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Parque Eólico Beira Interior Sobreequipamento

Projeto de Licenciamento

MEMÓRIA DESCRITIVA

3 DE JANEIRO DE 2025

HISTÓRICO DO DOCUMENTO

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DEFINIÇÕES

AC	Corrente Alternada
AT	Alta Tensão
BT	Baixa Tensão
BESS	*Battery Energy Storage System*
CSF	Central Solar Fotovoltaica
DC	Corrente Continua
DGEG	Direção Geral de Energia e Geologia
EC	Edifício de Comando
EE	Estação de Entrega
MT	Média Tensão
MVA	Mega Volts Ampere
MW	Mega Watt
MWp	Mega Watt pico
ORD	Operador da Rede de Distribuição
ORT	Operador da Rede de Transporte
PE	Parque Eólico
PT	Posto de Transformação
REN	Redes Energéticas Nacionais
RESP	Redes Elétrica de Serviço Público
RND	Rede Nacional de Distribuição
RNT	Rede Nacional de Transporte
RTIEBT	Regras Técnicas das Instalações Elétricas de Baixa Tensão
SE	Subestação

1 INTRODUÇÃO

O Promotor Eólica da Lajeira, S.A., com sede na Rua Ofélia Diogo da Costa, 115, 6.º 4149-022, vem afirmar o interesse na construção do sobreequipamento de um de três subparques englobados pelo Parque Eólico da Beira Interior, nomeadamente o Subparque Eólico de Aldeia Nova localizado na freguesia de Aldeia Nova, concelho de Trancoso, distrito da Guarda e uma potência instalada de 23 MW, ao abrigo do Decreto-Lei n.º 15/2022 de 14 de janeiro[1] que permite aumentar a potência instalada até ao limite de 20% da potência de ligação atribuída ao centro electroprodutor na licença de produção inicial, mantendo-se inalterada a potência de ligação. A potência a instalar neste sobreequipamento será de 7 MW.

O presente documento apresenta o projeto do sobreequipamento do centro electroprodutor a partir de fontes de energia renováveis nos termos do disposto no n° 5 do Anexo I do Decreto-Lei acima mencionado.

O Termo de Responsabilidade do projeto e justificativos necessários são apresentados em anexo próprio.

[1] Documento que revoga os Decretos-Leis n° 328/90, de 22 de outubro, 29/2006, de 15 de fevereiro, 90/2006, de 24 de maio, 172/2006, de 23 de agosto, 237-B/2006, de 18 de dezembro, 165/2008, de 21 de agosto, 104/2010, de 29 de setembro, 138-A/2010, de 28 de dezembro, 75/2012, de 26 de março, 35/2013, de 28 de fevereiro, 94/2014, de 24 de junho, 172/2014, de 14 de novembro, 38/2017, de 31 de março e 162/2019, de 25 de outubro.

2 PROMOTOR

O projeto será desenvolvido pela Nadara, cujos detalhes se apresentam em seguida:

Designação da Empresa ..... Eólica da Lajeira, S.A.
Nº de Contribuinte 510978258
Sede Social..... Rua Ofélia Diogo da Costa, 115, 6.º
4149-022 Porto
Morada para correspondência ..... Rua João Chagas, 53 Piso 5
1495-072 Algés, Portugal
Pessoa de contacto ..... João Brissos e Silva
E-mail..... joao.silva@nadara.com
devprojects.portugal@nadara.com
Telefone..... +351 918 947 875

3 NORMAS E REGULAMENTOS

No âmbito do presente projeto serão respeitadas as normas e os regulamentos nacionais e internacionais aplicáveis em vigor com natural evidência para os regulamentos nacionais, nomeadamente:

- Regulamento da Rede de Distribuição/Transporte
- Organização e funcionamento do SEN
  - Decreto/Lei n°15/2022 de 14 de janeiro, alterado pelo Decreto-Lei n.º 99/2024, de 3 de dezembro
  - Decreto/Lei nº 72/2022 de 19 de outubro
  - Decreto/Lei nº 11/2023 de 10 de fevereiro
- Instalações Elétricas de Alta Tensão
  - Regulamento de Segurança de Linhas Elétricas de Alta Tensão e Decreto Regulamentar nº 1/92 de 18 de fevereiro
  - Regulamento de Segurança de Subestações e Postos de Transformação e Seccionamento (Decreto-Lei n.º 42895, de 31 de março de 1960, alterado pela Portaria n.º 37/70, de 17 de janeiro e pelos Decretos Regulamentares n.º 14/77, de 14 de fevereiro e n.º 56/85, de 6 de setembro)
  - Diretivas europeias transpostas para o enquadramento legal nacional pelos DL nº 441/91 de 14 de novembro e DL nº 155/95 de 1 de julho, regulamentada pela Portaria nº101/96 de 3 de abril
  - Norma Portuguesa NP ENV 206 (1993)
- Instalações Elétricas de Baixa Tensão
  - Regras Técnicas das Instalações Elétricas de Baixa Tensão (Decreto-Lei n.º 226/2005, de 28 de dezembro, e Portaria n.º 949-A/2006, de 11 de setembro) – RTIEBT
  - Regulamento de Segurança de Redes de Distribuição de Energia Elétrica de Baixa Tensão e Decreto Regulamentar nº 90/84 de 26 de dezembro

- Decreto-Lei n.º 740/74 de 26.12.74 (Regulamento de Segurança de Instalações de Utilização de Energia Elétrica)
- Decreto-Lei n.º 303/76 de 26.4.76 (Alterações ao D.L. 740/74)
- Decreto regulamentar n.º 90/84 de 26.12.84 (Regulamento de Segurança das Linhas elétricas de baixa tensão)
- Decreto-Lei n.º 313/95 de 24.11.95
- Decreto-Lei n.º 168/99 de 18.5.99
- Resolução do conselho de Ministros nº 154/2001 de 19.10.2001
- Decreto-Lei n.º 312/01 de 10.12.01
- Decreto-Lei n.º 339-C/2001 de 29.12.2001

– Segurança, Higiene e Saúde no Trabalho
  - Decreto-Lei n.º 441/91 de 14.11.91
  - Decreto-Lei n.º 155/95 de 1.7.95
  - Portaria n.º 101/96 de 3.4.96

– Ambiente
  - Decreto-Lei 69/2000 de 03.05.00
  - Decreto Regulamentar nº 50/97 de 20.11.97
  - Despacho nº 11091/2001 (2ª série)
  - Despacho Conjunto nº 583/2001
  - Despacho nº 12006/2001

– Especialidades civis
  - RSA - Regulamento de Segurança e Ações para Estruturas de Edifícios e Pontes.
  - Eurocódigo 1990– Bases para projetos de estruturas
  - Eurocódigo 1991 – Ações nas estruturas
  - Eurocódigo 1993 - Estruturas de Aço
  - Eurocódigo 1997 – Projeto Geotécnico
  - Eurocódigo 1998 - Disposições para Projeto de Estruturas Sismo-resistentes

4 OBJETIVO

O projeto do sobreequipamento Parque Eólico da Beira Interior, desenvolvido pela Nadara, surge como resposta a uma necessidade da sociedade, atendida pela administração pública favorecendo o desenvolvimento desta forma de energia renovável.

5 DESCRIÇÃO DO PARQUE EÓLICO

O sobreequipamento do subparque eólico de Aldeia Nova terá uma potência instalada de 7 MW, sendo constituída por 1 aerogerador do fabricante Enercon, modelo E-175 EP5 E2, ou similar.

Para a evacuação elétrica em 30 kV projetam-se canalização subterrada, que culminará na cela de reserva da subestação elevatória de 60/30 kV do subparque.

A alternativa escolhida para este projeto foi um aerogerador E-175 EP5 E2 / 7000kW, ou similar, com as seguintes características:

- Potência unitária: 7 MW
- Diâmetro do rotor: 175 m
- Altura máxima da torre: 263 m



Figura 1 - Aerogerador E-175 EP5 E2 / 7000kW

Baseado nos cálculos do estudo de vento, desenhou-se uma disposição ótima do aerogerador, tendo ainda em conta restrições de tipo técnico e ambiental, assim como o menor impacto em terrenos com vegetação natural.

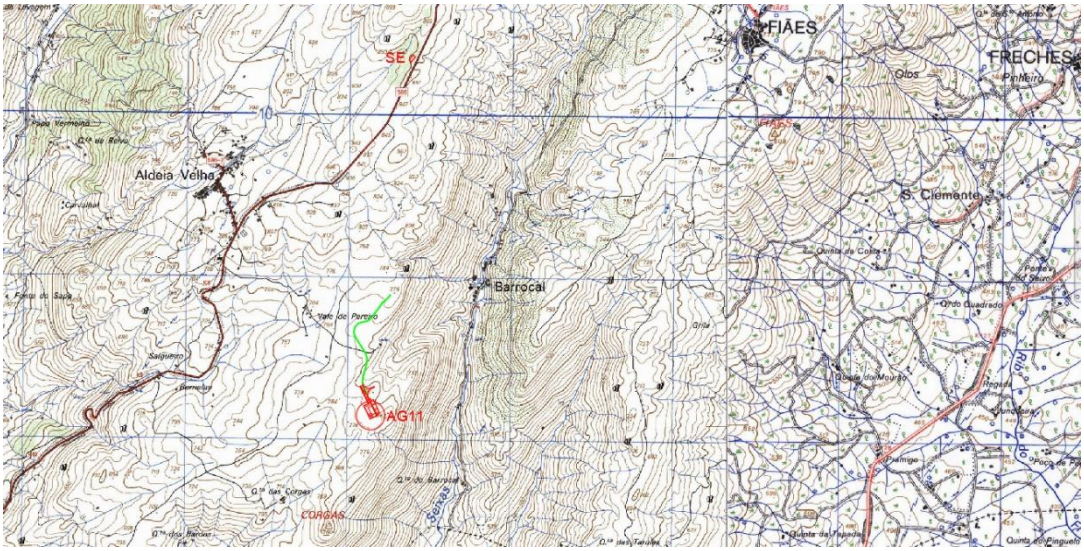


Figura 2 - Localização do Parque Eólico

No que diz respeito às Obras de Construção Civil, o âmbito do Projeto são os acessos, plataformas e fundações do aerogerador, acessos temporários e valas para cabos elétricos do subparque eólico.

Em caso de viabilidade, a Nadara construirá o referido subparque criando todas as infraestruturas necessárias à sua exploração comercial, como sistema produtor de energia elétrica, contribuindo para o aproveitamento da energia eólica e fomentando a incorporação de energias renováveis.

6 ELEIÇÃO DA LOCALIZAÇÃO

Tratando-se de um sobreequipamento do parque, é de antemão conhecido o elevado potencial eólico da zona. Para o sobreequipamento do subparque foram seguidos os seguintes critérios para a eleição da localização do novo aerogerador:

- Potencial eólico adequado
- Acessos ao parque adequados
- Possibilidades de evacuação

Aerogerador	ETRS89 Portugal TM06	
	X	Y
AG11	61810,064	116071,808

Quadro 1 – Coordenadas do ponto de instalação do aerogerador

A planta de implantação do novo aerogerador pode ser consultada no Anexo II.

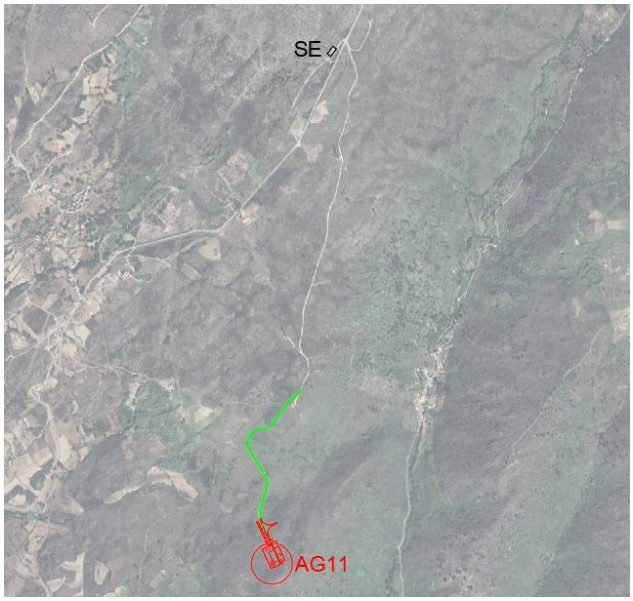


Figura 3 – Vista aérea da implantação do Parque

7 CLASSIFICAÇÃO DOS LOCAIS

As classificações dos locais quanto às influências externas (ambiente – A; Utilização - B e Construção –C) das áreas constituintes do Estabelecimento estão identificadas e estão em conformidade com os respetivos códigos IP e IK mínimos dos materiais e equipamentos e quadros elétricos, segundo as normas NP EN 60529 e EN 50102.

8 SISTEMA DE TELECONTAGEM DE ENERGIA

Sendo o ponto de interface à RESP, o painel de chegada de linha na subestação REN de Chafariz, a telecontagem de energia total (energia produzida no subparque de Rio de Mel-Castanheira, subparque de Cabeço de Oiro e subparque eólico de Aldeia Nova) é e continuará a ser realizada em AT na subestação de Chafariz, de acordo com os requisitos necessários e respetiva legislação em vigor.

O sistema de telecontagem de energia ativa e reativa, é feito através de um contador bidirecional a colocado em armário próprio e acessível ao ORD, com características e instalação conforme “Guia de Medição Leitura e Disponibilização de Dados” publicado em Diário da República pelo Despacho nº 4591-A/2007 (2ª série).

A contagem bidirecional de energia elétrica possibilitará às instalações (subparque de Rio de Mel-Castanheira, subparque de Cabeço de Oiro e subparque eólico de Aldeia Nova e respetivo sobreequipamento), além da alimentação dos restantes equipamentos através de transformadores auxiliares, o consumo nas horas sem produção.

Para efeitos de contabilização especifica do sobreequipamento, será instalado um contador bidirecional na subestação elevadora que faz a contagem na cela de interligação do sobreequipamento considerando assim todo os consumo/produção referente ao sobreequipamento.

Os equipamentos de contagem/telecontagem do sobreequipamento serão instalados em caixa apropriada a localizar no interior do edifício de comando da subestação elevadora e que garantem a proteção contra ações mecânicas, poeiras e humidade. O acesso ao interior da caixa só é possível por pessoal técnico do ORD, através de fechadura tipo.

9 CONSTITUIÇÃO GERAL DA CENTRAL EÓLICA - SOBREEQUIPAMENTO

9.1 CARACTERÍSTICAS GERAIS DA CENTRAL EÓLICA - SOBREEQUIPAMENTO

A expansão da central eólica terá um aerogerador com potência nominal total de 7 000 kW / 7 000 kVA, considerando a opção de fator de potência (cos φ) = 1, pretendendo-se optar pelo regime de não injeção de energia reativa na Rede.

O Plano de Implantação detalhado da central pode ser consultado no Anexo II.

A entrega de energia será efetuada através de linha aérea, a 60kV, entre a subestação do subparque eólico de Aldeia Nova e a subestação REN de Chafariz, com uma extensão de aproximadamente 12km.

Existe um posto de transformação instalado na base do aerogerador, equipado com um transformador com uma potência nominal de 7 MW.

O sistema elétrico de média tensão permite conduzir a energia elétrica gerada a partir do aerogerador até à subestação e desta até ao ponto de conexão. Desde o gerador da turbina conduz-se a energia à tensão de geração de 750 V até ao centro de transformação incorporado no aerogerador.

No centro de transformação, que essencialmente consta de um transformador de potência com os seus elementos de proteção, faz-se a transformação da energia elétrica na tensão de geração de 0,75 kV a 30 kV.

A energia circulará até à subestação à tensão de 30 kV. Este circuito será enterrado ao longo dos caminhos desenhados, sem articulações intermédias.

Na torre metálica do aerogerador estabelece-se uma ligação à terra e interconectam-se todas as ligações de terra mediante um circuito que percorre as mesmas trincheiras que os circuitos de potência anteriores. Nas mesmas trincheiras dos circuitos de potência e de ligação a terra, instala-se o circuito de controlo, composto por cabo de fibra ótica para controlo do aerogerador.

O sobreequipamento do aerogerador é composto por 1 ramal:

Ramal	Aerogerador
Ramal 4	AG11 –SE

Quadro 2 – Ramal de média tensão

O transporte da energia para entrega à Rede Elétrica Nacional é efetuado a uma tensão de 60 kV. A instalação elétrica, já existente com exceção do cabo MT que irá ligar ao novo aerogerador, é constituída por:

- Pórticos de saída e chegadas das linhas aéreas
- Barramento de 60kV
- Equipamentos de manobra em AT (60 kV)
- TC's e TT's para contagem e proteção em AT (60 kV)
- Transformador de potência 60/30 kV
- Descarregadores de sobretensão AT e MT (60 kV e 30 kV);
- Quadro de Média Tensão (30 kV)
- Transformador de Serviços Auxiliares (TSA)
- Cabos de média tensão enterrados de ligação entre os postos de transformação dos aerogeradores e a subestação
- Posto de transformação (celas MT e Transformador 30/0,8 kV)
- Aerogerador e as partes que o constituem

As características técnicas desta instalação são detalhadas nos capítulos subsequentes. O Esquema Unifilar pode ser consultado no Anexo V.

9.2 JUSTIFICAÇÃO DA SOLUÇÃO TÉCNICA PREFERIDA

A solução geral que foi escolhida para a central é a da integração na sua zona de localização, respeitando a morfologia, dimensões e características do terreno. A localização do aerogerador pretende maximizar a produção de energia e diminuir as perdas, assim como otimizar a sua integração no meio envolvente com o menor impacto de construção possível. Do mesmo modo, neste projeto serão contempladas as estruturas intrínsecas e elementos localizados no terreno tais como árvores, postes, entre outros.

9.3 APARELHAGEM DE MÉDIA TENSÃO

9.3.1 Características gerais das celas

As celas do Quadro Metálico de Média Tensão existente são da gama NXPlus da SIEMENS. A gama NXPlus são de isolamento no ar, de construção modular, compartimentada e facilmente extensível. A área de instalação ocupada é bastante reduzida, sem comprometer a simplicidade da exploração, assim como a acessibilidade para a manutenção. A operação normal dos equipamentos é feita exclusivamente pela parte frontal, sendo apenas necessário o acesso traseiro para montagem dos cabos MT.

A construção dos NXPlus é resistente ao arco interno conforme IEC 62271-200, tipo PM, acessibilidade A FLR, para a proteção de pessoas e restantes equipamentos. As celas estão equipadas com disjuntores de corte no vácuo, de elevadas prestações elétricas e mecânicas segundo IEC 62271-200, classes E3 e M2.

As celas estão divididas em quatro compartimentos separados, da seguinte forma:

- Compartimento do Barramento;
- Compartimento de Disjuntor e Transformadores de Medida;
- Compartimento de Baixa Tensão;
- Compartimento de Cabos.

9.3.2 Características técnicas das celas

Apresentam-se em seguida as características técnicas das celas:

Celas de Média Tensão	
Tensão nominal:	**36 kV**
Nível de isolamento:	
- frequência industrial (50 Hz/1 min)	**70 kVp**
- ao choque (1,2 / 50 µs)	**170 kVp**
Frequência:	**50 Hz**
Corrente nominal das celas:	
- transformador de potência	**1250 A**
- ramais	**1250 A**
- fusível	**1250 A**
Poder de fecho:	**80 kAp**
Corrente nominal de curta duração:	**31,5 kA (1 seg)**
Grau de proteção:	**IP3XD**
Cor:	**RAL 7035**
Temperatura:	**- 5°C / + 55°C**

O condutor de ligação à terra está disposto ao longo de todo o comprimento das celas e está dimensionado para suportar a intensidade de curta-duração admissível.

O barramento está sobredimensionado para suportar sem deformação permanente os esforços dinâmicos, em caso de curto-circuito.

9.4 CABOS ELÉTRICOS

9.4.1 Média Tensão

Os cabos de média tensão para o novo aerogerador (sobreequipmento) serão, igualmente, em alumínio, monopolares, com isolamento em polietileno reticulado (PEX), do tipo LXHIOV ou equivalente, sendo instalados enterrados em vala, no exterior de acordo com as secções indicadas no quadro seguinte, assim como as respetivas perdas e queda de tensão:

Ramal	Ligação	Tipo de Cabo	Perdas (W)	Queda de Tensão (ΔV)
Ramal 4	**SE - AG11**	**LXHIOZ1 (cbe,frt) 18/30kV 3x1x240/16 mm²**	**23946**	**59,251**

Quadro 3 – Ligação em Média Tensão do Aerogerador

Assim, a queda de tensão será de 59,251V o que corresponde a um valor de cerca de 0,3421% da tensão nominal.

As perdas por efeitos joule serão cerca de 23946 W, o que corresponde a um valor de cerca de 0,3421% da potência instalada.

9.5 LIGAÇÃO À RESP (SISTEMA ELÉTRICO PÚBLICO)

O subparque está ligado à subestação da REN de Chafariz, através de uma linha de transporte a 60 kV. Esta linha pertence ao promotor e, portanto, o ponto de interface à RESP é, e continuará a ser, o painel de chegada de linha na subestação REN de Chafariz.

9.6 SISTEMA DE COMADO, CONTROLO E PROTEÇÃO

Sistema de Monitorização (SCADA)

Relativamente ao sobreequipamento (novo aerogerador), este será integrado no sistema de comando e controlo de alarmes permanente existente (chamado de SCADA dos aerogeradores), que permite o controlo e análise à distância ou localmente dos aerogeradores. Esta integração deverá ser feita pelo fornecedor do aerogerador.

Este sistema está equipado por uma rede de autómatos e um central que está instalado no edifício de comando da subestação e que comunica via fibra ótica. O autómato central recolhe ainda informações da subestação (via comunicação com a unidade central de comando da subestação ou a fio).

Quanto à subestação, esta possui um sistema de comando e controlo de alarmes permanente, que permite o controlo e análise à distância ou localmente da mesma.

Este sistema de monitorização está equipado por uma unidade central com HMI (UC) e switches ethernet para garantir a comunicação entre a UC e as várias unidades de proteção e comando através de uma rede de comunicação em fibra ótica. Este sistema permite o funcionamento da subestação em regime abandonado, assegurando as seguintes funções:

- Comando e a supervisão de toda a instalação
- Sinalização de defeitos e indicação de medidas elétricas da Central
- Registar os defeitos e mudanças de estado da instalação
- Seccionamento automático dos equipamentos com defeitos (posto de transformação, posto de seccionamento, etc…)
- Deslastre e reposição

O SCADA da subestação está ainda ligado com o SCADA dos aerogeradores de forma a haver um intercambio de informações necessárias entre estes dois sistemas.

A comunicação com o novo armário de contagem do ORT para o sobreequipamento será assegurada por um modem com comunicação GSM/GPRS.

Todos os equipamentos de comando e proteção têm todo o hardware necessário à sincronização horária, via GPS, para datação de eventos e registos oscilográficos.

10 OBRAS DE CONSTRUÇÃO CIVIL

As obras de construção civil consistem na abertura da fundação e realização da sapata da torre, bem como a execução da plataforma da torre e acessos à mesma.

10.1 FUNDAÇÃO DA TORRE DO AEROGERADOR

A fundação da torre será executada em função dos esforços aplicados pelo aerogerador, conforme indicado pelo respetivo fabricante por forma a garantir a estabilidade global do conjunto, em consonância com a regulamentação aplicável e as condições existentes no local.

10.2 PLATAFORMA DA TORRE DO AEROGERADOR

Nas áreas adjacentes à torre, e no prolongamento dos acessos, serão construídas plataformas pavimentadas para trânsito e estacionamento de camiões de transporte da torre e aerogerador durante a sua instalação, bem como para posicionamento das gruas de montagem.

Estas plataformas ocupam apenas a área necessária à referida montagem dos equipamentos e têm características construtivas semelhantes às dos acessos.

Os acessos serão realizados por ramais abertos a partir dos já existentes que, por sua vez, sofreram melhoramentos e alargamentos, conforme necessário para instalação da Torre.

10.3 VALAS PARA CABOS MT

Os cabos serão instalados em valas de 0,9 m de profundidade e uma largura mínima de 0,4 m. Uma camada de areia com 0,10 m de espessura será colocada no leito da trincheira, onde serão depositados os cabos a serem instalados. Acima dela irá outra camada de areia com uma espessura mínima de 0,15 m, sobre a qual será instalada uma proteção mecânica, constituída por placas PPC, ao longo do comprimento total do cabo. As duas camadas de areia cobrirão a largura total da vala levando em conta que entre os lados e os cabos é mantida uma distância de cerca de 0,10 m.

Em seguida será colocada uma camada de 0,30 m de espessura de terra cirandada e compactada, sobre a qual será colocada uma camada final de 0,35 m de espessura constituída por produtos de escavação. A uma distância de 0,35 m do solo uma fita plástica sinalizadora será colocada como aviso da presença de cabos elétricos.

As valas serão devidamente marcadas por marcos, instalados a uma razão de um a cada 60 metros (máximo), bem como em todas as junções e mudanças de direção.

11 TERMO DE RESPONSABILIDADE

O Termo de Responsabilidade devidamente assinado e acompanhado dos justificativos necessários pode ser consultado no Anexo VIII.

12 de novembro de 2024

Assinado por: **PEDRO MARQUES MAIO**
Num. de Identificação: 10341473
Data: 2025.03.07 16:54:20+00'00'

Pedro Maio

Engº Eletrotécnico

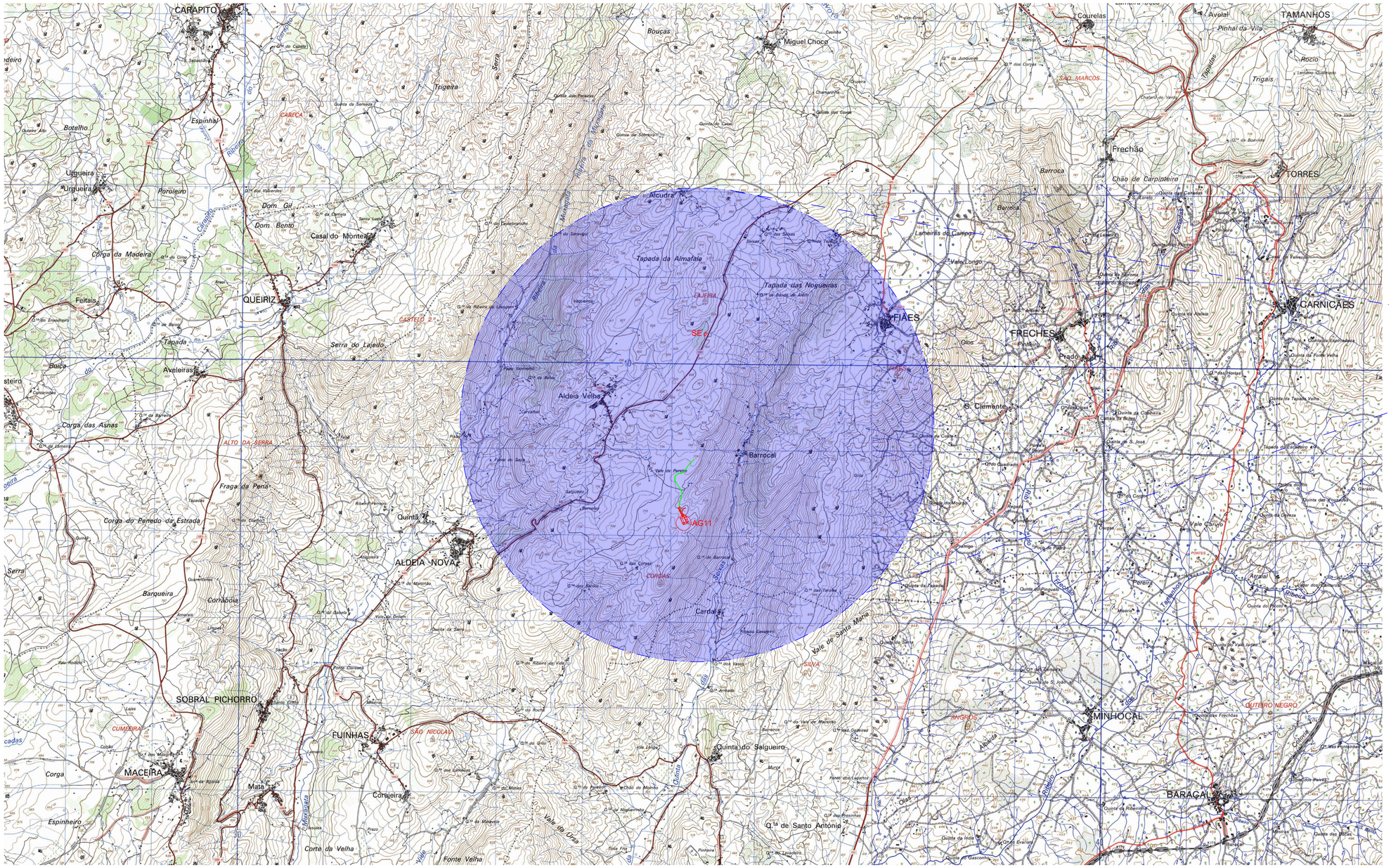
Membro da OE nº 45194

ANEXOS

ANEXO I

PLANTA DE LOCALIZAÇÃO

GEN-A24024-003-001


CARAPITO
Miguel Choco
Courelas
Avelal
TAMANHOS
Pinhal da Vila
Rocio
Trigais
Tapadas
SANT. MARCOS
Frechão
Chão de Carpinteiro
TORRES
Barroca
Botelho
Espinhal
Trigeira
Serra
CABEÇA
Ribeira
Urgueira
Poroleiro
Dom. Gil
Dom. Bento
Casal do Monte
Corga da Madeira
Feitais
QUEIRIZ
Tapada
Serra do Laredo
Boiça
Aveleiras
Corga das Asnas
ALTO DA SERRA
Fraga da Pena
Corga do Penedo da Estrada
Alcudra
Tapada da Almafala
Tapada das Nogueiras
LAJEIRA
SE
FIAES
Aldeia Velha
Barrocal
AG11
Cardal
CORGAS
ALDEIA NOVA
Barroca
Lameiras do Campo
Vale Longo
FRECHES
Prado
S. Clemente
CARNIÇAES
Cabeça Espinadeira
Quinta da Fonte Velha
Quinta da Tapada Velha
Quinta da Carreira
Quinta de S. José
Vale Caruço
Pereira
Quinta da Ribeira
Quinta da Cabeça
Quinta da Geneza
Quinta dos Pereiros
Quinta dos Prados
Quinta das Torres
Quinta das Videiras
Quinta do Garrido
Quinta das Amoreiras
Quinta da Tapada
Quinta da Ribeira
Quinta da Fonte Nova
Quinta da Fonte Velha
Quinta da Fonte Nova
Quinta da Fonte Velha
Quinta da Fonte Nova
Quinta da Fonte Velha

ANEXO II

PLANTA DE IMPLANTAÇÃO

GEN-A24024-003-002



LEGENDA:

- EQUIPAMENTO A INSTALAR
- SUBESTAÇÃO EXISTENTE
- NOVO ACESSO À PLATAFORMA

REFERÊNCIAS:

- GEN-A24024-003-001 – PLANTA DE LOCALIZAÇÃO
- GEN-A24024-003-003 – LAYOUT GERAL
- GEN-A24024-003-006 – ESQUEMA UNIFILAR

REV.	DESCRIÇÃO	ALTEROU	APROVOU	DATA
A.2	Revisão geral conforme projeto civil	J. Riboira	P. Maio	07/03/2025

PROJETISTA:

SISINT - Supervisão, Conservação, Manutenção e Gestão de Redes de Energia, Lda.
www.sisint.pt | +351 227 418 810 | sisint@sisint.pt

CLIENTE:

nadara

PROJETO:

Parque Eólico da Beira Interior
Subparque Eólico de Aldeia Nova
- SOBREEQUIPAMENTO -

FASE DO PROJETO:

PROJETO DE LICENCIAMENTO

TÍTULO:

Planta de Implantação

PROJETOU:	DESENHOU:	ESPECIALIDADE:
João Riboira	João Riboira	Geral
VERIFICOU:	APROVOU:	EMISSÃO INICIAL:
Pedro Maio	Nadara	03/01/2025

DESENHO Nº: GEN-A24024-003-002

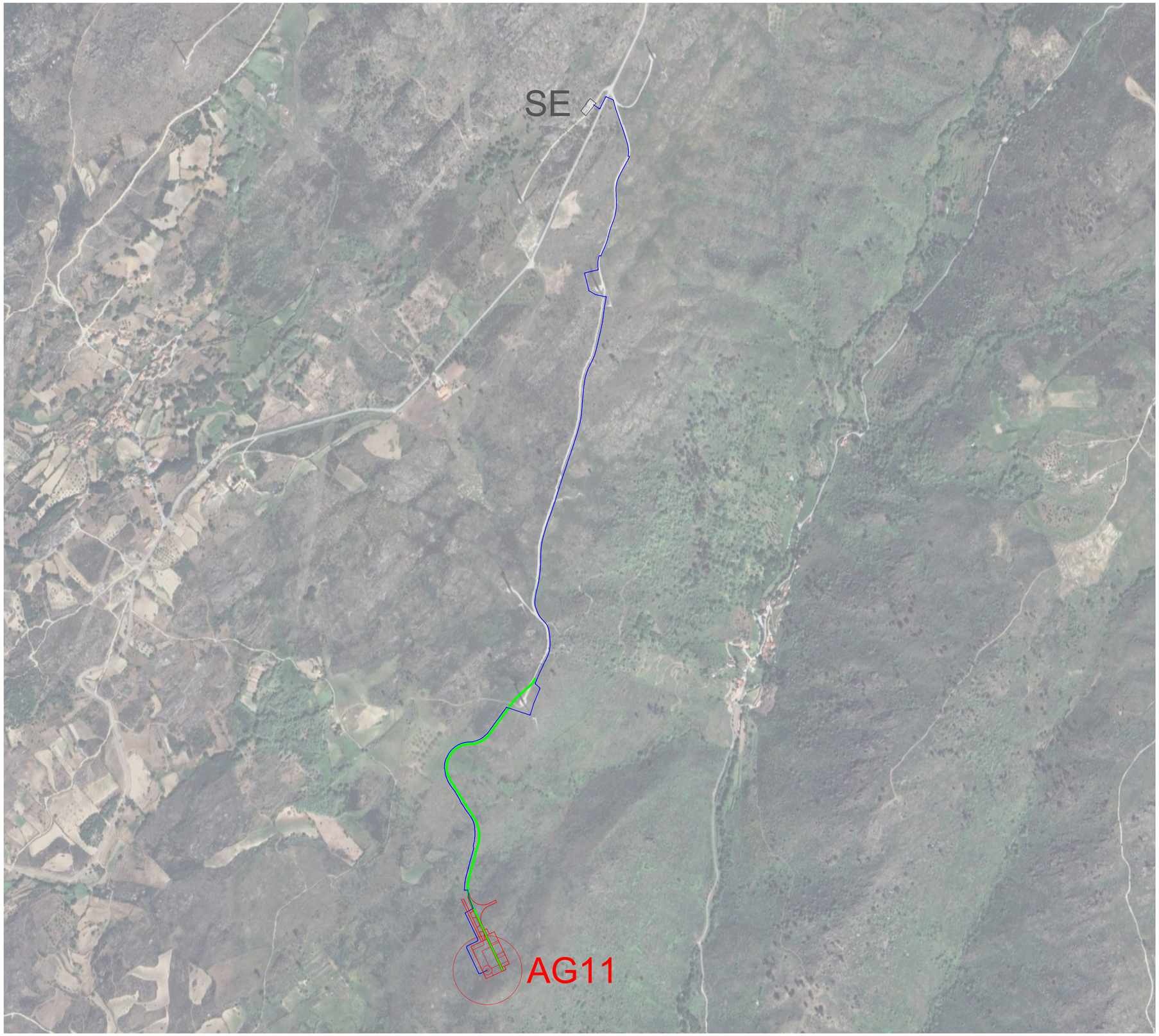
REVISÃO: A.2

ESCALAS:	FORMATO:	FOLHA:
1:5000	A1 (594 x 841 mm)	01 / 01

ANEXO III

LAYOUT GERAL

GEN-A24024-003-003



LEGENDA:

- EQUIPAMENTO A INSTALAR
- SUBESTAÇÃO EXISTENTE
- VALA DE CABOS PARA 1 CIRCUITO
- NOVO ACESSO À PLATAFORMA

REFERÊNCIAS:

- GEN-A24024-003-001 – PLANTA DE LOCALIZAÇÃO
- GEN-A24024-003-002 – PLANTA DE IMPLANTAÇÃO
- GEN-A24024-003-005 – PLANTA DA SUBESTAÇÃO
- GEN-A24024-003-004 – VALAS DE CABOS

REV.	DESCRIÇÃO	ALTEROU	APROVOU	DATA
A.2	Revisão geral conforme projeto civil	J. Riboira	P. Maio	07/03/2025

PROJETISTA:

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CLIENTE:

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PROJETO:

Parque Eólico da Beira Interior
Subparque Eólico de Aldeia Nova
- SOBREEQUIPAMENTO -

FASE DO PROJETO:

PROJETO DE LICENCIAMENTO

TÍTULO:

Layout Geral

PROJETOU:	DESENHOU:	ESPECIALIDADE:
João Riboira	João Riboira	Geral
VERIFICOU:	APROVOU:	EMISSÃO INICIAL:
Pedro Maio	Nadara	03/01/2025

DESENHO Nº: GEN-A24024-003-003

REVISÃO: A.2

ESCALAS:	FORMATO:	FOLHA:
1:5000	A1 (594 x 841 mm)	01 / 01

ANEXO IV

PLANTA DA SUBESTAÇÃO

GEN-A24024-003-005



COORDENADAS DE IMPLANTAÇÃO:

A - M=60 101.658
P=118 306.016

B - M=62 097.123
P=118 298.943

C - M=62 084.818
P=118 280.437

D - M=62 075.491
P=118 286.638

E - M=62 087.797
P=118 305.145

F - M=62 087.264
P=118 305.499

G - M=62 093.742
P=118 315.242

H - M=62 099.988
P=118 311.089

I - M=62 098.161
P=118 308.341

J - M=62 079.677
P=118 289.138

K - M=62 082.589
P=118 287.200

L - M=62 085.504
P=118 285.259

NOTAS:

- ESTE DESENHO FOI IMPORTADO DO PROCESSO ORIGINAL COM A REFERÊNCIA 4400-0060-13

REFERÊNCIAS:

- GEN-A24024-005-001 – PLANTA DE LOCALIZAÇÃO
- GEN-A24024-005-002 – PLANTA DE IMPLANTAÇÃO
- GEN-A24024-005-003 – LAYOUT GERAL
- GEN-A24024-005-006 – ESQUEMA UNIFILAR

REV.	DESCRIÇÃO	ALTEROU	APROVOU	DATA
A.1	Versão inicial	J. Riboira	P. Maio	07/03/2025

PROJETISTA:

SISINT - Supervisão, Conservação, Manutenção e Gestão de Redes de Energia, Lda.
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CLIENTE:

PROJETO:

Parque Eólico da Beira Interior
Subparque Eólico de Aldeia Nova
- SOBREEQUIPAMENTO -

FASE DO PROJETO:

PROJETO DE LICENCIAMENTO

TÍTULO:

Planta da Subestação

PROJETOU:	DESENHOU:	ESPECIALIDADE:
João Riboira	João Riboira	Geral
VERIFICOU:	APROVOU:	EMISSÃO INICIAL:
Pedro Maio	Nadara	07/03/2025

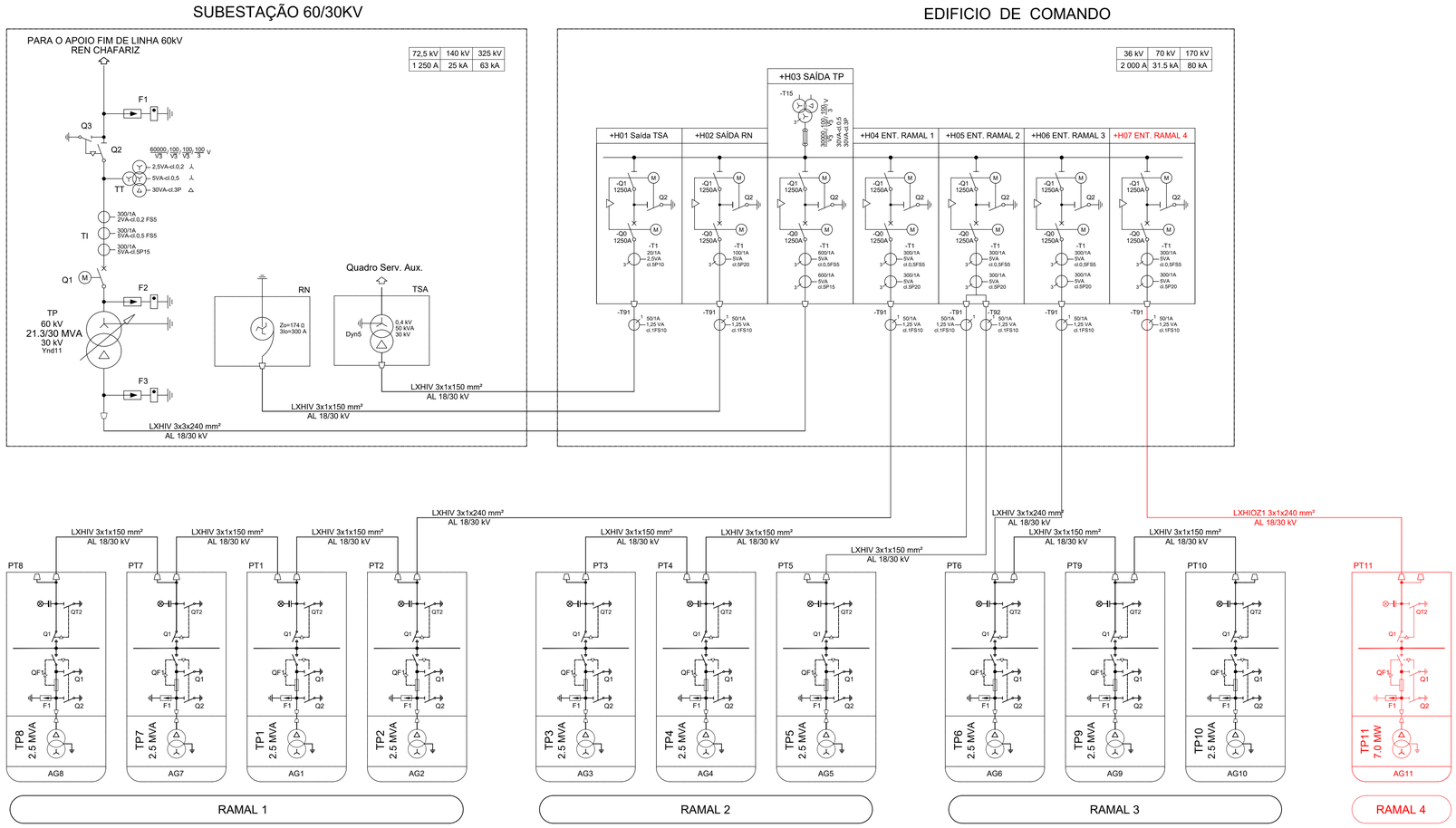
DESENHO Nº:	REVISÃO:
GEN-A24024-003-005	A.1

ESCALAS:	FORMATO:	FOLHA:
1:200	A2 (420 x 594 mm)	01 / 01

ANEXO V

ESQUEMA UNIFILAR GERAL

GEN-A24024-003-006



DESIGNAÇÃO DE EQUIPAMENTO	
TIPO	EQUIPAMENTO
TP	TRANSFORMADOR DE POTÊNCIA 63/30kV - 21,5/30 MVA - YNd11 (Siemens)
F1	DESCARREGADORES DE SOBRETENSÕES LINHA AT 3EL2 066, Un = 66KV, In = 10kA + 3EX5030 (Siemens)
F2	DESCARREGADORES DE SOBRETENSÕES TP AT 3EL2 066, , Un = 66KV, In = 10kA + 3EX5030 (Siemens)
F3	DESCARREGADORES DE SOBRETENSÕES TP MT 3EL1 045, Un = 45KV, In = 10kA + 3EX5030 (Siemens)
Q1	DISJUNTOR AT 3AP1FG 72,5kV , 2500A, 31,5kA/3seg (Siemens)
Q2	SECCIONADOR LINHA AT 3DN1CB72.5EB, 1250 A, 31,5kA/3seg (Siemens)
Q3	SECCIONADOR C/FACAS DE TERRA AT 3DN1CB72.5EB (Siemens)
TI	TRANSFORMADOR DE INTENSIDADE AT IOSK 72, 25kA/3seg (Siemens/Trench)
TT	TRANSFORMADOR DE TENSÃO AT VEOT 72 ,25kA/3seg (Siemens/Trench)
TSA	TRANSFORMADOR DE SERVIÇOS AUXILIARES 30/0,4kV - 50 KVA - Dyn5 (Siemens)
RN	REACTÂNCIA DE NEUTRO ARTIFICIAL Zo=174 OHMS, 3Io=300 A - ZN (Siemens)
QMMT	QUADRO METÁLICO DE MÉDIA TENSÃO, NXPlus, 36KV, 1250A, 25 kA (Siemens)

NOTAS:

- ESTE DESENHO FOI IMPORTADO DO PROCESSO ORIGINAL COM A REFERÊNCIA 004.237-00.01

REFERÊNCIAS:

- GEN-A24024-005-001 – PLANTA DE LOCALIZAÇÃO
- GEN-A24024-005-002 – PLANTA DE IMPLANTAÇÃO
- GEN-A24024-005-003 – LAYOUT GERAL

REV.	DESCRIÇÃO	ALTEROU	APROVOU	DATA
A.1	Versão inicial	J. Riboira	P. Maio	07/03/2025

PROJETISTA:

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CLIENTE:

nadara

PROJETO:

Parque Eólico da Beira Interior
Subparque Eólico de Aldeia Nova
- SOBREEQUIPAMENTO -

FASE DO PROJETO:

PROJETO DE LICENCIAMENTO

TÍTULO:

Esquema Unifilar Geral

PROJETOU:	DESENHOU:	ESPECIALIDADE:
João Riboira	João Riboira	Geral
VERIFICOU:	APROVOU:	EMISSÃO INICIAL:
Pedro Maio	Nadara	07/03/2025

DESENHO Nº:

GEN-A24024-003-006

REVISÃO:

A.1

ESCALAS:	FORMATO:	FOLHA:
n/a	A1 (594 x 841 mm)	01 / 01

ANEXO VI

DOCUMENTAÇÃO TÉCNICA

Technical description

ENERCON E-175 EP5 E2 / 7000 kW wind energy converter

Early Customer Information Package

Subject to technical change without prior notice.

ENERCON
ENERGY FOR THE WORLD

Publisher

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VAT ID no.: DE 181 977 360

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Date	**Language**	**DCC**	**Plant/department**
2024-04-15	en	DB	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.

Document ID	Document
D02885203	Übersichtszeichnung E-175 EP5 E2-HST-132-FB-C-01 (Layout drawing E-175 EP5 E2-HST-132-FB-C-01)
D02885451	Übersichtszeichnung E-175 EP5 E2-HT-162-ES-C-01 (Layout drawing E-175 EP5 E2-HT-162-ES-C-01)
D03011491	Übersichtszeichnung E-175 EP5 E2-HST-112-FB-C-01 (Layout drawing E-175 EP5 E2-HST-112-FB-C-01)
D03011510	Übersichtszeichnung E-175 EP5 E2-HT-175-ES-C-01 (Layout drawing E-175 EP5 E2-HT-175-ES-C-01)

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List of abbreviations

CFRP	Carbon fibre reinforced plastic
DIBt	Deutsches Institut für Bautechnik (German institute for civil engineering)
FACTS	Flexible Alternating Current Transmission System
FTQS	FACTS Transmission with Q+ option and STATCOM option (electrical configuration with extended reactive power range and STATCOM option)
GFRP	Glass-fibre reinforced plastic
HST	Hybrid steel tower
HT	Hybrid tower
IEC	International Electrotechnical Commission
SCADA	Supervisory Control and Data Acquisition
STATCOM	Static compensator

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5 Grid performance 15

6 Safety and protection 16

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1 Preliminary remarks

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This document is neither a statement of work nor a technical data sheet. The purpose of this document is solely to provide the user with assistance in assessing the fundamental suitability of the wind energy converter described for the site and its approximate yield. The information contained in this document is based on the technical information available as of the date of issue of this document.

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2 Product overview



Fig. 1: E-175 EP5 E2/7000 kW wind energy converter

The new E-175 EP5 E2 wind energy converter with a nominal power of 7000 kW is a top-of-the-line model that is more powerful and has a higher yield.

With the E-175 EP5 E2, the current EP5 platform for low-wind sites has been further optimised on the basis of the E-nacelle with integrated electrical engineering.

The E-175 EP5 E2 is designed for wind class S or II (IEC) and a service life of 25 years. The wind energy converter is offered by ENERCON worldwide in all its markets. The requirements of DIBt wind zone S or DIBt wind zone 2 are met for ENERCON's core market, Germany.

Different tower versions with hub heights of up to 175 m are available for the E-175 EP5 E2. Depending on the size of the project, it is also possible to develop site-specific towers.

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3 Technical specifications

General data	
Manufacturer	ENERCON GmbH Dreekamp 5 26605 Aurich Germany
Type designation	E-175 EP5 E2
Nominal power	7000 kW
Rotor diameter	175 m
Horizontal distance between tower centre and lowest blade position	26.44 m
Horizontal distance between tower centre and highest blade position	8.23 m
Swept area	23,840.5 m^2
Swept ground area (eccentricity area)	24,784.1 m^2
Cut-in wind speed	2.5 m/s
Nominal wind speed (simulated value, power-optimised operation)	12.5 m/s
Start of storm control (power reduction wind speed)	21 m/s
Cut-out wind speed	25 m/s (10-minute mean)
Design service life	25 years

Tower data	E-175 EP5 E2-HST-112-FB-C-01	E-175 EP5 E2-HST-132-FB-C-01	E-175 EP5 E2-HT-162-ES-C-01	E-175 EP5 E2-HT-175-ES-C-01
Hub height above ground level[1]	Max. 113 m	Max. 133 m	Max. 163 m	Max. 176 m
Total height above ground level[1]	Max. 200 m	Max. 220 m	Max. 250 m	Max. 263 m
Type	Hybrid steel tower	Hybrid steel tower	Hybrid tower	Hybrid tower
Foundation diameter of deep foundation/ shallow foundation	Under development/24.7 m	Under development/under development	Under development/under development	Under development/under development

[1] The maximum value is specified to avoid any inconsistencies caused by rounding.

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Design (tower-specific)					
	E-175 EP5 E 2-HST-112-FB-C-01	E-175 EP5 E2-HST-132-FB-C-01	E-175 EP5 E 2-HT-162-ES-C-01	E-175 EP5 E2-HT-175-ES-C-01	
Characteristic	**Value**	**Value**	**Value**	**Value**	**Unit**
Wind class (IEC 4th edition)	II	S	S	S	
Turbulence category (IEC 4th edition)	A	A	A	A	
Wind zone (DIBt 2012)	WZ S	WZ S	WZ 2	WZ S	
50-year extreme wind speed at hub height (10-minute mean) (IEC 4th edition)	42.50	42.50	42.50	42.50	m/s
Corresponds to a load equivalent of approx. (3-second gust)	59.50	59.50	59.50	59.50	m/s
50-year extreme wind speed at hub height (10-minute mean) (DIBt 2012)	42.50	42.50	42.50	42.50	m/s
Annual average wind speed at hub height (IEC 4th edition)[2]	8.50	7.20	7.80	7.20	m/s
Annual average wind speed at hub height (DIBt 2012)	8.50	7.20	7.80	7.20	m/s
c value of extreme turbulence model	2	2	2	2	
Form parameter of Weibull function k	2	2	2	2	
Wind shear	0.10 to 0.20	0.20	0.20	0.20 to 0.40	

Design (cross-tower)	
Flow inclination	8°
Relative air humidity	≤ 95 %
Maximum solar irradiance	1000 W/m²
Standard air density	1.225 kg/m³
Normal temperature range	-10 °C to +40 °C

[2] An increase in the annual average wind speed at hub height is being tested for various towers.

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Design (cross-tower)	
Extreme temperature range	-20 °C to +50 °C

Generator rotor with pitch unit	
Type	Upwind rotor with active pitch unit
Rotational direction	Clockwise (viewed from upwind)
Number of rotor blades	3
Rotor blade length	85.98 m
Rotor blade material	GFRP sandwich structure with CFRP spar booms
Conical angle	-5°
Incline of rotor axis to horizontal	6°
Pitch unit	One independent electrical pitch unit per rotor blade with dedicated emergency power supply

Drive train with generator	
Wind energy converter concept	Gearless, variable speed, full-scale converter
Hub	Rigid
Bearing	2 tapered roller bearings
Generator	Direct-driven, permanent magnet synchronous generator

Brake system	
Aerodynamic brake	Aerodynamic via 3 independent pitch units with emergency power supply
Rotor holding brake	E-brake
Rotor lock	Latching in 30° steps

Yaw control	
Yaw system	Electromechanical yaw system
Yaw brake	Electromechanical

Wind energy converter control system	
Type	Programmable logic controller (PI-CS)
Grid feed	Full-scale converter with integrated microprocessor control system
Remote monitoring system	ENERCON SCADA Edge system
Uninterruptible power supply (UPS)	Integrated

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4 Power values and sound power levels

Site characteristics

The power and c_t curves as well as the corresponding sound power levels have been calculated for the conditions stated in the following table with undamaged rotor blade leading edges and clean rotor blades.

Site characteristics (10-minute mean)	
Standard air density	1.225 kg/m³
Relative air humidity	70 %
Temperature	10 °C
Wind shear exponent	0.0 to 0.3
Maximum difference in wind direction between upper and lower blade tip	10°
Maximum flow inclination	± 2°
Terrain	According to IEC 61400-12-1:2017
Snow/ice	No
Rain	No

Otherwise, the framework conditions according to IEC 61400-12-1:2017 apply.

4.1 OM-0-0 operating mode

The OM-0-0 operating mode represents the optimum mode of operation for standard design conditions in order to achieve the maximum yield within the framework of the design specifications and the sound setpoint.

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4.1.1 Calculated power, cp and ct values in OM-0-0 operating mode

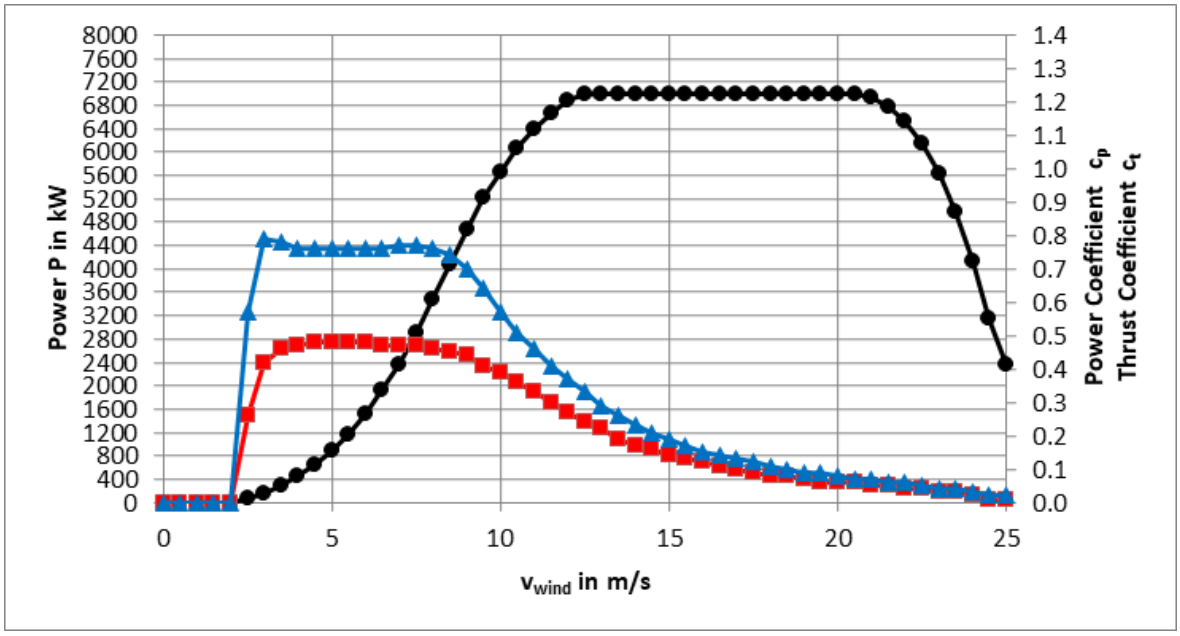


Fig. 2: Power, c_p and c_t curves for E-175 EP5 E2 / 7000 kW in OM-0-0 operating mode

	Power P in kW
	c_t value
	c_p value

Tab. 1: Calculated power, c_p and c_t values for E-175 EP5 E2 / 7000 kW in OM-0-0 operating mode

Wind speed v in m/s	Power P in kW	c_p value	c_t value
0.00	0	0.00	0.00
0.50	0	0.00	0.00
1.00	0	0.00	0.00
1.50	0	0.00	0.00
2.00	0	0.00	0.00
2.50	60	0.26	0.57
3.00	165	0.42	0.79
3.50	287	0.46	0.78
4.00	444	0.47	0.76
4.50	644	0.48	0.76
5.00	885	0.48	0.76
5.50	1174	0.48	0.76
6.00	1515	0.48	0.76
6.50	1913	0.47	0.76
7.00	2373	0.47	0.77

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Wind speed v in m/s	Power P in kW	c_p value	c_t value
7.50	2897	0.47	0.77
8.00	3478	0.46	0.76
8.50	4090	0.45	0.74
9.00	4684	0.44	0.70
9.50	5214	0.41	0.64
10.00	5665	0.39	0.57
10.50	6053	0.36	0.51
11.00	6392	0.33	0.46
11.50	6677	0.30	0.41
12.00	6892	0.27	0.37
12.50	6997	0.24	0.33
13.00	7000	0.22	0.29
13.50	7000	0.19	0.26
14.00	7000	0.17	0.23
14.50	7000	0.16	0.21
15.00	7000	0.14	0.19
15.50	7000	0.13	0.17
16.00	7000	0.12	0.15
16.50	7000	0.11	0.14
17.00	7000	0.10	0.13
17.50	7000	0.09	0.12
18.00	7000	0.08	0.11
18.50	7000	0.08	0.10
19.00	7000	0.07	0.09
19.50	7000	0.06	0.09
20.00	7000	0.06	0.08
20.50	7000	0.06	0.07
21.00	6936	0.05	0.07
21.50	6780	0.05	0.06
22.00	6519	0.04	0.06
22.50	6142	0.04	0.05
23.00	5636	0.03	0.04
23.50	4977	0.03	0.04
24.00	4137	0.02	0.03
24.50	3138	0.01	0.02

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Wind speed v in m/s	Power P in kW	c_p value	c_t value
25.00	2371	0.01	0.02

4.1.2 Calculated sound power level in OM-0-0 operating mode

The highest sound power level to be expected in the nominal power range is 106.9 dB(A). After reaching the nominal power, the sound power level will not increase further.

Wind speed at hub height v_H in m/s	Sound power levels in dB(A)
5.0	97.6
5.5	98.6
6.0	99.8
6.5	101.1
7.0	102.4
7.5	103.8
8.0	105.2
8.5	106.5
9.0	106.9
9.5	106.9
10.0	106.9
10.5	106.9
11.0	106.9
11.5	106.9
12.0	106.9
12.5	106.9
13.0	106.9
13.5	106.9
14.0	106.9
14.5	106.9
15.0	106.9

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5 Grid performance

The values given in this chapter refer to the FTQS configuration.

General data	
Nominal frequency	50 Hz/60 Hz
Nominal active power	7000 kW
Rated reactive power	4410 kvar
Rated apparent power	8300 kVA
Nominal voltage	750 V
Nominal current	5389 A

Reactive power (export/import)	
Maximum reactive power (export)	4410 kvar
Minimum reactive power (import)	-4410 kvar

Operating voltages	
Max. continuous operating voltage	120 % U_n
Min. continuous Operating Voltage	85 % U_n
Temporary minimum voltage	80 % U_n

Frequency range	Nominal grid frequency 50 Hz	Nominal grid frequency 60 Hz
Maximum frequency	53 Hz	63 Hz
Nominal frequency	50 Hz	60 Hz
Minimum frequency	47 Hz	55.5 Hz

Fault Ride Through behaviour

The wind energy converter is equipped with a Fault Ride Through capability that enables it to remain in operation in the event of fault-related undervoltage (Undervoltage Ride Through) and overvoltage (Overvoltage Ride Through).

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6 Safety and protection

Additional information on the following chapters will be created and made available in separate documents during the further development process of the wind energy converter.

Lightning protection

In order to prevent damage from lightning strikes and to ensure safe operation, the wind energy converter is fitted with a lightning protection system.

The lightning protection system (lightning protection level/LPL) is classified from IV (low) to I (high). The wind energy converter is designed to meet the requirements of LPL I. In some cases, modifications to the earthing system may be necessary. This is dependent on the conductivity of the soil at the location which is investigated as part of the project-specific soil investigations.

Fire safety

Numerous technical and organizational fire protection measures are being taken for the wind energy converter that minimise the probability of a fire occurring, the spread of fire and smoke and damage to persons and property.

Ice detection

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

Remote monitoring system/SCADA

The wind energy converter is connected as standard to Technical Service Dispatch via the ENERCON SCADA Edge System. Technical Service Dispatch can retrieve the operating data of the wind energy converters at any time and instantly respond to any irregularities or faults.

At the operator/owner's request, monitoring of the wind energy converters can be performed by a third party.

Functional safety

The safety-related part of the wind energy converter control system is developed in accordance with DIN EN ISO 13849-1.

Protection against emissions

Various sound-reduced operating modes are available for the wind energy converter. The various sound-reduced operating modes differ in the level of sound reduction they offer and serve to satisfy the requirements applicable at the installation site with regard to permissible sound emissions.

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.

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Technical specification

Access Road and Construction Site Areas

ENERCON wind energy converter
E-175 EP5 112 m steel tower

Prototype

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ENERCON
ENERGY FOR THE WORLD

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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
DIN 18134	Soil - Testing procedures and testing equipment - Plate load test
DIN 4017	Subsoil – Calculation of design bearing capacity of soil beneath shallow foundations
DIN 4019:2015	Soil - Analysis of settlement

Associated documents

Document ID	Document
D02108591	Baustellenordnung (Construction site regulations)
D02768819	Anforderungen Zusatzbelastung Fundamentanschüttung und Fundamentauflast für Servicetätigkeiten (Additional load requirements for foundation soil cover/load for service activities)

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List of abbreviations

Abbreviations

CM	Construction Manager
GPM	General Project Manager
LHV	Abnormal load
SPMT	Self-propelled modular transporter
WEC	Wind energy converter

Variables, units, formulas

D_{Pr}	Degree of compaction after Proctor compaction test
E_{V1}	Calculated deformation modulus of the first load cycle of a static plate load test
E_{V2}	Calculated deformation modulus of the second load cycle of a static plate load test

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1 Introduction

Meticulous planning and design of construction site infrastructure are the basis for cost-effective construction work. Transport routes and construction site areas in the wind farm must ensure safe and cost-effective construction site traffic. Trouble-free functionality must be ensured throughout the entire period of use.

Deviations from this specification may affect the installation and logistics concept. This will result in extra costs, longer construction times and possibly delays in the course of the project. If deviations from the standards described here occur, they must be coordinated with the ENERCON GPM. An alternative solution can be offered by ENERCON for standards from this specification that may not be capable of being implemented for topographical reasons. This must be commissioned through the ENERCON GPM. The customer shall bear the resulting additional costs.

This specification applies to the transport and installation, using a standard large crane, of a WEC with the tower designation:

- E-175 EP5-ST-112-FB-C-01

This specification describes the requirements for access roads and construction site areas for the wind farm infrastructure. In addition to this information, the following documents must also be included in the planning.

- Foundation data sheet for the applicable foundation version of the tower type
- Technical description of the tower type
- Data sheets on weights and dimensions of tower type, nacelle and rotor blades
- D02108591 ‘Baustellenordnung’ (Construction site regulations)
- D02768819 ‘Anforderungen Zusatzbelastung Fundamentanschüttung und Fundamentauflast für Servicetätigkeiten’ (Additional load requirements for foundation soil cover/load for service activities)

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2 WEC installation

The ENERCON WEC is assembled in several stages: Foundation construction, deep foundation where necessary, and installation and assembly of the tower and nacelle. Depending on the wind farm size, project-specific installation concepts are developed to ensure economically efficient execution and to permit completion of the WEC in the shortest possible time. As such, the work steps described in the following subchapters can be performed in parallel in the wind farm.

2.1 Delivery of the tower and WEC components

The manner of delivery depends on the installation concept for the intended construction site area. The tower and the WEC components are delivered in advance. They are stored in accordance with a predefined stowage plan. The necessary areas must be dimensioned and set up precisely in accordance with this specification.

2.2 Tower installation

Depending on the type of tower and installation concept, assembly can be performed in different ways. Depending on tower type, pre-assembly may be necessary that is performed in a separate work section directly on the planned construction site area. The pre-assembled sections are temporarily stored on the construction site or assembled directly after pre-assembly. Tower assembly is carried out with suitable crane equipment, depending on the installation concept and tower.

2.3 Nacelle installation

The nacelle components are delivered directly to the designated construction site areas (e.g. assembly area). Once pre-assembly is complete, the pre-assembled nacelle is lifted using the designated crane equipment and mounted on the tower.

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3 Crane equipment

3.1 Cranes used

The relevant crane type is selected during the planning phase of the wind farm concept. The max. permissible soil bearing pressure under the crane tracks or outriggers is limited with load distribution plates and must be verified via geotechnical calculations. If crawler cranes are used, it may be possible, among other things, to move from site to site in an assembled state. Prior to this, the bearing capacity of the soil and the loading gauge must be tested on the crane routes.

3.2 Installing the crane with a lattice tower

A lattice tower crane is used to install the WECs. This crane technology places specific demands on the crane platform and requires sufficient space to assemble the lattice tower. The basic unit and the individual crane parts (e.g. lattice tower parts, ballast, fixtures) are delivered to the wind farm in the required quantities by truck. The number of truck transports required depends on the crane type and mast length. The lattice tower crane is assembled in the following individual stages:

- Delivery of the basic unit and auxiliary cranes
- Alignment of the basic unit on the crane platform
- Positioning of Superlift ballast
- Lattice tower assembly

To assemble the lattice tower, the existing access road to the crane platform is used. If the access road cannot be used, a temporary site road is needed. The technical framework conditions for assembling the crane and jib will be explained in this document.

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4 Transport and logistics

4.1 General information

The installation of a WEC requires a large number of abnormal loads. These abnormal load transports are needed to deliver the tower and WEC components and crane equipment, and for subsoil improvement measures and foundation construction. These abnormal load transports require approval in some cases and are subject to country-specific and official regulations. The resultant max. transport weights and axle loads must be taken into account.

4.2 Construction and logistics concept

Specific installation and logistics concepts are necessary for large wind farms and for WECs erected at sites with special requirements (e.g. industrial sites, dikes, hills). In order to enable optimal project execution, the local conditions must be incorporated directly into the concept. Depending on the WEC type and the installation and logistics concept, there may be additional areas required, e.g. a logistics area and/or rotor blade storage area. The additional logistical costs are borne by the customer. If necessary, contractually agreed deadlines must be adjusted by the contractor.

4.3 Use of SPMT

If an SPMT is used, there may be changes in the following areas, depending on the component and system platform:

- Width of road
- Loading gauge
- Curve radii and swept paths
- Lateral gradient on straight routes and in curves

These points must then be agreed with ENERCON and the transport service provider.

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5 Access roads

Access roads in the wind farm are an integral part of the supply of material to the respective WEC sites. In addition, access roads ensure cranes can move around the wind farm. Access roads are used over the entire course of the project as the access for all transport types. In addition, the access roads are also needed for service and to dismantle the WECs. The access road and construction site area concept and the construction work shall be designed in accordance with this specification.

5.1 Routeing

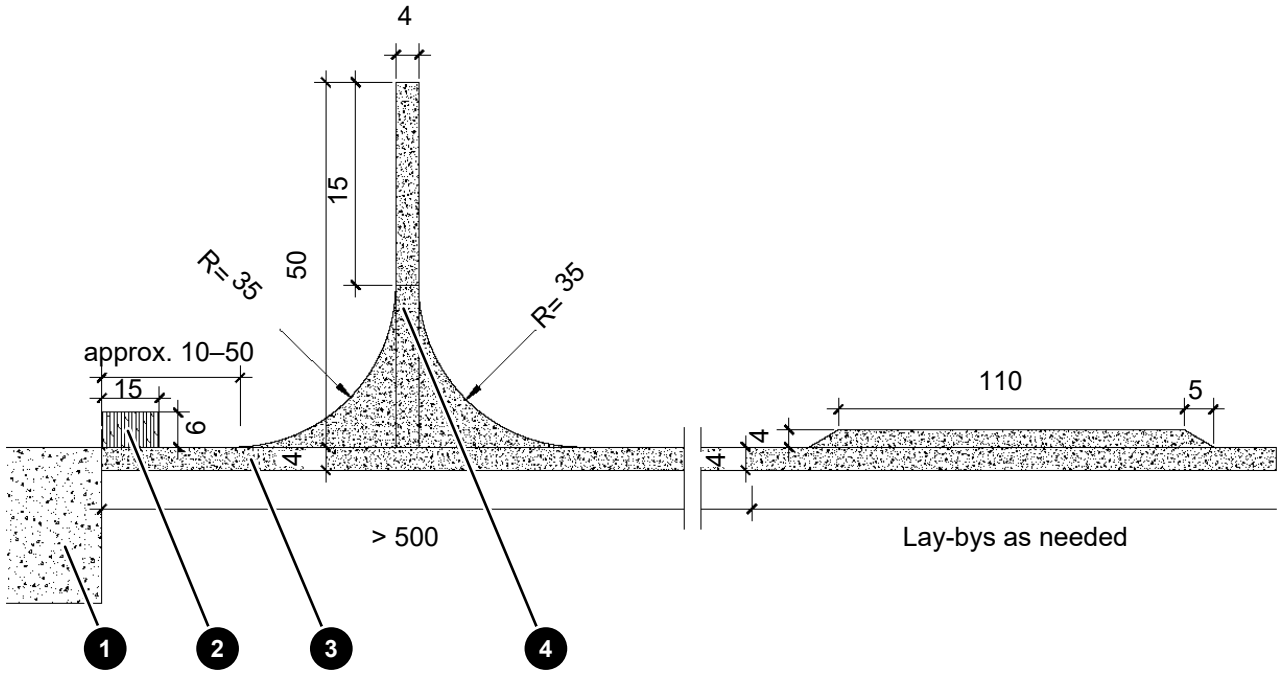


Fig. 1: Routing elements (all dimensions in metres)

1	Crane platform	2	Parking area
3	Access road	4	Turning area

The use of large and abnormal loads presents special challenges for the internal wind farm access roads, at intersections and curves, wind farm entrances and public roads.

Routing elements

In most cases, transport vehicles with a high total weight and excess width are used to transport components to the construction site. Due to the major transport requirements and the transport costs, the routing of the access roads in the wind farm must be kept short and straight. The routes must be selected so that transport vehicles carrying abnormal loads are not forced to travel in reverse. If WEC sites are located in a dead-end position that has an access road longer than 500 m, a turning area for empty transports must be provided. The turning area must have a minimum length of 50 m. Depending on the location, turning areas may also be needed at shorter intervals (less than 500 m). This is decided by the ENERCON GPM. On long

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access roads, lay-bys and/or parking bays in sufficient number and length must be planned in consultation with the ENERCON GPM in order to guarantee flowing traffic and free rescue routes.

Wind farm entrance

If there are wind farm entrances from public roads, we recommend asphalting the first 50 m of the entrance. This enables vehicles exiting the site to clean their wheels before accessing the public road. Depending on the number of access roads to the wind farm and the number of trucks driving into the wind park, other options may be explored, such as wheel washing facilities. This requirement shall be checked in consultation with the ENERCON GPM according to local conditions. Regulatory specifications must be observed.

Parking areas for long transports

In the wind farm or in the immediate vicinity, one or more areas must be identified on which at least 3 long transports can be parked on an interim basis. This ensures that waiting transport vehicles do not impede the other construction site traffic. Long transports include the transport of rotor blades or steel sections of towers. For instance, lay-bys are suitable areas.

Obstacles on the route

Any particular obstacles to be crossed on the route must be clearly indicated with the appropriate markings, so that they can be detected by traffic. If lines must be crossed (e.g. pipelines, gas lines), a prior investigation must be carried out to make sure that it is possible to drive over them. The results of the investigation shall be submitted to the ENERCON GPM for inspection. In addition, approval to drive over them must be obtained from the pipeline operator. Lines must be secured by construction of special superstructures. To avoid contact with the construction traffic passing beneath, overhead lines must be clearly indicated by means of height limitation markings (e.g. wooden frames).

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5.1.1 Intersections and curves

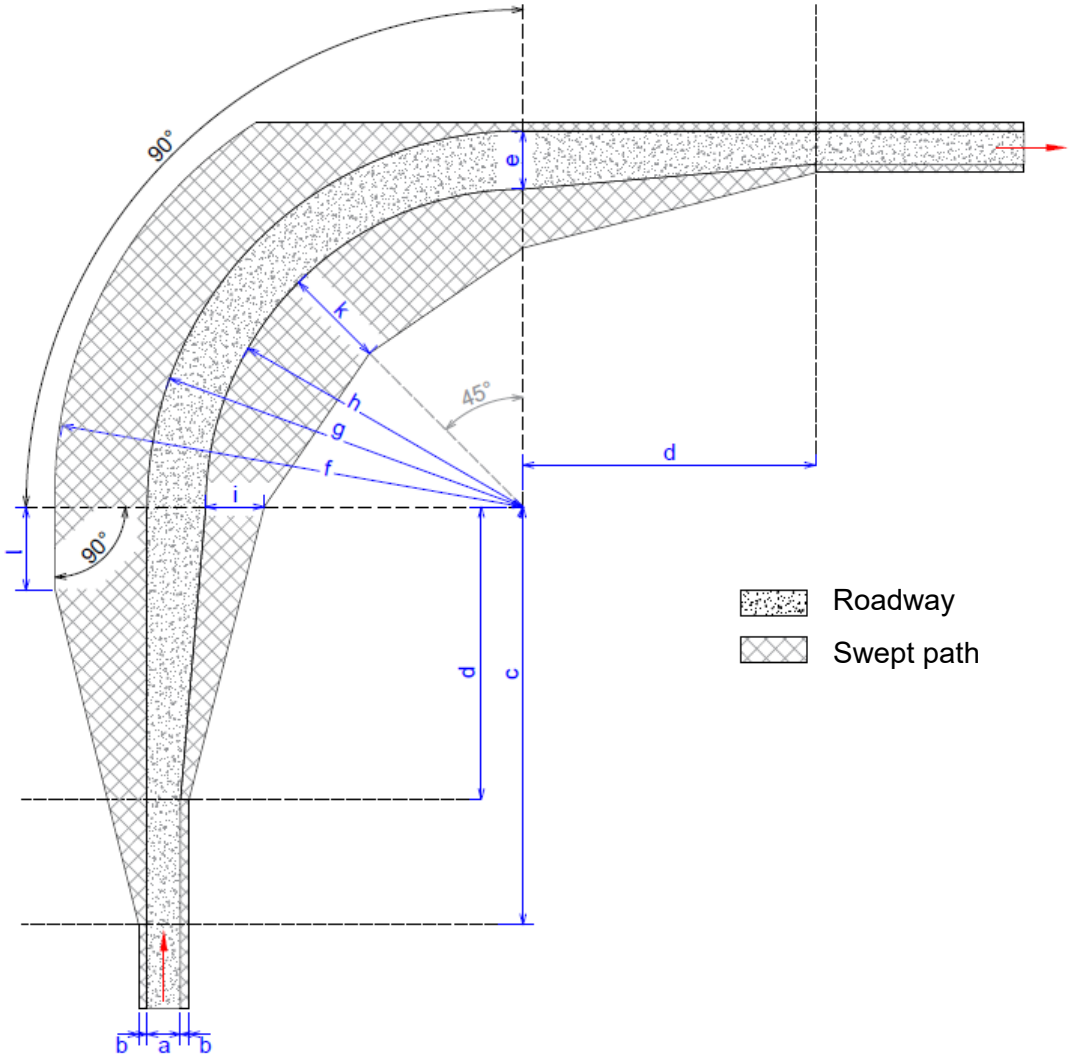


Fig. 2: 90 degree curve (construction diagram)

	90 degree curve	60 degree curve			90 degree curve	60 degree curve	
a	4 m		Drivable width of road in straight line	b	1.5 m		Lateral swept path including safe distance
c	60 m		Start of outer swept path at curve entry	d	40 m		Start of inner swept path at curve entry
e	7 m		Drivable width of road in curves	f	70 m	69 m	Outer radius of outer swept path
g	60 m	60 m	Outer radius of curve	h	53 m	53 m	Inside radius of curve
i	7 m	7 m	Dimension 1 of inner swept path	k	13 m	12 m	Dimension 2 of inner swept path
l	10 m	10 m	Dimension 3 of outer swept path				

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The longest transport combination is decisive for curve dimensioning. The curves and swept paths are implemented structurally in accordance with the dimensions indicated in the drawing. If this radius cannot be maintained due to local conditions, it is imperative that the ENERCON GPM is consulted to find an alternative solution.

Swept paths

Transport combinations with flatbed and/or swing-out load must be able to pass through curves without problem. Obstacles in the swept paths must be removed for this purpose if these obstacles exceed a certain height.

- Obstacles in the inner swept path must not protrude by more than 0.15 m max. above the level of the roadway.
- Obstacles in the outer swept path must not protrude by more than 1.25 m max. above the level of the roadway.

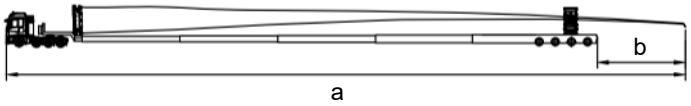


Fig. 3: Rotor blade transport overhang

a	100 m	b	10 m

5.1.2 Crests, sags and gradients

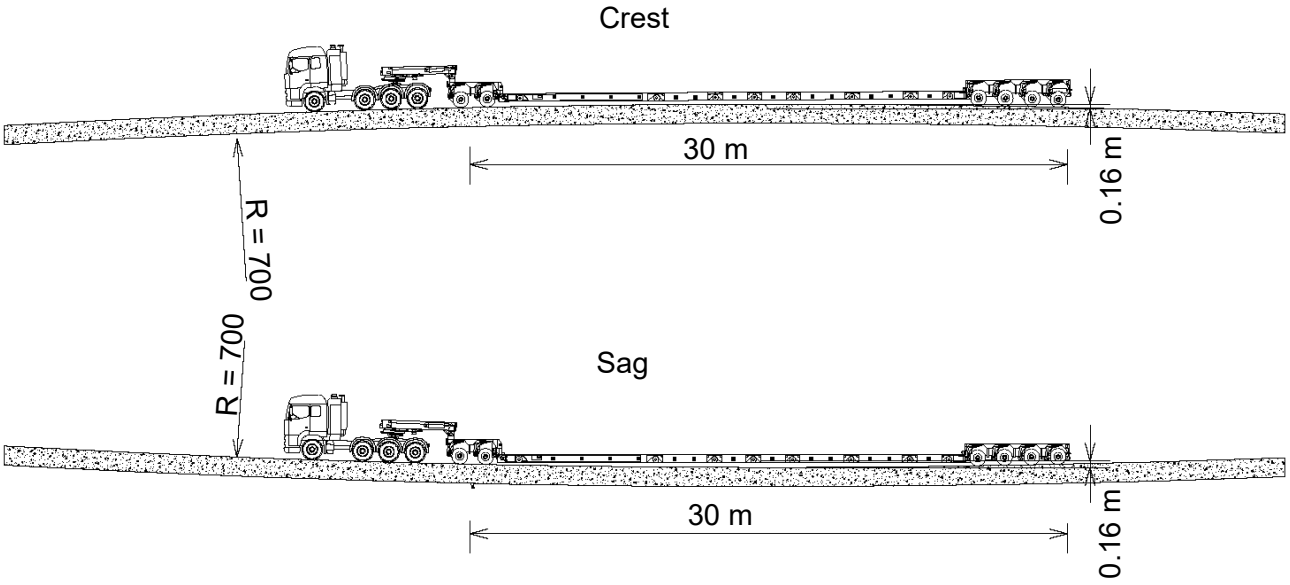


Fig. 4: Crest and sag (R = 700 m)

Vehicles with a maximum total length of 100 m are used to transport components to the construction site. For these transport vehicle combinations with excess length, the access roads must fulfil crest and sag radii of 700 m. This prevents the transports from hitting the ground, e.g.in the case of flatbed transport vehicle combinations.

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In specific instances, the radius can be reduced to R = 400 m. However, this requires specific transport vehicles that can lift the flatbed to a minimum height of 45 cm. R = 400 m corresponds to a camber (crest) or depression (sag) of 0.26 m over a length of 30 m.

Uphill and downhill gradients

Abnormal loads are only able to travel on access roads with maximum uphill and downhill gradients of ≤ 12 %. With gradients of 7 % or more, a bonded surface course (e.g. asphalt, concrete) is installed. This ensures nonpositive traction for the transport vehicles. In individual instances, traction vehicles may be required (hilly or mountainous locations). This is clarified in advance in detail with the ENERCON GPM. The ENERCON GPM must evaluate the economic and scheduling effects to be borne by the customer.

For curves with gradient > 7 %, the width of the road must be adapted to the local conditions. The planning must take any such adjustments into account and the plans must be checked and approved by ENERCON.

When planning the access route around bends and intersections with inclines and declines, make sure that the torsion between the towing vehicle and trailer or trailer is ≤ 5 %.

Tab. 1: Requirements for the longitudinal profile of the access road

Parameter	Requirement
Gradient, loose surface course	≤ 7 %
Gradient, paved surface course	≤ 12 %
Ground clearance of transport vehicles	0.10 m
Radius of hilltop/bottom of valley	700 m

5.1.3 Loading gauge

For abnormal loads, there must be a specific loading gauge above the access roads. Complying with this loading gauge ensures unhindered access by all vehicles on the access roads. This area must be kept free from obstacles of any kind (e.g. structures, power supply cables, masts, trees, and branches) during construction.

The loading gauge may vary depending on the country, vehicle technology or delivery concept. If the specified loading gauge cannot be implemented, consult with the ENERCON GPM regarding an alternative solution.

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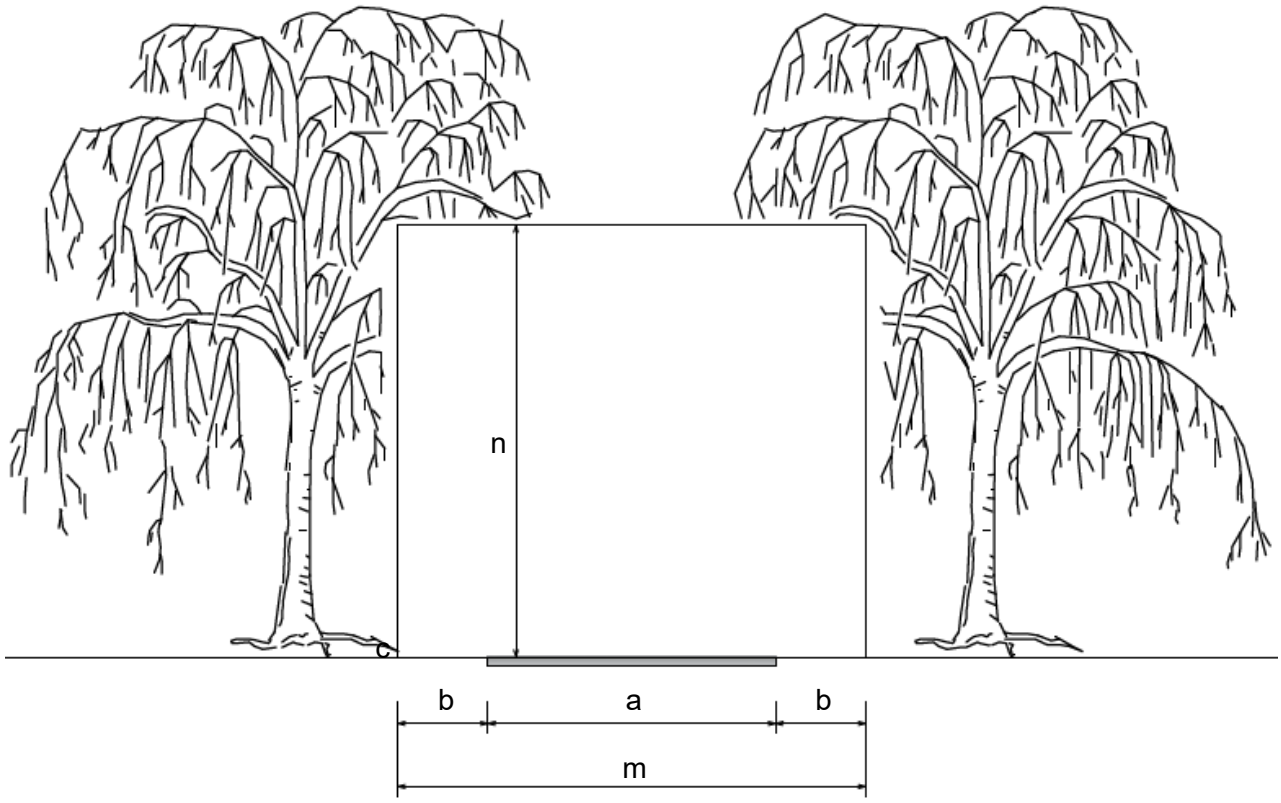


Fig. 5: Loading gauge

a	4 m	Drivable width of road in straight line	b	1.5 m	Lateral swept path including safe distance
m	7 m	Clearance width	n	4.8-6 m	Clearance height

5.2 Structure of access roads

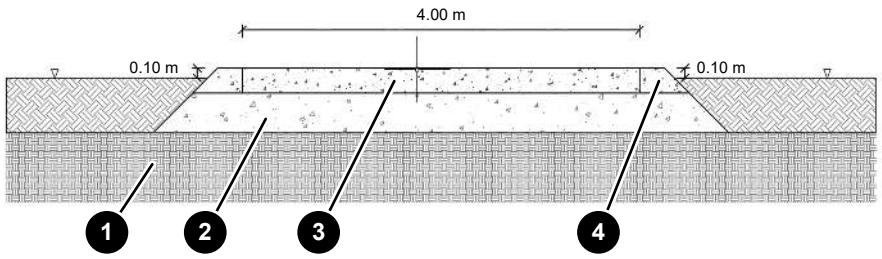


Fig. 6: Schematic structure of access roads

1	Load-bearing subsoil	2	Binder course
3	Surface course	4	Side area (shoulder)

The upper surface course is contoured with a cross slope or a straight crossfall. This ensures drainage to the sides. A drivable width of 4 m must be ensured. The construction of the side area (shoulder) is dependent on the subsoil and load transfer angle of the binder course.

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The actual design is sized and determined by the traffic engineer in accordance with the local soil conditions and coordinated with the ENERCON GPM before implementation. A drivable width of 4 m must be ensured for the access road. More comprehensive expansion works may be required in order to ensure correct load transfer.

5.2.1 Lateral slopes: crown and camber

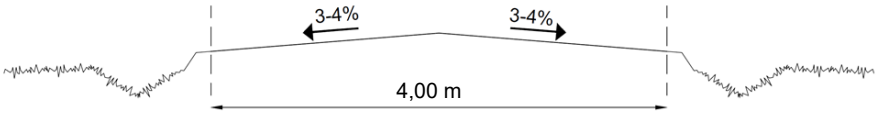


Fig. 7: Cross slope

In general, the access road must be created with a camber (cross slope) and an incline of 3–4 %. This cross slope on the road ensures that rainwater flows away from the road surface, minimising erosion, pothole formation and wheel ruts. If the road surface is paved (with concrete or asphalt), a cross slope of 2 % is sufficient to ensure adequate drainage.

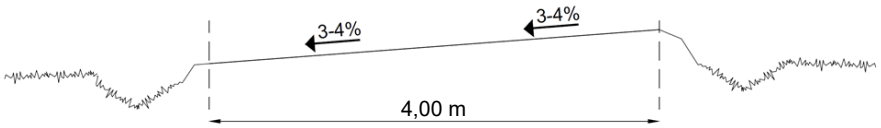


Fig. 8: Lateral slope

If the topography of the area makes it impossible to build the road with a cross slope, the lateral slope must be no more than 3–4 % over the whole width. In this case, the section regarding transitions to lateral slopes applies.

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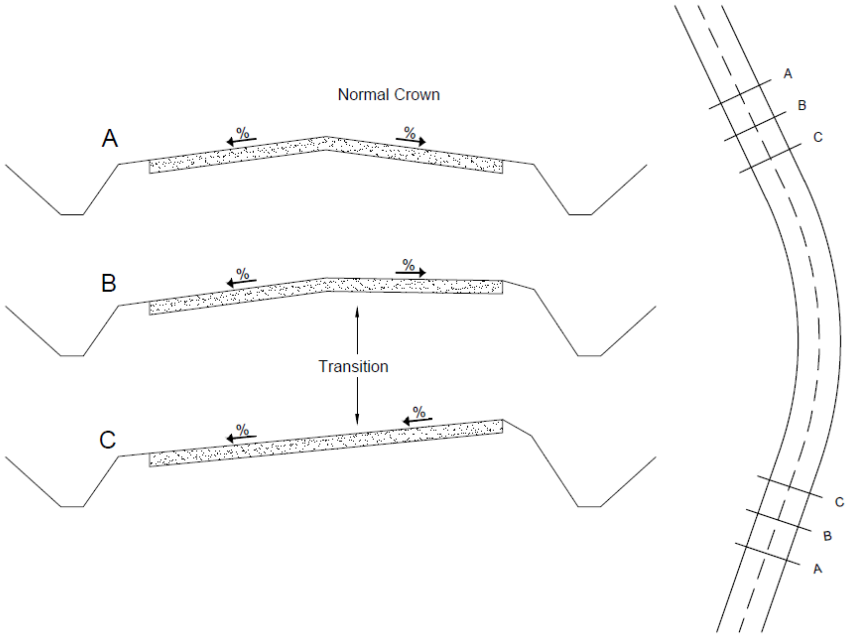


Fig. 9: Transition to lateral slope

When transitioning from a cross slope to a lateral slope, the normal crown profile must be taken out and converted to a camber profile. As a result, the surface can transition from the camber (highest point on the profile on the outer side of the curve) to the crest (highest point on the profile on the road axis). The lateral slope must be max. 2.5 % for double curves. The torsion between the towing vehicle and semitrailer/trailer must not exceed 5 %. If this cannot be realised, at least one vehicle length of the longest vehicle must be planned between the curves.

5.2.2 Road classifications

Within the wind farm, 3 different road types are used, depending on the starting situation for the road and the works required during construction: All 3 road types must fulfil the requirements with respect to the form, strength and bearing capacity as stated in this document.

Existing roads in good condition

Any existing roads within the wind farm with good surface and profile properties (sufficient bearing capacity, lateral incline and roughness) and a drivable width of at least min. 4 m. If these parameters are met, no additional works must be performed on these roads. The usual maintenance works on the road network after the start of the installation phase are mandatory.

Existing roads in need of expansion

Any existing roads within the wind farm that do not meet the requirements with respect to the road surface, the road profile, or the drivable width. Additional works to improve the road conditions are required for these roads. By using the existing road platform, the extent of the works to be performed is significantly reduced.

New roads

New roads to be build on natural ground. For these roads, all construction works must be performed:

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- Clearing of vegetation
- Levelling
- Removal of topsoil
- Earthwork
- Alignment of strata
- etc.

5.2.3 Requirements

Soil investigation

The structural design of the access road is dependent on the properties of the subsoil and the expected stress from traffic. The subsoil must be investigated adequately by subsoil exploration drill holes and probing. The number and depth of the probes must be defined by the geotechnical expert, depending on the subsoil structure. The expected abnormal loads must be estimated for each relevant road section. In these estimations, the abnormal loads for each WEC must be taken into account that result from the construction of the road and paved surfaces, and from the delivery of WEC components and WEC assembly. The number of WECs operated on the relevant road section must also be considered. The structural design of the access road is defined based on the results of the soil investigations and the expected traffic.

Suitability for use

The access roads are designed with sufficient bearing capacity with consideration to the expected traffic loads, so that they will remain usable throughout the duration of their use. Suitability for use and bearing capacity must be ensured even in heavy rainfall. It must be ensured that the surface course remains permanently free of potholes. The max. wheel rut depth is limited to 7.5 cm. The design of the construction site areas must include plans for drainage on access roads. In the event of snow or ice, the operator/customer must ensure safe working and driving conditions through use of gritting and snow clearance services. The implementation plan as well as all specifications for testing, examinations, evaluations and verifications must be submitted to the ENERCON GPM for inspection unsolicited.

5.2.4 Subsoil and pavement

In order to ensure safe, effective and economical traffic conditions during the construction phase, the following geometric requirements with respect to road construction must be fulfilled.

Tab. 2: Minimum requirements for the access road

Parameter	Requirement
Drivable width of access road	4 m
Max. permitted depth of ruts	7.5 cm
Max. lateral incline of the access road on straight stretches and in curves	3-4 %

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Parameter	Requirement
Height of the road surface above the natural ground	10 cm

5.2.4.1 Requirements relating to compaction and bearing capacity

In order to ensure safe, effective and economical transport during the construction phase, the following requirements relating to the bearing capacity of the road must be fulfilled.

Tab. 3: Minimum requirements for the access road

Parameter	Requirement
Max. axle load	12 t
Max. total weight of transport combination	210 t
Surface course, deformation modulus	$E_{V2} \geq 100$ MN/m²
Surface course, Proctor density	$D_{Pr} \geq 100$ %
Binder course, deformation modulus (if required)	$E_{V2} \geq 80$ MN/m²
Binder course, Proctor density	$D_{Pr} \geq 100$ %
Ratio E_{V2}/E_{V1}	≤ 2.3

The construction firm must inspect and document the specified deformation moduli for each stratum constructed. If the specified values are not achieved, improvement measures must be implemented. Generally, a static plate load test is recommended for each stratum constructed.

The required values for the second deformation modulus (E_{V2}) and the ratio E_{V2}/E_{V1} reflect the plate load tests performed in accordance with German standard DIN 18134. This document summarises various aspects of the inspection to be performed, such as the plate diameter, max. pressure, load levels, E_V calculation formula, etc. Plate load tests that are performed on the basis of differing standards are not directly comparable.

Depending on the results of the geotechnical expert report, a static plate load test must be performed every 200 to 500 m along the access road. Static plate load tests must also be performed at transitions between existing roads and site roads, at crossings, and at junctions.

For existing roads in good condition, it is recommended to inspect the bearing capacity of the road by way of plate load tests, whereby the same requirements apply as with other road types.

The following points shall be checked and the results recorded:

- Structure of access roads (material and installation thickness)
- Sufficient compaction of the construction material
- Bearing capacity of access roads

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- Bearing capacity of bridges
- Bearing capacity of culverts and pipework
- Distances to ditches, pits and bodies of water
- Distances to cable routes and overhead lines
- Feasibility of crossing installed lines (e.g. pipelines)

It may be advisable (e.g. in the case of long traffic routes or poor subsoil) to not dimension the access road based on the specified deformation modulus but instead based on the traffic load with consideration of the axle transitions.

A drivable width of 4 m must be ensured for the access road. Depending on the load transfer and subsoil properties, more extensive expansion works may be required.

5.2.4.2 Subsoil and ground

The load-bearing subsoil is the basis for supporting high levels of surface pressure that can occur as a result of unusual loads or the cranes used. Therefore, the topsoil and any soft strata must be excavated until the first load-bearing stratum of natural ground has been reached. If cohesive and organic soils are not load-bearing, these are exchanged or replaced with layers of a suitable compacted filling material (e.g. sand). Alternatively, other technical methods can also be used (e.g. injecting, geogrid).

The bearing capacity of the subsoil must be verified. The required load distribution angle of the planned access roads is taken into account when excavating the width of the road.

5.2.4.3 Binder course

The binder course for the access roads within the wind farm consists of loose materials, such as sand, gravel, moraine, or a mixture thereof.

The proportion of fine aggregate cannot exceed 6 % of the total amount.

The gravel material for the binder course generally consists of larger stones with a much smaller proportion of clay or fine materials than the gravel material for the surface course. This is necessary in order to achieve the required strength and good drainage properties in the binder courses. Equally, the binder course material requires low plasticity index values.

The live loads are transferred to the subsoil via this binder course. The binder course must withstand the climatic and mechanical loads. The material used must be approved for use in road construction. The grading curve of the materials used must comply with whichever national regulations are applicable. The suitability of the material must be evidenced before installation by presenting valid inspection certificates. The required bearing capacity is guaranteed by way of graded grain size distribution, which must be agreed upon in coordination with the geotechnical expert.

Brick fragments are not used as bulk material for the binder course. The material is pulverised by moisture and loses its strength.

The binder course must be properly compacted in layers.

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5.2.4.4 Surface course

Material

The proportion of fine aggregate cannot exceed 10 % of the total amount. The gravel material for the surface course generally contains a finer aggregate than the gravel for the binder course. Aggregate that is too coarse will make maintenance more difficult and result in a rough road surface. A higher proportion of fine aggregate and a higher plasticity index are also required in order to be able to create a binding property and a smooth road surface in the surface course. In order to account for the stress resulting from high live loads, the surface course must be correctly compacted in layers.

The grading curve of the materials used must comply with whichever national regulations are applicable. The suitability of materials must be evidenced before installation by presenting valid inspection certificates. The surface course is constructed to be as even as possible, with a minimum height offset of 10 cm above the adjacent land. The minimum layer thickness is 25 cm.

Surface course

If the access road has a pitch of 7 % to a maximum of 12 %, the surface course has a hydraulic or bituminous bond. The surface course provides a friction fit that prevents the wheels of vehicles with abnormal loads from spinning.

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6 Construction site areas and foundation

6.1 Work area at the WEC site

6.1.1 General information

Different jobs are performed on the construction area at the site of the WEC to be erected. These range from foundation construction, storage of components, pre-assembly and WEC assembly through to grid connection and commissioning. The construction area is divided into different areas that are used for assembly and storage of the WEC components. Different requirements apply to these areas. The construction site areas must therefore be sufficiently dimensioned and have sufficient bearing capacity to ensure safe and cost-effective progress of the project.

Differences in level

In order to ensure a smooth sequence of construction, the following differences in level must be observed:

- Between construction site areas and surrounding terrain: If the height difference between the construction site areas and the surrounding area is > 0.30 m, the side areas need to be sloped with a gradient of 45°. Depending on the height of the slope, there is a circumferential strip around the perimeter on which loads must not be placed. If necessary, the area must be increased in size in order to create the required useful area.
- Between access road, crane platform, storage area and assembly area: A height difference or offset is not permitted.
- Between crane platform and foundation top edge: The permissible height difference can be found in the foundation data sheet.

If height differences are necessary due to the topographical conditions, the point ‘Slopes’ must be taken into account and coordinated with the ENERCON GPM.

- If the construction area is built into an elevation or a hill, an edge strip of 4 m must be planned, which means that the base area is increased by this edge strip. In this case, sufficient drainage must be guaranteed. This regulation applies to the edge area as well as to elevations within the construction area.

Slopes

In the case of slopes, the safety zone that must not be loaded must be taken into account. The base area is thus increased by the safety zone. This regulation applies to the edge area as well as to slopes within the construction area. The safety zone must be determined by the geotechnical expert.

Storing spoil

Spoil generated during the construction phase that will not be re-used is to be stored exclusively in heaps outside of the work area. When creating heaps of earth, take into account the planned cable route and cable bushing from and to the WEC. The minimum distance from the heaps of earth to the work area is 4 m. So as not to impede delivery of the tower and WEC components, spoil must not be stored in

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the swept path of the transport vehicles. The same applies along the crane jib assembly area. If not used, excess spoil is to be completely removed by the customer. For orientation, observe the fig. 12, p. 32.

Locations for winches

In order to guide the WEC components during lifting, they are held in position with ropes and winches. The position of the winches depends, among other factors, on the component to be lifted and the wind situation and is coordinated shortly beforehand with the ENERCON CM or installation team. The winches are positioned at a minimum distance of 1 hub height in metres from the tower base.

The winch location must be accessible with a telescopic handler. The owner of the plots of land in question must be notified of the activities, and in some cases, their permission may be required. Driving over the land with a telescopic handler can cause damage to it. This must be borne by the customer to a reasonable extent.

Depending on the local forest density, additional areas may have to be cleared. In the case of forest locations, the winch location must be agreed with ENERCON at an early stage.

6.1.2 Foundation

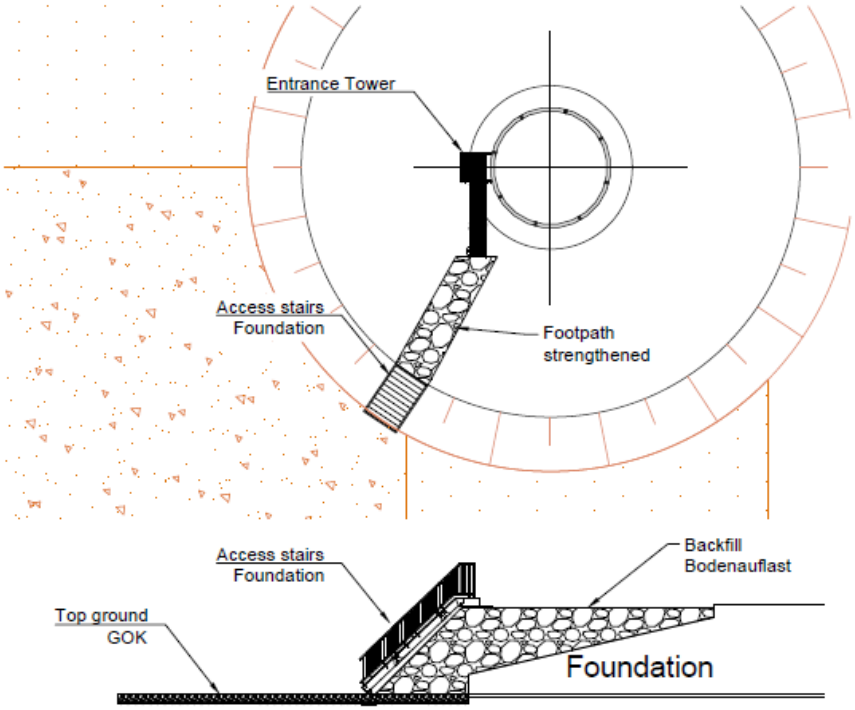


Fig. 10: Foundation at GL with soil load

For operation of the WEC, the foundation requires a soil cover that must be applied before the start of construction of the WEC. Here the outer diameter of the slope must not be greater than the foundation outside edge +< 3 m.

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If there are differences between the specified height levels, such that the distance between the foundation top edge and ground level is greater or smaller than the prescribed standard, this must be agreed with ENERCON. The space required for the soil cover and adapted entrance stairs must be taken into account in the plans.

Once the soil cover is in place, entrance stairs must be installed for access. This stairway is included in the scope of delivery of the WEC and is installed by the assembly team. If the customer prefers to install their own stairs, this must be agreed with ENERCON in advance. Height differences other than those specified on the foundation formwork plan must be taken into account. The standard stairway is only adapted if there are height differences > 0.4 m. If the stairway is too short, gravel will be used at the bottom end to compensate for the height difference. If the stairway is too long, the bottom end will be dug in or shimmed above the soil cover.

For HSTs, a temporarily drivable strip 3 m wide must be planned around the soil cover. A telescopic work platform will be driven onto this strip during pre-assembly of the foundation section. The strip can be made from e.g. steel plates.

Other than the soil cover, additional loads on foundations are not covered by the scope of the type testing. Additional loads require approval from ENERCON.

- Prohibited additional loads during the installation phase:
  - Storing or driving any kind of vehicle or crane on the area
  - Any soil density properties for the materials or soil cover properties that deviate from the formwork plan
  - Unloading and storage of crane components and weights
  - Unloading or storage of brickwork, stone or concrete foundation curbs
  - Erecting transformer stations, etc.
- Permissible additional loads during the installation phase:
  - Laying down cables and small tools required for assembly
  - Access by installation and service personnel

Sequence of construction

1. Creating the entire substructure of the crane platform and assembly area. The surface course is applied up to a distance of +3 m from the outside edge of the foundation.
2. Creating the foundation.
3. Applying and sloping the foundation slope according to the specifications, whereby the slope outer diameter must not exceed +3 m from the outside edge of the foundation.
4. Installing a stairway with handrail at the slope, in the direction of the crane platform. Here, the safety and construction regulations that currently apply in the region must be complied with.
5. Using gravel to secure the foundation from the entrance stairs to the crane platform up to the access to the outer tower stairs in order to ensure safe and clean access routes.
6. Reworking and profiling the entire building area as per minimum requirements.

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6.1.3 Building area

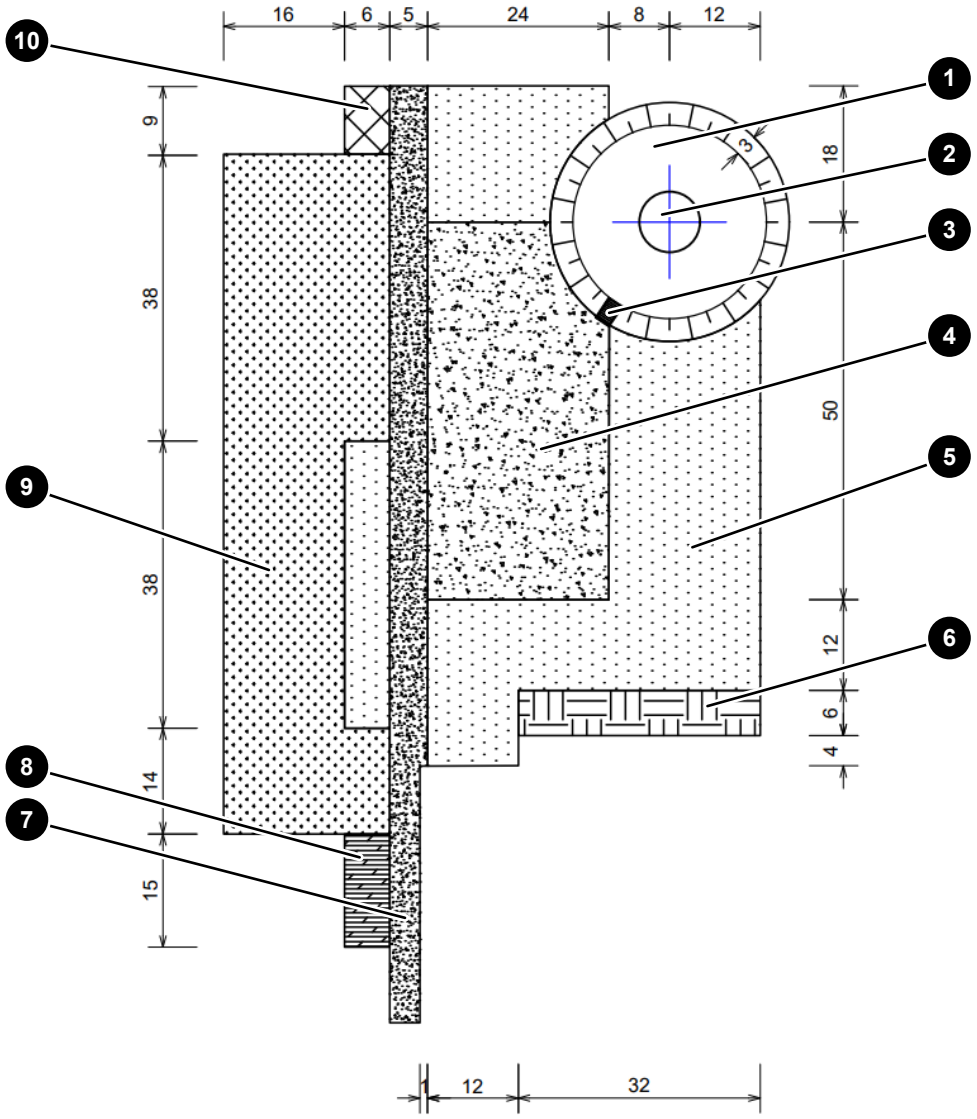


Fig. 11: Working area dimensions at the WEC site (all dimensions in metres)

1	Foundation	2	Tower
3	Stairs	4	Crane platform
5	Assembly area	6	Container area
7	Access road	8	Parking area
9	Storage area	10	Waste collection point

Soil investigation The structural design of the crane platform and assembly area may differ, depending on the nature of the subsoil. The subsoil must be investigated adequately by subsoil exploration drill holes and probing. All strata relevant to settlement and soil failure must be recorded during this process. The number and depth of the explorations must be specified by the geotechnical expert in relation to the subsoil structure. The structural design of the crane platform and assembly area is then determined based on the results of the soil investigations.

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Suitability for use

The construction site areas are designed with sufficient bearing capacity with consideration to the expected loads, so that they will remain usable throughout the duration of their use. Suitability for use and bearing capacity must be ensured even in heavy rainfall. The max. wheel rut depth is limited to 7.5 cm. The design of the areas must include an option for drainage. In the event of snow or ice, the operator/customer must ensure safe working and driving conditions through use of gritting and snow clearance services. The implementation plan as well as all specifications for testing, examinations, evaluations and verifications must be submitted to the ENERCON GPM for inspection unsolicited.

6.1.3.1 Material

Certified crushed bulk materials, e.g. gravel or similar, that fulfil the requirements may be used as a material for the surface course. The minimum layer thickness is 25 cm. The following considerations apply to materials that will be used both on the crane platform and in the assembly area.

6.1.3.2 Subsoil and soil

The load-bearing subsoil is the basis for supporting high levels of surface pressure that can occur as a result of unusual loads or the cranes used. Therefore, the topsoil and any soft strata must be excavated until the first load-bearing stratum of natural ground has been reached. If cohesive and organic soils are not load-bearing, these are exchanged or replaced with layers of a suitable compacted filling material (e.g. sand). Alternatively, other technical methods can also be used (e.g. injecting, geogrid).

Binder course

The binder course for the crane platforms and hardstands can consist of loose materials, such as sand, gravel, moraine, or a mixture thereof. The proportion of fine aggregate cannot exceed 6 % of the total amount. The gravel material for the binder course generally consists of larger stones with a much smaller proportion of clay or fine materials than the gravel material for the surface course. This is necessary in order to achieve the required strength and good drainage properties in the binder courses. Equally, the binder course material requires lower plasticity index values.

The live loads are transferred to the subsoil via this binder course. The binder course must withstand the climatic and mechanical loads. The material used must be approved for use in road construction and building construction. The grading curve of the materials used must comply with whichever national regulations are applicable. The suitability of the material must be evidenced before installation by presenting valid inspection certificates. The required bearing capacity is ensured by way of graded grain size distribution, which must be agreed upon in coordination with the geotechnical expert.

Brick fragments are not to be used as bulk material for the binder course. This material is pulverised by moisture and loses its strength. It must be ensured that the compaction is correct.

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Surface course Certified crushed bulk material, e.g. gravel or crushed stone, is used as material for the surface course. An aggregate of 0/32-0/45 mm is used. The proportion of fine aggregate cannot exceed 10 % of the total amount. The gravel material for the surface course generally contains a finer aggregate than the gravel for the binder course. Aggregate that is too coarse will make maintenance more difficult and result in a rough road surface. A higher proportion of fine aggregate and a higher plasticity index are also required in order to be able to create a binding property and a smooth road surface in the surface course. The grading curve of the materials used must comply with whichever national regulations are applicable. The suitability of materials must be evidenced before installation by presenting valid inspection certificates. The minimum layer thickness is 25 cm. In order to account for the stress resulting from high live loads, the surface course must be well compacted in layers.

6.1.3.3 Crane platform

The crane is set up on the crane platform. This is where the main works are carried out. This area is subjected to the highest levels of stress as a result of live loads and distributed loads. An improperly designed or dimensioned crane platform may result in unforeseen movements or toppling of the crane.

Tab. 4: Crane platform minimum requirements

Parameter	Requirement
Surface evenness	≤ 0.25 %
Minimum bearing capacity	220 kN/m²
Surface course, deformation modulus	E_{V2} ≥ 120 MN/m²
Surface course, Proctor density	D_{Pr} ≥ 103 %
Binder course, deformation modulus (if required)	E_{V2} ≥ 100 MN/m²
Binder course, Proctor density	D_{Pr} ≥ 100 %
Ratio E_{V2}/E_{V1}	≤ 2.3

The bearing capacity of the crane platform must be verified by soil failure calculations or, on slopes, by slope failure calculations in accordance with DIN 4017. Settlement calculations are required in order to prevent the crane from standing at an incline that is greater than the maximum permitted by DIN 4019:2015. The crane loads are reduced to the specified permissible soil pressure by load distribution plates underneath the crawlers or outriggers.

The required geotechnical verifications of the load distribution shall be provided in each case for an area with the following dimensions:

- 2 m x 10 m
- 5 m x 10 m

The construction firm must check and document the specified deformation moduli for each stratum constructed. If the specified values are not achieved, improvement measures must be implemented. Gener-

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ally, a static plate load test is recommended for each stratum constructed. The recommended values for the second deformation modulus (E_{V2}) and the ratio E_{V2}/E_{V1} reflect the plate load tests performed in accordance with German standard DIN 18134. This document summarises various aspects of the inspection to be performed, such as the plate diameter, max. pressure, load levels, E_V calculation formula, etc. Plate load tests that are performed on the basis of differing standards are not directly comparable.

The following points shall be checked and the results recorded:

- Structure of the construction site area (material and installation thickness)
- Sufficient compaction of the construction material
- Distances to ditches, pits and bodies of water
- Distances to cable routes and overhead lines

For the compaction test of the crane platform, a minimum of 3 plate load tests should be performed that provide a representative result of the condition of the surface. Plate load tests in the edge area must be avoided. If there are doubts with respect to the suitability for use of the crane plate, further tests must be performed if necessary.

6.1.3.4 Assembly area

The assembly area serves as a work area for pre-assembly and assembly purposes and for storing WEC and tower components. This area is required during construction and can be restored to its original state after work in the wind farm has been completed. In the case of component replacement or dismantling, a section of this area must be restored. The size and position of this section must be agreed upon in coordination with the ENERCON GPM.

Tab. 5: Minimum requirements for the assembly area

Parameter	Requirement
Surface evenness	≤ 1 %
Minimum bearing capacity	135 kN/m²
Surface course, deformation modulus	E_{V2} ≥ 120 MN/m²
Surface course, Proctor density	D_{Pr} ≥ 103 %
Binder course, deformation modulus (if required)	E_{V2} ≥ 80 MN/m²
Binder course, Proctor density	D_{Pr} ≥ 100 %
Ratio E_{V2}/E_{V1}	≤ 2.3

The bearing capacity of the assembly area must be verified by soil failure calculations or, on slopes, by slope failure calculations in accordance with DIN 4017. Settlement calculations are required in order to prevent the crane from standing at an incline that is greater than the maximum permitted by DIN 4019:2015. The crane loads are reduced to the specified permissible soil pressure by load distribution plates underneath the crawlers or outriggers.

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The required geotechnical verifications of the load distribution shall be provided in each case for an area with the following dimensions:

- 1.5 m x 5 m
- 3 m x 5 m

The construction firm must check and document the specified deformation moduli for each stratum constructed. If the specified values are not achieved, improvement measures must be implemented. Generally, a static plate load test is recommended for each stratum constructed. The recommended values for the second deformation modulus (E_{V2}) and the ratio E_{V2}/E_{V1} reflect the plate load tests performed in accordance with German standard DIN 18134. This document summarises various aspects of the inspection to be performed, such as the plate diameter, max. pressure, load levels, E_V calculation formula, etc. Plate load tests that are performed on the basis of differing standards are not directly comparable.

The following points shall be checked and the results recorded:

- Structure of the construction site area (material and installation thickness)
- Sufficient compaction of the construction material
- Distances to ditches, pits and bodies of water
- Distances to cable routes and overhead lines

At least 1 plate load test per assembly area must be performed for the compaction check of the assembly area.

6.1.3.5 Storage area

The storage area serves to store assembly materials, containers, flat racks and rotor blades, among other things. This area is set up to the side of the crane platform. It does not have to be surfaced but it must be level, smooth and free of roots, trees and shrubs. Drainage measures must be in place. Practicability for telescopic handlers must be ensured.

Additional measures may be required for the correct mounting of the rotor blades. These additional measures, such as ballast surfaces, steel plates or load distribution plates, vary depending on the rotor blade and must be agreed with the ENERCON GPM.

6.1.3.6 Working levels (where necessary)

The carrier device used for constructing pile foundations or for ground improvement measures through vibro replacement/vibro compaction is located on the working level.

Tab. 6: Minimum requirements for the work area

Parameter	Requirement
Form: Circle	Coordination with ENERCON GPM
Surface evenness	≤ 1 %
Minimum bearing capacity	Coordination with ENERCON GPM

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Parameter	Requirement
Binder course, deformation modulus (if required)	$E_{V2} \geq 80$ MN/m²
Binder course, Proctor density	$D_{Pr} \geq 100$ %
Ratio E_{V2}/E_{V1}	≤ 2.3

The following tests must be carried out and recorded:

- Compaction (static plate load tests, dynamic probing)
- Distances to ditches, pits and bodies of water
- Distances to cable routes and overhead lines
- Surface gradients for drainage

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6.1.4 Clearing and safety area

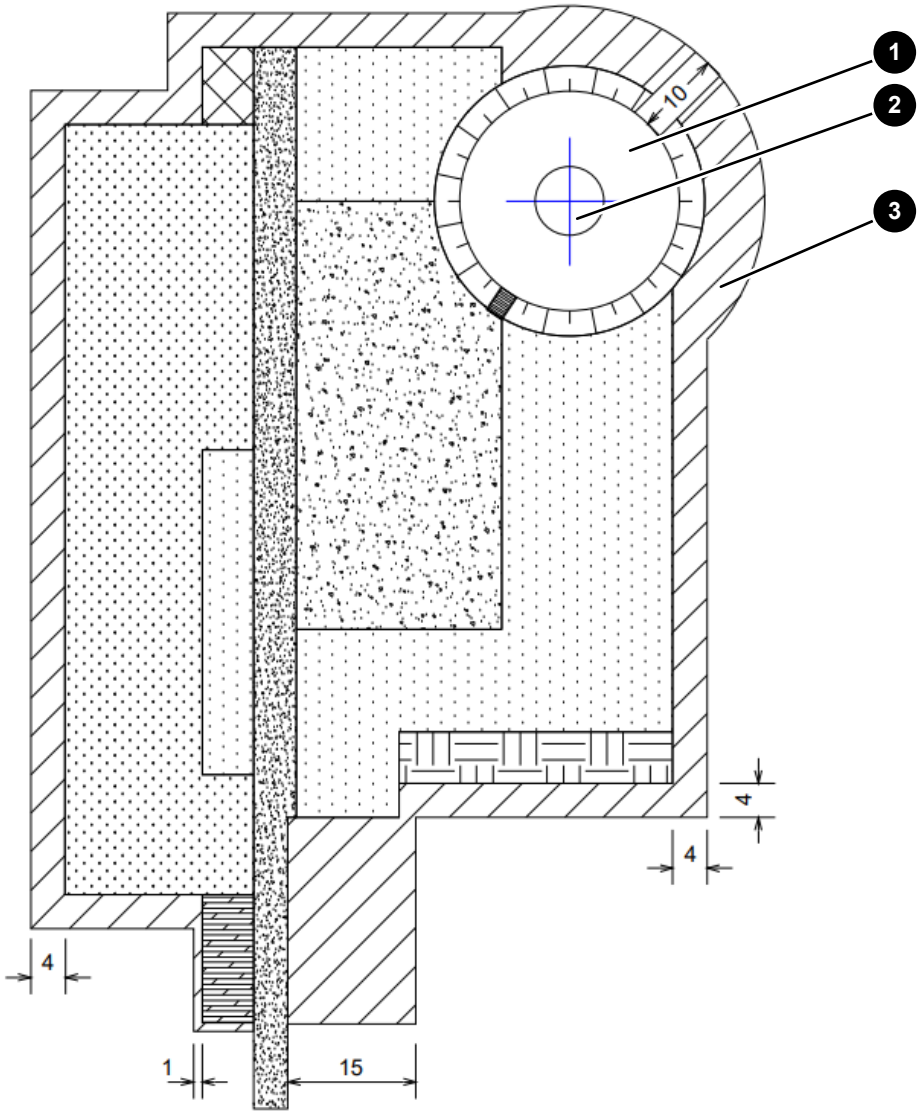


Fig. 12: Site clearing and safety area, dimensions (all dimensions in metres)

1	Foundation	2	Tower
3	Site clearing and safety area		

When erecting the WEC, a safety area must be kept clear around the foundation and the construction area, or the area must be cleared. No excavated soil may be stored in the clearing and safety area during construction work. The clearing and safety area can be partly reforested after the WEC has been installed. In the event of component replacement or dismantling, a section of this area must be kept clear or cleared again. The size and dimensions of this section must be agreed upon in coordination with the ENERCON GPM.

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6.2 Crane jib assembly area

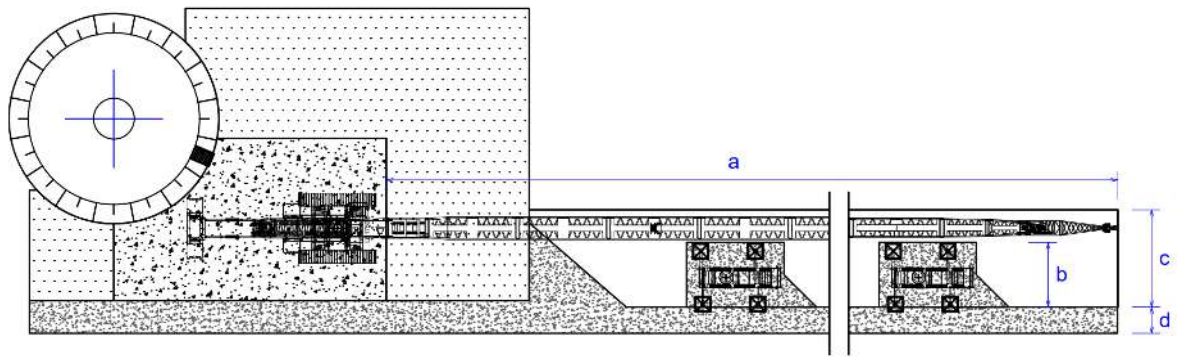


Fig. 13: Crane jib assembly area

a	140 m	Length of crane jib assembly area, starting from crane platform	b	10 m	Width of auxiliary crane platform
c	15 m	Total width of crane jib assembly area	d	4 m	Drivable width of road

The lattice tower jib of the main crane is assembled from individual components. It must be ensured that the lattice tower for the large crane can be set down in the event of rising wind speeds during assembly as well. This requires a clearing that is the same length as the lattice tower jib, which is the same height as the crane platform as standard. Lattice tower jibs can be installed only up to a certain gradient. If there are height differences in the crane jib assembly area, consult with the ENERCON GPM. This particularly applies to gradients between the basic unit and the lattice tower jib.

Auxiliary crane areas

The lattice tower jib of the large crane is assembled and erected with the support of an auxiliary crane. The auxiliary crane is positioned to the side of the lattice tower tip. In order to facilitate consecutive assembly of the individual jib components, a paved roadway is required for the auxiliary crane. If the access road to the crane platform is straight, long enough and if local conditions make lattice tower assembly possible, it is used for that purpose. If not, a temporary auxiliary road will be built. Approval by an authority may be required for the construction of the temporary road for lattice tower assembly. The customer must check in advance if this approval is necessary. In order to support the auxiliary crane and distribute its loads, auxiliary crane platforms measuring 10 m in width must be established at certain intervals, immediately adjacent to the access road or auxiliary road. The number and location of auxiliary crane areas is coordinated with the ENERCON GPM and crane service provider. If a crawler crane is used as an auxiliary crane, the access road must be widened correspondingly for the crane. This can be realised with gravel or plates, depending on the ground conditions.

Tab. 7: Requirements for the crane jib assembly area

Parameter	Requirement
Bearing capacity of the access road or auxiliary road	12 t axle load

Subject to technical change without prior notice.

Released: 2024-03-07 15:37;Translation of D02784779/3.1-de

Parameter	Requirement
Surface pressure of the auxiliary crane platforms	min. 135 kN/m²

6.3 Alternative construction area

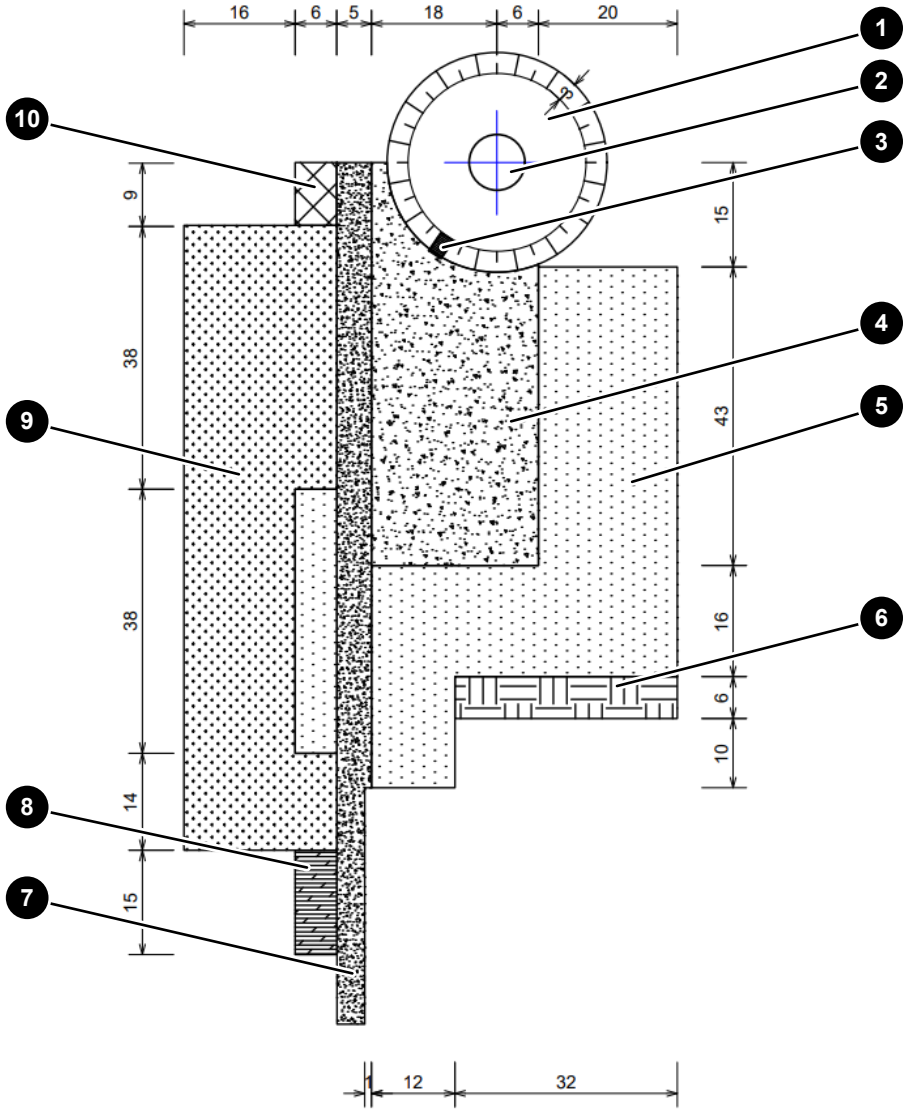


Fig. 14: Alternative working area at the WEC site, dimensions (all dimensions in metres)

1	Foundation	2	Tower
3	Stairs	4	Crane platform
5	Assembly area	6	Container area
7	Access roads	8	Parking area
9	Storage area	10	Waste collection point

Subject to technical change without prior notice.

Released: 2024-03-07 15:37;Translation of D02784779/3.1-de

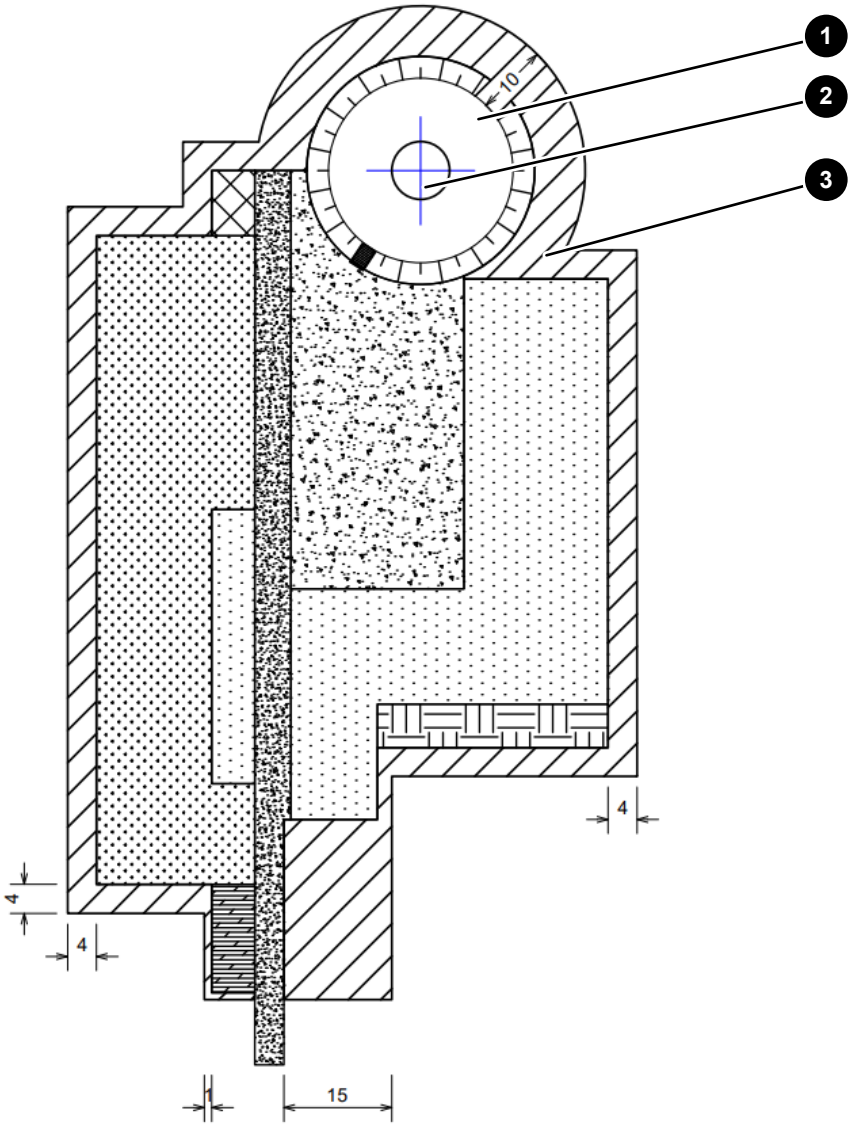


Fig. 15: Alternative site clearing and safety area, dimensions (all dimensions in metres)

1	Foundation	2	Tower
3	Site clearing and safety area		

The alternative construction areas shown here meet the same requirements for delivery and assembly as in the standard shown (fig. 11, p. 26 and fig. 12, p. 32). There are restrictions to the assembly direction of the jib: namely, here it can only be assembled in the direction opposite to the tower. Use of the alternative construction areas must be agreed with ENERCON.

Subject to technical change without prior notice.

Released: 2024-03-07 15:37;Translation of D02784779/3.1-de

6.4 Optional rotor blade storage area

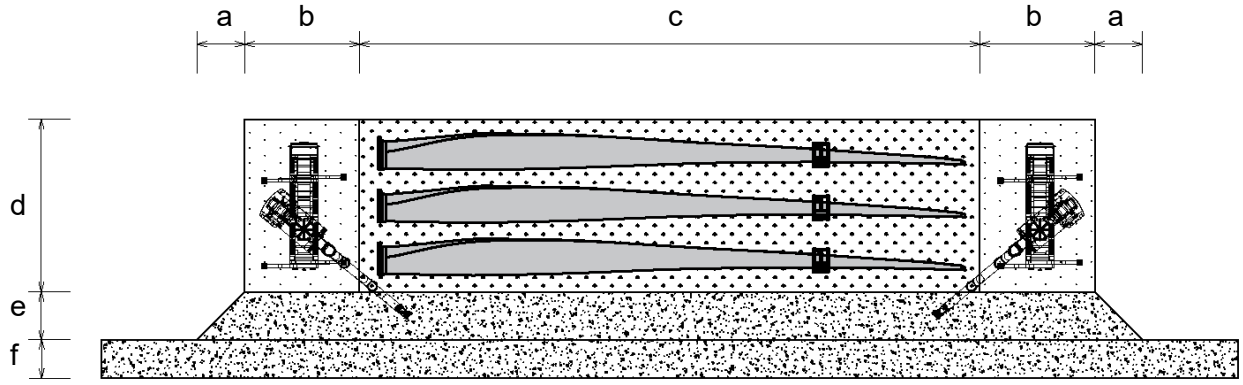


Fig. 16: Rotor blade storage area (construction diagram)

a	5 m	Length of funnel lay-by	b	12 m	Width of auxiliary crane platform
c	90 m	Length of rotor blade storage area	d	18 m	Width of rotor blade storage area/ length of auxiliary crane platform
e	5 m	Width of lay-by	f	4 m	Drivable width of road

The rotor blade storage area serves as temporary storage for rotor blades. The area can also be used for transferring rotor blades. The rotor blade storage area is located in a lay-by along the access road. The storage area is free of stumps and roots. An auxiliary crane is located on each of the two front sides of the storage area for moving the rotor blades. The rotor blade storage area does not replace the parking spaces for excess length transport vehicles required to be specially indicated (see *Parking areas for long transports*, p. 12).

The rotor blade storage area is included in the plans if no storage area can be constructed at the WEC location or if no just-in-time delivery of the rotor blades is possible due to the installation and logistics concept. The size of the rotor blade storage area and its position within the wind farm are derived from the installation and logistics concept and are agreed upon with the ENERCON GPM. The additional logistical costs are borne by the customer. If necessary, contractually agreed deadlines must be adjusted by the contractor.

Tab. 8: Requirements for the rotor blade storage area

Parameter	Requirement
Bearing capacity of the lay-by	12 t axle load
Minimum load-bearing capacity of the auxiliary crane platforms	min. 135 kN/m²

Subject to technical change without prior notice.

Released: 2024-03-07 15:37;Translation of D02784779/3.1-de

7 Central contact point

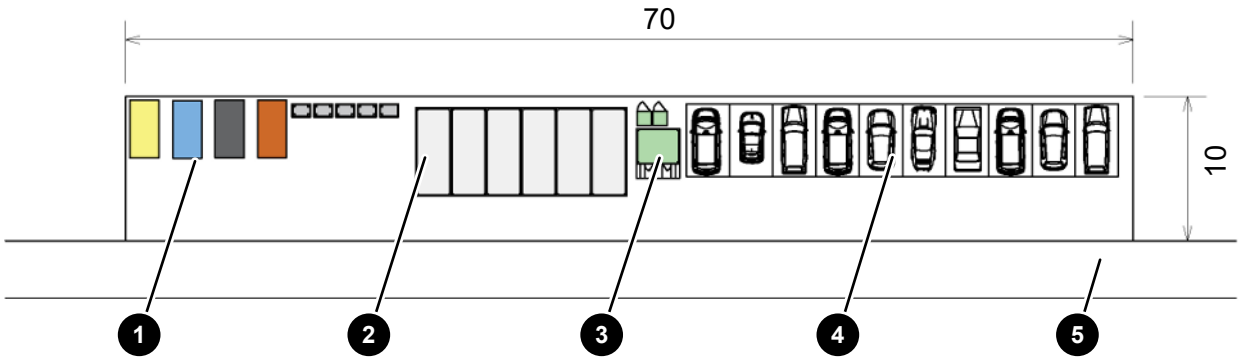


Fig. 17: Central contact point (all dimensions in metres)

1	Waste containers	2	Construction site containers
3	Sanitary facilities	4	Car parking spaces
5	Access road		

Central infrastructure is required in every wind farm. The central infrastructure includes the office container of the ENERCON CM, car parking spaces, waste containers and sanitary facilities. A dedicated space can be created for this to serve as a central facility. Existing spaces may also be used and may require adaptation. The office containers and waste containers do not have to be located in the same area. The waste containers must be accessible for loading and unloading by truck.

The area of the central contact point is gravelled or covered with steel or composite panels. The bearing capacity of the area is dimensioned for vehicles with an axle load of 12 t.

The construction site equipment, the location within the wind farm as well as dimensions and distances on the area are coordinated on a project-specific basis with the ENERCON GPM. Local conditions and country-specific regulations must be taken into account.

Subject to technical change without prior notice.

Released: 2024-03-07 15:37;Translation of D02784779/3.1-de

8 Access for service vehicles after commissioning

Once the WEC has been commissioned, ENERCON Service needs access (a ramp) for service vehicles, in order to bring heavy components such as yaw gears to the WEC. This ramp can be installed at the same time as dismantling the temporary assembly areas. When doing so, the specifications document D02768819 ‘Anforderungen Zusatzbelastung Fundamentanschüttung und Fundamentauflast für Servicetätigkeiten’ (Additional load requirements for foundation soil cover/load for service activities) must be taken into account. This specification applies only for servicing after commissioning a WEC.

It is not permitted to have a ramp during the assembly phase.

Subject to technical change without prior notice.

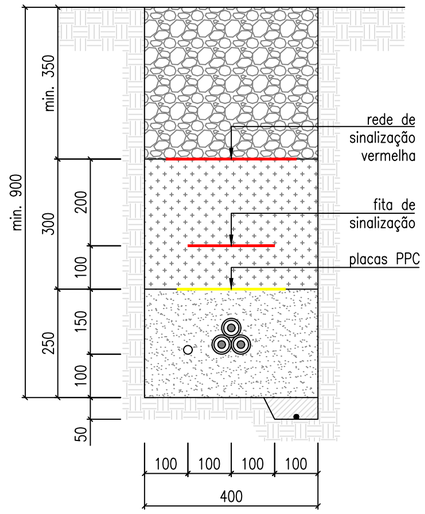
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ANEXO VII

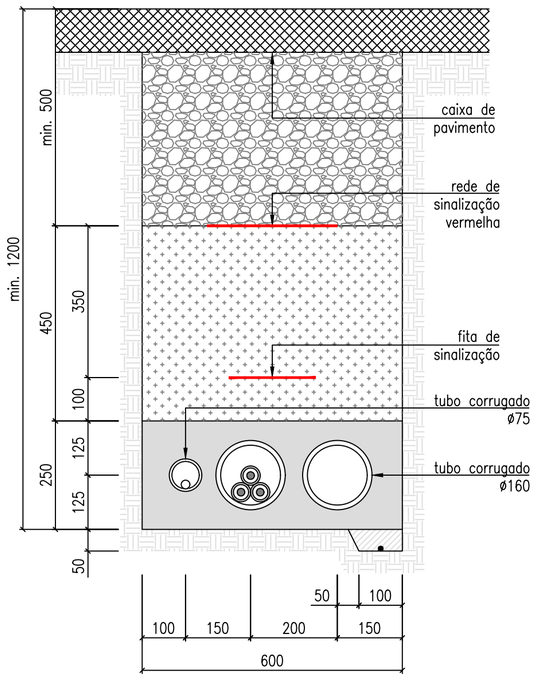
VALAS DE CABOS

GEN-A24024-003-004

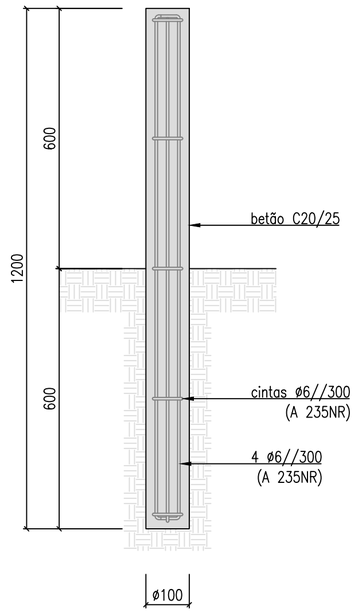
VALA CABOS MT
1 RAMAL



VALA CABOS MT – TRAVESSIAS
1 RAMAL



PRUMOS DE SINALIZAÇÃO
DAS VALAS DE CABOS



NOTAS:

- os 30 cm do topo dos prumos deverão ser pintados a cor branca
- os prumos deverão ser colocados em todos os vértices das mudanças de direção da vala de cabos
- em alinhamentos retos o espaçamento máximo entre prumos será de 60 m

LEGENDA:

- AREIA
- TERRA CIRANDADA E COMPACTADA
- PRODUTOS DE ESCAVAÇÃO
- BETÃO C20/25
- TERRA VEGETAL
- CABOS DE MÉDIA TENSÃO
- CABO DE COMUNICAÇÕES
- CABO DE COBRE NU

REFERÊNCIAS:

- GEN-A24024-005-001 – PLANTA DE LOCALIZAÇÃO
- GEN-A24024-005-002 – PLANTA DE IMPLANTAÇÃO
- GEN-A24024-005-003 – LAYOUT GERAL

REV.	DESCRIÇÃO	ALTEROU	APROVOU	DATA
A.2	Revisão geral conforme projeto civil	J. Riboira	P. Maio	07/03/2025

PROJETISTA:

sisint sistemas integrados

SISINT - Supervisão, Conservação, Manutenção e Gestão de Redes de Energia, Lda.
www.sisint.pt | +351 227 418 810 | sisint@sisint.pt

CLIENTE:

nadara

PROJETO:

Parque Eólico da Beira Interior
Subparque Eólico de Aldeia Nova
- SOBREEQUIPAMENTO -

FASE DO PROJETO:

PROJETO DE LICENCIAMENTO

TÍTULO:

Valas de cabos

PROJETOU:	DESENHOU:	ESPECIALIDADE:
João Riboira	João Riboira	Geral
VERIFICOU:	APROVOU:	EMISSÃO INICIAL:
Pedro Maio	Nadara	03/01/2025

DESENHO Nº: GEN-A24024-003-004

REVISÃO: A.2

ESCALAS:	FORMATO:	FOLHA:
1:10	A2 (420 x 594 mm)	01 / 01

ANEXO VIII

TERMO DE RESPONSABILIDADE

TERMO DE RESPONSABILIDADE PELO PROJETO
DE INSTALAÇÕES ELÉTRICAS DE SERVIÇO PARTICULAR

(artigo 5.º do Decreto-Lei n.º 96/2017, de 10 de agosto)

1 Promotor / Entidade Exploradora					
Nome:	Eólica da Lajeira, S.A.				
Telefone:	918947875	E-mail:	joao.silva@nadara.com devprojects.portugal@nadara.com	NIF:	510978258

2 Técnico responsável pelo projeto					
Nome:	Pedro Marques Maio				
N.º BI/CC:	10341473				
Telefone:	962011355	E-mail:	pmm@sisint.pt	NIF:	206976496
N.º DGEG:	78757	N.º OE:	45194	N.º OET:	-
Morada:	Rua Industrial de São Caetano 79				
C. Postal:	4410-311 Vila Nova de Gaia				

3 Identificação do imóvel			
Lugar/Rua:	Parque Eólico da Beira Interior – Subparque Eólico de Aldeia Nova – Sobreequipamento		
Freguesia:	Aldeia Nova		
Concelho:	Trancoso	Distrito:	Guarda
Tipo de estabelecimento:	Central Eólica		

4 Identificação da instalação elétrica			
NIP:	-	Instalação nova	-
CPE(s):	-	Instalação existente	X

Declaro que se observam, no projeto de execução, as disposições regulamentares em vigor, bem como outra legislação aplicável.
Declaro também que o projeto simplificado está em conformidade com o projeto de execução, no que respeita às disposições regulamentares de segurança aplicáveis para efeitos de vistoria/inspeção.

Assinado por: **PEDRO MARQUES MAIO**
Num. de Identificação: 10341473
Data: 2025.03.07 16:19:53+00'00'

(Data e assinatura do técnico responsável pelo projeto)

ANEXO IX

FICHA ELETROTÉCNICA

FICHA ELETROTÉCNICA

DE INSTALAÇÕES ELÉTRICAS DE SERVIÇO PARTICULAR

(emitido nos termos do disposto no artigo 12.º do Decreto-Lei n.º 96/2017, de 10 de agosto)

1 - Requerente/Entidade Exploradora					
Nome:	Eólica da Lajeira, S.A			NIF/NIPC:	510978258
Telefone:	918947875	E-Mail:	joao.silva@nadara.com / devprojects.portugal@nadara.com		
Morada:	Rua João Chagas, 53 Piso 5				
C. Postal:	1495-072 Algés, Portugal				

2 - Técnico Responsável					
Nome:	Pedro Marques Maio			NIF:	206976496
Telefone:	962 011 365	E-Mail:	pmm@sisint.pt	N.º DGEG:	78757

3 - Localização do imóvel						
Freguesia:	Aldeia Nova		Concelho:	Trancoso	Distrito:	Guarda
Entrada[1] principal (Lugar/Rua):	E1	Parque Eólico da Beira Interior - Subparque Eólico de Aldeia Nova			Coordenadas GPS:	Lat: 40°43'41.13"N
Outra Entrada[1] do Imóvel:					Coordenadas GPS:	Long: 7°24'0.46"W

4 - Caraterização do imóvel			
Descrição do Imóvel:	Outros	Instalação:	Existente
Classificação das instalações[2]:	Central Eólica - Sobreequipamento	Total Ramais:	

5 - Instalação Eletrica

Tipo da Instalação [3]	Entrada do Imóvel	Ramal N.º	NIP[4] (existente)	CPE[5] (existente)	Andar	Fração	Tipo utilização individual [6]	Entrada	Total Instalado (kVA)	Fator de Simulta-neidade	Potência a Alimentar (kVA)
B	E1	-	-	PT0001906000800041TH	-	-	Outros (Central Eólica)	-	7000.00	1.00	7000.00

Tipo de Instalação	Potência Total Instalada (kVA)
Tipo A: geradores de segurança e de socorro	
Tipo B: instalações alimentadas em MT/AT/MAT	7000.00
Tipo C: instalações alimentadas em BT	

Declaro que a informação apresentada caracteriza a instalação elétrica.

Assinado por: **PEDRO MARQUES MAIO**
Num. de Identificação: 10341473
Data: 2025.03.07 16:20:29+00'00'

(Data e assinatura do técnico responsável)

FE_v.20190222

(1) Localização (Rua e numeração de porta ou Lugar) do(s) ponto(s) de entrega ao imóvel (ramais de alimentação).
Caso a instalação de utilização seja alimentada por um ramal próprio, deve mencionar a respetiva localização.
(2) Conforme Anexo I do Despacho n.º 1/2018 da DGEG.
(3) Conforme art.º 3.º do Decreto-Lei nº 96/2017. Para instalações do "Tipo A", de socorro ou segurança, indicar a "Entrada", "Ramal N.º", "NIP" e "CPE" da instalação de utilização a que está associado.
(4) NIP - Número de Identificação do Prédio. Caso ainda não esteja atribuído, colocar "-".
(5) CPE - Código do Ponto de Entrega (conforme art.º 229º do RRC). Caso ainda não esteja atribuído, colocar "-".
(6) Conforme Anexo II do Despacho n.º 1/2018 da DGEG.

ANEXO X

FICHA DE IDENTIFICAÇÃO DO PROJETO

IDENTIFICAÇÃO DO PROJETO
DE INSTALAÇÕES ELÉTRICAS DE SERVIÇO PARTICULAR

(artigo 20.º do Decreto-Lei n.º 96/2017, de 10 de agosto)

1 Promotor / Entidade Exploradora					
Nome:	Eólica da Lajeira, S.A.				
Telefone:	918947875	E-mail:	joao.silva@nadara.com devprojects.portugal@nadara.com	NIF:	510978258
Morada:	Rua João Chagas, 53 Piso 5				
C. Postal:	1495-072 Algés, Portugal				

2 Técnico responsável pelo projeto							
Nome:	Pedro Marques Maio						
N.º BI/CC:	10341473						
Telefone:	962011355	E-mail:	pmm@sisint.pt			NIF:	206976496
N.º DGEG:	78757	N.º OE:	45194	N.º OET:	-		
Morada:	Rua Industrial de São Caetano 79						
C. Postal:	4410-311 Vila Nova de Gaia						

3 Identificação do imóvel					
Lugar/Rua:	Parque Eólico da Beira Interior – Subparque Eólico de Aldeia Nova				
Freguesia:	Aldeia Nova				
Concelho:	Trancoso		Distrito:	Guarda	
Coordenadas GPS:	Latitude: 40°43'41.13"N Longitude: 7°24'0.46"W			NIP:	-
Tipo de estabelecimento:	Central Eólica - Sobreequipamento				
Tensão da RESP [kV]:	60		Potência a alimentar pela RESP [kVA]:		7000

4 Identificação da instalação elétrica			
Tipo de instalação	Instalação nova	Instalação existente	Observações
Grupos geradores		Sim	Potência Instalada de 7000 kW.

Declaro que a informação apresentada identifica a instalação elétrica.

Assinado por: **PEDRO MARQUES MAIO**
Num. de Identificação: 10341473
Data: 2025.03.07 16:20:56+00'00'

(Data e assinatura do técnico responsável pelo projeto)

Legenda:
SE: Subestações; PS: Postos de Seccionamento; PTC: Postos de Transformação de Consumo.
RESP: Rede Elétrica de Serviço Público; MT/AT: Média e Alta Tensão; BT: Baixa Tensão.