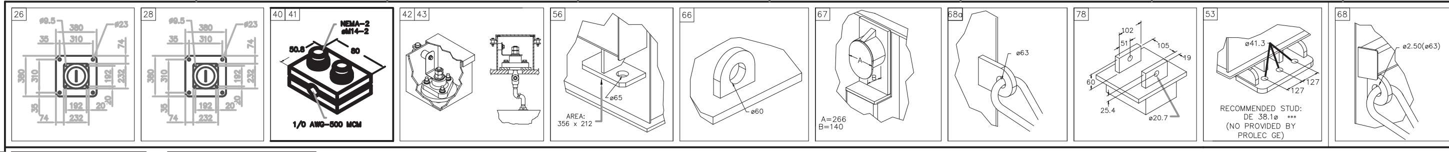


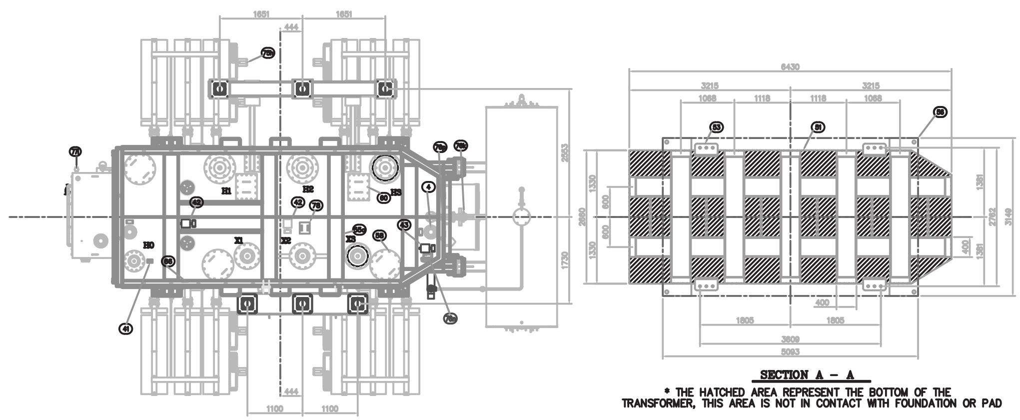
GUIDE		QTY.	ITEM	DESCRIPTION	CAT./MOD.
		1	1d	LIQUID TEMPERATURE INDICATOR (26Q-1)	QUALITROL, 104-885-03
		1	2d	THERMO-WELL FOR LIQUID TEMPERATURE INDICATOR	
5.4	*	2	4	PRESSURE RELIEF DEVICE WITH SEMAPHORE (63PR-1,2)	QUALITROL, 208-60F
5.6	*	1	5	RAPID PRESSURE RELAY (OIL) (63FP-1)	QUALITROL, 900-003-02
		1	5b	RAPID PRESSURE RELAY VALVE (2.00 ø) BALL-TYPE	
		1	7	THERMO-WELL FOR RESISTANCE TEMPERATURE DEVICE FOR ETM (TOP)	
		1	10	ELECTRONIC TEMPERATURE MONITOR (INSIDE CONTROL CABINET)	APT, ECLIPSE-000H
		1	10a	RESISTANCE TEMPERATURE DEVICE FOR ETM (TOP OIL) RTD-1	
		1	10c	RESISTANCE TEMPERATURE DEVICE FOR ETM (AMBIENT) RTD-2	
		1	11	PRESSURE-VACUUM GAUGE FOR SHIPPING	QUALITROL, 050-35E
5.15	*	3	14	H.V. BUSHING EXTERNAL CONNECTOR	DELTA, PM60C12-1-4N4-E
5.15	*	3	14a	L.V. BUSHING EXTERNAL CONNECTOR	DELTA, PM60C12-1-422-M1-E
5.15	*	1	14d	NEUTRAL BUSHING H0 EXTERNAL CONNECTOR	BURNDY, FD67C12W
3.2	*	3	15	H.V. BUSHING	PCORE, POC650G1216CMS
3.2	*	3	16	L.V. BUSHING	ABB 034Z3000AS
3.2	*	1	19	NEUTRAL BUSHING H0	ABB 034Z0412UT
4.2	*	3	25	H.V. SURGE-ARRESTERS	SIEMENS, 3EQ4 108-2PK31-4NH5
	*	3	25a	H.V. BUSHING TO SURGE-ARRESTER FLEXIBLE CONNECTOR	
4.1	*	1	26	H.V. SURGE-ARRESTER SUPPORT	
4.2	*	3	27	L.V. SURGE-ARRESTER	SIEMENS 3EQ4 045-2PD31-4NH5
	*	3	27a	L.V. BUSHING TO SURGE-ARRESTER FLEXIBLE CONNECTOR	
4.1	*	1	28	L.V. SURGE-ARRESTER SUPPORT	
	*	5	37	H.V. SURGE-ARRESTERS GROUND CABLE CONNECTOR	
	*	5	37a	L.V. SURGE-ARRESTERS GROUND CABLE CONNECTOR	
	*	1	38	H.V. SURGE-ARRESTERS COPPER GROUND CABLE	
	*	1	38a	L.V. SURGE-ARRESTERS COPPER GROUND CABLE	
		5	40	GROUND PAD	
		1	41	NEUTRAL H0 GROUND PAD	
		1	42	CORE GROUND BUSHING TERMINAL BOX (MAIN UNIT)	
		1	43	FRAME GROUND BUSHING BOX	
		1	46	NAMEPLATE	
		7	46b	IDENTIFICATION NAMEPLATE	
		1	47	CONTROL CABINET	
		1	51	REINFORCED BASE WELDED TO TANK	
		4	53	TRANSFORMER ANCHOR PADS	
		13	55	TANK BRACES	
		4	55a	COVER BRACES	
		4	56	JACKING PADS AND PULLING EYES	
		1	57	MAIN COVER	
		3	58	INSPECTION MANHOLE (COVER)	
		2	60	INSPECTION RECTANGULAR MANHOLE (COVER)	
		3	65	CT TERMINAL BOX	
		4	66	LIFTING EYE COVER ONLY	
		4	67	LIFTING HOOK FOR LIFTING COMPLETE UNIT	
		4	68	SHIPPING LUGS FOR SECURING THE UNIT LONGITUDINALLY (SHORT LUGS)	
		4	68a	SHIPPING LUGS FOR SECURING THE UNIT LONGITUDINALLY (LONG LUGS)	
		1	72c	TOP FILTER PRESS VALVE (50.8 ø) GLOBE-TYPE	
		1	73	MAIN TANK DRAIN VALVE (50.8ø) GLOBE-TYPE WITH SAMPLING DEVICE (9.65) AND PLUG	
		1	74	IMPACT RECORDER FOR SHIPPING	
		1	74a	ELECTRONIC IMPACT RECORDER FOR SHIPPING	
1.3	*	9	75	COOLING RADIATORS	
		18	75b	RADIATOR VENT AND DRAIN PLUG (25.4 ø)	
		18	75c	RADIATOR VALVE BUTTERFLY-TYPE (101.6 ø)	
		24	75h	COOLING FAN	KRENZ, F26-A8678
1.4	*	4	75n	TOP/BOTTOM RADIATOR SUPPORTS	
1.2	*	7	75o	RADIATOR BRACE	
2.3	*	1	76	CONSERVATOR TANK WITH INTERNAL BLADDER	
2.1	*	2	76a	CONSERVATOR TANK SUPPORT	QUALITROL, 042-144-07
2.2	*	1	76b	CONSERVATOR MAGNETIC LIQUID LEVEL GAUGE (71Q-1)	
		1	76c	HANDHOLE TO INSTALL BLADDER	
5.8	*	1	76d	SILICA-GEL BREATHER WITH PIPE	MESSKO, DB200-RM-T
		2	76e	CONSERVATOR MANHOLE	
5.8	*	1	76f	SILICA-GEL SHUT OFF VALVE (12.7 ø) BALL-TYPE	
		1	76g	CONSERVATOR PRESSURE EQUALIZATION VALVE (25.4 ø) GLOBE-TYPE	
		1	76h	CONSERVATOR FILL VALVE (50.8 ø) GLOBE-TYPE	
		1	76i	CONSERVATOR DRAIN VALVE (50.8 ø) GLOBE-TYPE	
		1	76j	CONSERVATOR TANK NIPPLE FOR VENT WITH CAP.	
2.2	*	1	76k	CONSERVATOR TANK TO MAIN TANK VALVE (76.2 ø) BALL-TYPE	
		1	76l	GAS SAMPLING DEVICE	QUALITROL, 038-002-02
5.13	*	1	76n	GAS ACCUMULATION DEVICE (63G-1)	
2.4	*	1	76p	EXPANSION JOINT FOR PIPING	
		1	77	ON-LOAD TAP-CHANGER	MR, RMV-II-1800-72.5
		1	77a	LTC MAGNETIC LIQUID LEVEL GAUGE (71Q-2)	
		1	77b	LTC PRESSURE RELIEF DEVICE (63PR-4)	
		1	77i	LTC DRAIN VALVE (25.4 ø) GATE-TYPE WITH SAMPLING DEVICE (9.65 ø) AND PLUG	
5.8	*	1	77k	LTC SILICA-GEL BREATHER WITH PIPE	
		1	77l	LTC MOTOR DRIVE CABINET	
		1	78	TETHER POLE MOUNTING PLATE	
		2	79	VALVES FOR INSTALLATION OF A KELMAN MINITRANS DGA MONITOR (BALL TYPE)	

GENERAL ELECTRIC CANADA
P.O. No: 512-03118
GE Req No: TD7-04344
CUSTOMER ID: JERICHO
PROLEC GE Serial No: G2994-01

STEP UP TRANSFORMER
ONAN/ONAF/ONAF
102/136/170 MVA
60 HZ, THREE PHASE, 65°C, 1000 MASL
121/69.86 KV ⅄ – 34.5 KV ◁

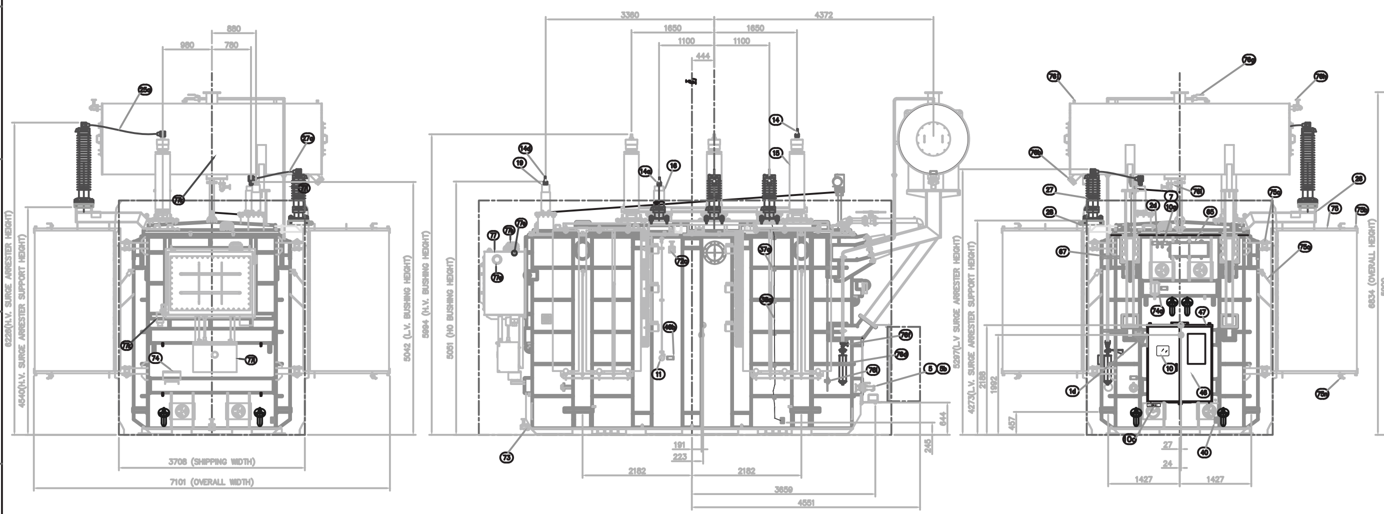
APPROVAL DRAWING
FEB/15/2013

APPROXIMATE WEIGHTS (KGS)	
CORE AND COILS	94760
TANK AND FITTINGS	40330
MAIN TANK INSULATING LIQUID (45730 LTS)	41160
COOLING EQUIPMENT INSULATING LIQUID (4015 LTS)	3615
CONSERVATOR TANK INSULATING LIQUID (2355 LTS)	2120
LTC TANK INSULATING LIQUID (1300 LTS)	1170
TOTAL WEIGHT	183175
UNTANKING WEIGHT (HEAVIEST PIECE)	94760
SHIPPING WEIGHT (WITHOUT INSULATING LIQUID)	116240



SECTION A – A

* THE HATCHED AREA REPRESENT THE BOTTOM OF THE TRANSFORMER, THIS AREA IS NOT IN CONTACT WITH FOUNDATION OR PAD



PROLEC GE

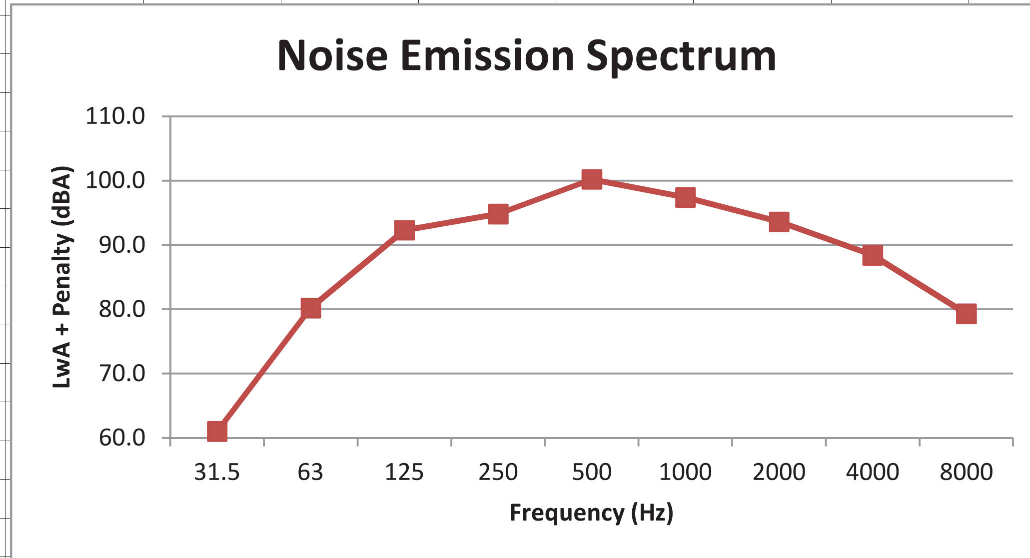
PROLEC GE ENGINEERING POWER DIVISION
http://www.prolecge.com

TITLE: TRANSFORMER'S OUTLINE

DFTM: CTC	01/18/2013
CHKD: CSP	01/18/2013
PROJECTION	
SCALE:	1:45
DIMENSIONS:	MM
REVISION:	INDICATED
DRAWING NO.:	G299401D801
sheet:	1 of 1

Transformer Noise Emissions

Noise Rating	**75.0**	**dBA**
Measurement Dist	0.30	m
Measurement Surface Area	238.7	m^2
Sound Power Level	98.78	dBA
Tonal Penalty	5.0	dB
Sound Power Level	103.8	dBA



Octave Band Emission Estimates

Centre Frequency	Corr[1]	Ncor[2]	Lw	LwA	Tonal Penalty	Lw + Penalty	LwA + Penalty
31.5	-1.0	-2.37	95.4	56.0	5.0	100.4	61.0
63	5.0	-2.37	101.4	75.2	5.0	106.4	80.2
125	7.0	-2.37	103.4	87.3	5.0	108.4	92.3
250	2.0	-2.37	98.4	89.8	5.0	103.4	94.8
500	2.0	-2.37	98.4	95.2	5.0	103.4	100.2
1000	-4.0	-2.37	92.4	92.4	5.0	97.4	97.4
2000	-9.0	-2.37	87.4	88.6	5.0	92.4	93.6
4000	-14.0	-2.37	82.4	83.4	5.0	87.4	88.4
8000	-21.0	-2.37	75.4	74.3	5.0	80.4	79.3
Overall Sound Power Level			107.4	**98.78**		112.4	**103.8**

1. Correction from "Engineering Noise Control", David A. Bies and Colin H. Hansen
2. Normalization correction to ensure total sound power after band corrections does not exceed measured overall value

AECOM

JOB TITLE Jericho Wind Energy Centre

JOB NO. 60155032

CALCULATION NO. Measurement Area

ORIGINATOR AD

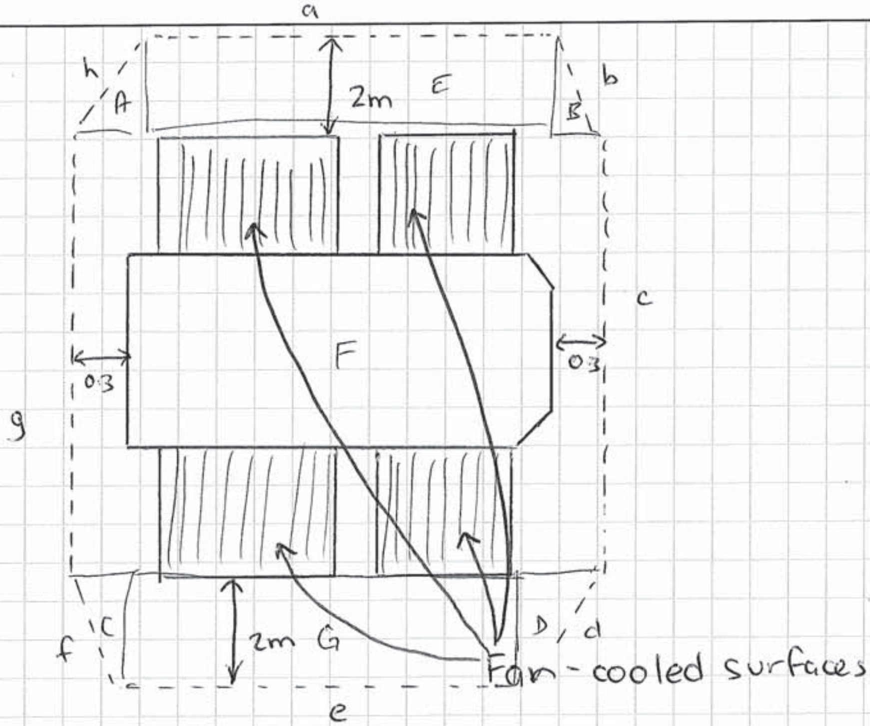
DATE Genset

REVIEWER

DATE

SCALE

SHEET NO. OF



Perimeter = a + b + c + d + e + f + g + h

$e = a = 6.43\,m$ (from drawing)

$f = h = d = b = \sqrt{2^2 + 0.3^2} = 2.02\,m$

$c = g = 7.10\,m$

$\therefore$ Perimeter = 35.14 m

Top Area = 4 triangles (A + B + C + D)
+ 2 Rectangles (E + G)
+ 1 Rectangle (F)

Area of A = B = C = D = $\frac{1}{2} \times 2 \times 0.3$
$= 0.6\,m^2$

Area of E = $a \times 2 = 12.86\,m^2$ = G

Area of F = $[a + (2 \times 0.3)] \times c$
$= 49.9\,m^2$

$\therefore$ Top area = $78.02\,m^2$

Side area = perimeter × (height + 0.3)
$= 35.14 \times 4.573 = 160.7\,m^2$

$\therefore$ Total area = ~~79.0~~ 78.0 + 160.7

Area = 238.7 m²

Grid: 5x5 = 1 in

Goshen Transformer Noise Barrier Sketch

Wind Shear Calculation

Night-time Monthly Average Wind Speed Data (2300 to 0700)

Data Set	Wind Speed Sensor	Height	Wind Speed (m/s)											
			Winter	Winter	Winter	Spring	Spring	Spring	Summer	Summer	Summer	Fall	Fall	Fall
			January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	48.5m_W	48.50	6.31	6.01	5.88	6.36	5.56	4.42	4.15	4.25	5.07	5.91	6.37	7.10
2	48.5m_S	48.50	6.36	6.05	5.85	6.38	5.58	4.45	4.17	4.27	5.11	5.91	6.46	7.14
3	41.5m_W	41.00	6.08	5.78	5.57	5.98	5.24	4.19	3.85	3.89	4.66	5.51	6.04	6.85
4	41.5m_S	41.00	6.05	5.79	5.54	6.06	5.29	4.21	3.89	3.90	4.72	5.53	6.12	6.83
5	30m_W	30.00	5.68	5.41	5.17	5.52	4.84	3.88	3.51	3.48	4.18	5.02	5.58	6.46
6	10m_W	10.00	4.88	4.61	4.30	4.59	4.04	3.24	2.69	2.54	3.17	3.85	4.51	5.52

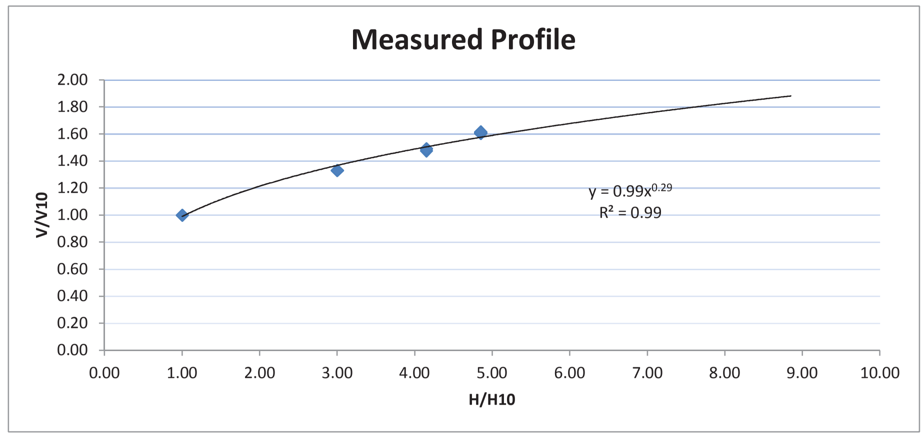
Summer Average Night-time Monthly Average Wind Speed - Based on Measurements

Data Set	Wind Speed Sensor	Height (m)	Vsavg (m/s)	H/H10	Vsavg/V10
1	spd_avg_48.5m_W_ch01	48.50	4.49	4.85	1.61
2	spd_avg_48.5m_S_ch02	48.50	4.52	4.85	1.62
3	spd_avg_41.5m_W_ch03	41.50	4.13	4.15	1.48
4	spd_avg_41.5m_S_ch04	41.50	4.17	4.15	1.49
5	spd_avg_30m_W_ch05	30.00	3.72	3.00	1.33
6	spd_avg_10m_W_ch06	10.00	2.80	1.00	1.00

Model	Vsavg(hub) = Vsavg(10m)*k k=C*(H/H10)^(n)
Hub Height (m)	80
C	1
n	0.29
k	1.83

Vsavg - Summer Average Night-time Wind Speed (July, August and Sept)

V10 - Vsavg at 10m height



Technical Description of the 1.56-100 Wind Turbine and Major Components

The wind turbine is a three bladed, upwind, horizontal-axis wind turbine with a rotor diameter of 100 m. The turbine rotor and nacelle are mounted on top of a tubular tower giving a rotor hub height of 80m. The machine employs active yaw control (designed to steer the machine with respect to the wind direction), active blade pitch control (designed to regulate turbine rotor speed), and a generator/power electronic converter system.

The wind turbine features a distributed drive train design wherein the major drive train components including main shaft bearings, gearbox, generator, yaw drives, and control panel are attached to a bedplate (see Figure 1).

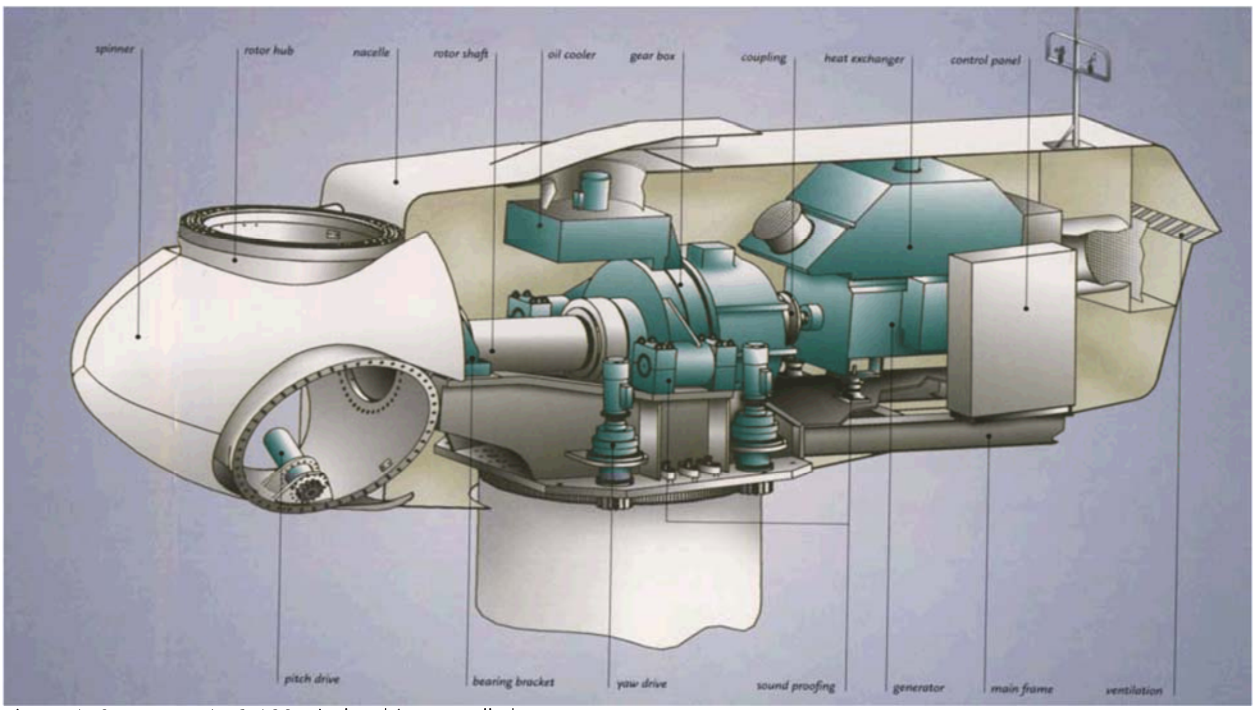


Figure 1: GE Energy 1.56-100 wind turbine nacelle layout

Rotor

The rotor diameter is 100 m, resulting in a swept area of 7,854 m, and is designed to operate between 9.75 and 16.18 revolutions per minute (rpm). Rotor speed is regulated by a combination of blade pitch angle adjustment and generator/converter torque control. The rotor spins in a clock-wise direction under normal operating conditions when viewed from an upwind location.

Full blade pitch angle range is approximately 90°, with the 0°-position being with the airfoil chord line flat to the prevailing wind. The blades being pitched to a full feather pitch angle of approximately 90° accomplishes aerodynamic braking of the rotor; whereby the blades "spill" the wind thus limiting rotor speed.

Blades

There are three rotor blades used on each wind turbine. The airfoils transition along the blade span with the thicker airfoils being located in-board towards the blade root (hub) and gradually tapering to thinner cross sections out towards the blade tip.

Blade Pitch Control System

The rotor utilizes three (one for each blade) independent electric pitch motors and controllers to provide adjustment of the blade pitch angle during operation. Blade pitch angle is adjusted by an electric drive that is mounted inside the rotor hub and is coupled to a ring gear mounted to the inner race of the blade pitch bearing (see Figure 1).

GE's active-pitch controller enables the wind turbine rotor to regulate speed, when above rated wind speed, by allowing the blade to "spill" excess aerodynamic lift. Energy from wind gusts below rated wind speed is captured by allowing the rotor to speed up, transforming this gust energy into kinetic which may then be extracted from the rotor.

Three independent back-up units are provided to power each individual blade pitch system to feather the blades and shut down the machine in the event of a grid line outage or other fault. By having all three blades outfitted with independent pitch systems, redundancy of individual blade aerodynamic braking capability is provided.

Hub

The hub is used to connect the three rotor blades to the turbine main shaft. The hub also houses the three electric blade pitch systems and is mounted directly to the main shaft. Access to the inside of the hub is provided through a hatch.

Gearbox

The gearbox in the wind turbine is designed to transmit power between the low-rpm turbine rotor and high-rpm electric generator. The gearbox is a multi-stage planetary/helical gear design. The gearbox is mounted to the machine bedplate. The gearing is designed to transfer torsional power from the wind turbine rotor to the electric generator. A parking brake is mounted on the high-speed shaft of the gearbox.

Bearings

The blade pitch bearing is designed to allow the blade to pitch about a span-wise pitch axis. The inner race of the blade pitch bearing is outfitted with a blade drive gear that enables the blade to be driven in pitch by an electric gear-driven motor/controller.

The main shaft bearing is a roller bearing mounted in a pillow-block housing arrangement. The bearings used inside the gearbox are of the cylindrical, spherical and tapered roller type. These bearings are designed to provide bearing and alignment of the internal gearing shafts and accommodate radial and axial loads.

Brake System

The electrically actuated individual blade pitch systems act as the main braking system for the wind turbine. Braking under normal operating conditions is accomplished by feathering the blades out of the wind. Any single feathered rotor blade is designed to slow the rotor, and each rotor blade has its own back-up to provide power to the electric drive in the event of a grid line loss.

The turbine is also equipped with a mechanical brake located at the output (high-speed) shaft of the gearbox. This brake is only applied as an auxiliary brake to the main aerodynamic brake and to prevent rotation of the machinery as required by certain service activities.

Generator

The generator is a doubly-fed induction type. The generator meets protection class requirements of the International Standard IP 54 (totally enclosed). The generator is mounted to the bedplate and the mounting is designed so as to reduce vibration and noise transfer to the bedplate.

Flexible Coupling

Designed to protect the drive train from excessive torque loads, a flexible coupling is provided between the generator and gearbox output shaft this is equipped with a torque-limiting device sized to keep the maximum allowable torque below the maximum design limit of the drive train.

Yaw System

A roller bearing attached between the nacelle and tower facilitates yaw motion. Planetary yaw drives (with brakes that engage when the drive is disabled) mesh with the outside gear of the yaw bearing and steer the machine to track the wind in yaw. The automatic yaw brakes engage in order to prevent the yaw drives from seeing peak loads from any turbulent wind.

The controller activates the yaw drives to align the nacelle to the average wind direction based on the wind vane sensor mounted on top of the nacelle.

A cable twist sensor provides a record of nacelle yaw position and cable twisting. After the sensor detects excessive rotation in one direction, the controller automatically brings the rotor to a complete stop, untwists the cable by counter yawing of the nacelle, and restarts the wind turbine.

Tower

The wind turbine is mounted on top of a tubular tower. The tubular tower is manufactured in sections from steel plate. Access to the turbine is through a lockable steel door at the base of the tower. Service platforms are provided. Access to the nacelle is provided by a ladder and a fall arresting safety system is included. Interior lights are installed at critical points from the base of the tower to the tower top.

Nacelle

The nacelle houses the main components of the wind turbine generator. Access from the tower into the nacelle is through the bottom of the nacelle. The nacelle is ventilated. It is illuminated with electric light. A hatch at the front end of the nacelle provides access to the blades and hub. The rotor can be secured in place with a rotor lock.

Anemometer, Wind Vane and Lightning Rod

An anemometer, wind vane and lightning rod are mounted on top of the nacelle housing. Access to these sensors is accomplished through a hatch in the nacelle roof.

Lightning Protection

The rotor blades are equipped with a lightning receptors mounted in the blade. The turbine is grounded and shielded to protect against lightning, however, lightning is an unpredictable force of nature, and it is possible that a lightning strike could damage various components notwithstanding the lightning protection deployed in the machine.

Wind Turbine Control System

The wind turbine machine can be controlled automatically or manually from either an interface located inside the nacelle or from a control box at the bottom of the tower. Control signals can also be sent from a remote computer via a Supervisory Control and Data Acquisition System (SCADA), with local lockout capability provided at the turbine controller.
Service switches at the tower top prevent service personnel at the bottom of the tower from operating certain systems of the turbine while service personnel are in the nacelle. To override any machine operation, Emergency-stop buttons located in the tower base and in the nacelle can be activated to stop the turbine in the event of an emergency.

Power Converter

The wind turbine uses a power converter system that consists of a converter on the rotor side, a DC intermediate circuit, and a power inverter on the grid side.

The converter system consists of a power module and the associated electrical equipment. Variable output frequency of the converter allows operation of the generator.

Technical Data for the 1.56-100

Rotor

Diameter	100 m
Number of blades	3
Swept area	7,854 m^2
Rotor speed range	9.75 to 16.18 rpm
Rotational direction	Clockwise looking downwind
Maximum tip speed	84.7 m/s
Orientation	Upwind
Speed regulation	Pitch control
Aerodynamic brakes	Full feathering

Pitch System

Principle	Independent blade pitch control
Actuation	Individual electric drive

Yaw System

Yaw rate	0.5 degree/s

1.56-100 Calculated Octave Band Spectra – Canada Specific

Table 1 below provides simulated, A-weighted octave band spectra as a function of standardized wind speed at 10 m height, and expressed as apparent sound power levels. The uncertainties for octave sound power levels are generally higher than for total sound power levels. Guidance is given in IEC 61400-11, Annex D.

1.56-100 Octave Band Spectra									
Standard WS at 10m [m/s]		5	5.5	6	6.5	7	8	9	10-Cutout
Hub Height WS at 100m [m/s]		7.2	7.9	8.6	9.3	10	11.5	12.9	14-Cutout
Frequency [Hz]	32	71.2	74.2	76.5	78.8	80.9	81.5	81.5	81.5
	63	80.9	83.9	86.2	88.4	90.5	91.2	91.2	91.2
	125	85.4	88.2	90.1	92.1	94.2	94.8	94.9	94.8
	250	89.1	91.6	91.9	92.5	93.9	94.2	94.2	94.2
	500	90.4	93.3	94.6	95.4	95.7	94.6	94.5	94.5
	1000	88.1	91.4	95.2	98.2	99.6	99.1	98.9	98.8
	2000	85.8	87.7	91.3	94.8	97.2	98	98.1	98.2
	4000	81.4	82.8	84.6	86.5	88.4	88.8	89.2	89.5
	8000	65.9	66.5	68	69.6	71.1	71.2	70.7	70.5
	16000	26.8	24.7	25.9	28.2	30.5	31.8	31.1	31.2
Lwa [dBA]		95.5	98.3	100.4	102.5	104	104	104	104

Table 1: Octave Spectra for 1.56-100 - hub height wind speeds were calculated based on equation (7) from IEC standard 61400-11:2002, using a representative roughness height of 0.05 m

1.56-100 Normal Operation Calculated Tonal Audibility – Canada Specific

The nominal acoustic performances for 1.56-100, 60 Hz version equipped with 100 m rotor diameter (GE 48.7 type blade) operating in normal operation (NO), specified at reference ground measuring distance Ro measurement point #1 per both IEC 61400-11 and GE's "Machine noise performance test" reference guidelines:

- Tonal audibility **$\Delta L_{a,k} \leq 2$ dB**.

1.56-100 Testing Uncertainty and Product Variation per IEC/TS 61400-14 Standard

Per IEC/TS 61400-14, L_{WAd} is the maximum apparent sound power level resulting from ***n*** measurements performed according to IEC 61400-11 standard for 95 % confidence level: $L_{WAd} = \overline{L_{WA}}$ + K, where $\overline{L_{WA}}$ is the mean apparent sound power level from ***n*** IEC 61400-11 testing reports and **K = 1,645 · σT**.

The testing standard deviation values **σ_T**, **σ_R** and **σ_P** for measured apparent sound power level are described by IEC/TS 61400-14 where **σ_T** is the total standard deviation, **σ_P** is the standard deviation for product variation and **σ_R** is the standard deviation for test reproducibility.

Assuming **σ_R** < 0.8 dB and **σ_P** < 0.8 dB typical values, leads to calculated **K < 2 dB** for 95 % confidence level.

IEC 61400-11 and IEC/TS 61400-14 Terminology

- **$L_{WA,k}$** is wind turbine apparent sound power level (referenced to 1^{-12} W) measured with A-weighting as function of reference wind speed v_{10m}. Derived from multiple measurement reports per IEC 61400-11, it is considered as a mean value.
- **σ_P** is the product variation i.e. the 1.56-100 unit-to-unit product variation; typically < 0.8 dB
- **σ_R** is the overall measurement testing reproducibility as defined per IEC 61400-11; typically < 0.8 dB with adequate measurement conditions and sufficient amount of data samples
- **σ_T** is the total standard deviation combining both **σ_P** and **σ_R**

- **$K = 1,645 \cdot \sigma_T$** is defined by IEC/TS 61400-14 for 95 % confidence level
- **R_o** is the ground measuring distance from the wind turbine tower axis per IEC 61400-11
- **$\Delta L_{a,k}$** is the tonal audibility according to IEC 61400-11, described as potentially audible narrow band sound

GE Power & Water

– Original Instructions –

Technical Documentation Wind Turbine Generator Systems 1.6-100 with LNTE 50 Hz and 60 Hz

Product Acoustic Specifications

Normal Operation according to IEC Incl. Octave Band Spectra Incl. 1/3rd Octave Band Spectra

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Table of Contents

1 Introduction

This document summarizes the acoustic emission characteristics of the 1.6-100 with Low Noise Trailing Edge (LNTE) wind turbine for normal operation, including calculated apparent sound power levels $L_{WA,k}$, as well as uncertainty levels associated with the apparent sound power levels, tonal audibility, and calculated third octave band apparent sound power level.

All provided sound power levels are A-weighted.

GE continuously verifies specifications with measurements, including those performed by independent institutes. If a wind turbine noise performance test is carried out, it needs to be done in accordance with the regulations of the international standard IEC 61400-11, ed. 2.1: 2006 and Machine Noise Performance Test document.

2 Normal Operation Calculated Apparent Sound Power Level

The apparent sound power levels $L_{WA,k}$ are initially calculated as a function of the hub height wind speed v_{HH}. The corresponding wind speeds v_{10m} at 10 m height above ground level have been evaluated assuming a logarithmic wind profile. In this case a surface roughness of z_{0ref} = 0.05 m has been used, which is representative of average terrain conditions.

$$v_{10m} = v_{HH} \frac{\ln\left({10m}/{z_{0ref}} \right)}{\ln\left({hub\ height}/{z_{0ref}} \right)} \;*$$

The calculated apparent sound power levels $L_{WA,k}$ and the associated octave-band spectra are given in Table 1 and Table 2 for two different hub heights. The values are provided as mean levels as a function of v_{10m} for Normal Operation (NO) over cut-in to cut-out wind speed range. The uncertainties for octave sound power levels are generally higher than for total sound power levels. Guidance is given in IEC 61400-11, Annex D.

1.6-100 with LNTE – Normal Operation Octave Spectra									
Standard wind speed at 10 m [m/s]		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10-Cutout**
Hub height wind speed at 80 m [m/s]		**4.2**	**5.6**	**7.0**	**8.4**	**9.7**	**11.1**	**12.5**	**14-Cutout**
Frequency (Hz)	**31.5**	62.5	62.2	66.1	70.1	73.5	73.7	73.6	73.5
	63	72.1	71.9	75.9	80.3	84.0	84.1	84.1	84.0
	125	79.0	79.2	83.8	88.4	91.6	91.8	91.8	91.7
	250	84.0	84.6	89.4	94.7	95.4	95.3	95.4	95.5
	500	85.5	84.9	89.7	95.5	97.1	96.6	96.7	97.0
	1000	83.4	83.0	86.9	91.8	97.1	97.5	97.6	97.8
	2000	81.7	83.4	87.9	92.4	95.7	95.7	95.5	95.1
	4000	74.9	77.7	83.5	88.9	89.7	89.1	88.4	87.9
	8000	55.5	57.6	63.5	70.3	70.4	70.6	69.4	69.1
	16000	7.9	13.2	18.9	24.7	27.2	26.6	27.5	29.0
Total apparent sound power level $L_{WA,k}$ [dB]		**90.4**	**90.7**	**95.3**	**100.5**	**103.0**	**103.0**	**103.0**	**103.0**

Table 1: Normal Operation Calculated Apparent Sound Power Level, 1.6-100 with LNTE with 80 m hub height as a function of 10 m wind speed (z_{0ref} = 0.05 m), the octave band spectra are for information only

* Simplified from IEC 61400-11, ed. 2.1: 2006 equation 7

1.6-100 with LNTE – Normal Operation Octave Spectra									
Standard wind speed at 10 m [m/s]		3	4	5	6	7	8	9	10-Cutout
Hub height wind speed at 96 m [m/s]		4.3	5.7	7.1	8.6	10.0	11.4	12.8	14-Cutout
Frequency (Hz)	31.5	62.4	62.4	66.6	70.6	73.7	73.7	73.6	73.5
	63	72.1	72.0	76.5	80.8	84.1	84.1	84.1	84.0
	125	79.0	79.5	84.4	89.0	91.6	91.8	91.8	91.7
	250	84.0	84.9	90.1	95.0	95.3	95.3	95.5	95.5
	500	85.4	85.0	90.3	96.0	96.8	96.6	96.8	97.0
	1000	83.4	83.1	87.5	92.4	97.2	97.4	97.7	97.8
	2000	81.8	83.7	88.5	92.9	95.8	95.7	95.4	95.1
	4000	75.1	78.2	84.2	89.3	89.7	88.8	88.4	87.9
	8000	55.7	57.9	64.4	70.7	71.1	69.8	69.3	69.1
	16000	8.4	13.6	19.5	25.2	27.3	26.4	27.8	29.0
Total apparent sound power level $L_{WA,k}$ [dB]		90.4	90.9	96.0	101.0	103.0	103.0	103.0	103.0

Table 2: Normal Operation Calculated Apparent Sound Power Level, 1.6-100 with LNTE with 96 m hub height as a function of 10 m wind speed (z_{0ref} = 0.05 m), the octave band spectra are for information only

At 10 m wind speeds lower than 5 m/s the sound power levels decreases, and may get so low that the wind turbine noise becomes indistinguishable from the background noise. For a conservative calculation the data at 5 m/s may be used.

For 10 m wind speeds above 10 m/s, the wind turbine has reached rated power and the blade pitch regulation acts in a way that tends to decrease the noise levels. For a conservative calculation the data at 10 m/s may be used.

The highest normal operation calculated apparent sound power level for the 1.6-100 with LNTE is $L_{WA,k}$ = 103.0 dB.

3 Uncertainty Levels

The apparent sound power levels given above are calculated mean levels. If a wind turbine noise performance test is carried out, it needs to be done in accordance with the regulations of the international standard IEC 61400-11, ed. 2.1: 2006. Uncertainty levels associated with measurements are described in IEC/TS 61400-14.

Per IEC/TS 61400-14, L_{WAd} is the maximum apparent sound power level for 95 % confidence level resulting from n measurements performed according to IEC 61400-11 standard: $L_{Wad} = L_{WA} + K$, where L_{WA} is the mean apparent sound power level from IEC 61400-11 testing reports and $K = 1.645\ \sigma_T$.

The testing standard deviation values σ_T, σ_R and σ_P for measured apparent sound power level are described by IEC/TS 61400-14, where σ_T is the total standard deviation, σ_P is the standard deviation for product variation and σ_R is the standard deviation for test reproducibility.

Assuming $\sigma_R < 0.8$ dB and $\sigma_P < 0.8$ dB as typical values leads to a calculated $K < 2$ dB for 95 % confidence level.

4 Tonal Audibility

The tonal audibility ($\Delta L_{a,k}$), when measured in accordance with the IEC 61400-11 standard, for the GE's 1.6-100 with LNTE is less than or equal to 2 dB.

5 IEC 61400-11 and IEC/TS 61400-14 Terminology

- $L_{WA,K}$ is wind turbine apparent sound power level (referenced to 10^{-12}W) measured with A-weighting as function of reference wind speed v_{10m}. Derived from multiple measurement reports per IEC 61400-11, it is considered as a mean value
- σ_P is the product variation i.e. the 1.6-100 with LNTE unit-to-unit product variation; typically < 0.8 dB
- σ_R is the overall measurement testing reproducibility as defined per IEC 61400-11; typically < 0.8 dB with adequate measurement conditions and sufficient amount of data samples
- σ_T is the total standard deviation combining both σ_P and σ_R
- **$K = 1.645\ \sigma_T$** is defined per IEC/TS 61400-14 for 95 % confidence level
- R_0 is the ground measuring distance from the wind turbine tower axis per IEC 61400-11, which shall equal the hub height plus half the rotor diameter
- $\Delta L_{a,k}$ is the tonal audibility according to IEC 61400-11, described as potentially audible narrow band sound

6 1/3rd Octave Band Spectra

The tables in Annex I are showing the 1/3rd octave band values for different hub heights in different wind speeds.

Reference:

- IEC 61400-1. Wind turbines – part 1: Design requirements. ed. 2. 1999
- IEC 61400-11, wind turbine generator systems part 11: Acoustic noise measurement techniques, ed. 2.1, 2006-11
- IEC/TS 61400-14, Wind turbines – part 14: Declaration of apparent sound power level and tonality values, ed. 1, 2005-03
- MNPT – Machine Noise Performance Test, Technical documentation, GE 2011

Appendix I - Calculated 1/3rd Octave Band Apparent Sound Power Level $L_{WA,k}$

1.6-100 with LNTE - Normal Operation 1/3rd Octave Band Spectra									
Standard wind speed at 10 m [m/s]		3	4	5	6	7	8	9	10-Cutout
Hub height wind speed at 80 m [m/s]		4.2	5.6	7.0	8.4	9.7	11.1	12.5	14-Cutout
Frequency (Hz)	25	52.2	52.1	55.8	59.7	63.0	63.2	63.1	62.9
	32	56.6	56.4	60.2	64.2	67.5	67.7	67.7	67.5
	40	60.6	60.3	64.2	68.3	71.6	71.9	71.8	71.7
	50	63.7	63.5	67.4	71.6	75.0	75.2	75.2	75.0
	63	66.5	66.2	70.3	74.6	78.1	78.3	78.3	78.2
	80	69.7	69.5	73.6	78.0	81.8	82.0	81.9	81.8
	100	72.3	72.2	76.5	81.0	84.8	84.9	84.9	84.7
	125	74.1	74.2	78.7	83.3	86.6	86.9	86.9	86.8
	160	75.6	76.1	80.8	85.6	88.3	88.5	88.6	88.5
	200	77.5	78.1	83.0	87.9	89.7	89.9	90.0	90.0
	250	79.5	80.1	85.0	90.2	91.0	90.9	91.0	91.1
	315	80.3	80.7	85.6	91.0	91.1	90.8	90.8	91.0
	400	80.7	80.6	85.4	91.1	91.5	91.0	91.0	91.2
	500	81.0	80.4	85.1	91.0	92.4	91.9	91.9	92.2
	630	80.3	79.4	84.0	89.9	92.9	92.6	92.7	93.0
	800	79.0	78.0	82.3	87.8	92.6	92.6	92.7	93.0
	1000	78.4	77.9	81.7	86.4	92.3	92.7	92.8	93.0
	1250	78.5	78.7	82.4	86.6	92.1	92.8	92.9	93.0
	1600	77.9	78.7	82.8	87.0	91.4	91.9	91.9	91.6
	2000	77.0	78.8	83.3	87.8	91.1	91.0	90.6	90.2
	2500	75.7	78.5	83.4	88.1	90.4	89.7	89.1	88.6
	3150	73.2	76.1	81.8	86.9	88.1	87.2	86.7	86.1
	4000	69.1	71.7	77.7	83.5	83.6	83.5	82.5	82.2
	5000	63.7	65.4	72.0	78.0	78.0	78.2	76.7	76.7
	6300	55.3	57.3	63.3	70.0	70.1	70.2	69.1	68.7
	8000	42.6	45.5	51.0	57.4	58.6	58.8	57.9	57.4
	10000	27.1	31.3	36.5	42.5	44.6	44.4	44.4	44.4
	12500	7.9	13.2	18.9	24.6	27.2	26.6	27.4	29.0
	16000	-19.0	-13.2	-6.1	-0.3	1.9	1.8	4.0	6.3
	20000	-47.8	-42.5	-34.1	-26.9	-25.9	-24.6	-21.8	-19.1
Total apparent sound power level $L_{WA,k}$ [dB]		90.4	90.7	95.3	100.5	103.0	103.0	103.0	103.0

Table 3: Calculated Apparent 1/3rd Octave Band Sound Power Level (A-weighted) 1.6-100 with LNTE with 80 m hub height as Function of Wind Speed v_{10m}

1.6-100 with LNTE - Normal Operation 1/3rd Octave Band Spectra									
Standard wind speed at 10 m [m/s]		3	4	5	6	7	8	9	10-Cutout
Hub height wind speed at 96 m [m/s]		4.3	5.7	7.1	8.6	10.0	11.4	12.8	14-Cutout
Frequency (Hz)	25	52.1	52.2	56.4	60.2	63.2	63.2	63.1	62.9
	32	56.6	56.5	60.7	64.7	67.7	67.7	67.6	67.5
	40	60.6	60.5	64.7	68.8	71.8	71.9	71.8	71.7
	50	63.7	63.6	67.9	72.1	75.2	75.2	75.2	75.0
	63	66.5	66.4	70.8	75.1	78.3	78.3	78.3	78.2
	80	69.7	69.7	74.2	78.6	81.9	81.9	81.9	81.8
	100	72.3	72.4	77.0	81.5	84.9	84.9	84.9	84.7
	125	74.0	74.5	79.3	83.8	86.7	86.9	86.9	86.8
	160	75.6	76.4	81.4	86.1	88.3	88.5	88.6	88.5
	200	77.5	78.5	83.6	88.4	89.7	89.9	90.0	90.0
	250	79.5	80.4	85.6	90.6	90.9	90.9	91.1	91.1
	315	80.3	81.0	86.2	91.4	90.9	90.8	90.9	91.0
	400	80.7	80.8	86.1	91.5	91.2	90.9	91.1	91.2
	500	80.9	80.5	85.8	91.5	92.1	91.8	92.0	92.2
	630	80.3	79.4	84.7	90.5	92.7	92.6	92.8	93.0
	800	78.9	78.1	82.9	88.5	92.5	92.5	92.8	93.0
	1000	78.3	78.1	82.2	87.2	92.5	92.6	92.9	93.0
	1250	78.5	78.8	82.9	87.2	92.4	92.8	93.0	93.0
	1600	77.9	78.9	83.3	87.5	91.6	91.9	91.9	91.6
	2000	77.1	79.1	83.9	88.3	91.1	90.9	90.6	90.2
	2500	75.9	78.8	84.0	88.6	90.3	89.6	89.0	88.6
	3150	73.4	76.5	82.4	87.3	87.9	87.0	86.6	86.1
	4000	69.2	72.2	78.4	83.8	83.7	83.2	82.5	82.2
	5000	63.8	65.9	72.8	78.3	78.4	77.5	76.8	76.7
	6300	55.4	57.6	64.1	70.4	70.8	69.4	69.0	68.7
	8000	42.9	45.8	51.8	57.9	59.1	58.4	57.7	57.4
	10000	27.5	31.6	37.2	43.0	44.9	44.1	44.4	44.4
	12500	8.4	13.6	19.5	25.2	27.3	26.4	27.8	29.0
	16000	-18.5	-12.7	-5.4	0.2	1.8	2.0	4.6	6.3
	20000	-47.5	-41.9	-33.2	-26.3	-26.0	-24.1	-21.1	-19.1
Total apparent sound power level $L_{WA,k}$ [dB]		90.4	90.9	96.0	101.0	103.0	103.0	103.0	103.0

Table 4: Calculated Apparent 1/3rd Octave Band Sound Power Level (A-weighted), 1.6-100 with LNTE with 96 m hub height as Function of Wind Speed v_{10m}

SWT-2.3-113, Rev. 1, Max. Power 1824 kW Contract Acoustic Emission, Hub Height 99.5 m Ontario - Canada

Sound Power Levels

The warranted sound power level is presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (LWA) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Up to cut-out**
Max. Power 1824kW	96.0	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 1: Acoustic emission, L_{WA} [dB(A) re 1 pW]

Typical Sound Power Frequency Distribution

Typical spectra for L_{WA} in dB(A) re 1pW for the corresponding centre frequencies are tabulated below for 6 - 10 m/s referenced to a height of 10.0 m above ground level.

	Wind Speed (m/s)				
Octave band, centre frequency [Hz]	**6**	**7**	**8**	**9**	**10**
63	83.9	83.3	82.7	82.8	82.5
125	89.4	88.2	87.3	86.8	85.9
250	94.0	93.1	92.8	92.2	91.4
500	92.1	92.4	92.9	92.7	92.4
1000	94.1	94.5	94.1	94.0	94.3
2000	92.9	93.2	93.3	93.5	94.0
4000	83.5	86.2	88.2	90.1	90.3
8000	66.7	69.9	72.1	72.1	72.0

Table 2: Typical octave bands for 6-10 m/s, L_{WA} [dB(A) re 1 pW]

Tonality

Typical tonal audibility for the Siemens wind turbine generators has not exceeded 2 dB as determined in accordance with IEC 61400-11:2002.

Measurement Uncertainty

A measurement uncertainty range of -1.5dB(A) to +1.5dB(A) is applicable.

SWT-2.3-113, Rev. 1, Max. Power 1903 kW Contract Acoustic Emission, Hub Height 99.5 m Ontario - Canada

Sound Power Levels

The warranted sound power level is presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (LWA) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	4	5	6	7	8	9	10	11	12	Up to cut-out
Max. Power 1903kW	96.2	100.4	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0

Table 1: Acoustic emission, L_{WA} [dB(A) re 1 pW]

Typical Sound Power Frequency Distribution

Typical spectra for L_{WA} in dB(A) re 1pW for the corresponding centre frequencies are tabulated below for 6 - 10 m/s referenced to a height of 10.0 m above ground level.

	Wind Speed (m/s)				
Octave band, centre frequency [Hz]	6	7	8	9	10
63	84.1	83.5	82.9	83.0	82.7
125	89.8	88.6	87.7	87.2	86.3
250	95.2	94.4	94.0	93.4	92.6
500	93.6	93.9	94.2	94.0	93.7
1000	95.0	95.4	95.1	95.0	95.3
2000	93.6	94.0	94.3	94.5	95.0
4000	83.6	86.7	88.8	90.7	90.8
8000	66.7	70.3	72.6	72.6	72.5

Table 2: Typical octave bands for 6-10 m/s, L_{WA} [dB(A) re 1 pW]

Tonality

Typical tonal audibility for the Siemens wind turbine generators has not exceeded 2 dB as determined in accordance with IEC 61400-11:2002.

Measurement Uncertainty

A measurement uncertainty range of -1.5dB(A) to +1.5dB(A) is applicable.

SWT-2.3-113, Rev. 1, Max. Power 2030 kW Contract Acoustic Emission, Hub Height 99.5 m Ontario - Canada

Sound Power Levels

The warranted sound power level is presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (LWA) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Up to cut-out**
Max. Power 2030kW	96.4	101.3	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0

Table 1: Acoustic emission, L_{WA} [dB(A) re 1 pW]

Typical Sound Power Frequency Distribution

Typical spectra for L_{WA} in dB(A) re 1pW for the corresponding centre frequencies are tabulated below for 6 - 10 m/s referenced to a height of 10.0 m above ground level.

	Wind Speed (m/s)				
Octave band, centre frequency [Hz]	**6**	**7**	**8**	**9**	**10**
63	84.3	83.6	83.1	83.2	82.9
125	90.2	89.0	88.1	87.6	86.7
250	96.4	95.5	95.1	94.5	93.8
500	95.2	95.5	95.5	95.3	95.1
1000	96.0	96.3	96.1	96.0	96.3
2000	94.4	94.7	95.2	95.4	95.9
4000	83.8	87.0	89.3	91.2	91.4
8000	66.9	70.7	73.1	73.1	73.0

Table 2: Typical octave bands for 6-10 m/s, L_{WA} [dB(A) re 1 pW]

Tonality

Typical tonal audibility for the Siemens wind turbine generators has not exceeded 2 dB as determined in accordance with IEC 61400-11:2002.

Measurement Uncertainty

A measurement uncertainty range of -1.5dB(A) to +1.5dB(A) is applicable.

SWT-2.3-113, Rev. 1, Max. Power 2126 kW Contract Acoustic Emission, Hub Height 99.5 m Ontario - Canada

Sound Power Levels

The warranted sound power level is presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (LWA) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Up to cut-out**
Max. Power 2126kW	96.5	102.3	103.0	103.0	103.0	103.0	103.0	103.0	103.0	103.0

Table 1: Acoustic emission, L_{WA} [dB(A) re 1 pW]

Typical Sound Power Frequency Distribution

Typical spectra for L_{WA} in dB(A) re 1pW for the corresponding centre frequencies are tabulated below for 6 - 10 m/s referenced to a height of 10.0 m above ground level.

	Wind Speed (m/s)				
Octave band, centre frequency [Hz]	**6**	**7**	**8**	**9**	**10**
63	84.6	83.9	83.3	83.4	83.2
125	90.6	89.3	88.5	88.0	87.2
250	97.0	96.3	96.3	95.7	95.0
500	96.7	96.9	97.0	96.9	96.6
1000	97.4	97.7	97.0	97.0	97.3
2000	95.0	95.2	96.0	96.2	96.8
4000	84.0	87.0	89.3	91.2	91.4
8000	66.3	70.4	73.0	73.1	73.0

Table 2: Typical octave bands for 6-10 m/s, L_{WA} [dB(A) re 1 pW]

Tonality

Typical tonal audibility for the Siemens wind turbine generators has not exceeded 2 dB as determined in accordance with IEC 61400-11:2002.

Measurement Uncertainty

A measurement uncertainty range of -1.5dB(A) to +1.5dB(A) is applicable.

SWT-2.3-113, Rev. 1, Max. Power 2221 kW Contract Acoustic Emission, Hub Height 99.5 m Ontario - Canada

Sound Power Levels

The warranted sound power level is presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (LWA) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Up to cut-out**
Max. Power 2221kW	96.6	102.6	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0

Table 1: Acoustic emission, L_{WA} [dB(A) re 1 pW]

Typical Sound Power Frequency Distribution

Typical spectra for L_{WA} in dB(A) re 1pW for the corresponding centre frequencies are tabulated below for 6 - 10 m/s referenced to a height of 10.0 m above ground level.

	Wind Speed (m/s)				
Octave band, centre frequency [Hz]	**6**	**7**	**8**	**9**	**10**
63	84.8	83.6	83.5	83.7	83.4
125	90.9	91.3	88.8	88.3	87.5
250	97.6	97.7	97.2	96.7	95.9
500	98.2	98.0	97.8	97.7	97.4
1000	98.8	98.7	98.0	98.0	98.3
2000	95.6	95.4	97.1	97.4	97.9
4000	84.1	87.8	90.8	92.7	92.9
8000	65.6	71.2	74.5	74.6	74.5

Table 2: Typical octave bands for 6-10 m/s, L_{WA} [dB(A) re 1 pW]

Tonality

Typical tonal audibility for the Siemens wind turbine generators has not exceeded 2 dB as determined in accordance with IEC 61400-11:2002.

Measurement Uncertainty

A measurement uncertainty range of -1.5dB(A) to +1.5dB(A) is applicable.

SWT-2.3-113, Rev. 1, Max. Power 2300 kW Contract Acoustic Emission, Hub Height 99.5 m Ontario - Canada

Sound Power Levels

The warranted sound power level is presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (LWA) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Up to cut-out**
Max. Power 2300kW	96.6	102.6	104.4	105.0	105.0	105.0	105.0	105.0	105.0	105.0

Table 1: Acoustic emission, L_{WA} [dB(A) re 1 pW]

Typical Sound Power Frequency Distribution

Typical spectra for L_{WA} in dB(A) re 1pW for the corresponding centre frequencies are tabulated below for 6 - 10 m/s referenced to a height of 10.0 m above ground level.

	Wind Speed (m/s)				
Octave band, centre frequency [Hz]	**6**	**7**	**8**	**9**	**10**
63	85.0	84.6	83.7	83.9	83.6
125	91.3	92.4	89.2	88.7	87.9
250	96.8	97.6	98.4	97.8	97.1
500	98.9	99.4	99.3	99.2	98.9
1000	99.7	100.3	98.9	98.9	99.2
2000	95.3	95.9	97.9	98.2	98.7
4000	84.9	86.1	90.8	92.7	93.0
8000	67.4	68.1	74.4	74.5	74.4

Table 2: Typical octave bands for 6-10 m/s, L_{WA} [dB(A) re 1 pW]

Tonality

Typical tonal audibility for the Siemens wind turbine generators has not exceeded 2 dB as determined in accordance with IEC 61400-11:2002.

Measurement Uncertainty

A measurement uncertainty range of -1.5dB(A) to +1.5dB(A) is applicable.

Extract I of test report

Master Information „Noise", according to "Wind turbine generator systems - Part 11: Acoustic noise measurement techniques."

IEC 61400-11 ED. 2 from 2002 (published by: Central Office of the IEC, Geneva, Switzerland)

Extract of test report WICO 439SEC04/07 regarding noise emission of wind turbine (WT) type ENERCON E-48 (Mode I), hub height 75.6 m

General			Technical specifications (manufacturer)	
Manufacturer:	**ENERCON GmbH** **Dreekamp 5** **D-26605 AURICH**		**Rated power (generator):**	**800 kW**
			Rotor diameter:	**48,0 m**
			Hub height above ground:	**75,6 m**
Serial number:	**48087**		**Kon. Stahlrohr**	**Tubular steel tower**
WT-location:	**WP Holtriem**	**RW 25.95.228** **HW 59.42.988**	**Pitch**	**pitch/stall/active-stall**

Complementations of rotor (manufacturer)		Complementations of gear and generator (manufacturer)	
Manufacturer of rotor blades	**ENERCON GmbH**	**Manufacturer of gear:**	**No**
Type of blades:	**E48/1**	**Type of gear:**	**No**
Pitch angle:	**variabel**	**Manufacturer of generator:**	**ENERCON GmbH**
Number of blades	**3**	**Type of generator:**	**E-48**
Rated speed(s)/speed range:	**16 – 29,5 rpm (Mode I)**	**Rated speed(s):**	**16 – 29,5 rpm (Mode I)**

Report power curve: calculated power curve, date: 31.08.2004

	Reference		Noise emission parameter	Remarks
	Standardized wind speed at 10 m above ground	Electric power		
Sound power level L_{WA}	*5 ms^{-1}*	*182 kW*	*94.0* dB(A)*	*(1)*
	6 ms^{-1}	315 kW	97.8 dB(A)	
	7 ms^{-1}	499 kW	100.3 dB(A)	
	8 ms^{-1}	671 kW	101.4 dB(A)	
	8.9 ms^{-1}	*760 kW*	*101.9 dB(A)*	*(2)*
	9 ms^{-1}	765 kW	102.0 dB(A)	
	9.6 ms^{-1}	*794 kW*	*102.1 dB(A)*	*(3)*
	10 ms^{-1}	800 kW	101.9 dB(A)	(4)
Tonal components ΔL_a (near proximity)	*5 ms^{-1}*	*182 kW*	No tone	*(1)*
	6 ms^{-1}	315 kW	No tone	
	7 ms^{-1}	499 kW	No tone	
	8 ms^{-1}	671 kW	No tone	
	8.9 ms^{-1}	*760 kW*	No tone	*(2)*
	9 ms^{-1}	765 kW	*No tone*	
	9.6 ms^{-1}	*794 kW*	No tone	*(3)*
	10 ms^{-1}	800 kW	*No tone*	(4)

One third octave sound power level at reference point v_{10} = 5 m/s [dB(A)]

Frequency	50	63	80	100	125	160	200	250	315	400	500	630
L_{WA}	67.6	71.2	72.9	74.5	78.0	77.0	79.3	84.2	85.6	84.6	84.2	84.4
L_{WA}		75.8			81.5			88.5			89.2	
Frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
L_{WA}	82.6	82.0	81.4	79.2	78.5	76.6	75.2	74.8	73.1	72.4	70.9	67.4
L_{WA}		86.8			83.0			79.2			75.5	

One third octave sound power level at reference point v_{10} = 6 m/s [dB(A)]

Frequency	50	63	80	100	125	160	200	250	315	400	500	630
L_{WA}	71.7	74.2	76.9	77.6	78.8	79.7	80.6	86.1	87.8	87.4	87.4	89.0
L_{WA}		79.5			83.6			90.5			92.8	
Frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
L_{WA}	88.3	88.1	86.9	84.0	82.4	80.9	79.4	79.0	78.1	77.3	74.9	72.9
L_{WA}		92.6			87.4			83.6			80.2	

One third octave sound power level at reference point v_{10} = 7 m/s [dB(A)]												
Frequency	50	63	80	100	125	160	200	250	315	400	500	630
L_{WA}	72.7	76.1	79.3	80.5	80.9	82.9	84.3	89.2	91.2	90.7	90.5	91.5
L_{WA}		81.6			86.3			93.8			95.7	
Frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
L_{WA}	90.2	89.7	87.9	85.5	84.1	82.6	81.7	81.6	80.7	80.2	79.2	76.3
L_{WA}		94.1			89.0			86.1			83.6	

One third octave sound power level at reference point v_{10} = 8 m/s [dB(A)]												
Frequency	50	63	80	100	125	160	200	250	315	400	500	630
L_{WA}	70.1	74.3	77.3	79.0	81.7	82.3	84.4	90.5	92.7	92.0	91.9	92.9
L_{WA}		79.6			86.0			95.1			97.1	
Frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
L_{WA}	91.7	90.9	89.1	86.0	83.9	82.1	80.9	81.6	80.6	79.7	79.2	77.3
L_{WA}		95.5			89.1			85.8			83.6	

One third octave sound power level at reference point v_{10} = 9 m/s [dB(A)]												
Frequency	50	63	80	100	125	160	200	250	315	400	500	630
L_{WA}	71.8	74.5	77.1	79.4	82.6	84.2	86.6	91.5	93.5	92.6	92.3	93.1
L_{WA}		79.8			87.3			96.1			97.5	
Frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
L_{WA}	91.4	90.5	88.7	86.2	85.0	84.3	83.9	84.4	83.9	83.7	82.5	80.1
L_{WA}		95.1			90.0			88.8			87.1	

One third octave sound power level at reference point v_{10} = 9.6 m/s [dB(A)]												
Frequency	50	63	80	100	125	160	200	250	315	400	500	630
L_{WA}	69.9	73.9	75.9	77.4	80.2	80.7	83.4	88.3	91.0	90.8	91.5	93.4
L_{WA}		78.6			84.4			93.3			96.8	
Frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
L_{WA}	93.2	93.6	92.6	89.9	87.4	85.0	83.2	83.3	82.0	81.1	79.9	77.8
L_{WA}		97.9			92.7			87.6			84.6	

(1) Because of the signal to noise ratio laying in between 3 dB to 6 dB the sound pressure level was corrected with 1.3 dB.
(2) Sound power level at 95% of the rated power.
(3) Wind speed at the maximum sound pressure level minute measured.
(4) One value was measured in the wind bin of 10 ms^{-1}.

This extract of test report is valid only in connection with the enclosed „Manufacturer's certificate" from 2004-08-31.

This declaration does not replace above-mentioned report.

measured by: WIND-consult GmbH
Reuterstraße 9
D-18211 Bargeshagen

- pdf - document was signed electronically -

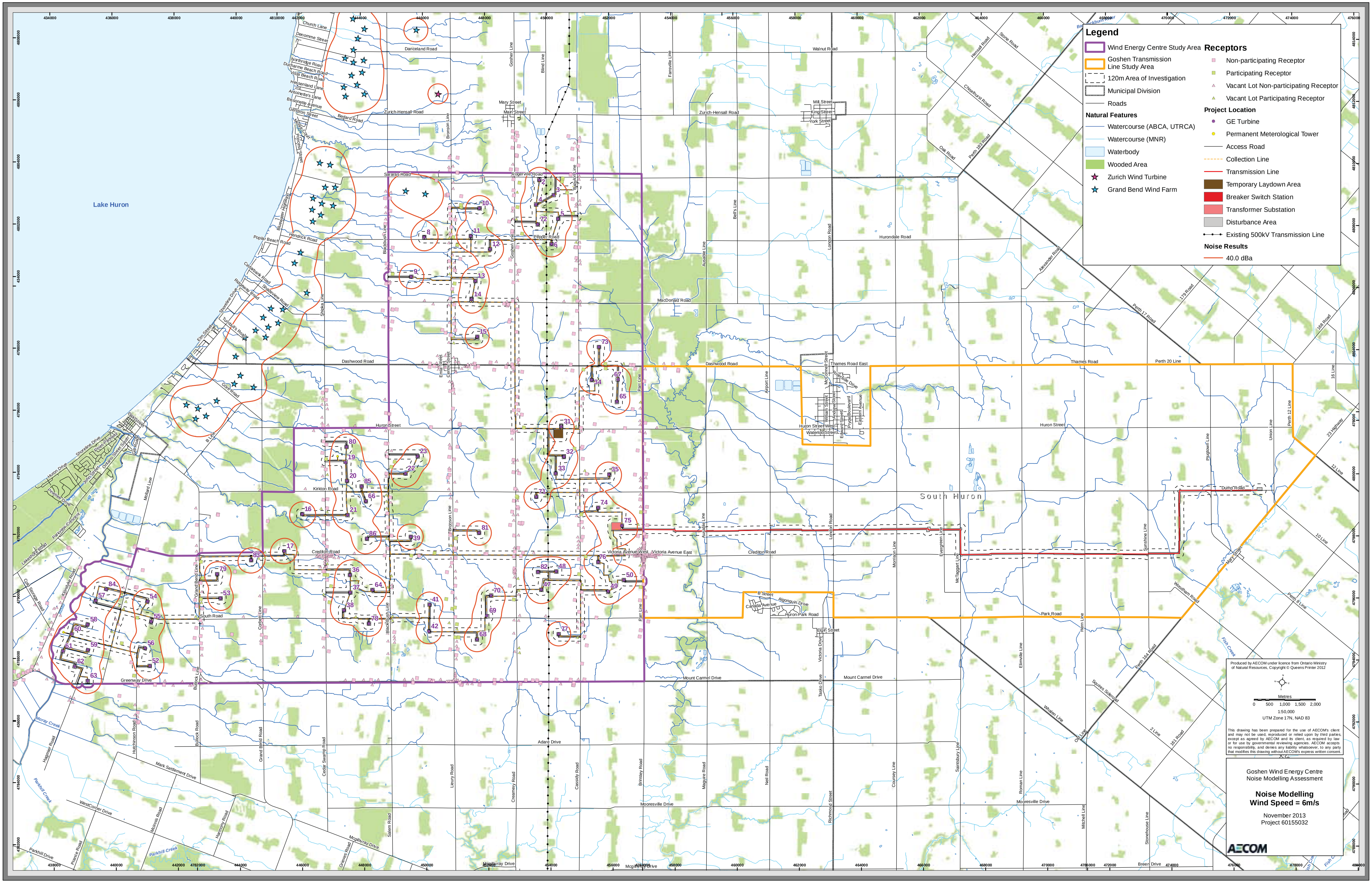
date: 2006-01-24

Dipl.-Ing. A. Petersen   Dipl.-Ing. W. Wilke

Appendix C

Noise Contour Maps

Noise contours calculated at 4.5 metres above grade



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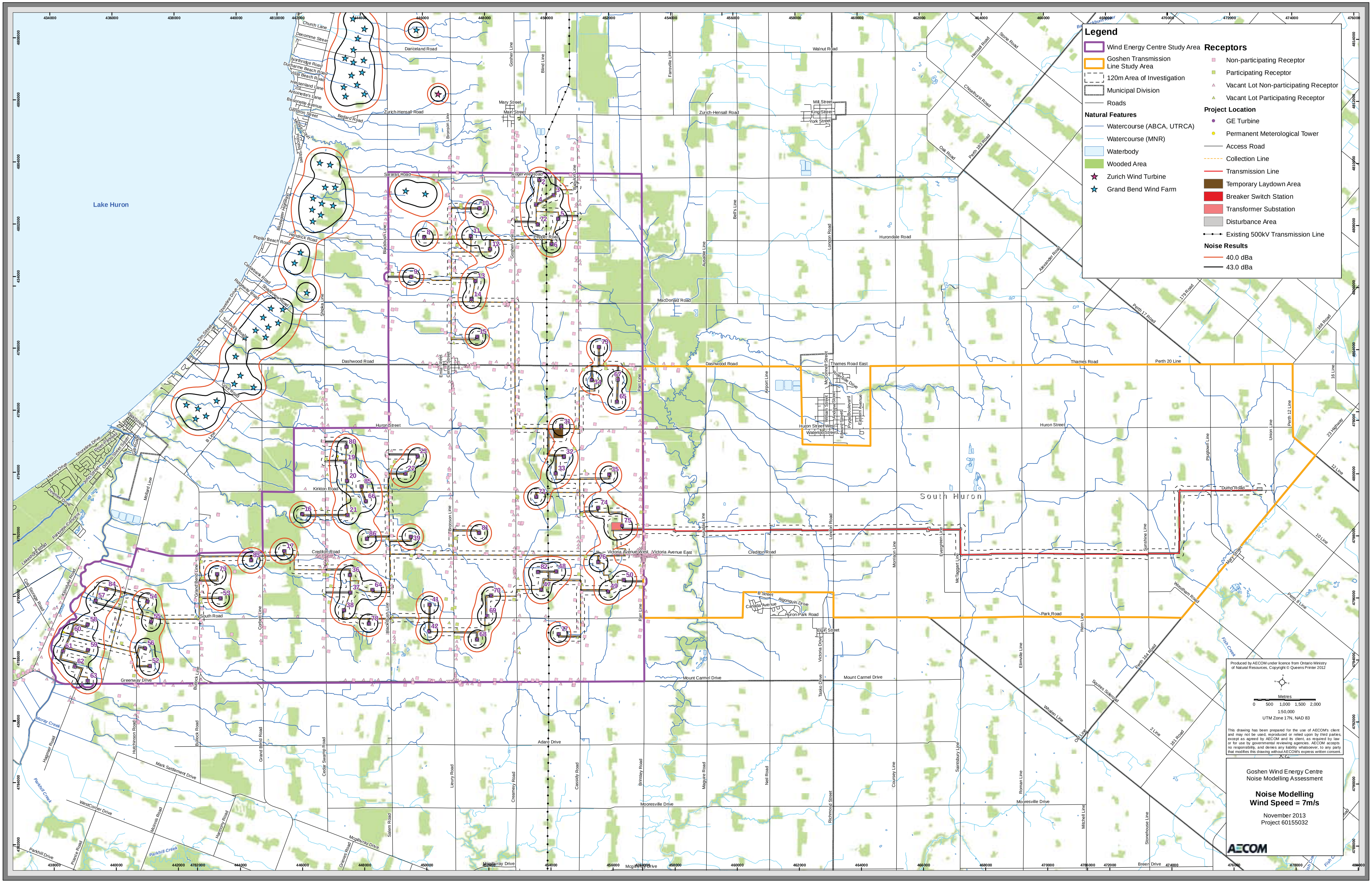

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