REGIONE BASILICATA

Comune principale impianto

COMUNE DI MONTEMILONE
PROVINCIA DI POTENZA

Opere connesse

COMUNE DI VENOSA
PROVINCIA DI POTENZA

COMUNE DI SPINAZZOLA
PROVINCIA DI BAT

COMUNE DI BANZI
PROVINCIA DI POTENZA

COMUNE DI GENZANO DI LUCANIA
PROVINCIA DI POTENZA

COMUNE DI PALAZZO SAN GERVASIO
PROVINCIA DI POTENZA

PROGETTO PER LA REALIZZAZIONE DI UN IMPIANTO PER LA PRODUZIONE DI ENERGIA ELETTRICA DA FONTE EOLICA, AI SENSI DEL D.LGS N. 387 DEL 2003, COMPOSTO DA N° 17 AEREOGENERATORI, PER UNA POTENZA COMPLESSIVA DI 71.4 MW, SITO NEL COMUNE DI MONTEMILONE (PZ) E OPERE CONNESSE NEI COMUNI DI VENOSA (PZ), PALAZZO SAN GERVASIO (PZ), BANZI (PZ), GENZANO DI LUCANIA(PZ) E SPINAZZOLA (BT)

COD.REG	DESCRIZIONE
A.5	***Indagine anemologica del sito e requisiti anemologici***
COD. INT.	
Elab.5	

ORDINE DEGLI INGEGNERI PROVINCIA DI SALERNO INGEGNERE GIUSEPPE DELLI PRISCOLI Albo N. 5333

ORDINE DEGLI INGEGNERI DELLA PROVINCIA DI CASERTA Dott. Ing. GIUSEPPE DE MASI N. 3457 "Sez. A"

REDATTO	**VERIFICATO**	**APPROVATO**	**REVISIONE**
Dott. M. Angioletti	*Arch. M. Lombardi*	*Ing. G. Delli Priscoli* *Ing. G. De Masi*	*Revisione 0*
			DATA
			12/2019

Cogein ENERGY
Via Diocleziano, 107 - 80125 Napoli Tel. 081.19566613 - Fax. 081.7618640 www.newgreen.it

Indice

1 Descrizione del sito

1.1 Identificazione geografica del sito

L'area di interesse è situata a nella Regione Basilicata, in Provincia di Potenza nel Comune di Montemilone. Il comune si estende su una superficie di 114,14 km^2, sorge su un rialzo, che si spinge dai 320 m s.l.m. a 351 m s.l.m. Il territorio è compreso tra l'altopiano delle Murge a est, la depressione bradanica (Forra di Venosa) a sud, e il Tavoliere delle Puglie a nord. in prossimità del confine con la Puglia, in Figura 1 viene riportato l'inquadramento generale dell'area.

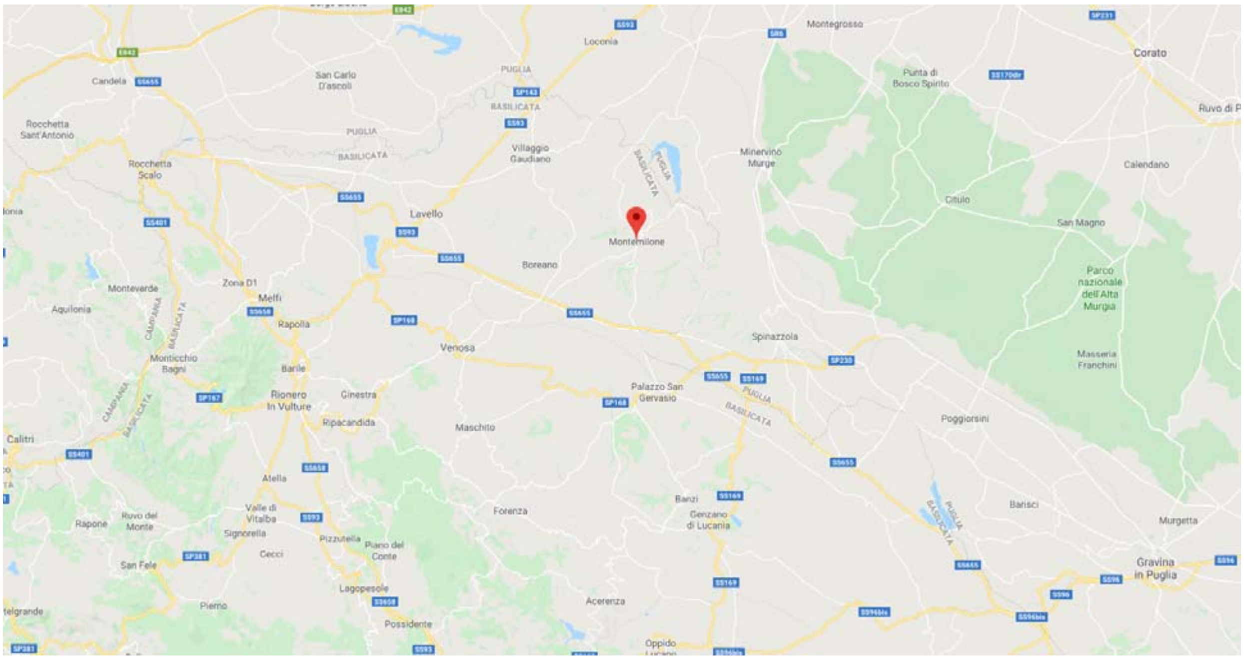

Figura 1 - Inquadramento generale

Il sito d'interesse è collocato geograficamente nell'area a sud del Comune di Montemilone come mostrato in Figura 2.

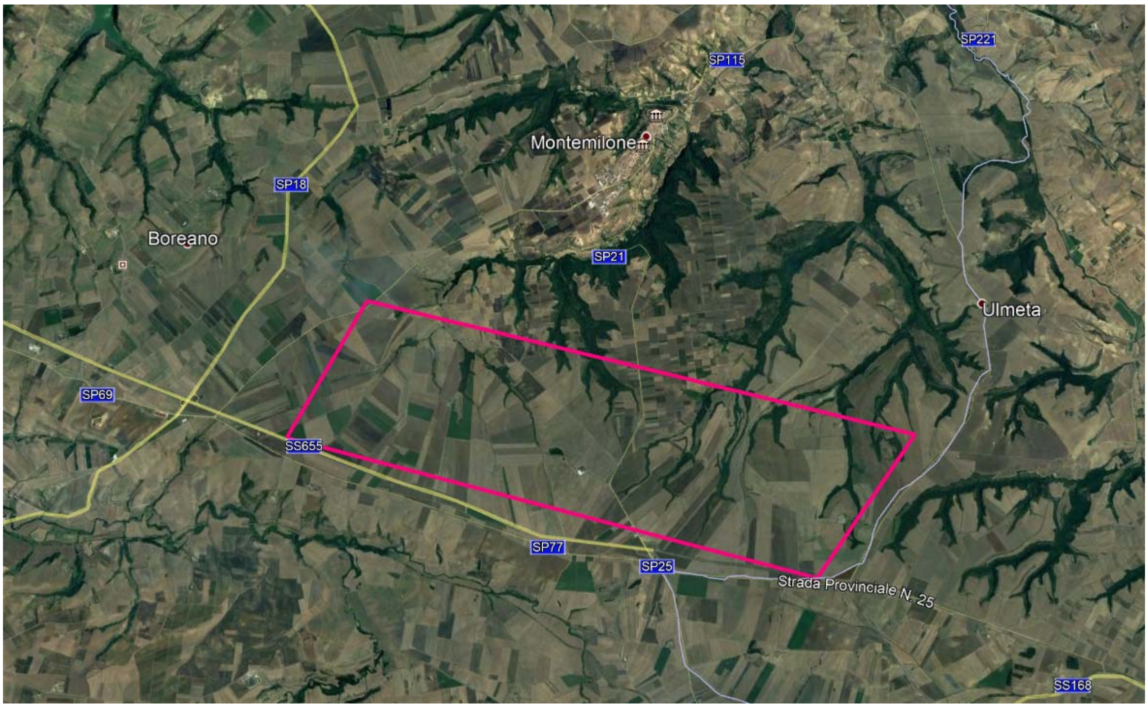

Figura 2 - Localizzazione area sud

L'area risulta essere priva di aree boschive ed è situata ad un'altitudine compresa tra i 360 e i 410m.s.l.m.. Il sito risulta estendersi su una grande area semi-pianeggiante, con assenza di ostacoli geomorfologici, per tanto presenta una buona esposizione ai venti provenienti, da qualsiasi quadrante. Tale caratteristica, non sempre ritrovabile in un parco eolico, garantisce la massima efficienza della risorsa vento che potrà essere sfruttata in tutte le sue direzioni.

1.2 Accessibilità al sito

L'accesso all'area interessata è garantito dalla Strada Provinciale SP25 derivante dalla Puglia, che consente di arrivare agevolmente nei punti in cui è prevista l'installazione degli aerogeneratori. Si prevedono, comunque, alcuni piccoli interventi di miglioramento e la creazione di piccoli tratti stradali per l'accesso al sito per il passaggio dei mezzi pesanti necessari all'installazione degli aerogeneratori.

La viabilità per l'accesso al campo è stata realizzata in modo da evitare, per quanto possibile, aree tutelate ai sensi della D.LGS 42/2004. Infatti come accennato e meglio dettagliato nelle relazioni specifiche, si è provveduto all'utilizzo delle strade già esistenti e delle aree scevre da vincoli.

2 Caratteristiche anemometriche dell'area

2.1 Misurazione anemometrica

Il parametro meteo climatico più importante, in relazione all'impianto in progetto è costituito, ovviamente, dal regime anemometrico, dal momento che su di esso si basano i criteri di individuazione del sito e l'intera progettazione del parco eolico.

La qualità di un sito, infatti, relativamente alla sua capacità di produrre energia dal vento, è strettamente legata a due fattori:

- Ventosità del sito;
- Corretta ubicazione e scelta degli aerogeneratori.

In riferimento al fattore "ventosità del sito", risulta chiaro che la verifica dell'effettiva quantità di vento disponibile in un sito può essere effettuata solo attraverso una campagna di misurazione anemometrica. A tal proposito la società COGEIN ENERGY. s.r.l., proponente del presente progetto, ha installato in data 16/09/2010 una stazione anemometrica specifica (Lavello h60) per i progetti eolici e rispettosa degli standard richiesti per la validazione delle misure effettuate in modo da poter caratterizzare il regime anemometrico di un'area vasta di studio. Nell'allegato A sono riportati i report di istallazione e manutenzione della torre su citata, ed i corrispettivi certificati di calibrazione. L'anemometro ha condotto una campagna di misurazione fino al 31/7/2013 per un totale di circa 3 anni di misurazione.

L'ubicazione della stazione di misura, è individuata nel Comune di Lavello ad un altezza di 181m s.l.m.. Tale stazione di misura, in relazione alle medesime caratteristiche orografiche delle aree oggetto di questo studio, è stata considerata per la determinazione della rosa dei venti rappresentativa delle aree costituenti il sito di interesse e della risorsa eolica.

La stazione di misura anemometrica è di tipo tubolare alta 60m e dotata di quattro sensori di velocità, rispettivamente due a 60m s.l.s., uno a 40m s.l.s. ed uno a 30m s.l.s ., e di due sensori di direzione, alle altezze di 58 e 38m s.l.s., un sensore di temperatura a 6m s.l.s..

La torre è situata leggermente defilata nel lato ovest rispetto all'area di studio, come riportato in Figura 4:

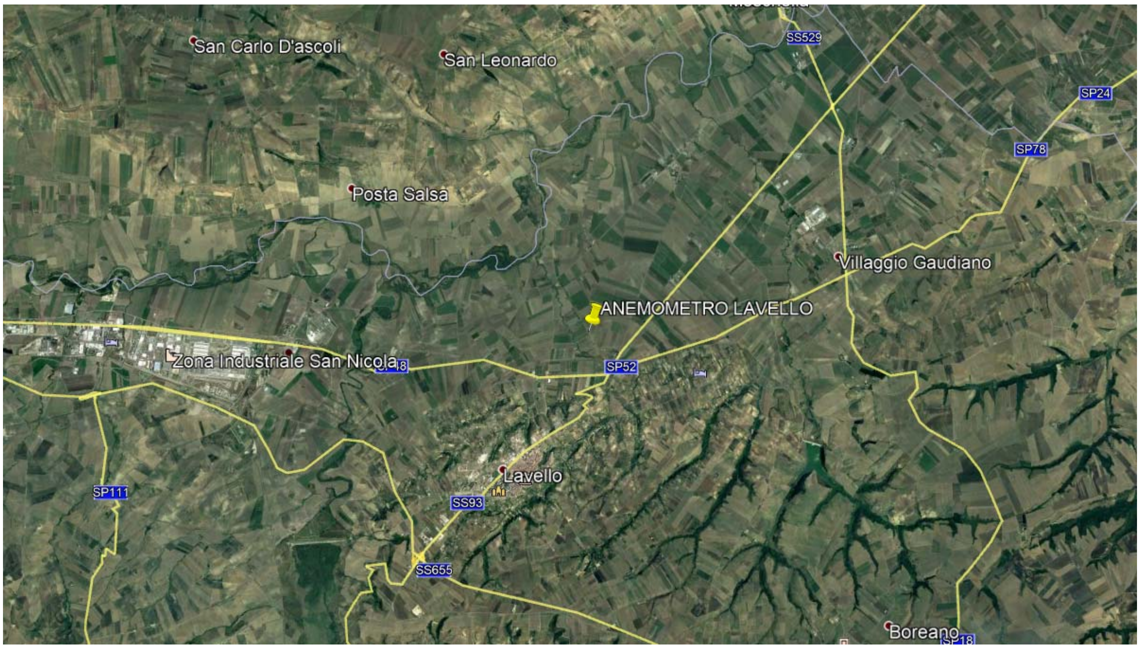

Figura 3 - Localizzazione torre anemometrica

con coordinate, in WGS-84(fuso 33) E 568225 N 4547387ad un altitudine di circa 180m s.l.m..

2.2 Caratteristiche anemometriche dell'area

L'ubicazione della torre è stata individuata in modo tale da essere rappresentativa per tutta l'area sulla quale si intende realizzare il campo e da rimanere a considerevole distanza, da ostacoli o irregolarità territoriali che potrebbero influire fortemente sul flusso indisturbato della vena fluida.

La stazione è stata soggetta a costanti controlli e manutenzioni sia ordinarie che straordinarie, per il corretto funzionamento, da società leader nel settore dei servizi tecnici per lo sviluppo dei parchi eolici. Dall'elaborazione dei dati del vento si è potuto estrapolare le rose dei venti che caratterizzano tale area, funzione delle frequenze e dell'intensità del vento.

Tale studio preliminare ha consentito un primo imprinting di layout, successivamente ottimizzato.

2.3 Analisi dati

In Figura 4 si nota come il sito sia esposto a venti sinottici, infatti l'andamento delle medie mensili presenta valori maggiori nei mesi Autunnali e Invernali, per poi scemare nei mesi primaverili ed estivi.

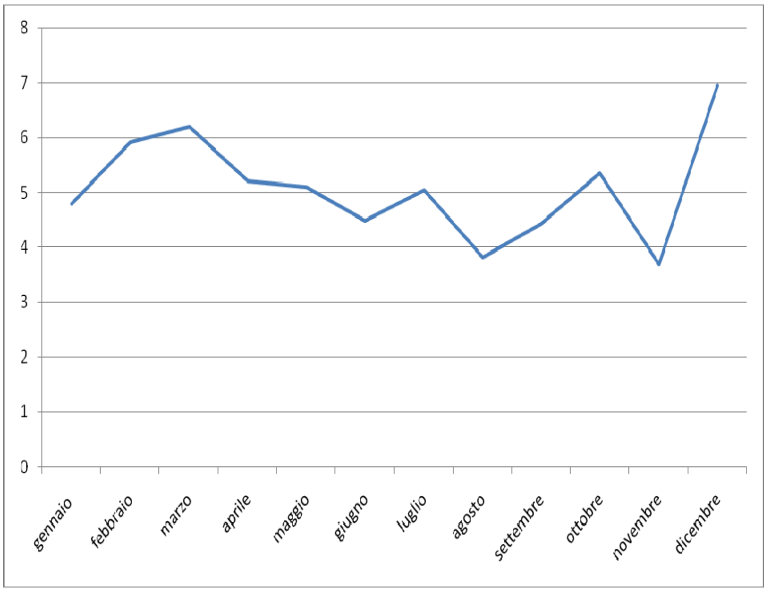

Figura 4 - Andamento medio mensile delle velocità misurate

Nella Figura successiva è riportata la rosa dei venti in frequenze, estrapolata dai dati rilevati, ove si mette in evidenza la netta prevalenza dei venti provenienti da Nord-ovest e Ovest.

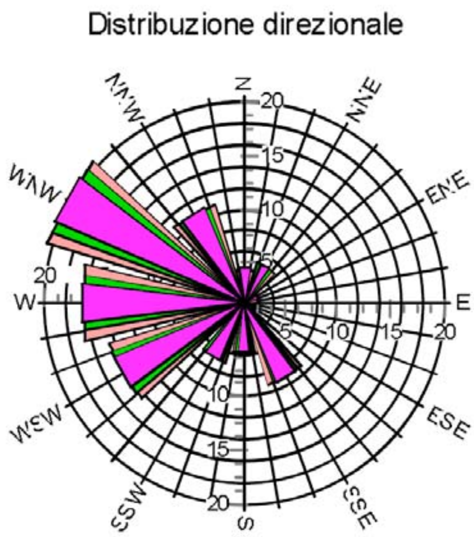

Figura 5 - Rosa dei venti puntuale

L'istallazione dei sensori sui pali anemometrici potrebbero, se non installati in maniera adeguata, causare effetti scia o di accelerazioni sulle direzioni prevalente dei venti, con errori sulla valutazione dei dati anemologici. Per tale motivo è stato condotto uno studio a monte dell'installazione dei braccetti di sospensione.

Tale studio ha riscontrato assenza dell'effetto di shading sui sensori di velocità da parte delle strutture di sostegno come evidenziato nella Figura 6.

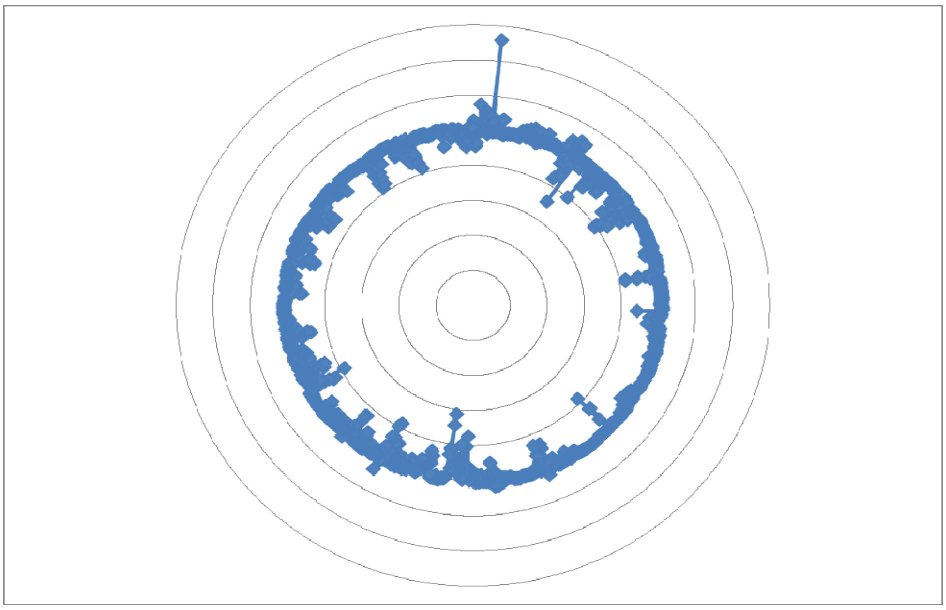

Figura 6 - Effetto di shading calcolato sul sensore di velocità al top

2.4 Layout impianto

Sulla base della rosa dei venti relativa alla vicina torre anemometrica di Lavello di proprietà del proponente è stato determinata una bozza di layout del parco. Tale bozza è servita come imprinting per giungere al layout definitivo a valle di uno studio di fattibilità e di opportuni e ripetuti sopralluoghi in sito. La tipologia di aerogeneratori considerata, in questa fase di studio, è quella appartenente alla classe di grande taglia 4.2MW con un'altezza al mozzo di 105 m con diametro delle pale pari a 150m.

Si riportano di seguito le coordinate (WGS84 e GAUSS-BOAGA per il fuso 33) degli aerogeneratori:

DENOMINAZIONE	COORDINATE				QUOTA
	GAUSS-BOAGA		UTM WGS84		m s.l.m.
	EST	NORD	EST	NORD	
MN 01	2601055	4538013	581047	4538008	393
MN 02	2601498	4537589	581490	4537584	395
MN 03	2602050	4537836	582041	4537831	390
MN 04	2602654	4537875	582645	4537870	388
MN 05	2603343	4538059	583334	4538054	384
MN 06	2604295	4538342	584287	4538337	372
MN 07	2604795	4538680	584786	4538674	366
MN 08	2605228	4539099	585219	4539094	355
MN 09	2606071	4539907	586063	4539902	354
MN 10	2601976	4536759	581968	4536754	408
MN 11	2602628	4536833	582619	4536828	406
MN 12	2603322	4536785	583314	4536780	403
MN 13	2603948	4536815	583940	4536810	402
MN 14	2605072	4537097	585064	4537092	400
MN 15	2605683	4537838	585675	4537833	386
MN 16	2606107	4538272	586099	4538267	378
MN 17	2606470	4539441	586461	4539435	361

Tabella 1 – Coordinate aerogeneratori in 2 sistemi di riferimento

Il layout realizzato presenta 17 aerogeneratori disposti su 2 file immaginarie parallele, tutte le turbine ricadono nel territorio del comune di Montemilone al confine con il comune di Spinazzola:

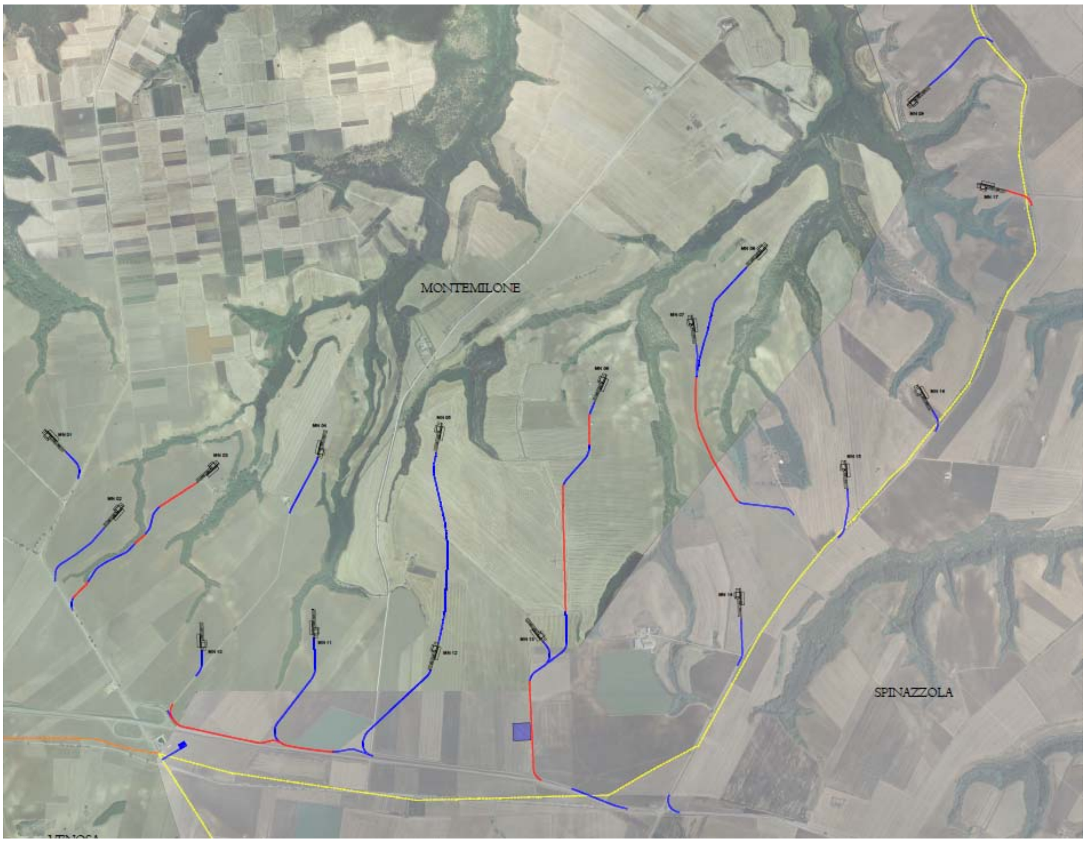

Figura 7 - Layout impianto

2.5 Stima della producibilità

Il rendimento del parco è funzione si dell'orografia circostante e dell'intensità del vento, ma l'ottimizzazione del layout, accuratamente elaborato, permette una drastica diminuzione degli effetti scia e la conseguente diminuzione del rendimento del parco che si hanno nel caso di macchine ravvicinate, a causa delle modifiche causate dalla presenza di queste nella vena fluida che le attraversa; le perdite di cui sopra, definite come perdite per effetto scia, sono dovute al fatto che la velocità del vento risulta rallentata, in quanto il rotore cattura parte dell'energia cinetica per trasformarla in energia meccanica. Venendo a contatto con la corrente indisturbata, il flusso di vento riprende a poco a poco le proprie caratteristiche di velocità.

Per quanto riguarda il fattore "corretta ubicazione degli aerogeneratori" esso tiene conto di una serie di parametri peculiari del territorio quali l'orografia, la rugosità (ostacoli vari: fitta vegetazione, edifici, ecc.), presenza di recettori sensibili (abitazioni sparse, ecc.), vincoli idrogeologici, ecc..

Oltre alle caratteristiche morfologiche del territorio ed antropiche, un ulteriore fattore preso in considerazione è stata la geometria dell'aerogeneratore utilizzato, in particolar modo si è utilizzato il modello V150 della Vestas con potenza nominale 4.2MW.

Inoltre ci si è attenuti a quanto disposto dal "Piano di Indirizzo Energetico Ambientale Regionale della Basilicata" ed in particolare nell'Appendice "A", Principi generali per la progettazione la costruzione, l'esercizio e la dismissione degli impianti alimentati da fonti rinnovabili nel paragrafo denominato "La progettazione". In particolar modo per garantire corridoi di transito alla fauna oltre che ridurre l'impatto visivo gli aerogeneratori devono essere disposti in modo tale che:

a) la distanza minima tra gli aerogeneratori, misurata a partire dall'estremità delle pale disposte orizzontalmente, sia pari a tre volte il diametro del rotore più grande;

b) la distanza minima tra le file di aerogeneratori, disposti lungo la direzione prevalente del vento, sia pari a 6 volte il diametro del rotore più grande; nel caso gli aerogeneratori siano disposti su file parallele con una configurazione sfalsata, la distanza minima tra le file non può essere inferiore a 3 volte il diametro del rotore più grande.

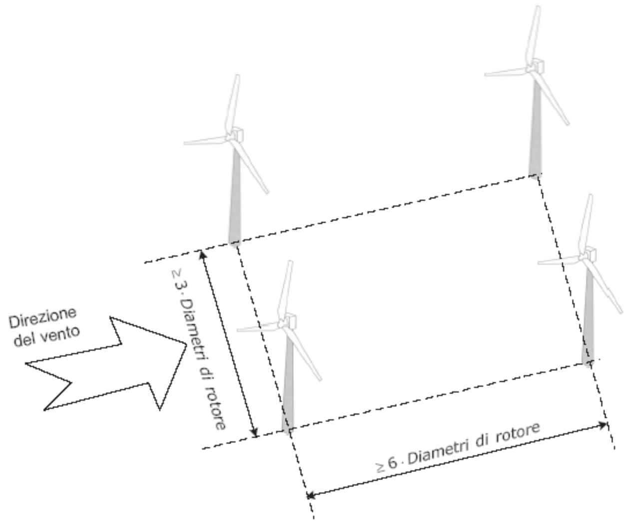

Fig.8-Distanze minime tra aerogeneratori.

Le misure di vento raccolte attraverso la campagna anemometrica e quindi riferite ad una determinata posizione del campo ed a una determinata quota, sono state estrapolate sia spazialmente (verticalmente e orizzontalmente) sia temporalmente, attraverso modelli di calcolo numerici, con i quali sarà possibile definire, nel modo più attendibile possibile una previsione di producibilità del parco eolico in esame e decidere, il modello di aerogeneratore che maggiormente si adatta al sito oggetto di studio.

Infatti, gli aerogeneratori riescono a catturare solo parte della potenza eolica disponibile in un sito e per tale motivo sono progettati e costruiti in maniera specifica per i diversi regimi di vento esistenti.

2.5.1 Modello aerogeneratore

La Vestas, leader mondiale nel settore eolico, annovera tra la sua gamma di prodotti turbine eoliche di diversa grandezza geometrica e diversa potenza nominale a seconda delle svariate esigenze di mercato e soprattutto per le diverse tipologie di siti. Come anticipato, il modello selezionato, idoneo al campo in oggetto è la V150-4.2Mw con altezza al mozzo 105m. Si rimanda all'allegato B per la scheda tecnica dettagliata.

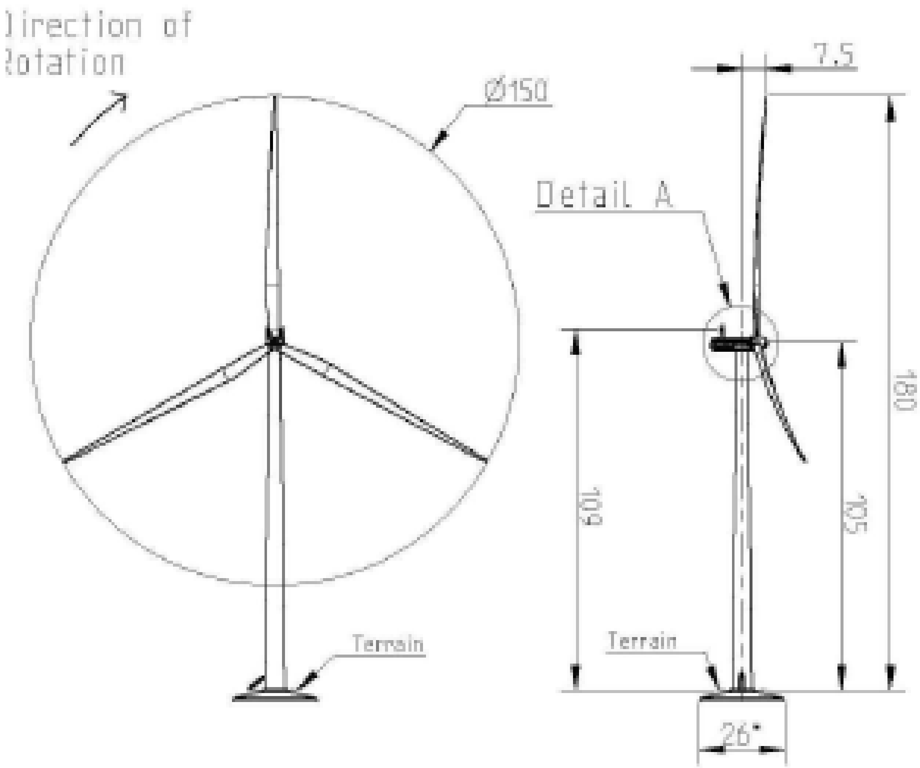

Fig.9-Schema turbina Vestas modello V150

2.6 Parametri di simulazione

Per la stima della producibilità del parco in oggetto, la proponente, si è avvalsa dei più comuni ed avanzati software di modellistica fluidodinamica. In particolare sono stati utilizzati i seguenti programmi:

- Nomad2;
- Wasp;
- Wind Farmer.

I dati anemometrici sono stati filtrati e ripuliti da eventuali malfunzionamenti, prima di essere utilizzati, in modo da rendere gli stessi maggiormente attendibili. La procedura, per il calcolo della stima di producibilità, ha previsto la creazione di una mappa dei venti, tecnicamente definita "risorsa eolica".

La mappa della risorsa eolica è stata calcolata ad un altezza pari all'altezza hub(105m) con un passo della griglia di 25m, caratterizzando le tre tipologie di aree prese in considerazione ove ricadono gli aerogeneratori. In seguito sono state sovrapposte all'area di studio per individuare le zone di maggior interesse anemologico, come mostrato in Figura 9. L'area di maggior interesse, sulla base dei riscontri anemometrici ottenuti dalla campagna di misurazione in corso, presenta una buona ventosità. Nella seguente Figura 10, che mostra la mappa del vento ottenuta sulla base dei dati rilevati dall'anemometro, il colore blu sta ad indicare una zona con scarsa ventosità, mentre passando per il colore verde, giallo, arancione e andando verso il colore rosso si ha una ventosità crescente, con medie sopra i 7m/s ad altezza mozzo.

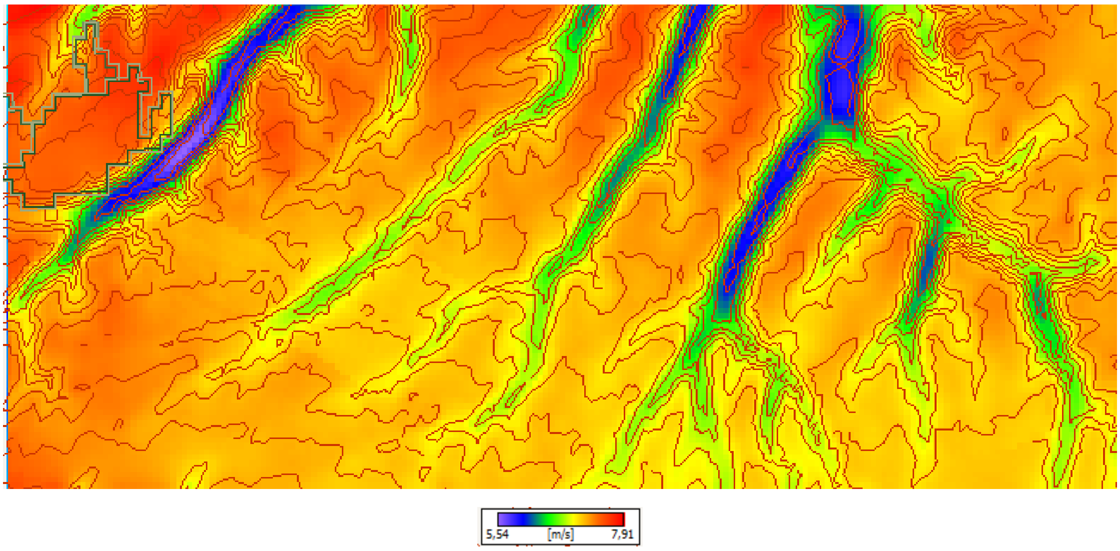

Figura 10 - Risorsa eolica ad altezza mozzo

Con tali assunzioni tramite modelli matematici, su citati, si è estrapolato il potenziale di producibilità che risulta essere, superiore ai 3530 MWh/MW, come si evince dalla seguente tabella:

ID turbina	Velocità media del vento libero (m/s)	Resa Netta (MWh/yr)	ORE EQ
MN 01	6,36	14880	3543
MN 02	6,37	14879	3543
MN 03	6,27	14888	3545
MN 04	6,33	14879	3543
MN 05	6,39	14862	3539
MN 06	6,33	14885	3544
MN 07	6,36	14822	3529
MN 08	6,32	14808	3526
MN 09	6,34	14855	3537
MN 10	6,29	14807	3525
MN 11	6,34	14809	3526
MN 12	6,31	14810	3526
MN 13	6,34	14825	3530
MN 14	6,3	14895	3546
MN 15	6,33	14791	3522
MN 16	6,33	14788	3521
MN 17	6,34	14790	3521
		252273	**3533**

Tabella 2 –Producibilità per singolo aerogeneratore

2.7 Indice densità volumetrica

In diverse Regioni Italiane, si richiede il calcolo della densità volumetrica di energia annua che non deve risultare minore a 0,20 Kwh yr/m^3 come si evince dall' *"Attuazione del Piano Energetico Ambientale Regionale (PEAR)"* deliberato dalla Giunta Regionale della Basilicata, allegato “A”.

In particolare la densità volumetrica di energia annua (E_v) è stata calcolata secondo la seguente formula riportata:

$$E_v = \frac{E}{18 \cdot D^2 \cdot H} \quad \left[kWh\ anno / m^3 \right]$$

dove E risulta essere l'energia annua prodotta, D il diametro rotore ed H l'altezza dell'aerogeneratore calcolata come la somma dell'altezza hub più raggio rotore come riportato in Figura 13.

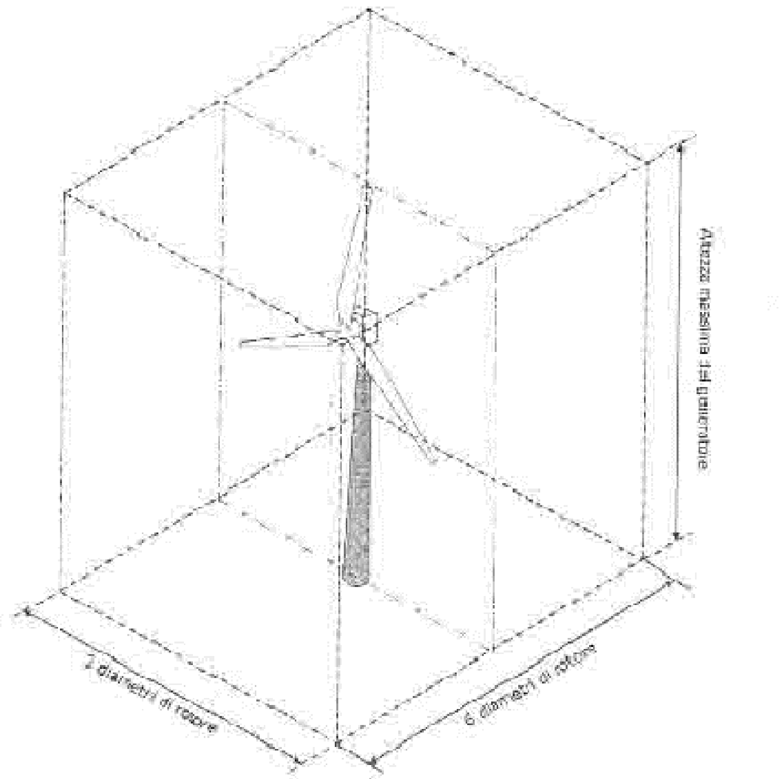

Figura 11 - Calcolo della densità volumetrica

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Il calcolo della densità volumetrica riportato in tabella 3, riporta per singolo aerogeneratore il valore di Ev ove si evince il rispetto della normativa vigente con valori leggermente superiori a 0.2 Kwh yr/m^3.

ID turbina	Resa Netta (MWh/yr)	Ev
MN 01	14880	0,204
MN 02	14879	0,204
MN 03	14888	0,204
MN 04	14879	0,204
MN 05	14862	0,204
MN 06	14885	0,204
MN 07	14822	0,203
MN 08	14808	0,203
MN 09	14855	0,204
MN 10	14807	0,203
MN 11	14809	0,203
MN 12	14810	0,203
MN 13	14825	0,203
MN 14	14895	0,204
MN 15	14791	0,203
MN 16	14788	0,203
MN 17	14790	0,203

Tabella 3 –Indice di densità volumetrica per singolo aerogeneratore

ALLEGATO A.1 – Certificato di calibrazione

1 Detailed MEASNET[1] Calibration Results

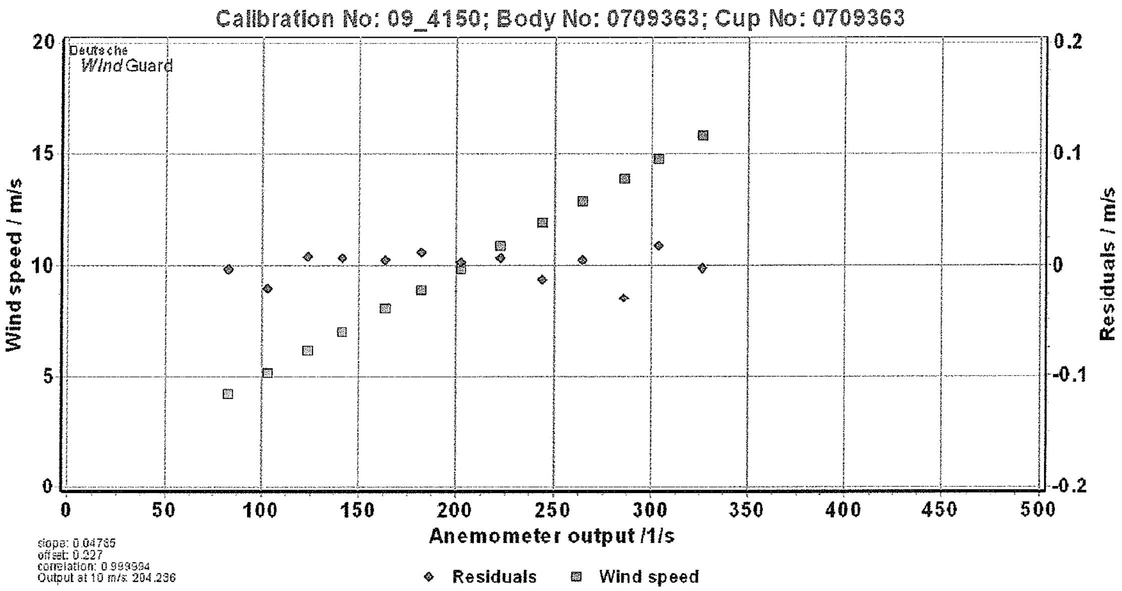
DKD calibration no.	09/4150
Body no.	0709363
Cup no.	0709363
Date	16.07.2009
Air temperature	25.8 °C
Air pressure	1019.9 hPa
Humidity	55.4 %

Deutsche WindGuard Wind Tunnel Services GmbH – measnet

Linear regression analysis

Slope	0.04785 (m/s)/(1/s) ±0.00005 (m/s)/(1/s)
Offset	0.227 m/s ±0.011 m/s
St.err(Y)	0.012 m/s
Correlation coefficient	0.999994

Remarks	no



[1]) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 9515 0

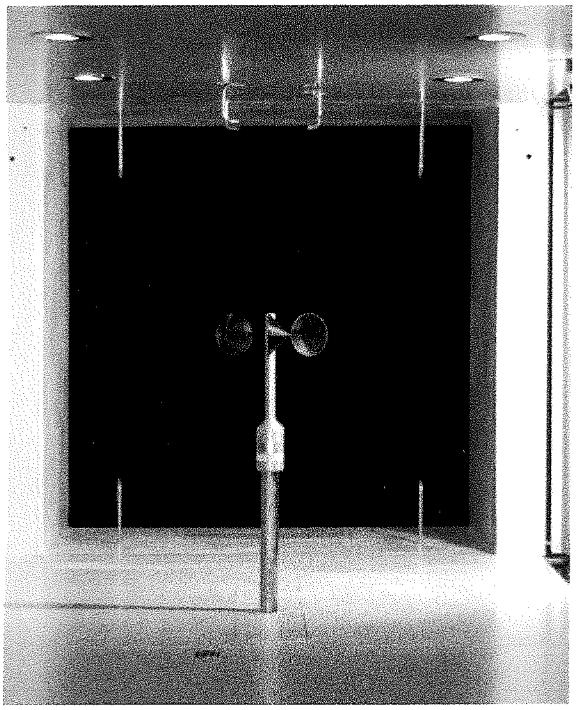
Deutsche WindGuard Wind Tunnel Services GmbH

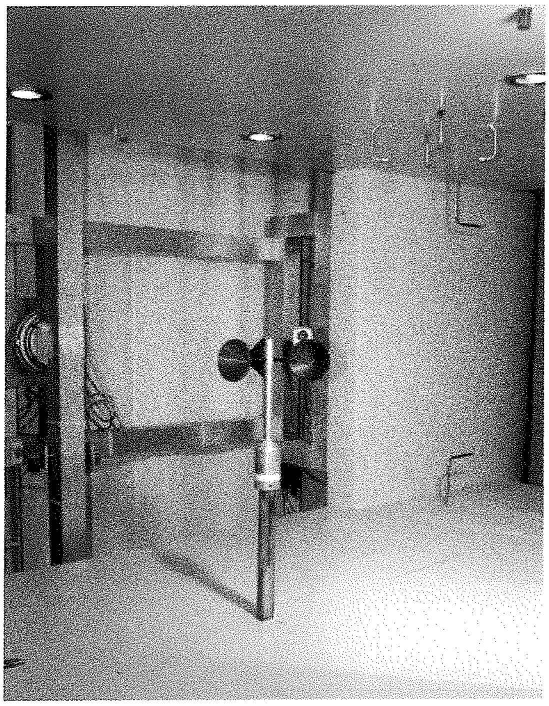
2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year	Calibration
1	Pitot static tube	Airflow	483/8 Nr. 000142	02	06/02
2	Pitot static tube	Airflow	483/8 Nr. 000143	02	06/02
3	Pitot static tube	Airflow	483/8 Nr. 000144	02	06/02
4	Pitot static tube	Airflow	483/8 Nr. 000145	02	06/02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02	DWG12/07
6	Pressure transducer	Setra	C 239 Nr. 1688082	02	DWG12/07
7	Pressure transducer	Setra	C 239 Nr. 1688083	02	03/07
8	Pressure transducer	Setra	C 239 Nr. 1688084	02	03/05
9	El. Barometer	Vaisala	100 A Nr. X2010004	02	DWG12/07
10	El. Thermometer	Galltec	KPK 1/6-ME	02	DWG12/07
11	El. Humidity sensor	Galltec	KPK 1/6-ME	02	DWG12/07
12	Wind tunnel control	-	-	-	-
13	CAN-BUS / PC	esd	-	04	05/04
14	Anemometer		-		
15	Universal Isolator	Knick	P2700 - 58285/8198430	05	01/06

Table 1 Description of the data acquisition system

3 Photo of the calibration set-up





Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel.
The anemometer shown is of the same type as the calibrated one.
Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

[1] J. Mander, D. Westermann, 12/2007 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
[2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
[3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
[4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

DEUTSCHER KALIBRIERDIENST DKD

Kalibrierlaboratorium / Calibration laboratory
Akkreditiert durch die / *accredited by the*
Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

Deutscher Akkreditierungs Rat
DAR

DKD-K- 36801

09/4397
DKD-K- 36801
07/2009

Kalibrierschein Kalibrierzeichen
Calibration Certificate *Calibration label*

Gegenstand *Object*	Cup Anemometer
Hersteller *Manufacturer*	Thies Clima D-37083 Göttingen
Typ *Type*	4.3350.10.000
Fabrikat/Serien-Nr. *Serial number*	Body: 0709391 Cup: 0709391
Auftraggeber *Customer*	Thies Clima D-37083 Göttingen
Auftragsnummer *Order No.*	VT09428
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	3
Datum der Kalibrierung *Date of calibration*	31.07.2009

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Der DKD ist Unterzeichner der multi- lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.

Stempel *Seal*	Datum *Date*	Leiter des Kalibrierlaboratoriums *Head of the calibration laboratory*	Bearbeiter *Person in charge*
Deutscher Kalibrierdienst DKD-K-36801	31.07.2009	Dipl. Phys. D. Westermann	Dipl.-Ing.(FH) M. Meyer zu Himmern

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 9515 0

Deutsche WindGuard Wind Tunnel Services GmbH

09/4397
DKD-K-36801
07/2009

Kalibriergegenstand *Object*	Anemometer		
Kalibrierverfahren *Calibration procedure*	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977		
Ort der Kalibrierung *Place of calibration*	Windtunnel of Deutsche WindGuard, Varel		
Messbedingungen *Test Conditions*	wind tunnel area [1]	10000 cm²	
	anemometer frontal area [2]	230 cm²	
	diameter of mounting pipe [3]	34 mm	
	blockage ratio [4]	0.023 [-]	
	blockage correction [5]	1.000 [-]	
	average WindGuard reference [6]	203.8 1/s (Thies First Class)	
	present WindGuard reference [7]	203.7 1/s	
Umgebungsbedingungen *Test conditions*	air temperature	24.2 °C	± 1.0 K
	air pressure	1022.9 hPa	± 1.0 hPa
	relative air humidity	52.0 %	± 2.5 %
Dateiinformation *File info*			
Anmerkungen *Remarks*		-	
Auswertesoftware *Software version*		4.0	

[1] Querschnittsfläche der Auslassdüse des Windkanals

[2] Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

[3] Durchmesser des Montagerohrs

[4] Verhältnis von 2) zu 1)

[5] Korrekturfaktor durch die Verdrängung der Strömung durch den Prüfling

[6] Referenzwert des Referenzanemometers bei 10 m/s (Mittelwert)

[7] Aktueller Wert des Referenzanemometers

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

Kalibrierergebnis:
Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
82.607	4.181	0.10
124.459	6.174	0.10
163.128	8.057	0.10
202.665	9.923	0.10
244.711	11.887	0.10
286.286	13.873	0.10
327.188	15.840	0.11
305.059	14.799	0.10
264.740	12.887	0.10
222.913	10.884	0.10
182.928	8.961	0.10
142.332	7.023	0.10
102.458	5.138	0.10

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the mea-surement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agree-ments of the European co-operation for Accredita-tion (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

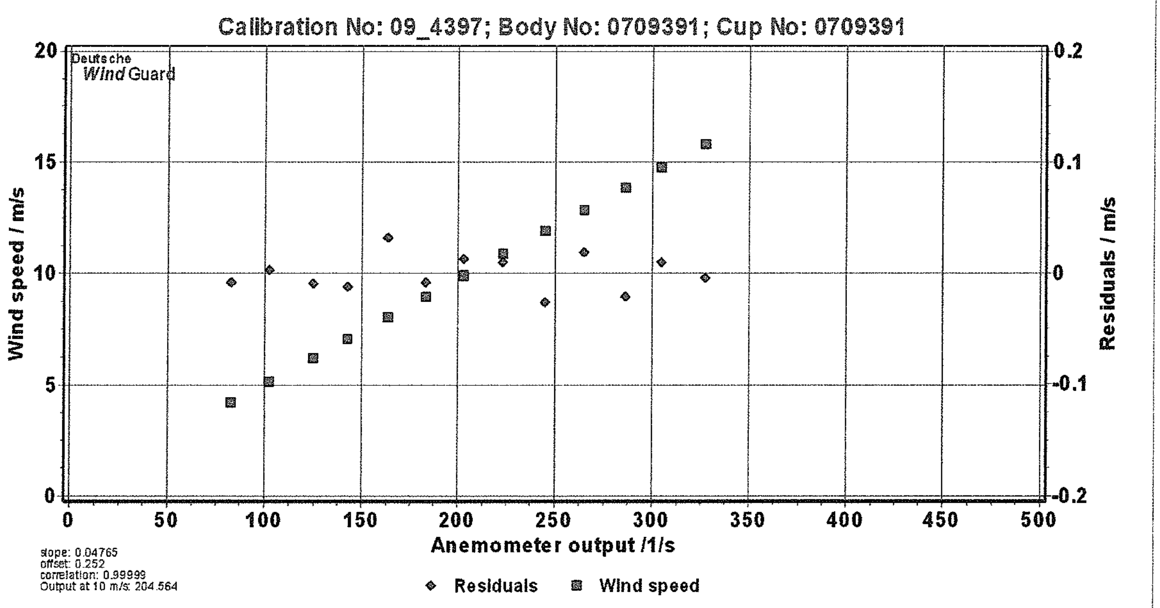
1 Detailed MEASNET[1] Calibration Results

DKD calibration no.	09/4397
Body no.	0709391
Cup no.	0709391
Date	31.07.2009
Air temperature	24.2 °C
Air pressure	1022.9 hPa
Humidity	52.0 %

Linear regression analysis

Slope	0.04765 (m/s)/(1/s) ±0.00006 (m/s)/(1/s)
Offset	0.252 m/s ±0.014 m/s
St.err(Y)	0.016 m/s
Correlation coefficient	0.999990

Remarks	no



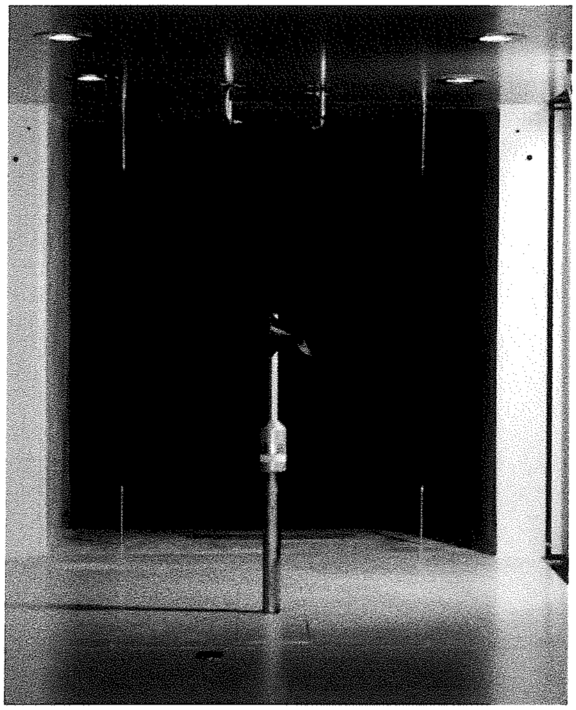
[1]) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

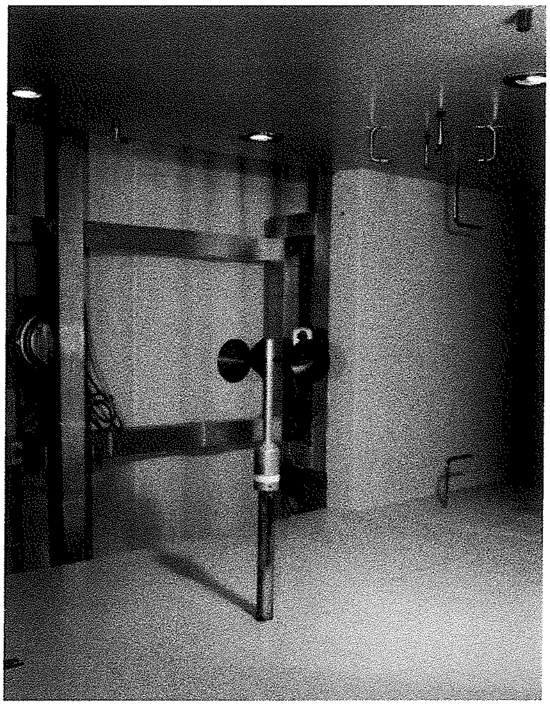
2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year	Calibration
1	Pitot static tube	Airflow	483/8 Nr. 000142	02	06/02
2	Pitot static tube	Airflow	483/8 Nr. 000143	02	06/02
3	Pitot static tube	Airflow	483/8 Nr. 000144	02	06/02
4	Pitot static tube	Airflow	483/8 Nr. 000145	02	06/02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02	DWG12/07
6	Pressure transducer	Setra	C 239 Nr. 1688082	02	DWG12/07
7	Pressure transducer	Setra	C 239 Nr. 1688083	02	03/07
8	Pressure transducer	Setra	C 239 Nr. 1688084	02	03/05
9	El. Barometer	Vaisala	100 A Nr. X2010004	02	DWG12/07
10	El. Thermometer	Galltec	KPK 1/6-ME	02	DWG12/07
11	El. Humidity sensor	Galltec	KPK 1/6-ME	02	DWG12/07
12	Wind tunnel control	-	-	-	-
13	CAN-BUS / PC	esd	-	04	05/04
14	Anemometer		-		
15	Universal Isolator	Knick	P2700 - 58285/8198430	05	01/06

Table 1 Description of the data acquisition system

3 Photo of the calibration set-up





Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel.
The anemometer shown is of the same type as the calibrated one.
Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

[1] J. Mander, D. Westermann, 12/2007 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
[2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
[3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
[4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

DEUTSCHER KALIBRIERDIENST DKD

C 3

Kalibrierlaboratorium / Calibration laboratory
Akkreditiert durch die / *accredited by the*
Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

Deutscher Akkreditierungs Rat
DAR
DKD-K- 36801

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration label

09/3314
DKD-K- 36801
06/2009

Gegenstand *Object*	Cup Anemometer
Hersteller *Manufacturer*	Thies Clima D-37083 Göttingen
Typ *Type*	4.3350.10.000
Fabrikat/Serien-Nr. *Serial number*	Body: 0509006 Cup: 0509006
Auftraggeber *Customer*	EURO SERVICE S.r.l. 82020 San Giorgio la Molara
Auftragsnummer *Order No.*	VT09356
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	3
Datum der Kalibrierung *Date of calibration*	08.06.2009

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Der DKD ist Unterzeichner der multi- lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Stempel *Seal*	Datum *Date*	Leiter des Kalibrierlaboratoriums *Head of the calibration laboratory*	Bearbeiter *Person in charge*
Deutscher Kalibrierdienst DKD-K-36801	08.06.2009	Dipl. Phys. D. Westermann	Dipl.-Ing. (FH) M. Meyer zu Himmern

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 9515 0

Deutsche WindGuard Wind Tunnel Services GmbH

Kalibriergegenstand *Object*	Anemometer		
Kalibrierverfahren *Calibration procedure*	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977		
Ort der Kalibrierung *Place of calibration*	Windtunnel of Deutsche WindGuard, Varel		
Messbedingungen *Test Conditions*	wind tunnel area [1]	10000 cm²	
	anemometer frontal area [2]	230 cm²	
	diameter of mounting pipe [3]	34 mm	
	blockage ratio [4]	0.023 [-]	
	blockage correction [5]	1.000 [-]	
	average WindGuard reference [6]	203.8 1/s (Thies First Class)	
	present WindGuard reference [7]	203.6 1/s	
Umgebungsbedingungen *Test conditions*	air temperature	20.6 °C	± 1.0 K
	air pressure	1006.4 hPa	± 1.0 hPa
	relative air humidity	46.9 %	± 2.5 %
Dateiinformation *File info*			
Anmerkungen *Remarks*		-	
Auswertesoftware *Software version*		4.0	

[1] Querschnittsfläche der Auslassdüse des Windkanals
[2] Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr
[3] Durchmesser des Montagerohrs
[4] Verhältnis von 2) zu 1)
[5] Korrekturfaktor durch die Verdrängung der Strömung durch den Prüfling
[6] Referenzwert des Referenzanemometers bei 10 m/s (Mittelwert)
[7] Aktueller Wert des Referenzanemometers

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

Kalibrierergebnis:
Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
82.416	4.211	0.10
123.422	6.183	0.10
163.434	8.108	0.10
202.044	9.957	0.10
243.239	11.943	0.10
284.841	13.931	0.10
326.217	15.905	0.11
304.071	14.861	0.10
263.922	12.943	0.10
221.811	10.930	0.10
182.458	9.003	0.10
141.518	7.062	0.10
102.238	5.162	0.10

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

Der Deutsche Kalibrierdienst ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the mea-surement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agree-ments of the European co-operation for Accredita-tion (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

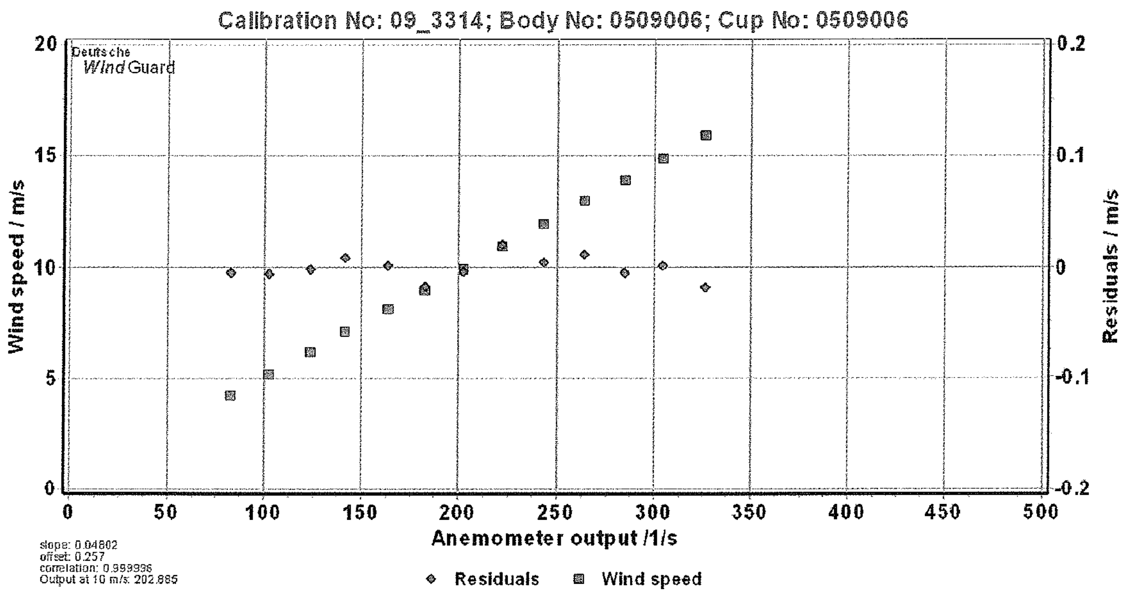
1 Detailed MEASNET[1] Calibration Results

DKD calibration no.	09/3314
Body no.	0509006
Cup no.	0509006
Date	08.06.2009
Air temperature	20.6 °C
Air pressure	1006.4 hPa
Humidity	46.9 %

Linear regression analysis

Slope	0.04802 (m/s)/(1/s) ±0.00004 (m/s)/(1/s)
Offset	0.257 m/s ±0.009 m/s
St.err(Y)	0.007 m/s
Correlation coefficient	0.999996

Remarks	no



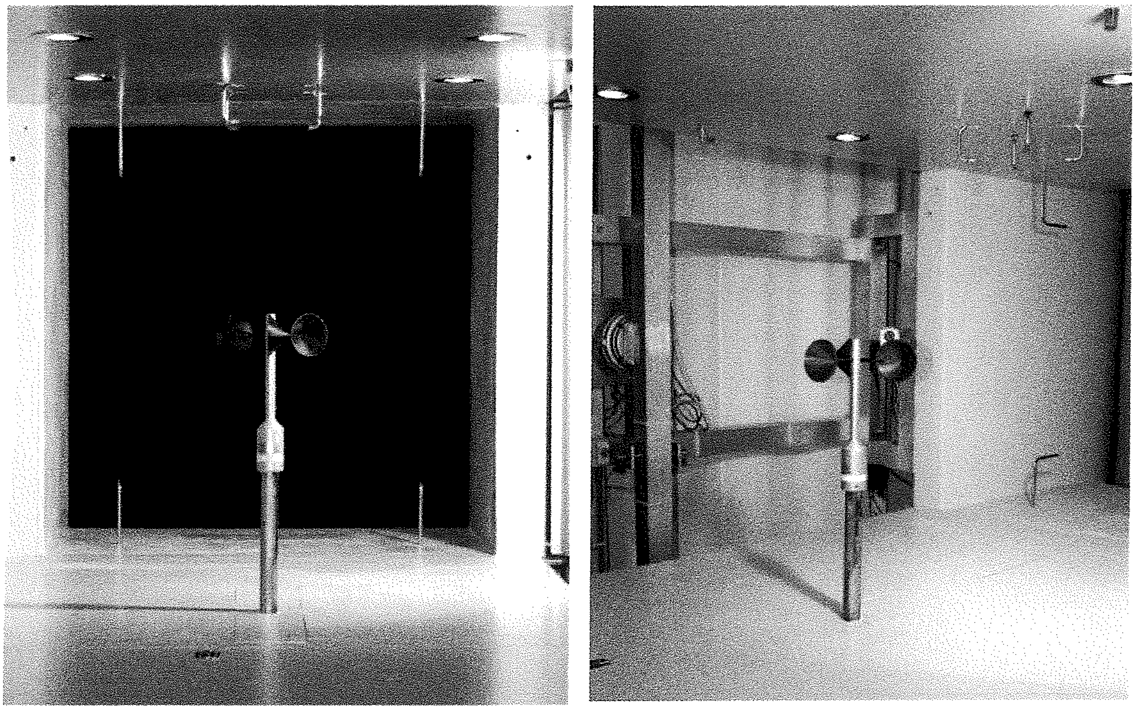
[1]) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year	Calibration
1	Pitot static tube	Airflow	483/8 Nr. 000142	02	06/02
2	Pitot static tube	Airflow	483/8 Nr. 000143	02	06/02
3	Pitot static tube	Airflow	483/8 Nr. 000144	02	06/02
4	Pitot static tube	Airflow	483/8 Nr. 000145	02	06/02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02	DWG12/07
6	Pressure transducer	Setra	C 239 Nr. 1688082	02	DWG12/07
7	Pressure transducer	Setra	C 239 Nr. 1688083	02	03/07
8	Pressure transducer	Setra	C 239 Nr. 1688084	02	03/05
9	El. Barometer	Vaisala	100 A Nr. X2010004	02	DWG12/07
10	El. Thermometer	Galltec	KPK 1/6-ME	02	DWG12/07
11	El. Humidity sensor	Galltec	KPK 1/6-ME	02	DWG12/07
12	Wind tunnel control	-	-	-	-
13	CAN-BUS / PC	esd	-	04	05/04
14	Anemometer		-		
15	Universal Isolator	Knick	P2700 - 58285/8198430	05	01/06

Table 1 Description of the data acquisition system

3 Photo of the calibration set-up



Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel.
The anemometer shown is of the same type as the calibrated one.
Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

[1] J. Mander, D. Westermann, 12/2007 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
[2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
[3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
[4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

DEUTSCHER KALIBRIERDIENST DKD

C4

Kalibrierlaboratorium / Calibration laboratory
Akkreditiert durch die / *accredited by the*
Akkreditierungsstelle des Deutschen Kalibrierdienstes

Deutsche WindGuard Wind Tunnel Services GmbH

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

Deutscher Akkreditierungs Rat
DAR
DKD-K- 36801

09/4391
DKD-K- 36801
07/2009

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration label

Gegenstand *Object*	Cup Anemometer
Hersteller *Manufacturer*	Thies Clima D-37083 Göttingen
Typ *Type*	4.3350.10.000
Fabrikat/Serien-Nr. *Serial number*	Body: 0709396 Cup: 0709396
Auftraggeber *Customer*	Thies Clima D-37083 Göttingen
Auftragsnummer *Order No.*	VT09428
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	3
Datum der Kalibrierung *Date of calibration*	31.07.2009

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Der DKD ist Unterzeichner der multi- lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DKD is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Stempel *Seal*	Datum *Date*	Leiter des Kalibrierlaboratoriums *Head of the calibration laboratory*	Bearbeiter *Person in charge*
Deutscher Kalibrierdienst DKD-K-36801	31.07.2009	Dipl. Phys. D. Westermann	Dipl.-Ing.(FH) M. Meyer zu Himmern

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 9515 0

Deutsche WindGuard Wind Tunnel Services GmbH

09/4391
DKD-K-36801
07/2009

Kalibriergegenstand *Object*	Anemometer		
Kalibrierverfahren *Calibration procedure*	IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005 MEASNET - Cup Anemometer Calibration Procedure – 09 1997 ISO 3966 – Measurement of fluid in closed conduits - 1977		
Ort der Kalibrierung *Place of calibration*	Windtunnel of Deutsche WindGuard, Varel		
Messbedingungen *Test Conditions*	wind tunnel area [1]	10000 cm²	
	anemometer frontal area [2]	230 cm²	
	diameter of mounting pipe [3]	34 mm	
	blockage ratio [4]	0.023 [-]	
	blockage correction [5]	1.000 [-]	
	average WindGuard reference [6]	203.8 1/s (Thies First Class)	
	present WindGuard reference [7]	203.7 1/s	
Umgebungsbedingungen *Test conditions*	air temperature	23.3 °C	± 1.0 K
	air pressure	1023.0 hPa	± 1.0 hPa
	relative air humidity	53.5 %	± 2.5 %
Dateiinformation *File info*			
Anmerkungen *Remarks*		-	
Auswertesoftware *Software version*		4.0	

1) Querschnittsfläche der Auslassdüse des Windkanals

2) Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

3) Durchmesser des Montagerohrs

4) Verhältnis von 2) zu 1)

5) Korrekturfaktor durch die Verdrängung der Strömung durch den Prüfling

6) Referenzwert des Referenzanemometers bei 10 m/s (Mittelwert)

7) Aktueller Wert des Referenzanemometers

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 9515 0

Deutsche WindGuard Wind Tunnel Services GmbH

Kalibrierergebnis:
Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
83.215	4.186	0.10
123.849	6.167	0.10
163.526	8.048	0.10
201.981	9.913	0.10
243.287	11.888	0.10
285.679	13.882	0.10
327.431	15.861	0.11
305.878	14.805	0.10
265.647	12.895	0.10
222.903	10.901	0.10
182.171	8.943	0.10
141.338	7.011	0.10
102.873	5.160	0.10

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k=2 ergibt. Sie wurde gemäß DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Wertintervall.

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The expanded uncertainty assigned to the mea-surement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agree-ments of the European co-operation for Accredita-tion (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

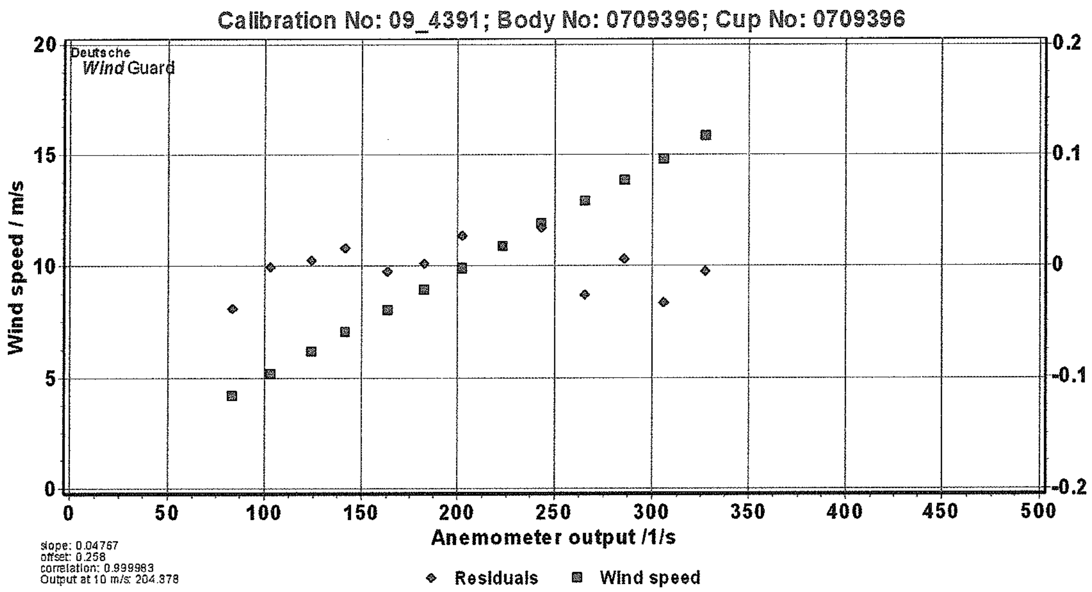
1 Detailed MEASNET[1] Calibration Results

DKD calibration no.	09/4391
Body no.	0709396
Cup no.	0709396
Date	31.07.2009
Air temperature	23.3 °C
Air pressure	1023.0 hPa
Humidity	53.5 %

Linear regression analysis

Slope	0.04767 (m/s)/(1/s) ±0.00008 (m/s)/(1/s)
Offset	0.258 m/s ±0.018 m/s
St.err(Y)	0.023 m/s
Correlation coefficient	0.999983

Remarks no



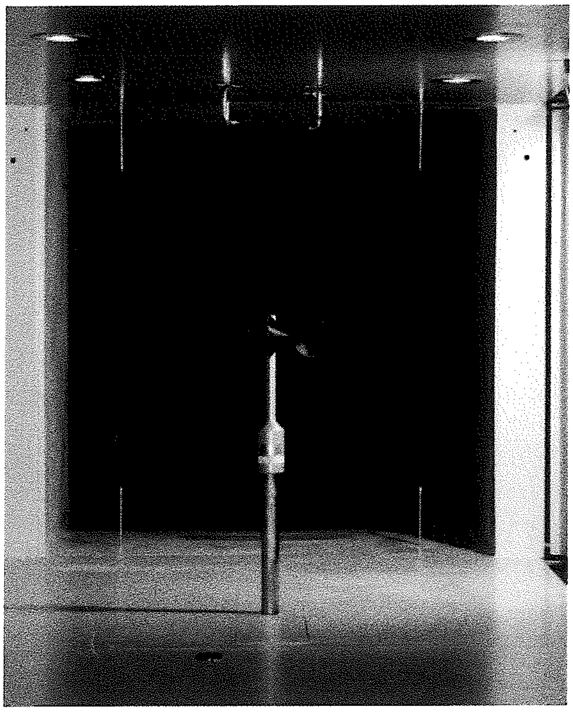
[1]) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

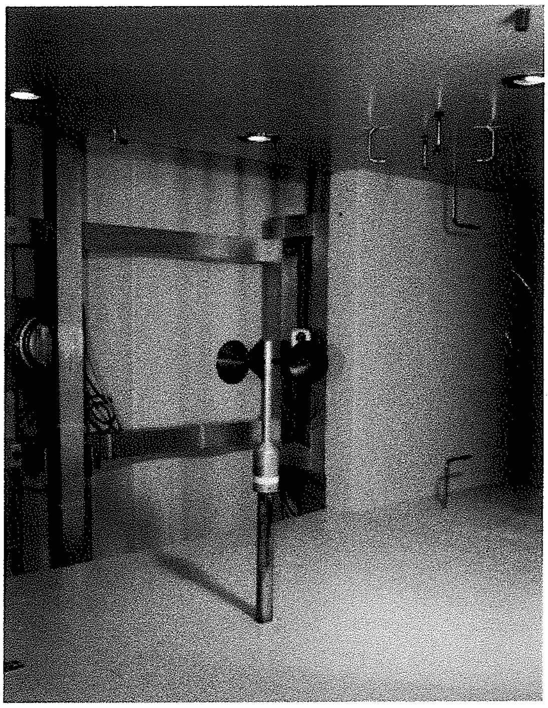
2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year	Calibration
1	Pitot static tube	Airflow	483/8 Nr. 000142	02	06/02
2	Pitot static tube	Airflow	483/8 Nr. 000143	02	06/02
3	Pitot static tube	Airflow	483/8 Nr. 000144	02	06/02
4	Pitot static tube	Airflow	483/8 Nr. 000145	02	06/02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02	DWG12/07
6	Pressure transducer	Setra	C 239 Nr. 1688082	02	DWG12/07
7	Pressure transducer	Setra	C 239 Nr. 1688083	02	03/07
8	Pressure transducer	Setra	C 239 Nr. 1688084	02	03/05
9	El. Barometer	Vaisala	100 A Nr. X2010004	02	DWG12/07
10	El. Thermometer	Galltec	KPK 1/6-ME	02	DWG12/07
11	El. Humidity sensor	Galltec	KPK 1/6-ME	02	DWG12/07
12	Wind tunnel control	-	-	-	-
13	CAN-BUS / PC	esd	-	04	05/04
14	Anemometer		-		
15	Universal Isolator	Knick	P2700 - 58285/8198430	05	01/06

Table 1 Description of the data acquisition system

3 Photo of the calibration set-up





Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel.
The anemometer shown is of the same type as the calibrated one.
Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

[1] J. Mander, D. Westermann, 12/2007 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
[2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
[3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
[4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

ALLEGATO A.2 – Rapporto di installazione stazione anemometrica

COMMITTENTE

COMPAGNIA GENERALE INVESTIMENTI S.r.l.

Via F. Giordani, 30
80122 Napoli

STAZIONE ANEMOMETRICA DI

LAVELLO (PZ) H 60

LOCALITÁ

CODICE STAZIONE

010

Gestione stazione anemometrica
Allegati alla pratica operativa

Data: 16/09/2010	Responsabile Euro Service Group S.r.l.: Geom. Giuseppe Russo	Giuseppe Russo

ALLEGATO A 1 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

SITO

Località	-------------					
Reticolo **UTM**	Map datum: **European 1950**	Altitudine: **qt. s.l.m. 181**	Zone: **33 T**	Longitudine X: EST **0568293**	Latitudine Y: NORD **4547579**	
Suolo	Prevalenza Terra		Misto Terra-Roccia		Prevalenza Roccia	
	X					
Terreno	Incolto	Seminativo	Frutteto	Abitativo	Industriale	Pascolo
	X					
Vegetazione	Assente	Brullo	Macchia	Foresta	Alberi Sparsi	
	X					
Morfologia	Pianura	Collina	Fondovalle	Altopiano	Sommità	Crinale
	X					

STRUMENTI

Descrizione	Matricola	Tipo	Orientamento direzioni	Orientamento supporti sensori	Lunghezza supporti sensori
Sensore Velocità a m 60	**07101391**	**THIES**	**----**	**105°**	**155 cm**
Sensore Velocità a m 60	**07101411**	**THIES**	**----**	**285°**	**155 cm**
Sensore Velocità a m 40	**07101416**	**THIES**	**----**	**285°**	**155 cm**
Sensore Velocità a m 30	**07101400**	**THIES**	**----**	**285°**	**155 cm**
Sensore Velocità a m	**----**	**----**	**----**	**----**	**----**
Sensore Direzione a m 58	**----**	**NRG #200P**	**0°**	**0°**	**155 cm**
Sensore Direzione a m 38	**----**	**NRG #200P**	**0°**	**0°**	**155 cm**
Sensore Direzione a m	**----**	**----**	**----**	**----**	**----**
Sensore Direzione a m	**----**	**----**	**----**	**----**	**----**
Sensore Pressione a m	**----**	**----**			
Sensore Umidità					
Sensore Temperatura m 6	**----**	**NRG #110S**			
Logger	**07947**	**Nomad 2 GSM**			
Luce di Segnalazione	**SI** ~~NO~~				

Memory Card	**Compact Flash Card**	
Torre tipo	**ESG 60**	**Altezza: m 60**
Cavo schermato tripolare	**Cavo UL Style 3×20 AWG**	**Metri: m 62+32**
Cavo schermato tripolare	**Cavo UL Style 3×20 AWG**	**Metri: m 62+62+42+32**
Calata in rame per scarico a terra	**Gialloverde Ø 16**	**Metri: m 63**
Captatore di fulmini	**Asta + captatore di rame**	**Metri: m 3.00**
Dispersore di terra	**N. 2 puntazze in acciaio ramato**	**Metri: m 1.50**

MONTAGGIO

Installatori	**EURO SERVICE GROUP S.r.l.**		
Installazione	Data: **16/09/2010**		
Avvio Logger	Data: **16/09/2010**	Ora: **13.30.00**	
Verifica corretta installazione e registrazione (Allegato A 6)		~~SI~~	NO

Data: **16/09/2010**	Responsabile Montaggio: **Daniele De Ieso**	De Ieso Daniele
	Responsabile Euro Service Group S.r.l.: **Geom. Giuseppe Russo**	[signature]
	Responsabile Gestione:	

ALLEGATO A 2 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

	Descrizione	Fornitore	Note
COMPONENTI STRUTTURALI	n.18 pezzi tubolari da ml 3,00 Ø 152	**ESG**	
	n. 6 pezzi tubolari da ml 1,50 Ø 152	**ESG**	
	n. 8 stralli compresi di cavi d'acciaio	**ESG**	
	n. 96 morsetti chiave 10 per cavi	**ESG**	
	n. 12 picchetti da mt 1,50	**ESG**	
	n. 1 piastra d'ancoraggio torre	**ESG**	
	n. 1 perno d'ancoraggio	**ESG**	
	n. 32 tenditori mm 16	**ESG**	
	n. 20 grilli mm 16	**ESG**	
	n. 32 grilli mm 14	**ESG**	
	n. 6 supporti sensori	**ESG**	
	n. 1 perno per base	**ESG**	
	n. 1 cassetta logger	**ESG**	
	Note: **TORRE USATA EX CASALBUONO (SA).** **TORRE INSTALLATA A METRI 35 DALLA STRADA. OGNI RESPONSABILITÀ È A CARICO DELLA COMPAGNIA GENERALE INVESTIMENTI S.r.l..**		

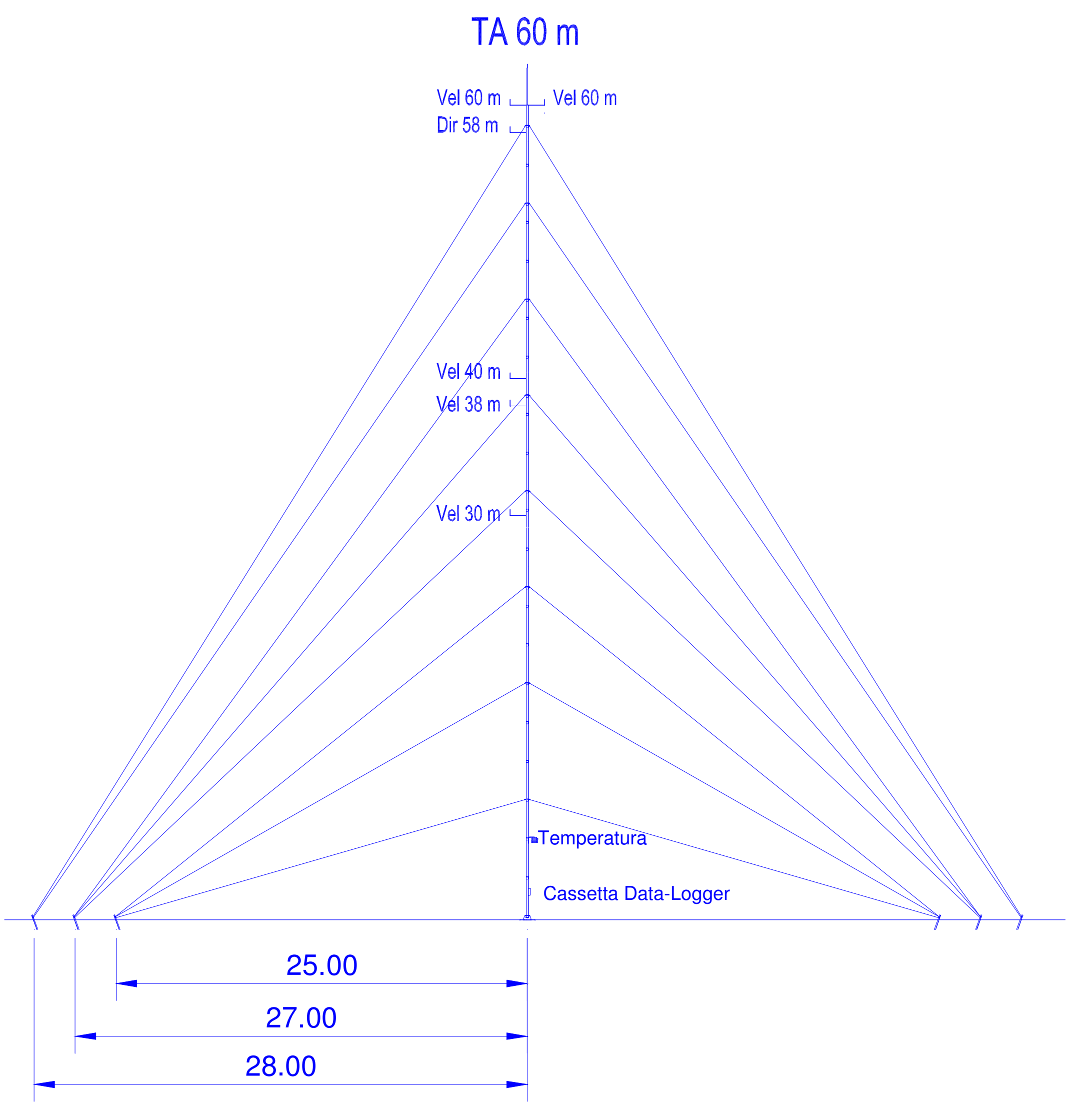
MONTAGGIO	Installatori	**EURO SERVICE GROUP S.r.l.**	
	Installazione	Data: **16/09/2010**	
	Avvio Logger	Data: **16/09/2010**	Ora: **13.30.00**
	Verifica corretta installazione e registrazione (Allegato A 6)	**SI** (X)	**NO**

Data: **16/09/2010**	Responsabile Montaggio: **Daniele De Ieso**	[signature]
	Responsabile Euro Service Group S.r.l.: **Geom. Giuseppe Russo**	[signature]
	Responsabile Gestione:	

ALLEGATO A 3 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**



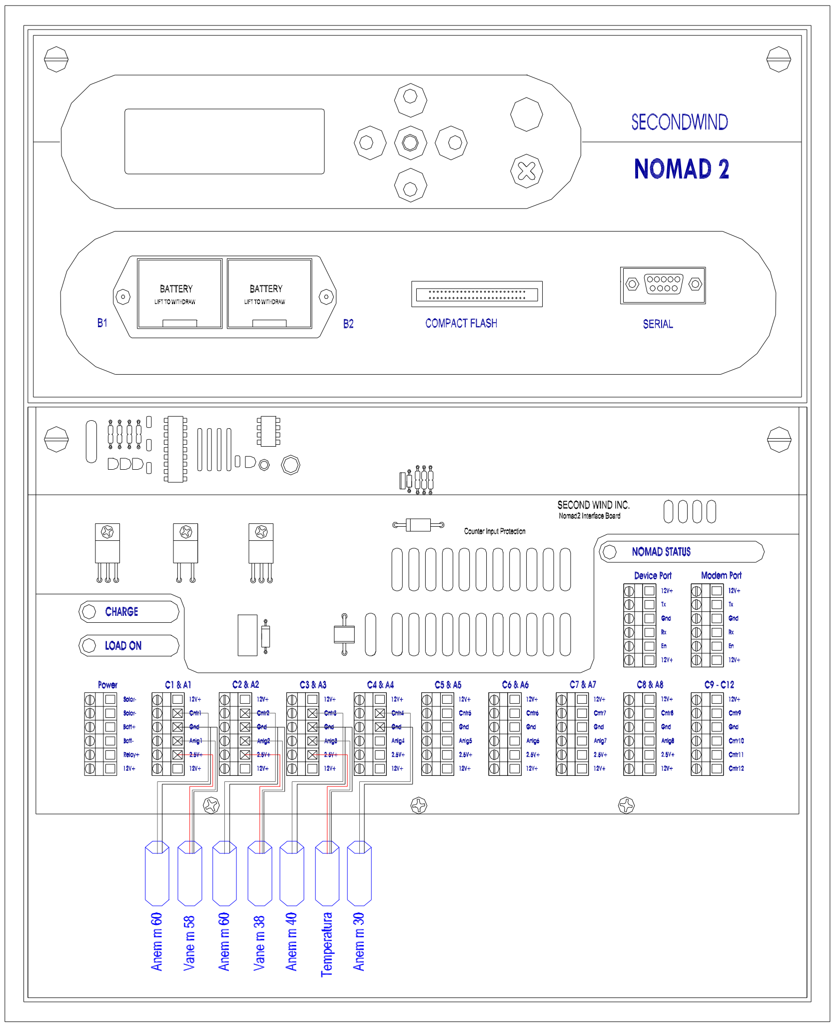
Data: **16/09/2010**

Firma dell'operatore: **Daniele De Ieso**

ALLEGATO A 4 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**



Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso**

De Ieso Daniele

ALLEGATO A 5/1 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

Immagine Satellitare del Sito

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso**

ALLEGATO A 5/2 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

Foto del sito prima dell'intervento

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso** De Ieso Daniele

ALLEGATO A 5/3 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

Foto del sito dopo l'intervento

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso** De Ieso Daniele

ALLEGATO A 5/4 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

Vista N

Vista NE

Vista E

Vista SE

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso**

ALLEGATO A 5/5 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

Vista S

Vista SO

Vista O

Vista NO

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso** De Ieso Daniele

ALLEGATO A 6 alla pratica operativa

Verifica prima installazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

N° codice sensore di velocità a m 60	**07101391**	**Verifica Struttura**	**C**	**NC**
N° codice sensore di velocità a m 60	**07101411**	Verifica ancoraggi	**X**	
N° codice sensore di velocità a m 40	**07101416**	Tensione degli stralli	**X**	
N° codice sensore di velocità a m 30	**07101014**	Linearità della torre	**X**	
N° codice sensore di velocità a m		Perpendicolarità della torre	**X**	
N° codice sensore di direzione a m 58	**----**	Controllo parafulmine	**X**	
N° codice sensore di direzione a m 38	**----**	Controllo dei supporti	**X**	
N° codice sensore di direzione a m		Controllo angolo di direzione	**X**	
N° codice sensore di direzione a m				
N° codice sensore di pressione a m		**Verifica Trasmissione Dati**		
N° codice sensore di umidità a m		Test e-mail	**X**	
N° codice sensore di temperatura a m 6	**----**	Prova collegamento	**X**	
N° codice logger **Nomad 2 GSM**	**07947**	Copertura GSM	**60%**	

Verifica Strumentazione Elettrica		**C**	**NC**	**Note**
Controllo orario e data		**X**		
ora e data logger	ora attuale			
13.30.00 16/09/2010	**13.30.00**			
Controllo voltaggio batterie		**X**		**B1 = 9.60 V; B2 = 9.70 V; P = 12.30 V;**
Controllo presenza segnale canale C1-A1		**X**		
Controllo presenza segnale canale C2-A2		**X**		
Controllo presenza segnale canale C3-A3		**X**		
Controllo presenza segnale canale C4		**X**		
Controllo presenza segnale canale _____				
Controllo presenza segnale canale _____				
Controllo luce di segnalazione				
Controllo allacciamento cavi elettrici		**X**		
Controllo sensore di velocità a m 60		**X**		**5.60 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m 60		**X**		**5.50 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m 40		**X**		**6.50 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m 30		**X**		**6.10 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m				**m/s** velocità all'inserimento della scheda
Controllo sensore di direzione a m 58		**X**		**224°** direzione all'inserimento della scheda
Controllo sensore di direzione a m 38		**X**		**220°** direzione all'inserimento della scheda
Controllo sensore di direzione a m				direzione all'inserimento della scheda
Controllo sensore di direzione a m				direzione all'inserimento della scheda
Controllo sensore di pressione a m				**mB** pressione all'inserimento della scheda
Controllo sensore di umidità				**%** umidità all'inserimento della scheda
Controllo sensore di temperatura a m 6		**X**		**22.5 °C** temperatura all'inserimento della scheda
Controllo della Memory Card		**X**		**100% - 523** days left

LEGENDA: C = CONFORME ÷ NC = NON CONFORME

Note aggiuntive:

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso**

ALLEGATO A 7 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

RACCOMANDAZIONI IMPORTANTI

È buona norma eseguire un controllo periodico della torre anche se essa è stata studiata per un uso temporaneo e non definitivo nel suo sito d'installazione. Si consiglia di eseguire un controllo dei picchetti e della tensione dei tiranti entro il 1° mese dall'installazione e successivamente ogni tre mesi. È da tenere presente che la tensione dei cavi è soggetta a piccole variazioni in funzione del vento e della temperatura.

Non eseguire alcuna riparazione sui cavi in condizioni di forte vento.

Si raccomanda la revisione periodica della struttura nelle zone di alta concentrazione di salinità (zone costiere) e zone con ambienti corrosivi.

È importante che le installazioni e le manutenzioni delle torri vengano valutate ed eseguite solo da personale specializzato

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso** De Ieso Daniele

ALLEGATO A 8 alla pratica operativa

Rapporto di prima installazione stazione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

CERTIFICATO DI QUALITÁ

PLC Srl
ISPEZIONI
VERIFICHE
CERTIFICAZIONI

SISTEMA GESTIONE QUALITÀ

CERTIFICATO N° *453/A/2008*

Si attesta che il Sistema di Gestione per la Qualità di:

EURO SERVICE GROUP
SERVIZI PER L'ENERGIA RINNOVABILE

EURO SERVICE GROUP S.R.L.
Via Airella, 49 – 82020 San Giorgio La Molara (BN)

Applicato nell'Unità Operativa sita in
S.S. 212 km 9 – Zona Industriale – 82020 Pietrelcina (BN)

È conforme ai requisiti della norma

UNI EN ISO 9001:2008

E valutato secondo le prescrizioni del documento SINCERT RT - 05

Relativamente al seguente campo applicativo:

Progettazione, fornitura, assemblaggio, installazione, manutenzione, rimozione di torri anemometriche e relativa strumentazione. Elaborazione ed analisi dei dati del vento.

Classificazione EA: 28 - 35

Data 1° emissione **2008-06-03**
Data di aggiornamento **2010-05-20**
Data di scadenza **2011-06-02**

La Direzione
Dott.ssa Antonella De Vitis

La presente certificazione si intende riferita agli aspetti gestionali dell'impresa nel suo complesso ed è utilizzabile ai fini della qualificazione delle imprese di costruzione ai sensi dell'articolo 8 della legge 11 Febbraio 1994 e successive modificazioni e del DPR 25 Gennaio 2000, N° 34.

La validità del presente certificato è subordinata a sorveglianza periodica e al riesame completo del sistema di gestione aziendale con periodicità triennale.

Riferirsi al Manuale della Qualità per i dettagli delle esclusioni dei requisiti della Norma ISO 9001:2008 e per i processi affidati in outsourcing.
Per informazioni puntuali e aggiornate circa eventuali variazioni intervenute nello stato della certificazione di cui al presente certificato, si prega di contattare PLC S.r.l. ai recapiti a lato riportati.

00198 Roma
Via Ancona, 21
Tel. 06.85.35.28.30
Fax 06.85.30.09.69
www.plcert.com
E.mail: info@plcert.com
Iscr. R.E.A. 1074669
C.F. / P.IVA 08118891004

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

SGQ N°059 A - SGA N° 040 D

Membro di MLA EA per gli schemi di accreditamento SGQ, SGA, PRD, PRS, ISP e LAB, di MLA IAF per gli schemi di accreditamento SGQ, SGA, SSI, FSM e PRD e di MRA ILAC per lo schema di accreditamento LAB

Signatory of EA MLA for the accreditation schemes QMS, EMS, PRD, PRS, INSP and TL, of IAF MLA for the accreditation schemes QMS, EMS, ISMS, FSMS and PRD, and of ILAC MRA for the accreditation scheme TL

Data: **16/09/2010**	Firma dell'operatore: **Daniele De Ieso**

ALLEGATO A.3 – Rapporto di ispezione stazione anemometrica

COMMITTENTE

COMPAGNIA GENERALE INVESTIMENTI S.r.l.

Via F. Giordani, 30
80122 Napoli

STAZIONE ANEMOMETRICA DI

LAVELLO (PZ) H 60

LOCALITÁ

CODICE STAZIONE

010

Gestione stazione anemometrica
Allegati alla pratica operativa

Data: **21/12/2012**	Responsabile Area Tecnica: **Ing. Gianfranco Tolace**	
	Redattore: **Donatella Smiraglia**	

ALLEGATO A 1 alla pratica operativa

Rapporto d'ispezione

Stazione Anemometrica di			**LAVELLO (PZ) H 60**		
Codice Stazione			**010**		
Coordinate Gps **UTM**	Map datum: **European 1950**	Altitudine: **qt. s.l.m. 219**	Zone: **33 T**	Longitudine X: EST **0568309**	Latitudine Y: NORD **4547573**
Coordinate Gps **UTM**	Map datum: **WGS 84**	Altitudine: **qt. s.l.m. 219**	Zone: **33 T**	Longitudine X: EST **0568221**	Latitudine Y: NORD **4547339**
Coordinate **WGS 84** in gradi, primi e secondi			N: **41°'04'29.5"**	E:**15°48'44.2"**	

Denominazione Stazione Anemometrica	**LAVELLO (PZ) H 60**
Codice Stazione	**010**
Nazione	**Italia**
Regione	**Basilicata**
Provincia	**Potenza**
Comune	**Lavello**

Strumentazione Presente (*)

	Strumentazione	Marca e modello	Codice	Note
	Sensore di velocità a m 60	**THIES**	**07101391**	
	Sensore di velocità a m 60	**THIES**	**07101411**	
	Sensore di velocità a m 40	**THIES**	**07101416**	
	Sensore di velocità a m 30	**THIES**	**07101400**	
	Sensore di velocità a m			
	Sensore di direzione a m 58	**NRG #200P**	**----------**	
	Sensore di direzione a m 38	**NRG #200P**	**----------**	
	Sensore di direzione a m			
	Sensore di direzione a m			
	Sensore di pressione a m			
	Sensore di umidità a m			
	Sensore di temperatura a m 5	**NRG#110S**	**---------**	
	Sensore di pioggia			
	Data-logger	**Nomad 2 GSM**	**07947**	

(*) Le notizie di cui sopra sono state rilevate dal report d'installazione o dall'ultimo report di manutenzione

Note aggiuntive:

Si è bruciato il regolatore interno della scheda interfaccia, pertanto è stato collegato il regolatore esterno al logger.

Data: **21/12/2012**	Firma dell'operatore: **Alessio Coico** Alessio Coico

ALLEGATO A 2 alla pratica operativa

Rapporto d'ispezione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

Descrizione		C	NC	Note
Verifica ancoraggi		X		
Tensione degli stralli		X		
Linearità della torre		X		
Perpendicolarità della torre		X		
Controllo orario e data		X		
ora e data logger	ora attuale			
11:00 21/12/2012	**11:00**	X		
Controllo voltaggio batterie		X		**B1 = 9.60 V; B2 = 9.50 V; P = 14.00V**
Controllo pannello solare		X		
Controllo orientamento supporti sensori		X		
Controllo luce di segnalazione				
Controllo presenza segnale canale C1-A1		X		
Controllo presenza segnale canale C2-A2		X		
Controllo presenza segnale canale C3-A3		X		
Controllo presenza segnale canale C4		X		
Controllo presenza segnale canale				
Controllo sensore di velocità a m 60		X		**2.50 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m 60		X		**2.50 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m 40		X		**2.80 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m 30		X		**2.80 m/s** velocità all'inserimento della scheda
Controllo sensore di velocità a m				**m/s** velocità all'inserimento della scheda
Controllo sensore di direzione a m 58		X		**58 °** direzione all'inserimento della scheda
Controllo sensore di direzione a m 38		X		**44 °** direzione all'inserimento della scheda
Controllo sensore di direzione a m				direzione all'inserimento della scheda
Controllo sensore di direzione a m				direzione all'inserimento della scheda
Controllo sensore di pressione a m				**mB** pressione all'inserimento della scheda
Controllo sensore di umidità a m				**%** umidità all'inserimento della scheda
Controllo sensore di temperatura a m 5		X		7.0 **°C** temperatura all'inserimento della scheda
Controllo del parafulmine		X		
Controllo allaccio cavi elettrici		X		
Controllo della Memory Card		X		**100 %** - 534 days left
Test e-mail		X		
Prova collegamento		X		
Copertura GSM		**75 %**		

LEGENDA: C = CONFORME ÷ NC = NON CONFORME

Note aggiuntive:

Sostituita memory card

Data: **21/12/2012**	Firma dell'operatore: **Alessio Coico** Alessio Coico

ALLEGATO A 3/1 alla pratica operativa

Rapporto d'ispezione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

CERTIFICATO UNI EN ISO 9001:2008

PLC Srl
ISPEZIONI VERIFICHE CERTIFICAZIONI

SISTEMA GESTIONE QUALITÀ

CERTIFICATO N° 453/A/2008

Si attesta che il Sistema di Gestione per la Qualità di:

IDNAMIC

IDNAMIC ITALIA S.r.l.
Area PIP Strada Statale 212 km 9,00 snc – 82020 Pietrelcina (BN)

Applicato nell'Unità Operativa sita in
Area PIP Strada Statale 212 km 9,00 snc – 82020 Pietrelcina (BN)

È conforme ai requisiti della norma

UNI EN ISO 9001:2008
E valutato secondo le prescrizioni del documento SINCERT RT – 05 (*)

Relativamente a:

settore EA	*Campo di applicazione:*
28 (*)	**Progettazione, fornitura, assemblaggio, installazione, manutenzione, rimozione di torri anemometriche e relativa strumentazione.**
Settore EA	*Campo di applicazione:*
35	**Elaborazione ed analisi dei dati del vento.**

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La Direzione
Dott.ssa Antonella De Vitis

00198 Roma
Via Ancona, 21
Tel. 06.85.35.28.30
Fax 06.85.30.09.69
www.plcert.com
E.mail: info@plcert.com
Iscr. R.E.A. 1074669
C.F. / P.IVA 08118891004

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

SGQ N°059 A - SGA N° 040 D

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La presente certificazione si intende riferita agli aspetti gestionali dell'impresa nel suo complesso ed è utilizzabile ai fini della qualificazione delle imprese di costruzione ai sensi dell'articolo 8 della legge n° 109 del 11 Febbraio 1994 e successive modificazioni e del DPR 25 Gennaio 2000, N° 34.

La validità del presente certificato è subordinata a sorveglianza periodica e al riesame completo del sistema di gestione aziendale con periodicità triennale.
Riferirsi al Manuale della Qualità per i dettagli delle esclusioni dei requisiti della Norma ISO 9001:2008 e per i processi affidati in outsourcing.
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* Variazione Denominazione e Sede Legale.

Data: **21/12/2012**	Firma dell'operatore: **Alessio Coico**

ALLEGATO A 3/2 alla pratica operativa

Rapporto d'ispezione

Stazione Anemometrica di	**LAVELLO (PZ) H 60**
Codice Stazione	**010**

CERTIFICATO BS OHSAS 18001:2007

RINA
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CERTIFICATO N.
CERTIFICATE No.
OHS-806

Si certifica che il Sistema di Gestione della Sicurezza e della Salute sul luogo di lavoro di
It is hereby certified that the Occupational Health and Safety Management System of

IDNAMIC ITALIA S.R.L.

S.S. 212 KM 9 AREA P.I.P. 82020 PIETRELCINA (BN) ITALIA

nelle seguenti unità operative / *in the following operational units*

S.S. 212 KM 9 AREA P.I.P. 82020 PIETRELCINA (BN) ITALIA
E CANTIERI OPERATIVI

è conforme alla norma
is in compliance with the standard

BS OHSAS 18001:2007
E AL DOCUMENTO SINCERT RT-12

per le seguenti attività / *for the following activities*

EA:28,35

PROGETTAZIONE, ASSEMBLAGGIO, INSTALLAZIONE, MANUTENZIONE E RIMOZIONE DI TORRI ANEMOMETRICHE E RELATIVA STRUMENTAZIONE. ELABORAZIONI ED ANALISI DEI DATI DEL VENTO.

DESIGN, ASSEMBLY, INSTALLATION, MAINTENANCE AND REMOVAL OF ANEMOMETRIC TOWERS AND RELATED INSTRUMENTATION. WIND DATA PROCESSING AND ANALYSIS.

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The use and validity of this certificate are subject to compliance with the RINA document: Rules for the Certification of Occupational Health and Safety Management Systems

Prima emissione / *First Issue*	26.01.2012
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Data scadenza / *Expiry Date*	26.01.2015

Dott. Roberto Cavanna
(Managing Director)

RINA Services S.p.A.
Via Corsica 12 - 16128 Genova Italy

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The validity of this certificate is dependent on an annual / six monthly audit and on a complete review, every three years, of the management system

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Data: **21/12/2012**	Firma dell'operatore: **Alessio Coico**

ALLEGATO B – Descrizione generale Vestas

Restricted
Document no.: 0067-7060 V02
2018-10-26

General Description

4MW Platform

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

Table of contents

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See general reservations, notes and disclaimers (including, section 12, p. 39) to this general description.

1 Introduction

The 4MW Platform wind turbine configurations covered by this General Description are listed below with designations according to IEC61400-22.

DIBt 2012 wind classes are also listed where applicable.

Please refer to the Performance Specification for the relevant turbine variant for full wind class definition.

This General Description contains data and descriptions common among the platform variants.

The variant specific performance can be found in the Performance Specifications for the turbine variant and operational mode required.

Turbine Type Class	Turbine Type | Operating Mode
V117-4.0/4.2 MW Strong Wind	V117-4.0 MW IEC IB / IEC IIA 50/60 Hz | Mode 0
	V117-4.0 MW IEC IB / IEC IIA 50/60 Hz | Reactive Power Optimized Mode (QO1)
	V117-4.2 MW IEC S / IEC IIA 50/60 Hz | Power Optimized Mode (PO1)
	V117-3.8 MW IEC IB / IEC IIA 50/60 Hz | Load Optimized Mode (LO1)
	V117-3.6 MW IEC IB / IEC IIA+ 50/60 Hz | Load Optimized Mode (LO2)
V117-4.0/4.2 MW Typhoon	V117-4.0 MW IEC IB-T / IEC IIA-T 50/60 Hz | Mode 0
	V117-4.0 MW IEC IB-T / IEC IIA-T 50/60 Hz | Reactive Power Optim. Mode (QO1)
	V117-4.2 MW IEC S-T / IEC IIA-T 50/60 Hz | Power Optimized Mode (PO1)
	V117-3.8 MW IEC IB-T / IEC IIA-T 50/60 Hz | Load Optimized Mode (LO1)
	V117-3.6 MW IEC IB-T / IEC IIA+-T 50/60 Hz | Load Optimized Mode (LO2)
V136-4.0/4.2 MW	V136-4.0 MW IEC IIB / IEC IIIB 50/60 Hz | Mode 0
	V136-4.0 MW IEC IIB / IEC IIIB 50/60 Hz | Reactive Power Optim. Mode (QO1)
	V136-4.2 MW IEC S / IEC IIIB 50/60 Hz | Power Optimized Mode (PO1)
	V136-3.8 MW IEC IIB / IEC IIIB 50/60 Hz | Load Optimized Mode (LO1)
	V136-3.6 MW IEC IIB / IEC IIIB 50/60 Hz | Load Optimized Mode (LO2)
	V136-4.0 MW DIBt S 50 Hz | Mode 0
	V136-4.0 MW DIBt S 50 Hz | Reactive Power Optimized Mode (QO1)
	V136-4.2 MW DIBt S 50 Hz | Power Optimized Mode (PO1)
	V136-3.8 MW DIBt S 50 Hz | Load Optimized Mode (LO1)
	V136-3.6 MW DIBt S 50 Hz | Load Optimized Mode (LO2)
V150-4.0/4.2 MW	V150-4.0 MW IEC IIIB 50/60 Hz | Mode 0
	V150-4.0 MW IEC IIIB 50/60 Hz | Reactive Power Optim. Mode (QO1)
	V150-4.2 MW IEC S 50/60 Hz | Power Optimized Mode (PO1)
	V150-3.8 MW IEC IIIB / IEC S 50/60 Hz | Load Optimized Mode (LO1)
	V150-3.6 MW IEC IIIB / S 50/60 Hz | Load Optimized Mode (LO2)
	V150-4.0 MW DIBt S 50 Hz | Mode 0

Turbine Type Class	Turbine Type | Operating Mode
V150-4.0/4.2 MW (cont'd)	V150-4.0 MW DIBt S 50 Hz | Reactive Power Optimized Mode (QO1)
	V150-4.2 MW DIBt S 50 Hz | Power Optimized Mode (PO1)
	V150-3.8 MW DIBt S 50 Hz | Load Optimized Mode (LO1)
	V150-3.6 MW DIBt S 50 Hz | Load Optimized Mode (LO2)

Table 1-1: 4MW Platform turbine configurations covered.

2 General Description

Vestas 4MW Platform comprises a family of wind turbines sharing a common design basis.

The 4MW Platform family of wind turbines includes V105-3.45/3.6 MW, V112-3.45/3.6 MW, V117-3.45/3.6 MW, V126-3.45 MW LTq, V126-3.45/3.6 MW HTq, V136-3.45/3.6 MW, V117-4.0/4.2 MW Strong Wind, V117-4.0/4.2 MW Typhoon, V136-4.0/4.2 MW and V150-4.0/4.2 MW.

For V105-3.45/3.6 MW, V112-3.45/3.6 MW, V117-3.45/3.6 MW, V126-3.45 MW LTq, V126-3.45/3.6 MW HTq and V136-3.45/3.6 MW, please refer to General Description 0053-3707.

This General Description only applies to V117-4.0/4.2 MW Strong Wind, V117-4.0/4.2 MW Typhoon, V136-4.0/4.2 MW and V150-4.0/4.2 MW.

These turbines are pitch regulated upwind turbines with active yaw and a three-blade rotor.

The turbines covered in this General Description are equipped with rotor with diameters residing in the range 117 m to 150 m and a rated output power of 4.0 MW.

A 4.0 MW Reactive Power Optimized Mode (QO1) is available for all variants.

A 4.2 MW Power Optimized Mode (PO1) is available for all variants.

Also, a 3.8 MW Load Optimized Mode (LO1) and a 3.6 MW Load Optimized Mode (LO2) is available for all variants.

The wind turbine family utilises the OptiTip® concept and a power system based on an induction generator and full-scale converter. With these features, the wind turbine is able to operate the rotor at variable speed and thereby maintain the power output at or near rated power even in high wind speed. At low wind speed, the OptiTip® concept and the power system work together to maximise the power output by operating at the optimal rotor speed and pitch angle.

Operating the wind turbine in 4.0 MW Reactive Power Optimized Mode (QO1) is achieved by applying an extended ambient temperature derate strategy compared with 4.0 MW Mode 0 operation.

Operating the wind turbine in 4.2 MW Power Optimized Mode (PO1) is achieved by applying an extended ambient temperature derate strategy and reduced reactive power capability compared with 4.0 MW Mode 0 operation.

3 Mechanical Design

3.1 Rotor

The wind turbine is equipped with a rotor consisting of three blades and a hub. The blades are controlled by the microprocessor pitch control system OptiTip®. Based on the prevailing wind conditions, the blades are continuously positioned to optimise the pitch angle.

Rotor	V117	V136	V150
Diameter	117 m	136 m	150 m
Swept Area	10751 m^2	14527 m^2	17671 m^2
Speed, Dynamic Operation Range	6.7-17.5	5.6-14.0	4.9-12.0
Rotational Direction	Clockwise (front view)		
Orientation	Upwind		
Tilt	6°		
Hub Coning	4°	4°	5.5°
No. of Blades	3		
Aerodynamic Brakes	Full feathering		

Table 3-1: Rotor data

3.2 Blades

The blades are made of carbon and fibreglass and consist of two airfoil shells bonded to a supporting beam or with embedded structure.

Blades	V117	V136	V150
Type Description	Airfoil shells bonded to supporting beam	Prepreg or infused structural airfoil shell	Prepreg or infused structural airfoil shell
Blade Length	57.15 m	66.66 m	73.66 m
Material	Fibreglass reinforced epoxy, carbon fibres and Solid Metal Tip (SMT)		
Blade Connection	Steel roots inserted		
Airfoils	High-lift profile		
Maximum Chord	4.0 m	4.1 m	4.2 m
Chord at 90% blade radius	1.1 m	1.2 m	1.4 m

Table 3-2: Blades data

3.3 Blade Bearing

The blade bearings allow the blades to operate at varying pitch angles.

Blade Bearing	
Blade bearing type	Double-row four-point contact ball bearings
Lubrication	Manual grease lubrication

Table 3-3: Blade bearing data

3.4 Pitch System

The turbine is equipped with a pitch system for each blade and a distributor block, all located in the hub. Each pitch system is connected to the distributor block with flexible hoses. The distributor block is connected to the pipes of the hydraulic rotating transfer unit in the hub by means of three hoses (pressure line, return line and drain line).

Each pitch system consists of a hydraulic cylinder mounted to the hub and a piston rod mounted to the blade bearing via a torque arm shaft. Valves facilitating operation of the pitch cylinder are installed on a pitch block bolted directly onto the cylinder.

Pitch System	
Type	Hydraulic
Number	1 per blade
Range	-10° to 95°

Table 3-4: Pitch system data

Hydraulic System	
Main Pump	Two redundant internal-gear oil pumps
Pressure	260 bar
Filtration	3 µm (absolute)

Table 3-5: Hydraulic system data.

3.5 Hub

The hub supports the three blades and transfers the reaction loads to the main bearing and the torque to the gearbox. The hub structure also supports blade bearings and pitch cylinders.

Hub	
Type	Cast ball shell hub
Material	Cast iron

Table 3-6: Hub data

3.6 Main Shaft

The main shaft transfers the reaction forces to the main bearing and the torque to the gearbox.

Main Shaft	
Type Description	Hollow shaft
Material	Cast iron or forged steel

Table 3-7: Main shaft data

3.7 Main Bearing Housing

The main bearing housing covers the main bearing and is the first connection point for the drive train system to the bedplate.

Main Bearing Housing	
Material	Cast iron

Table 3-8: Main bearing housing data

3.8 Main Bearing

The main bearing carries all thrust loads.

Main Bearing	
Type	Double-row spherical roller bearing
Lubrication	Automatic grease lubrication

Table 3-9: Main bearing data

3.9 Gearbox

The main gear converts the low-speed rotation of the rotor to high-speed generator rotation.

The disc brake is mounted on the high-speed shaft. The gearbox lubrication system is a pressure-fed system.

Gearbox	
Type	Planetary stages + one helical stage
Gear House Material	Cast
Lubrication System	Pressure oil lubrication
Backup Lubrication System	Oil sump filled from external gravity tank
Total Gear Oil Volume	1000-1500
Oil Cleanliness Codes	ISO 4406-/15/12
Shaft Seals	Labyrinth

Table 3-10: Gearbox data

3.10 Generator Bearings

The bearings are grease lubricated and grease is supplied continuously from an automatic lubrication unit.

3.11 High-Speed Shaft Coupling

The coupling transmits the torque of the gearbox high-speed output shaft to the generator input shaft.

The coupling consists of two 4-link laminate packages and a fibreglass intermediate tube with two metal flanges.

The coupling is fitted to two-armed hubs on the brake disc and the generator hub.

3.12 Yaw System

The yaw system is an active system based on a robust pre-tensioned plain yaw-bearing concept with PETP as friction material.

Yaw System	
Type	Plain bearing system
Material	Forged yaw ring heat-treated. Plain bearings PETP
Yawing Speed (50 Hz)	0.45°/sec.
Yawing Speed (60 Hz)	0.55°/sec.

Table 3-11: Yaw system data

Yaw Gear	
Type	Multiple stages geared
Ratio Total	944:1
Rotational Speed at Full Load	1.4 rpm at output shaft

Table 3-12: Yaw gear data

3.13 Crane

The nacelle houses the internal safe working load (SWL) service crane. The crane is a single system hoist.

Crane	
Lifting Capacity	Maximum 800 kg

Table 3-13: Crane data

3.14 Towers

Tubular towers with flange connections, certified according to relevant type approvals, are available in different standard heights. The towers are designed with the majority of internal welded connections replaced by magnet supports to create a predominantly smooth-walled tower.

Magnets provide load support in a horizontal direction and internals, such as platforms, ladders, etc., are supported vertically (that is, in the gravitational direction) by a mechanical connection. The smooth tower design reduces the required steel thickness, rendering the tower lighter compared to one with all internals welded to the tower shells.

Available hub heights are listed in the Performance Specification for each turbine variant. Designated hub heights include a distance from the foundation section to the ground level of approximately 0.2 m depending on the thickness of the bottom flange and a distance from tower top flange to centre of the hub of 2.2 m.

Towers	
Type	Cylindrical/conical tubular

Table 3-14: Tower structure data

3.15 Nacelle Bedplate and Cover

The nacelle cover is made of fibreglass. Hatches are positioned in the floor for lowering or hoisting equipment to the nacelle and evacuation of personnel. The roof section is equipped with wind sensors and skylights.

The skylights can be opened from inside the nacelle to access the roof and from outside to access the nacelle. Access from the tower to the nacelle is through the yaw system.

The nacelle bedplate is in two parts and consists of a cast iron front part and a girder structure rear part. The front of the nacelle bedplate is the foundation for the drive train and transmits forces from the rotor to the tower through the yaw system. The bottom surface is machined and connected to the yaw bearing and the yaw gears are bolted to the front nacelle bedplate.

The crane girders are attached to the top structure. The lower beams of the girder structure are connected at the rear end. The rear part of the bedplate serves as the foundation for controller panels, the cooling system and transformer. The nacelle cover is installed on the nacelle bedplate.

Type Description	**Material**
Nacelle Cover	GRP
Bedplate Front	Cast iron
Bedplate Rear	Girder structure

Table 3-15: Nacelle bedplate and cover data

3.16 Thermal Conditioning System

The thermal conditioning system consists of a few robust components:

- The Vestas CoolerTop® located on top of the rear end of the nacelle. The CoolerTop® is a free flow cooler, thus ensuring that there are no electrical components in the thermal conditioning system located outside the nacelle.

- The CoolerTop® comes as standard in a "naked" form, with no side cover panels. Side cover panels are available as an option.
- The Liquid Cooling System, which serves the gearbox, hydraulic systems, generator and converter is driven by an electrical pumping system.
- The transformer forced air cooling comprised of an electrical fan.

3.16.1 Generator and Converter Cooling

The generator and converter cooling systems operate in parallel. A dynamic flow valve mounted in the generator cooling circuit divides the cooling liquid flow. The cooling liquid removes heat from the generator and converter unit using a free-air flow radiator placed on the top of the nacelle. In addition to the generator, converter unit and radiator, the circulation system includes an electrical pump and a three-way thermostatic valve.

3.16.2 Gearbox and Hydraulic Cooling

The gearbox and hydraulic cooling systems are coupled in parallel. A dynamic flow valve mounted in the gearbox cooling circuit divides the cooling flow. The cooling liquid removes heat from the gearbox and the hydraulic power unit through heat exchangers and a free-air flow radiator placed on the top of the nacelle.

In addition to the heat exchangers and the radiator, the circulation system includes an electrical pump and a three-way thermostatic valve.

3.16.3 Transformer Cooling

The transformer is equipped with forced-air cooling. The ventilator system consists of a central fan, located below the converter and an air duct leading the air to locations beneath and between the high voltage and low voltage windings of the transformer.

3.16.4 Nacelle Cooling

Hot air generated by mechanical and electrical equipment is dissipated from the nacelle by a fan system located in the nacelle.

3.16.5 Optional Air Intake Hatches

Specific air intakes in the nacelle can optionally be fitted with hatches which can be operated as a part of the thermal control strategy. In case of lost grid to the turbine, the hatches will automatically be closed.

4 Electrical Design

4.1 Generator

The generator is a three-phase asynchronous induction generator with cage rotor that is connected to the grid through a full-scale converter. The generator housing allows the circulation of cooling air within the stator and rotor.

The air-to-water heat exchange occurs in an external heat exchanger.

Generator	
Type	Asynchronous with cage rotor
Rated Power [P_N]	4250 / 4450 kW
Frequency [f_N]	0-100 Hz
Voltage, Stator [U_{NS}]	3 x 800 V (at rated speed)
Number of Poles	6
Winding Type	Form with VPI (Vacuum Pressurized Impregnation)
Winding Connection	Delta
Rated rpm	1450-1550 rpm
Overspeed Limit Acc. to IEC (2 minutes)	2400 rpm
Generator Bearing	Hybrid/ceramic
Temperature Sensors, Stator	3 PT100 sensors placed at hot spots and 3 as back-up
Temperature Sensors, Bearings	1 per bearing
Insulation Class	H
Enclosure	IP54

Table 4-1: Generator data

4.2 Converter

The converter is a full-scale converter system controlling both the generator and the power quality delivered to the grid. The converter consists of 3 machine-side converter units and 3 line-side converter units operating in parallel with a common controller.

The converter controls conversion of variable frequency AC power from the generator into fixed frequency AC power with desired active and reactive power levels (and other grid connection parameters) suitable for the grid.

The converter is located in the nacelle and has a grid side voltage rating of 720 V. The generator side voltage rating is up to 800 V dependent on generator speed.

Converter	
Rated Apparent Power [S_N]	5100 kVA
Rated Grid Voltage	3 x 720 V
Rated Generator Voltage	3 x 800 V
Rated Grid Current	4100 A (≤30°C ambient) / 4150 (≤20°C ambient)
Rated Generator Current	3600 A (≤30°C ambient) / 3650 (≤20°C ambient)
Enclosure	IP54

Table 4-2: Converter data

4.3 HV Transformer

The step-up HV transformer is located in a separate locked room in the back of the nacelle.

The transformer is a three-phase, three limb, two-winding, dry-type transformer that is self-extinguishing. The windings are delta-connected on the high-voltage side and star connected on the low voltage side.

The transformer is designed according to IEC standards, but also complying to European Ecodesign regulation No 548/2014 set by the European Commission. Refer to Table 4-3.

4.3.1 Ecodesign - IEC 50 Hz/60 Hz version

Transformer	
Type description	Ecodesign dry-type cast resin transformer.
Basic layout	3 phase, 3 limb, 2 winding transformer.
Applied standards	IEC 60076-11, IEC 60076-16, IEC 61936-1, Commission Regulation No 548/2014.
Cooling method	AF
Rated power	5150 kVA
Rated voltage, turbine side	
U_m 1.1kV	0.720 kV
Rated voltage, grid side	
U_m 24.0kV	12.9-22.0 kV
U_m 36.0kV	22.1-33.0 kV
U_m 40.5kV	33.1-36.0 kV
Insulation level AC / LI / LIC	
U_m 1.1kV	3[1] / 3 / 3 kV
U_m 24.0kV	50[1] / 125 / 125 kV
U_m 36.0kV	70[1] / 170 / 170 kV
U_m 40.5kV	80[1] / 170 / 170 kV
Off-circuit tap changer	±2 x 2.5 %
Frequency	50 Hz / 60 Hz
Vector group	Dyn5
No-load current [2]	~0.5 %
Positive sequence short-circuit impedance @ rated power, 120°C [3]	9.9 %
Positive sequence short-circuit resistance@ rated power, 120°C [2]	~0.8 %
Zero sequence short-circuit impedance@ rated power, 120°C [2]	~8.3 %
Zero sequence short-circuit resistance@ rated power, 120°C [2]	~0.7 %
No-load reactive power [2]	~20 kVAr
Full load reactive power [2]	~550 kVAr
Inrush peak current [2]	5-8 x $\hat{I}_n$ A
Half crest time [2]	~ 0.6 s
Sound power level	≤ 80 dB(A)

Transformer	
Average temperature rise at max altitude	≤ 90 K
Max altitude [4]	2000 m
Insulation class	
LV coil	155 (F)
HV coil	155 (F) or 180 (H)
Environmental class	E2
Climatic class	C2
Fire behaviour class	F1
Corrosion class	C4
Weight	≤11000 kg
Temperature monitoring	PT100 sensors in LV windings and core
Overvoltage protection	Surge arresters on HV terminals
Temporary earthing	3 x Ø25 mm earthing ball points

Table 4-3: Transformer data for Ecodesign IEC 50 Hz/60 Hz version.

The transformer loss limits are given at rated power as combination of load loss and no-load loss which shall fulfil the Peak Efficiency Index (PEI) of the Ecodesign requirement.

The maximum losses are described by the PEI limit section of

Figure *4-1* and stretch over a range between Loss variant 1 and Loss variant 2. The Loss variant values are selected based on energy loss optimization with the turbine user profile hence the energy loss of transformers between Loss variant 1 and Loss variant 2 are comparable.

Figure 4-1 Transformer losses allowable area

The actual load losses vary depend on the operation mode of the turbine, hence in Table 4-4 the load losses are provide at different operation modes for the two loss variants. For further recalculation of load losses at different operation modes, refer to Figure 4-2.

Transformer losses			
Peak Efficiency Index (PEI)	> 99.354		
Loss variant 1			
No-load loss	7.75 kW		
Load loss @ power, 120°C	**@5150kVA**	**@4200kVA[5]**	**@4000kVA[5]**
	≤ 35.7 kW	≤ 23.8 kW	≤ 21.6 kW
Loss variant 2			
No-load loss	8.5 kW		
Load loss @ power, 120°C	**@5150kVA**	**@4200kVA[5]**	**@4000kVA[5]**
	≤ 32.55 kW	≤ 21.7 kW	≤ 19.7 kW

Table 4-4: Transformer losses for Ecodesign IEC 50 Hz/60 Hz version.

NOTE
[1] @1000m. According to IEC 60076-11, AC test voltage is altitude dependent.
[2] Based on an average of calculated values across voltages and manufacturers.
[3] Subjected to standard IEC tolerances.
[4] Transformer max altitude may be adjusted to match turbine location.
[5] Information values based on operation mode, see Figure 4-2

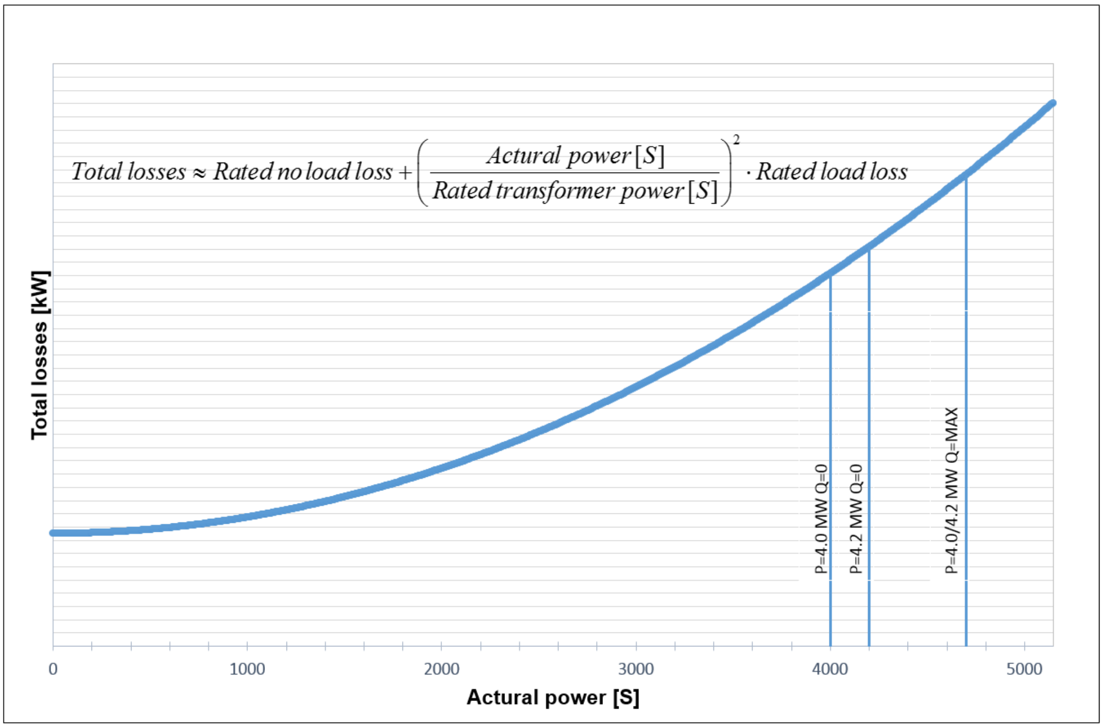


Figure 4-2: Total Losses vs. Actual Power.

4.4 HV Cables

The high-voltage cable runs from the transformer in the nacelle down the tower to the HV switchgear located at the bottom of the tower. The high-voltage cable can be of two different constructions:

- A three-core, rubber-insulated, halogen-free, high-voltage cable with a three-core split earth conductor.
- A four-core, rubber-insulated, halogen-free, high-voltage cable.

HV Cables	
High-Voltage Cable Insulation Compound	Improved ethylene-propylene (EP) based material-EPR or high modulus or hard grade ethylene-propylene rubber-HEPR
Pre-terminated	HV termination in transformer end. T-Connector Type-C in switchgear end.
Maximum Voltage	24 kV for 19.1-22.0 kV rated voltage 42 kV for 22.1-36.0 kV rated voltage
Conductor Cross Sections	3x70 / 70 mm^2 (Single PE core) 3x70 + 3x70/3 mm^2 (Split PE core)

Table 4-5: HV cables data

4.5 HV Switchgear

A gas insulated switchgear is installed in the bottom of the tower as an integrated part of the turbine. Its controls are integrated with the turbine safety system, which monitors the condition of the switchgear and high voltage safety related devices in the turbine. This system is named 'Ready to Protect' and ensures all protection devices are operational, whenever high voltage components in the turbine are energised. To ensure that the switchgear is always ready to trip, it is equipped with redundant trip circuits consisting of an active trip coil and an undervoltage trip coil.

In case of grid outage the circuit breaker will disconnect the turbine from the grid after an adjustable time.

When grid returns, all relevant protection devices will automatically be powered up via UPS.

When all the protection devices are operational, the circuit breaker will re-close after an adjustable time. The re-close functionality can furthermore be used to implement a sequential energization of a wind park, in order to avoid simultaneous inrush currents from all turbines once grid returns after an outage.

In case the circuit breaker has tripped due to a fault detection, the circuit breaker will be blocked for re-connection until a manual reset is performed.

In order to avoid unauthorized access to the transformer room during live condition, the earthing switch of the circuit breaker, contains a trapped-key interlock system with its counterpart installed on the access door to the transformer room.

The switchgear is available in three variants with increasing features, see Table 4-6. Beside the increase in features, the switchgear can be configured depending on the number of grid cables planned to enter the individual turbine. The design of the switchgear solution is optimized such grid cables can be connected to the switchgear even before the tower is installed and still maintain its protection toward weather conditions and internal condensation due to a gas tight packing.

The switchgear is available in an IEC version and in an IEEE version. The IEEE version is however only available in the highest voltage class. The electrical parameters of the switchgear are seen in Table 4-7 for the IEC version and in Table 4-8 for the IEEE version.

HV Switchgear			
Variant	**Basic**	**Streamline**	**Standard**
IEC standards	○	⊙	⊙
IEEE standards	⊙	○	⊙
Vacuum circuit breaker panel	⊙	⊙	⊙
Overcurrent, short-circuit and earth fault protection	⊙	⊙	⊙
Disconnector / earthing switch in circuit breaker panel	⊙	⊙	⊙
Voltage Presence Indicator System for circuit breaker	⊙	⊙	⊙
Voltage Presence Indicator System for grid cables	⊙	⊙	⊙
Double grid cable connection	⊙	⊙	⊙
Triple grid cable connection	⊙	○	○
Preconfigured relay settings	⊙	⊙	⊙
Turbine safety system integration	⊙	⊙	⊙
Redundant trip coil circuits	⊙	⊙	⊙
Trip coil supervision	⊙	⊙	⊙
Pendant remote control from outside of tower	⊙	⊙	⊙
Sequential energization	⊙	⊙	⊙
Reclose blocking function	⊙	⊙	⊙
Heating elements	⊙	⊙	⊙
Trapped-key interlock system for circuit breaker panel	⊙	⊙	⊙
Motor operation of circuit breaker	⊙	⊙	⊙
Cable panel for grid cables (configurable)	○	⊙	⊙
Switch disconnector panels for grid cables – max three panels (configurable)	○	⊙	⊙
Earthing switch for grid cables	○	⊙	⊙
Internal arc classification	○	⊙	⊙
Supervision on MCB's	○	⊙	⊙
Motor operation of switch disconnector	○	○	⊙
SCADA operation and feedback of circuit breaker	○	○	⊙

HV Switchgear			
Variant	**Basic**	**Streamline**	**Standard**
SCADA operation and feedback of switch disconnector	○	○	⦿

Table 4-6: HV switchgear variants and features

4.5.1 IEC 50/60Hz version

HV Switchgear	
Type description	Gas Insulated Switchgear
Applied standards	IEC 62271-103 IEC 62271-1, 62271-100, 62271-102, 62271-200, IEC 60694
Insulation medium	SF_6
Rated voltage	
U_r 24.0kV	15.7-22.0 kV
U_r 36.0kV	22.1-33.0 kV
U_r 40.5kV	33.1-36.0 kV
Rated insulation level AC // LI Common value / across isolation distance	
U_r 24.0kV	50 / 60 // 125 / 145 kV
U_r 36.0kV	70 / 80 // 170 / 195 kV
U_r 40.5kV	85 / 90 // 185 / 215 kV
Rated frequency	50 Hz / 60 Hz
Rated normal current	630 A
Rated Short-time withstand current	
U_r 24.0kV	20 kA
U_r 36.0kV	25 kA
U_r 40.5kV	25 kA
Rated peak withstand current 50 / 60 Hz	
U_r 24.0kV	50 / 52 kA
U_r 36.0kV	62.5 / 65 kA
U_r 40.5kV	62.5 / 65 kA
Rated duration of short-circuit	1 s
Internal arc classification (option)	
U_r 24.0kV	IAC A FLR 20 kA, 1 s
U_r 36.0kV	IAC A FLR 25 kA, 1 s
U_r 40.5kV	IAC A FLR 25 kA, 1 s
Connection interface	Outside cone plug-in bushings, IEC interface C1.
Loss of service continuity category	LSC2
Ingress protection	
Gas tank	IP 65
Enclosure	IP 2X
LV cabinet	IP 3X
Corrosion class	C3

Table 4-7: HV switchgear data for IEC version

4.5.2 IEEE 60Hz version

HV Switchgear	
Type description	Gas Insulated Switchgear
Applied standards	IEEE 37.20.3, IEEE C37.20.4, IEC 62271-200, ISO 12944.
Insulation medium	SF_6
Rated voltage	
U_r 38.0kV	22.1-36.0 kV
Rated insulation level AC / LI	70 / 150 kV
Rated frequency	60 Hz
Rated normal current	600 A
Rated Short-time withstand current	25 kA
Rated peak withstand current	65 kA
Rated duration of short-circuit	1 s
Internal arc classification (option)	IAC A FLR 25 kA, 1 s
Connection interface grid cables	Outside cone plug-in bushings, IEEE 386 interface type deadbreak, 600A.
Ingress protection	
Gas tank	NEMA 4X / IP 65
Enclosure	NEMA 2 / IP 2X
LV cabinet	NEMA 2 / IP 3X
Corrosion class	C3

Table 4-8: HV switchgear data for IEEE version

4.6 AUX System

The AUX system is supplied from a separate 650/400/230 V transformer located in the nacelle inside the converter cabinet. All motors, pumps, fans and heaters are supplied from this system.

230 V consumers are generally supplied from a 400/230 V transformer located in the tower base. Internal heating and ventilation of cabinets as well as specific option 230 V consumers are supplied from the auxiliary transformer in the converter cabinet.

Power Sockets	
Single Phase (Nacelle)	230 V (16 A) (standard) 110 V (16 A) (option) 2 x 55 V (16 A) (option)
Single Phase (Tower Platforms)	230 V (10 A) (standard) 110 V (16 A) (option) 2 x 55 V (16 A) (option)
Three Phase (Nacelle and Tower Base)	3 x 400 V (16 A)

Table 4-9: AUX system data

4.7 Wind Sensors

The turbine is equipped with two ultrasonic wind sensors. The sensors have built-in heaters to minimise interference from ice and snow. The wind sensors are redundant, and the turbine is able to operate with one sensor only.

4.8 Vestas Multi Processor (VMP) Controller

The turbine is controlled and monitored by the VMP8000 control system.

VMP8000 is a multiprocessor control system comprised of main controller, distributed control nodes, distributed IO nodes and ethernet switches and other network equipment. The main controller is placed in the tower bottom of the turbine. It runs the control algorithms of the turbine, as well as all IO communication.

The communications network is a time triggered Ethernet network (TTEthernet).

The VMP8000 control system serves the following main functions:

- Monitoring and supervision of overall operation.
- Synchronizing of the generator to the grid during connection sequence.
- Operating the wind turbine during various fault situations.
- Automatic yawing of the nacelle.
- OptiTip® - blade pitch control.
- Reactive power control and variable speed operation.
- Noise emission control.
- Monitoring of ambient conditions.
- Monitoring of the grid.
- Monitoring of the smoke detection system.

4.9 Uninterruptible Power Supply (UPS)

During grid outage, an UPS system will ensure power supply for specific components.

The UPS system is built by 3 subsystems:

1. 230V AC UPS for all power backup to nacelle and hub control systems
2. 24V DC UPS for power backup to tower base control systems and optional SCADA Power Plant Controller.
3. 230V AC UPS for power backup to internal lights in tower and nacelle. Internal light in the hub is fed from built-in batteries in the light armature.

UPS		
Backup Time	**Standard**	**Optional**
Control System* **(230V AC and 24V DC UPS)**	15 min	Up to 400 min**

UPS		
Internal Lights **(230V AC UPS)**	30 min	60 min***
Optional SCADA Power Plant Controller **(24V DC UPS)**	N/A	48 hours****

Table 4-10: UPS data

**The control system includes: the turbine controller (VMP8000), HV switchgear functions, and remote control system.*

***Requires upgrade of the 230V UPS for control system with extra batteries.*

****Requires upgrade of the 230V UPS for internal light with extra batteries.*

*****Requires upgrade of the 24V DC UPS with extra batteries.*

NOTE For alternative backup times, consult Vestas.

5 Turbine Protection Systems

5.1 Braking Concept

The main brake on the turbine is aerodynamic. Stopping the turbine is done by full feathering the three blades (individually turning each blade). Each blade has a hydraulic accumulator to supply power for turning the blade.

In addition, there is a mechanical disc brake on the high-speed shaft of the gearbox with a dedicated hydraulic system. The mechanical brake is only used as a parking brake and when activating the emergency stop buttons.

5.2 Short Circuit Protections

Breakers	Breaker for Aux. Power. Back-up CB (T5V-HA 400A TMA 800V) and aux. power CB (T4V-HA 125A TMA 800V) tested in coordination	Breaker 1 for Converter Modules MTZ2 1600A 1000 V	Breaker 2 for Converter Modules MTZ2 3200A 1000 V
Breaking Capacity Icu, Ics	75 kA rms @ max 840 V Ics = 100%	66 kA rms @ max 1000 V Ics = 100%	66 kA rms @ max 1000 V Ics = 100%
Making Capacity Icm	166 kA peak @ max 840 V	145 kA peak @ max 1000 V	145 kA peak @ max 1000 V

Table 5-1: Short circuit protection data

5.3 Overspeed Protection

The generator rpm and the main shaft rpm are registered by inductive sensors and calculated by the wind turbine controller to protect against overspeed and rotating errors.

The safety-related partition of the VMP8000 control system monitors the rotor rpm. In case of an overspeed situation, the safety-related partition of the VMP8000 control system activates the emergency feathered position (full feathering) of the three blades independently of the non-safety related partition of VMP8000 control system.

Overspeed Protection	
Sensors Type	Inductive
Trip Level (variant dependent)	12.0-17.5 rpm / 2000 (generator rpm)

Table 5-2: Overspeed protection data

5.4 Arc Detection

The turbine is equipped with an Arc Detection system including multiple optical arc detection sensors placed in the HV transformer compartment and the converter cabinet. The Arc Detection system is connected to the turbine safety system ensuring immediate opening of the HV switchgear if an arc is detected.

5.5 Smoke Detection

The turbine is equipped with a Smoke Detection system including multiple smoke detection sensors placed in the nacelle (above the disc brake), in the transformer compartment, in main electrical cabinets in the nacelle and above the HV switchgear in the tower base. The Smoke Detection system is connected to the turbine safety system ensuring immediate opening of the HV switchgear if smoke is detected.

5.6 Lightning Protection of Blades, Nacelle, Hub and Tower

The Lightning Protection System (LPS) helps protect the wind turbine against the physical damage caused by lightning strikes. The LPS consists of five main parts:

- Lightning receptors. All lightning receptor surfaces on the blades are unpainted, excluding the Solid Metal Tips (SMT).
- Down conducting system (a system to conduct the lightning current down through the wind turbine to help avoid or minimise damage to the LPS itself or other parts of the wind turbine).
- Protection against overvoltage and overcurrent.
- Shielding against magnetic and electrical fields.
- Earthing system.

V136 blades and V150 blades:

Lightning Protection Design Parameters			Protection Level I
Current Peak Value	i_{max}	[kA]	200
Impulse Charge	$Q_{impulse}$	[C]	100
Long Duration Charge	Q_{long}	[C]	200
Total Charge	Q_{total}	[C]	300
Specific Energy	W/R	[MJ/Ω]	10
Average Steepness	di/dt	[kA/µs]	200

Table 5-3: Lightning protection design parameters (IEC)

Hub/Nacelle/Tower/Foundation and V117 blades:

Lightning Protection Design Parameters			Protection Level I
Current Peak Value	i_{max}	[kA]	200
Impulse Charge	$Q_{impulse}$	[C]	200
Long Duration Charge	Q_{long}	[C]	600
Total Charge	Q_{total}	[C]	800
Specific Energy	W/R	[MJ/Ω]	20
Average Steepness	di/dt	[kA/µs]	200

Table 5-4: Lightning protection design parameters (IEC & JIS)

NOTE The Lightning Protection System is designed according to IEC and JIS standards (see section 8 Design Codes, p. 28).

5.7 EMC

The turbine and related equipment fulfils the EU Electromagnetic Compatibility (EMC) legislation:

- DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility.

5.8 Earthing

The Vestas Earthing System consists of a number of individual earthing electrodes interconnected as one joint earthing system.

The Vestas Earthing System includes the TN-system and the Lightning Protection System for each wind turbine. It works as an earthing system for the medium voltage distribution system within the wind farm.

The Vestas Earthing System is adapted for the different types of turbine foundations. A separate set of documents describe the earthing system in detail, depending on the type of foundation.

In terms of lightning protection of the wind turbine, Vestas has no separate requirements for a certain minimum resistance to remote earth (measured in ohms) for this system. The earthing for the lightning protection system is based on the design and construction of the Vestas Earthing System.

A primary part of the Vestas Earthing System is the main earth bonding bar placed where all cables enter the wind turbine. All earthing electrodes are connected to this main earth bonding bar. Additionally, equipotential connections are made to all cables entering or leaving the wind turbine.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements, as well as project requirements, may require additional measures.

5.9 Corrosion Protection

Classification of corrosion protection is according to ISO 12944-2.

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5-M	C3
Hub	C5-M	C3
Tower	C5-I	C3

Table 5-5: Corrosion protection data for nacelle, hub, and tower

6 Safety

The safety specifications in this section provide limited general information about the safety features of the turbine and are not a substitute for Buyer and its agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, and (c) conducting all appropriate safety training and education.

6.1 Access

Access to the turbine from the outside is through a door located at the entrance platform approximately 3 meter above ground level. The door is equipped with a lock. Access to the top platform in the tower is by a ladder or service lift. Access to the nacelle from the top platform is by ladder. Access to the transformer room in the nacelle is controlled with a lock. Unauthorised access to electrical switchboards and power panels in the turbine is prohibited according to IEC 60204-1 2006.

6.2 Escape

In addition to the normal access routes, alternative escape routes from the nacelle are through the crane hatch, from the spinner by opening the nose cone, or from the roof of the nacelle. Rescue equipment is placed in the nacelle.

The hatch in the roof can be opened from both the inside and outside. Escape from the service lift is by ladder.

An emergency response plan, placed in the turbine, describes evacuation and escape routes.

6.3 Rooms/Working Areas

The tower and nacelle are equipped with power sockets for electrical tools for service and maintenance of the turbine.

6.4 Floors, Platforms, Standing, and Working Places

All floors have anti-slip surfaces.

There is one floor per tower section.

Rest platforms are provided at intervals of 9 metres along the tower ladder between platforms.

Foot supports are placed in the turbine for maintenance and service purposes.

6.5 Service Lift

The turbine is delivered with a service lift installed as an option.

6.6 Climbing Facilities

A ladder with a fall arrest system (rigid rail) is installed through the tower.

There are anchor points in the tower, nacelle and hub, and on the roof for attaching fall arrest equipment (full-body harness). Over the crane hatch there is an anchor point for the emergency descent equipment. Anchor points are coloured yellow and are calculated and tested to 22.2 kN.

6.7 Moving Parts, Guards, and Blocking Devices

All moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and drive train.

Blocking the pitch of the cylinder can be done with mechanical tools in the hub.

6.8 Lights

The turbine is equipped with lights in the tower, nacelle and hub.

There is emergency light in case of the loss of electrical power.

6.9 Emergency Stop

There are emergency stop buttons in the nacelle, hub and bottom of the tower.

6.10 Power Disconnection

The turbine is equipped with breakers to allow for disconnection from all power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and bottom of the tower.

6.11 Fire Protection/First Aid

A handheld 5-6 kg CO_2 fire extinguisher, first aid kit and fire blanket are required to be located in the nacelle during service and maintenance.

- A handheld 5-6 kg CO_2 fire extinguisher is required only during service and maintenance activities, unless a permanently mounted fire extinguisher located in the nacelle is mandatorily required by authorities.
- First aid kits are required only during service and maintenance activities.
- Fire blankets are required only during non-electrical hot work activities.

6.12 Warning Signs

Warning signs placed inside or on the turbine must be reviewed before operating or servicing the turbine.

6.13 Manuals and Warnings

The Vestas Corporate OH&S Manual and manuals for operation, maintenance and service of the turbine provide additional safety rules and information for operating, servicing or maintaining the turbine.

7 Environment

7.1 Chemicals

Chemicals used in the turbine are evaluated according to the Vestas Wind Systems A/S Environmental System certified according to ISO 14001:2015. The following chemicals are used in the turbine:

- Anti-freeze to help prevent the cooling system from freezing.
- Gear oil for lubricating the gearbox.
- Hydraulic oil to pitch the blades and operate the brake.
- Grease to lubricate bearings.
- Various cleaning agents and chemicals for maintenance of the turbine.

8 Design Codes

8.1 Design Codes – Structural Design

The turbine design has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes	
Nacelle and Hub	IEC 61400-1 Edition 3 EN 50308
Tower	IEC 61400-1 Edition 3 Eurocode 3
Blades	DNV-OS-J102 IEC 1024-1

Design Codes	
	IEC 60721-2-4 IEC 61400 (Part 1, 12 and 23) IEC WT 01 IEC DEFU R25 ISO 2813 DS/EN ISO 12944-2
Gearbox	ISO 81400-4
Generator	IEC 60034
Transformer	IEC 60076-11, IEC 60076-16, CENELEC HD637 S1
Lightning Protection	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006 IEC 61400-24:2010 JIS C 1400-24 2014
Rotating Electrical Machines	IEC 34
Safety of Machinery, Safety-related Parts of Control Systems	IEC 13849-1
Safety of Machinery – Electrical Equipment of Machines	IEC 60204-1

Table 8-1: Design codes

9 Colours

9.1 Nacelle Colour

Colour of Vestas Nacelles	
Standard Nacelle Colour	RAL 7035 (light grey)
Standard Logo	Vestas

Table 9-1: Colour, nacelle

9.2 Tower Colour

Colour of Vestas Tower Section		
	External:	**Internal:**
Standard Tower Colour	RAL 7035 (light grey)	RAL 9001 (cream white)

Table 9-2: Colour, tower

9.3 Blade Colour

Blade Colour	
Standard Blade Colour	RAL 7035 (light grey). All lightning receptor surfaces on the blades are unpainted, excluding the Solid Metal Tips (SMT).
Tip-End Colour Variants	RAL 2009 (traffic orange), RAL 3020 (traffic red)
Gloss	< 30% DS/EN ISO 2813

Table 9-3: Colour, blades

10 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.

10.1 Climate and Site Conditions

Values refer to hub height:

Extreme Design Parameters	
Wind Climate	**All**
Ambient Temperature Interval (Standard Temperature Turbine)	-40° to +50°C

Table 10-1: Extreme design parameters

10.2 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 (V117 and V136 Standard Turbine)	-20° to +45°C
Ambient Temperature Interval (V117 and V136 Low Temperature Turbine)	-30° to +45°C
Ambient Temperature Interval (V150 Standard Turbine)	-30° to +45°C

Table 10-2: Operational envelope – temperature

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.

10.3 Operational Envelope – Temperature and Altitude

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 in Figure 10-1 below, the turbine will maintain derated production. Additional derating will take place at altitudes above 1000 m.a.s.l.

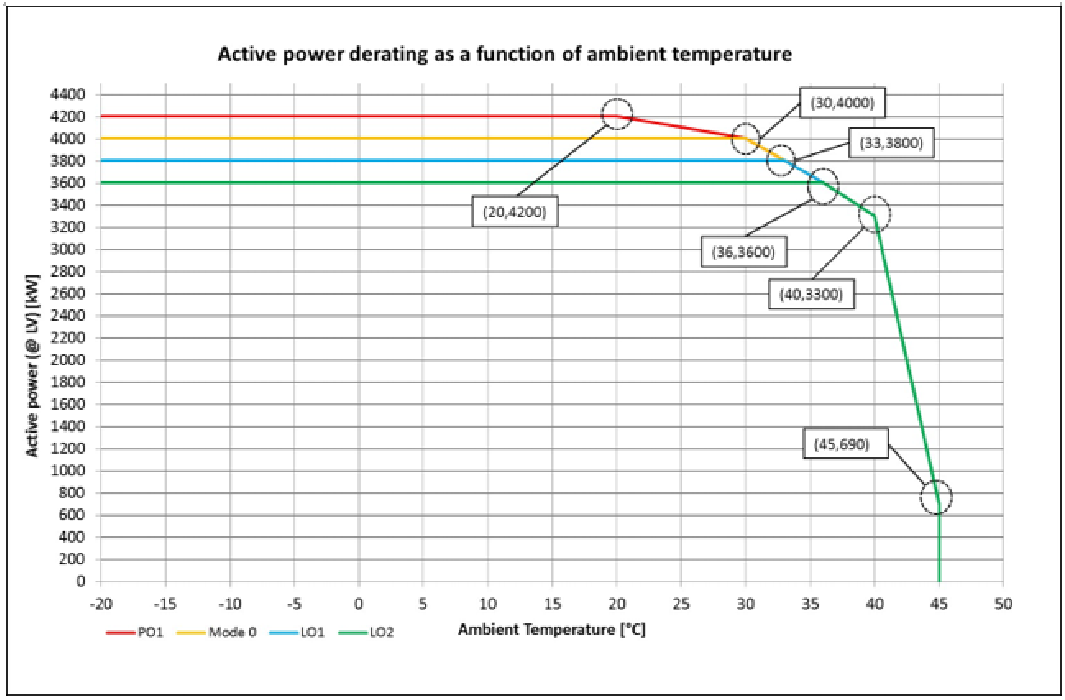


Figure 10-1: Temperature dependant derated operation.

NOTE All derating settings are preliminary and subject to change.

10.4 Operational Envelope – Grid Connection

Operational Envelope – Grid Connection		
Nominal Phase Voltage	[U_{NP}]	720 V
Nominal Frequency	[f_N]	50/60 Hz
Maximum Frequency Gradient	±4 Hz/sec.	
Maximum Negative Sequence Voltage	3% (connection) 2% (operation)	
Minimum Required Short Circuit Ratio at Turbine HV Connection	5.0 (contact Vestas for lower SCR levels)	
Maximum Short Circuit Current Contribution	1.05 p.u. (continuous) 1.45 p.u. (peak)	

Table 10-3: Operational envelope – grid connection

The generator and the converter will be disconnected if*:

Protection Settings	
Voltage Above 110% of Nominal for 1800 Seconds**	792 V
Voltage Above 116% of Nominal for 60 Seconds	835 V
Voltage Above 125% of Nominal for 2 Seconds	900 V
Voltage Above 136% of Nominal for 0.150 Seconds	979 V
Voltage Below 90% of Nominal for 180 Seconds (FRT)**	648 V
Voltage Below 85% of Nominal for 12 Seconds (FRT)	612 V
Voltage Below 80% of Nominal for 4 Seconds (FRT)	576 V
Frequency is Above 106% of Nominal for 0.2 Seconds	53/63.6 Hz
Frequency is Below 94% of Nominal for 0.2 Seconds	47/56.4 Hz

Table 10-4: Generator and converter disconnecting values

NOTE

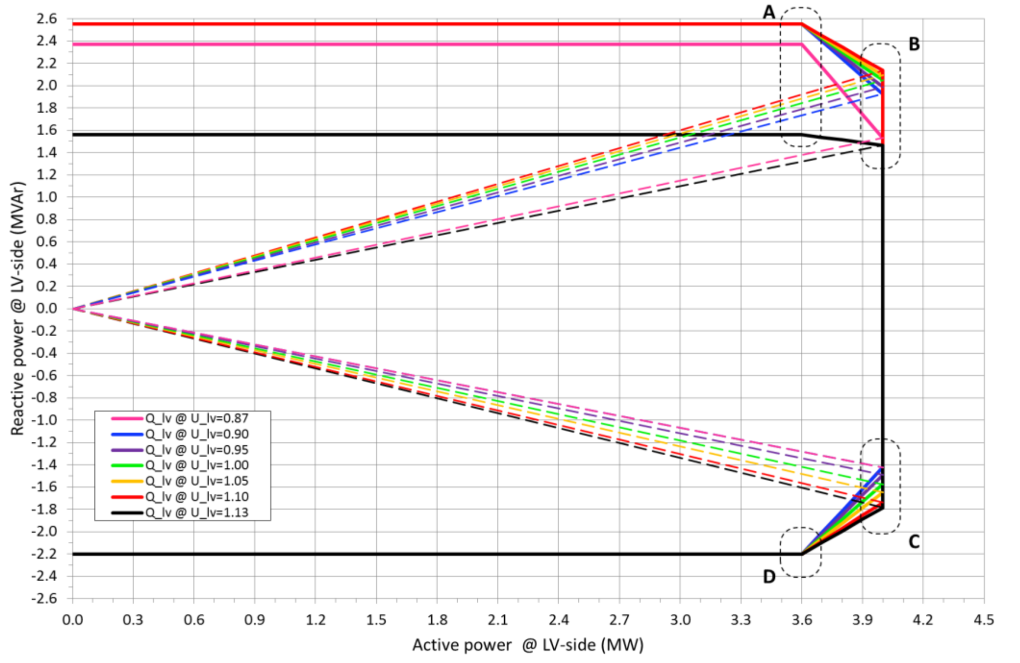
* Over the turbine lifetime, grid drop-outs are to occur at an average of no more than 50 times a year.

** The turbine may be configured for continuous operation @ +/- 13 % voltage. Reactive power capability is limited for these widened settings to an extent that is yet to be determined.

All protection settings are preliminary and subject to change.

10.5 Operational Envelope – Reactive Power Capability in 4.0 MW Mode 0

The turbine has a reactive power capability in 4.0 MW Mode 0 on the low voltage side of the HV transformer as illustrated in Figure 10-2:



		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	3.600	2.370	4.000	1.530	4.000	-1.425	3.600	-2.200	0.934	0.942
	Reactive power [kVAr] @ LV side @ U_lv = 0.90 p.u. voltage	3.600	2.550	4.000	1.926	4.000	-1.425	3.600	-2.200	0.901	0.942
	Reactive power [kVAr] @ LV side @ U_lv = 0.95 p.u. voltage	3.600	2.550	4.000	1.988	4.000	-1.491	3.600	-2.200	0.895	0.937
	Reactive power [kVAr] @ LV side @ U_lv = 1.00 p.u. voltage	3.600	2.550	4.000	2.049	4.000	-1.575	3.600	-2.200	0.890	0.930
	Reactive power [kVAr] @ LV side @ U_lv = 1.05 p.u. voltage	3.600	2.550	4.000	2.093	4.000	-1.648	3.600	-2.200	0.886	0.925
	Reactive power [kVAr] @ LV side @ U_lv = 1.10 p.u. voltage	3.600	2.550	4.000	2.137	4.000	-1.740	3.600	-2.200	0.882	0.917
	Reactive power [kVAr] @ LV side @ U_lv = 1.13 p.u. voltage	3.600	1.560	4.000	1.465	4.000	-1.787	3.600	-2.200	0.939	0.913

Figure 10-2: Reactive power capability for 4.0 MW Mode 0.

When operating at 4.0 MW nominal power at LV side of the HV transformer, the reactive power capability on the high voltage side of the HV transformer is approximately:

- cosφ(HV) = 0.93/0.91 capacitive/inductive @ U(HV) = 0.90 p.u. voltage
- cosφ(HV) = 0.95/0.89 capacitive/inductive @ U(HV) = 1.10 p.u. voltage

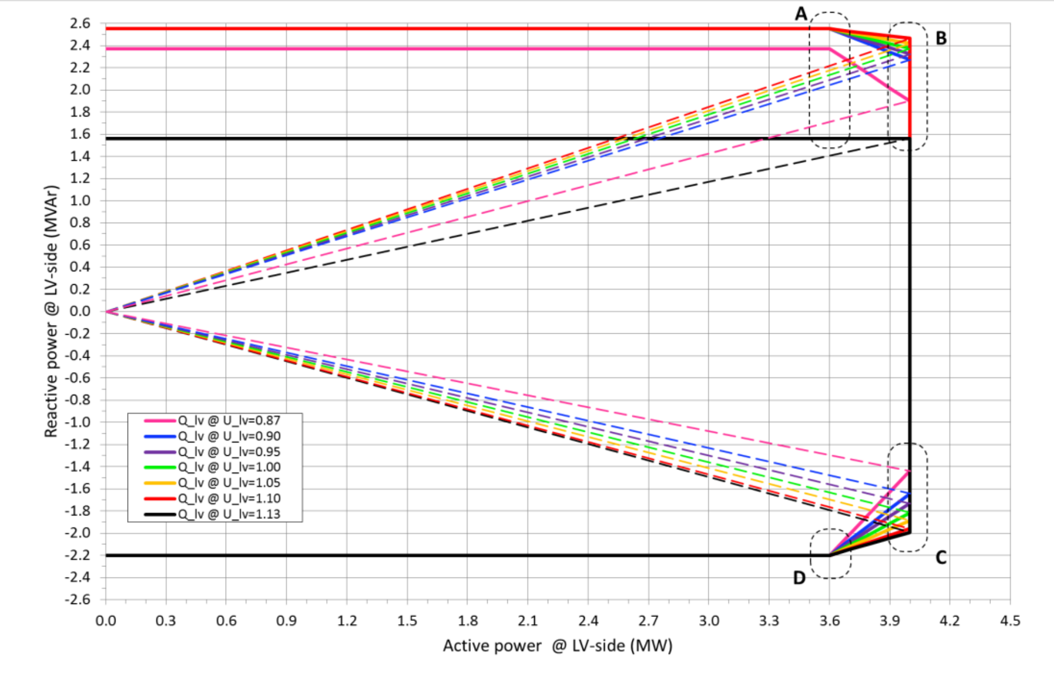
Reactive power is produced by the full-scale converter. Traditional capacitors are, therefore, not used in the turbine.

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

NOTE 4.0 MW Mode 0 derates above +30°C ambient temperature for ≤1000 m.a.s.l. according to Figure 10-1.

10.6 Operational Envelope – Reactive Power Capability in 4.0 MW Reactive Power Optimized Mode (QO1)

An optional, extended reactive power capability is available with 4.0 MW Reactive Power Optimized Mode (QO1) when ambient temperature is below +20°C for ≤1000 m.a.s.l. The reactive power capability is as seen in Figure 10-3:



	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	3.600	2.370	4.000	1.900	4.000	-1.438	3.600	-2.200	0.903	0.941
Reactive power [kVAr] @ LV side @ U_lv = 0.90 p.u. voltage	3.600	2.550	4.000	2.272	4.000	-1.643	3.600	-2.200	0.870	0.925
Reactive power [kVAr] @ LV side @ U_lv = 0.95 p.u. voltage	3.600	2.550	4.000	2.323	4.000	-1.733	3.600	-2.200	0.865	0.918
Reactive power [kVAr] @ LV side @ U_lv = 1.00 p.u. voltage	3.600	2.550	4.000	2.373	4.000	-1.815	3.600	-2.200	0.860	0.911
Reactive power [kVAr] @ LV side @ U_lv = 1.05 p.u. voltage	3.600	2.550	4.000	2.419	4.000	-1.888	3.600	-2.200	0.856	0.904
Reactive power [kVAr] @ LV side @ U_lv = 1.10 p.u. voltage	3.600	2.550	4.000	2.464	4.000	-1.960	3.600	-2.200	0.851	0.898
Reactive power [kVAr] @ LV side @ U_lv = 1.13 p.u. voltage	3.600	1.560	4.000	1.560	4.000	-1.994	3.600	-2.200	0.932	0.895

Figure 10-3: Reactive power capability for 4.0 MW Reactive Power Optimized Mode (QO1).

When operating at 4.0 MW in Reactive Power Optimized Mode (QO1) at LV side of the HV transformer, the reactive power capability on the high voltage side of the HV transformer is approximately:

- cosφ(HV) = 0.91/0.90 capacitive/inductive @ U(HV) = 0.90 p.u. voltage
- cosφ(HV) = 0.94/0.87 capacitive/inductive @ U(HV) = 1.10 p.u. voltage

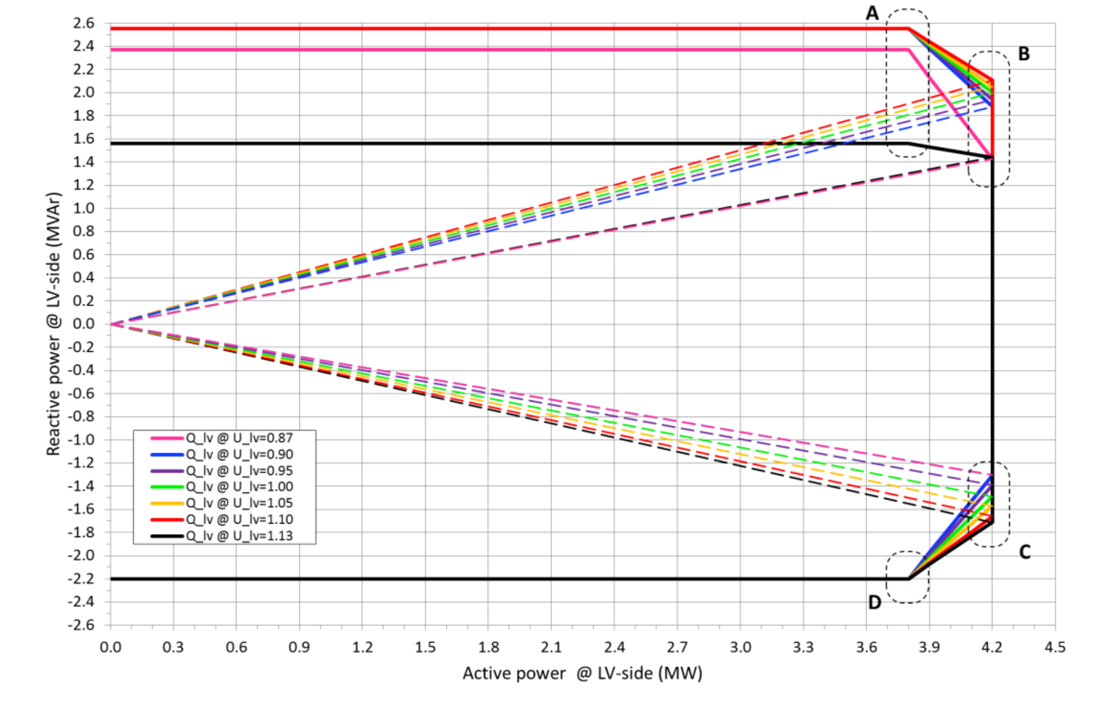
The turbine is able to maintain the reactive power capability at low wind with no active power production.

NOTE

4.0 MW Reactive Power Optimized Mode (QO1) derates reactive power linearly above +20°C ambient temperature for ≤1000 m.a.s.l. to converge with the reactive power capability of 4.0 MW Mode 0 in Figure 10-2 at +30°C.

10.7 Operational Envelope – Reactive Power Capability in 4.2 MW Power Optimized Mode (PO1)

The reactive power capability for the 4.2 MW Power Optimized Mode (PO1) is as illustrated in Figure 10-4:



		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	3.800	2.370	4.200	1.425	4.200	-1.304	3.800	-2.200	0.947	0.955
	Reactive power [kVAr] @ LV side @ U_lv = 0.90 p.u. voltage	3.800	2.550	4.200	1.877	4.200	-1.304	3.800	-2.200	0.913	0.955
	Reactive power [kVAr] @ LV side @ U_lv = 0.95 p.u. voltage	3.800	2.550	4.200	1.938	4.200	-1.392	3.800	-2.200	0.908	0.949
	Reactive power [kVAr] @ LV side @ U_lv = 1.00 p.u. voltage	3.800	2.550	4.200	1.998	4.200	-1.490	3.800	-2.200	0.903	0.942
	Reactive power [kVAr] @ LV side @ U_lv = 1.05 p.u. voltage	3.800	2.550	4.200	2.052	4.200	-1.570	3.800	-2.200	0.898	0.937
	Reactive power [kVAr] @ LV side @ U_lv = 1.10 p.u. voltage	3.800	2.550	4.200	2.105	4.200	-1.660	3.800	-2.200	0.894	0.930
	Reactive power [kVAr] @ LV side @ U_lv = 1.13 p.u. voltage	3.800	1.560	4.200	1.439	4.200	-1.712	3.800	-2.200	0.946	0.926

Figure 10-4: Reactive power capability for 4.2 MW Power Optimized Mode (PO1).

When operating at 4.2 MW in Power Optimized Mode (PO1) at LV side of the HV transformer, the reactive power capability on the high voltage side of the HV transformer is approximately:

- cosφ(HV) = 0.95/0.92 capacitive/inductive @ U(HV) = 0.90 p.u. voltage
- cosφ(HV) = 0.96/0.91 capacitive/inductive @ U(HV) = 1.10 p.u. voltage

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

NOTE

4.2 MW Power Optimized Mode (PO1) derates above +20°C ambient temperature for ≤1000 m.a.s.l. according to Figure 10-1.

4.2 MW Power Optimized Mode (PO1) is mutually exclusive with 4.0 MW Reactive Power Optimized Mode (QO1) (since Q is traded for P).

10.8 Performance – Fault Ride Through

The turbine is equipped with a full-scale converter to gain better control of the wind turbine during grid faults. The turbine control system continues to run during grid faults.

The turbine is designed to stay connected during grid disturbances within the voltage tolerance curve as illustrated below:

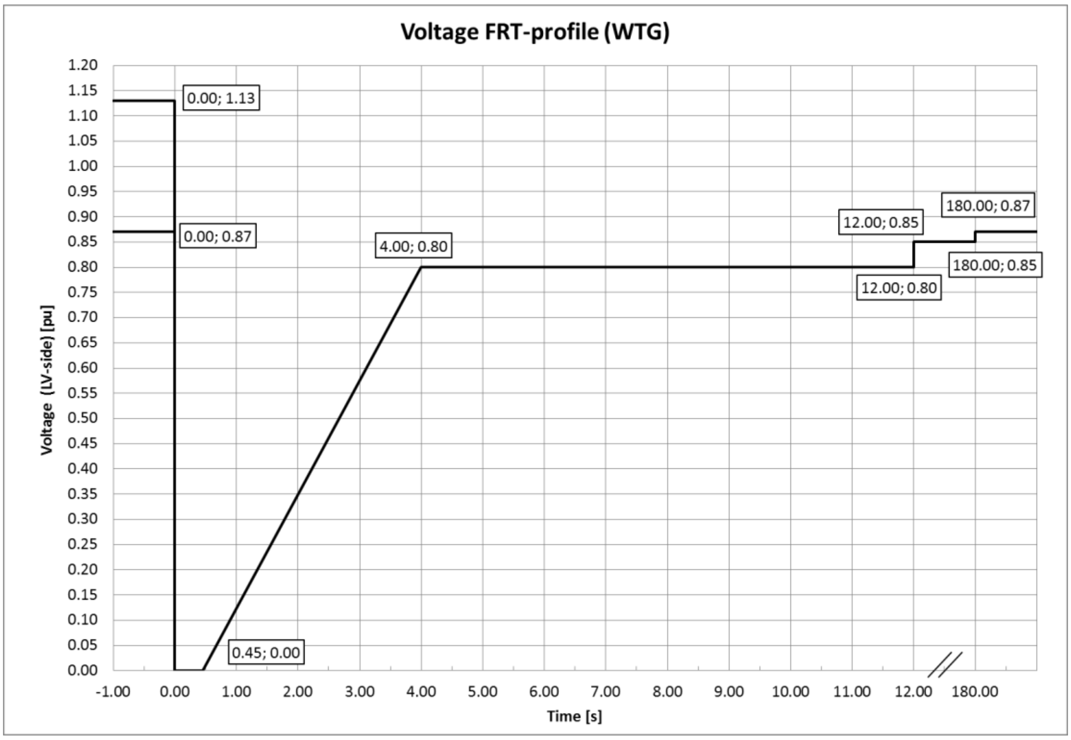


Figure 10-5: Low voltage tolerance curve for symmetrical and asymmetrical faults, where U represents voltage as measured on the grid.

For grid disturbances outside the tolerance curve in Figure 10-5, the turbine will be disconnected from the grid.

NOTE All fault ride through capability values are preliminary and subject to change.

Power Recovery Time	
Power Recovery to 90% of Pre-Fault Level	Maximum 0.1 seconds

Table 10-5: Power recovery time

10.9 Performance – Reactive Current Contribution

The reactive current contribution depends on whether the fault applied to the turbine is symmetrical or asymmetrical.

NOTE All reactive current contribution values are preliminary and subject to change.

10.9.1 Symmetrical Reactive Current Contribution

During symmetrical voltage dips, the wind farm will inject reactive current to support the grid voltage. The reactive current injected is a function of the measured grid voltage.

The default value gives a reactive current part of 1 p.u. of the rated active current at the high voltage side of the HV transformer. Figure 10-6, indicates the reactive current contribution as a function of the voltage. The reactive current contribution is independent from the actual wind conditions and pre-fault power level. As seen in Figure 10-6, the default current injection slope is 2% reactive current increase per 1% voltage decrease. The slope can be parameterized between 0 and 10 to adapt to site specific requirements.

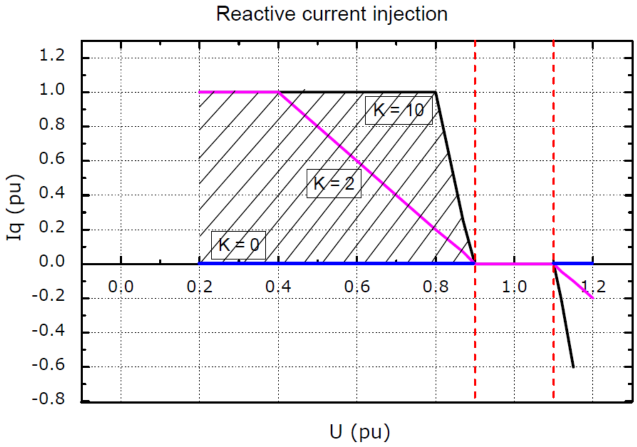


Figure 10-6: Reactive current injection

10.9.2 Asymmetrical Reactive Current Contribution

The injected current is based on the measured positive sequence voltage and the used K-factor. During asymmetrical voltage dips, the reactive current injection is limited to approximate 0.4 p.u. to limit the potential voltage increase on the healthy phases.

10.10 Performance – Multiple Voltage Dips

The turbine is designed to handle re-closure events and multiple voltage dips within a short period of time due to the fact that voltage dips are not evenly distributed during the year. For example, the turbine is designed to handle 10 voltage dips of duration of 200 ms, down to 20% voltage, within 30 minutes.

10.11 Performance – Active and Reactive Power Control

The turbine is designed for control of active and reactive power via the VestasOnline® SCADA system.

Maximum Ramp Rates for External Control	
Active Power	0.1 p.u./sec for max. power level change of 0.3 p.u. 0.3 p.u./sec for max. power level change of 0.1 p.u.
Reactive Power	20 p.u./sec

Table 10-6: Active/reactive power ramp rates (values are preliminary)

To support grid stability the turbine is capable to stay connected to the grid at active power references down to 10 % of nominal power for the turbine. For active power references below 10 % the turbine may disconnect from the grid.

10.12 Performance – Voltage Control

The turbine is designed for integration with VestasOnline® voltage control by utilising the turbine reactive power capability.

10.13 Performance – Frequency Control

The turbine can be configured to perform frequency control by decreasing the output power as a linear function of the grid frequency (over frequency). Dead band and slope for the frequency control function are configurable.

10.14 Distortion – Immunity

The turbine is able to connect with a pre-connection (background) voltage distortion level at the grid interface of 8% and operate with a post-connection voltage distortion level of 8%.

10.15 Main Contributors to Own Consumption

The consumption of electrical power by the wind turbine is defined as the power used by the wind turbine when it is not providing energy to the grid. This is defined in the control system as Production Generator 0 (zero).

The components in Table 10-7 have the largest influence on the own consumption of the wind turbine (the average own consumption depends on the actual conditions, the climate, the wind turbine output, the cut-off hours, etc.).

The VMP8000 control system has a hibernate mode that reduces own consumption when possible. Similarly, cooling pumps may be turned off when the turbine idles.

Main contributors to Own Consumption	
Hydraulic Motor	2 x 15 (V117) / 18.5 kW (V136 + V150) (master-slave)
Yaw Motors	Maximum 21 kW in total
Water Heating	10 kW
Water Pumps	2.2 + 5.5 kW
Oil Heating	7.9 kW
Oil Pump for Gearbox Lubrication	12.5 kW
Controller Including Heating Elements for the Hydraulics and all Controllers	Approximately 3 kW
HV Transformer No-load Loss	See section 4.3 HV Transformer, p. 14

Table 10-7: Main contributors to own consumption data (values are preliminary).

11 Drawings

11.1 Structural Design – Illustration of Outer Dimensions

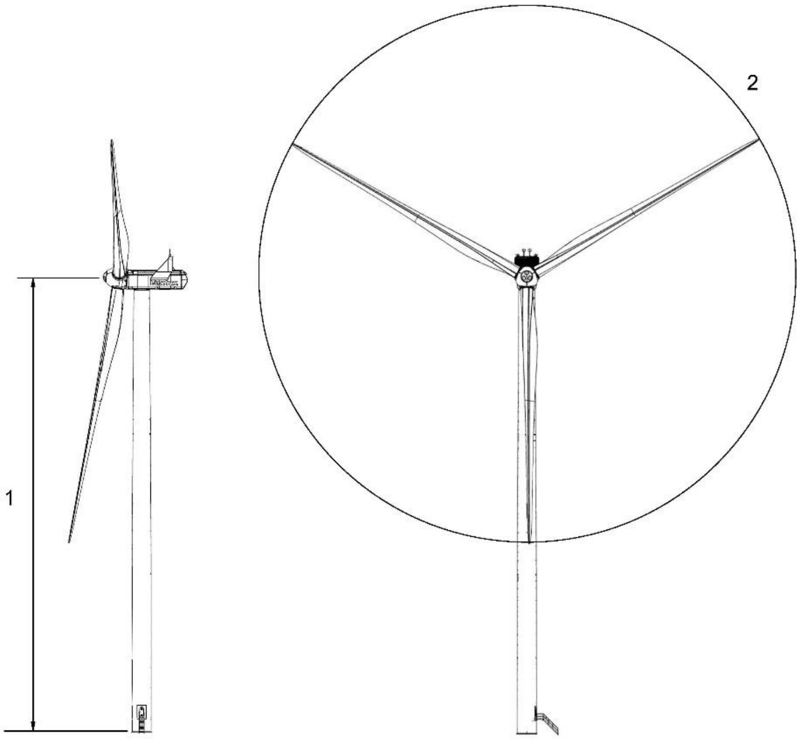


Figure 11-1: Illustration of outer dimensions – structure

1 Hub heights: See Performance Specification

2 Rotor diameter: 117-150 m

11.2 Structural Design – Side View Drawing

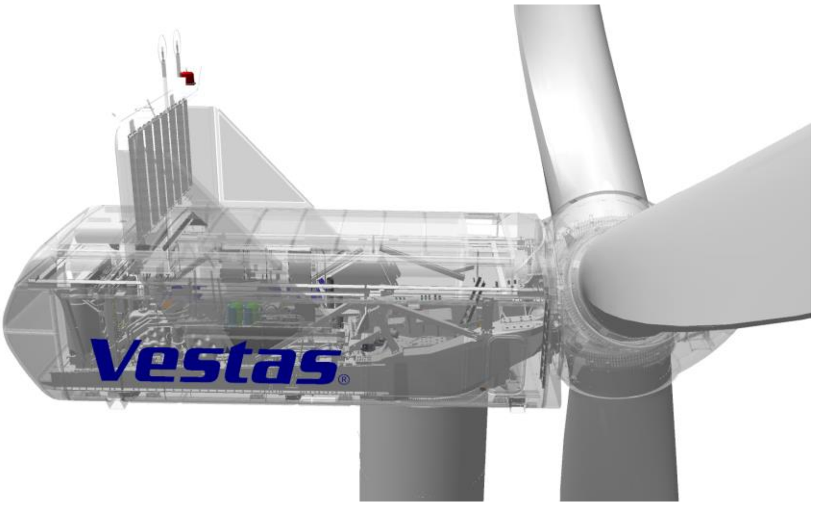


Figure 11-2: Side-view drawing

12 General Reservations, Notes and Disclaimers

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- The general descriptions in this document apply to the current version of the 4MW Platform wind turbines. Updated versions of the 4MW Platform wind turbines, which may be manufactured in the future, may differ from this general description. In the event that Vestas supplies an updated version of a specific 4MW Platform wind turbine, Vestas will provide an updated general description applicable to the updated version.
- Vestas recommends that the grid be as close to nominal as possible with limited variation in frequency and voltage.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- All listed start/stop parameters (e. g. wind speeds and temperatures) 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.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements and codes of standards.
- This document, General Description, is not an offer for sale, and does not contain any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.