REGIONE BASILICATA

PROVINCIA DI POTENZA

COMUNE DI FORENZA

COMUNE DI MASCHITO

COMUNE DI RIPACANDIDA

Committente:

ENPower
Energy One

Oggetto:

PROGETTO DEFINITIVO
"PARCO EOLICO PIANO DELLA SPINA"

Titolo:

Piano di manutenzione e gestione dell'impianto

Tavola:

B

-Progettista Architettonico/Elettromecc.:

Ing. Paolo Battistella

-Consulenza Geologica:

Dott.Geologo Antonio Viviani

-Responsabile V.I.A.:

Ing. Rocco Sileo

A.d.R. s.r.l.s.
INGEGNERIA - ARCHITETTURA
TOPOGRAFIA

-Consulenza Topografica:

Geom. Rocco Galasso

N°	REVISIONE	DATA	RED.	APPR.
0	Emissione	10/2021	G.M.	P.B.

Data:

Ottobre 2021

Committente:
EN POWER S.r.l.s.
Via Principe Amedeo, 7 – 85010 Pignola (PZ)

Parco Eolico Piano della Spina
GESTIONE E MANUTENZIONE B

	Redatto	Verificato	Note	Data
Emissione	G.Montanari	P.Battistella		Ottobre 2021

A. PARTE GENERALE

A.1 Componenti dell'impianto

L'impianto eolico "Piano della Spina" presenta i seguenti componenti principali:

- 16 aerogeneratori Vestas di due Modelli diversi:
  - V162 da 5.6 MW di potenza nominale con altezza mozzo di 125m;
  - V136 da 4.2 MW di potenza nominale con altezza mozzo di 86 m.
- 1 cavidotto interrato di impianto a 30 kV
- 1 cabina di raccolta delle linee di impianto
- 1 cavidotto interrato di collegamento tra cabina e sottostazione costituito da due o più terne da 30 kV
- 1 stallo produttore di trasformazione 30-150 kV
- 1 cavidotto/linea area da 150kV per il collegamento tra stallo produttore e sottostazione di Vaglio

La gestione e la manutenzione dell'impianto devono contemplare tutti i componenti elencati.

A.2 Schede Tecniche dei Componenti dell'impianto.

AEROGENERATORE

Lo schema costruttivo degli aerogeneratori VESTAS rimane quello classico, in cui la navicella è progettata con struttura portante saldata. Al suo interno sono alloggiati il sistema di trasmissione con moltiplicatore di giri, il generatore elettrico e i dispositivi ausiliari.

L'avvio della turbina avviene con un vento di 3m/s, a passo massimo.

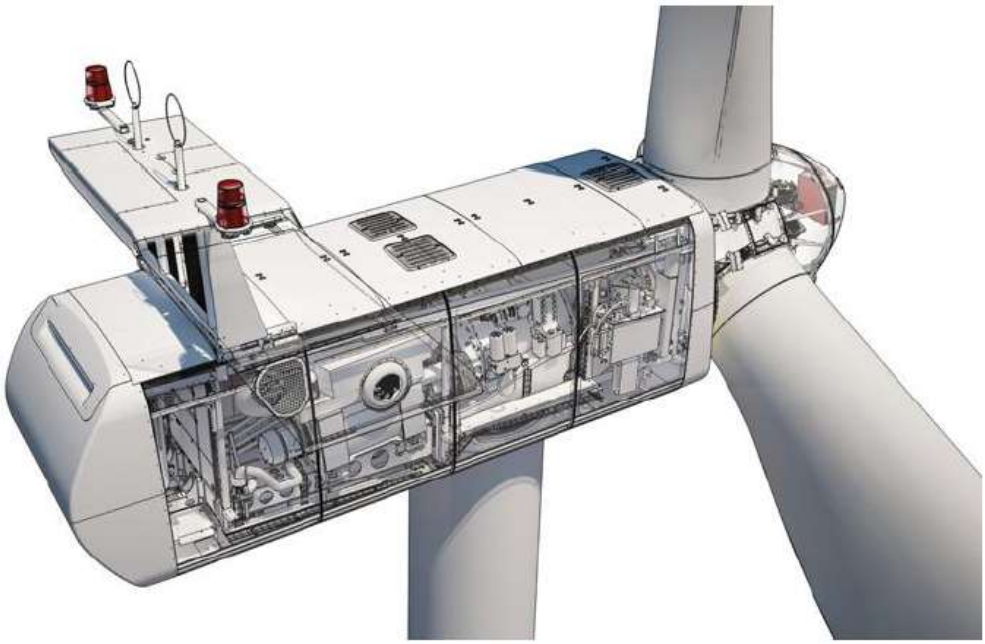


Figura 1 - Navicella Vestas

Al crescere del vento il rotore può aumentare la sua velocità fino a quella nominale, variando il passo delle pale e regolando il generatore.

A velocità del vento alte, oltre quella di raggiungimento della potenza nominale, il sistema di regolazione del passo e quello del generatore mantengono la potenza al valore prefissato, indipendentemente da variazioni di velocità del vento, di carico, di temperatura o di densità dell'aria.

Quando necessario, l'aerogeneratore frena aerodinamicamente mettendo completamente in bandiera le pale.

Tutte le funzioni dell'aerogeneratore sono monitorate e controllate da diverse unità di controllo basate su microprocessori.

COMPONENTI PRINCIPALI DELLA TURBINA

Pale:

- ✓ Numero: 3
- ✓ Lunghezza: 79.35 m V162 e 66.66 m V136
- ✓ Materiale: materiale composito a matrice epossidica rinforzata con fibra di carbonio e Tip metallico.

Rotore:

- ✓ Diametro: 162m per V162 e136 m per V136
- ✓ Area spazzata: 20612 m^2 per V162 e 14.527 m^2 per V136
- ✓ Rotazione: oraria (vista frontale)
- ✓ Orientamento: sopravento
- ✓ Angolo di tilt: 6°
- ✓ Intervallo funzionamento 4.3 – 12.1 rpm (V162) e 5,6 – 14 rpm (V136)

Navicella/mozzo:

- ✓ Pitch System:
  - Tipo: idraulico
  - Numero: uno per ogni pala
  - Intervallo: da -5° a 95° (V162) da -10° a 95° (V136)
  - Tipo: a due stadi;
  - Lubrificazione: olio a pressione

- ✓ Moltiplicatore (Gearbox):
  - Tipo: a due stadi;
  - Lubrificazione: olio a pressione

- ✓ Generatore e convertitore di frequenza:
  - Generatore: sincrono a magneti permanenti (V162) e asincrono a doppia alimentazione (V136).
  - Numero di poli: 36 Potenza: 5650 kW (V162)
  - Numero poli: 6 con Potenza 4.250/ 4.450 kW (V136)
  - Classe Isolamento: H
  - Protezione IP54

- ✓ Trasformatore:
  - Trasformatore trifase a due avvolgimenti
  - Immerso in liquido isolante (V162) - A secco (V136)
  - Design ecocompatibile nel rispetto del regolamento UE 2019/1783 (classe 2) – (V162)
  - Design ecocompatibile nel rispetto del regolamento UE 2014/548 (V136)

- ✓ Sistema Yaw di orientamento della navicella
  - Motori e riduttori
  - Ralla di collegamento
- ✓ Sistema freni
- ✓ Unità di controllo superiore
- ✓ Sistema rilevamento/misura vento
- ✓ Captatori sistema parafulmine

Torre:

- ✓ Tubolare/conica
- ✓ Altezza mozzo: 125m (V162) - 86 m (V136)
- ✓ Collegamento di potenza e di segnale fra la base e la navicella
- ✓ Circuito d'illuminazione
- ✓ Sistema monofase di alimentazione dell'unità di controllo
- ✓ Sistema monofase per l'alimentazione della resistenza di riscaldamento
- ✓ Unità di controllo inferiore
- ✓ Quadro dei servizi ausiliari
- ✓ Quadro di media tensione
- ✓ Collegamenti sistema equipotenziale e di messa a terra.

In allegato vengono riportate le schede tecniche dei due modelli di aerogeneratore adottati per il Parco Eolico Piano della Spina.

CAVI ELETTRICI

I cavi elettrici unipolari a 30 kV di riferimento sono i Prysmian. La relativa scheda tecnica, “Medium Voltage Systems” – Prysmian Cavi e Sistemi Energia Srl, è allegata [1].

Tutti i collegamenti elettrici, tra gli aerogeneratori e alla sottostazione, sono realizzati per mezzo di **cavidotti interrati**: questa soluzione permette di minimizzare l’emissione elettromagnetica ed elimina del tutto il problema della visibilità delle linee aeree e il relativo impatto sull’avifauna.

SOTTOSTAZIONE MT/AT

Lo schema elettrico dell’impianto è descritto dall’unifilare di tav. A16b7.

La produzione elettrica del parco eolico, costituito da 16 aerogeneratori, viene raccolta in una cabina di raccolta collegata con cavidotto alla sottostazione mediante cavidotto a due terne.

La sottostazione dell’impianto è nel Comune di Palazzo San Gervasio in prossimità della nuova progettata Stazione Elettrica Terna.

I lavori prevedono la presenza di un trasformatore 30/150 kV, la strumentazione di misura e tutti i vari servizi ausiliari. Per la componentistica si veda la Relazione “A15 Disciplinare degli Elementi Tecnici”.

La sottostazione verrà collegata con cavo AT a 150kV con la nuova stazione elettrica di Vaglio di Basilicata.

Per la stazione utente si rimanda alla tav.A.16.b.9.

A.3 Schemi di Funzionamento dell'impianto

I sistemi di controllo per la gestione dell'aerogeneratore sono il *pitch control* e lo *yaw control.*

Il primo, *pitch control,* di cui è dotata ciascuna pala in modo indipendente, esegue la rotazione delle pale intorno al loro asse principale e permette la riduzione della potenza al suo valore nominale, evitando così l'utilizzo di freni meccanici. Gli angoli aerodinamici e costruttivi sono costantemente monitorati, in modo da permettere veloci regolazioni in funzione del vento.

La velocità del vento e la sua direzione sono rilevati in continuo mediante anemometro e bandiera di macchina.

Il carico elettrico è costantemente monitorato ed in caso di caduta di rete, ovvero mancanza di carico, si ha un arresto di emergenza del rotore tramite frenatura aerodinamica e stazionamento meccanico. Stessa procedura in caso di grave guasto e incendio.

Il secondo, *yaw control* detto anche *imbardata*, modifica l'orientamento della navicella, allineando la macchina rispetto alla direzione del vento e garantendo, indipendentemente dalla direzione del vento, la migliore esposizione del rotore ovvero perpendicolare alla direzione del vento in posizione sopravento rispetto alla torre.

Per gli schemi di funzionamento dell'impianto far riferimento alle seguenti tavole di progetto:

- A.16.b.3 Schemi funzionali dei singoli aerogeneratori
- A.16.b.7 Schemi elettrici impianto eolico
- A.16.b.4 Schemi di collegamento alla rete elettrica di distribuzione e trasmissione.

B. SISTEMA DI MANUTENZIONE DELL'IMPIANTO

L'aerogeneratore è dotato di un sistema di controllo remoto che permette di monitorarne costantemente lo stato, e in caso di anomalie, opportuni sensori trasmettono gli allarmi relativi consentendo tempestivi interventi anche per manutenzione non programmata.

Relativamente alla manutenzione dell'aerogeneratore la progettazione dello stesso ha raccolto le esigenze degli operatori sviluppando una macchina con le seguenti caratteristiche:

- ✓ accesso alla navicella dall'interno della torre con utilizzo di ascensore;
- ✓ montacarichi esterno
- ✓ notevole disponibilità di spazio nella navicella per interventi facili ed ergonomici
- ✓ accesso al mozzo agevole direttamente dalla navicella
- ✓ facilità nel raggiungere tutti i componenti
- ✓ sicurezza durante la manutenzione grazie alla protezione di tutte le parti rotanti
- ✓ in caso di necessità, la macchina consente lo smontaggio di molti componenti

Le istruzioni VESTAS per la Manutenzione degli aerogeneratori prevede un gran numero di documenti secondo la seguente gerarchia:

Figura 2 Documentazione Vestas

Il Manuale di Uso e Manutenzione parte dalle specifiche di sicurezza per definire le istruzioni delle singole operazioni di manutenzione a sua volta correlate dalle specifiche ambientali e di sicurezza.

La manutenzione delle macchine richiede l'accesso alle piazzole a base torre. È quindi necessaria una costante manutenzione delle piste e della piazzola predisponendo anche il servizio di sgombero neve nei mesi invernali.

C. MANUALE D'USO DI TUTTI I COMPONENTI DELL'IMPIANTO

Le turbine eoliche sono macchine nel pieno senso e quindi ricadono nel campo di applicazione della direttiva Macchine UE98/37 con successivi aggiornamenti e norme collegate.

La normativa di riferimento per la progettazione e la sicurezza è la CEI-EN 61400-1 ed.3 "Turbine eoliche – Parte 1: Prescrizioni per la progettazione" del febbraio 2006 (recepimento della IEC 61400-1 ed.3 del novembre 2005 "Wind Turbines – Part 1: Design requirements) e norme collegate.

Le turbine vengono progettate, costruite, collaudate, secondo le normative di cui sopra, e vengono sottoposte nel loro complesso all'esame di enti indipendenti di certificazione, che in caso di esito positivo, emettono differenti certificati. Il più completo, che riassume anche gli altri, è la certificazione di tipo (Type Certificate). Prima di questa vengono verificati il progetto, il sistema e l'organizzazione di costruzione, i materiali.

Per questo motivo il "Manuale d'Uso e Manutenzione" dell'aerogeneratore è un requisito essenziale che raccoglie in dettaglio tutte le operazioni di manutenzione ordinaria e straordinaria di tutti i componenti. La complessità della macchina ed il numero dei vari componenti incorporati rende il documento complessivo così articolato che solo alla consegna del WTG viene fornita la copia specifica per il tipo di macchina.

I contenuti del Manuale possono essere desunti dall'indice generale:

Title	Chapter
Preface	00
Definitions	01
Roles and Responsibility	02
OH&S Programme Management	03
Emergency Response Plan and Procedures	04
Incident Reporting and Investigation	05
Code of Safe Practices – General Safety	06
Fire Protection and Prevention	07
Personal Safety	08
Personal Protective Equipment	09
Work at Height	10
Rules for Electrical Work	11
Working with Hydraulics	12
Rotating Parts	13
Working with Hazardous Materials	14
Tools and Other Equipment	15
Vehicles, Heavy Transport and Lifting Equipment	16
Contractor Health & Safety Requirements	17
Construction and Wind Turbine Site Arrangements	18

Figura 3 Indice Manuale Vestas

D. PROGRAMMA DI MANUTENZIONE

D.1 Generalità

Il programma di manutenzione generale prevede scadenze regolari con intervallo variabile a seconda della tipologia di controllo. Gli intervalli previsti sono:

- Manutenzione iniziale – ad 1 mese dall'entrata in funzione;
- Manutenzione semestrale;
- Manutenzione annuale (o secondo multipli di anno);

In tal modo si ottiene un ottimale livello di efficienza dell'impianto, garantendo costantemente adeguati livelli di sicurezza.

D.2 Aerogeneratore: Parte strutturale

In particolare, le principali azioni riguardanti la torre sono:

- verifica della coppia di serraggio dei bulloni (cadenza annuale);
- controllo visivo dello stato delle lamiere (primo controllo dopo tre anni, successivi con cadenza annuale);
- misura dello spessore della vernice in diverse parti della torre (primo controllo dopo cinque anni e successivi dopo due anni).

Risulta evidente che grazie alla presenza di una squadra di manutenzione sulla macchina ogni semestre, vi sia la possibilità di segnalare eventuali anomalie riscontrate.

D.3 Aerogeneratore: Parte impiantistica

La macchina è controllata periodicamente secondo apposite check-list. In particolare vengono monitorati rumori anomali, controllati i livelli e la qualità dell'olio lubrificante del moltiplicatore, circuiti di raffreddamento e tutta la componentistica elettrica. Verifica visiva della condizione delle pale.

Ogni turbina è munita di apposito registro nel quale vengono annotati tutti gli interventi di manutenzione ordinaria e straordinaria.

D.4 Cabine MT/BT

In materia di impianti elettrici industriali la manutenzione delle cabine MT/BT è sempre più importante.

Quando parliamo di "manutenzione delle cabine elettriche MT/ BT" stiamo facendo riferimento alla normativa CEI 78-17, anche se, è bene sottolineare che in via generale, l'obbligo giuridico della manutenzione, proviene da: Codice Civile, decreti legislativi e da altre norme CEI specifiche per attività.

La manutenzione di una cabina elettrica consiste nelle operazioni necessarie per poter garantire (nel tempo) l'efficienza degli impianti, evitando di conseguenza guasti che potrebbero essere critici oltre che per la produttività, anche per la sicurezza dell'operatore.

Il suo principale scopo è quello di assicurare la conformità a regola d'arte degli impianti (e secondo le condizioni di progetto), per questo, è fondamentale che la manutenzione sia effettuata con regolare periodicità.

La manutenzione delle cabine MT/BT si applica sia agli utenti passivi che attivi ed è bene ricordare che se fatta con costanza riduce i costi di gestione delle cabine, allontanando la possibilità di perdite.

Si tratta quindi di un fattore strategico utile alla competitività di impresa, dove efficienza produttiva e qualità del prodotto sono considerate priorità.

La CEI 78-17 individua due principali tipi di manutenzione di cabine MT/BT:

- Preventiva
- Correttiva

La manutenzione preventiva è finalizzata a contenere il degrado dei componenti e a far fronte ad eventuali incidenti che comportino la necessità di primi interventi, questo a significare che l'operatore interverrà in anticipo sull'impianto, non modificando quella che è la sua struttura essenziale o la sua destinazione d'uso.

La manutenzione correttiva invece, viene attuata per risolvere eventuali danneggiamenti, è utile al ripristino delle condizioni ordinarie di utilizzo e non va a modificare in modo sostanziale l'impianto.

Ogni risorsa che si occupa di manutenzione deve essere preparata per questa attività in modo approfondito, conoscendo ogni tipologia di impianto e venendo sottoposta periodicamente a formazione e verifiche.

Per poter monitorare gli interventi di manutenzione e farne una valutazione complessiva, la normativa prevede la redazione di precise "schede manutentive" che una volta realizzate diventeranno parte di un fascicolo di manutenzione.

Gli elementi che vengono richiesti nella compilazione delle schede sono dieci:

- la data di entrata in servizio della cabina elettrica (insieme alla data di costruzione)
- la data in cui avviene l'intervento manutentivo
- il numero identificativo della cabina MT/BT cui si riferisce la scheda
- la codifica o il n. progressivo della scheda
- il titolo riferito all'unità funzionale e/o elemento da esaminare ai fini della manutenzione
- la descrizione sintetica delle verifiche o degli interventi da eseguire sull'elemento
- la periodicità massima

- l'esito dell'intervento
- la firma del manutentore
- le ulteriori note informative (se necessarie)

Solitamente per predisporre queste schede, occorre richiamare i manuali tecnici e le schede di manutenzione create dal fornitore delle varie componenti e apparecchiature.

Dal 01 gennaio 2020 si è passati dalla norma CEI 0-15, abrogata, alla norma CEI 78-17 (variante V1), la quale modifica le periodicità dei controlli (come riportato nella Tabella A CEI 78-17) mantenendo invariate le schede di manutenzione.

Tabella A - Cabina MT/BT con i requisiti semplificati. Interventi di manutenzione per i quali è cambiata la periodicità.

Tipo di scheda	*Numero riga della scheda*	*Intervento*	*Periodicità (anni)*	
			Vecchia (CEI 0-15)	*Nuova (CEI 78-17 V1)*
Scheda F Esame del fabbricato	1	Muri e tetto relativi alla cabina - Verifiche/interventi: integrità dei muri, degli intonaci e del tetto, infiltrazioni di acqua, umidità	1	5
	11	Barriere tagliafiamma - Verifiche/interventi: controllo dell'esistenza e/o integrità	1	2
Scheda S Sezionatore e sezionatore sotto carico MT, fusibili MT	10	Sez. - Sez. sotto carico - Verifiche/operazioni: funzionalità dei blocchi e interblocchi elettrici e meccanici e manovre relative	1	5
	11	Sez. - Sez. sotto carico - Verifiche/operazioni: ingrassaggio contatti fissi e mobili con esclusione di quelli d'arco	1	5
	12	Sez. - Sez. sotto carico - Verifiche/operazioni: inserzione delle lame di contatto IMS e ST	1	5
	13	Sez. - Sez. sotto carico - Fusibili MT - Verifiche/operazioni: controllo serraggio delle connessioni	1	5
Scheda TR - L Esame del trasformatore in olio	1	TR – L - Verifiche/interventi: controllo dati di targa e tipo di liquido isolante	1	5
	3	TR – L - Verifiche /interventi: controllo presenza dispositivi contro la dispersione liquido	1	5
Scheda QMT Esame del quadro MT	4	QMT - Verifiche/interventi: controllo serraggio della bulloneria	- (1)	1
	5	QMT - Verifiche/interventi: controllo aperture per passaggio cavi e tamponature	1	3
	7	QMT - Verifiche/interventi: controllo blocchi e interblocchi	1	2
Scheda IVOR Esame interruttore a volume d'olio ridotto	6	IVOR - Verifiche/interventi: pulizia e lubrificazione dei meccanismi di comando	1	3
	7	IVOR - Verifiche/interventi: regolazione del meccanismo di comando, se necessario	1	3
	9	IVOR - Verifiche/interventi: funzionalità relè diretto	1	3
Scheda ISV Esame dell'interruttore sotto vuoto	4	ISV - Verifiche/interventi: pulizia e lubrificazione meccanismi di comando	1	2
	5	ISV - Verifiche/interventi: regolazione del comando	1	5
	6	ISV - Verifiche/interventi: verifica tempi di apertura e chiusura, ad esempio con oscilloscopio	1	5
	9	ISV - Verifiche/interventi: verifica funzionalità relè diretto da TA integrati, impostazioni regolazioni	1	5
	10	ISV - Verifiche/interventi: verifica funzionalità relè indiretto, impostazione regolazioni	1	5
Scheda ISF_6 Esame dell'interruttore in SF_6	5	ISF_6 - Verifiche/interventi: pulizia e lubrificazione meccanismi di comando	1	2
	6	ISF_6 - Verifiche/interventi: regolazione del comando	1	5
	10	ISF_6 - Verifiche/interventi: verifica funzionalità relè diretto da TA integrati, impostazione regolazioni	1	5
	11	ISF_6 - Verifiche/interventi: verifica funzionalità relè indiretto, impostazione regolazioni	1	5

(1) La norma CEI 0-15 non riportava la periodicità per un errore di stampa.

E. ALLEGATI

[1] 0067-7065_V10 - Performance Specification V136-4.0_4.2MW

[2] 0081-5098_V01 - Performance Specification V162-5.6 MW

[3] “Medium Voltage Systems” – Prysmian Cavi e Sistemi Energia Srl

Restricted
Document no.: 0067-7065 V10
2021-04-23

Performance Specification

V136-4.0/4.2 MW 50/60 Hz

Vestas Wind Systems A/S · Hedeager 42 · 8200 Aarhus N · Denmark · www.vestas.com

Table of contents

Recipient acknowledges that (i) this Performance Specification is provided for recipient's information only, and, does not create or constitute a warranty, guarantee, promise, commitment, or other representation (Commitment) by Vestas Wind Systems or any of its affiliated or subsidiary companies (Vestas), all of which are disclaimed by Vestas and (ii) any and all Commitments by Vestas to recipient as to this Performance Specification (or any of the contents herein) are to be contained exclusively in signed written contracts between recipient and Vestas, and not within this document.

See general reservations, notes and disclaimers (including, Section 5, p. 12) to this Performance Specification.

1 General Description

The Vestas V136-4.0/4.2 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V136-4.0/4.2 MW turbine has a rotor diameter of 136 m and a rated power of 4.0 MW.

Vestas offers an optional Power Optimized (PO) mode at 4.2 MW for the V136-4.0 MW variant.

2 Type Approvals and Available Hub Heights

The standard turbine is type certified according to the certification standards and available hub heights listed below:

Certification	Wind Class	Hub Height	
Tower type		**Standard**	**Large diameter (split)**
IEC61400-22	IEC IIB	105 m(1) / 112 m / 117 m(1)	
	IEC IIIB		
DIBt 2012	WZ4(S), GK2	112 m	
	WZ2(S), GK2		149 m / 166 m

Table 2-1: Type approval data and available hub heights

(1): Special transport optimized tower for US/Canada.

The hub height can be increased by up to 3 m by use of raised foundation. Use of raised foundation is subject to site-specific evaluation and is not available for all soil conditions.

3 Operational Envelope and Performance Guidelines

Actual climate and site conditions have many variables and should be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section does not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

3.1 Climate and Site Conditions

The standard turbine is designed for the wind climate conditions listed below. Values refer to hub height.

Wind Climate	IEC IIB	IEC IIB S
Hub Height	**105/112/117 m**	**105/112/117 m**
Power Rating	**4.0MW**	**4.2MW**
Extr Wind Speed (10 min average), V_{50}	42.5 m/s	42.5 m/s
Survival Wind Speed (3 s gust), V_{e50}	59.5 m/s	59.5 m/s
Turbulence Intensity, I_{V50}	11%	11%

Table 3-1: Extreme design parameters – IEC

Wind Climate	IEC IIB	IEC IIB S
Hub Height	**105/112/117 m**	**105/112/117 m**
Power Rating	**4.0MW**	**4.2MW**
Wind Speed (10 min average), V_{ave}	8.5 m/s	8.0 m/s
Weibull Scale Factor, C	9.6 m/s	8.9 m/s
Weibull Shape Factor, k	2.0	2.0
I_{ref} acc. to IEC 61400-1	0.14	0.14
Turbulence Intensity acc. to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s) I_{90} (90% quantile)	15.7%	15.7%
Wind Shear, α	0.20	0.20
Inflow Angle (vertical)	8°	8°

Table 3-2: Average design parameters – IEC

Wind Climate / Terrain Category	WZ4(S), GK2	WZ2(S), GK2	WZ2(S), GK2
Hub Height	**112 m**	**149 m**	**166 m**
Power Rating	**4.0/4.2MW**	**4.0/4.2MW**	**4.0/4.2MW**
Extr Wind Speed (10 min average), V_{50}	42.5 m/s	38.5 m/s	39.2 m/s
Survival Wind Speed (3 s gust), V_{e50}	59.5 m/s	53.9 m/s	54.9 m/s
Turbulence intensity, $I_{v(z)}$	12.9%	12.3%	12.1%

Table 3-3: Extreme design parameters – DIBt

Wind Climate / Terrain Category	WZ4(S), GK2	WZ2(S), GK2	WZ2(S), GK2
Hub Height	**112 m**	**149 m**	**166 m**
Power Rating	**4.0/4.2MW**	**4.0/4.2MW**	**4.0/4.2MW**
Wind Speed (10 min average), V_{ave}	7.95 m/s	7.63 m/s	7.05 m/s
I_{rcf} acc. to IEC 61400-1	0.14	0.14	0.14
Turbulence Intensity acc. to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s) I_{90} (90% quantile)	15.7%	15.7%	15.7%

Table 3-4: Average design parameters – DIBt

3.1.1 Complex Terrain

Classification of complex terrain according to IEC 61400-1:2005 Chapter 11.2. For sites classified as complex, appropriate measures are to be included in site assessment. Positioning of each turbine must be verified via Vestas Site Check.

3.1.2 Altitude

The turbine is designed for use at altitudes up to 1000 m above sea level as standard and optional up to 2000 m above sea level.

3.1.3 Wind Power Plant Layout

Turbine spacing is to be evaluated site-specifically. Spacing below two rotor diameters (2D) may require sector-wise curtailment.

NOTE As evaluation of climate and site conditions is complex, consult Vestas for every project. If conditions exceed the above parameters, Vestas must be consulted.

3.2 Operational Envelope – Wind

Values refer to hub height and are determined by the sensors and control system of the turbine.

Wind climate	**IEC IIB / IEC IIB S**
Hub height	**105 / 112 / 117 m**
Cut-In, V_{in}	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	27.0 m/s
Re-Cut In (10 min exponential avg.)	25.0 m/s

Table 3-5: Operational envelope – wind – IEC

Wind climate	**WZ4(S)**	**WZ2(S)**
Hub height	**112 m**	**149 / 166 m**
Cut-In, V_{in}	3 m/s	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	27.0 m/s	27.0 m/s
Re-Cut In (10 min exponential avg.)	25.0 m/s	25.0 m/s

Table 3-6: Operational envelope – wind – DIBt

3.3 Operational Envelope – Wind (HWO)

Optionally, the turbine can be offered with the High Wind Operation (HWO) control feature. The HWO control feature allows the turbine to operate up to the extended cut-out wind speeds listed in Table 3-7, p. 8 and Table 3-8, p. 8, with a controlled derating of power and speed. The power curves associated with optional HWO control are found in Sections 7, 9, 11, 13, 15, 17 and 19. Values refer to hub height and are determined by the sensors and control system of the turbine.

Wind climate	IEC IIB / IEC IIB S
Hub height	**105 / 112 / 117 m**
Cut-In, V_{in}	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	32.0 m/s
Re-Cut In (10 min exponential avg.)	30.0 m/s

Table 3-7: Operational envelope – wind – IEC (High Wind Operation)

Wind climate	WZ4(S)	WZ2(S)
Hub height	**112 m**	**149 / 166 m**
Cut-In, V_{in}	3 m/s	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	32.0 m/s	32.0 m/s
Re-Cut In (10 min exponential avg.)	30.0 m/s	30.0 m/s

Table 3-8: Operational envelope – wind – DIBt (High Wind Operation)

3.4 Operational Envelope – Conditions for Power Curve and Ct Values (at Hub Height)

Consult Section 6 and following sections for power curves and C_t values.

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear, α	0.00-0.30 (10 minute average)
Turbulence Intensity, I	6-12% (10 minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Voltage	Nominal Voltage ±2.5%
Grid Frequency	Nominal Frequency ±0.5 Hz
Grid Active Power (at LV-side of turbine transformer)	As per tabulated values from Section 6 and onwards
Grid Reactive Power (at LV-side of turbine transformer)	Power Factor 1.0

Table 3-9: Conditions for power curve and Ct values

3.5 Sound Modes

The sound modes listed below are available for the turbine.

Sound modes			
Mode No.	**Maximum Sound Level**	**Serrated trailing edges**	**Available hub heights**
0	103.9 dBA	Yes (standard)	105 / 112 / 117 / 149 / 166 m
0-0S	106.9 dBA	No (option)	105 / 112 / 117 / 149 / 166 m
PO1	103.9 dBA	Yes (standard)	105 / 112 / 117 / 149 / 166 m
PO1-0S	106.9 dBA	No (option)	105 / 112 / 117 / 149 / 166 m

Table 3-10: Available sound performance

NOTE The turbine is as standard equipped with serrated trailing edges on the blades. Optionally, Mode 0-0S can be offered without serrated trailing edges mounted on the blades.

In addition, Sound Optimized (SO) modes as listed below are available as options for the turbine.

Sound Optimized (SO) modes			
Mode No.	**Maximum Sound Level**	**Serrated trailing edges**	**Available hub heights**
SO1	102.0 dBA	Yes	105 / 112 / 117 / 149 / 166 m
SO2	99.5 dBA	Yes	105 / 112 / 117 / 149 / 166 m
SO11	99.2 dBA	Yes	112 m(1)
SO12	99.9 dBA	Yes	112 m(1)
SO13	97.0 dBA	Yes	112 m(1)

Table 3-11: Available Sound Optimized modes

(1): SO11, SO12, SO13 is not applicable for DIBt towers

NOTE Sound Optimized (SO) modes are only available with serrated trailing edges on the blades. For further details on sound performance and in case of specific requests for sound modes per tower, please contact Vestas Wind Systems A/S.

3.6 Load Modes

The Load Optimized (LO) modes listed below are available for the turbine.

Load Optimized (LO) modes				
Mode No.	**Power**	**Maximum Sound Level**	**Serrated trailing edges**	**Available hub heights**
LO1	3.8 MW	103.9 dBA	Yes	105 / 112 / 117 / 149 / 166 m
LO2	3.6 MW	103.9 dBA	Yes	105 / 112 / 117 m

Table 3-12: Available Load Optimized modes

NOTE Load Optimized (LO) modes are only available with serrated trailing edges mounted on the blades.

4 Drawings

4.1 Structural Design – Illustration of Outer Dimensions

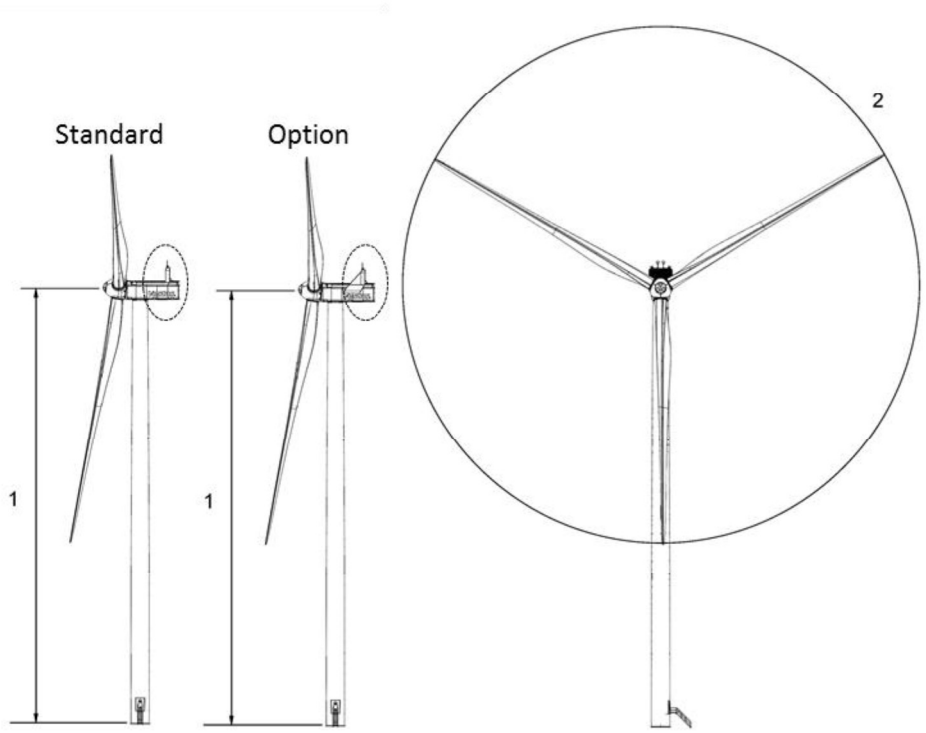


Figure 4-1: Illustration of outer dimensions – structure

1 Hub height:
105/112/117/149/166 m

2 Diameter:
136 m

NOTE The turbine to the right is shown with side panels on the cooler top (Option).

5 General Reservations, Notes and Disclaimers

-
- The performance specifications described in this document apply to the current version of the V136-4.0/4.2 MW wind turbine. Updated versions of the V136-4.0/4.2 MW wind turbine, which may be manufactured in the future, may differ from these performance specifications. In the event that Vestas supplies an updated version of the V136-4.0/4.2 MW wind, Vestas will provide an updated performance specification applicable to the updated version.
- All listed start/stop parameters (e.g. wind speeds) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- This document, Performance Specification, is not an offer for sale, and does not contain any guarantee, warranty and/or verification of the power curve and sound (including, without limitation, the power curve and sound verification method). Any guarantee, warranty and/or verification of the power curve and sound (including, without limitation, the power curve and sound verification method) must be agreed to separately in writing.

6 Power Curves, Ct Values and Sound Curves, Mode 0/0-0S

NOTE The power curves and Ct values presented in Section 6 are not valid for hub heights ≤ 104 m. For hub heights ≤ 104 m, Vestas must be consulted for project specific evaluation.

6.1 Power Curves, Mode 0/0-0S

Air density [kg/m³]														
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	**57**	32	35	37	39	41	43	46	48	50	52	55	59	61
3.5	**132**	91	95	99	102	106	110	114	117	121	125	128	136	140
4.0	**224**	162	168	173	179	185	190	196	201	207	213	218	229	235
4.5	**337**	250	258	265	273	281	289	297	305	313	321	329	344	352
5.0	**478**	358	369	380	391	402	413	423	434	445	456	467	488	499
5.5	**648**	490	505	519	533	548	562	576	591	605	619	633	662	676
6.0	**853**	649	668	687	705	724	742	761	779	798	816	835	872	890
6.5	**1096**	838	861	885	908	932	955	979	1002	1026	1049	1072	1119	1142
7.0	**1380**	1059	1088	1118	1147	1176	1206	1235	1264	1293	1322	1351	1410	1439
7.5	**1704**	1312	1347	1383	1419	1455	1491	1526	1562	1598	1633	1668	1739	1774
8.0	**2070**	1600	1643	1686	1730	1773	1816	1858	1901	1944	1986	2028	2112	2153
8.5	**2472**	1924	1975	2026	2077	2128	2178	2228	2278	2327	2376	2424	2520	2567
9.0	**2874**	2273	2330	2388	2446	2504	2558	2612	2667	2721	2772	2823	2923	2972
9.5	**3238**	2621	2681	2742	2803	2864	2919	2975	3030	3085	3136	3187	3286	3334
10.0	**3566**	2950	3011	3073	3135	3196	3251	3307	3362	3418	3467	3517	3610	3655
10.5	**3821**	3252	3314	3376	3438	3500	3552	3604	3656	3708	3746	3784	3849	3876
11.0	**3954**	3526	3582	3638	3694	3750	3787	3824	3861	3898	3916	3935	3964	3975
11.5	**3992**	3757	3797	3837	3877	3917	3932	3948	3963	3978	3983	3988	3994	3996
12.0	**3999**	3912	3929	3946	3964	3981	3985	3989	3993	3997	3998	3998	3999	4000
12.5	**4000**	3974	3979	3985	3991	3996	3997	3998	3999	4000	4000	4000	4000	4000
13.0	**4000**	3993	3994	3996	3998	3999	4000	4000	4000	4000	4000	4000	4000	4000
13.5	**4000**	3995	3996	3997	3998	3999	4000	4000	4000	4000	4000	4000	4000	4000
14.0	**4000**	3998	3999	3999	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
14.5	**4000**	3999	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
15.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
15.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
25.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
25.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
26.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
26.5	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
27.0	**4000**	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000

Table 6-1: Power curve, Mode 0/0-0S

6.2 Ct Values, Mode 0/0-0S

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.878**	0.883	0.882	0.882	0.882	0.881	0.881	0.880	0.880	0.880	0.879	0.879	0.878	0.878
3.5	**0.852**	0.855	0.855	0.855	0.855	0.854	0.854	0.854	0.853	0.853	0.853	0.852	0.851	0.851
4.0	**0.852**	0.859	0.857	0.856	0.855	0.853	0.853	0.853	0.853	0.853	0.853	0.852	0.852	0.853
4.5	**0.855**	0.854	0.854	0.855	0.855	0.855	0.855	0.856	0.856	0.856	0.856	0.856	0.855	0.855
5.0	**0.851**	0.855	0.855	0.855	0.855	0.854	0.854	0.853	0.853	0.853	0.852	0.852	0.851	0.850
5.5	**0.846**	0.852	0.852	0.851	0.851	0.850	0.850	0.849	0.849	0.848	0.848	0.847	0.846	0.846
6.0	**0.841**	0.847	0.847	0.846	0.846	0.845	0.845	0.844	0.844	0.843	0.842	0.842	0.840	0.840
6.5	**0.835**	0.843	0.842	0.842	0.841	0.840	0.840	0.839	0.838	0.837	0.837	0.836	0.834	0.833
7.0	**0.828**	0.838	0.837	0.836	0.835	0.834	0.833	0.832	0.832	0.831	0.830	0.829	0.827	0.826
7.5	**0.821**	0.832	0.831	0.830	0.829	0.828	0.827	0.826	0.825	0.824	0.823	0.822	0.820	0.818
8.0	**0.822**	0.837	0.836	0.835	0.834	0.833	0.831	0.830	0.829	0.827	0.826	0.824	0.821	0.819
8.5	**0.802**	0.838	0.836	0.833	0.831	0.828	0.825	0.821	0.818	0.814	0.810	0.806	0.798	0.793
9.0	**0.745**	0.810	0.805	0.800	0.795	0.790	0.784	0.777	0.771	0.765	0.759	0.752	0.739	0.732
9.5	**0.673**	0.753	0.746	0.738	0.731	0.724	0.717	0.709	0.702	0.694	0.687	0.680	0.666	0.659
10.0	**0.606**	0.687	0.679	0.671	0.663	0.656	0.648	0.641	0.634	0.627	0.620	0.613	0.599	0.591
10.5	**0.541**	0.625	0.618	0.610	0.603	0.595	0.588	0.581	0.573	0.566	0.557	0.549	0.532	0.523
11.0	**0.471**	0.570	0.561	0.553	0.545	0.537	0.528	0.519	0.510	0.501	0.491	0.481	0.461	0.451
11.5	**0.404**	0.517	0.507	0.498	0.488	0.478	0.467	0.456	0.446	0.435	0.425	0.414	0.395	0.386
12.0	**0.348**	0.463	0.451	0.439	0.428	0.416	0.406	0.395	0.385	0.374	0.365	0.357	0.340	0.332
12.5	**0.302**	0.406	0.395	0.383	0.372	0.361	0.352	0.343	0.333	0.324	0.317	0.309	0.296	0.289
13.0	**0.265**	0.354	0.344	0.334	0.324	0.315	0.307	0.299	0.292	0.284	0.278	0.271	0.260	0.254
13.5	**0.236**	0.312	0.304	0.295	0.287	0.279	0.272	0.265	0.259	0.252	0.247	0.241	0.231	0.226
14.0	**0.210**	0.276	0.269	0.261	0.254	0.247	0.241	0.236	0.230	0.224	0.220	0.215	0.206	0.202
14.5	**0.188**	0.246	0.239	0.233	0.227	0.221	0.216	0.211	0.206	0.201	0.197	0.192	0.185	0.181
15.0	**0.169**	0.219	0.214	0.208	0.203	0.197	0.193	0.189	0.184	0.180	0.176	0.173	0.166	0.162
15.5	**0.153**	0.198	0.193	0.188	0.183	0.178	0.174	0.170	0.167	0.163	0.159	0.156	0.150	0.147
16.0	**0.139**	0.179	0.175	0.170	0.166	0.162	0.158	0.155	0.151	0.148	0.145	0.142	0.136	0.134
16.5	**0.127**	0.163	0.159	0.155	0.151	0.147	0.144	0.141	0.138	0.135	0.132	0.129	0.125	0.122
17.0	**0.116**	0.149	0.145	0.142	0.138	0.135	0.132	0.129	0.126	0.123	0.121	0.119	0.114	0.112
17.5	**0.107**	0.136	0.133	0.130	0.127	0.123	0.121	0.118	0.116	0.113	0.111	0.109	0.105	0.103
18.0	**0.098**	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
18.5	**0.091**	0.115	0.113	0.110	0.107	0.105	0.103	0.101	0.098	0.096	0.095	0.093	0.089	0.088
19.0	**0.084**	0.106	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.086	0.082	0.081
19.5	**0.078**	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.084	0.083	0.081	0.080	0.077	0.075
20.0	**0.073**	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
20.5	**0.068**	0.085	0.083	0.081	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.066
21.0	**0.064**	0.080	0.078	0.076	0.074	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061
21.5	**0.060**	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.059	0.058
22.0	**0.057**	0.070	0.069	0.067	0.066	0.064	0.063	0.062	0.061	0.060	0.059	0.058	0.056	0.055
22.5	**0.053**	0.066	0.065	0.063	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.052
23.0	**0.050**	0.062	0.061	0.059	0.058	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.048
23.5	**0.047**	0.058	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046
24.0	**0.045**	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.046	0.044	0.043
24.5	**0.042**	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.045	0.044	0.043	0.042	0.041
25.0	**0.040**	0.049	0.048	0.047	0.046	0.045	0.045	0.044	0.043	0.042	0.042	0.041	0.040	0.039
25.5	**0.039**	0.047	0.046	0.045	0.044	0.043	0.043	0.042	0.041	0.040	0.040	0.039	0.038	0.037
26.0	**0.037**	0.045	0.044	0.043	0.042	0.041	0.041	0.040	0.039	0.038	0.038	0.037	0.036	0.036
26.5	**0.035**	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.037	0.036	0.036	0.034	0.034
27.0	**0.033**	0.041	0.040	0.039	0.038	0.038	0.037	0.036	0.036	0.035	0.034	0.034	0.033	0.033

Table 6-2: C_t values, Mode 0/0-0S

6.3 Sound Curves, Mode 0/0-0S

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Mode 0 (Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA]** **Mode 0-0S (Blades without serrated trailing edge)**
3	90.9	93.2
4	91.1	93.6
5	92.9	96.5
6	96.0	100.0
7	99.6	103.2
8	102.9	106.0
9	103.9	106.9
10	103.9	106.9
11	103.9	106.9
12	103.9	106.9
13	103.9	106.9
14	103.9	106.9
15	103.9	106.9
16	103.9	106.9
17	103.9	106.9
18	103.9	106.9
19	103.9	106.9
20	103.9	106.9

Table 6-3: Sound curves, Mode 0/0-0S

Restricted
Document no.: 0081-5098 V01
2019-01-24

Performance Specification

EnVentus™ 5 MW

V162-5.6 MW 50/60 Hz

Vestas Wind Systems A/S · Hedeager 42 · 8200 Arhus N · Denmark · www.vestas.com

Table of contents

Recipient acknowledges that (i) this Performance Specification is provided for recipient's information only, and, does not create or constitute a warranty, guarantee, promise, commitment, or other representation (Commitment) by Vestas Wind Systems or any of its affiliated or subsidiary companies (Vestas), all of which are disclaimed by Vestas and (ii) any and all Commitments by Vestas to recipient as to this Performance Specification (or any of the contents herein) are to be contained exclusively in signed written contracts between recipient and Vestas, and not within this document.

See general reservations, notes and disclaimers (including, Section 5, p. 13) to this Performance Specification.

1 General Description

The Vestas V162-5.6 MW is a wind turbine variant within the EnVentus™ 5 MW turbine range. It is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The V162-5.6 MW turbine has a rotor diameter of 162 m and a rated power of 5.6 MW.

For more details, please refer to the General Description of the EnVentus™ 5MW turbine range (General Description EnVentus™ 5 MW - 0081-5017).

2 Type Approvals and Available Hub Heights

The standard turbine is type certified according to the certification standards and available hub heights listed below:

Certification	Wind Class	Hub Height
IEC 61400-22	IEC S	119 / 125 / 149 m
DIBt 2012	DIBt S	119 / 148 / 166 m

3 Operational Envelope and Performance Guidelines

Actual climate and site conditions have many variables and should be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

3.1 Climate and Site Conditions

The standard turbine is designed for the wind climate conditions listed below. Values refer to hub height.

Wind Climate	**IEC S**	**IEC S**	**IEC S**
Power Rating	**5.6 MW**	**5.6 MW**	**5.6 MW**
Hub Height	**119**	**125**	**149**
Average design parameters - IEC			
Wind Speed (10 min average), V_{ave}	7.4 m/s	8.5 m/s	7.9 m/s
Weibull Scale Factor, *C*	8.4 m/s	9.6 m/s	8.9 m/s
Weibull Shape Factor, *k*	2.48	2.3	2.48
I_{ref} acc. to IEC 61400-1	0.15	0.14	0.15
Turbulence Intensity acc. to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s) I_{90} (90% quantile)	16.9%	15.7%	16.9 %
Wind Shear, *α*	0.30	0.20	0.30
Inflow Angle (vertical)	8°	8°	8°
Extreme design parameters – IEC			
Extr. Wind Speed (10 min average), V_{50}	37.1 m/s	37.5 m/s	39.5 m/s
Survival Wind Speed (3 s gust), V_{e50}	51.9 m/s	52.5 m/s	55.3 m/s
Turbulence Intensity, I_{V50}	11%	11 %	11 %

Wind Class	DIBt S	DIBt S	DIBt S
Hub Height	**119 m**	**148 m**	**166 m**
Power Rating	**5.6 MW**	**5.6 MW**	**5.6 MW**
Average design parameters – DIBt			
Wind Speed (10 min average), V_{ave}	7.1 m/s	7.3 m/s	7.5 m/s
I_{ref} acc. to IEC 61400-1	S	S	S
Turbulence Intensity, I_{90} (90% quant.)	S	S	S
Extreme design parameters – DIBt			
Extr Wind Speed (10 min average), V_{50}	39.4 m/s	37.0 m/s	37.6 m/s
Survival Wind Speed (3 s gust), V_{e50}	55.2 m/s	51.8 m/s	52.6 m/s
Turbulence intensity, $I_{v(z)}$	12.8%	12.3%	12.1%
Wind Shear, α	0.20	0.20	0.20
Inflow Angle	8°	8°	8°

NOTE The turbine is intended for low to medium wind speed sites and is classified as DIBt S. Please contact Vestas Wind Systems A/S for further information if needed.

3.1.1 Wind Power Plant Layout

Turbine spacing is to be evaluated site-specifically. Spacing below two rotor diameters (2D) may require sector-wise curtailment.

NOTE As evaluation of climate and site conditions is complex, consult Vestas for every project. If conditions exceed the above parameters, Vestas must be consulted.

3.2 Operational Envelope – Wind

Values refer to hub height and are determined by the sensors and control system of the turbine.

Wind Climate	IEC S / DIBt S	
	Mode 0	SO2, SO3, SO4, SO5, SO6
Cut-In, V_{in}	3 m/s	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	24 m/s	20 m/s
Re-Cut In (10 min exponential avg.)	22 m/s	18 m/s

3.3 Operational Envelope – Temperature and Altitude

Values below refer to hub height and are determined by the sensors and control system of the turbine.

Operational Envelope – Temperature	
Ambient Temperature Interval (Standard Turbine)	-20° to +45°C
Ambient Temperature Interval (Low Temperature Turbine)	-30° to +45°C

NOTE The wind turbine will stop producing power at ambient temperatures above 45°C. For the low temperature options of the wind turbine consult Vestas.

The turbine is designed for use at altitudes up to 1000 m above sea level as standard and optional up to 2000 m above sea level.

3.3.1 Temperature dependent operation

Values below refer to hub height and are determined by the sensors and control system of the turbine. At ambient temperatures above the thresholds shown for each operating mode, the turbine will maintain derated production.

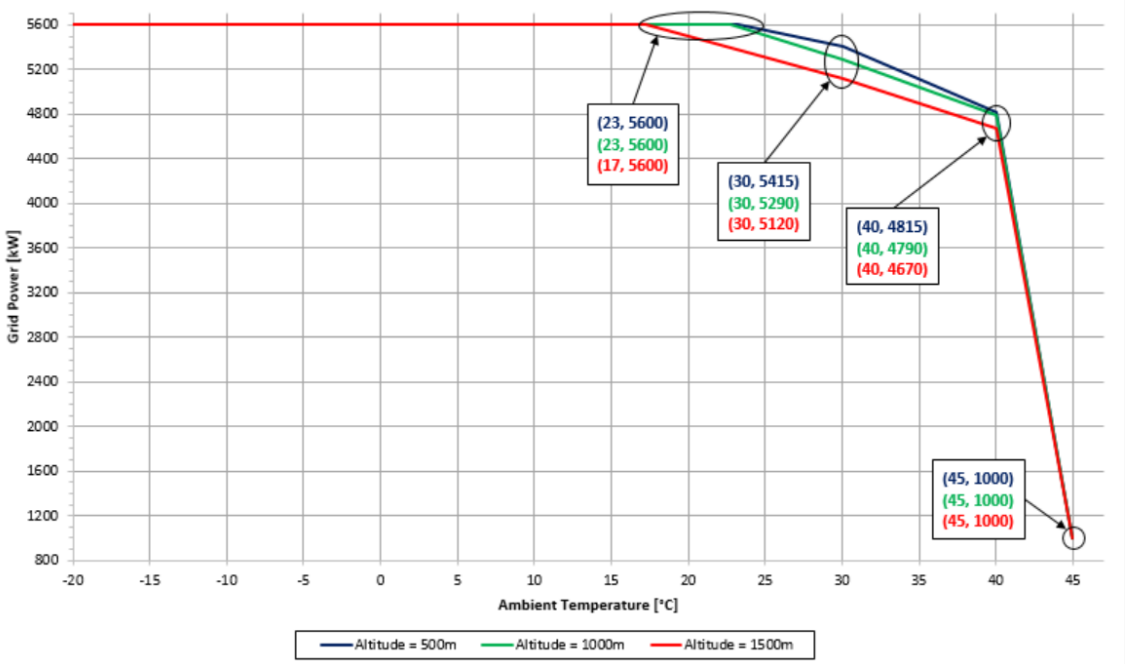


Figure 3-1: Temperature dependant derated operation.

NOTE All derating settings are preliminary and subject to change.

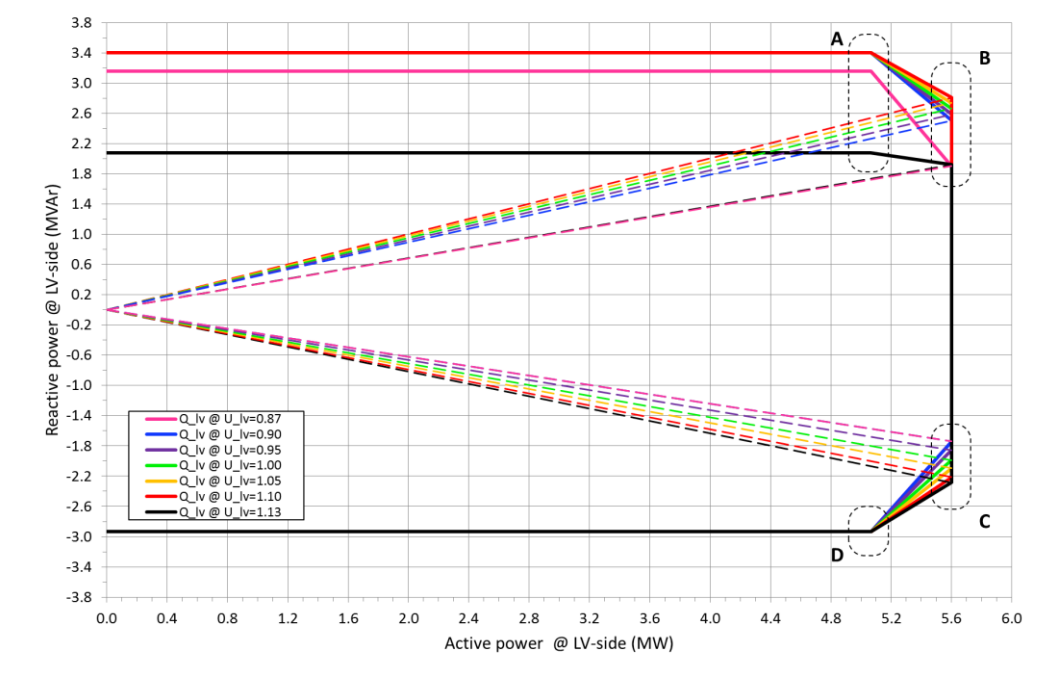
3.4 Operational Envelope – Conditions for Power Curve and Ct Values (at Hub Height)

Please consult section 6 and subsequent, for power curves and C_t values.

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear, *α*	0.00-0.30 (10-minute average)
Turbulence Intensity, *I*	6-12% (10-minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Voltage	Nominal Voltage ±2.5%
Grid Frequency	Nominal Frequency ±0.5 Hz
Grid Active Power (LV-side)	Per tabulated values in Section 6 and following sections
Grid Reactive Power (LV-side)	Power Factor 1.0

3.5 Operational Envelope – Reactive Power Capability

The turbine has a reactive power capability on the low voltage side of the HV transformer as illustrated in Figure 3-2:



		Coordinates								Power factor	
	Point:	A		B		C		D		B (Capacitive)	C (Inductive)
	Coordinate:	x (P)	y (Q)	x (P)	y (Q)	x (P)	y (Q)	x (P)	y (Q)		
	Reactive power [kVAr] @ LV side @ U_lv = 0.87 p.u. voltage	5.067	3.160	5.600	1.900	5.600	-1.739	5.067	-2.933	0.947	0.955
	Reactive power [kVAr] @ LV side @ U_lv = 0.90 p.u. voltage	5.067	3.400	5.600	2.503	5.600	-1.739	5.067	-2.933	0.913	0.955
	Reactive power [kVAr] @ LV side @ U_lv = 0.95 p.u. voltage	5.067	3.400	5.600	2.584	5.600	-1.856	5.067	-2.933	0.908	0.949
	Reactive power [kVAr] @ LV side @ U_lv = 1.00 p.u. voltage	5.067	3.400	5.600	2.664	5.600	-1.987	5.067	-2.933	0.903	0.942
	Reactive power [kVAr] @ LV side @ U_lv = 1.05 p.u. voltage	5.067	3.400	5.600	2.736	5.600	-2.093	5.067	-2.933	0.898	0.937
	Reactive power [kVAr] @ LV side @ U_lv = 1.10 p.u. voltage	5.067	3.400	5.600	2.807	5.600	-2.213	5.067	-2.933	0.894	0.930
	Reactive power [kVAr] @ LV side @ U_lv = 1.13 p.u. voltage	5.067	2.080	5.600	1.919	5.600	-2.283	5.067	-2.933	0.946	0.926

Figure 3-2: Reactive power capability.

The turbine is able to maintain the reactive power capability at low wind with no active power production.

NOTE

All reactive power capabilities are preliminary and subject to change.

3.6 Sound Modes

The sound modes listed below are available for the turbine.

Sound modes			
Mode No.	**Maximum Sound Level**	**Serrated trailing edges**	**Available hub heights**
0	104 dBA	Yes (standard)	119 / 125 / 148 / 149 / 166 m
0-0S	106.8 dBA	No (option)	119 / 125 / 148 / 149 / 166 m

In addition, Sound Optimized (SO) modes as listed below are available as options for the turbine.

Sound Optimized (SO) modes			
Mode No.	**Maximum Sound Level**	**Serrated trailing edges**	**Available hub heights**
SO2	102 dBA	Yes (standard)	119 / 125 / 148 / 149 / 166 m
SO3	101 dBA	Yes (standard)	119 / 125 / 148 / 149 / 166 m
SO4	100 dBA	Yes (standard)	119 / 125 / 148 / 149 / 166 m
SO5	99 dBA	Yes (standard)	119 / 125 / 148 / 149 / 166 m
SO6	98 dBA	Yes (standard)	Site specific

NOTE Sound Optimized (SO) modes are only available with serrated trailing edges on the blades. For further details on sound performance and in case of specific requests, please contact Vestas Wind Systems A/S.

4 Drawings

Overview drawings describing the wind turbines, tower and foundation are shown in these documents.

V162 HH119 – 0075-8518
V162 HH125 – 0079-6651
V162 HH148 – 0075-8517
V162 HH149 – 0079-6675
V162 HH166 – 0075-8514

NOTE For detailed drawings, please contact Vestas Wind Systems A/S.

4.1 Turbine visual impression – side view

5 General Reservations, Notes and Disclaimers

- The performance specifications described in this document apply to the current version of the V162-5.6 MW wind turbine. Updated versions of the V162-5.6 MW wind turbine, which may be manufactured in the future, may differ from these performance specifications. In the event that Vestas supplies an updated version of the V162-5.6 MW wind turbine, Vestas will provide an updated performance specification applicable to the updated version.
- All listed start/stop parameters (e.g. wind speeds) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- This document, Performance Specification, is not an offer for sale, and does not contain any guarantee, warranty and/or verification of the power curve and sound (including, without limitation, the power curve and sound verification method). Any guarantee, warranty and/or verification of the power curve and sound (including, without limitation, the power curve and sound verification method) must be agreed to separately in writing.

6 Power Curves, Ct Values and Sound Curves, Mode 0

6.1 Power Curves, Mode 0

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**27**	9	10	12	13	15	16	18	20	21	23	25	29	32
3.5	**144**	91	95	100	105	110	115	120	125	129	134	139	149	153
4.0	**289**	205	212	220	228	235	243	251	258	266	274	281	297	304
4.5	**464**	341	352	363	375	386	397	408	419	430	441	452	475	486
5.0	**669**	502	517	532	547	563	578	593	608	624	639	654	685	700
5.5	**919**	693	714	734	755	775	796	816	837	857	878	899	940	960
6.0	**1220**	925	952	979	1005	1032	1059	1086	1113	1139	1166	1193	1246	1273
6.5	**1574**	1200	1235	1269	1303	1337	1371	1405	1439	1473	1506	1540	1608	1641
7.0	**1990**	1525	1567	1610	1652	1694	1737	1779	1821	1864	1906	1948	2032	2074
7.5	**2467**	1896	1948	2000	2052	2104	2156	2208	2260	2312	2364	2415	2519	2570
8.0	**3010**	2319	2382	2445	2508	2571	2634	2697	2760	2822	2885	2948	3073	3135
8.5	**3617**	2794	2869	2945	3020	3095	3170	3245	3320	3394	3469	3543	3690	3764
9.0	**4257**	3313	3401	3489	3577	3665	3751	3836	3922	4008	4091	4174	4337	4418
9.5	**4834**	3851	3947	4043	4139	4235	4324	4414	4504	4593	4673	4753	4903	4973
10.0	**5256**	4377	4475	4572	4670	4767	4846	4924	5002	5080	5139	5198	5301	5346
10.5	**5482**	4852	4934	5016	5098	5180	5233	5285	5338	5390	5421	5451	5499	5516
11.0	**5578**	5238	5294	5349	5405	5460	5483	5506	5528	5551	5560	5569	5583	5588
11.5	**5598**	5460	5485	5509	5533	5558	5565	5573	5581	5589	5592	5595	5598	5599
12.0	**5600**	5548	5558	5568	5578	5589	5591	5594	5597	5599	5600	5600	5600	5600
12.5	**5600**	5576	5582	5587	5592	5598	5598	5599	5599	5600	5600	5600	5600	5600
13.0	**5600**	5587	5590	5594	5597	5600	5600	5600	5600	5600	5600	5600	5600	5600
13.5	**5600**	5593	5595	5597	5598	5600	5600	5600	5600	5600	5600	5600	5600	5600
14.0	**5600**	5595	5596	5598	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600
14.5	**5600**	5596	5597	5598	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600
15.0	**5600**	5597	5598	5598	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600
15.5	**5600**	5597	5598	5599	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600
16.0	**5600**	5598	5598	5599	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600
16.5	**5600**	5598	5599	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600	5600
17.0	**5600**	5599	5599	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600	5600
17.5	**5600**	5599	5599	5599	5600	5600	5600	5600	5600	5600	5600	5600	5600	5600
18.0	**5600**	5594	5595	5596	5597	5598	5598	5598	5598	5599	5599	5599	5600	5600
18.5	**5568**	5528	5532	5536	5540	5544	5548	5551	5555	5558	5562	5565	5571	5574
19.0	**5418**	5335	5343	5351	5359	5367	5374	5381	5388	5396	5403	5410	5425	5432
19.5	**5179**	5073	5082	5091	5100	5110	5120	5129	5139	5149	5159	5169	5189	5199
20.0	**4894**	4796	4804	4812	4820	4828	4837	4846	4855	4864	4874	4884	4903	4913
20.5	**4609**	4516	4525	4533	4541	4549	4558	4566	4575	4584	4592	4601	4618	4628
21.0	**4329**	4242	4250	4257	4265	4272	4280	4288	4295	4303	4312	4320	4338	4346
21.5	**4043**	3960	3967	3974	3982	3989	3996	4004	4011	4019	4027	4035	4051	4059
22.0	**3764**	3689	3696	3702	3709	3715	3722	3729	3736	3744	3750	3757	3772	3780
22.5	**3488**	3414	3420	3425	3431	3437	3444	3451	3458	3465	3473	3480	3495	3501
23.0	**3203**	3133	3139	3145	3151	3156	3164	3170	3178	3184	3191	3197	3209	3214
23.5	**2914**	2849	2855	2860	2866	2872	2878	2885	2891	2897	2903	2909	2920	2926
24.0	**2616**	2551	2556	2562	2567	2573	2579	2585	2591	2598	2604	2610	2622	2627

6.2 Ct Values, Mode 0

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.914**	0.911	0.912	0.913	0.914	0.915	0.915	0.915	0.915	0.915	0.915	0.914	0.913	0.913
3.5	**0.888**	0.894	0.893	0.893	0.893	0.892	0.892	0.891	0.891	0.890	0.890	0.889	0.888	0.887
4.0	**0.851**	0.857	0.856	0.855	0.855	0.854	0.854	0.853	0.853	0.852	0.852	0.852	0.851	0.850
4.5	**0.822**	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
5.0	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
5.5	**0.797**	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
6.0	**0.797**	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
6.5	**0.796**	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.796	0.796	0.796	0.796	0.795
7.0	**0.795**	0.797	0.797	0.797	0.797	0.797	0.796	0.796	0.796	0.796	0.795	0.795	0.794	0.794
7.5	**0.797**	0.800	0.800	0.800	0.799	0.799	0.799	0.799	0.798	0.798	0.798	0.797	0.796	0.796
8.0	**0.796**	0.801	0.800	0.800	0.800	0.799	0.799	0.799	0.798	0.798	0.797	0.797	0.796	0.795
8.5	**0.792**	0.798	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.794	0.794	0.793	0.791	0.790
9.0	**0.766**	0.789	0.788	0.787	0.786	0.785	0.783	0.781	0.778	0.776	0.773	0.770	0.762	0.758
9.5	**0.703**	0.761	0.757	0.753	0.749	0.745	0.739	0.734	0.729	0.723	0.717	0.710	0.695	0.687
10.0	**0.621**	0.713	0.707	0.700	0.693	0.687	0.678	0.669	0.660	0.651	0.641	0.631	0.610	0.599
10.5	**0.531**	0.654	0.644	0.634	0.624	0.614	0.603	0.591	0.580	0.568	0.556	0.543	0.519	0.507
11.0	**0.449**	0.589	0.577	0.564	0.551	0.538	0.525	0.511	0.498	0.485	0.473	0.461	0.438	0.428
11.5	**0.382**	0.515	0.501	0.487	0.473	0.459	0.447	0.435	0.423	0.411	0.402	0.392	0.373	0.364
12.0	**0.328**	0.443	0.430	0.418	0.406	0.393	0.383	0.373	0.363	0.353	0.345	0.337	0.321	0.314
12.5	**0.286**	0.382	0.371	0.361	0.351	0.340	0.332	0.323	0.315	0.307	0.300	0.293	0.280	0.274
13.0	**0.251**	0.332	0.324	0.315	0.306	0.297	0.290	0.283	0.276	0.269	0.263	0.257	0.246	0.241
13.5	**0.223**	0.293	0.285	0.278	0.270	0.262	0.256	0.250	0.244	0.238	0.233	0.228	0.218	0.214
14.0	**0.199**	0.259	0.253	0.246	0.240	0.233	0.228	0.223	0.217	0.212	0.208	0.203	0.195	0.191
14.5	**0.178**	0.232	0.226	0.220	0.214	0.209	0.204	0.199	0.195	0.190	0.186	0.182	0.175	0.171
15.0	**0.161**	0.208	0.203	0.198	0.193	0.187	0.183	0.179	0.175	0.171	0.168	0.164	0.158	0.155
15.5	**0.146**	0.188	0.183	0.179	0.174	0.169	0.166	0.162	0.159	0.155	0.152	0.149	0.143	0.140
16.0	**0.132**	0.170	0.166	0.162	0.158	0.154	0.151	0.147	0.144	0.141	0.138	0.135	0.130	0.128
16.5	**0.121**	0.155	0.151	0.147	0.144	0.140	0.137	0.134	0.131	0.128	0.126	0.123	0.119	0.117
17.0	**0.111**	0.141	0.138	0.135	0.131	0.128	0.126	0.123	0.120	0.118	0.115	0.113	0.109	0.107
17.5	**0.102**	0.130	0.127	0.124	0.121	0.118	0.116	0.113	0.111	0.109	0.107	0.105	0.101	0.099
18.0	**0.095**	0.120	0.117	0.114	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.093	0.091
18.5	**0.087**	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.090	0.089	0.085	0.084
19.0	**0.078**	0.097	0.095	0.093	0.091	0.089	0.087	0.086	0.084	0.082	0.081	0.080	0.077	0.076
19.5	**0.070**	0.086	0.084	0.082	0.081	0.079	0.077	0.076	0.075	0.073	0.072	0.071	0.069	0.068
20.0	**0.062**	0.076	0.074	0.073	0.071	0.070	0.068	0.067	0.066	0.065	0.064	0.063	0.061	0.060
20.5	**0.054**	0.067	0.065	0.064	0.063	0.061	0.060	0.059	0.058	0.057	0.056	0.055	0.054	0.053
21.0	**0.048**	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.051	0.050	0.049	0.048	0.047
21.5	**0.043**	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.045	0.044	0.043	0.042	0.041
22.0	**0.038**	0.046	0.045	0.044	0.043	0.042	0.041	0.041	0.040	0.039	0.039	0.038	0.037	0.037
22.5	**0.033**	0.040	0.039	0.039	0.038	0.037	0.036	0.036	0.035	0.035	0.034	0.034	0.033	0.032
23.0	**0.029**	0.035	0.034	0.034	0.033	0.033	0.032	0.032	0.031	0.031	0.030	0.030	0.029	0.028
23.5	**0.026**	0.031	0.030	0.029	0.029	0.028	0.028	0.028	0.027	0.027	0.026	0.026	0.025	0.025
24.0	**0.022**	0.026	0.026	0.025	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.023	0.022	0.022

6.3 Sound Curves, Mode 0

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Mode 0 (Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA]** **Mode 0-0S (Blades without serrated trailing edge)**
3	93.5	96.3
4	93.7	96.5
5	94.3	97.1
6	97.3	100.1
7	100.2	103.0
8	102.9	105.7
9	104.0	106.8
10	104.0	106.8
11	104.0	106.8
12	104.0	106.8
13	104.0	106.8
14	104.0	106.8
15	104.0	106.8
16	104.0	106.8
17	104.0	106.8
18	104.0	106.8
19	104.0	106.8
20	104.0	106.8

6.4 Power Curves, Sound Optimized Mode SO2

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**27**	9	10	12	13	14	16	18	20	21	23	25	29	32
3.5	**144**	91	95	100	105	110	115	120	125	129	134	139	149	153
4.0	**289**	205	212	220	228	235	243	251	258	266	274	281	297	304
4.5	**464**	341	352	363	375	386	397	408	419	430	441	452	475	486
5.0	**669**	502	517	532	547	563	578	593	608	624	639	654	685	700
5.5	**919**	693	714	734	755	775	796	816	837	857	878	898	939	960
6.0	**1219**	925	952	979	1005	1032	1059	1086	1113	1140	1166	1193	1246	1272
6.5	**1574**	1201	1235	1269	1303	1337	1371	1405	1439	1473	1507	1540	1608	1642
7.0	**1991**	1525	1568	1610	1653	1695	1737	1780	1822	1864	1906	1948	2033	2075
7.5	**2461**	1892	1944	1995	2047	2099	2151	2203	2255	2306	2358	2410	2513	2564
8.0	**2983**	2299	2362	2424	2486	2549	2611	2673	2735	2797	2859	2921	3044	3106
8.5	**3530**	2729	2802	2876	2949	3022	3095	3168	3241	3314	3386	3458	3601	3672
9.0	**4079**	3173	3257	3342	3426	3511	3594	3677	3760	3843	3922	4001	4153	4226
9.5	**4500**	3611	3706	3800	3895	3989	4071	4152	4234	4316	4377	4438	4546	4592
10.0	**4745**	4028	4120	4212	4304	4396	4457	4518	4579	4640	4675	4710	4766	4787
10.5	**4860**	4381	4453	4526	4599	4672	4707	4743	4779	4815	4830	4845	4869	4877
11.0	**4928**	4650	4700	4750	4800	4851	4866	4881	4896	4911	4917	4923	4931	4934
11.5	**4972**	4824	4851	4878	4905	4932	4940	4947	4955	4963	4966	4969	4973	4974
12.0	**5009**	4928	4942	4957	4972	4986	4991	4996	5001	5006	5007	5008	5009	5008
12.5	**5038**	4987	4997	5006	5016	5026	5029	5032	5034	5037	5037	5037	5037	5037
13.0	**5052**	5016	5024	5031	5038	5045	5047	5049	5051	5052	5052	5052	5052	5052
13.5	**5057**	5028	5035	5041	5047	5053	5054	5055	5056	5057	5057	5057	5057	5057
14.0	**5057**	5033	5038	5043	5048	5053	5054	5055	5056	5057	5057	5057	5057	5057
14.5	**5052**	5029	5034	5038	5043	5048	5048	5049	5050	5051	5051	5051	5052	5052
15.0	**5037**	5012	5017	5022	5027	5032	5032	5033	5034	5035	5036	5036	5037	5038
15.5	**5015**	4992	4996	5000	5005	5009	5010	5011	5012	5013	5014	5014	5016	5016
16.0	**4990**	4968	4972	4976	4980	4984	4986	4986	4988	4988	4989	4990	4991	4992
16.5	**4964**	4942	4946	4950	4954	4958	4959	4960	4961	4962	4963	4964	4965	4966
17.0	**4938**	4916	4920	4924	4927	4931	4932	4933	4935	4936	4936	4937	4938	4939
17.5	**4912**	4888	4893	4897	4901	4905	4906	4907	4909	4910	4910	4911	4912	4913
18.0	**4885**	4864	4867	4871	4875	4879	4880	4881	4882	4882	4883	4884	4886	4886
18.5	**4859**	4841	4844	4847	4850	4853	4854	4855	4856	4857	4857	4858	4860	4860
19.0	**4836**	4818	4821	4824	4826	4829	4831	4832	4833	4834	4835	4836	4837	4837
19.5	**4813**	4789	4793	4796	4800	4803	4805	4806	4808	4810	4811	4812	4814	4815
20.0	**4736**	4690	4695	4701	4706	4711	4714	4718	4722	4726	4729	4732	4740	4744

6.5 Ct Values, Sound Optimized Mode SO2

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.914**	0.912	0.913	0.913	0.914	0.915	0.915	0.915	0.915	0.915	0.915	0.914	0.913	0.913
3.5	**0.888**	0.894	0.893	0.893	0.893	0.892	0.892	0.891	0.891	0.891	0.890	0.889	0.888	0.887
4.0	**0.851**	0.857	0.856	0.856	0.855	0.854	0.854	0.853	0.853	0.852	0.852	0.852	0.851	0.850
4.5	**0.822**	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
5.0	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
5.5	**0.797**	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
6.0	**0.797**	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
6.5	**0.798**	0.799	0.799	0.799	0.799	0.799	0.799	0.799	0.799	0.798	0.798	0.798	0.798	0.798
7.0	**0.801**	0.804	0.804	0.803	0.803	0.803	0.803	0.803	0.802	0.802	0.802	0.802	0.801	0.801
7.5	**0.796**	0.798	0.798	0.798	0.798	0.798	0.797	0.797	0.797	0.797	0.796	0.796	0.795	0.795
8.0	**0.784**	0.787	0.787	0.786	0.786	0.786	0.786	0.785	0.785	0.785	0.784	0.784	0.783	0.783
8.5	**0.747**	0.751	0.750	0.750	0.750	0.749	0.749	0.749	0.748	0.748	0.748	0.747	0.746	0.745
9.0	**0.707**	0.717	0.717	0.717	0.716	0.716	0.715	0.715	0.714	0.713	0.711	0.709	0.703	0.699
9.5	**0.634**	0.683	0.682	0.681	0.680	0.679	0.675	0.670	0.665	0.660	0.651	0.643	0.624	0.613
10.0	**0.541**	0.631	0.627	0.623	0.619	0.615	0.606	0.597	0.588	0.578	0.566	0.554	0.528	0.516
10.5	**0.455**	0.566	0.559	0.552	0.544	0.537	0.525	0.513	0.502	0.490	0.478	0.466	0.444	0.433
11.0	**0.385**	0.500	0.490	0.481	0.471	0.461	0.450	0.438	0.427	0.415	0.405	0.395	0.376	0.368
11.5	**0.332**	0.437	0.427	0.416	0.406	0.395	0.386	0.376	0.366	0.357	0.348	0.340	0.325	0.317
12.0	**0.289**	0.382	0.372	0.363	0.353	0.343	0.335	0.327	0.319	0.311	0.303	0.296	0.283	0.277
12.5	**0.254**	0.335	0.326	0.318	0.309	0.301	0.294	0.287	0.280	0.273	0.267	0.261	0.249	0.244
13.0	**0.225**	0.294	0.287	0.280	0.272	0.265	0.259	0.253	0.247	0.241	0.235	0.230	0.220	0.216
13.5	**0.200**	0.260	0.254	0.248	0.241	0.235	0.230	0.224	0.219	0.214	0.209	0.205	0.196	0.192
14.0	**0.179**	0.232	0.226	0.220	0.215	0.209	0.205	0.200	0.195	0.191	0.187	0.183	0.175	0.172
14.5	**0.160**	0.207	0.202	0.197	0.192	0.187	0.183	0.179	0.175	0.171	0.167	0.164	0.157	0.154
15.0	**0.144**	0.185	0.181	0.177	0.172	0.168	0.164	0.161	0.157	0.153	0.150	0.147	0.142	0.139
15.5	**0.130**	0.167	0.163	0.159	0.155	0.151	0.148	0.145	0.142	0.138	0.136	0.133	0.128	0.125
16.0	**0.118**	0.151	0.147	0.144	0.140	0.137	0.134	0.131	0.128	0.125	0.123	0.120	0.116	0.114
16.5	**0.107**	0.136	0.133	0.130	0.127	0.124	0.122	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17.0	**0.098**	0.124	0.121	0.119	0.116	0.113	0.111	0.108	0.106	0.104	0.102	0.100	0.096	0.094
17.5	**0.090**	0.114	0.111	0.109	0.106	0.104	0.102	0.100	0.097	0.095	0.094	0.092	0.088	0.087
18.0	**0.083**	0.104	0.102	0.100	0.097	0.095	0.093	0.091	0.089	0.087	0.086	0.084	0.081	0.080
18.5	**0.076**	0.096	0.094	0.092	0.090	0.087	0.086	0.084	0.082	0.080	0.079	0.078	0.075	0.073
19.0	**0.070**	0.088	0.086	0.084	0.082	0.080	0.079	0.077	0.075	0.074	0.073	0.071	0.069	0.067
19.5	**0.065**	0.081	0.079	0.078	0.076	0.074	0.073	0.071	0.070	0.068	0.067	0.066	0.064	0.063
20.0	**0.060**	0.074	0.072	0.071	0.069	0.068	0.067	0.065	0.064	0.063	0.062	0.061	0.059	0.058

6.6 Sound Curves, Sound Optimized Mode SO2

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO2 (Blades with serrated trailing edge)**
3	93.5
4	93.7
5	94.3
6	97.3
7	100.2
8	102.0
9	102.0
10	102.0
11	102.0
12	102.0
13	102.0
14	102.0
15	102.0
16	102.0
17	102.0
18	102.0
19	102.0
20	102.0

6.7 Power Curves, Sound Optimized Mode SO3

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**27**	9	10	12	13	14	16	18	20	21	23	25	29	32
3.5	**144**	91	95	100	105	110	115	120	125	129	134	139	149	153
4.0	**289**	205	212	220	228	235	243	251	258	266	274	281	297	304
4.5	**464**	341	352	363	375	386	397	408	419	430	441	452	475	486
5.0	**669**	502	517	532	547	563	578	593	608	624	639	654	685	700
5.5	**919**	693	714	734	755	775	796	816	837	857	878	898	939	960
6.0	**1219**	925	952	979	1005	1032	1059	1086	1113	1140	1166	1193	1246	1272
6.5	**1574**	1201	1235	1269	1303	1337	1371	1405	1439	1473	1507	1540	1608	1642
7.0	**1990**	1525	1567	1610	1652	1694	1737	1779	1821	1864	1906	1948	2032	2074
7.5	**2453**	1886	1937	1989	2041	2092	2144	2196	2247	2299	2350	2402	2504	2556
8.0	**2953**	2277	2339	2400	2462	2524	2585	2647	2708	2770	2831	2892	3014	3076
8.5	**3458**	2674	2745	2817	2889	2960	3032	3103	3174	3246	3317	3387	3528	3598
9.0	**3940**	3059	3140	3222	3303	3385	3465	3546	3626	3706	3784	3862	4012	4083
9.5	**4306**	3423	3514	3604	3694	3784	3866	3948	4031	4113	4177	4242	4353	4400
10.0	**4532**	3760	3853	3945	4037	4130	4199	4268	4337	4406	4448	4490	4557	4582
10.5	**4659**	4070	4154	4237	4320	4403	4451	4498	4545	4592	4615	4637	4671	4683
11.0	**4742**	4331	4398	4466	4534	4602	4629	4657	4685	4713	4723	4733	4748	4754
11.5	**4800**	4532	4580	4628	4676	4723	4738	4753	4768	4782	4788	4794	4803	4806
12.0	**4829**	4647	4680	4714	4747	4780	4789	4799	4809	4818	4822	4826	4830	4832
12.5	**4839**	4698	4725	4751	4777	4803	4810	4817	4824	4831	4834	4836	4840	4840
13.0	**4841**	4724	4745	4767	4789	4811	4817	4823	4829	4835	4837	4839	4842	4842
13.5	**4841**	4731	4752	4774	4795	4817	4822	4827	4833	4838	4839	4840	4842	4842
14.0	**4840**	4746	4765	4783	4801	4820	4824	4828	4833	4837	4838	4839	4840	4841
14.5	**4834**	4754	4770	4786	4801	4817	4820	4824	4828	4831	4832	4833	4835	4835
15.0	**4819**	4744	4758	4773	4787	4801	4805	4808	4812	4816	4817	4818	4820	4820
15.5	**4798**	4728	4741	4754	4767	4781	4784	4788	4791	4794	4796	4797	4798	4799
16.0	**4773**	4707	4719	4732	4744	4756	4759	4763	4766	4770	4771	4772	4774	4774
16.5	**4746**	4685	4696	4708	4719	4730	4734	4737	4740	4743	4744	4745	4747	4748
17.0	**4720**	4664	4674	4684	4695	4705	4708	4710	4713	4716	4717	4718	4720	4720
17.5	**4693**	4637	4648	4658	4668	4679	4681	4684	4687	4690	4691	4692	4694	4694
18.0	**4666**	4620	4629	4637	4646	4654	4656	4659	4661	4664	4664	4665	4667	4668
18.5	**4640**	4604	4611	4617	4623	4630	4632	4634	4636	4638	4638	4639	4640	4641
19.0	**4617**	4584	4589	4595	4600	4606	4608	4610	4612	4614	4615	4616	4618	4618
19.5	**4598**	4574	4578	4582	4586	4590	4592	4593	4595	4596	4597	4597	4598	4599
20.0	**4575**	4548	4552	4555	4559	4563	4565	4567	4569	4571	4572	4573	4576	4577

6.8 Ct Values, Sound Optimized Mode SO3

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.914**	0.912	0.913	0.913	0.914	0.915	0.915	0.915	0.915	0.915	0.915	0.914	0.913	0.913
3.5	**0.888**	0.894	0.893	0.893	0.893	0.892	0.892	0.891	0.891	0.891	0.890	0.889	0.888	0.887
4.0	**0.851**	0.857	0.856	0.856	0.855	0.854	0.854	0.853	0.853	0.852	0.852	0.852	0.851	0.850
4.5	**0.822**	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
5.0	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
5.5	**0.797**	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
6.0	**0.797**	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
6.5	**0.798**	0.799	0.799	0.799	0.799	0.799	0.799	0.799	0.799	0.798	0.798	0.798	0.798	0.798
7.0	**0.801**	0.803	0.803	0.803	0.803	0.802	0.802	0.802	0.802	0.802	0.801	0.801	0.801	0.800
7.5	**0.792**	0.794	0.794	0.794	0.794	0.794	0.793	0.793	0.793	0.793	0.792	0.792	0.792	0.791
8.0	**0.769**	0.772	0.771	0.771	0.771	0.771	0.770	0.770	0.770	0.770	0.769	0.769	0.768	0.768
8.5	**0.720**	0.723	0.723	0.722	0.722	0.722	0.722	0.721	0.721	0.721	0.720	0.720	0.719	0.718
9.0	**0.670**	0.676	0.676	0.676	0.676	0.675	0.675	0.675	0.674	0.674	0.672	0.671	0.667	0.663
9.5	**0.594**	0.622	0.621	0.621	0.621	0.620	0.618	0.616	0.613	0.611	0.605	0.600	0.585	0.576
10.0	**0.508**	0.562	0.560	0.559	0.557	0.556	0.551	0.545	0.540	0.535	0.526	0.517	0.497	0.487
10.5	**0.431**	0.506	0.502	0.499	0.495	0.491	0.483	0.476	0.468	0.460	0.450	0.440	0.421	0.412
11.0	**0.368**	0.454	0.448	0.442	0.436	0.431	0.422	0.413	0.404	0.395	0.386	0.377	0.360	0.352
11.5	**0.319**	0.405	0.397	0.390	0.383	0.376	0.367	0.359	0.350	0.342	0.334	0.327	0.312	0.305
12.0	**0.278**	0.357	0.349	0.342	0.335	0.328	0.320	0.313	0.305	0.298	0.291	0.285	0.272	0.266
12.5	**0.244**	0.313	0.306	0.300	0.293	0.286	0.280	0.274	0.267	0.261	0.255	0.249	0.239	0.234
13.0	**0.215**	0.276	0.270	0.264	0.258	0.252	0.246	0.241	0.235	0.230	0.225	0.220	0.211	0.206
13.5	**0.191**	0.244	0.239	0.234	0.229	0.223	0.219	0.214	0.209	0.204	0.200	0.195	0.187	0.183
14.0	**0.171**	0.218	0.213	0.208	0.204	0.199	0.195	0.191	0.186	0.182	0.178	0.174	0.167	0.164
14.5	**0.153**	0.195	0.191	0.187	0.183	0.178	0.175	0.171	0.167	0.163	0.160	0.156	0.150	0.147
15.0	**0.138**	0.175	0.171	0.168	0.164	0.160	0.157	0.153	0.150	0.147	0.144	0.141	0.135	0.133
15.5	**0.124**	0.158	0.154	0.151	0.148	0.144	0.141	0.138	0.135	0.132	0.130	0.127	0.122	0.120
16.0	**0.113**	0.143	0.140	0.137	0.134	0.130	0.128	0.125	0.122	0.120	0.117	0.115	0.111	0.109
16.5	**0.102**	0.129	0.127	0.124	0.121	0.118	0.116	0.114	0.111	0.109	0.107	0.105	0.101	0.099
17.0	**0.093**	0.118	0.115	0.113	0.110	0.108	0.106	0.103	0.101	0.099	0.097	0.095	0.092	0.090
17.5	**0.086**	0.108	0.106	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.089	0.088	0.084	0.083
18.0	**0.079**	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.077	0.076
18.5	**0.073**	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.077	0.075	0.074	0.071	0.070
19.0	**0.067**	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.064
19.5	**0.062**	0.078	0.076	0.074	0.073	0.071	0.070	0.068	0.067	0.065	0.064	0.063	0.061	0.060
20.0	**0.057**	0.072	0.070	0.069	0.067	0.066	0.064	0.063	0.062	0.061	0.060	0.058	0.056	0.055

6.9 Sound Curves, Sound Optimized Mode SO3

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO3 (Blades with serrated trailing edge)**
3	93.5
4	93.7
5	94.3
6	97.3
7	100.2
8	101.0
9	101.0
10	101.0
11	101.0
12	101.0
13	101.0
14	101.0
15	101.0
16	101.0
17	101.0
18	101.0
19	101.0
20	101.0

6.10 Power Curves, Sound Optimized Mode SO4

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**27**	9	10	12	13	14	16	18	20	21	23	25	29	32
3.5	**144**	91	95	100	105	110	115	120	125	129	134	139	149	153
4.0	**289**	205	212	220	228	235	243	251	258	266	274	281	297	304
4.5	**464**	341	352	363	375	386	397	408	419	430	441	452	475	486
5.0	**669**	502	517	532	547	563	578	593	608	624	639	654	685	700
5.5	**919**	693	714	734	755	775	796	816	837	857	878	898	940	960
6.0	**1220**	926	953	979	1006	1033	1060	1087	1114	1140	1167	1194	1247	1274
6.5	**1575**	1201	1235	1269	1303	1337	1371	1405	1439	1473	1507	1541	1608	1642
7.0	**1986**	1522	1564	1606	1649	1691	1733	1776	1818	1860	1902	1944	2028	2070
7.5	**2437**	1874	1925	1977	2028	2079	2131	2182	2233	2284	2335	2386	2488	2539
8.0	**2909**	2243	2304	2365	2426	2486	2547	2607	2668	2728	2789	2849	2970	3030
8.5	**3367**	2602	2672	2742	2811	2881	2951	3020	3090	3160	3229	3298	3435	3504
9.0	**3783**	2932	3011	3089	3167	3246	3323	3401	3478	3556	3632	3708	3854	3924
9.5	**4086**	3219	3304	3390	3475	3560	3641	3722	3803	3884	3951	4019	4138	4190
10.0	**4294**	3496	3586	3675	3764	3854	3927	4001	4074	4147	4196	4245	4327	4359
10.5	**4434**	3770	3855	3941	4027	4113	4171	4228	4286	4344	4374	4404	4451	4469
11.0	**4519**	3996	4072	4148	4224	4299	4342	4384	4427	4469	4486	4502	4527	4536
11.5	**4548**	4117	4185	4254	4322	4390	4421	4453	4484	4515	4526	4537	4554	4559
12.0	**4556**	4182	4244	4306	4368	4430	4455	4480	4505	4530	4539	4548	4560	4564
12.5	**4559**	4228	4285	4341	4398	4454	4475	4496	4517	4538	4545	4552	4563	4566
13.0	**4562**	4274	4324	4375	4425	4476	4492	4509	4526	4543	4549	4555	4565	4568
13.5	**4566**	4308	4352	4396	4440	4484	4501	4517	4534	4550	4555	4560	4568	4570
14.0	**4566**	4347	4385	4423	4461	4500	4513	4526	4540	4553	4558	4562	4568	4570
14.5	**4561**	4372	4405	4438	4471	4504	4516	4528	4539	4551	4554	4558	4563	4564
15.0	**4547**	4374	4404	4434	4464	4494	4504	4515	4526	4536	4540	4544	4549	4550
15.5	**4526**	4368	4396	4423	4450	4477	4487	4497	4506	4516	4519	4523	4527	4529
16.0	**4502**	4360	4384	4409	4433	4458	4466	4475	4484	4492	4496	4498	4503	4504
16.5	**4475**	4352	4373	4394	4415	4436	4444	4452	4460	4467	4470	4473	4476	4478
17.0	**4449**	4347	4364	4382	4399	4417	4423	4430	4436	4442	4445	4447	4450	4452
17.5	**4424**	4322	4340	4358	4377	4395	4400	4406	4412	4418	4420	4422	4425	4426
18.0	**4397**	4319	4333	4347	4361	4375	4379	4384	4388	4392	4394	4396	4398	4399
18.5	**4371**	4314	4324	4334	4344	4354	4358	4361	4364	4367	4368	4370	4371	4372
19.0	**4348**	4303	4310	4318	4326	4333	4336	4339	4341	4344	4345	4346	4348	4349
19.5	**4329**	4298	4304	4309	4314	4320	4321	4323	4325	4327	4328	4328	4330	4330
20.0	**4316**	4296	4299	4303	4307	4310	4312	4313	4314	4315	4316	4316	4317	4317

6.11 Ct Values, Sound Optimized Mode SO4

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.914**	0.912	0.913	0.913	0.914	0.915	0.915	0.915	0.915	0.915	0.915	0.914	0.913	0.913
3.5	**0.888**	0.894	0.893	0.893	0.893	0.892	0.892	0.891	0.891	0.891	0.890	0.889	0.888	0.887
4.0	**0.851**	0.857	0.856	0.856	0.855	0.854	0.854	0.853	0.853	0.852	0.852	0.852	0.851	0.850
4.5	**0.822**	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
5.0	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
5.5	**0.798**	0.797	0.797	0.797	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.798
6.0	**0.803**	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.803	0.803	0.803	0.803
6.5	**0.802**	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.802	0.802	0.802	0.802	0.802
7.0	**0.798**	0.800	0.800	0.800	0.800	0.800	0.800	0.799	0.799	0.799	0.799	0.799	0.798	0.798
7.5	**0.784**	0.786	0.786	0.786	0.786	0.786	0.785	0.785	0.785	0.785	0.785	0.784	0.784	0.784
8.0	**0.749**	0.751	0.751	0.751	0.751	0.750	0.750	0.750	0.750	0.749	0.749	0.749	0.748	0.748
8.5	**0.692**	0.694	0.694	0.694	0.694	0.693	0.693	0.693	0.693	0.692	0.692	0.692	0.691	0.691
9.0	**0.630**	0.633	0.633	0.633	0.633	0.632	0.632	0.632	0.632	0.631	0.631	0.630	0.628	0.626
9.5	**0.549**	0.563	0.563	0.563	0.563	0.563	0.562	0.561	0.560	0.559	0.555	0.552	0.543	0.537
10.0	**0.472**	0.504	0.504	0.503	0.503	0.502	0.499	0.496	0.493	0.490	0.484	0.478	0.464	0.456
10.5	**0.405**	0.456	0.454	0.452	0.450	0.448	0.443	0.438	0.433	0.428	0.420	0.413	0.397	0.389
11.0	**0.349**	0.410	0.407	0.403	0.400	0.396	0.390	0.384	0.378	0.371	0.364	0.356	0.341	0.334
11.5	**0.301**	0.361	0.357	0.353	0.349	0.346	0.339	0.333	0.327	0.321	0.314	0.308	0.295	0.288
12.0	**0.262**	0.316	0.312	0.309	0.305	0.301	0.296	0.290	0.284	0.279	0.273	0.267	0.256	0.251
12.5	**0.229**	0.278	0.275	0.271	0.268	0.264	0.259	0.254	0.249	0.244	0.239	0.234	0.225	0.220
13.0	**0.202**	0.247	0.244	0.240	0.237	0.233	0.229	0.224	0.220	0.215	0.211	0.207	0.198	0.194
13.5	**0.180**	0.221	0.218	0.214	0.211	0.207	0.203	0.200	0.196	0.192	0.188	0.184	0.177	0.173
14.0	**0.161**	0.199	0.195	0.192	0.189	0.186	0.182	0.178	0.175	0.171	0.168	0.164	0.158	0.155
14.5	**0.145**	0.179	0.176	0.173	0.170	0.167	0.164	0.160	0.157	0.154	0.151	0.148	0.142	0.139
15.0	**0.130**	0.161	0.159	0.156	0.153	0.150	0.147	0.144	0.141	0.138	0.136	0.133	0.128	0.125
15.5	**0.118**	0.146	0.143	0.141	0.138	0.135	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.0	**0.106**	0.132	0.130	0.127	0.125	0.122	0.120	0.118	0.115	0.113	0.111	0.109	0.104	0.102
16.5	**0.097**	0.120	0.118	0.116	0.114	0.111	0.109	0.107	0.105	0.103	0.101	0.099	0.095	0.093
17.0	**0.088**	0.110	0.108	0.106	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.090	0.087	0.085
17.5	**0.081**	0.101	0.099	0.097	0.095	0.093	0.092	0.090	0.088	0.086	0.084	0.083	0.080	0.078
18.0	**0.075**	0.093	0.091	0.089	0.088	0.086	0.084	0.082	0.081	0.079	0.077	0.076	0.073	0.072
18.5	**0.069**	0.086	0.084	0.082	0.081	0.079	0.077	0.076	0.074	0.073	0.071	0.070	0.067	0.066
19.0	**0.063**	0.079	0.077	0.076	0.074	0.072	0.071	0.070	0.068	0.067	0.065	0.064	0.062	0.061
19.5	**0.058**	0.073	0.072	0.070	0.069	0.067	0.066	0.064	0.063	0.062	0.061	0.060	0.057	0.056
20.0	**0.054**	0.068	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.057	0.056	0.055	0.053	0.052

6.12 Sound Curves, Sound Optimized Mode SO4

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO4 (Blades with serrated trailing edge)**
3	93.5
4	93.7
5	94.3
6	97.3
7	99.7
8	100.0
9	100.0
10	100.0
11	100.0
12	100.0
13	100.0
14	100.0
15	100.0
16	100.0
17	100.0
18	100.0
19	100.0
20	100.0

6.13 Power Curves, Sound Optimized Mode SO5

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**27**	9	10	12	13	14	16	18	20	21	23	25	29	32
3.5	**144**	91	95	100	105	110	115	120	125	129	134	139	149	153
4.0	**289**	205	212	220	228	235	243	251	258	266	274	281	297	304
4.5	**464**	341	352	363	375	386	397	408	419	430	441	452	475	486
5.0	**669**	502	517	532	547	563	578	593	608	624	639	654	685	700
5.5	**919**	693	714	734	755	775	796	816	837	857	878	899	940	960
6.0	**1220**	926	952	979	1006	1032	1059	1086	1113	1140	1166	1193	1247	1274
6.5	**1570**	1198	1232	1266	1299	1333	1367	1401	1435	1469	1502	1536	1603	1637
7.0	**1968**	1509	1551	1593	1635	1677	1718	1760	1802	1844	1885	1927	2010	2051
7.5	**2386**	1835	1886	1936	1986	2036	2086	2136	2186	2236	2286	2336	2436	2486
8.0	**2788**	2147	2205	2264	2322	2380	2439	2497	2555	2613	2671	2730	2846	2904
8.5	**3160**	2438	2503	2569	2635	2701	2767	2833	2898	2964	3029	3095	3225	3290
9.0	**3480**	2693	2765	2837	2909	2980	3052	3124	3195	3267	3338	3409	3550	3620
9.5	**3719**	2891	2968	3044	3121	3198	3274	3350	3425	3501	3574	3646	3783	3848
10.0	**3888**	3047	3127	3208	3288	3369	3447	3525	3603	3681	3750	3819	3943	3998
10.5	**3984**	3155	3238	3320	3403	3486	3564	3642	3720	3798	3860	3922	4030	4075
11.0	**4029**	3234	3319	3404	3488	3573	3646	3719	3792	3864	3919	3974	4071	4112
11.5	**4069**	3302	3386	3471	3556	3641	3710	3779	3848	3917	3968	4018	4105	4141
12.0	**4106**	3375	3458	3542	3625	3708	3773	3838	3903	3968	4014	4060	4135	4164
12.5	**4138**	3455	3536	3617	3698	3779	3839	3899	3959	4019	4059	4099	4161	4184
13.0	**4162**	3531	3608	3686	3764	3841	3896	3952	4007	4063	4096	4129	4180	4198
13.5	**4171**	3594	3666	3738	3810	3882	3932	3983	4034	4084	4113	4142	4188	4205
14.0	**4185**	3652	3720	3789	3857	3926	3972	4019	4065	4111	4136	4161	4200	4214
14.5	**4199**	3713	3778	3842	3907	3972	4013	4054	4096	4137	4158	4178	4211	4223
15.0	**4209**	3773	3834	3896	3957	4018	4053	4088	4124	4159	4176	4192	4218	4228
15.5	**4219**	3839	3895	3951	4007	4063	4092	4121	4150	4180	4193	4206	4227	4234
16.0	**4228**	3909	3958	4007	4056	4105	4128	4152	4175	4198	4208	4218	4234	4240
16.5	**4237**	3978	4019	4060	4102	4143	4161	4178	4196	4213	4221	4229	4241	4246
17.0	**4244**	4041	4074	4107	4140	4174	4187	4200	4213	4226	4232	4238	4246	4249
17.5	**4246**	4074	4102	4130	4157	4185	4197	4209	4221	4233	4237	4242	4249	4251
18.0	**4251**	4122	4144	4166	4188	4209	4218	4226	4234	4242	4245	4248	4252	4253
18.5	**4253**	4164	4179	4195	4211	4226	4232	4237	4242	4248	4250	4251	4254	4254
19.0	**4253**	4189	4200	4211	4222	4234	4237	4241	4245	4248	4250	4251	4253	4254
19.5	**4254**	4212	4220	4227	4234	4242	4244	4247	4249	4252	4253	4253	4254	4255
20.0	**4255**	4228	4232	4237	4242	4247	4249	4250	4252	4254	4254	4255	4255	4255

6.14 Ct Values, Sound Optimized Mode SO5

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.914**	0.912	0.913	0.913	0.914	0.915	0.915	0.915	0.915	0.915	0.915	0.914	0.913	0.913
3.5	**0.888**	0.894	0.893	0.893	0.893	0.892	0.892	0.891	0.891	0.891	0.890	0.889	0.888	0.887
4.0	**0.851**	0.857	0.856	0.856	0.855	0.854	0.854	0.853	0.853	0.852	0.852	0.852	0.851	0.850
4.5	**0.822**	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
5.0	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
5.5	**0.799**	0.798	0.798	0.798	0.799	0.799	0.799	0.799	0.799	0.799	0.799	0.799	0.799	0.799
6.0	**0.803**	0.803	0.803	0.804	0.804	0.804	0.804	0.803	0.803	0.803	0.803	0.803	0.803	0.803
6.5	**0.797**	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.797	0.797	0.797	0.797	0.797
7.0	**0.786**	0.788	0.788	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.786	0.786	0.786
7.5	**0.754**	0.756	0.756	0.756	0.756	0.756	0.756	0.755	0.755	0.755	0.755	0.755	0.754	0.754
8.0	**0.703**	0.705	0.705	0.705	0.704	0.704	0.704	0.704	0.704	0.704	0.703	0.703	0.703	0.703
8.5	**0.633**	0.635	0.635	0.635	0.634	0.634	0.634	0.634	0.634	0.633	0.633	0.633	0.633	0.633
9.0	**0.554**	0.555	0.555	0.555	0.555	0.555	0.554	0.554	0.554	0.554	0.554	0.554	0.553	0.553
9.5	**0.481**	0.484	0.484	0.484	0.483	0.483	0.483	0.483	0.483	0.483	0.482	0.481	0.479	0.477
10.0	**0.416**	0.422	0.422	0.422	0.422	0.422	0.421	0.421	0.420	0.420	0.419	0.417	0.413	0.409
10.5	**0.358**	0.367	0.367	0.367	0.367	0.367	0.366	0.365	0.365	0.364	0.362	0.360	0.354	0.350
11.0	**0.307**	0.320	0.320	0.320	0.320	0.319	0.318	0.317	0.316	0.315	0.312	0.310	0.304	0.301
11.5	**0.267**	0.281	0.281	0.281	0.280	0.280	0.279	0.277	0.276	0.275	0.272	0.270	0.264	0.261
12.0	**0.235**	0.250	0.249	0.249	0.249	0.248	0.247	0.245	0.244	0.242	0.240	0.237	0.232	0.228
12.5	**0.208**	0.224	0.224	0.223	0.222	0.222	0.220	0.219	0.217	0.215	0.213	0.210	0.205	0.202
13.0	**0.185**	0.203	0.202	0.201	0.200	0.199	0.198	0.196	0.194	0.192	0.190	0.187	0.182	0.179
13.5	**0.165**	0.183	0.182	0.181	0.180	0.179	0.177	0.175	0.174	0.172	0.170	0.167	0.162	0.160
14.0	**0.148**	0.166	0.165	0.164	0.163	0.162	0.160	0.158	0.157	0.155	0.153	0.150	0.146	0.143
14.5	**0.133**	0.152	0.151	0.150	0.148	0.147	0.145	0.144	0.142	0.140	0.138	0.136	0.131	0.129
15.0	**0.121**	0.139	0.138	0.137	0.136	0.134	0.133	0.131	0.129	0.127	0.125	0.123	0.119	0.117
15.5	**0.110**	0.128	0.127	0.126	0.124	0.123	0.121	0.119	0.118	0.116	0.114	0.112	0.108	0.106
16.0	**0.100**	0.119	0.117	0.116	0.115	0.113	0.111	0.110	0.108	0.106	0.104	0.102	0.099	0.097
16.5	**0.092**	0.110	0.109	0.107	0.106	0.104	0.102	0.101	0.099	0.097	0.095	0.094	0.090	0.089
17.0	**0.084**	0.103	0.101	0.099	0.098	0.096	0.094	0.093	0.091	0.089	0.088	0.086	0.083	0.081
17.5	**0.078**	0.096	0.094	0.092	0.091	0.089	0.088	0.086	0.084	0.083	0.081	0.080	0.077	0.075
18.0	**0.072**	0.089	0.088	0.086	0.084	0.083	0.081	0.080	0.078	0.076	0.075	0.074	0.071	0.070
18.5	**0.067**	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.064
19.0	**0.062**	0.077	0.076	0.074	0.072	0.071	0.069	0.068	0.067	0.065	0.064	0.063	0.061	0.060
19.5	**0.057**	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.056	0.055
20.0	**0.054**	0.067	0.066	0.064	0.063	0.061	0.060	0.059	0.058	0.057	0.056	0.055	0.053	0.052

6.15 Sound Curves, Sound Optimized Mode SO5

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3 Maximum turbulence at hub height: 30% Inflow angle (vertical): 0 ±2° Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] Sound Optimized Mode SO5 (Blades with serrated trailing edge)**
3	93.5
4	93.7
5	94.3
6	97.2
7	99.0
8	99.0
9	99.0
10	99.0
11	99.0
12	99.0
13	99.0
14	99.0
15	99.0
16	99.0
17	99.0
18	99.0
19	99.0
20	99.0

6.16 Power Curves, Sound Optimized Mode SO6

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**27**	9	10	12	13	14	16	18	20	21	23	25	29	32
3.5	**144**	91	95	100	105	110	115	120	125	129	134	139	149	153
4.0	**289**	205	212	220	228	235	243	251	258	266	274	281	297	304
4.5	**464**	341	352	363	375	386	397	408	419	430	441	452	475	486
5.0	**669**	502	517	532	547	563	578	593	608	624	639	654	685	700
5.5	**919**	693	714	734	755	775	796	817	837	858	878	899	940	960
6.0	**1219**	925	952	978	1005	1032	1059	1085	1112	1139	1165	1192	1245	1272
6.5	**1559**	1190	1224	1257	1291	1325	1358	1392	1425	1459	1492	1526	1592	1626
7.0	**1928**	1479	1520	1561	1602	1642	1683	1724	1765	1806	1847	1887	1969	2010
7.5	**2278**	1751	1799	1847	1895	1943	1991	2039	2087	2134	2182	2230	2326	2374
8.0	**2603**	2004	2058	2113	2168	2222	2277	2331	2386	2440	2495	2549	2658	2712
8.5	**2881**	2225	2285	2345	2404	2464	2524	2583	2643	2702	2762	2821	2939	2998
9.0	**3097**	2398	2462	2526	2590	2654	2717	2781	2845	2909	2972	3034	3157	3217
9.5	**3237**	2522	2588	2656	2722	2790	2856	2922	2988	3054	3115	3176	3290	3342
10.0	**3324**	2608	2676	2745	2814	2883	2950	3017	3083	3150	3208	3266	3369	3414
10.5	**3379**	2675	2745	2816	2886	2956	3023	3089	3155	3222	3274	3326	3419	3459
11.0	**3412**	2737	2809	2881	2952	3024	3086	3147	3209	3270	3318	3365	3449	3485
11.5	**3454**	2808	2879	2951	3022	3094	3152	3209	3267	3325	3368	3411	3486	3517
12.0	**3492**	2880	2950	3020	3090	3160	3214	3268	3322	3376	3414	3453	3517	3541
12.5	**3519**	2947	3014	3082	3150	3218	3268	3318	3368	3418	3451	3485	3538	3557
13.0	**3538**	3008	3072	3137	3201	3266	3312	3359	3406	3453	3481	3510	3554	3569
13.5	**3546**	3065	3124	3184	3244	3303	3346	3388	3431	3473	3498	3522	3561	3575
14.0	**3561**	3125	3181	3238	3294	3351	3389	3426	3464	3502	3522	3541	3573	3586
14.5	**3575**	3188	3240	3293	3346	3398	3431	3463	3495	3527	3543	3559	3585	3595
15.0	**3588**	3256	3304	3352	3400	3449	3475	3501	3527	3553	3565	3576	3595	3602
15.5	**3599**	3327	3369	3410	3452	3493	3513	3533	3553	3572	3581	3590	3604	3609
16.0	**3607**	3394	3428	3462	3496	3530	3545	3559	3573	3587	3594	3600	3610	3614
16.5	**3613**	3453	3479	3505	3532	3558	3568	3578	3588	3598	3603	3608	3615	3617
17.0	**3617**	3504	3523	3541	3560	3579	3586	3593	3601	3608	3611	3614	3618	3620
17.5	**3619**	3528	3543	3559	3575	3590	3596	3602	3608	3613	3615	3617	3620	3621
18.0	**3621**	3560	3571	3582	3593	3604	3607	3611	3614	3618	3619	3620	3622	3622
18.5	**3622**	3584	3592	3599	3606	3613	3615	3617	3619	3620	3621	3621	3622	3622
19.0	**3622**	3595	3600	3605	3610	3614	3616	3617	3619	3620	3621	3621	3622	3622
19.5	**3622**	3606	3609	3612	3615	3618	3619	3620	3621	3622	3622	3622	3622	3622
20.0	**3622**	3613	3615	3617	3618	3620	3621	3621	3622	3622	3622	3622	3622	3622

6.17 Ct Values, Sound Optimized Mode SO6

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.914**	0.912	0.913	0.913	0.914	0.915	0.915	0.915	0.915	0.915	0.915	0.914	0.913	0.913
3.5	**0.888**	0.894	0.893	0.893	0.893	0.892	0.892	0.891	0.891	0.890	0.890	0.889	0.888	0.887
4.0	**0.851**	0.857	0.856	0.856	0.855	0.854	0.854	0.853	0.853	0.852	0.852	0.852	0.851	0.850
4.5	**0.822**	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
5.0	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
5.5	**0.800**	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
6.0	**0.802**	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802
6.5	**0.789**	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.788	0.788
7.0	**0.757**	0.758	0.758	0.758	0.758	0.758	0.758	0.758	0.758	0.758	0.757	0.757	0.757	0.757
7.5	**0.702**	0.704	0.704	0.703	0.703	0.703	0.703	0.703	0.703	0.703	0.703	0.703	0.702	0.702
8.0	**0.627**	0.629	0.629	0.628	0.628	0.628	0.628	0.628	0.627	0.627	0.627	0.627	0.626	0.626
8.5	**0.542**	0.544	0.544	0.544	0.544	0.544	0.543	0.543	0.543	0.543	0.543	0.543	0.542	0.542
9.0	**0.468**	0.469	0.469	0.469	0.469	0.469	0.469	0.468	0.468	0.468	0.468	0.468	0.467	0.466
9.5	**0.402**	0.406	0.406	0.406	0.405	0.405	0.405	0.405	0.405	0.404	0.404	0.403	0.400	0.398
10.0	**0.344**	0.350	0.350	0.350	0.350	0.350	0.349	0.349	0.349	0.348	0.347	0.346	0.342	0.339
10.5	**0.296**	0.304	0.304	0.304	0.304	0.303	0.303	0.302	0.302	0.301	0.300	0.298	0.293	0.290
11.0	**0.256**	0.266	0.266	0.266	0.266	0.266	0.265	0.264	0.263	0.262	0.260	0.258	0.253	0.250
11.5	**0.224**	0.236	0.236	0.236	0.235	0.235	0.234	0.233	0.231	0.230	0.228	0.226	0.222	0.219
12.0	**0.198**	0.212	0.211	0.211	0.210	0.210	0.208	0.207	0.206	0.204	0.202	0.200	0.195	0.193
12.5	**0.176**	0.190	0.190	0.189	0.188	0.188	0.186	0.185	0.183	0.182	0.180	0.178	0.173	0.170
13.0	**0.157**	0.172	0.171	0.170	0.170	0.169	0.167	0.166	0.164	0.163	0.161	0.159	0.154	0.152
13.5	**0.140**	0.156	0.155	0.154	0.153	0.152	0.150	0.149	0.147	0.146	0.144	0.142	0.138	0.135
14.0	**0.126**	0.142	0.141	0.140	0.139	0.138	0.137	0.135	0.133	0.132	0.130	0.128	0.124	0.122
14.5	**0.114**	0.131	0.129	0.128	0.127	0.126	0.124	0.123	0.121	0.120	0.118	0.116	0.112	0.110
15.0	**0.103**	0.120	0.119	0.118	0.117	0.116	0.114	0.112	0.110	0.109	0.107	0.105	0.102	0.100
15.5	**0.094**	0.112	0.110	0.109	0.108	0.106	0.104	0.103	0.101	0.099	0.098	0.096	0.092	0.091
16.0	**0.086**	0.104	0.102	0.101	0.099	0.098	0.096	0.094	0.093	0.091	0.089	0.088	0.084	0.083
16.5	**0.079**	0.096	0.095	0.093	0.092	0.090	0.088	0.087	0.085	0.083	0.082	0.080	0.077	0.076
17.0	**0.072**	0.090	0.088	0.086	0.085	0.083	0.081	0.080	0.078	0.077	0.075	0.074	0.071	0.070
17.5	**0.067**	0.083	0.082	0.080	0.079	0.077	0.076	0.074	0.073	0.071	0.070	0.068	0.066	0.065
18.0	**0.062**	0.078	0.076	0.074	0.073	0.071	0.070	0.068	0.067	0.066	0.064	0.063	0.061	0.060
18.5	**0.057**	0.072	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.056	0.055
19.0	**0.053**	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.052	0.051
19.5	**0.049**	0.062	0.061	0.059	0.058	0.057	0.056	0.055	0.053	0.052	0.051	0.050	0.049	0.048
20.0	**0.046**	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.045	0.045

6.18 Sound Curves, Sound Optimized Mode SO6

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO6 (Blades with serrated trailing edge)**
3	93.5
4	93.7
5	94.3
6	97.1
7	98.0
8	98.0
9	98.0
10	98.0
11	98.0
12	98.0
13	98.0
14	98.0
15	98.0
16	98.0
17	98.0
18	98.0
19	98.0
20	98.0

PRYSMIAN
CABLES & SYSTEMS

Medium Voltage Systems

System Solution and Innovation

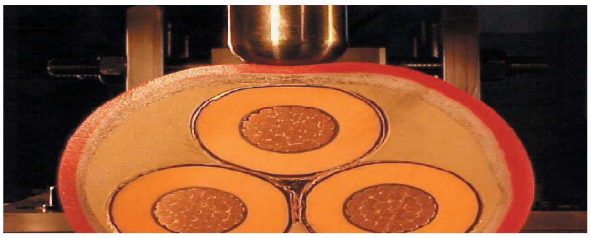
Prysmian is one of the worldwide leading players in the energy cable systems market, thanks to its innovative technological approach and to its capability in maintaining cost leadership, together with a strong commitment to Research and Development.

Extensive research has been conducted by Prysmian to provide solutions, which fully meet customers' requirements, with a strong focus on the development of competitive and reliable underground systems.

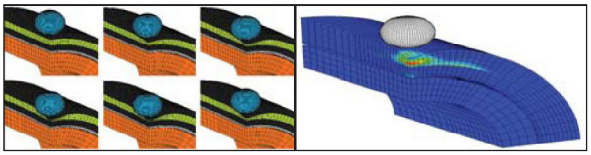
Prysmian dominates the technology scenario in all phases of power circuits development - engineering, design, production, installation and maintenance - with a turnkey approach, which covers the asset's entire lifetime and provides customers with the benefits of a lower total cost of ownership of the system.

Major Utilities are currently installing Pirelli power distribution solutions and exploiting their benefits.

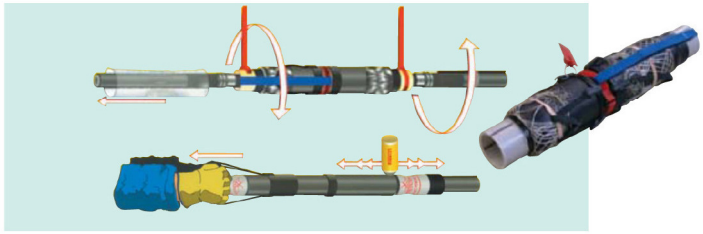
> AIR BAG™ Cable System



Prysmian has patented an innovative polymeric mechanical protection for cables, which, extended to accessories and installation aspects, has resulted into a new full system approach. This fully polymeric protection employed in the **Air Bag**™ cables absorbs impacts and reduces the risk of permanent deformations and damage to the sensitive underlying cable layers. Generally, **Air Bag**™ cable designs have reduced weights and dimensions, compared to traditional cables. This provides for significant economic advantages in terms of total system cost, allowing easier handling, longer delivery lengths and, therefore, a reduced need for joints. Another key advantage of the **Air Bag**™ Cable System is related to installation: **Air Bag**™ perfectly combines the new technologies applied to cables and accessories to exploit its innovative installation solutions at their best. **Air Bag**™ Cable Systems can be installed in simplified compact trenches with no need for sand, backfill selection and/or special external protections like tiles and pipes, thanks to its superior mechanical properties. Also mechanised installation technologies benefit of the exceptional robustness of **Air Bag**™, which allows quicker and more efficient operations.



> Elaspeed™ V1.2



Following the success of the original **Elaspeed**™ range, Prysmian has developed the second generation of these products, to further improve and speed up installation operations.

The new **Elaspeed**™ 1.2 joints adopt the well proven cold-shrink technique, combined with the acknowledged leadership of Prysmian EPDM rubber technology, and enhanced with innovative features:

- The new self-ejecting tube reduces risks of errors during the installation.
- The standardised mastic pads ensure correct positioning and optimal water tightness.
- The inner part of the joint body is pre-greased with silicone lubricant and allows a cleaner installation and better electrical performances.
- The new textile straps allow easier handling.

Most importantly, **Elaspeed**™ 1.2 joints allow checking and monitoring any single jointing operation, and ensure superior quality and reliability of the installation.
Elaspeed™ 1.2 joints are suitable for most applications and cable constructions, including transition jointing. They are available in **Air Bag**™ configuration to ensure full system mechanical protection and compatibility. All joints are 100% factory tested and comply with the strictest national and international standards.

YOUR ENERGY... OUR SYSTEMS... ANYWHERE

> Microtunnelling

Environmental and social issues are nowadays putting strong pressure on the growing need for upgrading and renewing power distribution and transmission grids. In this scenario Prysmian dedicates its efforts to the development of new cable designs, which allow for optimised installation techniques. A typical example of this is **Air Bag**™ Microtunneling. The **Air Bag**™ Microtunnelling technique consists of two phases. Horizontal drilling is carried out by means of a drilling head with a remote control sensor placed inside of it. Constant radar monitoring allows to precisely track even highly complex routes. The **Air Bag**™ cable is laid with no additional protection pipes or ducts, which would instead be required by a standard cable, and installation time is reduced by up to 30 percent. This type of installation does not require to open trenches in the carriageway, thus minimising disruption inconveniences, and, thereby, cuts down all costs related to restoration of road surfaces and removal of excavation debris. Installation works are carried out with the same equipment commonly used for pipelines laying and require limited resources for handling. The **Air Bag**™ Microtunnelling technology proves to be very fast, easy and effective. Thanks to its minimum environmental impact, the system proposed by Prysmian is the perfect solution for the installation of power distribution lines in densely populated urban areas or in protected rural environments, such as parks and reserves. For installation operations carried out with innovative techniques and systems, such as Microtunnelling, Prysmian may offer to its customers full turn-key project consulting and supervision.

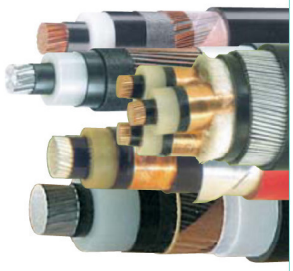
> New Services

In addition to the innovative products resulted from our strong industrial background and technical expertise, we also offer to our customers fully integrated supply chain services.

The range includes:

- Cut-to-length
- Delivery to site
- Drum management
- Vendor Managed Inventory
- Order tracking
- E-business

All service packages are tailored to the real customer needs in order to optimise efficiencies and to continuously improve our relationship.



PRYSMIAN CABLES & SYSTEMS

About us

Prysmian Cables & Systems is a world-class multinational company. Founded in 1872 as "Ditta Pirelli & C.", it has achieved a leading position for more than a century of operations in its two key international markets - "Energy Cables & Systems" and "Telecom Cables & Systems".

Prysmian Cables and Systems is one of the worldwide leading manufacturer of power and telecommunications cables, with 52 manufacturing facilities in 21 countries in five continents and a market share in excess of 10%.

Prysmian Energy Cables and Systems is a global solutions provider, offering a wide range of integrated solutions, such as cable systems, system design and engineering, project management, installation and post-sale services.

Prysmian Energy Cables and Systems concentrates on continuous product innovation and on achieving a competitive edge by focusing on research and development. This is done through Prysmian's own R&D centres and by co-operating with universities, scientific institutions and above all, our customers. Prysmian's world-wide organisation makes and delivers advanced technological solutions to customers anywhere in the world.

Global
Solutions Provider

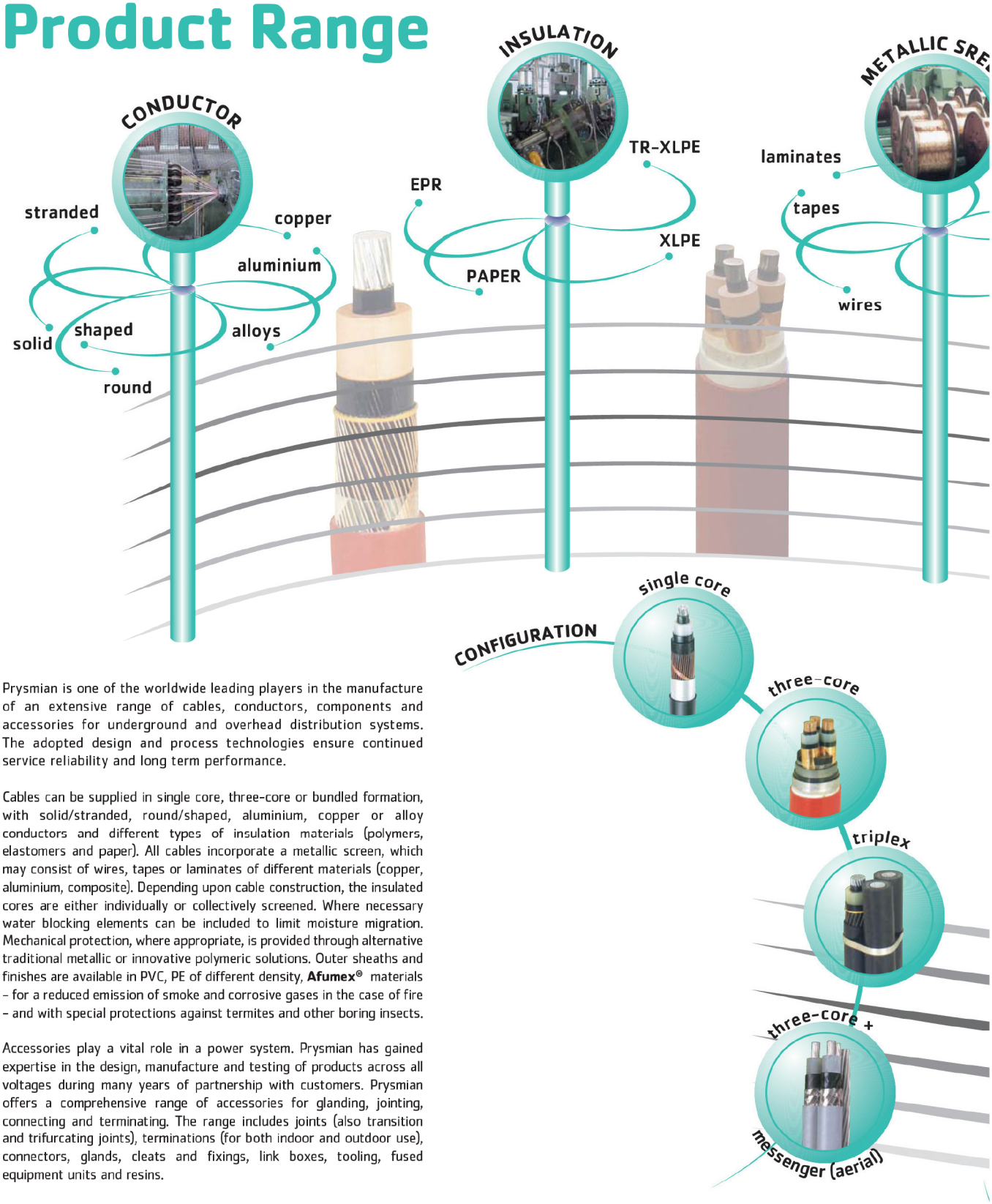
The energy market has been changing dramatically in recent years, as a result of deregulation and privatisation. To face the challenge of competition, energy transmission and distribution operators are driven towards an optimum use of their existing resources and new investments.

To support its customers, Prysmian has evolved over the years from the traditional role of cable manufacturer to that of a **Global Solution Provider**. Prysmian focuses on a total system approach, to give its customers the lowest cost of ownership of their new and installed cable networks.

This "Total System" approach is, at all voltages, the ultimate solution to provide power utilities with real advantages in terms of asset optimisation. Besides an increasing activity on product innovation to lower investment costs, Prysmian is developing additional pre and post sales services for its customers – e.g. network services, enhanced logistics, engineering studies – to optimise asset management and give the best possible exploitation of transmission and distribution networks.

PRYSMIAN
CABLES & SYSTEMS

Product Range



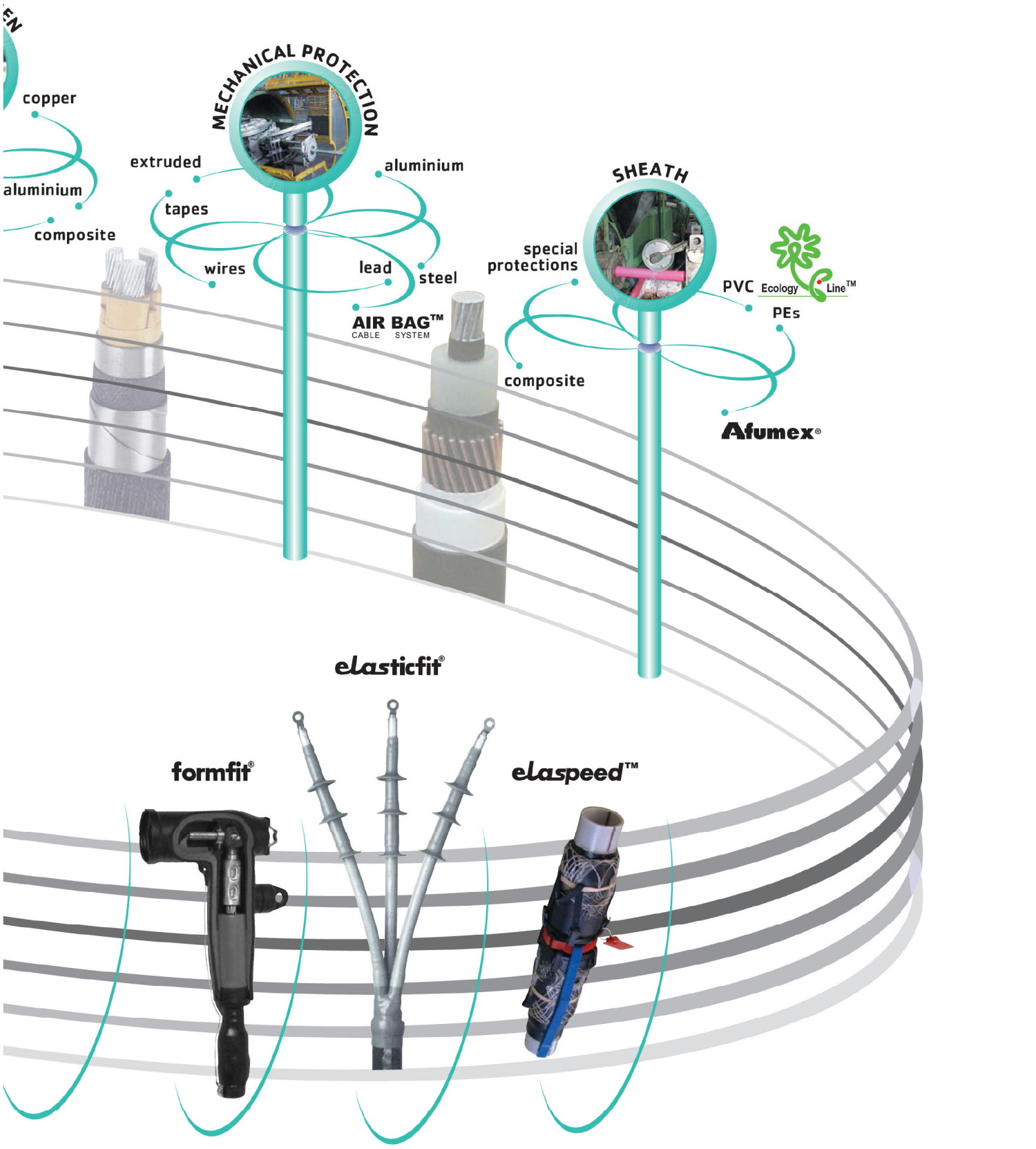
Prysmian is one of the worldwide leading players in the manufacture of an extensive range of cables, conductors, components and accessories for underground and overhead distribution systems. The adopted design and process technologies ensure continued service reliability and long term performance.

Cables can be supplied in single core, three-core or bundled formation, with solid/stranded, round/shaped, aluminium, copper or alloy conductors and different types of insulation materials (polymers, elastomers and paper). All cables incorporate a metallic screen, which may consist of wires, tapes or laminates of different materials (copper, aluminium, composite). Depending upon cable construction, the insulated cores are either individually or collectively screened. Where necessary water blocking elements can be included to limit moisture migration. Mechanical protection, where appropriate, is provided through alternative traditional metallic or innovative polymeric solutions. Outer sheaths and finishes are available in PVC, PE of different density, **Afumex®** materials – for a reduced emission of smoke and corrosive gases in the case of fire – and with special protections against termites and other boring insects.

Accessories play a vital role in a power system. Prysmian has gained expertise in the design, manufacture and testing of products across all voltages during many years of partnership with customers. Prysmian offers a comprehensive range of accessories for glanding, jointing, connecting and terminating. The range includes joints (also transition and trifurcating joints), terminations (for both indoor and outdoor use), connectors, glands, cleats and fixings, link boxes, tooling, fused equipment units and resins.

Prysmian also provides engineering services capable of fulfilling any power system specification or requirement and of delivering customised solutions.

PRYSMIAN
CABLES & SYSTEMS



PRYSMIAN CABLES & SYSTEMS

Total Quality Commitment

Prysmian is characterised by a competent and experienced approach to global solutions with state-of-the-art resources applied to research, engineering and manufacturing. Within the Prysmian Group, there are manufacturing facilities dedicated to the production of LV cables, accessories and components in all five continents, and a single business unit, which gathers all critical functions in a co-ordinated management structure with common operative policies. The main advantages of this organisation are: great manufacturing flexibility, strong engineering expertise, advanced services and **total quality commitment**.

The Prysmian brand has always been a guarantee for the supply of products and services based on worldwide excellence in quality standards. Prysmian has a built-in multi-step quality assurance program, which covers the entire production process from cable design and raw materials purchasing, to final inspection and testing documentation.
Prysmian business locations and manufacturing sites are certified according to **ISO 9001 Quality Management System standards** for their specific activities and products and **ISO 14001 Environmental Quality standards**.

Standards and Recommendations

Prysmiam products are designed to comply with all major national and international standards (e.g. **IEC, CENELEC, BS, CEI, DIN VDE, ICEA, IRAM, NBR, NF, SABS, SFS, TSE, UNE, UTE, NBN, AEIC, ANSI, AS/NZS** etc.) and with customer's specific requirements.

Besides, thanks to an undisputed expertise developed over decades in servicing all major utilities anywhere in the world, Prysmian relies on a long-standing tradition of participation and on a strong presence within international scientific bodies– **IEC, CENELEC** and **AEIC** among others – to develop relevant standards, technical recommendations and guidelines.

References Major Customers

Americas

Canada	Hydro Quebec, ENMAX, Toronto Hydro
USA	Nevada Power, Florida Power & Light, Georgia Power, Exelon, National Grid, ConEdison, Entergy, Detroit Edison, Keyspan, ...
Argentina	Edenor, Edesur,Epe de Santa Fé
Brazil	Coelba, Cosern, Coelce, Eletropaulo, Light, Eletronorte, ...
Chile	Chilectra, CGE
Colombia	Codensa, EEPM, ISA
Mexico	CFE, LyFC
Peru	Edelnor, Tecsur
Uruguay	UTE
Venezuela	Electricidad de Caracas

Africa and M. East

Algeria	Sonelgaz
Libya	GEC
Morocco	ONE
Nigeria	NEPA
Tunisia	STEG
South Africa	Eskom
Lebanon	EDL
Kuwait	MEW
U.A.E.	ADWEA, DEWA, SEWA, FEWA

Europe

Austria	Wienström, EVN
Belgium	Electrabel
Czech Republic	SME, JME, PRE, STE, ZCE
France	EDF
Germany	RWE, HEW, e.on, EnBW
Hungary	ELMU, ÉMÁSZ, DÉMÁSZ, DÉDÁSZ, TITÁSZ, ÉDÁSZ, MVM
Italy	Enel, ACEA, AEM Milano, ACEGAS Trieste, AEC Bolzano
Netherlands	NUON, TZH, ESSENT, ENECO, DELTA, REMU
Romania	Electrica SA, Transelectrica
Scandinavia	Wattenfall
Slovakia	ZSE, SSE, VSE
Spain	Iberdrola, Endesa, Union Fenosa
Turkey	TEIAS, TEDAS EDM
UK	Western Power Distribution, GPU, East Midlands Electricity, Scottish and Southern, National Grid, Scottish Power, NEDL, United Utilities, SEEB, 24 Seven, Northern Ireland Electricity, ...

Asia

Brunei	DES
China	Tianjin Power Bureau, Beijing PSB, Lahsa PSB, Qindao PSB, Daqing PSB, Shanghai PSB, Nanjing PSB...
Hong Kong	CLP Power, Hong kong Electric (HEC)
Malaysia	TNB, SESB, SESCO
Singapore	PowerGrid, Singapore Power
Thailand	MEA, PEA
Vietnam	HCMC PC, Hanoi PC

Australia

Western Power, Integral Energy, Country Energy, Energy Australia,...

PRYSMIAN CABLES & SYSTEMS

PRYSMIAN
CABLES & SYSTEMS

ARGENTINA
Prysmian Energía Cables y Sistemas de Argentina S. A.
Fábrica La Rosa, Av.da Argentina 6784
1439 Capital Federal
tel. +54 11 4630 2000
fax +54 11 4630 2100

AUSTRALIA
Prysmian Power Cables & Systems
Australia PTY LTD
1 Heathcote Road, Locked Bag 7042
Liverpool Business Centre 1871, NSW
tel. +61 2 9600 0777
fax +61 2 9600 0747

AUSTRIA
Prysmian OEKW GmbH
Lembockgasse 47A
1230 Wien
tel. +43 1 8667 70
fax +43 1 8667 7109

BRAZIL
Prysmian Energia Cabos e Sistemas do Brasil S. A.
Av. Alexandre de Gusmao 145
09110-900 Santo André – SP
tel. +55 11 4998 4000
fax +55 11 4998 4811

CHINA
Prysmian Cables & Systems
1505-06, Tower A, City Center of Shanghai
No. 100 ZunYi Road, Shanghai 200051
tel. +86 21 6237 1411
fax +86 21 6237 1195

EGYPT
Prysmian Cables & Systems
8 Abd El Azim Aoudallah st. Hegaz sq.
Heliopolis - Cairo
tel. +20 2 2418 557
fax +20 2 6381 327

FINLAND
Prysmian Cables & Systems Oy
P.O. Box 13
FIN-02401 Kirkkonummi
tel. +358 10 77551
fax +358 9 2982204

FRANCE
Prysmian Energie Cables et Systèmes
France s.a.
Zone Industrielle du Port au Vin
GRON, 89100 SENS
tel. +33 3 8695 7769
fax +33 3 8695 7781

GERMANY
Prysmian Kabel und Systeme GmbH
Alt-Moabit 91 D
10599 Berlin
tel. +49 30 3675 40
fax +49 30 3675 4640

HONG KONG
Prysmian Cable Systems Pte. Ltd.
Unit A, 18/F, China Overseas Building
139 Hennessy Road, Wanchai, Hong Kong
tel. +85 2 2827 8308
fax +85 2 2827 7212

HUNGARY
Prysmian MKM Magyar Hungarian Cable
Works Co. Ltd.
Baràzda u. 38, H-1116 Budapest
tel. +36 1 3822 222
fax +36 1 3822 202

INDONESIA
PT. Prysmian Cables Indonesia
Gedung BRI II, Suite 1502
Jln. Jend Sudirman No 44-46
Jakarta 10210
tel. +62 264 351 222
fax +62 264 351 780

ITALY
Prysmian Cavi e Sistemi Energia Italia Srl
Viale Sarca 222
20126 Milano
tel. +39 02 6449 1
fax +39 02 6449 2931

KUWAIT
Prysmian Cables & Systems – Kuwait Office
Villa No 4 (next to Hyatt Regency Hotel)
Bidda - KUWAIT
tel. +965 575 7704
fax +965 572 5780

MALAYSIA
Prysmian Cable Systems Pte. Ltd.
Power Cable Malaysia Sdn Bhdn
Lot 2 Jalan Kawat 15/18
40702 Shah Alam, Selangor Darul Ehsan
tel. +60 3 5518 4528
fax +60 3 5511 9590

NETHERLANDS
Prysmian Cables and Systems B.V.
Schieweg 9, 2627 AN Delft
P.O. Box 495, 2600 AL Delft
The Netherlands
tel. +31 15 260 5260
fax +31 15 261 3808

NORTH AMERICA
Prysmian Cables & Systems North America
700 Industrial Drive
Lexington, SC 29072 - USA
tel. +1 803 9511 130
fax +1 803 9511 092

ROMANIA
Prysmian Cabluri si Sisteme SA
Soseaua Draganesti, Km. 4, 0500 Slatina
tel. +40 49 435 699
fax +40 49 433 484

RUSSIA
Prysmian Cables and Systems
6th street 8 Marta, 6a, bldg 1
Moscow 125167
tel. +7 095 9337036
fax +7 095 9337035

SINGAPORE
Prysmian Cable Systems Pte. Ltd.
No 4 Tuas Avenue 12. 3rd Storey
639047 Singapore
tel. +65 6862 9866
fax +65 6862 9877

SLOVAKIA
Prysmian Kablo s.r.o.
Trnavska cesta 50
821 02 Bratislava
tel. +421 2 4949 1215
fax +421 2 4949 1248

SPAIN
Prysmian Cables y Sistemas S.L.
Carretera C-15, Km. 2
08800 Vilanova i la Geltrú (Barcelona)
tel. +34 93 811 6181
fax +34 93 811 6011

SWEDEN
Prysmian Kablar och System AB
Turebergs Allé 2
SE-19162 Sollentuna
tel. +46 8 260416
fax +46 8 260413

THAILAND
Prysmian Cable Systems Pte. Ltd.
555 RASA Tower 11th floor
Phaholyothin Road, Lardyao
Chatuchak, Bangkok 10900
tel. +66 2 9370 316
fax +66 2 9370 318

TURKEY
Turk Prysmian Kablo ve Sistemleri A.S.
Buyukdere Caddesi No 117
34394 Gayrettepe, Istanbul
tel. +90 212 3551 500
fax +90 212 2175 810

U.A.E. (Dubai)
Prysmian Cables and Systems Middle East
P.O. Box 72125
Dubai
tel. +971 4 345 7870
fax. +971 4 345 7101

UK
Prysmian Cables and Systems Ltd.
Chickenhall Lane
Eastleigh
Hampshire, SO50 6YU
tel. +44 2380 295555
fax +44 2380 295111

dega design group

Prysmian Cavi e Sistemi Energia Srl
Viale Sarca 222, 20126 Milano, Italy - tel. +39 02 6449 1, fax +39 02 6449 2931 - www.prysmian.com