintenance	4	Measured value display area
5	Login button	6	Password input field
7	Username input field		

5.8.2 Start page

Overview of the start page

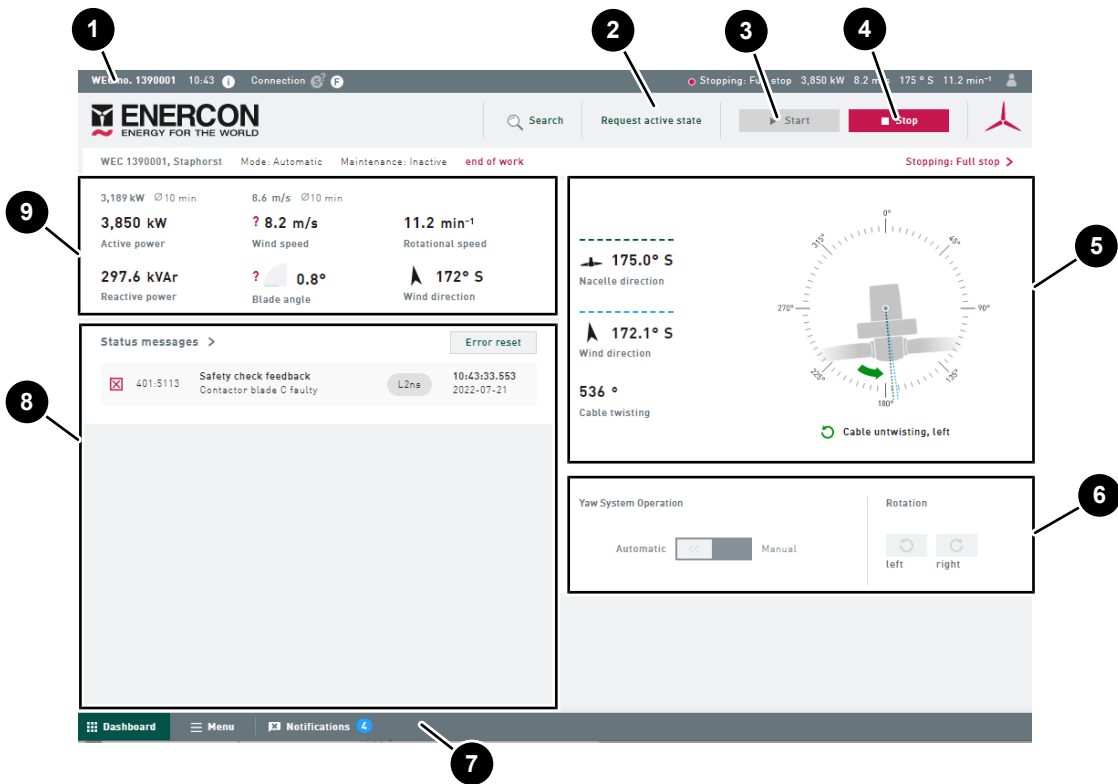





Fig. 33: Start page

1	Status bar	2	<i>Release active state or Request active state</i> button
3	<i>Start</i> button	4	<i>Stop</i> button
5	<i>Yawing</i> display area	6	<i>Yawing</i> control area
7	Taskbar	8	<i>Status messages</i> display area
9	<i>Measured values</i> display area		

Tab. 11: Operating controls and display elements on the start page

Element	Function/meaning
Status bar	<ul style="list-style-type: none"> Displays general information on the wind energy converter, the user and the time. Select the user icon to open the user menu.
<i>Release active state or Request active state</i> button	Requests the active state or releases the active state. Switching operations are only possible on the wind energy converter display when the active state is released.
<i>Start</i> button	Starts the wind energy converter when the <i>Maintenance</i> switch on the wind energy converter control console is switched off. Actuate this button again during the start phase to speed up the start process.
<i>Stop</i> button	Stops the wind energy converter.

Element	Function/meaning
<i>Yawing</i> display area	Displays the nacelle direction, the wind direction and the cable twisting.
<i>Yawing</i> control area	For changing the nacelle direction in manual mode.
Taskbar	<ul style="list-style-type: none"> ■ Permanently displays the <i>Dashboard</i>, <i>Menu</i> and <i>Notifications</i> tabs. ■ Displays any other open menu pages as tabs. These pages can be closed again individually as appropriate.
<i>Status messages</i> display area	<ul style="list-style-type: none"> ■ Displays the pending status messages. The status messages are marked as follows: <ul style="list-style-type: none">  Error  Warning  Info ■ Reset error messages on the wind energy converter display by selecting the <i>Reset error</i> button.
<i>Measured values</i> display area	Displays the current measured values (large numbers) and the 10-minute means (small numbers).

User menu Select the user name in the status bar to open the user menu.

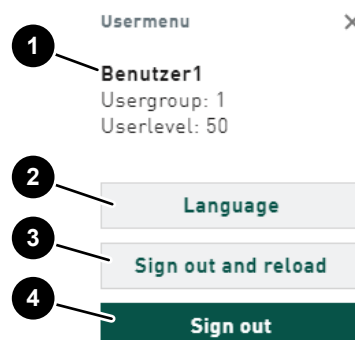


Fig. 34: User menu

1	User name	2	<i>Language</i> button
3	<i>Sign out and reload</i> button	4	<i>Sign out</i> button

Tab. 12: Operating controls and display elements in the user menu

Element	Function/meaning
<i>Language</i> button	Changes the language. The language can be changed when the active state is released.
<i>Sign out</i> button	Logs the user out.
<i>Sign out and reload</i> button	Logs the user out and reloads the application.

Communication fault warning

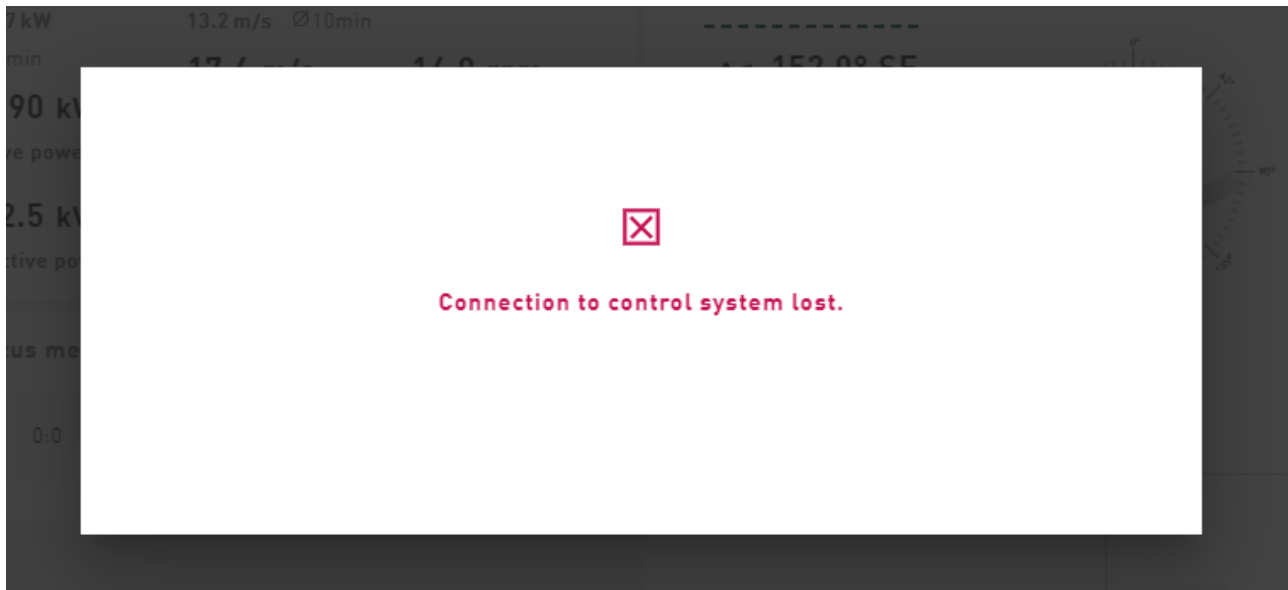


Fig. 35: Communication fault warning

If the connection between the HMI control system and the wind energy converter control system is interrupted for more than 10 seconds, a warning is displayed, see fig. 35, p. 90.

If the connection between the HMI control system and the wind energy converter control system is restored, the application resumes.

If the connection between the HMI control system and the wind energy converter control system is restored but the user session is no longer valid, e.g. because the wind energy converter control system has been restarted, a corresponding warning is displayed.

5.8.3 Active state

The active state is required in order to initiate actions or make changes to parameters.

Active state

You need the active state to execute this operation.

Close

Fig. 36: Active state required notice

The active state is only ever assigned to one user.

If there is a second user in a location with a higher priority than the current user, the second user can request the active state. This must be confirmed in a dialogue box.

The following priorities are defined:

1. Hub
2. Nacelle
3. Tower base
4. Wind farm
5. Remote

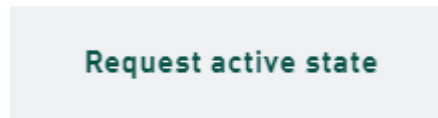


Fig. 37: Request active state button

The active state is requested by pressing the *Request active state* button.



Fig. 38: Confirm button

Once it has been requested, the active state must be confirmed with the *Confirm* button.

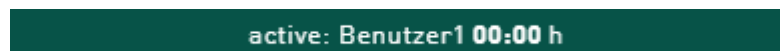


Fig. 39: Active user display

If the active state is successfully requested, the status bar turns green. The name of the user and how long the active state has been activated are also displayed.

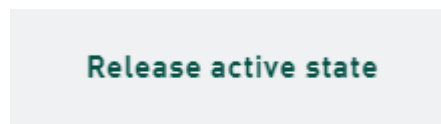


Fig. 40: Release active state button

The active state is released by pressing the *Release active state* button. The status bar turns grey.

When the user logs out, the active state is released automatically.

5.8.4 Menu

5.8.4.1 Overview

Screens		System	(HMI PICS 0.1.28/Next Generation 0.0.1)
Service	>	Operating state	>
Turbine	>	Status messages	>
Tower	>	Trig logs	>
Nacelle	>	Historical values	>
Yaw System	>	Operating data counters	>
Rotor	>	Access list	>
Generator	>	Trend analysis	>
Converter	>	Parameter management	>
Meteorology	>	Sound management	>
Grid	>	Software configuration	>
Power Control	>	Support	>
Options	>		

Fig. 41: *Menu* overview page

Other pages can be accessed from the *Menu* overview page. The pages displayed depend on the user's permissions.

The *Screens* group shows configured pages.

The *System* group shows the system pages. The current HMI version and the control system version are also displayed.

5.8.4.2 Manual pitching

The rotor blade angles are adjusted manually on the *Manual Pitching* page.

The *Manual Pitching* page is opened by selecting the following path from the *Menu* overview page:

Rotor > Manual Pitching

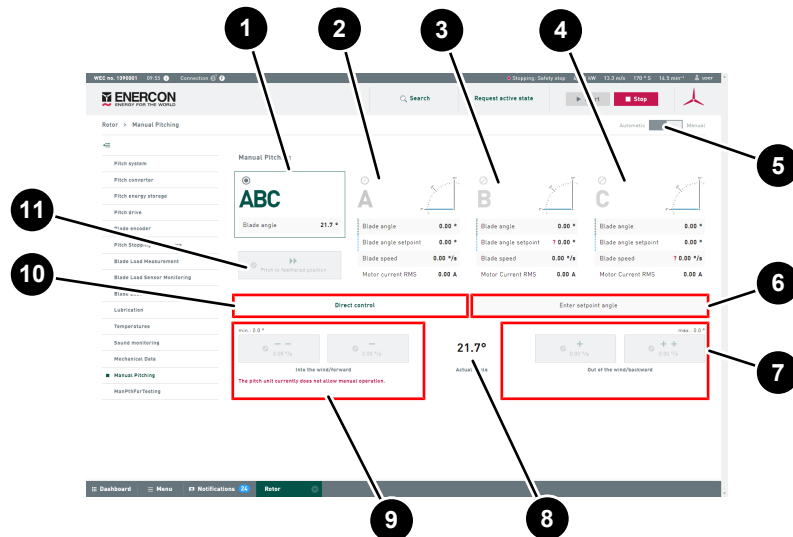


Fig. 42: Manual Pitching page

1	ABC selection field	2	A selection field
3	B selection field	4	C selection field
5	Automatic/Manual button	6	Set Target Angle button
7	Out of the wind/backward button	8	Current angle display field
9	Into the wind/forward button	10	Direct control button
11	Pitch to feathered position button		

Tab. 13: Operating controls and display elements on the Manual Pitching page

Element	Function/meaning
ABC selection field	For adjusting all rotor blades.
A selection field	For adjusting rotor blade A.
B selection field	For adjusting rotor blade B.
C selection field	For adjusting rotor blade C.
Automatic/Manual button	Activates manual mode or automatic mode for pitch control.
Set Target Angle button	For setting the target angle for the selected rotor blade.
Out of the wind/backward button	Turns the selected rotor blade out of the wind for as long as the button is pressed. + slow adjustment ++ fast adjustment This button is only active when the <i>Direct control</i> button has been selected.
Current angle display field	Displays the current rotor blade angle.
Into the wind/forward button	Turns the selected rotor blade into the wind for as long as the button is pressed. - slow adjustment -- fast adjustment









Element	Function/meaning
	This button is only active when the <i>Direct control</i> button has been selected.
<i>Direct control</i> button	For adjusting the selected rotor blade using the <i>Into the wind/forward</i> or the <i>Out of the wind/backward</i> button.
<i>Pitch to feathered position</i> button	Turns all rotor blades ABC to the feathered position.

5.8.5 Notifications

Notifications

Unmute alerts

Create info message

<div>Status Message</div> <div>  4:0 </div>	Pitch control error Transformer over temperature	 Going	<div>L2ts</div> <div>08:23:04.056</div> <div>2021-09-24</div>
<div>Operation State Change</div> <div>  </div>	Starting: Run-up (220) Old: Free run: Generator heating (460)		<div></div> <div>08:23:39.351</div> <div>2021-09-24</div>
<div>Operation State Change</div> <div>  </div>	Free run: Generator heating (460) Old: Stopped: Idling (510)		<div></div> <div>08:23:26.135</div> <div>2021-09-24</div>
<div>Status Message</div> <div>  2:0 </div>	Fault lubrication system Grease level pre warning (rotor)	 Going	<div>L2t</div> <div>08:17:07.362</div> <div>2021-09-24</div>
<div>User Action</div> <div>  fritz.walter </div>	A parameter value was changed. stepInitTurbine		<div></div> <div>08:23:19.047</div> <div>2021-09-24</div>
<div>Operation State Change</div> <div>  </div>	Stopped: Idling (510)		<div></div> <div>08:23:13.125</div> <div></div>

Dashboard

Menu

Notifications

5

Fig. 43: Notifications overview page

If changes occur in the wind energy converter that are relevant to the user, a pop-up notification is generated and displayed on the *Notifications* tab. A maximum of 100 notifications are stored. All notifications previously read are highlighted in grey. All unread notifications are highlighted in yellow with a blue dot to the left.

The following notifications are generated:

- Status messages
- Change of operating state

- Relevant actions, e.g.:
 - Login
 - Logout
 - Active state requested
 - Active state released
 - Parameter change
 - Program erased on SLC
 - Program updated on SLC
 - Module allocation performed on SLC
 - Program launched on SLC
 - Parameters loaded
 - Parameters saved
 - Control system update performed

Pop-up notifications

Pressing the *Mute alerts* or *Unmute alerts* button allows the notifications to be muted or activated. If the notifications are muted, they continue to be generated but are no longer displayed as pop-ups.

Create note

Pressing the *Create info message* button enables the user to create a general information message. This message is displayed as a pop-up to all users when they log in and on the *Notifications* overview page.




Once an info message has been created, it can be edited by pressing the *Edit info message* button. In edit mode, the info message can be deleted by pressing the *Delete info message* button.

To generate or edit an info message, the active state and relevant permissions are required.

Notifications tab

The *Notifications* tab symbol varies depending on the setting:

Tab. 14: Meaning of the symbols

Symbol	Meaning
	<ul style="list-style-type: none"> ■ Pop-up notifications are activated ■ 30 unread notifications since last visit to overview page
	<ul style="list-style-type: none"> ■ Pop-up notifications are muted (x symbol) ■ 34 unread notifications since last visit to overview page
	<ul style="list-style-type: none"> ■ Pop-up notifications are muted (x symbol) ■ 54 unread notifications since last visit to overview page ■ Info message generated by user (!)

6 Operation and functions

6.1 Power generation and conditioning

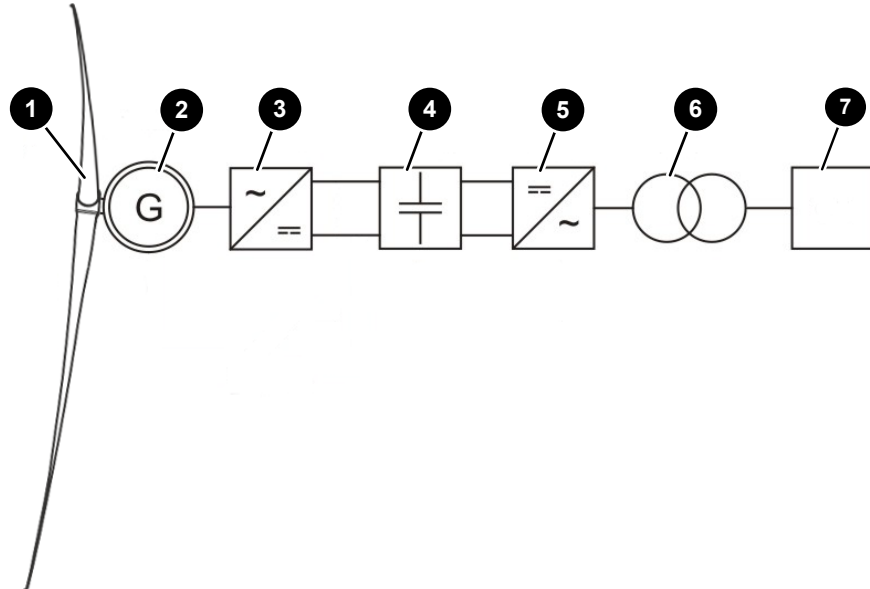


Fig. 44: Simplified electric diagram

1	Rotor	2	Generator
3	Rectifier	4	DC link
5	Inverter	6	Transformer
7	Power grid		

The wind energy converter operates at a variable rotor speed. The generator produces alternating current with varying voltage, frequency and amplitude from the rotational movement of the rotor. The generator is not connected directly to the power grid.

The windings of the generator stator form a number of electrical systems that produce three-phase current independently of one another. These are connected in parallel, actively rectified and then converted into three-phase current with a frequency and phase position that match the grid. The three-phase current is combined in a low voltage system. The transformer matches the three-phase current to the voltage level of the particular power grid, e.g. 20 kV.

6.2 Power supply for on-site power consumption

The power consumption requirements for the wind energy converter vary during operation. Components that are supplied with power include the control system, the transformer, the beacon system components and the lighting.

When the wind energy converter is generating sufficient power, the power generated covers the on-site consumption requirement. When it is at a standstill or in idle mode or during startup, however, the wind energy converter draws the power it requires from the grid of the relevant grid operator. The power supply is switched over automatically.

6.3 Operating modes

Automatic mode Automatic mode is the operating mode in which the wind energy converter normally operates. In this mode, the wind energy converter is operated automatically and with optimum efficiency. The nacelle turns automatically into the wind direction. The rotor blades are automatically adjusted.

In automatic mode, the wind energy converter switches automatically between different operating states.

- **Full load operation:** The wind energy converter is generating its nominal power.
- **Partial load operation:** The wind energy converter is generating part of its nominal power.
- **Idle mode:** The wind energy converter is not generating power. The rotor nevertheless continues to rotate slowly to keep the load on the rotor bearings low.

Wind speed V is normally the determining factor for the operating state. The following table shows which operating state is to be expected at which wind speed V . In addition, the table shows which rotor speed R and which generated power P is to be expected in each case.

The reference variables used for wind speed V are:

- Cut-in wind speed V_E
- Nominal wind speed V_N
- Power reduction wind speed V_{AR}
- Cut-out wind speed V_{AS}

Tab. 15: Relationship between wind speed, operating state, rotor speed and power generated

Wind speed V	Operating state in automatic mode	Rotor speed R	Power generated P
$V < V_E$	Idle mode	$R \leq$ maximum idle speed	$P = 0$
$V_E \leq V < V_N$	Partial load operation	$R <$ nominal speed	$P <$ nominal power
$V_N \leq V < V_{AR}$	Full load operation	$R =$ nominal speed	$P =$ nominal power
$V_{AR} < V \leq V_{AS}$	Partial load operation (storm control)	$R <$ nominal speed	$P <$ nominal power

Wind speed V	Operating state in automatic mode	Rotor speed R	Power generated P
$V > V_{AS}$	Idle mode	R = maximum idle speed	P = 0

Storm control When the wind speed moves between the cut-out and the power reduction wind speeds, the storm control dynamically reduces the power and increases it again. Storm control enables operation in high wind speeds and reduces losses of yield.

Further factors The operating state in automatic mode is not determined solely by the wind speed. The power can also be reduced by controlled means, e.g. if there is a need to reduce sound emissions (noise optimisation). The wind energy converter can also stop automatically, e.g. by shadow shutdown or in the event of faults. The wind energy converter then does not generate any power. Depending on the cause, the rotor will be braked or the wind energy converter will change into idle mode.

Manual mode Automatic yaw control and automatic pitch control are deactivated in manual mode. Emergency pitching of the rotor blades remains active. Manual mode is intended for maintenance, troubleshooting and testing. Remote monitoring and remote control of the wind energy converter are suppressed. No power is usually generated in manual mode.

6.4 Electrical configuration with FACTS properties

Various configurations for the wind energy converter are possible to meet different requirements of power grid operators. The wind energy converter can be equipped with the following power plant properties.

FACTS FACTS is a system of power electronics components and their control system for supporting the power flow in a power grid. The wind energy converter can supply its maximum reactive power even if it is only feeding in a fraction of its nominal power. FACTS forms the basis for the various configurations.

FT configuration The FT configuration includes various strategies for riding through grid faults. Riding through grid faults is also called Fault Ride Through (FRT).

In the event of undervoltage or overvoltage in the power grid, the wind energy converter initially continues to run without disconnecting from the grid. Possible strategies for riding through a grid fault include, for example, feeding in additional reactive current or a feed-in stop. The feed-in stop is also known as Zero Power Mode in which no active or reactive power is fed into the grid.

After riding through the grid fault, the wind energy converter returns to normal operation and feeds energy into the power grid in accordance with the setpoints for active and reactive power. The power grid is supported.

If energy cannot be fed into the power grid while the grid fault is present, the energy is converted into heat. If a grid fault occurs, the wind energy converter can continue to operate for up to 5 seconds and only then will it disconnect from the power grid. Most grid faults last less than 1 second.

FTQ configuration The FTQ configuration is similar to the FT configuration, but with an extended reactive power range.

FTS configuration The FTS configuration is similar to the FT configuration, but with the STATCOM option. STATCOM means that the wind energy converter can supply or absorb reactive power, regardless of whether it is itself generating active power and feeding it into the grid. The wind energy converter can actively support the grid, in a similar way to a conventional power plant. The FTS configuration can lead to higher power consumption of electrical energy.

FTQS configuration The FTQS configuration combines the properties described for the FT, FTQ and FTS configurations.

6.5 Wind energy converter monitoring

All relevant operating and ambient data is recorded continuously by sensors. The control system of the wind energy converter uses the recorded data to ensure optimum and safe operation.

Redundant sensors Redundant sensors are installed to enable plausibility checks for some operating states by comparing recorded values. This applies, for example, to the measurement of the generator temperature, the wind speed or the current rotor blade angle. Defective sensors are reliably detected and can be repaired or replaced through activation of a reserve sensor. The wind energy converter is thus usually able to continue safe operation without the need for immediate service work.

Checking the sensors Proper functioning of all sensors is either regularly checked by the wind energy converter control system itself during normal wind energy converter operation or, where this is not possible, in the course of wind energy converter maintenance work.

Speed monitoring The wind energy converter control system regulates the rotor speed by adjusting the blade angle in such a way that the nominal speed is not significantly exceeded, even if the wind is very strong. The pitch unit, however, may not be able to react quickly enough to sudden events such as a strong gust or a sudden reduction in generator load. If nominal speeds are exceeded by more than approx. 15 %, the open-loop control system stops the wind energy converter. After

3 minutes, the wind energy converter automatically attempts a restart. If this fault occurs more than 5 times within a 24-hour period, a defect is assumed. No further restart will then be attempted.

If the nominal speed is exceeded by more than approximately 20 %, emergency pitching of the rotor blades is triggered. To enable the wind energy converter to restart, the cause of the overspeed must be identified and eliminated.

The rotor speed is measured directly with a gyroscope installed in the hub. The signal is checked for plausibility with the rotor speed signal of a magnetic tape encoder.

Air gap monitoring

The width of the air gap between generator rotor and generator stator is monitored using microswitches distributed around the circumference of the rotor.

If one of the microswitches is triggered due to the gap falling below the minimum width, the wind energy converter is stopped and restarted after a short time.

If this fault occurs again within 24 hours, the wind energy converter remains stopped until the cause has been eliminated.

Oscillation monitoring

The oscillation monitoring system detects excessive vibrations and oscillations or excursions of the wind energy converter tower head.

Sensors record the acceleration of the nacelle towards the hub axis (longitudinal oscillation) and transverse to this axis (transverse oscillation). The control system of the wind energy converter uses this input to continuously calculate the tower excursion relative to its idle position.

Vibrations are also detected according to the control system type of the wind energy converter either via a function integrated into oscillation monitoring or by a separate vibration sensor.

If the oscillations or excursions exceed permissible limits, the wind energy converter stops. It restarts automatically after a short delay.

If impermissible vibrations are detected or if impermissible tower oscillations occur repeatedly, the wind energy converter stops and will not attempt any further restarts.

Temperature monitoring

Some components of wind energy converters are cooled. Temperature sensors also continuously measure the temperature of components that need to be protected from high temperatures.

In the event of excessive temperatures, the power output of the wind energy converter is reduced. If necessary, the wind energy converter stops. The wind energy converter cools down and generally restarts automatically as soon as the temperature falls below a predefined limit.

Some measuring points are equipped with additional overtemperature switches. These overtemperature switches also initiate a stop of the wind energy converter once the temperature exceeds a specific limit value, in certain cases without an automatic restart after cooling down.

At low temperatures, some assemblies such as the energy storage cabinet of the beaconing and the generator are heated in order to keep them operational.

Noise monitoring inside the nacelle

There are sensors located in the rotor head of wind energy converters with nacelle-internal noise monitoring, which respond to loud knocking sounds such as might be caused by loose or defective components. If any of these sensors detect noise and there is nothing to indicate a different cause, the wind energy converter stops.

In order to rule out external causes of noise (mainly the impact of hail), the status messages from all wind energy converters in a wind farm are compared with each other. For stand-alone wind energy converters, a noise sensor in the machine house is also used. If the sensors in multiple wind energy converters or the noise sensor in the machine house detect(s) noise simultaneously, an exterior cause is assumed. The noise sensors are deactivated briefly so that none of the wind energy converters in the wind farm have to stop.

Cable twisting monitoring

The tower cables have so much slack in the upper tower area that the nacelle can be turned left and right by 3 turns without damaging and/or overheating the tower cables. Depending on the degree of twisting and level of the wind speed, the control system of the wind energy converter decides when the tower cables are to be untwisted.

The cable twisting monitoring is equipped with sensors that prevent movement of the yaw motors if the permitted adjusting range is exceeded.

6.6 Remote monitoring

The wind energy converter is linked to ENERCON Technical Service Dispatch via a remote monitoring system. If requested by the operator, the wind energy converter can also be monitored by another organisation.

Operating data, irregularities and faults can be called up using the remote monitoring system. Faults that generate a status message are permanently stored.

If the wind energy converter is part of a wind farm, the wind energy converters are connected centrally via a server.

6.7 Pitch control

Pitch control rotates the rotor blades along their longitudinal axis. Rotating the rotor blades changes the angle of attack at which the air approaches the blades. Changing the angle of attack also changes the lift on the rotor blades and the force with which the blades turn the rotor.

The pitch unit runs automatically in automatic mode. In this case, the rotor blades are pitched synchronously, i.e. the blade angles of all 3 rotor blades are identical. The blade angles are measured by sensors.

The pitch unit consists of the following components for each rotor blade:

- Blade flange bearing
- Pitch drive
- Angle encoder
- Pitch control cabinet
- Capacitor box

Blade angle The typical blade angles that occur during operation are described below.

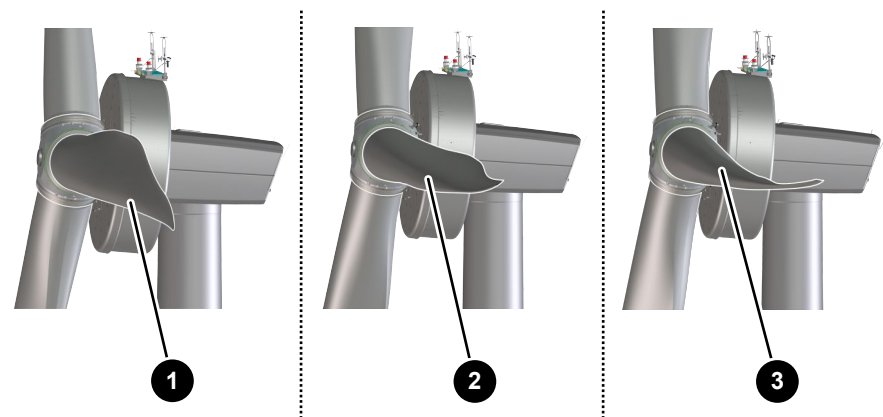


Fig. 45: Blade angle

1	Blade angle approx. 0°	2	Blade angle approx. 60°
3	Blade angle approx. 90°		

Tab. 16: Blade angles in operation

Blade angle	Explanation
Approx. 0°	Position in partial load operation. The blades generate maximum lift. The rotor turns.
Approx. 0 – 60°	Position in full load operation. Based on the wind speed, the rotor blades are turned far enough out of the wind for the wind energy converter to produce the required power. The rotor turns.
> approx. 60°	Position in idle mode. The rotor blades can generate a small amount of lift. The rotor idles or stands still if there is complete calm.
Approx. 90°	Feathered position. The rotor blades do not generate lift. The rotor is braked aerodynamically. It is at a standstill or moves only minimally.

6.8 Yawing

The nacelle rotates on top of the tower. For optimal power generation, the nacelle must be aligned with the wind direction. When the wind direction changes, the nacelle must turn with it.

The nacelle is rotated by means of the yaw system. The wind direction and the nacelle position are measured and compared. If the difference between the wind direction and the nacelle position is greater than the specified permissible maximum value, the yaw drives rotate the nacelle.

The wind direction is measured by the wind measuring units and the position of the nacelle is measured using the cable twist limit switch.

6.9 Cable untwisting

As the nacelle rotates, the tower cables become twisted. The tower cables are laid below the nacelle in what is known as the cable twisting area, with a large amount of slack. This ensures that they are not damaged by becoming twisted.

If the twisting of the tower cable becomes excessive, the wind energy converter stops and initiates a cable untwisting routine. In both cases the nacelle is turned further than the neutral position, so that the tower cables are twisted in the opposite direction slightly.

Untwisting the cables takes several minutes per nacelle rotation. Once the cables have been untwisted, the wind energy converter automatically resumes operation.

The cable untwisting sensors are located in the cable twist limit switch.

6.10 Lighting

The tower base lighting control centre is located in the combination cabinet and includes a power supply unit for the emergency lights in the tower and tower base. The test of the lighting emergency power supply is performed at the tower base lighting control centre. The tower lighting is switched on at a switch in the tower entrance area.

The nacelle lighting control centre includes a power supply unit for the emergency lights in the nacelle, a battery pack and status indicator lights. The interior lighting of the nacelle is switched on at the nacelle light and presence switch when a person accesses the nacelle from the tower.

The lights in the wind energy converter are installed along all routes from the rotor to the tower base. This therefore ensures sufficient lighting. In the event of a power failure, the lighting needed to navigate the tower is maintained for at least 1 hour. This leaves enough time to descend from the nacelle and leave the wind energy converter.

6.11 Heating of electrical components

Certain components, such as those for the emergency power supply for the pitch unit, the generator and the control and converter cabinets, must be heated at low temperatures to keep them ready for use or prevent condensation from building up. This is particularly the case when the wind energy converter is at a standstill. Temperature and air humidity are recorded by sensors. The wind energy converter control system regulates the component heating. Cabinet heating is used to heat the control and converter cabinets. The generator is heated by means of a limited short-circuit current in the generator stator windings or an excitation current in the generator rotor windings.

Power components connected to the liquid cooling system in the machine house can also be warmed by the coolant heating up.

6.12 Ice detection

In certain weather conditions, ice, hoarfrost or snow can build up on the rotor blades of wind energy converters. This usually happens when there is high air humidity, rain or snow while temperatures are just below freezing. A build-up of ice and hoarfrost leads to an unbalance of the wind energy converter rotor. Chunks of ice can detach from the rotor blades and become a hazard to persons and property (ice shedding or ice throw).

To reduce the dangers of ice throw, ice detection based on the ENERCON power curve method is employed as standard in ENERCON wind energy converters. If ice build-up is detected on a running wind energy converter, the wind energy converter stops at the end of a set detection time. Ice detection using the ENERCON power curve method can only function while the wind energy converter is running.

At certain sites, it is imperative to prevent any hazards caused by ice that has formed while the wind energy converter was at a standstill, e.g. where roads pass close to the wind energy converter. Depending on the site in question, the wind energy converter operator or owner must check whether ice detection measures are required. If ice detection measures are required, external ice detection systems can be used as an option. The suitability of the external ice detection systems to the specific project must be verified in advance. The following systems are available:

- Wölfel ice detection (Wölfel)

If residual risks remain despite the use of an ice detection system, the operator or owner of the wind energy converter must take appropriate protective measures.

6.13 Nacelle positioning with ice-build up

During de-icing, there is a danger of ice shedding while the wind energy converter is at a standstill. Wind energy converters located in the immediate vicinity of traffic routes or buildings pose an increased risk of injury and property damage.

In the event of ice build-up, a specific nacelle alignment can be pre-defined for the period of the ice build-up including the de-icing phase. This restricts the risk from ice shedding to a small zone along the swept area. The alignment of the nacelle can be configured by authorised specialist personnel.

If the *Nacelle positioning with ice build-up* function has been configured accordingly in the wind energy converter control system, yawing of the nacelle is disabled in the event of ice build-up. This can expose the rotor and the nacelle to wind from the sides or from behind. This can cause damage to the wind energy converter in unfavourable weather conditions, e.g. generator damage due to rainwater seeping in. To prevent more extensive damage, the function is automatically suspended above a certain wind speed level, which can be configured. The function is reactivated if the wind speed decreases provided that at least 15 minutes have passed since the interruption.

6.14 Extreme climate equipment

The use of special components expands the ambient temperature range in which the wind energy converter can generate electrical energy. Information on the extended ambient temperature range can be found in chapter *Technical specifications*.

The availability of possible wind energy converter configurations for cold and hot-climate sites depends on the certification of the respective configuration. Information on availability can be provided by ENERCON Sales.

Hot climate equipment

The hot climate equipment for the wind energy converter consists of a large number of nacelle fans used to cool the generator and the machine house. The large number of nacelle fans expands the ambient temperature range in which the wind energy converter can produce nominal power.

Cold climate equipment

The cold climate equipment of the wind energy converter consists of the following adaptations:

- Special lubricants for drive components
- Adapted material properties for cast-iron components
- Adapted tower structures and materials
- Additional heating for heating the cooling liquid in the machine house
- Modified power curve

6.15 Cooling of the medium-voltage components and the power electronics

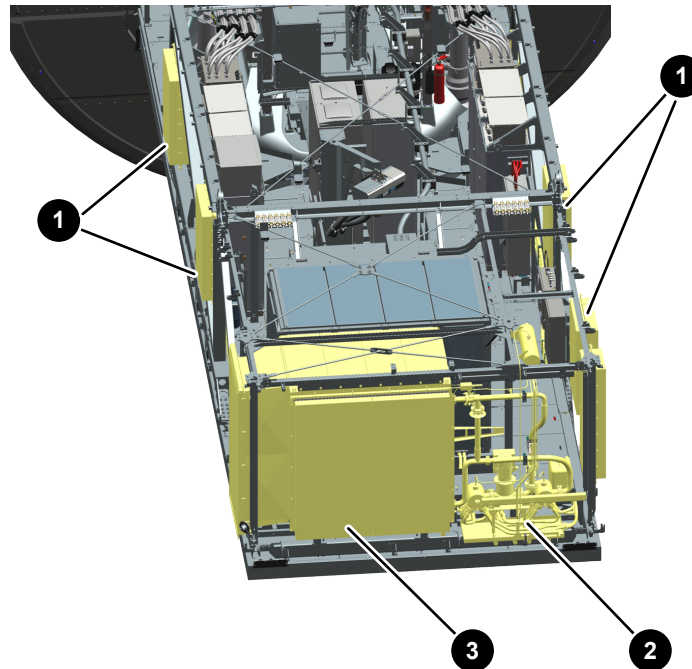


Fig. 46: Cooling system in the machine house

1	Air intake	2	Liquid cooling system pipes
3	Liquid cooling system chiller		

The medium-voltage components and the power electronics are cooled by a liquid cooling system. To effect cooling, the coolant pump pumps the cooling liquid through a system of hoses to the individual components. The heat generated in the components is dissipated into the cooling liquid and flows back to the liquid cooling system chiller. The heated cooling liquid is cooled there by outside air.

The inside of the machine house is also cooled with air. Cool outside air is drawn into the inside of the machine house through air intakes on the sides of the machine house. The cool air flows through the machine house and is then routed through a gap in the nacelle casing and out of the nacelle.

6.16 Generator cooling

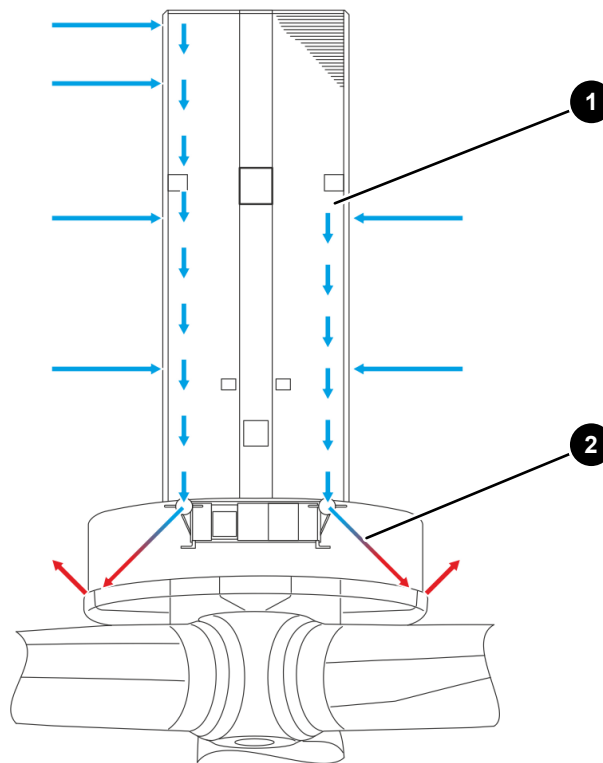


Fig. 47: Air cooling system of the generator

1	Machine house	2	Generator
→	Cold air	→	Warm air

Cooling of the generator is achieved with an air cooling system.

Fans are installed on the generator stator. The fans draw in outside air through the air intakes in the machine house and convey the air through the generator. As the air flows through the generator, the heat from the generator rotor and generator stator is released to the air, thereby cooling the generator. The warm exhaust air is discharged through the gap between the generator and the rotor head.

6.17 Fire protection system

The fire protection system comprises multiple components that minimise the probability of a fire starting, the spread of fire and smoke, injuries and property damage.

6.17.1 Technical fire safety

Reducing sources of ignition

Sources of ignition in the wind energy converter are reduced by design measures such as the following:

- Use of gearless drive systems. This avoids the use of a hot gear and flammable gear oil, which would pose a fire risk.
- Use of a lightning protection system. Lightning strikes are thus discharged without damaging the wind energy converter.

Preventing fires from starting or spreading

Design features including the following prevent fires from starting or spreading inside the wind energy converter as much as possible:

- Arranging flammable materials as far as possible so that they cannot be ignited.
- Using fire-retardant, fire-resistant or non-flammable materials wherever possible.
- Providing CO₂ fire extinguishers in the nacelle and in the tower base. Further information on the number and installation locations of the fire extinguishers is given in document D0648865 'Technisches Datenblatt Installationsorte der Feuerlöscher' (Technical data sheet – Installation locations of fire extinguishers).
- Using automatic extinguishing systems for fighting incipient fires.
- Using sensors for monitoring.

Monitoring using sensors

Possible sources of ignition in the wind energy converter are constantly monitored by sensors.

Smoke detectors in the nacelle and in the tower base are used to detect fires. Further information on the number and installation locations of smoke detectors is given in document D0701831 'Technisches Datenblatt Installationsorte der Rauchschalter' (Technical data sheet – Installation locations of smoke detectors). If a sensor detects a safety-relevant fault, e.g. overheating or smoke, the wind energy converter is switched to limited operation or stopped. The relevant status message is sent to ENERCON Service via the remote monitoring system. If anyone is present in the wind energy converter when a fire is detected, they are warned by visual warning signals in the service hoist and by acoustic warning signals in the nacelle and in the tower base.

Escape routes

The first escape route leads outside from the nacelle via the tower and is fitted with battery-powered emergency lights. This escape route is used if it is possible to descend within the tower. A second escape route leads through the crane hatch to the outside and requires use of the available rescue equipment. This escape route enables an exit from the nacelle if it is no longer possible to descend inside the tower. Both escape routes are marked.

6.17.2 Organisational fire safety

Protective measures during operation

Nobody is usually present in the wind energy converter while it is in operation. The wind energy converter is locked.

If a status message indicates a fire, ENERCON Service immediately dispatches a Service team to the wind energy converter and notifies the fire brigade that decides on further actions once on site. In addition, the utility is notified. ENERCON Service can be reached 24 hours a day.

Protective measures during maintenance

The wind energy converter is serviced at regular intervals, at least 1x per year depending on requirements, and is thereby entered by several persons. These persons are familiar with the systems in the wind

energy converter and how to perform a rescue from it. The wind energy converter is mostly not in operation during maintenance. The power electronics are switched off. Only a few components, e.g. lighting, sockets and the control system, remain active. This reduces the risk of fire when persons are present.

If smoke is detected, the wind energy converter activates the signal units in the tower base, the service hoist and the nacelle.

Incipient fires can be extinguished using the CO₂ fire extinguishers provided in the tower base and in the machine house. All information on the wind energy converter that might be required in the event of a fire (coordinates, directions, important telephone numbers for local services) and on what to do in the event of fires or accidents is provided in the emergency chart and in the escape and rescue plan. These plans are displayed in the tower entrance area and in the machine house.

6.17.3 Fire-fighting by the fire brigade

Fire in the tower base A fire in the tower base is restricted to a single location. It cannot spread to the nacelle or affect the surroundings of the wind energy converter. As soon as the wind energy converter has been de-energised, the fire in the tower base can be extinguished by the fire brigade.

Fire in the nacelle A fire in the nacelle can cause the nacelle to burn out and can spread to the rotor blades. At this point the rotor blades are already at a standstill. After burning for a prolonged period, a rotor blade will break off at the blade root due to its weight and fall to the ground.

Although the fire brigade cannot fight a fire in the nacelle, it can block access to the danger zone of the wind energy converter over a wide area and allow the nacelle and falling parts to burn out in a controlled manner.

6.18 Lightning protection system

The lightning protection system is designed to protect the wind energy converter from damage caused by lightning strikes. If lightning strikes the wind energy converter, the lightning current is absorbed by the lightning protection devices that are located, for example, in the rotor blade tips. The lightning current is directed from the lightning protection devices to earth in a controlled manner via discharge devices.

All conductive mechanical components and the tower itself are tied to the equipotential bonding system.

All electronic systems of the wind energy converter are galvanically isolated and all are contained in metal housings. All relevant components are equipped with surge protection devices.

6.19 Storm control

Storm control enables the wind energy converter to operate even at very high wind speeds, albeit with reduced rotor speed and power output. Storm control also improves the stability of the power grid because the wind energy converter reduces the power feed gradually rather than stopping it abruptly.

Above a set wind speed, the rotor speed is reduced on a straight-line basis as the wind speed increases further until idling speed is reached, by turning the rotor blades correspondingly far out of the wind.

The power feed-in falls accordingly until no power is generated or fed into the grid. However, the wind energy converter does not stop completely. When the wind speed drops back below the set level, the wind energy converter starts to feed power into the grid again.

6.20 Noise optimisation

Noise optimisation is applied at sites in which the sound emissions of the wind energy converter have to be reduced at certain times or with particular wind directions or wind speeds.

If the set conditions are met, the control system of the wind energy converter receives the command to change to a different control curve. The time of day, day of the week, wind direction sector, wind speed range, date range, rain, maximum temperature or an external signal are set as conditions. If the conditions for more than one control curve are met at the same time, the control curve with the highest priority is selected.

The switchover between control curves takes place smoothly during normal operation, with no need to stop the wind energy converter.

6.21 Beacon system components and coloured marking

Depending on their height, exposure at the site and the applicable national regulations, wind energy converters must be marked as aviation obstacles where necessary.

The design of the marking is based on the applicable local regulatory requirements and can be implemented by means of beaconing and/or coloured markings.

6.21.1 Beacon system components

The beacon system components are the technical components used to make the wind energy converter visible as an obstacle to aviation.

The beacon lights are installed on a carrier on the nacelle roof of the wind energy converter. As a rule, the beacon lights are installed in pairs so that they cannot be completely obscured by an obstacle from any direction.

With very high towers, the applicable requirements may call for up to 2 additional tiers on the tower, each fitted with 4 beacon lights.

The beacon lights are connected to a central control cabinet.

Various functions and actions are available to the beacon management system.

Needs-based nighttime marking	Needs-based nighttime marking limits the light emissions of the wind energy converter to only those periods during which aircraft are crossing the areas of the wind energy converter that are relevant to safety.
Wind farm synchronisation	The flashing nacelle beacon lights of wind energy converters can be synchronised within a wind farm via a central wind farm PC. Multiple wind farms can be synchronised using a GPS system on the individual wind farm PCs.
Luminous intensity control system	In good visibility conditions, a visibility meter and a luminous intensity control system reduce the luminous intensity of the beacon system components. This saves energy and mitigates any impact that the beacon system components might have on the surrounding area.
Remote monitoring system	Warning messages and fault messages from the beacon system components are automatically recorded by the remote monitoring system. The following are monitored: failure of supply voltage, failure of beacon lights, failure of emergency power supply batteries and faults in the visibility meter or battery charger.

6.21.2 Coloured markings

Coloured markings serve to identify the wind energy converters during the daytime as obstacles to aviation. They can be combined with beacon system components. The form of the coloured markings is determined by the regulations in force on the relevant site. They may take the form of coloured stripes on the rotor blade, on the nacelle or the tower.

6.22 Sector management

To reduce turbulence and the resultant loads on downstream wind energy converters in the wind farm, the wind energy converter can be limited or stopped as a function of nacelle alignment and wind speed by means of sector management.

For sector management, 25 sectors can be defined in the wind energy converter control system. A sector is formed by a start and stop angle for the nacelle position as well as a cut-in and cut-out wind speed. Each of the 25 sectors can be activated or deactivated via a parameter. Sector management as a whole can also be activated or deactivated via a parameter.

When the conditions for a sector are fulfilled, the wind energy converter can be limited by restricting the power, the minimum blade angle or the rotor speed, or the wind energy converter is stopped.

If the nacelle leaves the sector, the limitation or stop of the wind energy converter is cancelled after a certain period has elapsed.

6.23 Shadow shutdown

The shadow shutdown function stops the wind energy converter in line with requirements to minimise or prevent immissions caused by periodic shadow flickering at relevant locations.

Periodic shadow flickering is the moving shadow caused by direct sunlight being blocked by the movement of the rotor blades of the wind energy converter. The extent to which this effect will occur depends on current local weather conditions, the alignment of the nacelle to the wind direction, the position of the sun and the operating times of the wind energy converter.

The shadow shutdown function is integrated into the control system of the wind energy converter.

Sensors for measuring the light intensity are installed in the nacelle or in the tower area, depending on the type of wind energy converter. The ratio between the highest and the lowest light intensity, known as the shadow intensity, is determined based on the values measured by the sensors. This is compared with the reference value, i.e. the shutdown intensity.

If the shadow intensity falls below the reference value of shutdown intensity within the programmed time frame, shadow shutdown is activated and the wind energy converter stops.

When the programmed timeframe has elapsed or after light conditions have altered to the extent that shadows can no longer be cast, shadow shutdown is deactivated. The wind energy converter then resumes operation.

7 Operation

7.1 Preparing for operation

1. Enter the wind energy converter and switch on the lighting in the tower. To do this, press the lighting button in the entrance area.

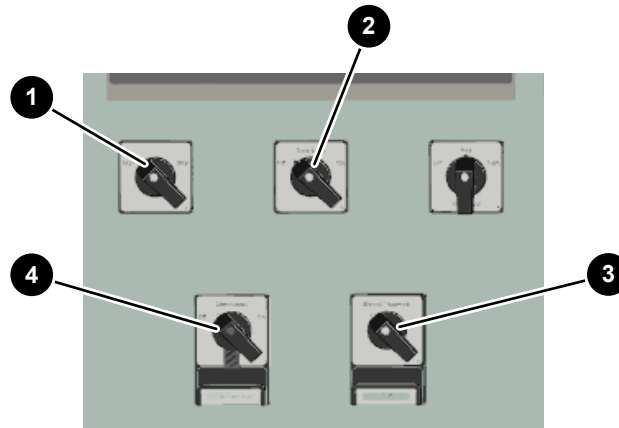


Fig. 48: Operating controls and display elements on the wind energy converter control console

1	<i>Start/Stop</i> switch	2	<i>Rotor brake</i> switch
3	<i>Manual/Automatic</i> switch	4	<i>Maintenance</i> switch

2. Set the *Start/Stop* switch on the wind energy converter control console to *Stop*.
 - ↪ The wind energy converter is stopped.
3. Wait until the rotor blades are in the feathered position.
4. Set the *Manual/Automatic* switch on the wind energy converter control console to *Manual*.
5. Set the *Maintenance* switch on the wind energy converter control console to *On*.
 - ↪ Operation of the wind energy converter via the remote monitoring system is blocked.
 - ↪ The wind energy converter switches to maintenance mode.
6. Check whether the warning signals are issued during the self-test of the warning devices in the tower. For more information, see ch. 3.11.15.2, p. 54.

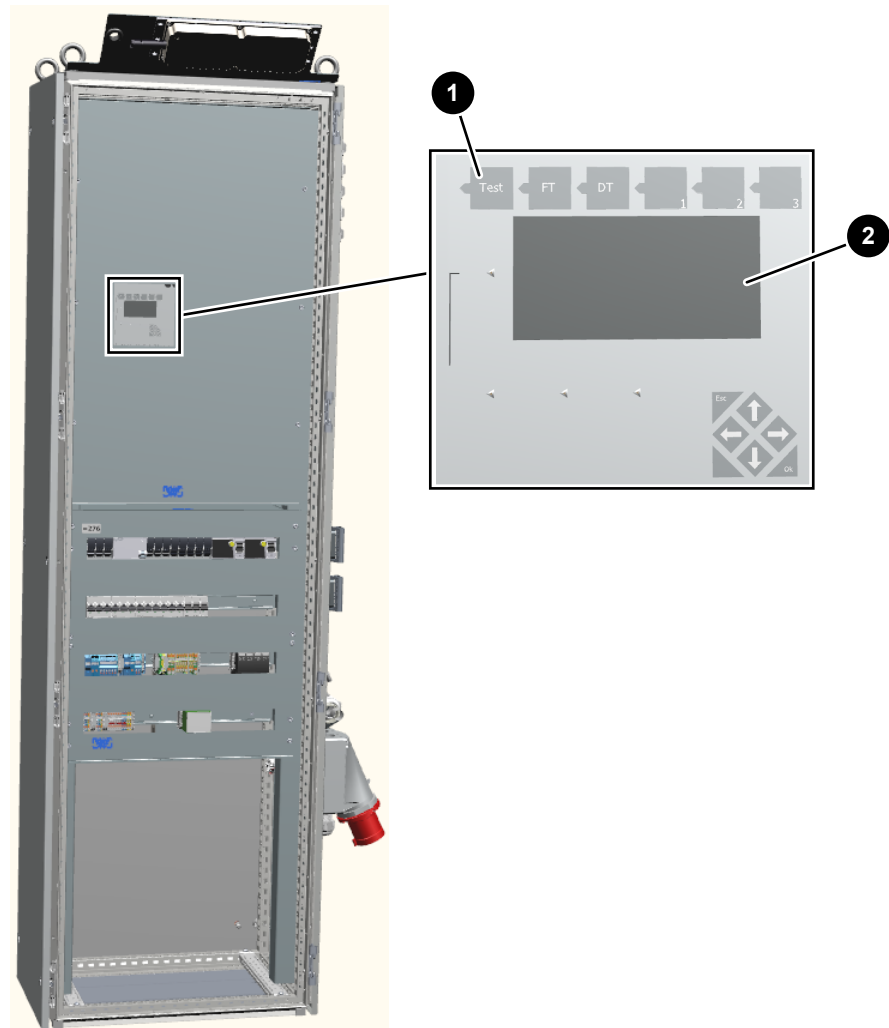


Fig. 49: Combination cabinet with open door

1	Test button	2	Display
---	-------------	---	---------

7. Check the function of the emergency lights in the tower.
 - a) 1st person: Stand ready to be deployed with the rescue equipment in the tower entrance area.
 - b) 2nd person: Descend to the lower level in the tower base.
 - c) Open the electrical cabinet door on the combination cabinet.
 - d) Briefly press the *Test* button.
 - ↪ A network loss is simulated for at least 5 s.
 - ↪ The emergency lights in the tower are on during the simulation.
8. If the emergency lights in the tower do not switch on, exit the wind energy converter and notify ENERCON Service.
9. Close the electrical cabinet door.
10. Ascend to the tower entrance level.
11. Switch on the lighting before entering the nacelle. To do this, turn the *Nacelle light and presence switch* rotary switch in the nacelle access area to the *On* position.

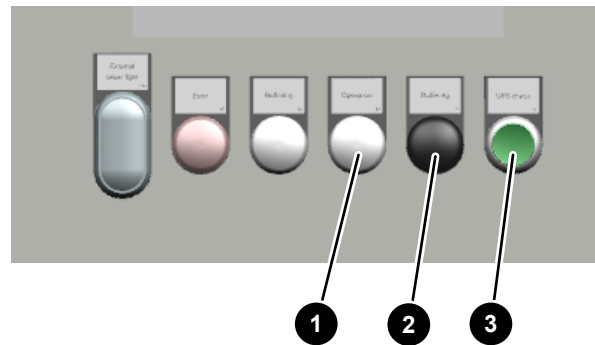


Fig. 50: Operating controls and display elements on the nacelle lighting control centre

1	<i>Operation</i> indicator light	2	<i>Buffering</i> indicator light
3	<i>UPS check</i> button		

12. Press and hold the *UPS check* button on the nacelle lighting control centre.
 - ↪ The UPS is disconnected from the grid and emergency power operation is activated.
 - ↪ The *Operation* indicator light is on.
13. Release the *UPS check* button on the nacelle lighting control centre.
 - ↪ The *Buffering* indicator light comes on after a few seconds.
14. If emergency power operation does not activate, exit the wind energy converter and notify ENERCON Service.

7.2 Operating the yaw system



NOTICE

Property damage if wind speeds are too high

Excessively high wind speeds can cause property damage if the nacelle is not aligned with the wind.

- ⇒ Only appropriately authorised specialist personnel may perform operations in manual mode.
- ⇒ Do not leave the nacelle out of alignment with the wind for extended periods at excessive wind speeds.

✓ Preparations for operation are complete.

**On the wind energy
converter control con-
sole**



Fig. 51: Operating controls and display elements on the wind energy converter control console

1	<i>Yaw control switch</i>		
---	---------------------------	--	--

1. Turn the *Yaw control* switch on the wind energy converter control console to the *Left* or *Right* position until the nacelle reaches the target position.
2. Turn the *Yaw control* switch on the wind energy converter control console to the *Stop* position.

**On the nacelle control
cabinet**

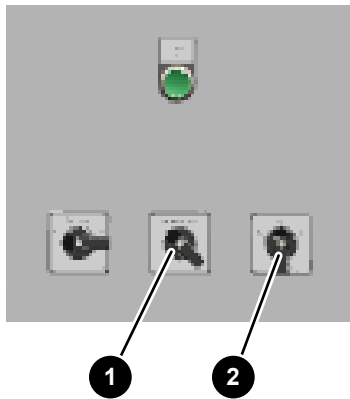


Fig. 52: Operating controls and display elements on the nacelle control cabinet

1	<i>Manual/Automatic switch</i>	2	<i>Yaw control switch</i>
---	--------------------------------	---	---------------------------

1. Set the *Manual/Automatic* switch on the nacelle control cabinet to *Manual*.
2. Turn the *Yaw control* switch on the nacelle control cabinet to the *Left* or *Right* position until the nacelle reaches the target position.
3. Turn the *Yaw control* switch on the nacelle control cabinet to the *Stop* position.

7.3 Starting the wind energy converter

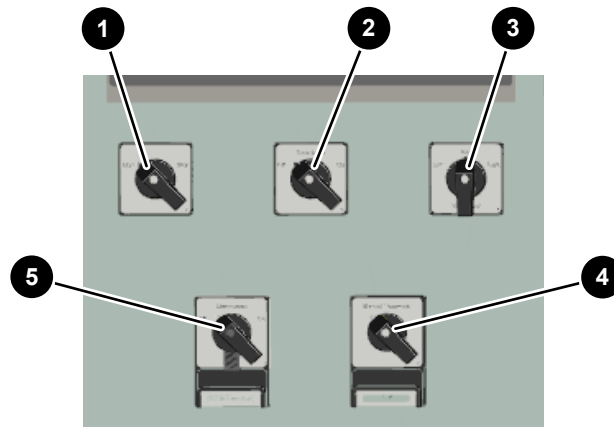


Fig. 53: Operating controls and display elements on the wind energy converter control console

1	<i>Start/Stop</i> switch	2	<i>Rotor brake</i> switch
3	<i>Yaw control</i> switch	4	<i>Manual/Automatic</i> switch
5	<i>Maintenance</i> switch		

- ✓ The machine house hatch and all access hatches in the tower are closed.
 - ✓ The rotor lock is released.
 - ✓ All persons have left the nacelle and descended the tower.
 - ✓ On the nacelle control cabinet, the *Rotor brake* switch is set to *Off*.
 - ✓ In the nacelle, the *Nacelle light and presence switch* rotary switch is set to *Off*.
 - ✓ On the wind energy converter control console, the *Rotor brake* switch is set to *Off*.
 - ✓ On the wind energy converter control console, the *Start/Stop* switch is set to *Stop*.
1. Set the *Manual/Automatic* switch on the wind energy converter control console to *Automatic*.
 2. Set the *Start/Stop* switch on the wind energy converter control console to *Start*.
 3. Wait until the wind energy converter is in operation.

7.4 Stopping the wind energy converter

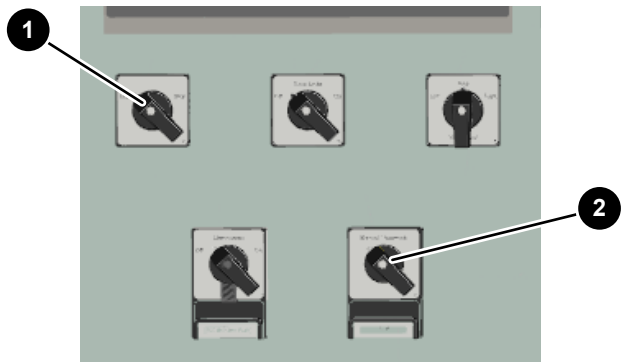


Fig. 54: Operating controls and display elements on the wind energy converter control console

1	<i>Start/Stop</i> switch	2	<i>Manual/Automatic</i> switch
---	--------------------------	---	--------------------------------

1. Set the *Start/Stop* switch on the wind energy converter control console to *Stop*.
2. Wait until the rotor blades are in the feathered position.
3. Set the *Manual/Automatic* switch on the wind energy converter control console to *Manual*.

7.5 Operating rotor blades manually

The rotor blades are operated manually using the wind energy converter display.

- ✓ Preparations for operation are complete.
 - ✓ The wind energy converter has stopped.
 - ✓ The user is logged in on the wind energy converter display.
 - ✓ The user has requested the active state on the wind energy converter display.
1. From the *Menu* overview page, select Rotor > Manual Pitching to open the *Manual Pitching* page.

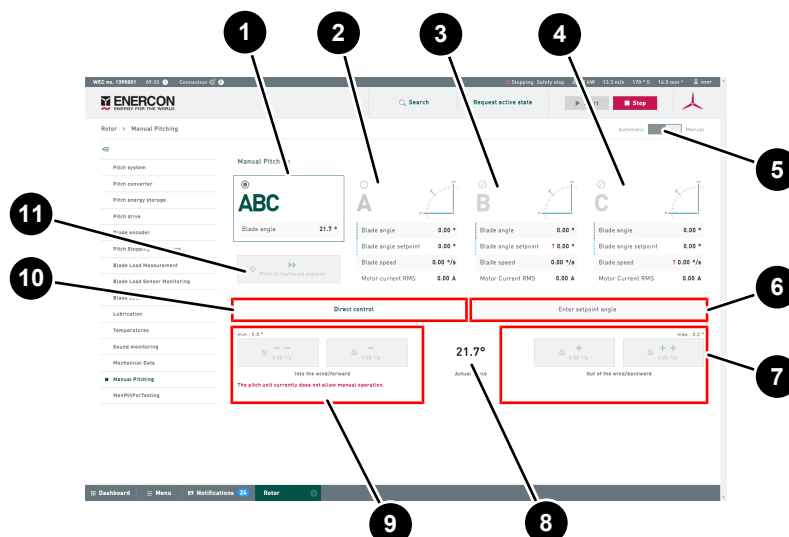


Fig. 55: Manual Pitching page

1	ABC selection field	2	A selection field
3	B selection field	4	C selection field
5	Automatic/Manual button	6	Set Target Angle button
7	Out of the wind/backward button	8	Current angle display field
9	Into the wind/forward button	10	Direct control button
11	Pitch to feathered position button		

2. Press the *Automatic/Manual* button.
↪ Manual mode is activated for pitch control.

Turning all rotor blades to the feathered position

1. Press the *ABC* selection field.
2. Press and hold the *Pitch to feathered position* button.
↪ All rotor blades are turned to the feathered position for as long as the button is pressed.

Setting the target angle for a rotor blade

1. Use the selection field to choose which rotor blade to adjust.
2. Press the *Set Target Angle* button.
3. Enter the selected target angle in the input field that opens.
4. Press and hold the *fast* or *slow* button until the target angle is reached.

Direct control of a rotor blade

1. Use the selection field to choose which rotor blade to adjust.
2. Press the *Direct control* button.
3. On the *Into the wind/forward* button, press the button for slow adjustment or the button for fast adjustment.
↪ The rotor blade is turned to the operating position for as long as the button is pressed.

4. On the *Out of the wind/backward* button, press the button for slow adjustment or the button for fast adjustment.
- ↪ The rotor blade is turned to the feathered position for as long as the button is pressed.

7.6 Clearing a fault message

7.6.1 Clearing a non-safety-relevant fault message

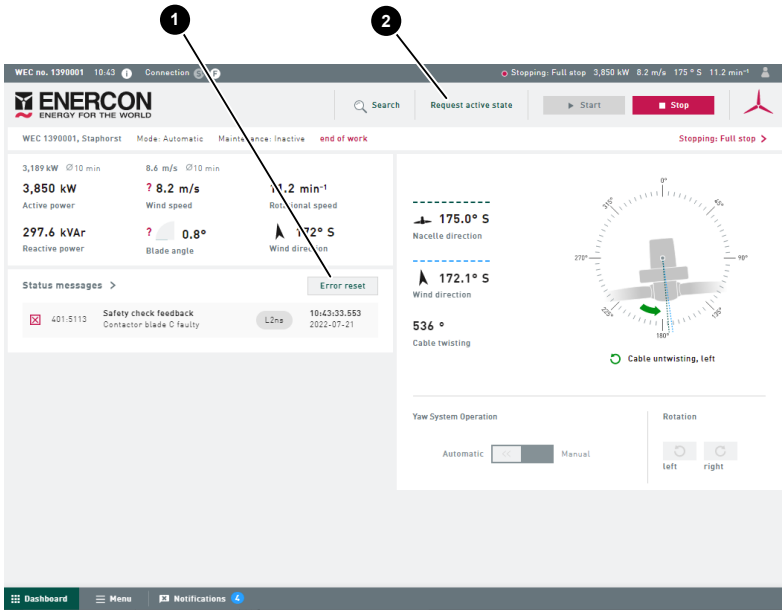


Fig. 56: Start page

1	Error reset button	2	Release active state or Request active state button
---	--------------------	---	---

- ✓ The cause of the fault message has been remedied.
 - ✓ The user has requested the active state on the wind energy converter display.
1. Press the *Error reset* button.
- ↪ The non-safety-relevant fault message is deleted from the message system of the wind energy converter control system and the wind energy converter can resume operation. If multiple non-safety-relevant fault messages are active, they are all deleted.

7.6.2 Clearing a safety-related fault message



Fig. 57: Operating controls and display elements on the nacelle control cabinet

1	Confirmation button		
---	---------------------	--	--

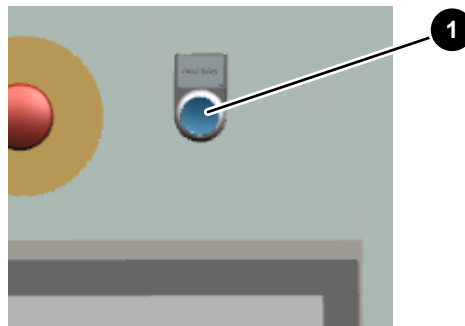


Fig. 58: Operating controls and display elements on the wind energy converter control console

1	Confirmation button		
---	---------------------	--	--

- ✓ The cause of the fault message has been remedied.
- 1. Depending on the location of the fault message display, press the *Confirmation* button on the nacelle control cabinet or on the wind energy converter control console.
- ↪ The safety-related fault message is deleted from the message system of the wind energy converter control system and the wind energy converter can resume operation. If multiple safety-related fault messages are active, they are all deleted.

7.7 Setting the rotor lock and enabling access to the rotor head and to the generator

WARNING



Risk of death if rotor is not completely locked

Under certain circumstances, the rotor can start to move if it has not been fully locked. This can cause injury to persons within range of the rotating components.

- ⇒ Activities that require the rotor to be stationary must only be carried out with the rotor lock fully engaged.

WARNING



Danger from escaping hydraulic fluid

Escaping hydraulic fluid can cause severe eye injury if it comes into contact with the eyes.

- ⇒ Always wear safety glasses when working on the hydraulic unit.

NOTICE



Risk of damage if rotor is not correctly locked

Incorrect locking of the rotor can damage the rotor lock. Emergency pitching of the rotor blades is immediately triggered and the rotor holding brake is activated.

- ⇒ The rotor lock may only be operated by trained personnel.
- ⇒ Do not actuate the rotor lock while the rotor is still spinning.
- ⇒ Observe the area of application of the hydraulic unit approved by the manufacturer. At temperatures lower than -30 °C, do not set or release the rotor lock.

NOTICE



Damage from high wind speeds when rotor lock is set

Damage to the wind energy converter can occur if the wind speed is > 16 m/s over a 10-minute mean while the rotor is locked.

- ⇒ Observe the *Alarm rotor locking* indicator light. If an indicator light is activated, do not set the rotor lock or exit the rotor head and then release the rotor lock.

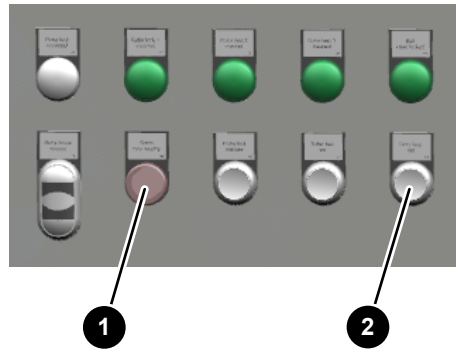


Fig. 59: Operating controls and display elements on the stator control cabinet

1	Alarm rotor locking indicator light	2	Door locked illuminated button
---	-------------------------------------	---	--------------------------------

- ✓ Preparations for operation are complete.
 - ✓ The *Door locked* illuminated button on the stator control cabinet lights up.
 - ✓ The *Alarm rotor locking* indicator light on the stator control cabinet does not light up.
 - ✓ The user is logged in on the wind energy converter display.
 - ✓ The user has requested the active state on the wind energy converter display.
1. Perform a visual inspection of the hydraulic unit. If hydraulic lines are damaged or hydraulic fluid is escaping, stop all work and notify ENERCON Service.

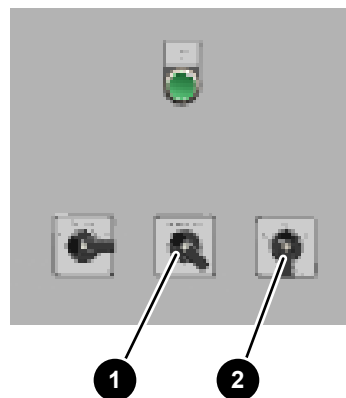


Fig. 60: Operating controls and display elements on the nacelle control cabinet

1	Manual/Automatic switch	2	Yaw control switch
---	-------------------------	---	--------------------

2. Set the *Manual/Automatic* switch on the nacelle control cabinet to *Manual*.
3. Turn the *Yaw control* switch on the nacelle control cabinet to the *Left* or *Right* position until the nacelle has been turned into the wind.
4. Turn the *Yaw control* switch on the nacelle control cabinet to the *Stop* position.

- From the wind energy converter display start page, select Rotor > Manual Pitching to open the *Manual Pitching* page.

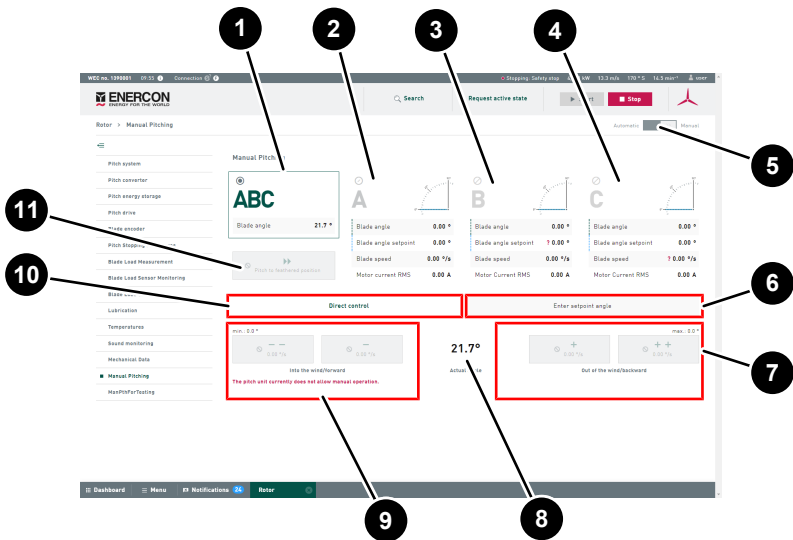


Fig. 61: Manual Pitching page

1	ABC selection field	2	A selection field
3	B selection field	4	C selection field
5	Automatic/Manual button	6	Set Target Angle button
7	Out of the wind/backward button	8	Current angle display field
9	Into the wind/forward button	10	Direct control button
11	Pitch to feathered position button		

- Choose the *ABC*, *A*, *B* or *C* selection field.
- Press the *Direct control* button.
- Press the *Into the wind/forward* button and turn the rotor blades into the wind until the rotor turns slowly.
- As soon as the rotor starts to turn, press the *Pitch to feathered position* button.
 - ↪ All rotor blades are turned to the feathered position.

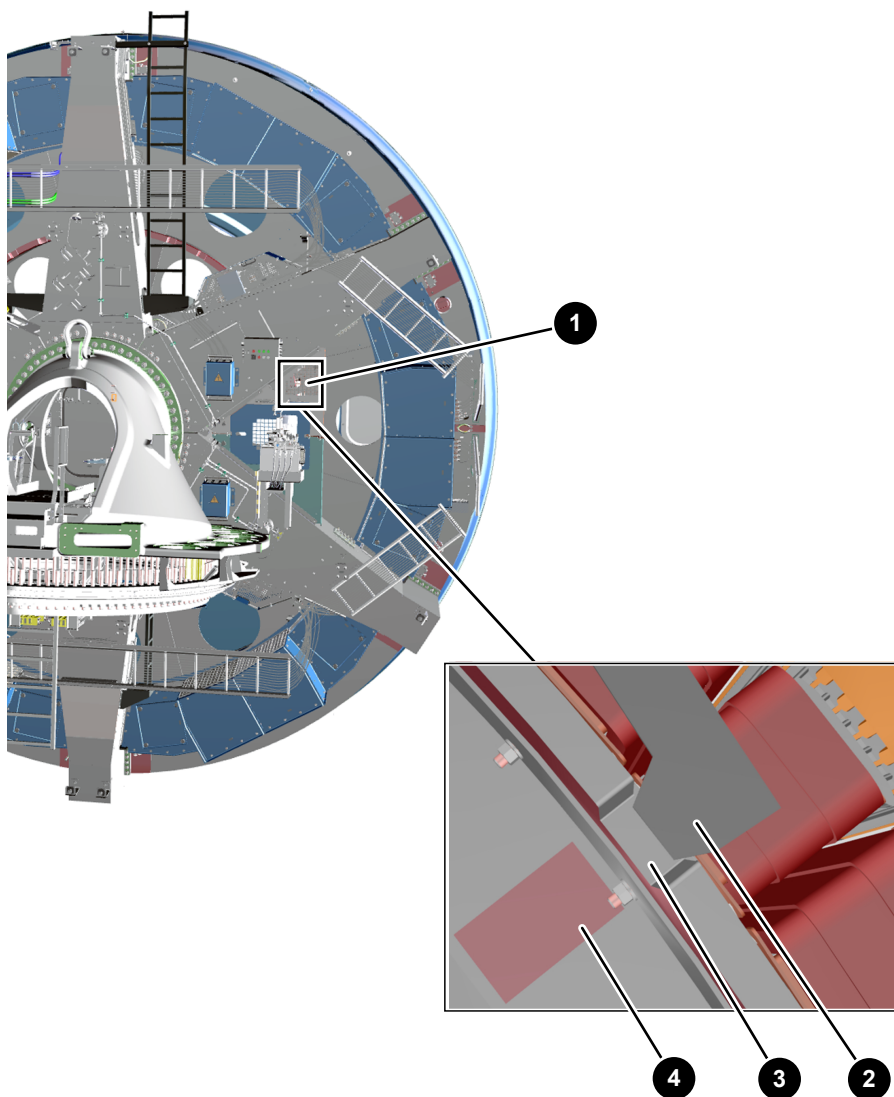


Fig. 62: Rotor lock guide plate

1	Rotor lock guide plate window	2	Rotor lock guide plate
3	Groove in rotor rim	4	Locking position indicator

10. Check the locking position in the rotor lock guide plate window.

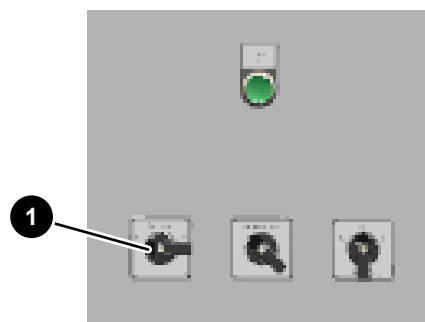


Fig. 63: Operating controls and display elements on the nacelle control cabinet

1	Rotor brake switch		
---	--------------------	--	--

11. Shortly before reaching the required locking position, turn the *Rotor brake* switch on the nacelle control cabinet to the *On* position.
 - ↪ The rotor holding brake engages.
 - ↪ The rotor is braked.

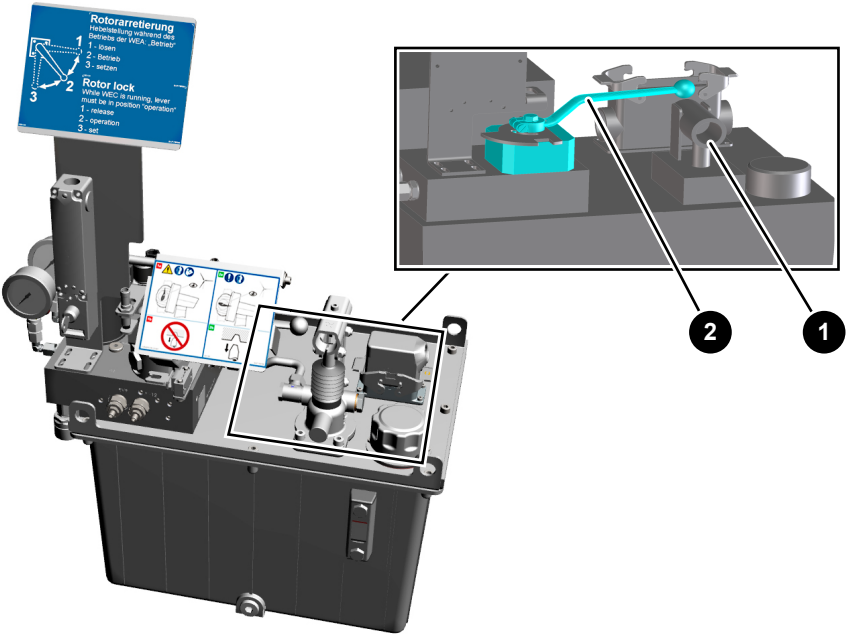


Fig. 64: Hydraulic unit, lever position

1	Hand pump	2	Lever of the <i>Rotor Lock</i> valve
---	-----------	---	--------------------------------------

12. Move the lever of the *Rotor Lock* valve on the hydraulic unit to the *Set* position.
13. Remove the lever for the hydraulic unit hand pump from the holder and attach it to the hand pump.

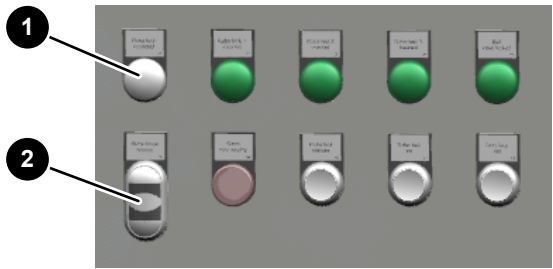


Fig. 65: Operating controls and display elements on the stator control cabinet

1	<i>Rotor lock retracted</i> indicator light	2	<i>Rotor holding brake release</i> double pushbutton
---	---	---	--

14. Work the hand pump until the *Rotor lock retracted* indicator light on the stator control cabinet goes out.
 - ↪ The nacelle fans are switched off as soon as the rotor lock bolts move from their home position.
15. On the stator control cabinet, press and hold the upper part of the *Rotor holding brake release* double pushbutton, i.e. the *Release* button, until the rotor holding brake opens slightly.

16. Now also press and hold the lower part of the *Rotor holding brake release* double pushbutton, i.e. the *STOP* button.

↪ The rotor holding brake is now held in the open position.

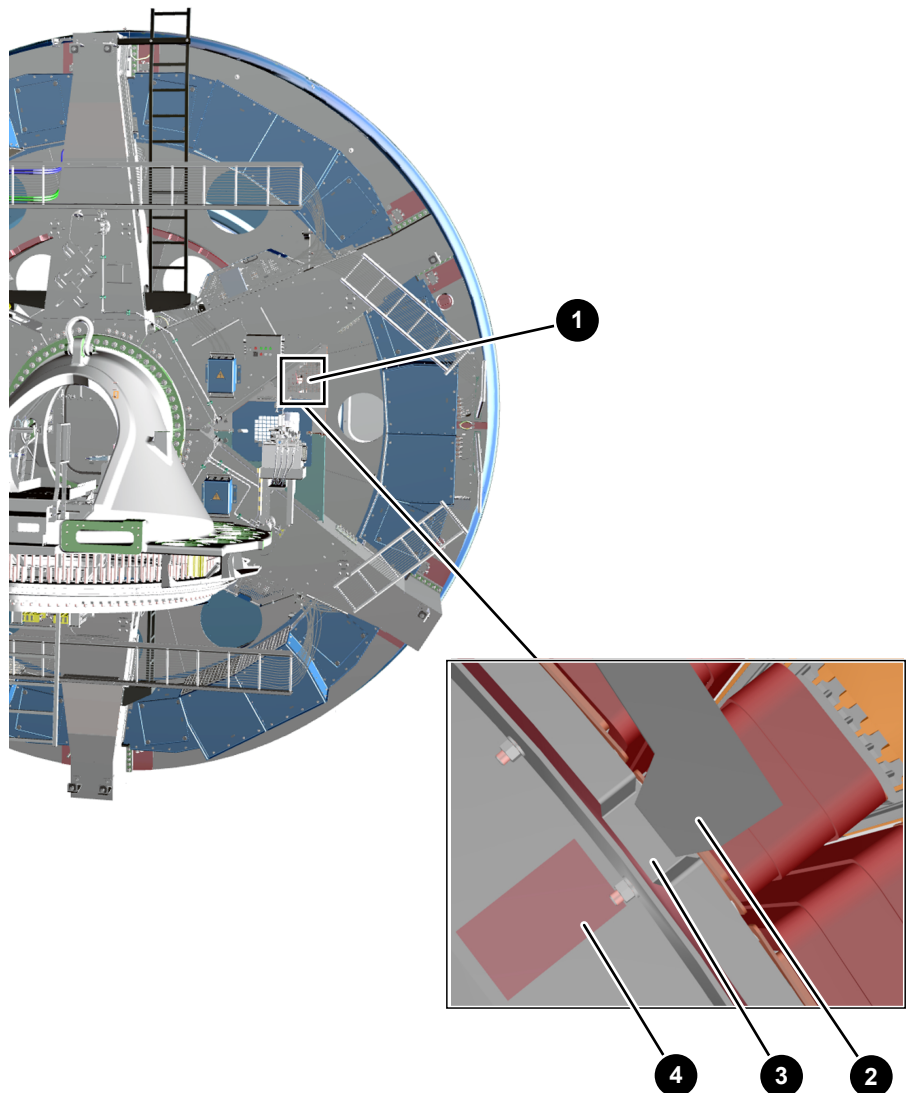


Fig. 66: Rotor lock guide plate

1	Rotor lock guide plate window	2	Rotor lock guide plate
3	Groove in rotor rim	4	Locking position indicator

17. Observe the rotor lock guide plate. Shortly before the locking position is reached, release both buttons of the *Rotor holding brake release* double pushbutton.

↪ The rotor is braked.

18. Check that the groove in the rotor rim and the rotor lock guide plate line up exactly. If they do not, release and apply the rotor holding brake again using the *Rotor holding brake release* double pushbutton until the groove in the rotor rim and the rotor lock guide plate line up exactly.

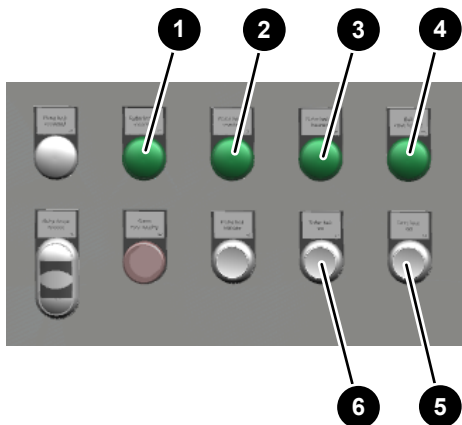


Fig. 67: Operating controls and display elements on the stator control cabinet

1	<i>Rotor lock 1 inserted</i> indicator light	2	<i>Rotor lock 2 inserted</i> indicator light
3	<i>Rotor lock 3 inserted</i> indicator light	4	<i>Ball valve locked</i> indicator light
5	<i>Door locked</i> illuminated button	6	<i>Rotor lock set</i> illuminated button

19. Work the hand pump until the *Rotor lock set* illuminated button on the stator control cabinet lights up.
 - ↪ The electric pump on the hydraulic unit is enabled.
20. Press and hold the *Rotor lock set* illuminated button on the stator control cabinet.
 - ↪ The rotor holding brake opens and the rotor aligns itself with the rotor lock bolts automatically.
 - ↪ The rotor lock bolts are extended into the grooves of the rotor.
21. Release the *Rotor lock set* illuminated button once the rotor lock bolts have reached their limit positions.
 - ↪ On the stator control cabinet, the 3 indicator lights *Rotor lock 1 inserted* to *Rotor lock 3 inserted* light up.
 - ↪ The rotor holding brake engages again automatically.
 - ↪ The *Door locked* illuminated button on the stator control cabinet lights up. The door locks of the access door to the rotor head and the access door to the generator are released.
 - ↪ The lever of the *Rotor Lock* valve is locked in the *Set* position by the electric locking system as soon as one of the access doors is opened.
 - ↪ The *Ball valve locked* indicator light on the stator control cabinet lights up.

7.8 Blocking access to the rotor head and to the generator

- ✓ All tools, materials and other objects have been removed from the rotor head and the generator.
 - ✓ The rotor blades are in feathered position.
 - ✓ No-one is in the rotor head, in the generator area or on the roof module.
 - ✓ On the pitch control cabinet, the *Service switch* rotary switch is in the *Aus* position.
1. Close the access door to the rotor head and the access door to the generator.
 2. Press the *Set door lock* illuminated button.
 - ↪ The *Set door lock* illuminated button on the stator control cabinet is no longer lit.
 - ↪ The lever of the *Rotor Lock* valve is released.

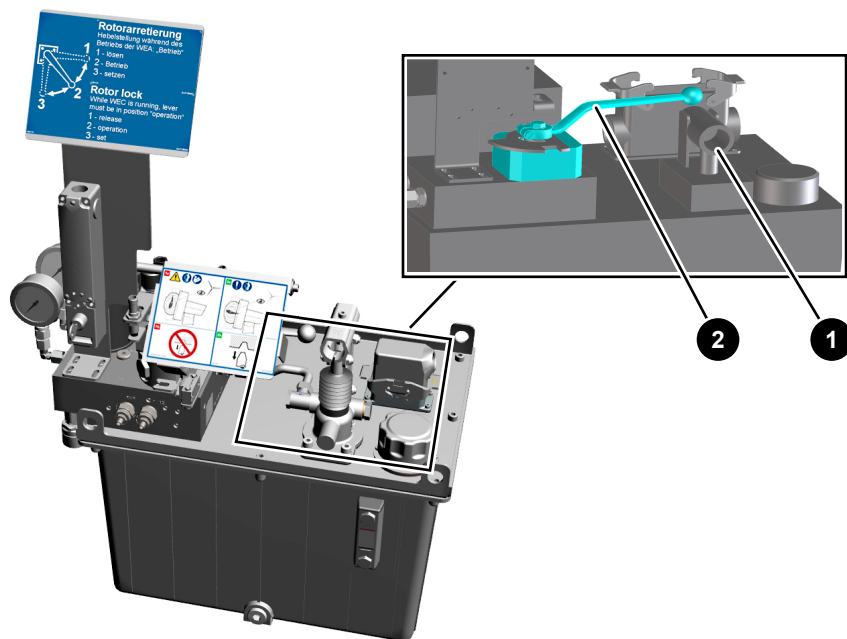


Fig. 68: Hydraulic unit, lever position

1	Hand pump	2	Lever of the <i>Rotor Lock</i> valve
---	-----------	---	--------------------------------------

3. Move the lever of the *Rotor Lock* valve to the *Release* position.
 - ↪ The electric locking system locks the access door to the rotor head and the access door to the generator.

7.9 Releasing the rotor lock

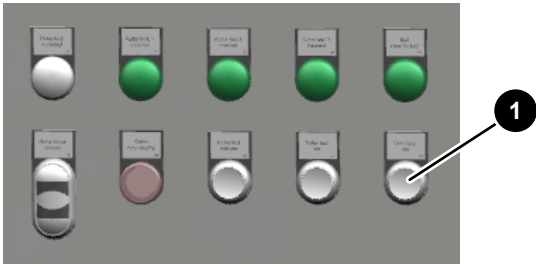


Fig. 69: Operating controls and display elements on the stator control cabinet

1	<i>Door locked</i> illuminated button		
---	---------------------------------------	--	--

✓ The *Door locked* illuminated button on the stator control cabinet does not light up.

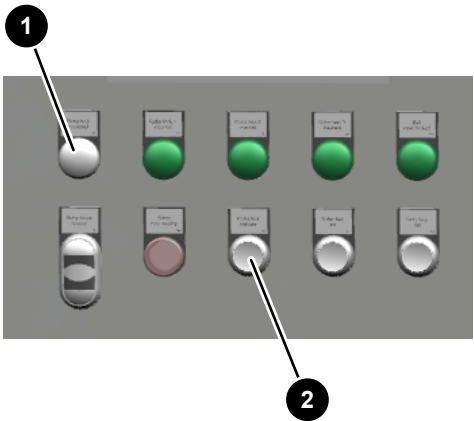


Fig. 70: Operating controls and display elements on the stator control cabinet

1	<i>Rotor lock retracted</i> indicator light	2	<i>Rotor lock release</i> illuminated button
---	---	---	--

1. Press the *Rotor lock release* illuminated button on the stator control cabinet until all the rotor lock bolts have been fully retracted to the initial position.
 - ↪ The *Rotor lock retracted* indicator light is on.
 - ↪ The nacelle fans are switched on.

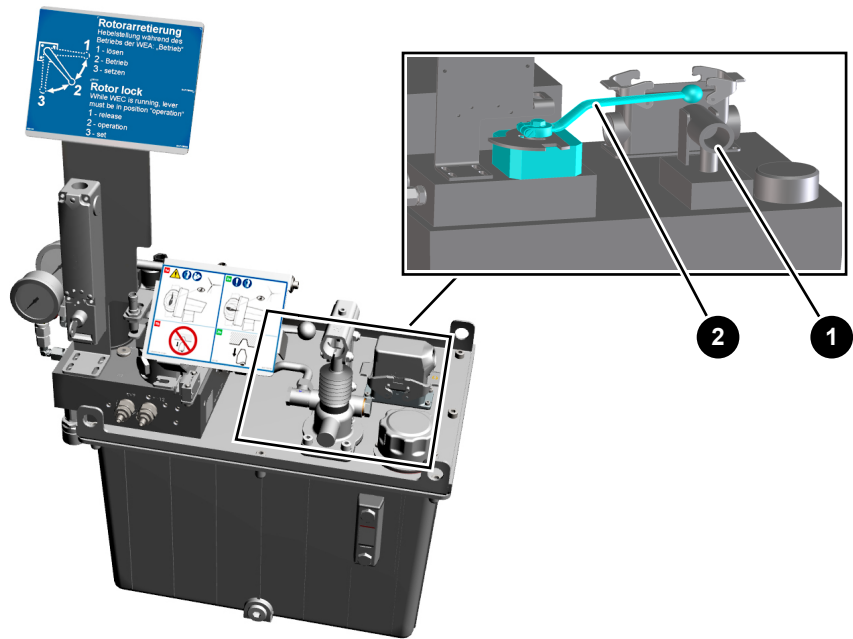


Fig. 71: Hydraulic unit, lever position

1 Hand pump	2 Lever of the <i>Rotor Lock</i> valve
-------------	--

2. Move the lever of the *Rotor Lock* valve to the *Operation* position.
↳ This prevents inadvertent movement of the rotor lock bolts.

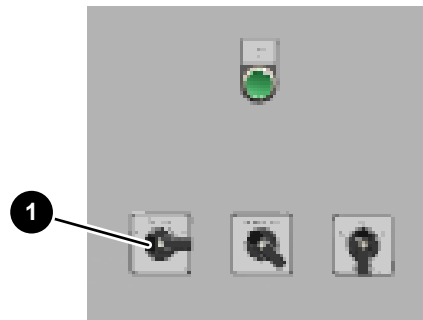


Fig. 72: Operating controls and display elements on the nacelle control cabinet

1 <i>Rotor brake</i> switch		
-----------------------------	--	--

3. Set the *Rotor brake* switch on the nacelle control cabinet to *Off*.
↳ The rotor holding brake is released and the rotor can rotate freely.
4. Place the lever for the hydraulic unit hand pump in the holder.

7.10 Operating the nacelle crane

The nacelle crane is designed as an electric chain hoist and is used to transport tools and materials between the ground and the nacelle. The chain runs outside the tower. The load is secured with a guide rope.

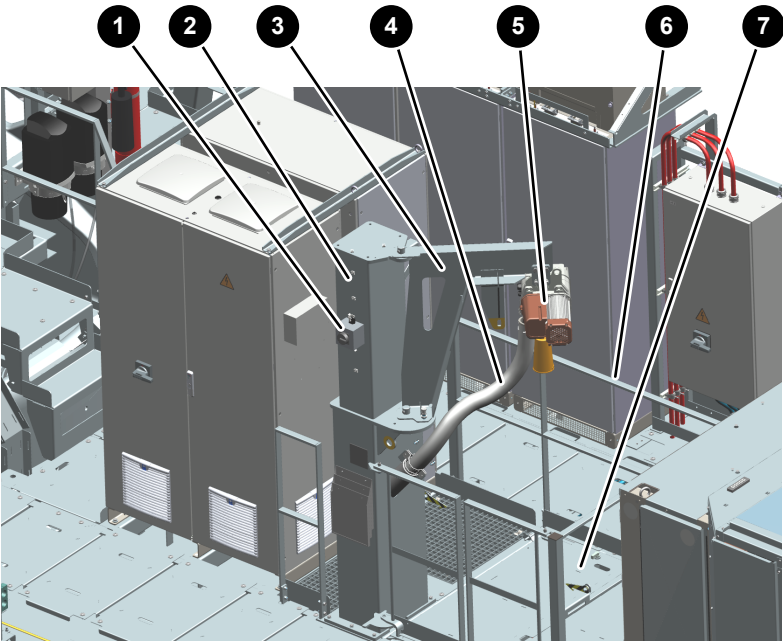


Fig. 73: Nacelle crane: jib crane version

1	Main switch for nacelle crane	2	Crane pillar
3	Swivel arm	4	Chain guide
5	Chain hoist	6	Crane hatch guardrail
7	Crane hatch		

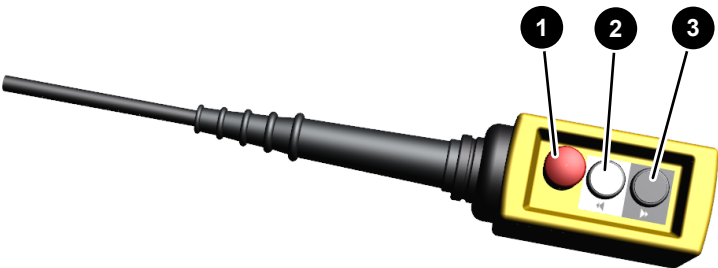


Fig. 74: Control console for nacelle crane

1	Emergency stop button	2	Button to raise chain
3	Button to lower chain		

7.10.1 Transporting materials and tools up to the nacelle

WARNING



Risk of death from improper use of nacelle crane

Improper use of the nacelle crane and potential falling loads pose a risk of death.

- ⇒ Do not touch the chain when hoisting or lowering loads.
- ⇒ Do not bypass or jam the buttons on the nacelle crane's control console. Use the other hand to operate the control console if one hand becomes tired.
- ⇒ If overhead lines are present in the immediate vicinity, rotate the nacelle to face away from the lines.
- ⇒ Do not stand under the open crane hatch or under suspended loads.
- ⇒ Do not position the nacelle crane directly above the tower door when hoisting or lowering loads. Ensure that the crane hatch is at least 30° to the left or right of the tower door.

WARNING



Risk of death due to falling from height

Persons present in the rear area of the nacelle while the guardrail gate and crane hatch are open are at risk of falling from a height with fatal consequences.

- ⇒ If you are in the rear area of the nacelle and the crane hatch and guardrail gate are open, always wear a personal fall protection system and use a shock-absorbing lanyard to attach yourself to an anchorage point.

- ✓ Communication is established between employee 1 (nacelle) and employee 2 (ground).
 - ✓ The rotor is locked.
 - ✓ Employee 1 is secured by a personal fall protection system to an anchorage point.
1. Switch on the nacelle crane main switch.
 2. Position the transport cage with the materials and tools at the tower base, below the crane hatch.
 3. Open the crane hatch.
 4. Lower the hook of the nacelle crane to the transport cage using the control console. While lowering, carry out a visual inspection of the chain.
 5. Attach the hook of the nacelle crane to the transport cage.
 6. Employee 2: secure the crane hook with a guide rope.
 7. Lift the transport cage above the level of the crane hatch.
 8. Open the door in the crane hatch guardrail.
 9. Once inside the nacelle, pull or slew the transport cage to beside or behind the crane hatch.

10. Set the transport cage down onto the nacelle floor.
11. Close the door in the crane hatch guardrail.
12. Close the crane hatch.
13. Employee 1: disconnect the personal fall protection system from the anchorage point.
14. Detach the nacelle crane hook from the transport cage.
15. Raise the nacelle crane hook using the control console until the limit stop is reached.
16. Switch off the nacelle crane main switch.

7.10.2 Transporting materials and tools down from the nacelle

WARNING



Risk of death from improper use of nacelle crane

Improper use of the nacelle crane and potential falling loads pose a risk of death.

- ⇒ Do not touch the chain when hoisting or lowering loads.
- ⇒ Do not bypass or jam the buttons on the nacelle crane's control console. Use the other hand to operate the control console if one hand becomes tired.
- ⇒ If overhead lines are present in the immediate vicinity, rotate the nacelle to face away from the lines.
- ⇒ Do not stand under the open crane hatch or under suspended loads.
- ⇒ Do not position the nacelle crane directly above the tower door when hoisting or lowering loads. Ensure that the crane hatch is at least 30° to the left or right of the tower door.

WARNING



Risk of death due to falling from height

Persons present in the rear area of the nacelle while the guardrail gate and crane hatch are open are at risk of falling from a height with fatal consequences.

- ⇒ If you are in the rear area of the nacelle and the crane hatch and guardrail gate are open, always wear a personal fall protection system and use a shock-absorbing lanyard to attach yourself to an anchorage point.

- ✓ Communication is established between employee 1 (nacelle) and employee 2 (ground).
- ✓ The rotor is locked.
- ✓ Employee 1 is secured by a personal fall protection system to an anchorage point.
- ✓ The guide rope is attached to the crane hook.
- 1. Switch on the nacelle crane main switch.

2. Lower the hook of the nacelle crane using the control console and attach it to the transport cage.
3. Lift the transport cage until it moves freely.
4. Open the crane hatch.
5. Open the door in the crane hatch guardrail.
6. Push or slew the transport cage until it is suspended above the crane hatch.
7. Close the door in the crane hatch guardrail.
8. Lower the transport cage to the ground (employee 1), guiding the crane hook with the guide rope (employee 2).
9. Detach the nacelle crane hook from the transport cage.
10. Raise the nacelle crane hook until the limit stop is reached.
11. Close the crane hatch.
12. Employee 1: disconnect the personal fall protection system from the anchorage point.
13. Switch off the nacelle crane main switch.

7.11 Concluding operation

- ✓ The rotor blades are in feathered position.

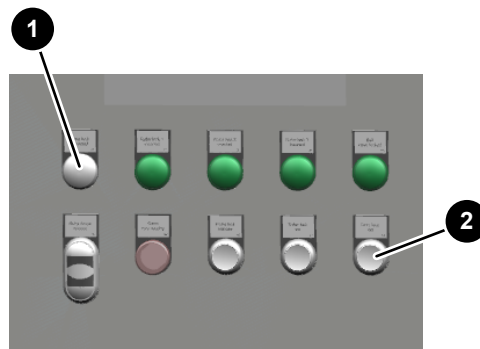


Fig. 75: Operating controls and display elements on the stator control cabinet

1	<i>Rotor lock retracted</i> indicator light	2	<i>Door locked</i> illuminated button
---	---	---	---------------------------------------

1. Ensure that the rotor lock is released. To do this, check that the *Rotor lock retracted* indicator light on the stator control cabinet lights up.
2. Ensure that the access door to the rotor head and the access door to the generator are locked. To do this, check that the *Door locked* illuminated button on the stator control cabinet does not light up.
3. Ensure that the *Manual/Automatic* switch is set to *Automatic* on the nacelle control cabinet.
4. When exiting the nacelle, set the *Nacelle light and presence switch* rotary switch to *Off*.

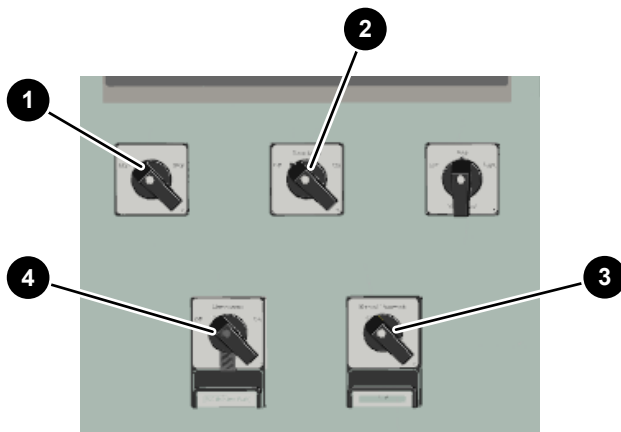


Fig. 76: Operating controls and display elements on the wind energy converter control console

1	<i>Start/Stop</i> switch	2	<i>Rotor brake</i> switch
3	<i>Manual/Automatic</i> switch	4	<i>Maintenance</i> switch

5. Set the *Rotor brake* switch on the wind energy converter control console to *Off*.
6. Set the *Manual/Automatic* switch on the wind energy converter control console to *Automatic*.
 - ↪ The wind energy converter switches to automatic mode.
7. Set the *Start/Stop* switch on the wind energy converter control console to *Start*.
8. Wait until the wind energy converter is in operation.
9. Set the *Maintenance* switch on the wind energy converter control console to *Off*.
 - ↪ Operation of the wind energy converter via the remote monitoring system is activated.
10. When exiting the wind energy converter, switch off the lighting in the tower. To do this, press the lighting button in the entrance area.
11. Close the wind energy converter door.

8 Moving about the wind energy converter

8.1 Entering the wind energy converter and making preparations

1. Enter the wind energy converter and switch on the lighting in the tower. To do this, press the lighting button in the entrance area.

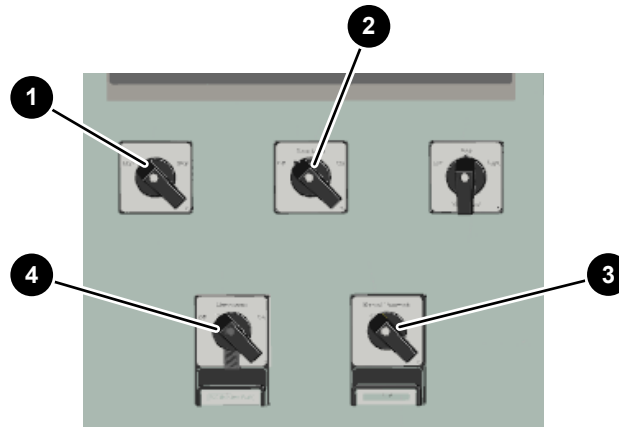


Fig. 77: Operating controls and display elements on the wind energy converter control console

1	<i>Start/Stop</i> switch	2	<i>Rotor brake</i> switch
3	<i>Manual/Automatic</i> switch	4	<i>Maintenance</i> switch

2. Set the *Start/Stop* switch on the wind energy converter control console to *Stop*.
 - ↪ The wind energy converter is stopped.
3. Wait until the rotor blades are in the feathered position.
4. Set the *Manual/Automatic* switch on the wind energy converter control console to *Manual*.
5. Set the *Maintenance* switch on the wind energy converter control console to *On*.
 - ↪ Operation of the wind energy converter via the remote monitoring system is blocked.
 - ↪ The wind energy converter switches to maintenance mode.
6. Check whether the warning signals are issued during the self-test of the warning devices in the tower. For more information, see ch. 3.11.15.2, p. 54.

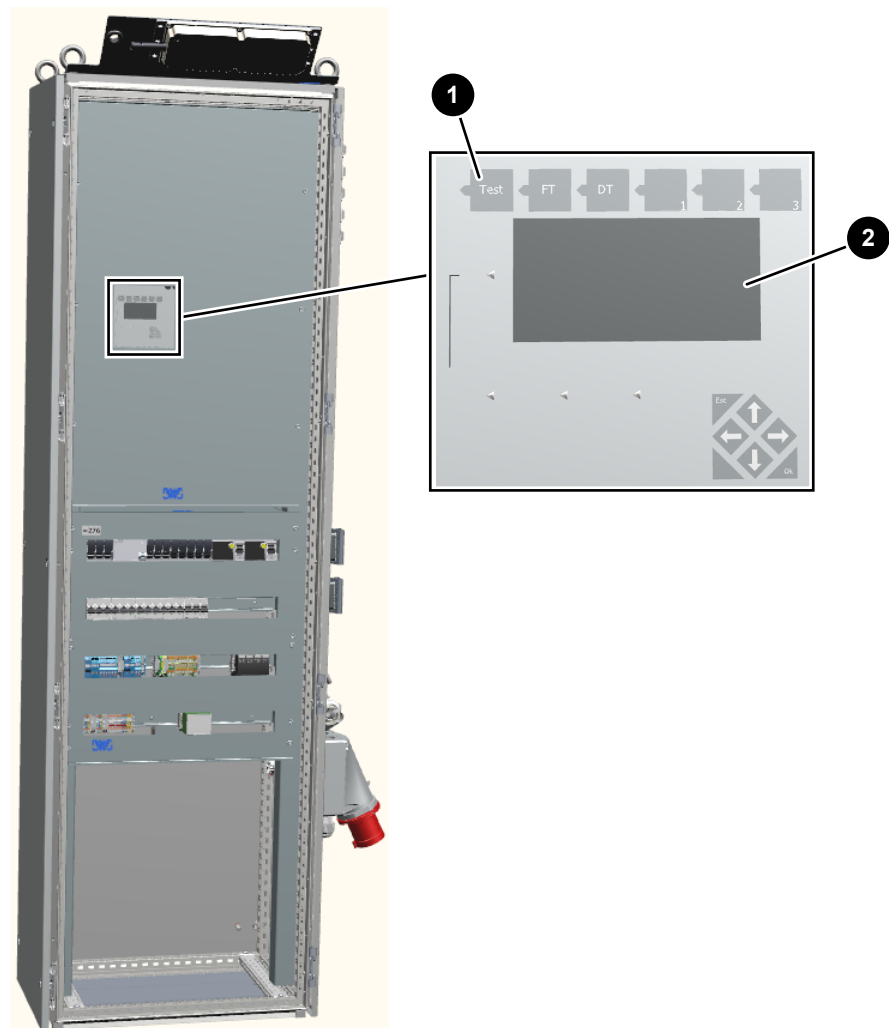


Fig. 78: Combination cabinet with open door

1	Test button	2	Display
---	-------------	---	---------

7. Check the function of the emergency lights in the tower.
 - a) 1st person: Stand ready to be deployed with the rescue equipment in the tower entrance area.
 - b) 2nd person: Descend to the lower level in the tower base.
 - c) Open the electrical cabinet door on the combination cabinet.
 - d) Briefly press the *Test* button.
 - ↪ A network loss is simulated for at least 5 s.
 - ↪ The emergency lights in the tower are on during the simulation.
8. If the emergency lights in the tower do not switch on, exit the wind energy converter and notify ENERCON Service.
9. Close the electrical cabinet door.
10. Ascend to the tower entrance level.

8.2 Using the service hoist



⚠ WARNING

Risk of crushing when using the ladder-guided service hoist and the safety ladder at the same time

Simultaneous use of the ladder-guided service hoist and the safety ladder can result in the crushing of persons on the ladder. This may lead to serious injury.

- ⇒ Use the safety ladder only when the ladder-guided service hoist is not in use.
- ⇒ Use the ladder-guided service hoist only when the safety ladder is not in use.



⚠ WARNING

Danger when using the service hoist

Various dangers can occur when the service hoist is used.

- ⇒ Read the service hoist manufacturer's documentation before using the service hoist.

- ✓ The preparatory activities have been carried out.
 - ✓ The service hoist is cleared for use.
 - ✓ The personal fall protection system is in place.
 - ✓ A suitable means of communication (e.g. mobile phone, two-way radio) is being carried.
 - ✓ At least one other person is present in the nacelle or the tower base.
 - ✓ The safety ladder is not being used by anyone else.
1. Go to the service hoist access level.
 2. Open the gate of the hoist cage of the service hoist.
 3. Open the guardrail gate.
 4. Enter the service hoist cage.
 5. Secure yourself to an anchorage point inside the service hoist with the personal fall protection system.
 6. If the personal fall protection system is secured to an anchorage point outside the service hoist, detach it.
 7. Close the guardrail gate.
 8. Close the gate of the hoist cage of the service hoist.
 9. Before the first run of the day with the service hoist, perform the daily inspection of the service hoist in accordance with the service hoist operating manual together with at least one other person standing outside the service hoist. The operating manual is kept in the document pouch inside the service hoist.
 10. If no faults are evident, operate the service hoist in accordance with its operating manual. The operating manual is kept in the document pouch inside the service hoist.

11. When the desired exit platform is reached, open the gate of the service hoist cage.
12. Open the guardrail gate.
13. Leave the service hoist cage.
14. Secure yourself to an anchorage point outside the service hoist with the personal fall protection system.
15. Detach the personal fall protection system from the anchorage point within the service hoist.
16. Close the guardrail gate.
17. Close the gate of the hoist cage of the service hoist.
18. After the last run of the day with the service hoist, perform the relevant usage completion procedures.
19. Leave the service hoist in the parked position in accordance with the service hoist operating manual. The operating manual is kept in the document pouch inside the service hoist.
 - a) Open the gate of the hoist cage of the service hoist.
 - b) Open the guardrail gate.
 - c) Leave the service hoist cage.
 - d) Detach the personal fall protection system from the anchorage point within the service hoist.
 - e) Close the guardrail gate.
 - f) Close the gate of the hoist cage of the service hoist.

8.3 Using the safety ladder



DANGER

Risk of falling if personal fall protection system is not properly secured

There is a risk of falling from height inside the tower when moving between the safety ladder and the tower floor. Death or severe injury can result.

- ⇒ It is preferable to use the service hoist instead of the safety ladder.
- ⇒ Secure yourself with the personal fall protection system during the whole process of moving between the safety ladder and the tower floor.


⚠ WARNING
Risk of crushing when using the ladder-guided service hoist and the safety ladder at the same time

Simultaneous use of the ladder-guided service hoist and the safety ladder can result in the crushing of persons on the ladder. This may lead to serious injury.

- ⇒ Use the safety ladder only when the ladder-guided service hoist is not in use.
- ⇒ Use the ladder-guided service hoist only when the safety ladder is not in use.


⚠ WARNING
Risk of injury from overexertion when using safety ladder

Use of the safety ladder can result in physical overexertion.

- ⇒ Use the service hoist where possible.
- ⇒ Take breaks.
- ⇒ The safety ladder may only be used by physically fit persons.


- ✓ The preparatory activities have been carried out.
- ✓ The personal fall protection system is in place.
- ✓ The service hoist is not in use and is switched off.
- ✓ A suitable means of communication (e.g. mobile phone, two-way radio) is being carried.
- ✓ Protective gloves are worn.

Ascent

1. Go to the access level of the safety ladder.
2. Insert the guided-type fall arrester into the rigid anchor line of the safety ladder.
3. Climb onto the safety ladder.
4. If necessary, take a break on the safety ladder. Always secure yourself to an anchorage point using the personal fall protection system.


DANGER! Fall from height inside the tower. Exercise extreme caution when moving between the safety ladder and the tower floor and secure yourself with the personal fall protection system at all times.

5. Move onto a tower floor. Make sure you are always secured with the personal fall protection system.

Descent  **DANGER! Fall from height inside the tower. Exercise extreme caution when moving between the safety ladder and the tower floor and secure yourself with the personal fall protection system at all times.**

1. Move from the tower floor to the safety ladder. Make sure you are always secured with the personal fall protection system.
2. Insert the guided-type fall arrester into the rigid anchor line of the safety ladder.
3. Descend the safety ladder.
4. If necessary, take a break on the safety ladder. Always secure yourself to an anchorage point using the personal fall protection system.
5. After descending, remove the guided-type fall arrester from the rigid anchor line of the safety ladder.

8.4 Entering and exiting the nacelle



WARNING

Risk of falling through open machine house hatch

A fall from height through the machine house hatch can result in severe injury or death.

⇒ Close the machine house hatch after climbing through.

- Entering the nacelle**
- ✓ The person is on the top tower floor.
 - ✓ The hatch of the top tower floor is closed.
1. Climb the ladder to the machine house.
 2. Switch on the nacelle lighting. To do this, turn the *Nacelle light and presence switch* rotary switch in the nacelle access area to the *On* position.
 3. Check whether the self-test is performed on the warning signals of the signal towers and the warning lights in the nacelle. For more information, see ch. 3.11.15.2, p. 54.
 4. Open the machine house hatch.
 5. Enter the machine house.
 6. Close the machine house hatch.

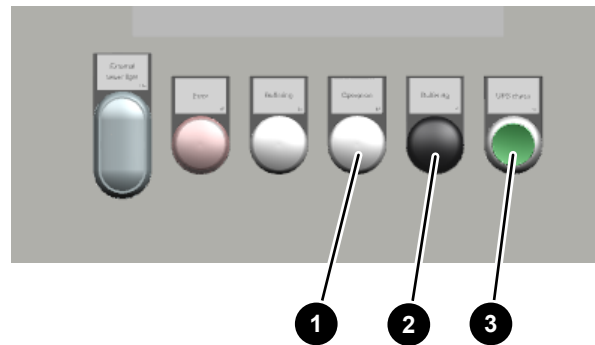


Fig. 79: Operating controls and display elements on the nacelle lighting control centre

1	<i>Operation</i> indicator light	2	<i>Buffering</i> indicator light
3	<i>UPS check</i> button		

7. Press and hold the *UPS check* button on the nacelle lighting control centre.
 - ↪ The UPS is disconnected from the grid and emergency power operation is activated.
 - ↪ The *Operation* indicator light is on.
8. Release the *UPS check* button on the nacelle lighting control centre.
 - ↪ The *Buffering* indicator light comes on after a few seconds.
9. If emergency power operation does not activate, exit the wind energy converter and notify ENERCON Service.

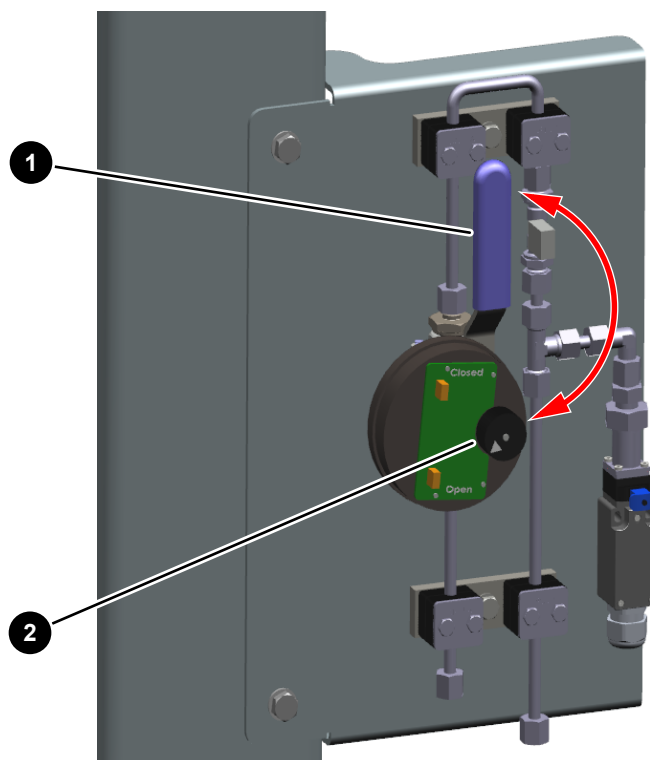


Fig. 80: Automatic extinguishing system shut-off valve

1	Shut-off valve lever	2	Indicator arrow
---	----------------------	---	-----------------

10. Deactivate the automatic extinguishing system by moving the shut-off valve lever downwards.

↪ The indicator arrow points to the *Closed* position.

Leaving the nacelle

- ✓ The person is in the nacelle.
- ✓ The machine house hatch is closed.
- ✓ The rotor lock and rotor holding brake are released.

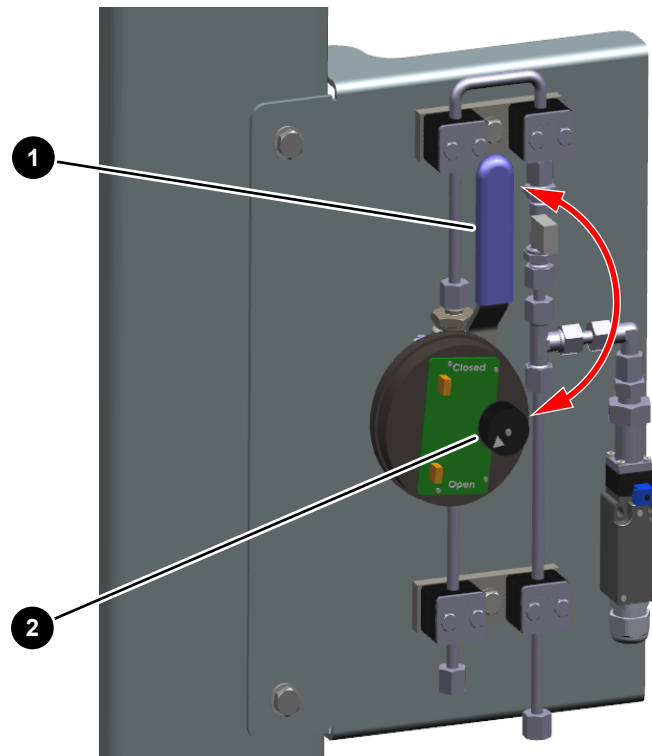


Fig. 81: Automatic extinguishing system shut-off valve

1	Shut-off valve lever	2	Indicator arrow
---	----------------------	---	-----------------

1. Activate the automatic extinguishing system by moving the shut-off valve lever upwards.
↪ The indicator arrow points to the *open* position.
2. Open the machine house hatch.
3. Leave the nacelle via the machine house hatch.
4. Close the machine house hatch.
5. Climb onto the nacelle access ladder.
6. Switch off the nacelle lighting. To do this, set the *Nacelle light and presence switch* rotary switch in the entrance area of the nacelle to the *Off* position.
7. Descend the nacelle access ladder to the topmost tower floor.

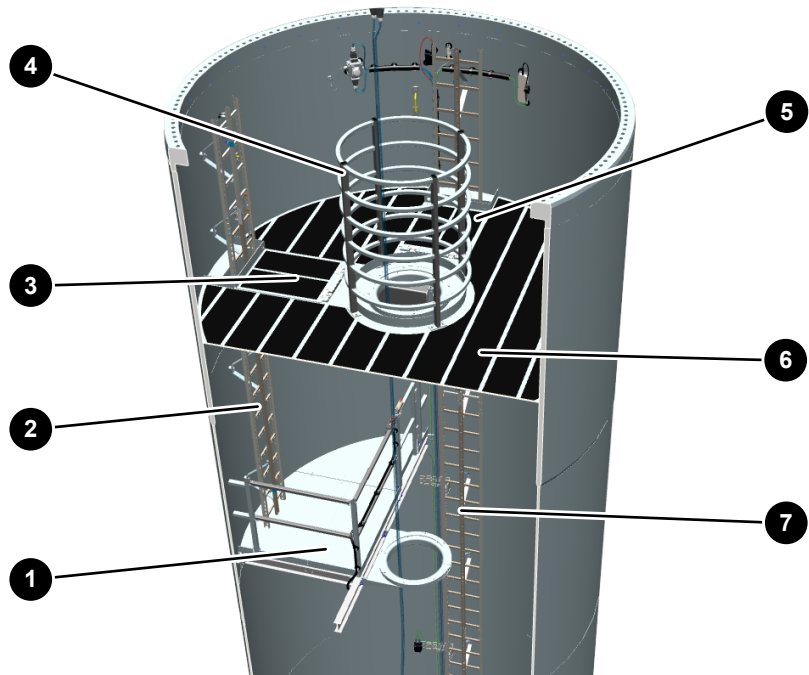


Fig. 82: Upper tower area

1	Service hoist exit platform	2	Safety ladder to the service hoist exit platform
3	Hatch to the service hoist	4	Nacelle access ladder
5	Hatch to the tower base	6	Topmost tower floor
7	Safety ladder to the tower base (also acts as a guide for the service hoist)		

8. Secure yourself to an anchorage point.
9. Open the hatch to the service hoist in order to access the service hoist exit platform.
10. Insert the guided-type fall arrester into the rigid anchor line of the safety ladder.
11. Release yourself from the anchorage point.
12. Descend the safety ladder to the service hoist exit platform. Close the hatch.

8.5 Entering and exiting the rotor head



⚠ WARNING

Risk of death if rotor is not completely locked

Under certain circumstances, the rotor can start to move if it has not been fully locked. This can cause injury to persons within range of the rotating components.

⇒ Activities that require the rotor to be stationary must only be carried out with the rotor lock fully engaged.

**⚠ CAUTION****Tripping hazard due to uneven stepping and standing surfaces in the rotor head**

Tripping due to uneven stepping and standing surfaces or tripping over struts close to the floor can cause injuries.

- ⇒ Move cautiously in the rotor head and hold on for stability.

Entering the rotor head

- ✓ The rotor is locked.
- 1. Step through the main carrier onto the axle pin.
- 2. Open the access door to the rotor head.
- 3. Climb from the axle pin into the rotor head.

Leaving the rotor head

- 1. Step through the access door to the rotor head onto the axle pin.
- 2. Close the access door to the rotor head.

8.6 Entering and exiting the nacelle roof**⚠ DANGER****Risk of death if rotor is not locked**

Access to the roof module is through the generator. If the generator rotor is not locked, persons in the generator may be crushed. This can result in severe injury or death.

- ⇒ Do not enter the generator or the roof module unless the rotor is locked.
- ⇒ Ensure that no-one is present in the generator or on the roof module before releasing the rotor lock.

**⚠ DANGER****Risk of death due to falling from height**

A fall from height normally results in severe injury or death.

- ⇒ Always ensure you are protected against falling from height. Use a personal fall protection system.
- ⇒ Secure yourself to an anchorage point before exiting onto the nacelle roof.

**⚠ WARNING****Risk of injury due to dazzle from beacon lights**

The beacon lights on the nacelle roof are a powerful light source. Looking into the light can damage the eyes.

- ⇒ Do not look into the light from the beacon lights.



⚠ WARNING

Risk of injury due to overload

The accessible areas on the nacelle roof may become overloaded if more than two persons climb onto them. In addition, parts of the nacelle casing that are not suitable for walking on may become overloaded if people climb onto them. This can result in injury or property damage.

- ⇒ A maximum of two people may enter the accessible areas on the nacelle roof.
- ⇒ Only stand on the central catwalk on the roof of the machine house.



⚠ WARNING

Risk of injury on slippery surfaces due to snow and ice

Wintry weather conditions present a risk of slipping. This may cause injuries.

- ⇒ Remove any snow and ice.

There are 2 accessible areas on the nacelle roof:

- The roof module is located on the generator. Access is through the generator when the generator is locked. A ladder that is permanently installed in the generator leads to the roof module.
- The roof of the machine house is accessed via a hook-on ladder.
- ✓ The rotor is locked.

Entering the roof module

1. Enter the generator via the generator access door.
2. Approach and climb the ladder to the nacelle hatch.
3. Open the nacelle hatch.
4. Secure yourself to an anchorage point with the personal fall protection system.
5. Climb through the open nacelle hatch onto the roof module.
6. Close the nacelle hatch.

Leaving the roof module

1. Open the nacelle hatch.
2. Carefully climb into the generator. Secure yourself sufficiently with the personal fall protection system.
3. After climbing into the generator, detach the personal fall protection system from the roof module.
4. Close the nacelle hatch.
5. Descend the ladder in the generator.
6. Exit the generator via the generator access door.
7. Close the generator access door.

Climbing onto the roof of the machine house

1. Take the ladder from where it is kept and hook it on underneath the nacelle hatch.
2. Climb up the ladder to the nacelle hatch.

3. Open the nacelle hatch.
4. Attach your personal fall protection system to an anchorage point on the machine house roof.
5. Climb through the open nacelle hatch onto the machine house roof.
6. Close the nacelle hatch.

Leaving the roof of the machine house

1. Open the nacelle hatch.
2. Climb carefully onto the ladder in the nacelle. Secure yourself sufficiently with the personal fall protection system.
3. Detach your personal fall protection system from the anchorage point on the machine house roof.
4. Close the nacelle hatch.
5. Climb down the ladder into the nacelle.
6. Remove the ladder from underneath the nacelle hatch and return it to where it is kept.

8.7 Performing final steps and exiting the wind energy converter

- ✓ The rotor blades are in feathered position.

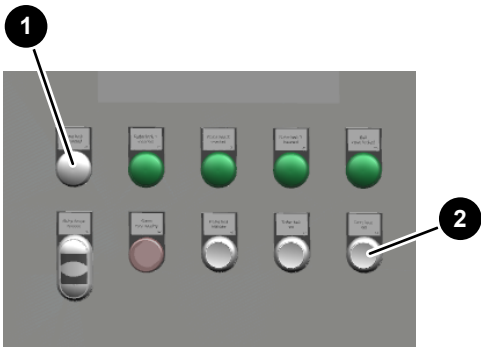


Fig. 83: Operating controls and display elements on the stator control cabinet

1	<i>Rotor lock retracted</i> indicator light	2	<i>Door locked</i> illuminated button
---	---	---	---------------------------------------

1. Ensure that the rotor lock is released. To do this, check that the *Rotor lock retracted* indicator light on the stator control cabinet lights up.
2. Ensure that the access door to the rotor head and the access door to the generator are locked. To do this, check that the *Door locked* illuminated button on the stator control cabinet does not light up.
3. Ensure that the *Manual/Automatic* switch is set to *Automatic* on the nacelle control cabinet.
4. When exiting the nacelle, set the *Nacelle light and presence switch* rotary switch to *Off*.

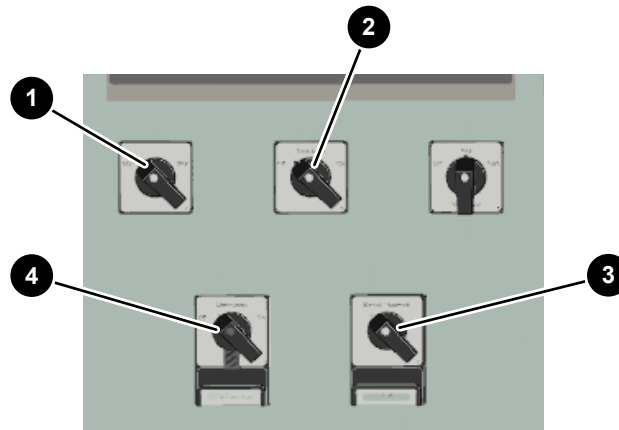


Fig. 84: Operating controls and display elements on the wind energy converter control console

1	<i>Start/Stop</i> switch	2	<i>Rotor brake</i> switch
3	<i>Manual/Automatic</i> switch	4	<i>Maintenance</i> switch

5. Set the *Rotor brake* switch on the wind energy converter control console to *Off*.
6. Set the *Manual/Automatic* switch on the wind energy converter control console to *Automatic*.
 - ↪ The wind energy converter switches to automatic mode.
7. Set the *Start/Stop* switch on the wind energy converter control console to *Start*.
8. Wait until the wind energy converter is in operation.
9. Set the *Maintenance* switch on the wind energy converter control console to *Off*.
 - ↪ Operation of the wind energy converter via the remote monitoring system is activated.
10. When exiting the wind energy converter, switch off the lighting in the tower. To do this, press the lighting button in the entrance area.
11. Close the wind energy converter door.

9 Maintenance

Maintenance performed by the operator	In order to ensure its safe and optimum operation over the long term, the wind energy converter must be maintained at regular intervals, depending on requirements, but at least once a year. The operator is responsible for organising the maintenance.
Maintenance by ENERCON	<p>ENERCON recommends taking out an EPK contract. For the term of the EPK contract, ENERCON will guarantee a very high level of technical availability, will assume responsibility for the optimum and safe operation of the wind energy converter and will cover the associated costs.</p> <p>Under the EPK contract, ENERCON will arrange maintenance and any necessary repairs and will ensure that all maintenance work, repairs, etc. are fully documented. Information on the maintenance activities performed can be viewed via the ENERCON SIP at any time. Further details of EPK contracts are available from ENERCON.</p>

10 Repair, retrofitting and replacement of parts

Only original spare parts and replacement parts from ENERCON may be used in any repair or retrofitting. Any modification to the wind energy converter that has not been expressly authorised by ENERCON or is not carried out in accordance with instructions issued by ENERCON is regarded as misuse.

Replacement and proof test

Regardless of the above, there is the risk that the operating permit of the wind energy converter may be invalidated. After 20 years of operating time, the electrical components of the safety equipment must be upgraded to meet the standard for the remaining service life of the wind energy converter. This can be ensured by means of a proof test (cf. DIN EN ISO 13849-1:2018) or by replacing the components.

Only new parts or parts reconditioned by the manufacturer may be used for the required replacement of the safety equipment's electrical components.

If the electrical components of the safety equipment are not upgraded after 20 years of operating time, any further operation of the wind energy converter will be prohibited.

11 Malfunctions and troubleshooting

A malfunction has occurred if the wind energy converter can no longer be operated optimally or safely following an unexpected occurrence. Depending on the nature of the malfunction, the wind energy converter continues to run, stops or tries to restart after stopping. The cause of the malfunction may lie within the wind energy converter itself or come from outside, such as a fault in the power grid.

If a malfunction is present or occurs while persons are inside the wind energy converter or if an emergency stop button has been triggered, the responsible person at the site and ENERCON Service must be notified. Do not attempt to remedy the malfunction yourself as this may lead to severe injury or serious property damage. The malfunction must be rectified by authorised specialist personnel.

Warning messages

Malfunctions that are not critical to the operation of the wind energy converter generate warning messages. Warning messages do not cause the wind energy converter to stop. Warning messages are not displayed on the wind energy converter display.

One example is a defect in a redundant temperature sensor in the generator. In such cases, the control system of the wind energy converter generates a warning message. The malfunction that triggered the warning message must be remedied within a specified period. If this is not done, the control system of the wind energy converter generates a fault message. The wind energy converter stops.

Fault messages

Operational faults that are critical to the operation of the wind energy converter are shown as fault messages on the wind energy converter display.

In formal terms, fault messages are considered to be status messages, meaning that the possible fault messages are listed together with the status messages in the status list.

Fault messages are transmitted to ENERCON Service via the remote monitoring system. The cause of the malfunction must be remedied and the fault message cleared before the wind energy converter can resume operation.

In the highly unlikely event that the wind energy converter is obviously not working properly or there is damage and the wind energy converter fails to stop or display a fault message, shut down the wind energy converter immediately and notify ENERCON Service.

12 Decommissioning, dismantlement and disposal

The wind energy converter is designed for a specific service life. The actual useful life of the wind energy converter may be longer than this. From a technical standpoint, the operation of the wind energy converter is permissible and worthwhile for so long as the wind energy converter can be operated safely and economically.

- Decommissioning** To decommission the wind energy converter, it must be switched off and disconnected from the power grid by qualified personnel. Once the wind energy converter has been switched off, it can be exposed to winds from unfavourable directions since yawing is also deactivated. The wind energy converter must therefore only be decommissioned when wind conditions permit. The wind energy converter must be dismantled as soon as it has been decommissioned.
- Dismantlement** A wind energy converter must be dismantled by ENERCON or other qualified personnel.
In exceptional cases, the dismantled wind energy converter may be reassembled at another location and operation resumed. In such cases, it must be dismantled, transported, reassembled and recommissioned by ENERCON or other qualified personnel.
- Disposal** Certain materials from the wind energy converter can be processed and recycled. The wind energy converter also contains materials that may be harmful to health or cause environmental damage if not handled correctly. Materials must be processed or disposed of correctly in accordance with the regulations in force at the disposal site.

13 Technical specifications

13.1 General data

Tab. 17: General data

Characteristic	Value	Unit
Type designation ⁸	E-138 EP3 E3	
Open-loop control system name	PI-CS-EP3-01	
Rotor blade name	E-138 EP3-RB-02	
Generator name	E-138 E3 EP3-GU-01	
E-module name	EP3-EM-EN01	
Hybrid steel tower name	E-138 EP3 E3-HST-111-FB-C-01 E-138 EP3 E3-HST-131-FB-C-01	
Hybrid tower name	E-138 EP3 E3-HT-160-ES-C-01	
Design service life	25	years
Lightning protection (IEC 61400-24)	LPL 1+	

⁸ Relevant for type plate

13.2 Operating data

Tab. 18: Operating data

Characteristic		Value		Unit	
Nominal power (power-optimised operating mode) ⁹	Max. sound power level (power-optimised operating mode)	4260	106.0	kW	dB(A)
Nominal power (noise-reduced operating modes)	Max. sound power level (noise-reduced operating modes)	4080	105.0		
		3870	104.0		
		3700	103.2		
		3000	101.0		
		2240	99.0		
Nominal wind speed (power-optimised operating mode)		13.0		m/s	
Nominal speed (power-optimised operating mode)		11.1		rpm	
Speed setpoint (power-optimised operating mode)		11.1		rpm	
Cut-in wind speed ⁹		2		m/s	
Power reduction wind speed ¹⁰		22		m/s	
Cut-out wind speed ^{9;11}		28		m/s	
Lower power-feed speed		4.4		rpm	
Maximum idle speed		2.5		rpm	
Minimum power consumption ¹²		21		kW	
Maximum power consumption ¹²		136		kW	
Operating range ¹³ with standard equipment		-25 to +40		°C	
Operating range ¹³ with cold climate equipment		-35 to +40		°C	
Operating range ¹³ with hot climate equipment		-25 to +40		°C	
Nominal power range ¹⁴ with standard equipment		-15 to +25		°C	
Nominal power range ¹⁴ with cold climate equipment		-30 to +25		°C	

⁹ Relevant for type plate

¹⁰ 12-second mean

¹¹ 10-minute mean

¹² 15-minute mean

¹³ Up to 500 m above mean sea level of the ambient temperature range in which the wind energy converter can generate power.

¹⁴ Up to 500 m above mean sea level of the ambient temperature range in which the wind energy converter can generate nominal power.

Characteristic	Value	Unit
Nominal power range ¹⁴ with hot climate equipment	-15 to +33	°C

13.3 Nacelle data

Tab. 19: Nacelle data

Characteristic	Value	Unit
Nacelle height	9.23	m
Nacelle width	9.23	m
Nacelle length	19.75	m
Machine house length	14.1	m
Total weight of the nacelle	297	t
Yaw control	Active, 5 yaw drives	

13.4 Rotor and pitch control data

Tab. 20: Rotor and pitch control data

Characteristic	Value	Unit
Rotor diameter	138.25	m
Rotor blade length	67.795	m
Swept area	15011.36	m ²
Eccentric surface at standstill	15440	m ²
Tip speed at nominal speed	80.27	m/s
Number of rotor blades	3	
Rotor blade material	GFRP (glass-fibre reinforced plastic), balsa wood, foam	
Rotational direction	Clockwise (viewed from upwind)	
Rotor axis angle to the horizontal	7	°
Conical angle	2.5	°
Pitch control	An independent pitch system for each rotor blade with dedicated emergency power supply	
Service brake	Aerodynamic action via pitch control	

Characteristic	Value	Unit
Rotor holding brake	Hydraulic disk brake	
Rotor lock	3× 2 hydraulic-action bolts; latching every 10°	
Hub	Made from spheroidal graphite cast iron, rotates on fixed axle pin	
Bearing	2 preloaded, tapered roller bear- ings in an 'O' arrangement	

13.5 Generator data

Tab. 21: Generator data

Characteristic	Value	Unit
Type	Direct-driven, externally ex- cited synchronous generator	
Generator diameter	8.85	m
IP code/insulation class	At least IP 23/F	
Number of electrical sys- tems on stator	8	
Number of pole pairs	57	
Stator conductor material	Aluminium form-wound coils	
Rotor conductor material	Aluminium strip winding	
Stator mechanical division	2	
Rotor mechanical division	3	
Voltage adjustment for grid feed	Active rectifier with inverter	
Cooling system	Air cooling system	
Number of nacelle fans (generator and axle pin) with standard equipment	8 + 1	
Number of nacelle fans (generator and axle pin) with hot climate equipment	12 + 1	

13.6 Tower data

Tab. 22: Tower data¹⁵

	E-138 EP3 E3- HST-111-FB-C-01	E-138 EP3 E3- HST-131-FB-C-01	E-138 EP3 E3- HT-160-ES-C-01	
Characteristic	Value	Value	Value	Unit
Type	Hybrid steel tower	Hybrid steel tower	Hybrid tower	
Number of sections and segments (steel/concrete)	5/0	7/0	3/31	
Total height of the wind energy converter above ground level	179.37	199.76	229.13	m
Hub height above ground level	110.24	130.64	160.00	m
Height of top edge of nacelle above ground level	114.53	134.93	164.29	m
Tower height above top edge of foundation	105.27	125.86	155.62	m
Outer diameter of tower base	6.79	5.54	8.73	m
Tower weight	328	379	1496	t

¹⁵ Information on other possible project-specific towers is available from ENERCON.

13.7 Design requirements

Tab. 23: Design of external conditions

Characteristic	Value	Unit
Flow inclination	8	°
Normal temperature range	-10 to +40	°C
Extreme temperature range	-20 to +50	°C
Relative air humidity	≤ 95	%
Maximum solar irradiance	1000	W/m ²
Standard air density	1.225	kg/m ³

The wind energy converter has been/will be certified for the following design requirements set out in DIBt 2012 and IEC 61400-1:2005+A1:2010 (4th edition). These design requirements must be taken into consideration for the site of the wind energy converter.

Tab. 24: Certified/target design requirements, tower-specific¹⁶

	E-138 EP3 E3-HST-111-FB-C-01	E-138 EP3 E3-HST-131-FB-C-01	E-138 EP3 E3-HT-160-ES-C-01	
Characteristic	Value	Value	Value	Unit
IEC wind class (IEC 4th edition) ¹⁷	S	S	III	
Turbulence category (IEC 4th edition)	A	A	A	
Wind zone (DIBt 2012) / Terrain category ¹⁸	WZ S	WZ S	WZ 2 GK II	
50-year extreme wind speed at hub height (10-minute mean) (IEC 4th edition)	37.50	37.50	37.50	m/s
Corresponds to a load equivalent of approx. (3-second gust)	52.50	52.50	52.50	m/s

¹⁶ Information on other possible project-specific towers is available from ENERCON.

¹⁷ Relevant for type plate

¹⁸ WZ: wind zone; GK: Geländekategorie (terrain category)

	E-138 EP3 E3- HST-111-FB-C-01	E-138 EP3 E3- HST-131-FB-C-01	E-138 EP3 E3- HT-160-ES-C-01	
Characteristic	Value	Value	Value	Unit
50-year extreme wind speed at hub height (10-minute mean) (DIBt 2012)	37.50	37.50	38.96	m/s
Annual average wind speed at hub height (IEC 4th edition) ¹⁹	7.80 ¹⁹	7.80 ¹⁹	7.50	m/s
Annual average wind speed at hub height (DIBt 2012)	7.80 ¹⁹	7.80 ¹⁹	7.71	m/s
Wind shear	0.05 to 0.2	0.05 to 0.2	0.05 to 0.2	

¹⁹ Although the tower configuration is designed for a reduced mean wind speed, the suitability of the site for higher mean wind speeds can be demonstrated by means of load calculations, depending on the site conditions. Taking into account a generic wind direction distribution, the design target is 8.50 m/s.

13.8 Type plate



Fig. 85: Sample of a wind energy converter type plate

1	Name and address of manufacturer	2	Product designation
3	Designation of wind energy converter type	4	Nominal power of wind energy converter
5	Location number of wind energy converter within the wind farm	6	Serial number of wind energy converter
7	Month and year of commissioning	8	Configuration of grid properties
9	IEC wind class	10	Reference wind speed at hub height as per IEC
11	Operating wind speed range	12	Operating temperature range
13	Nominal voltage on low-voltage side	14	Wind energy converter frequency protection: mains underfrequency and mains overfrequency level

The type plate is located in the entrance area of the wind energy converter.

