NANTICOKE WIND FARM PUBLIC MEETING

Comment Form

■ Jarvis Community Centre ■ Jarvis, ON ■ Monday, December 21, 2009 ■

We are collecting this information to help us understand and address your concerns. **Your comments will be considered.** *All comments will become part of the public record, with the exception of personal information (names, addresses, emails).*

1. Did this Public Meeting meet your information needs?
   - O Yes
   - O Somewhat
   - O No

   Please explain: ____________________

   ____

2. If you asked questions during the Public Meeting, did you get a satisfactory response?
   - O Yes
   - O Didn't speak to anyone
   - O Somewhat
   - O No

   Please explain: ____________________

   ____

3. After attending the Public Meeting, how do you feel about the Project?
   - O Support
   - O Neutral
   - O Oppose

   Please explain: ____________________

   ____

4. Are you satisfied with the level of assessment completed?
   - O Yes
   - O Somewhat
   - O No

   Please explain: ____________________

   ____

5. Please provide your comments or questions in the space provided below:

____

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6. If you would like to be kept informed about the status of the Project, please provide us with your contact information below.

Name: _______________________________

Place of Primary Residence: _______________________________

Address: _______________ Telephone Number(s): _______________

City/Province: _______________________________

Postal Code: _______________ E-mail: _______________

To learn more about the Project, or if you prefer to send your comment sheet to us, please contact:

Mark Gallagher, Project Manager
TCI Renewables
Suite 102, 381 Rue Notre-Dame W.,
Montreal, QC H2Y 1V2

Toll Free: 1-888-842-1923
Fax: (514) 842-7904
Email: nanticoke@tcir.net

Website: www.nanticokewindfarm.ca
www.CanadianWindProposals.com

Your feedback is very important to us.
We appreciate the time you took to fill out this comment form.

Thank You for joining us at the
Nanticoke Wind Farm Public Meeting

Public Meeting 1 Attendee List Available Upon Request

REPORT

A world of capabilities delivered locally

November 18, 2009

AET NANTICOKE WIND FACILITY

Draft Project Description Report

Submitted to:
Director
Environmental Approvals Branch

Report Number: 0911126066

Distribution:

Golder Associates Ltd.- 2 copies
Air Energy TCI Inc- 2 copies
Director- 1 copy

Golder Associates

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1.0 INTRODUCTION

This document has been written to advise federal and provincial agencies, local government, the public, First Nation communities and other Aboriginal groups of the proposed Nanticoke Wind Facility (the Project). The Project is a Class 4 wind facility with a generation capacity of up to 199 MW. The applicant proposing the Project is Air Energy TCI Inc. (AET). The Project is to be situated entirely on private lands and Country road easements in the vicinity of the community of Nanticoke, Haldimand County, Ontario (Figure 1). The physical components of the Project are also to be situated within the boundaries identified on Figure 1.

In late September 2008 a "Notice of Commencement of an Environmental Screening for the Proposed Nanticoke Wind Farm" (NOC) was published in four local newspapers by AET and circulated to the appropriate agencies, local government, the public, stakeholders and First Nations within or near the Project area. A Project Description, based on the design at that time, was also circulated to selected stakeholders. The NOC and Project Description distributed in 2008 were intended to meet the requirements of Ontario Regulation 116/01 of the *Environmental Assessment Act* (MOE, 2007; Government of Ontario, 1990).

Since the commencement of the Project under O. Reg. 116/01, the Project has increased in scope and regulatory requirements have changed significantly as a result of the passing of the *Green Energy and Green Economy Act* and O. Reg. 359/09 (Government of Ontario, 2009 ;MOE, 2009). The passing of this legislation means that the Project is now subject to revised environmental assessment (EA) process, and must adhere to the requirements of Regulation 359/09 of the *Environmental Protection Act.* Under Regulation 359/09, the applicant (AET) will be required to submit an Application for a Renewable Energy Approval and receive a Renewable Energy Approval for the Project from the Director of the Environmental Approvals Branch.

A Project area map depicting the outer boundary of the expanded Project area (relative to the former NOC and Project description) is provided in Figure 1. The geographic boundaries of the Project area have been established to allow for the selection of the most appropriate and least constraining locations for the wind turbines and associated infrastructure, while allowing for some flexibility in site selection in consideration of constraints or opportunities that may be identified.

2.0 PROJECT PROPONENT

The name of the Project is the Nanticoke Wind Farm, hereinafter referred to as “the Project”. The Project is being proposed directly by Air Energy TCI Inc. (AET), the licensed business name of the Project proponent in Canada. AET was established in 2006 as a subsidiary company of TCI Renewables Limited (TCI) a UK registered company, specifically to develop and promote North American projects. AET is a registered Canadian company (Registration Number: 4296508) with the North American head office located in Montreal, QC. AET is commonly known and trades as TCI Renewables in the North American marketplace. The first ‘TCI Group’ company, was created in 1996 specifically to integrate technology with the built environment. From its origins in mobile telecommunications network deployment, the the ‘TCI Group’ has developed expertise spanning several industries including the rapidly expanding renewable energy sector with the creation of TCI Renewables Limited in 2005. TCI Renewables is active in developing wind energy projects in Europe and through AET in North American. More information on the company is available at www.tci.net. The AET contact for the Project is:

Mark Gallagher, Development Manager

Air Energy TCI Inc.

381 Rue Notre-Dame (Ouest), Montreal, QC H2Y 1V2

Toll Free Phone: 1-888-842-1923

Fax: (514) 842-7904

Email: mark.gallagher@tcir.net

2.1 Proponent Renewable Energy Approval (REA) Team

AET has retained Golder Associates Ltd. (Golder) to conduct the EA and produce a Renewable Energy Approval Application. Contact information for the Golder Project Manager is:

Jeff Wright

Senior Biologist, Project Manager

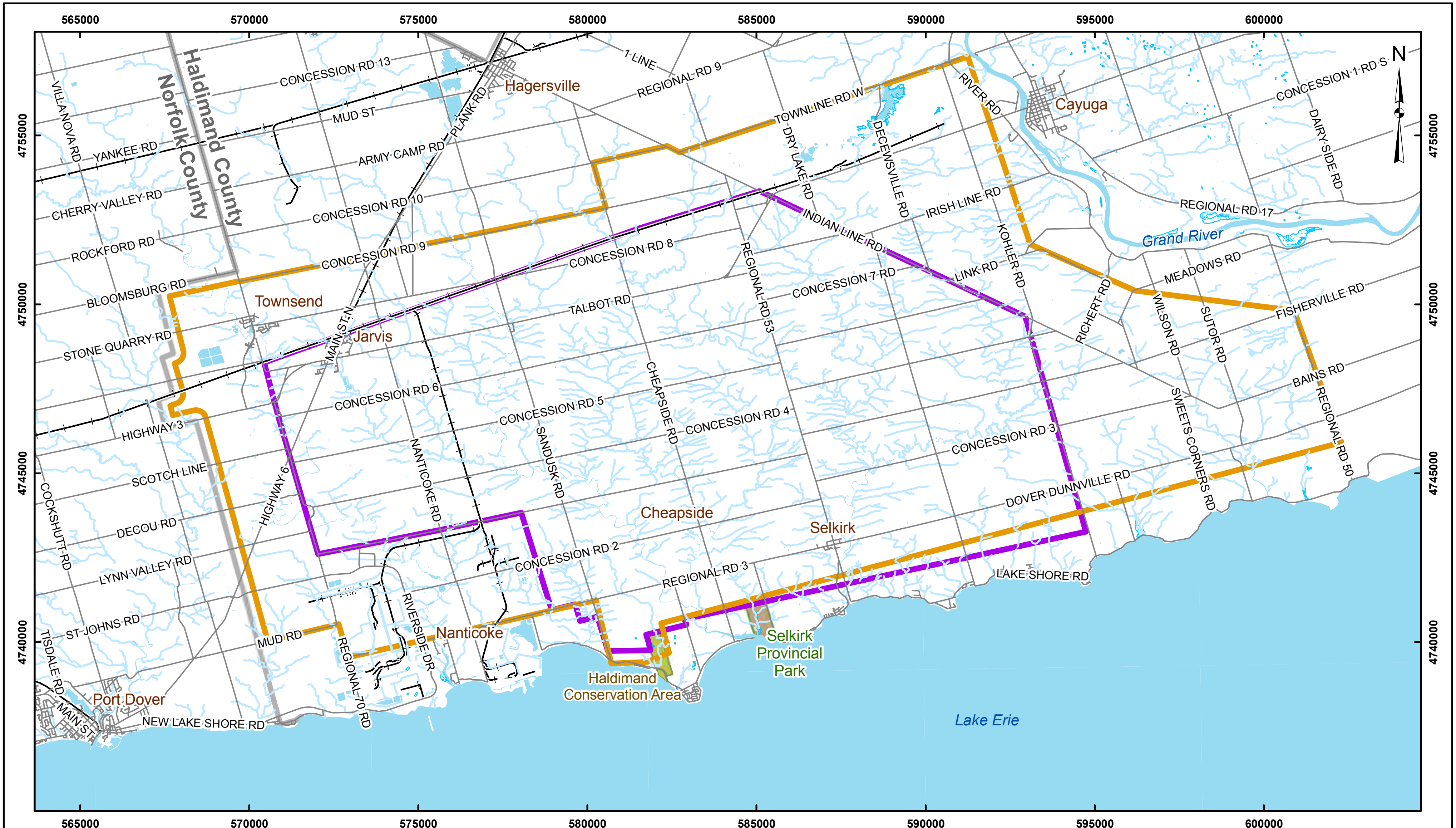
Golder Associates Ltd.

2390 Argentia Road

Mississauga, Ontario L5N 5Z7

Phone: (905) 567-4444 Fax: (905) 567-6561

E-mail: jawright@golder.com



LEGEND

- Road
- Watercourse
- Railway
- Project Area
- Old Project Area
- Water Area, Permanent
- Wetland, Permanent
- Provincial Park
- Haldimand Conservation Area
- Municipal Boundary

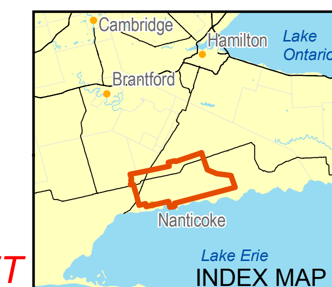
0 1 2 4 6 8 10

SCALE 1:160,000 KILOMETERS

REFERENCE

Base Data - MNR NRVIS, obtained 2004, CANMAP v2008.4
Haldimand Conservation Boundary provided by Long Point Region Conservation Authority
Constraints data - TCIR
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 17

DRAFT



INDEX MAP

PROJECT

NANTICOKE WIND POWER GENERATION PROJECT

tci renewables

TITLE

PROJECT AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-6066			SCALE AS SHOWN	REV. 0.0
DESIGN	PP	6 Oct. 2009	FIGURE: 1	
GIS	PP	20 Nov. 2009		
CHECK				
REVIEW				

G:\Projects\2008\08-1112-0141_AirEnergyTCIWindPowerGenerationProject-Nanticoke\GIS\MXDs\Draft\ProjectLayoutProjectDescription.mxd

3.0 PROJECT OVERVIEW AND HISTORY

The proposed Project is a wind facility to be located in the vicinity of the community of Nanticoke, Haldimand County (west of the town of Selkirk), Ontario.

The proposed Project was first prospected by AET in 2006 as a potential 10 MW Standard Offer Site, but distribution grid (<50kV) constraints halted development, and it was decided to consider the possibility of a larger project connecting to transmission voltage lines (>50kV). Work to option land within the Project area commenced in early 2008. Meteorological data was collected from two sites using 60 m tall meteorological towers; which will remain in operation and continue to monitor meteorological conditions.

The public, stakeholders and First nations were formally introduced to the Project with the issue and advertisement of a NOC, as originally required under Regulation 116/01, in early October 2008. Introduction letters and a copy of the NOC were also sent to residents situated in selected postal codes in the vicinity of the Project and to First Nations communities that were identified as having a possible interest in the Project.

The Project was also introduced to the general public at an energy symposium organised by MPP Toby Barrett in November 2008 at the Jarvis Community Hall (Photo 1 and 2). The event attracted over 250 people from the local community who came to learn about the various energy options for the Nanticoke and wider area. More public information events will be held in the coming months.

Since November 2008, AET has made considerable progress with the Project layout and design, and on consultation with County officials and certain stakeholders. At present, the proposed Project nameplate capacity will be a maximum of 199 MW generated by large scale commercial wind turbines in the 1.5MW – 2.5MW class. The make and model of the turbine are undecided at this time as there are certain on-site conditions, availability/supply and local content requirements that need to be considered. Once these are resolved the design and number of turbines will be finalized and presented during consultation and engagement processes. The total number of turbines will be dependent on the individual MW generation capacity of each turbine.

Following construction, the Project infrastructure and components that are expected to be in place during the period of operation will consist of the wind turbines and associated transformers, a permanent anemometer mast, access roads and gates, a site control room and substation, electrical cabling, site signage (for safety and information), and all ancillary works. Site access will require both temporary and permanent gravel access roads. During construction, short term hauling of oversized loads will be required to transport the turbine components to the site. At this time in the Project design process, the number of watercourse or cable crossings is unknown, though it is anticipated that upgrades to existing watercourse crossings and/or new watercourse or cable crossings may be required.

Photo 1: MPP Toby Barrett addresses attendees at "Nanticoke Energy Symposium", November 2008

Photo 2: AET staff engage with local community at Nanticoke Energy Symposium

4.0 RENEWABLE ENERGY INCENTIVE PROGRAMS

As a response to the release of the Intergovernmental Panel on Climate Change (IPCC), Working Group II Assessment Report, Climate Change 2007: Impacts, Adaptation and Vulnerability, the Canadian Government announced $4.5 billion in new environmental funding in the 2007 Federal budget. This entailed a comprehensive environmental strategy that totals $9 billion which includes ecoENERGY Initiatives, the ecoTRANSPORT Strategy and the ecoAUTO Program. The ecoENERGY program replaces the previous Wind Power Production Incentive (WPPI) program.

Through the ecoENERGY program, the Government of Canada is investing more than $1.5 billion to produce clean, low-impact renewable energy and encourage the production of 14.3 terrawatt hours of new electricity from renewable energy sources. The ecoENERGY program will provide financial support for the operation of new wind power capacity. The incentive is one cent per kilowatt-hour for up to 10 years. This incentive will also help establish wind power as a competitive energy source in the marketplace. This equates to enough electricity to power about one million homes. Although the ecoENERGY program funds are expected to have been depleted by the time of construction, there are lobbying efforts to extend or create a new federal funding mechanism. If such funds become available and the Project is eligible for such funding the proponent would make efforts to access such funds.

Ontario's commitment to energy conservation and securing a range of renewable energy suppliers to address the increasing energy demand in Ontario resulted in the creation of the Renewable Energy Standard Offer Program in 2006, where the provincial government set a fixed price for small renewable energy projects up to 10 MW. Following this, on August 27, 2007 the Minister of Energy issued a ministerial directive to the Ontario Power Authority (OPA) to procure 2,000 MW of renewable energy supply for projects that are greater than 10 MW in size. This Directive required that the OPA commence consultations on the design of the first procurement block for 500 MW of renewable energy supply by the end of 2007. Following two earlier procurement rounds (RES and RESII), the OPA launched the Renewable Energy Supply (RES) III program in June 2008 to acquire 500MW of renewable energy. The Project, under a previous design, was entered in the RES III Request for Proposals (RFP) but was unsuccessful in obtaining an electricity sales contract.

The OPA has recently launched the Feed in Tariff (FIT) Program which was enabled by the Green Energy and Green Economy Act, 2009. Ontario's feed-in tariff or FIT Program is North America's first comprehensive guaranteed pricing structure for renewable electricity production. It offers stable prices under long-term contracts for energy generated from renewable sources. The Ontario Power Authority is responsible for implementing this program.

5.0 SUMMARY OF PROJECT

5.1 Project Location

The Project will be located in the vicinity of the community of Nanticoke, Haldimand County (west of the town of Selkirk), in the province of Ontario, Canada (Figure 1). The proposed Project area, as shown on Figure 1, encompasses approximately 41,597 ha of privately-owned, predominantly cash-crop (corn, soy beans, wheat and other grains, alfalfa) agricultural land, although some lands are also used for pasture (predominantly cattle and sheep), or contain woodlots. The Nanticoke Industrial Park partially overlaps the west side of the Project area. This Industrial Park contains the Nanticoke Generating Station, one of the world's largest coal-fired power generating plants with a capacity of approximately 4,000 MW (OPA, 2006).

Haldimand County is located on the north shore of Lake Erie, between Norfolk County, Six Nations of the Grand River Territory, County of Brant, City of Hamilton and Niagara Region (Haldimand County, 2007). Agriculture is the primary land use in the area and is considered fundamental to the economic base and rural lifestyle of the County. The preservation of agricultural lands is also emphasized in the Haldimand County Official Plan (OP) (Haldimand County, 2006).

Wind farms are congruent with the goals of the Haldimand County OP in terms of conservation of agricultural practices and stimulating new economic investment and creation of a green economy. Haldimand County's OP and economic strategic direction specifically encourage harnessing wind energy resources through the development of wind energy systems for electricity production as a source of renewable energy for the economic benefit of the County and the Province of Ontario.

The most suitable locations for turbines and infrastructure will be determined through analysis of various design scenarios utilizing parcels that have land owner agreements in place. Since commencing planning for the Project, AET has produced several preliminary design scenarios as landowner agreements have been made and additional knowledge regarding the Project area has been acquired. Further refinement of the turbine, access road and other project component locations will occur as the Project design progresses to completion. The Project design scenarios consider various factors which represent constraints or opportunities to the Project. These constraints or opportunities include, but are not limited to wind speed, prevailing wind direction, turbulence, site topography and wake effects of one turbine on another, resultant noise level at dwellings adjacent to the proposed turbines, land ownership boundaries, access to interconnection and transmission, landowner interest, natural heritage constraints such as waterways, separation from woodlots, potential interference with radio and telecommunications infrastructure and frequencies, cultural heritage, land use and other constraints.

The Project design presently remains subject to change. When finalized, the Project components will reside primarily within portions of privately owned land parcels with cables being placed in County road easements. AET have currently secured License and Option Agreements on an area of land deemed to be sufficient to construct the Project, in consideration of the identified and anticipated constraints.

5.2 Major Project Phases and Schedule Milestones

Table 1 provides the details of the projected starting dates for Project pre-construction, construction, commissioning, operations and decommissioning activities. Pre-construction includes activities such as a preliminary engineering, geotechnical assessment and site surveys of the final turbine locations, and procurement of turbine and substation equipment. The construction schedule has been designed to account for minor delays that could result from an extended regulatory process, delayed equipment arrival, and adverse weather conditions. If regulatory approval is substantially delayed, there could be construction delays due to poor weather (i.e., difficult to construct during high wind conditions in the winter), which would likely lead to increased construction costs.

Table 1: Major Project Phases and Scheduling Milestones.

Project Design/ Obtain Renewable Energy Approval	Construction	Commissioning	Operations	Decommissioning or Repowering
June 2007 to Aug 2010	March 2011 to March 2012	March 2012	2011/2012 to 2037	2037

The wind turbines are estimated to be operational for approximately 25 years with decommissioning or repowering to begin in 2037. Barring routine scheduled maintenance, the turbines are expected to be operational 24 hours a day, 7 days a week, assuming appropriate wind conditions and any permit requirements that may require conditional turbine shut down periods.

5.3 Detailed Project Activities

The activities for the construction, operation and decommissioning phases of the Project, as well as the consideration of future phases of the Project are described below. A detailed analysis of the social, economic, environmental or cultural effects of the Project and the significance of any residual effects will be completed as part of the Project EA. Preliminary considerations which are being addressed through the EA, project design and consultation processes are discussed to the extent necessary for the Project Description requirements or guidelines described in Section 1.0.

5.3.1 Construction Phase

During the construction phase of the Project the following works will be undertaken:

- Upgrading of existing access roads and watercourse crossings and the construction of new permanent or temporary access roads to the turbine locations;
- Preparation and establishment of temporary site facilities;
- Excavation for turbine foundations;

- Concrete pouring to establish turbine foundations;
- Site grading as necessary; and
- Construction of equipment compounds and hard standing areas.

The main construction activities are expected to include:

- Earthworks for the foundations, hard standings and access roads;
- Construction of access roads;
- The fixing of formwork and reinforcement for the foundations;
- Installation of a temporary concrete batching plant;
- Placing of ready mixed concrete for the foundations;
- Back-filling and compacting around the foundations;
- Construction of substation, security fence and site compound;
- Completion of hard standing areas and landscaping;
- Burying cables between the turbine locations and the on-site substation; and
- Erection of wind turbines.

Table 2 provides a description of the Project construction phase by component and construction activity. The extent of new access road construction will be dependant on the final Project design. However, regardless of the final design configuration, new access roads will be placed near the edge of lot lines to minimise disturbance to the farm land and agricultural activities. During construction access roads are estimated to be 5-7 m wide and depending on final turbine and crane availability/selection. During the operational phase of the project some site access road widths will be decreased. The excavation and fill requirements for the foundations of the turbines have not yet been determined as this will depend upon final turbine selection and subsequent geotechnical investigation. .

Minor excavation for the feasibility stage of the Project and for geotechnical studies will involve small amounts of material being obtained via cores, which will be used to determine potential geotechnical constraints. Excavation during the construction phase will be more extensive in order to construct the turbine foundations, pad-mounted transformers, transformer station, install underground electrical lines and transmission line poles.

Fill required for the Project, other than aggregate for site access roads and turbine foundation construction, will generally be obtained from the specific excavations being undertaken, therefore the hauling of fill from outside of the Project area is not anticipated. Aggregate resources will be sourced from local suppliers where possible.

The transport routes for materials have not been finalized but will be selected and scheduled to occur at an appropriate time of the year to have minimal impacts. This will also depend on the local suppliers contracted and the turbine transport company. These details are being refined and will be discussed in the Application for a Renewable Energy Approval.

Typical construction equipment to be used for construction of the turbine and substation sites, roads and buried lines includes tracked bulldozers, excavators, tippers and dumpers, and mobile cranes (2) for general use. Large stationary cranes will be used for the tower section, turbine and blade erection. Various truck and trailer combinations will be used to transport the turbine and substation components to the site. Cement pumpers will be used to construct the turbine foundations, and two cranes will be used to erect the turbine towers. Additional vehicles will be used for personnel and small equipment transport to and within the site.

5.3.1.1 Temporary Facilities

Temporary Project facilities will include small portable trailers for office accommodation, staff rest/eating and First Aid area, and storage trailers or temporary storage containers for equipment. Washroom facilities will be provided either in the office trailer or by portable toilets. Turbine components will preferably be delivered to the turbine location and a storage area for the components may be required depending upon manufacturer's delivery schedule. This will be determined during contractual negotiations with the manufacturer. During the construction period there will be controlled access to the Project site.

A temporary concrete batching plant may be considered if the required quantities of material cannot be sourced locally. Gravel to construct the access roads will be sourced from local suppliers. On completion of the construction work, temporary facilities will be removed and the respective areas will be returned to their original state. The location of temporary storage areas for the site has not yet been determined and will be determined following further environmental studies and discussions with landowners.

The interconnection cabling and transmission line is expected to be completed over a 6 month period. This cable will be trenched in most cases to ensure no long term reduction in arable land.

5.3.1.2 Watercourse Crossings

The exact location and number of watercourse crossings are not yet known for the Project. At present, the Project design intends to avoid riparian setbacks that are associated with warm, cool or coldwater fisheries or Regulation Limit boundaries, wherever possible. Where watercourse crossings for site access or for underground cable are required, it will be desirable to construct the crossing following an existing Operational Statement such that a Project review by DFO is unnecessary. However, if new access or cable crossing are required an authorization or letter of advice from DFO may be required. Whether or not a *Fisheries Act* and/or *Navigable Waters Protection Act* trigger will occur is dependent on the crossing technique, mitigation employed and sensitivity of fish and fish habitat present. Consistent with Ontario Regulation 359/09, effects on natural heritage and water will be considered through a combination of a records review, site investigation and evaluation of significance as and to the extent required. This process will involve consultation with DFO, the Ontario Ministry of Natural Resources and the Long Point Region Conservation Authority, at a minimum.

Table 2: General Description of Project Construction Activities

Project Component and Activity	Description
Surveying	The boundaries of the construction areas, including turbine sites, substation site, access and connection cable routes, and temporary workspace will be staked. All existing buried infrastructure, such as pipelines and cables will also be located by the appropriate personnel and marked.
Access construction	The Project area will be accessed via existing road right-of-ways. Access to the turbine sites will require the construction of new access roads. In most cases the access roads will share routing with the connection cables. Access roads for use during construction will be built using tracked bulldozers and backhoes to strip topsoil and subsoil, as required, to create an even travel surface. Culverts, tiling or other drainage structure may be required to maintain adequate site drainage. Soil management will be incorporated into this process to facilitate site reclamation. Existing vegetation (crop stubble) will be stripped with the topsoil, which will be stockpiled separately from subsoil and stabilized to prevent erosion. When Project construction is complete, stripped subsoil and topsoil will be replaced.
Delivery of equipment	Equipment will be delivered by truck and trailer, (requiring approximately 10 to 12 loads per wind turbine delivery). Equipment will be delivered as needed throughout the construction phase, and will be stored if necessary at temporary storage facilities at the site or at the proposed turbine location. The primary roads used for equipment delivery will be a combination of highways, arterial roads and municipal right of ways. A traffic management plan will be prepared to limit traffic disturbance, particularly to school bus traffic, on public roads.
Turbine site construction	Sites will be built using tracked bulldozers and hoes to strip topsoil and subsoil, as required, to create an even work surface. Soil management will be incorporated into this process to facilitate site reclamation. Existing vegetation (crop stubble) will be stripped with the topsoil, which will be stockpiled separately from stripped subsoil. After the turbines are constructed, stripped subsoil and topsoil will be replaced.
Foundation	It is envisaged that the turbine base will be constructed as a gravity reinforced concrete foundation. The excavation for the turbine base will be approximately 17 m by 17 m by 3 m to accommodate the foundation depth and tower turbine inserts. Dependent upon the detailed engineering design the foundation may be supported by a number of piles. Formwork and rebar will be installed to construct the foundation and concrete pumps or elevators will be used to place the concrete. Formwork will be struck after 24 hours and the excavated area will be back filled and compressed such that only the tower base portion of the foundation is left above ground.
Turbine assembly and installation	The wind turbine tower normally consists of three sections that are assembled on the site and will be erected using two cranes. The nacelle and its components are lifted into place on the tower. Once the three blades are attached to nose cones on the ground, the assembled rotor is then normally lifted and assembled to the nacelle. In some circumstances a single blade lifting technique may be utilised where space or high wind constraints prevent the blade and nose cone assembly being lifted in one piece.

Table 2: General Description of Project Construction Activities (continued)

Project Component and Activity	Description
Temporary storage facilities	Temporary storage facilities and work areas will be used during construction, as described above. These areas will be used for equipment and materials storage, designated fuelling areas, and will house field offices for the construction phase of the Project. The temporary workspace around the turbine sites and adjacent the substation site measures approximately 60 m x 60 m, which is reduced to 8 m diameter footprint of the turbine equipment upon turbine operation. Workspace along the access and cabling routes is an additional 5 m wide, with additional 9 m wide workspace at bends in the route. Soil management, as described earlier for site construction, will be incorporated into the creation and use of these areas to facilitate site reclamation. After construction, subsoil will be ripped as necessary to alleviate compaction, and stripped subsoil and topsoil will be replaced.
Interconnection cabling	The collector system will be a mixture of over head lines and underground cable and will be constructed using Standard wooden poles and ACSR conductors. The on-site collector system will be buried, 34.5 kV standard utility cable, between turbines and to the substation. The cable routes will primarily follow the access routes described in the final Project design or directly between turbines in some cases where this is more practical. A combination of ploughing and trenching will be used to install the cables, depending on terrain. Soil management will be incorporated into this process to facilitate site reclamation. Typically, lines are trenched over short distances and where manoeuvrability of the ploughing equipment is difficult. A cat-mounted plough mechanism, which cuts a narrow furrow behind the cat, will be used to install the underground distribution lines. A plough seam will be excavated to a depth of approximately 2m, into which the cable is placed. The plough seam will be backfilled immediately to prevent soil loss and erosion. Trenching is accomplished in a manner similar to ploughing. A wheel-ditcher or Ditch Witch (a wheel-like or bar-like mechanism similar to a chainsaw) will be used to cut a narrow trench into which the cable is placed. Trenching equipment for underground cable is smaller than that used for pipeline construction, usually mounted on a bobcat or small backhoe. The soil removed from the trench is situated immediately adjacent to the trench. A backhoe or small bobcat will be used to push the soil back into place, and to recontour the disturbed area. Where the underground cable must be spliced (e.g., at the end of a reel or to pass underneath another utility cable) a splice pit is typically required. These pits are roughly 1 m deep, 1 m wide, and up to 5 m long (but usually 1 to 2 m long). At these locations, the topsoil will be stripped and stockpiled. After the procedure is complete, soil will be replaced and contoured.
Transmission line	It is envisaged that the Project will require approximately 200m of overhead 230kV transmission line installed on new steel pylons or monopoles. The design and final location will be evaluated in the detailed design of the Project.

Table 2: General Description of Project Construction Activities (continued)

Project Component and Activity	Description
Substation	Substation equipment will include an isolation switch, a circuit breaker, a step-up power transformer, distribution switch-gear, instrument transformers, grounding, revenue metering, and a substation control & communication building which include a small office and mess facilities' to include toilet and shower and associated parking and storage area. Substation grounding will follow CEC standards. An oil containment system will be installed at the site to prevent soil contamination in the event of a leak. The substation site will be built using tracked bulldozers and excavators to strip topsoil and subsoil, as required, to create an even work surface. Soil management will be incorporated into this process to facilitate site reclamation. Existing vegetation (crop stubble) will be stripped with the topsoil, which will be stockpiled separately from stripped subsoil. The substation site will be gravelled and contoured for effective surface drainage. After Project construction is complete, stripped subsoil and topsoil will be replaced at the temporary workspace. Topsoil stripped from the substation site will be re-distributed to the adjacent land. Installation and connection of the substation is expected to take six months.
Gates and fencing	The substation will be fenced and secured based on standard utility practices. The turbine sites or access routes will only be permanently fenced or gated if requested by the landowner or if identified as necessary by AET..
Parking lots	A temporary parking lot will be required during site construction. Some vehicle parking will also occur at the construction sites in the temporary workspaces. During operation the substation will contain a parking area for a small number of vehicles.
Clean-up and reclamation	Construction debris will be collected and disposed of at an approved location. All equipment and vehicles will be removed from the construction area. If spills occurred during construction, affected areas will be cleaned-up as appropriate. Stripped soil will be replaced and recontoured at the temporary workspace and lay-down areas. The disturbed areas (including trenches and plough seams) will be re-seeded. High voltage warning cable markers will be installed at the substation and elsewhere (such as where underground cables cross County Roads), Site clean-up and reclamation will be conducted concurrently with construction, and will be completed within one week of installation of the Project equipment.
Turbine commissioning	Prior to commencement of final commissioning a Commissioning and Testing Plan will be developed by AET in conjunction with the selected turbine manufacturer, the OPA and Hydro One. Turbine commissioning will occur once the wind turbines have been fully installed and may take place in sequential order prior to the planned Commercial Operation of the Project.. If this takes place prior the transmission interconnection being available the use of temporary diesel powered generators may be required to complete pre-commissioning activities. The commissioning will necessitate testing and inspection of electrical, mechanical, and communications operability. A detailed set of operating instructions must be followed in order to connect with the electrical grid.

5.3.2 Operation Phase

Operation is expected to begin in 2011/2012. The operational phase will see the generation of up to 199MW of wind energy for approximately 25 years. The turbines will require scheduled visits for maintenance during the operational phase, such as changing oil, cleaning and lubricating gearboxes and replacing worn parts. One to two visits are expected for scheduled services every week and routine maintenance visits will occur every 3-6 months.

5.3.3 Decommissioning Phase

At the end of its operational life, the wind turbine structures will be removed to the base of the foundation and the foundations will be back covered with earth to a depth that can be utilised as farm land. Access track removal will be dependent on the requirements of the landowner. Areas of land will be reseeded where appropriate.

Items to be dismantled and removed shall include:

- Turbines (hubs, nacelles, blades, towers);
- Collection system (underground/overhead lines and poles);
- Substation;
- Access roads (dependent upon agreement and desire of landowner and the location of such roads);
- Foundations (to be levelled and covered with clean top soil to return the surface as close as possible to its original state);
- Removal of contaminated soil, if any, caused by the wind farm; and
- All equipment subject to the decommissioning plan will be removed or recycled, where possible, within industry accepted standards.

AET will remove and sell any recyclable materials (WTG tower material, copper wiring, aluminum conductor, machine head (nacelle), down tower assembly and hub material) which will have some value in their respective scrap metals markets.

5.3.3.1 Toxic/Hazardous Materials

There is very little material that could be classified as toxic or hazardous that is used in constructing and operating a wind farm site. Toxic or hazardous materials to be used on-site during construction and the operation phase include oils, fuel and lubricants that will be used on-site in construction equipment and for maintenance of the turbine facilities. Only minor amounts of these materials will be generated and the small quantities will be disposed of through conventional waste-oil and hazardous waste disposal streams.

Small quantities of non-hazardous waste, such as plastics, will be generated and disposed of through the local landfill and recycling facilities where appropriate. Wastes will be disposed of locally in accordance with local procedures for management of conventional waste-oil and hazardous waste streams. A licensed contractor will remove special waste such as oily rags and oil from the service of turbines. All non-hazardous waste will be disposed of at the local waste facilities at the local landfill. Materials that are able to be recycled and reused will be stored temporarily on-site prior to reuse and recycling.

5.3.3.2 Solid, Liquid or Gaseous Wastes

Wind projects, by their nature, do not produce much waste. The waste streams produced from ongoing maintenance of the Project include the lubricant and hydraulic oils for the maintenance of the turbines, pad-mounted transformers and the transformer/substation.

The Project substation will include permanent toilet facilities that will be designed and constructed in accordance with required regulations. Portable toilets will be utilized during the construction phase and a licensed contractor will be responsible for waste removal.

5.4 Future Phases of Development

There are no proposed future stages for development at the current time.

6.0 ENVIRONMENTAL EFFECTS

From an environmental perspective, wind power is relatively benign compared to other forms of electricity generation. However, there are both real and perceived disadvantages to wind power which include the following:

- Wind is intermittent by nature and thus, the actual electricity generated by a wind turbine, measured by capacity factor, will be a percentage of the rated capacity;
- A small area of agricultural land is taken out of production over the lifespan of the Project;
- Potential for bird or bat collisions with turbines resulting in injury or mortality;
- Potential for birds and bats to alter migratory routes to avoid turbines;
- New sources of sound which could result in nuisance noise at nearby receptors;
- Potential public health and safety issues related to falling ice, ice throw, noise, shadow flicker and catastrophic failure (i.e., collapse) of the structures;
- A change in the landscape/viewscape over the lifespan of the Project, which will alter the rural character of the area; and
- There is a perceived notion of possible reductions in property values within the viewshed.

To the extent now required under Regulation 359/09, these effects will be assessed and reported on in the Application for Renewable Energy Approval and associated Consultation process with the public, Aboriginal communities, municipalities and local authorities.

7.0 CONSULTATION

A Notice of Commencement (NOC) was mailed to the federal, provincial and municipal governments identified in Table 3 on September 24, 2008 as part of the former Environmental Screening process under Regulation 116/01. A one-page mail-out of the NOC and an introductory letter was sent to 3,459 local residents and businesses within selected postal code areas around the Project area on September 26, 2008. On September 30, 2008 a separate introductory letter and the NOC were mailed to a list of local First Nations in order to introduce AET and the Project, invite them to participate in the Environmental Screening process and solicit their feedback on the Project. The NOC was published in four local newspapers on the following dates:

- The Simcoe Reformer, Haldimand and Norfolk County (September 30, 2008);
- The Turtle Island News, Grand River Territory of the Six Nations and surrounding area (October 1, 2008);
- The Port Dover Maple Leaf, Port Dover and area (October 1, 2008); and
- Haldimand Press, Haldimand County (October 2, 2008).

Comments from the NOC were directed to AET and directly responded to by AET. All comments received have been logged in a consultation database by Golder Associates.

Table 3: Distribution List of Government Agencies and Other Parties Provided with Notice of Commencement

Stakeholder Type	Agency/Affiliation
Federal Government	Canadian Environmental Assessment Agency, Ontario Region
Federal Government	Environment Canada
Federal Government	Fisheries and Oceans Canada
Federal Government	Health Canada, Ontario Region
Federal Government	Indian and Northern Affairs Canada - Comprehensive Claims Branch
Federal Government	Indian and Northern Affairs Canada – Environmental Officer
Federal Government	Indian and Northern Affairs Canada - Lands and Trusts Services
Federal Government	Indian and Northern Affairs Canada - Specific Claims Branch
Federal Government	International Joint Commission, Great Lake Regional Office
Federal Government	Natural Resources Canada
Federal Government	Public Works and Government Services Canada
Federal Government	Transport Canada, Environmental Affairs, Programs Branch
Provincial Government	Government Mobile Communications Office (GMCO)
Provincial Government	Haldimand Stewardship Council, Ontario Stewardship

Table 3: Distribution List of Government Agencies and Other Parties Provided with Notice of Commencement (continued)

Stakeholder Type	Agency/Affiliation
Provincial Government	Ministries of Citizenship and Immigration, Culture and Tourism and Recreation
Provincial Government	Ministry of Aboriginal Affairs
Provincial Government	Ministry of Agriculture Food and Rural Affairs
Provincial Government	Ministry of Culture
Provincial Government	Ministry of Energy
Provincial Government	Ministry of Health and Long-Term Care
Provincial Government	Ministry of Municipal Affairs and Housing, Southwestern Municipal Services Office
Provincial Government	Ministry of Natural Resources
Provincial Government	Ministry of Natural Resources - Aylmer District Office
Provincial Government	Ministry of Public Infrastructure Renewal
Provincial Government	Ministry of the Attorney General
Provincial Government	Ministry of the Environment - Environmental Assessment and Approvals Branch
Provincial Government	Ministry of the Environment - Hamilton District Office
Provincial Government	Ministry of the Environment - Hamilton Regional Office
Provincial Government	Ministry of Transportation
Provincial Government	MPP for Haldimand - Norfolk – Brant
Provincial Government	Niagara Escarpment Commission
Provincial Government	Norfolk Stewardship Council, Ontario Stewardship
Provincial Government	Ontario Energy Board
Provincial Government	Ontario Power Generation
Provincial Government	Ontario Provincial Police, Norfolk County Department
Regional Government	Long Point Region Conservation Authority
Regional Government	Grand River Conservation Authority
Municipal Government	Haldimand-Norfolk Area Provincial Fire Coordinator
Municipal Government	Mayor of Haldimand County
Municipal Government	Haldimand County Councillor Ward 1

Table 3: Distribution List of Government Agencies and Other Parties Provided with Notice of Commencement (continued)

Stakeholder Type	Agency/Affiliation
Municipal Government	Haldimand County Manager of Emergency Services/Fire Chief
Municipal Government	Haldimand County Acting Medical Officer of Health
Municipal Government	Haldimand County Planner, Planning Division
Municipal Government	Haldimand County Chief Administrative Officer
Municipal Government	Haldimand County Manager, Economic Development and Tourism
Municipal Government	Mayor of Norfolk County
First Nations	Six Nations of the Grand River Territory
First Nations	Association of Iroquois and Allied Indians
First Nations	Mississaugas of the New Credit
First Nations	Métis Nation of Ontario
First Nations	Métis Nation of Ontario, Region 9, Grand River Council
Industrial Neighbours	Air Products Canada, Ltd.
Industrial Neighbours	Imperial Oil, Nanticoke Refinery
Industrial Neighbours	U.S. Steel
Industrial Neighbours	Norfolk Power
Industrial Neighbours	Hydro One
Industrial Neighbours	Ontario Power Generation, Nanticoke Generating Station
Industrial Neighbours	Haldimand County Hydro
Community Advisory Group	Nanticoke Community Awareness Emergency Response
Businesses, Business Organizations	Grand Erie Business Centre
Businesses, Business Organizations	Jarvis Board of Trade
NGO	Ontario Clean Air Alliance
NGO	Haldimand-Norfolk Organization For A Pure Environment (HOPE)
NGO	Centre for Applied Renewable Energy
NGO	Niagara Peninsula Source Protection Region
NGO	Citizens for Renewable Energy
NGO	Nature Conservancy of Canada
NGO	Long Point World Biosphere Reserve Foundation

Table 3: Distribution List of Government Agencies and Other Parties Provided with Notice of Commencement (continued)

Stakeholder Type	Agency/Affiliation
NGO	Long Point Basin Land Trust
NGO	Norfolk Field Naturalists
NGO	Lower Grand River Land Trust Inc.

A pre-consultation meeting between AET, Golder Associates and Haldimand County representatives from their planning, engineering and infrastructure, building, fire and ambulance, and hydro departments was held on October 3, 2008. The purpose of the meeting was for AET to introduce their company and the planned Project, and for the County to outline their requirements for wind farm development. In general terms, the County is supportive of the Project. Consultation with the public, Aboriginal Communities, Haldimand County and local authorities will continue under the new REA process. The development and posting of this Project Description is a component of the REA consultation process.

8.0 REFERENCES

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Report Signature Page

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Golder Associates

December 2009

Nanticoke Wind Farm
project fact sheet

The Project

The Nanticoke Wind Farm Project is located near the community of Nanticoke in Haldimand County. The Project Study Area encompass's approximately 42,000 hectares of industrial park lands and privately-owned lands primarily under agricultural use; some lands are also used for pasture or contain woodlots.

The Project is a Class 4 wind facility that will generate up to 199 MW of electricity with up to 133 wind turbines. Project infrastructure will also include transformers, access roads, substation and electrical cabling.

The Partnership

Air Energy TCI Inc (AET) has entered into an agreement with NextEra Energy Canada, ULC (NextEra Energy) regarding the Nanticoke Wind Farm Project.

The agreement resulted from AET's recent strategic evaluation of how best to advance the Nanticoke Wind Farm Project to construction, and resulted in AET now being partnered with unrivalled wind energy expertise in the North American market.

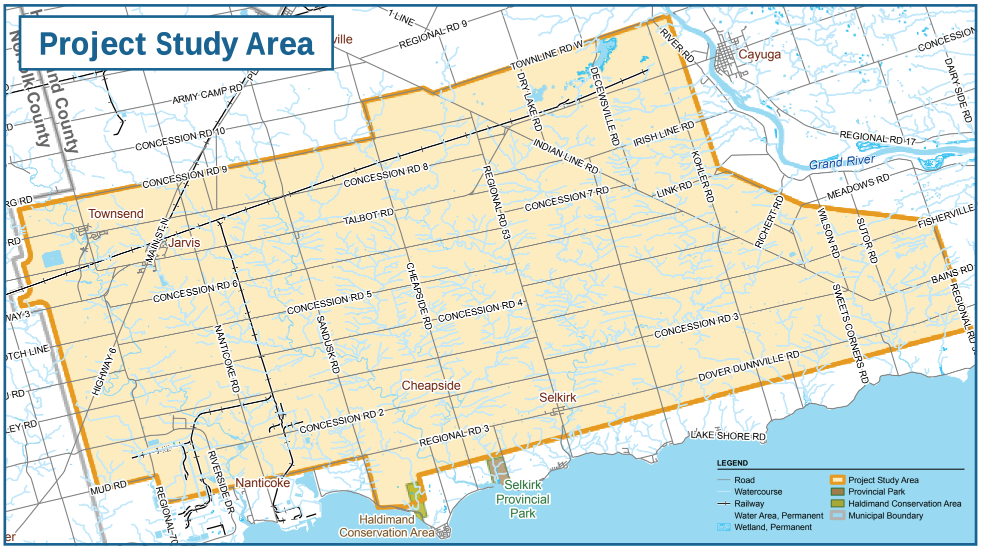
Both AET and NextEra Energy will be working closely over the next 12-18 months to obtain a Renewable Energy Approval for the Nanticoke Wind Farm Project. We look forward to discussing this in more detail as the project progresses.

TCI Renewables/Air Energy TCI Inc

TCI Renewables Ltd is a leading independent renewable energy business. Air Energy TCI Inc was established in 2006 as the North American subsidiary of TCI Renewables Ltd.

TCI Renewables Ltd has offices in Great Britain, Ireland and Canada with interests in over 30 wind power projects, including in the United States.

Our Canadian office is based in Montreal and was established to help develop two wind power projects in Quebec. The St. Valentin (50 MW) and New Richmond (66 MW) projects are both under development and are due to come on-line in 2012.



NextEra Energy Resources

Our expertise is in wholesale and retail electricity and project development and construction, as well as in offering customers the energy products and services they need. Our parent, FPL Group, is a leading clean-energy company with, approximately 39,000 megawatts of generating capacity and more than 15,000 employees in North America.

Nanticoke Wind Farm
project fact sheet

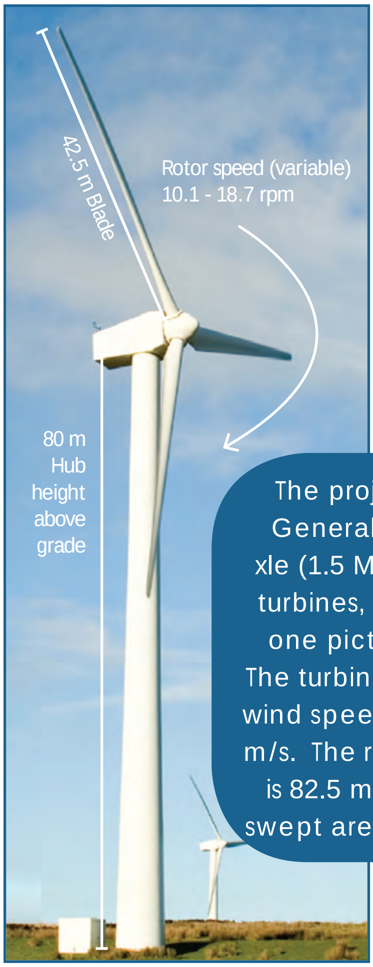
Benefits of Wind

Clean and Efficient
- Limited greenhouse gas emissions from electrical generation
- Efficient and mechanically reliable
- Easily coexists with agricultural land uses
- Does not need water as a cooling source
- Wind farms are low impact projects

Reliable Supply
- Project cost/benefit considers wind "capacity factor" predicted from wind monitoring and modelling

Economic Benefits
- 25 percent capital cost spent within Ontario
- Full-time employment for 8-10 people
- Direct income to participating landowners
- Construction jobs for 200-300 people

Price Stability
- Helps stabilize the cost of power
- Virtually zero fuel costs
- Can be produced domestically
- Contributes to the economy at many levels



The project will use General Electric 1.5 xle (1.5 MW capacity) turbines, similar to the one pictured at left. The turbines operate at wind speeds of 3.5 to 20 m/s. The rotor diameter is 82.5 m with a total swept area of 5,346 m^2.

Renewable Energy Approvals

(from the Ministry of Energy and Infrastructure website)

Ontario's Green Energy Act has made it easier to bring renewable energy projects to life. By developing provincial standards, a streamlined approvals process and a Feed-in Tariff program that guarantees specific rates for energy generated from renewable sources, Ontario is becoming the North American leader in attracting renewable energy projects and green jobs.

For the first time, province-wide standards for renewable energy projects have been established - including standardized setback requirements for wind farms. A streamlined government approvals process which provides service guarantees for renewable energy projects has also been established. Approval processes for renewable energy projects will continue to ensure high safety and environmental standards are met.

Project Timeline

- PLANNING: Fall 2006 – Summer 2010
- CONSTRUCTION: Fall 2010 – Spring 2011
- OPERATION: 2011 – 2036
- DECOMMISSION: 2036 – 2037

Providing Safe, Clean Wind Energy

Our Top Priority: Public Health and Safety

NextEra™ Energy Resources has been operating wind energy facilities for about 20 years, and we care about the communities in which our facilities are located. Public health and safety is our top priority, and we are proactive about any concerns. NextEra Energy operates more than 8,000 wind turbines, and we are pleased to say that we have never received a confirmed or documented claim of health effects from anyone as a result of the operation of our wind farms by a subsidiary of NextEra Energy.

About NextEra™ Energy Resources

» A leading clean energy provider operating wind, natural gas, solar, hydroelectric and nuclear power plants across the nation
» Approximately 17,000 megawatts of generating capacity in 25 states and Canada
» The largest wind generator in the country with approximately 65 facilities in 16 states and two Canadian provinces
» A subsidiary of FPL Group, Inc., with headquarters in Juno Beach, Florida

Wind Energy Facts

Wind plants are generally quiet

Wind turbines are very quiet, but because wind farms are typically located in rural areas where background sounds are lower, turbine sound may be more obvious under certain conditions. On the other hand, any audible turbine sounds are often masked by the sound of the wind itself - especially since turbines are located where the wind speed is higher than average and because wind turbines tend to operate only when the wind is blowing.

The nature of wind turbine sounds

Current turbine designs effectively reduce mechanical sound through sound proofing. In fact, the turbines used by NextEra Energy feature sound quietness warranties and guarantees to minimize sound. In those rare situations when wind turbine operation is not masked by the natural sound of wind, the resulting aerodynamic sound is often described as a faint "whooshing."

Each wind turbine is different

Each wind farm, and each wind turbine type, requires independent evaluation and analysis. Studies of other competitors' wind farms or wind farms in other countries are not proper or valid comparisons. NextEra Energy is aware of numerous studies dealing with older turbine types, larger turbines or different technologies, which have no application to the wind turbines used in the wind farms we construct. As a result, we have conducted our own analysis of the wind turbines we use and feel confident that there are no health impacts.

Literature claims

Literature opposing wind farms claims that a potential threat to health would exist due to: (1) The levels of sound reaching people; (2) infrasound; and (3) low-frequency sound.

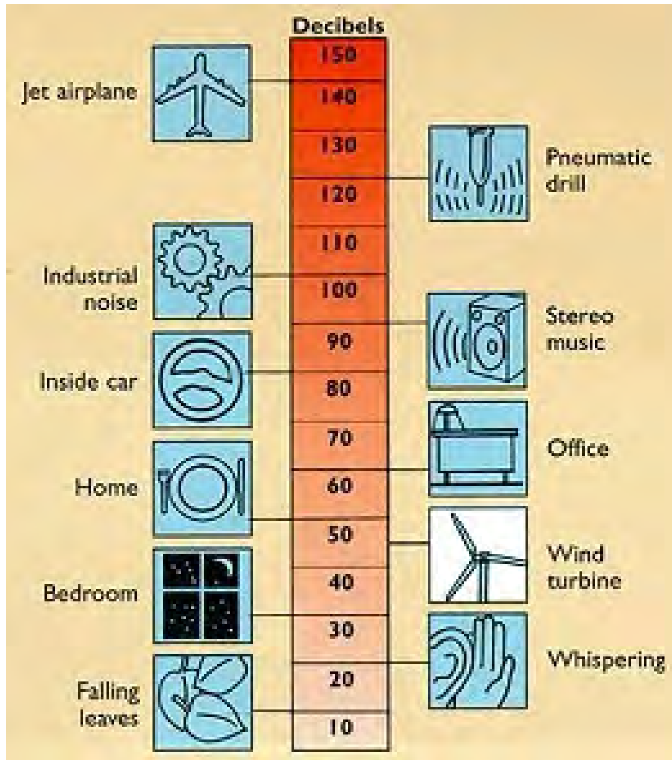
Careful siting
NextEra Energy is very careful in siting wind turbines. We address concerns about sound levels reaching people through our awareness of guidelines and local rules and requirements for proper separation of wind turbines from residences.

Sound levels are safe
Our studies confirm that infrasound and low-frequency sound from wind turbines are not a problem.

- *Infrasound* – Careful testing confirms that the turbine types used in the wind farms that NextEra Energy constructs do not emit infrasound.
- *Low–frequency sound* – The only turbines that have exhibited low-frequency sound at any level of concern were turbines that have their blades located behind the nacelle. NextEra Energy does not install this type of turbine in the wind farms it constructs. Testing has confirmed that the turbines we use do not generate any such sound at levels that could cause harmful health effects.

Our wind turbines meet all sound level standards as set by the American National Standards Institute.[1]

'Wind turbine syndrome' claims
This is a phrase that has been made up by anti-wind advocates. Neither the American Medical Association, the Canadian Medical Association, the World Health Organization, the Centers for Disease Control, the National Institutes of Health, the Environmental Protection Agency nor any leading medical journals or institutions recognize "wind turbine syndrome."



The graph shows the decibel level of common sounds, including wind turbines, which range between 35 and 45 decibels.

Wind energy can help improve air quality
Air quality has a direct impact on human health. According to the American Lung Association, particulate matter in the air has been shown to affect cardiovascular and respiratory health. Unhealthy levels of particle pollution can even cause otherwise healthy people to get sick. More than 25 percent of the people in the United States live in counties with unhealthy levels of short-term particle pollution. The generation of electricity from the wind does not result in any air emissions. By offsetting more polluting forms of energy generation, wind energy can actually improve air quality and our health.

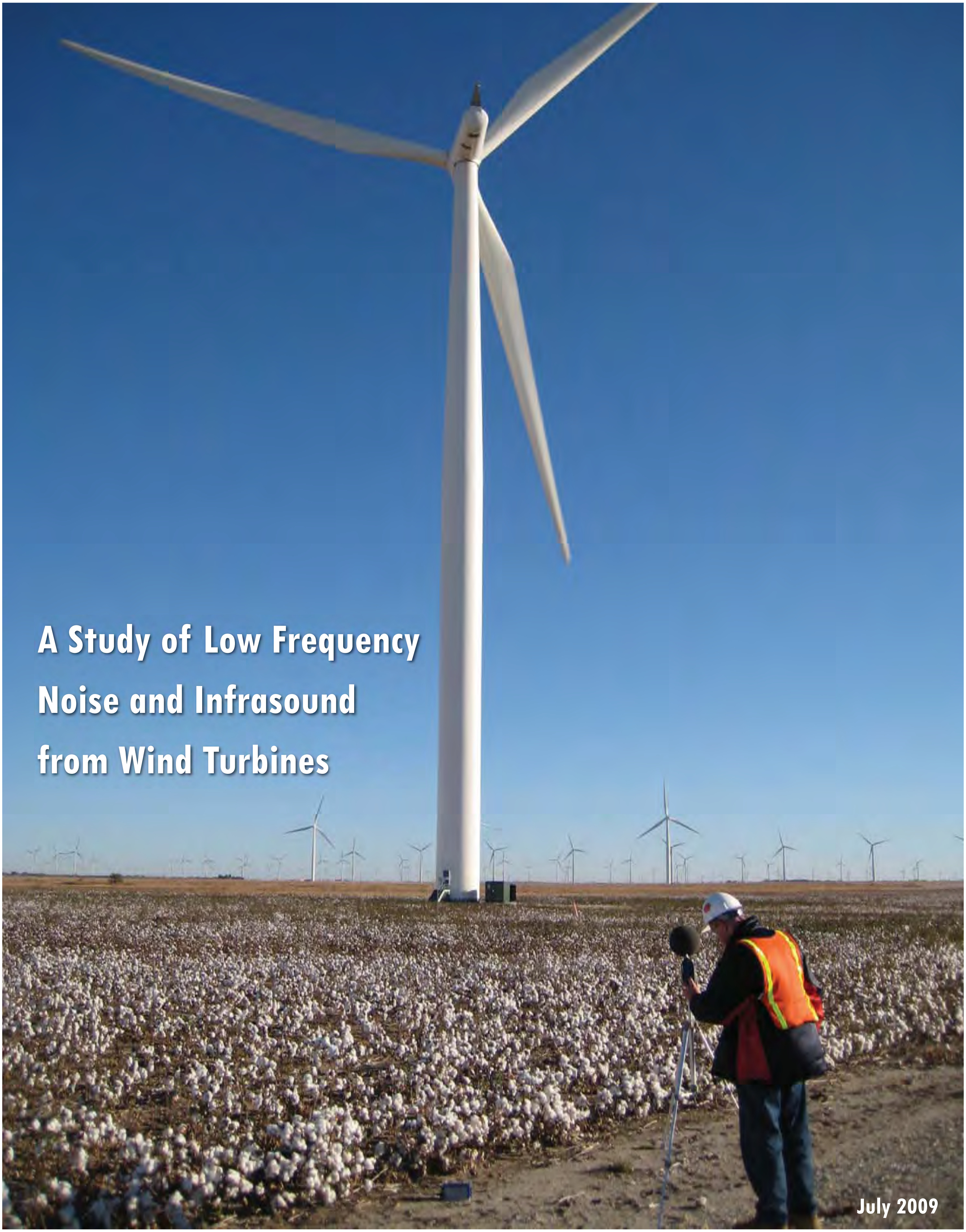
Wind energy can help reduce global warming pollutants
In 2008, NextEra Energy wind facilities prevented the emission of more than 13 million tons of carbon dioxide – a greenhouse gas that many scientists believe contributes to climate change. Human health can be adversely affected by rising global temperatures. According to the American Wind Energy Association, wind energy produces less than two percent of the emissions from coal combustion per megawatt-hour, even when the manufacturing process of wind turbines is accounted for, giving it one of the lowest greenhouse gas lifecycle emissions levels of any power technology.

More Information on Wind Energy Safety

- Epsilon's Low Frequency Sound and Infrasound Study – www.nexteraenergyresources.com/pdf/Epsilon_study.pdf
- American Wind Energy Association – www.awea.org
- Canadian Wind Energy Association – www.canwea.org

1 Low-frequency sound is generally defined as frequencies between 10 Hertz (Hz, oscillations per second) and 100 Hz. This type of sound has many sources, such as machinery, transportation or the ocean, and is generally always present as an element of background sound.

Prepared for **NextEra Energy Resources, LLC**, *700 Universe Boulevard, Juno Beach, FL 33408*



A Study of Low Frequency Noise and Infrasound from Wind Turbines

July 2009

Prepared by **Epsilon Associates, Inc.**, *3 Clock Tower Place, Suite 250, Maynard, MA 01754*

A Study of Low Frequency Noise and Infrasound from Wind Turbines

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July 2009

Report No. 2433-01

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ES EXECUTIVE SUMMARY

Early down-wind wind turbines in the US created low frequency noise; however current up-wind wind turbines generate considerably less low frequency noise. The results of Epsilon Associates, Inc. (Epsilon) analysis and field testing indicate that there is no audible infrasound either outside or inside homes at the any of the measurement sites – the closest site was approximately 900 feet from a wind farm. Wind farms at distances beyond 1000 feet meet the ANSI standard for low frequency noise in bedrooms, classrooms, and hospitals, meet the ANSI standard for thresholds of annoyance from low frequency noise, and there should be no window rattles or perceptible vibration of light-weight walls or ceilings within homes. In homes there may be slightly audible low frequency noise (depending on other sources of low frequency noise); however, the levels are below criteria and recommendations for low frequency noise within homes. In accordance with the above findings and in conjunction with our extensive literature search of scientific papers and reports, there should be no adverse public health effects from infrasound or low frequency noise at distances greater than 1000 feet from the wind turbine types measured by Epsilon: GE 1.5sle and Siemens SWT 2.3-93.

Siemens SWT 2.3-93 Wind Turbine. Outdoor measurements of Siemens SWT 2.3-93 wind turbines under high output and relatively low ground wind speed (which minimized effects of wind noise) at 1000 feet indicate that infrasound is inaudible to the most sensitive people (more than 20 dB lower than median thresholds of hearing); that outdoor equivalent ANSI/ASA S12.2 perceptible vibration criteria are met; that the low frequency sounds are compatible with ANSI S12.9 Part 4 levels for minimal annoyance and beginning of rattles; that levels meet outdoor equivalent UK Department for Environment, Food and Rural Affairs (DEFRA) disturbance-based guidelines for use by Environmental Health Officers, and that low frequency sounds might be audible in some cases. Based on the comparisons made to these criteria, there are no low frequency noise problems from Siemens SWT 2.3-93 wind turbines at 1000 feet or beyond.

Indoor measurements of two homes with windows open and closed of Siemens SWT 2.3-93 wind turbines at approximately 920 feet (under high output, maximum noise, and high ground winds) and at 1060 feet (under moderate-high output, maximum noise and relatively low ground winds) indicate infrasound is inaudible to the most sensitive people (more than 25 dB lower than median thresholds of hearing). The low frequency noise at 50 Hz and above might be slightly audible depending on background noises within the home or other external noises. The ANSI/ASA S12.2 low frequency criteria for bedrooms, classrooms and hospitals were met, as were the criteria for moderately perceptible vibrations in light-weight walls and ceilings. DEFRA disturbance based guidelines were met for steady low frequency sounds and were within 2 dB for non-steady low frequency sounds. Based on the comparisons made to these criteria, there are no low frequency noise problems indoors from Siemens SWT 2.3-93 wind turbines at 920 feet or beyond.

GE 1.5sle Wind Turbine. Outdoor measurements of GE 1.5sle wind turbines under high output and relatively low ground wind speed (which minimized effects of wind noise) at 1000 feet indicate that infrasound is inaudible to the most sensitive people (more than 20 dB lower than median thresholds of hearing); that outdoor equivalent ANSI/ASA S12.2 perceptible vibration criteria are met; that the low frequency sounds are compatible with ANSI S12.9 Part 4 levels for minimal annoyance and beginning of rattles; that levels meet or are within 1 dB of outdoor equivalent DEFRA disturbance-based guidelines; and that the low frequency sounds might be audible in some cases. Based on the comparisons made to these criteria, there are no low frequency noise problems from GE 1.5sle wind turbines at 1000 feet or beyond.

Indoor measurements with windows open and closed of GE 1.5sle wind turbines at approximately 950 feet (under moderate output, maximum noise, and high ground winds) and at approximately 1025 feet (under moderate output, within 1.5 dBA of maximum noise, and high ground winds) indicate infrasound is inaudible to the most sensitive people (more than 25 dB lower than median thresholds of hearing). The low frequency noise at or above 50 or 63 Hz might be slightly audible depending on background noises within the home or other external noises. The ANSI/ASA S12.2 low frequency criteria for bedrooms, classrooms and hospitals were met, as were the criteria for moderately perceptible vibrations in light-weight walls and ceilings. DEFRA disturbance based guidelines were met for steady low frequency sounds and non-steady low frequency sounds. Based on the comparisons made to these criteria, there are no low frequency noise problems indoors for GE 1.5sle wind turbines at distances beyond 950 feet.

Conclusions. Siemens SWT 2.93-93 and GE 1.5sle wind turbines at maximum noise at a distance more than 1000 feet from the nearest residence do not pose a low frequency noise problem. At this distance the wind farms:

- meet ANSI/ASA S12.2 indoor levels for low frequency sound for bedrooms, classrooms and hospitals;
- meet ANSI/ASA S12.2 indoor levels for moderately perceptible vibrations in light-weight walls and ceilings;
- meet ANSI S12.9 Part 4 thresholds for annoyance and beginning of rattles;
- meet UK DEFRA disturbance based guidelines;
- have no audible infrasound to the most sensitive listeners;
- might have slightly audible low frequency noise at frequencies at 50 Hz and above depending on other sources of low frequency noises in homes, such as refrigerators or external traffic or airplanes; and
- meet ANSI S2.71 recommendations for perceptible ground-borne vibration in residences during night time hours.

1.0 INTRODUCTION

Epsilon Associates, Inc. ("Epsilon") has been retained by NextEra Energy Resources, LLC ("NextEra"), formerly FPL Energy, to investigate whether the operation of their wind turbines may create unacceptable levels of low frequency noise and infrasound. This question has been posed to NextEra, and other wind energy developers and operators of utility-scale wind turbines. NextEra is one of the world's largest generators of wind power with approximately 6,400 net megawatts (MW) as of April 2009.

Epsilon determined all means, methods, and the testing protocol without interference or direction from NextEra. No limitations were placed on Epsilon by NextEra with respect to the testing protocol or upon the analysis methods.

This report is composed of two distinct sections: the first portion defines terms, discusses known effects of low frequency sound, and presents scientific guidelines and standards used to evaluate low frequency sound. The second portion of the report examines specific wind turbines used by NextEra, including data from field measurements at operating wind farms, and compares the measured data to guidelines and standards. In addition, each NextEra wind turbine vendor supplied detailed, reference sound level data in both A-weighted and octave band format in accordance with the international standard IEC 61400-11, "Wind Turbine Generator Systems-Part 11; Acoustic Noise Measurement Techniques." These data were used as an aide to focus the field portion of the measurement program.

2.0 DEFINITIONS

2.1 Low Frequency Noise/Sound

The frequency range 20 – 20,000 Hz is commonly described as the range of *"audible"* noise. The frequency range of low frequency sound is generally from 20 Hertz (Hz) to 200 Hz, and the range below 20 Hz is often described as "*infrasound*". However, audibility extends to frequencies below 20 Hz.

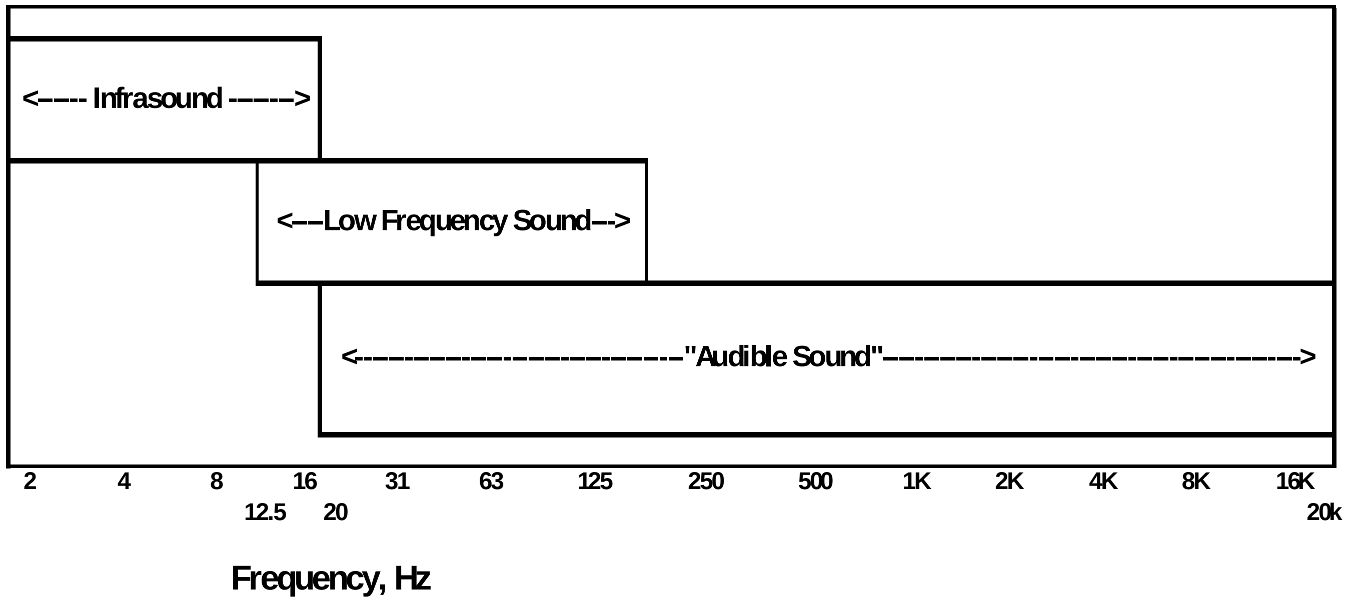
Low frequency sound has several definitions. American National Standards ANSI/ASA S12.2 and ANSI S12.9 Part 4 have provisions for evaluating low frequency noise, and these special treatments apply only to sounds in the octave bands with 16, 31.5, and 63-Hz mid-band frequencies. For these reasons, in this paper on wind turbine noise, we use the term "low frequency noise" to include 12.5 Hz – 200 Hz with emphasis on the 16 Hz, 31Hz and 63 Hz octave bands with a frequency range of 11 Hz to 89 Hz.

2.2 Infrasound

IEC 60050-801:1994 "International Electrotechnical Vocabulary – Chapter 801: Acoustics and electroacoustics" defines "*infrasound*" as "Acoustic oscillations whose frequency is below the low frequency limit of audible sound (about 16 Hz)." This definition is *incorrect* since sound remains audible at frequencies well below 16 Hz provided that the sound level is sufficiently high. In this paper we define infrasound to be below 20 Hz, which is the limit for the standardized threshold of hearing.

Figure 2.2-1 shows these frequency regions and their common labels. Since there is no sharp change in hearing at 20 Hz, the division into "low-frequency sound" and "infrasound" should only be considered "practical and conventional."

Figure 2.2-1 Frequency Range of "Infrasound", "Low Frequency Sound", and "Audible Sound".



3.0 EFFECTS OF LOW FREQUENCY SOUND AND INFRASOUND

3.1 Humans

3.1.1 Threshold of hearing

Moeller and Pedersen (2004) present an excellent summary on human perception of sound at frequencies below 200 Hz. The ear is the primary organ for sensing infrasound. Hearing becomes gradually less sensitive for decreasing frequencies. But, humans with a normal hearing organ can perceive infrasound at least down to a few hertz if the sound level is sufficiently high.

The threshold of hearing is standardized for frequencies down to 20 Hz (ISO 226:2003). Based on extensive research and data, Moeller and Pedersen propose normal hearing thresholds for frequencies below 20 Hz (see Figure 3.1-1). Moeller and Pedersen suggest that the curve for normal hearing is "probably correct within a few decibels, at least in most of the frequency range."

The hearing thresholds show considerable variability from individual to individual with a standard deviation among subjects of about 5 dB independent of frequency between 3 Hz and 1000 Hz with a slight increase at 20 – 50 Hz. This implies that the audibility threshold for 97.5% of the population is greater than the values in Figure 3.1-1 minus 10 dB and for 84% of the population is greater than the values in Figure 3.1-1 minus 5 dB. Moeller and Pedersen suggest using the pure-tone thresholds in Figure 3.1-1 for non-sinusoidal sound; this relationship is what is used in ISO 226 (International Organization for Standardization) for frequencies down to 20 Hz.

Below 20 Hz as frequency decreases, if the noise source is tonal, the tonal sensation ceases. Below 20 Hz tones are perceived as discontinuous. Below 10 Hz it is possible to perceive the single cycles of a tone, and the perception changes into a sensation of pressure at the ears.

3.1.2 Loudness

Below 100 Hz, the dynamic range of the auditory system decreases with decreasing frequency, and the compressed dynamic range has an effect on equal loudness contours: a slight change in sound level can change the perceived loudness from barely audible to loud. This combined with the large variation in individual hearing may mean that a low frequency sound that is inaudible to some may be audible to others, and may be relatively loud to some of those for whom it is audible. Loudness for low frequency sounds grows considerably faster above threshold than for sounds at higher frequencies. (Moeller and Pedersen, 2004)

3.1.3 Non-auditory perceptions

Non-auditory perception of low frequency and infrasound occurs only at levels above the auditory threshold. In the frequency range of 4 – 25 Hz and at "*levels 20 - 25 dB above [auditory] threshold it is possible to feel vibrations* in various parts of the body, e.g., the lumbar, buttock, thigh and calf regions. A feeling of pressure may occur in the upper part of the chest and the throat region" [emphasis added]. (Moeller and Pedersen, 2004).

3.2 Residential Structures

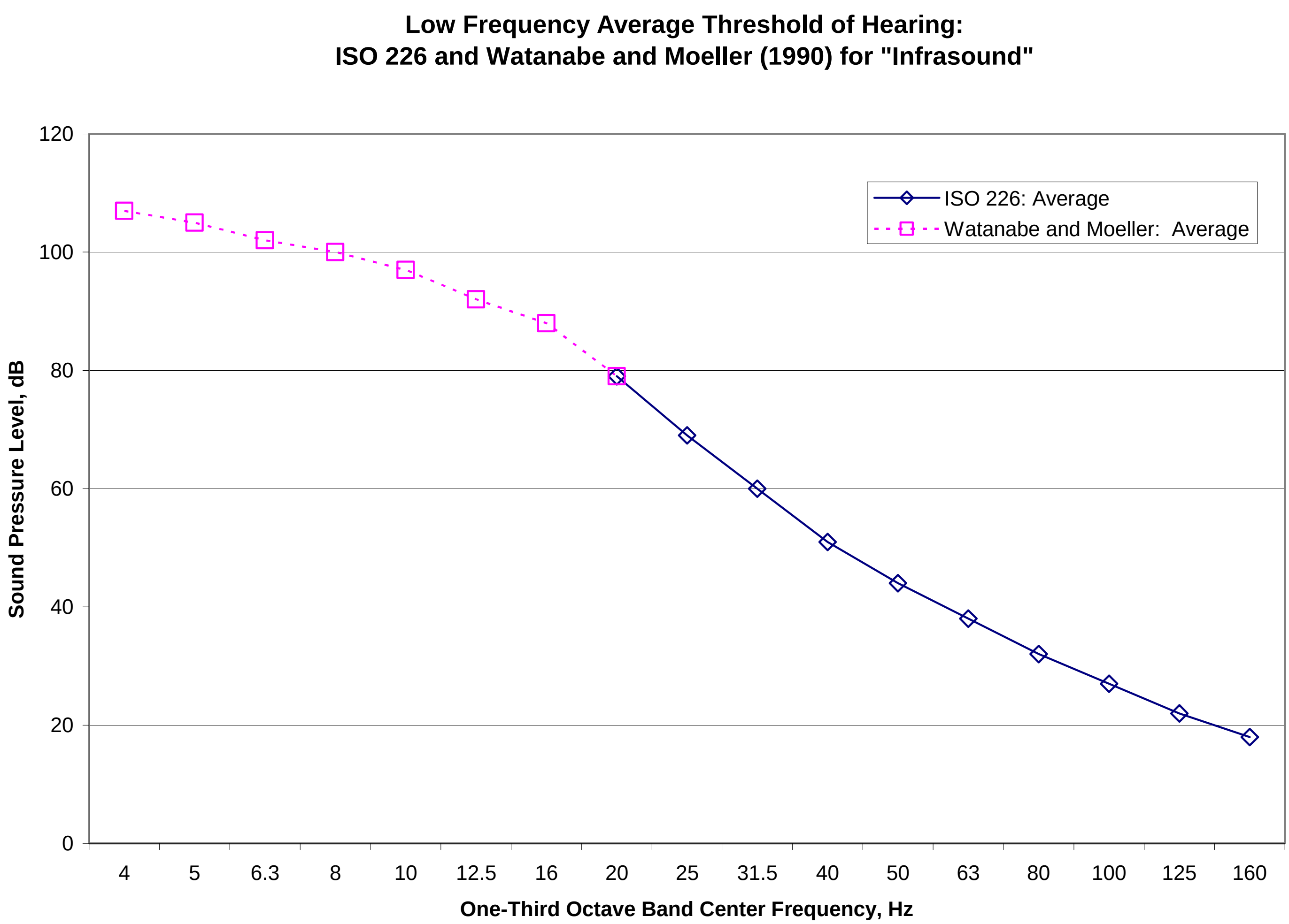
3.2.1 Airborne Vibration

Outdoor low frequency sounds of sufficient amplitude can cause building walls to vibrate and windows to rattle. Homes have low values of transmission loss at low frequencies, and low frequency noise of sufficient amplitude may be audible within homes. Window rattles are not low frequency noise, but may be caused by low frequency noise.

3.2.2 Ground borne Vibration

While not studied nearly as extensively as noise, a few papers were found that examined ground borne vibration from wind turbines (Styles, P. et al, 2005; Hayes McKenzie Partnership, 2006; Gastmeier and Howe (2008)). Measurement of ground borne vibration associated with wind turbine operations were detectable with instruments but were below the threshold of perception, even within the wind farm (Gastmeier and Howe 2008; Snow, D.J., 1997).

Figure 3.1-1 Low Frequency Average Threshold of Hearing



4.0 GUIDELINES AND CRITERIA

4.1 United States Government

There are no specific criteria for low frequency noise in the United States. The US Environmental Protection Agency (EPA) has guidelines for the protection of public health with an adequate margin of safety in terms of annual average A-weighted day-night average sound level (L_{dn}), but there are no corrections or adjustments for low frequency noise. The US Department of Transportation (DOT) has A-weighted sound pressure level criteria for highway projects and airports, but these do not have adjustments for low frequency noise.

4.2 American National Standards (voluntary)

4.2.1 ANSI/ASA S12.9-2007/Part 5

ANSI/ASA S12.9-2007/Part 5 "Quantities and Procedures for description and measurement of environmental sound. Part 5: Sound Level Descriptors for Determination of Compatible Land Use" has an informative annex which provides guidance for designation of land uses compatible with existing or predicted sound levels. The noise metric in ANSI S12.9 Part 5 is the annual average of the adjusted day-night average outdoor sound level (DNL). Ranges of the DNL are outlined, within which a specific region of compatibility may be drawn. These ranges take into consideration the transmission loss in sound level from outside to inside buildings as commonly constructed in that locality and living habits there. There are adjustments to day-night average sound level to account for the presence of low frequency noise, and the adjustments are described in ANSI S12.9 Part 4.

4.2.2 ANSI S12.9-2005/Part 4

ANSI S12.9-2005 Part 4 "Quantities and Procedures for description and measurement of environmental sound. Part 4: Noise assessment and prediction of long-term community response" provides procedures for assessing outdoor environmental sounds and provides for *adjustments* to measured or predicted adjusted annual outdoor day-night A-weighted sound level to account "for the change in annoyance caused by … sounds with strong low-frequency content…"

ANSI S12.9 Part 4 does not specifically define the frequency range for "low-frequency" sounds; however, evaluation methods for low frequency noise in Annex D use a sum of the sound pressure levels in the 16, 31 and 63 Hz octave bands. Procedures apply only when the difference in exterior C-weighted and A-weighted sound levels is greater than 10 dB, ($L_{pC} - L_{pA}$) > 10 dB. Complicated procedures are given for adjustments to L_{Aeq} and L_{dn} values. Adjustments are significant for high levels of low frequency sound.

ANSI S12.9 Part 4 states: "Generally, annoyance is minimal when octave-band sound pressure levels are less than 65 dB at 16, 31.5, and 63-Hz mid-band frequencies. However, low-frequency sound characterized by rapidly fluctuating amplitude ... may cause annoyance when these octave-band sound pressure levels are less than 65 dB."

For sounds with strong low-frequency content, adjusted sound exposure level (LNE) is calculated from low-frequency sound pressure level L_{LF} by:

$$LNE = 2(L_{LF} - 65) + 55 + 10\log(t/1)$$

$$= 2\,L_{LF} - 75 + 10\log(t/1) \qquad \text{(Equation D.1 of ANSI S12.9 Part 4)}$$

where L_{LF} is 10 times the logarithm of the ratio of time-mean square sound pressures in the 16, 31.5, and 63-Hz octave bands divided by the square of the reference sound pressure and

t is the time duration of interest, in seconds, over which the low-frequency sound is present.

The factor of 2 in equation (D.1) accounts for the rapid increase in annoyance with sound pressure level at low frequencies. ANSI S12.9 Part 4 states: "Equation (D.1) also accounts for the additional annoyance from rattles that begins when the low-frequency sound pressure level [L_{LF}] exceeds 75 dB." Later, ANSI S12.9/Part 4 has a contradictory recommendation: "To prevent the likelihood of noise-induced rattles, the low-frequency sound pressure level [L_{LF}] should be less than 70 dB."

ANSI S12.9 /Part 4 identifies two thresholds: annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each less than 65 dB and there are no rapidly fluctuations of the low frequency sounds. The second threshold is for increased annoyance which begins when rattles occur, which begins at L_{LF} 70 - 75 dB. Since determination of L_{LF} involves integrating concurrently the sound pressures in the three octave bands, an energy sum of the levels in each of these separate bands results in an upper bound to L_{LF}. (The sound pressure level from the summation of these bands will always be less than L_{LF} since the sound pressures are not in phase within these three bands.)

It should be noted that a recent study on low frequency noise from aircraft operations (Hodgdon, Atchley, Bernhard 2007) reported that an expert panel was critical of using this L_{LF} metric because it had not previously been used to characterize aircraft noise and its reliance on the 16 Hz band since aircraft data does not extend down to 16 Hz and can not be used with the FAA Integrated Noise Model.

The adjustment procedure for low frequency noise to the average annual A-weighted sound pressure level in ANSI S12.9 Part 4 uses a different and more complicated metric and procedure (Equation D.1) than those used for evaluating low frequency noise in rooms contained in ANSI/ASA S12.2. (See section 4.2.3). Since we are evaluating low frequency noise and not A-weighted levels, we do not recommend using the procedure for adjusting A-weighted levels. Instead we recommend using the following two guidelines from ANSI S12.4 Part 9: a sound pressure level of 65 dB in each of the 16-, 31.5-, and 63 Hz octave bands as an indicator of minimal annoyance, and 70 - 75 dB for the summation of the sound pressure levels from these three bands as an indicator of possible increased annoyance from rattles. This method is conservative since the sum of the levels in the three bands will always be less than L_{LF}.

4.2.3 ANSI/ASA S12.2-2008

ANSI/ASA S12.2-2008 discusses criteria for evaluating room noise, and has two separate provisions for evaluating low frequency noise: (1) the potential to cause perceptible vibration and rattles, and (2) meeting low frequency portions of room criteria curves.

Vibration and Rattles: Clause 6 and Table 6 of this standard contain limiting values of sound pressure levels for vibrations and rattles from low frequency noise. The frequency range is not defined, but limiting values and discussion relate only to octave-bands with center frequencies of 16, 31 and 63 Hz. This is the same narrow frequency range from low-frequency sounds as in ANSI S12.9/Part 4. Therefore, ANSI S12.9 Part 4 and ANSI/ASA S12.2 are consistent in evaluating and assessing low frequency sounds both for annoyance (interior and exterior measurements) and vibration (interior measurements) by using sound pressure levels only in the 16, 31 and 63 Hz octave-bands.

ANSI/ASA S12.2 presents limiting levels at low frequencies for assessing (a) the probability of *clearly* perceptible acoustically induced vibration and rattles in lightweight wall and ceiling constructions, and (b) the probability of *moderately* perceptible acoustically induced vibration in similar constructions. These 16, 31.5 and 63 Hz octave band sound pressure level values are presented in Table 4.2-1. One set of values is for when "clearly perceptible vibration and rattles" is likely, and a lower set of values is for when "moderately perceptible vibration and rattles" is likely.

Table 4.2-1 Measured interior sound pressure levels for perceptible vibration and rattle in lightweight wall and ceiling structures. [ANSI/ASA S12.2-2008]

Condition	Octave-band center frequency (Hz)		
	16	31.5	63
Clearly perceptible vibration and rattles likely	75 dB	75 dB	80 dB
Moderately perceptible vibration and rattles likely	65 dB	65 dB	70 dB

Since indoor measurements are not always possible, for comparison to outdoor sound levels the indoor criteria from ANSI/ASA S12.2 should be adjusted. Outdoor to indoor low frequency noise reductions have been reported by Sutherland for aircraft and highway noise for open and closed windows (Sutherland 1978) and by Hubbard for aircraft and wind turbine noise for closed windows (Hubbard 1991). Table 4.2-2 presents the average low frequency octave band noise reductions from outdoor to indoors from these two papers for open and closed windows. Sutherland only reported values down to 63 Hz; whereas Hubbard presented values to less than 10 Hz. The closed window conditions of Hubbard were used to estimate noise reductions less than 63 Hz by applying the difference between values for open and closed windows from Sutherland data at 63 Hz. It should be noted that the attenuation for wind turbines in Hubbard is based on only three homes at two different wind farms, whereas the traffic and aircraft data are for many homes. The wind turbine open window values were obtained from the wind turbine closed window values by subtracting the difference in values between windows closed and open obtained by Sutherland.

Table 4.2-2 Average low frequency octave band noise reductions from outdoor to indoors in dB (based on Sutherland (1978) and Hubbard (1991))

Noise Source	Window condition	Octave Band Center Frequency		
		16 Hz	31.5 Hz	63 Hz
Average aircraft and traffic sources	Closed windows	16	15	18
Average aircraft and traffic sources	Open Windows	(11)*	(10)*	12
Average Wind Turbine	Closed Windows	8	11	14
Average Wind Turbine	**Open Windows**	**(3)*+**	**(6)* +**	**9+**

* No data are available for windows open below 63 Hz octave band. The values for 16 Hz and 31 Hz were obtained by subtracting the difference between the levels for 63 Hz closed and open conditions to the 16 and 31 Hz closed values.

+ Used in this report to determine equivalent outdoor criteria from indoor criteria

To be conservative, we use the open window case instead of closed windows. To be further conservative, we use the wind turbine data (adjusted to open windows), which is based on only three homes. However, it should be noted that it is possible for some homes to have some slight amplification at low frequencies with windows open due to possible room resonances. Applying the outdoor to indoor attenuations for wind turbine sources with windows open given in the last row of Table 4.2-2 to the ANSI/ASA S12.2 indoor sound pressure levels in Table 4.2-1 yields the *equivalent* outdoor sound pressure levels that are consistent with the indoor criteria and are presented in Table 4.2-3.

Table 4.2-3 *Equivalent* outdoor sound pressure levels for perceptible vibration and rattle in lightweight wall and ceiling structures based on Tables 4.2-1 and 4.2-2 above for wind turbines.

Condition	Octave-band center frequency (Hz)		
	16	31.5	63
Clearly perceptible vibration and rattles likely	78 dB	81 dB	89 dB
Moderately perceptible vibration and rattles likely	68 dB	71 dB	79 dB

Room Criteria Curves: ANSI/ASA S12.2 has three primary methods for evaluating the suitability of noise within rooms: a survey method - A-weighted sound levels, an engineering method – noise criteria (NC) curves and a method for evaluating low-frequency fluctuating noise using room noise criteria (RNC) curves. "The RNC method should be used to determine noise ratings when the noise from HVAC systems at low frequencies is *loud* and is suspected of containing *sizeable fluctuations or surging*." [emphasis added] The NC curves are appropriate to evaluate low frequency noise from wind turbines in homes since wind turbine noise does not have significant fluctuating low frequency noise sufficient to warrant using RNC curves and since A-weighted sound levels do not adequately determine if there are low frequency problems. [ANSI/ASA S12.2. section 5.3 gives procedures for determining if there are large fluctuations of low frequency noise.]

Annex C.2 of this standard contains recommendations for bedrooms, which are the most stringent rooms in homes: NC and RNC criteria curve between 25 and 30. The recommended NC and RNC criteria for schools and private rooms in hospitals are the same. The values of the sound pressure levels in the 16 – 250 Hz octave bands for NC curves 25 and 30 are shown in Table 4.2-4.

Table 4.2-4 Octave band sound pressure levels for noise criteria curves NC-25 and NC-30. [From Table 1 of ANSI/ASA S12.2]

	Octave-band-center frequency in Hz				
	16	31.5	63	125	250
NC-25	80	65	54	44	37
NC-30	81	68	57	48	41

ANSI/ASA S12.2 also presents a method to determine if the levels below 500 Hz octave band are too high in relation to the levels in the mid-frequencies which could create a condition of "spectrum imbalance". The method for this evaluation is:

- Calculate the speech interference level (SIL) for the measured spectrum. [SIL is the arithmetic average of the sound pressure levels in the 500, 1000, 2000 and 4000 Hz octave bands.] Select the NC curve equal to the SIL value.

- Plot the measured spectra and the NC curve equal to the SIL value on the same graph and determine the differences between the two curves in the octave bands below 500 Hz.

- Estimate the likelihood that the excess low-frequency levels will annoy occupants of the space using Table 4.2-5.

Table 4.2-5 Measured sound pressure level deviations from an NC (SIL) curve that may lead to serious complaints [From ANSI/ASA S12.2:2008].

	Measured Spectrum – NC(SIL), dB			
Octave-band frequency, Hz =>	31.5	63	125	250
Possible serious dissatisfaction	*	6 - 9	6 - 9	6 - 9
Likely serious dissatisfaction	*	>9	>9	>9

*Insufficient data available to evaluate

4.3 Other Criteria

4.3.1 World Health Organization (WHO)

No specific low frequency noise criteria are proposed by the WHO. The Guidelines for Community Noise report (WHO, 1999) mentions that if the difference between dBC and dBA is greater than 10 decibels, then a frequency analysis should be performed to determine if there is a low frequency issue. A document prepared for the World Health Organization states that "there is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects. Infrasounds slightly above detection threshold may cause perceptual effects but these are of the same character as for 'normal' sounds. Reactions caused by extremely intense levels of infrasound can resemble those of mild stress reaction and may include bizarre auditory sensations, describable as pulsation and flutter" [Berglund (1995) p. 41]

4.3.2 The UK Department for Environment, Food, and Rural Affairs (DEFRA)

The report prepared by the University of Salford for the UK Department for Environment, Food, and Rural Affairs (DEFRA) on low frequency noise proposed one-third octave band sound pressure level L_{eq} criteria and procedures for assessing low frequency noise [DEFRA (2005)]. The guidelines are based on complaints of disturbance from low frequency sounds and are intended to be used by Environmental Health Officers. Reports by Hayes (2006) and others refer to the proposed criteria as "DEFRA criteria." Tables 4.3-1 and 4.3-2 present the DEFRA criteria for assessment of low frequency noise measured indoors. The criteria are "based on 5 dB below the ISO 226 (2003) average threshold of audibility for steady [low frequency] sounds." However, the DEFRA criteria are at 5 dB lower than ISO 226 only at 20 - 31.5 Hz; at higher frequencies the criteria are equal to the Swedish criteria which are higher levels than ISO 226 less 5 dB. For frequencies lower than 20 Hz, DEFRA uses the thresholds from Watanabe and Moeller (1990) less 5 dB. In developing the DEFRA guidelines, The University of Salford reviewed and considered existing low frequency noise criteria from several European countries.

The DEFRA criteria are based on measurements in an unoccupied room. Hayes Mackenzie (2006) noted that measurements should be made with windows closed; however, we conservatively used windows open conditions for our assessment. If the low frequency sound is "steady" then the criteria may be relaxed by 5 dB. A low frequency noise is considered steady if either of the conditions a) or b) below is met in the third octave band which exceeds the criteria by the greatest margin:

a) L_{10}-L_{90} < 5dB

b) the rate of change of sound pressure level (Fast time weighting) is less than 10 dB per second

Applying indoor to outdoor one-third octave band transfer functions for open windows (from analysis in Sutherland (1978) and Hubbard (1991) yields *equivalent* one-third octave band sound pressure level proposed DEFRA criteria for outdoor sound levels. Table 4.3-1 presents both the indoor DEFRA proposed criteria and equivalent proposed criteria for outdoors for non-steady low-frequency sounds. Table 4.3-2 presents the DEFRA proposed criteria for a steady low frequency sound.

Table 4.3-1 DEFRA proposed criteria for the assessment of low frequency noise disturbance: *indoor* and *equivalent outdoor* L_{eq} one-third sound pressure levels for *non-steady* low frequency sounds. [DEFRA (2005)]

Location	One-Third Octave Band Center Frequency, Hz												
	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Indoor L_{eq}, dB	92	87	83	74	64	56	49	43	42	40	38	36	34
Equivalent Outdoor L_{eq}, dB	94	89	86	78	68.5	61	56	51	51	49	47	45	43

Table 4.3-2 DEFRA criteria for the assessment of low frequency noise disturbance: *indoor* and *equivalent outdoor* L_{eq} one-third sound pressure levels for *steady* low frequency sounds. [DEFRA (2005)]

Location	One-Third Octave Band Center Frequency, Hz												
	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Indoor L_{eq}, dB	97	92	88	79	69	61	54	48	47	45	43	41	39
Equivalent Outdoor* L_{eq}, dB	99	94	91	83	73.5	66	61	56	56	54	52	50	48

* With windows open

4.3.3 C-weighted minus A-weighted (L_{pC}- L_{pA})

Leventhall (2003) and others indicate that the difference in C-weighted and A-weighted sound pressure levels can be a predictor of annoyance. Leventhall states that if (L_{pC} – L_{pA}) is greater than 20 dB there is "a potential for a low frequency noise problem." He further states that (L_{pC} – L_{pA}) cannot be a predictor of annoyance but is a simple indicator that further analysis may be needed. This is due in part to the fact that the low frequency noise may be inaudible even if (L_{pC} – L_{pA}) is greater than 20 dB.

4.3.4 Threshold of hearing

ISO 226:2003 gives one-third octave band threshold of hearing down to 20 Hz. Watanabe and Moeller (1990) have extended these to 10 Hz and lower, and the values are reported in Moeller and Pedersen (2004). Denmark has established low frequency noise criteria based on audibility. The Danish criteria are "based on hearing thresholds for the 10% most sensitive people in an ontologically unselected population aged 50-60 years. These 10% thresholds are typically about 4-5 dB lower than the average threshold for ontologically normal young adults (18-25 years) as given in ISO 226." [DEFRA (2005)]. Other reports indicate that the standard deviation of these thresholds is also about 5 dB. Table 4.3-3 presents one-third octave band threshold of hearing according to ISO 226 and Watanabe and Moeller. The second row in Table 4.3-3 presents the values that are 5 dB less than the threshold.

Table 4.3-3 Threshold of audibility from ISO 226 and Watanabe and Moeller (1990)

	One-Third Octave band center frequency, Hz																
	4	5	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Threshold	107	105	102	100	97	92	88	79	69	60	51	44	38	32	27	22	18
Threshold – 5 dB	102	100	97	95	92	87	83	74	64	55	46	39	33	27	22	17	13

The average threshold of hearing values in Table 4.3-3 are also shown in Figure 3.1-1.

4.3.5 Ground-Borne Vibration

ANSI S2.71-1983 (formerly ANSI S3.29-1983) presents recommendations for magnitudes of ground-borne vibration which humans will perceive and possibly react to within buildings. A basic rating is given for the most stringent conditions, which correspond to the approximate threshold of perception of the most sensitive humans. From the base rating, multiplication factors should be applied according to the location of the receiver; for continuous sources of vibration in residences at nighttime, the multiplication factor is 1.0 – 1.4.

ANSI S2.71-1983 presents one-third octave band acceleration or velocity ratings for z-axis, and x-, y-axis vibrations. For spaces in which the occupants may be sitting, standing, or lying at various times, the standard recommends using a combined axis rating which is obtained from the most stringent rating for each axis. Measurements in each of the 3 axes should be compared to the combined axis rating. Table 4.3-4 presents the base response velocity ratings for the combined axis. The velocity ratings are for root-mean-square (RMS) values.

Table 4.3-4 Base response one-third octave band RMS velocity ratings for the three biodynamic vibration axes and combined axis (From ANSI S2.71-1983 (R2006)

One-Third Octave band center frequency, Hz	Velocity (RMS), m/s		
	z axis	x, y axis	Combined axis
1	1.6×10^{-3}	5.7×10^{-4}	5.7×10^{-4}
1.25	1.1×10^{-3}	4.6×10^{-4}	4.6×10^{-4}
1.6	8.0×10^{-4}	3.6×10^{-4}	3.6×10^{-4}
2	5.6×10^{-4}	2.9×10^{-4}	2.9×10^{-4}
2.5	4.0×10^{-4}	2.9×10^{-4}	2.4×10^{-4}
3.15	2.9×10^{-4}	2.9×10^{-4}	2.1×10^{-4}
4	2.0×10^{-4}	2.9×10^{-4}	1.7×10^{-4}
5	1.6×10^{-4}	2.9×10^{-4}	1.4×10^{-4}
6.3	1.3×10^{-4}	2.9×10^{-4}	1.2×10^{-4}
8	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
10	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
12.5	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
16	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
20	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
25	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
31.5	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
40	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
50	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
63	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
80	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}

5.0 LITERATURE REVIEW

Epsilon performed an extensive literature search of over 100 scientific papers, technical reports and summary reports on low frequency sound and infrasound - hearing, effects, measurement, and criteria. The following paragraphs briefly summarize the findings from some of these papers and reports.

5.1 H. Moeller and C. S. Pedersen (2004)

Moeller and Pedersen (2004) present a comprehensive summary on hearing and non-auditory perception of sound at low and infrasonic regions, some of which has been cited in sections 3.1.1, 3.1.2, and 3.1.3 of this report.

5.2 Leventhall (2003)

Leventhall presents an excellent study on low frequency noise from all sources and its effects. The report presents criteria in place at that time. Included are figures and data relating cause and effects.

5.3 Leventhall (2006)

Leventhall reviewed data and allegations on alleged problems from low frequency noise and infrasound from wind turbines. Leventhall concluded the following: “It has been shown that there is insignificant infrasound from wind turbines and that there is normally little low frequency noise.” “Turbulent air inflow conditions cause enhanced levels of low frequency noise, which may be disturbing, but the overriding noise from wind turbines is the fluctuating audible swish, mistakenly referred to as “infrasound” or “low frequency noise”. “Infrasound from wind turbines is below the audible threshold and of no consequence”. Other studies have shown that wind turbine generated infrasound levels are below threshold of perception and threshold of feeling and body reaction.

5.4 Delta (2008)

The Danish Energy Authority project on “low frequency noise from large wind turbines” comprises a series of investigations in the effort to give increased knowledge on low frequency noise from wind turbines. One of the conclusions of the study is that wind turbines do not emit audible infrasound, with levels that are “far below the hearing threshold.” Audible low frequency sound may occur both indoors and outdoors, “but the levels in general are close to the hearing and/or masking level.” “In general the noise in the critical band up to 100 Hz is below both thresholds”. The summary report notes that for road traffic noise (in the vicinity of roads) the low frequency noise levels are higher [than wind turbine] both indoors and outdoors.

5.5 Hayes McKenzie (2006)

Hayes McKenzie performed a study for the UK Department of Trade & Industry (DTI) to investigate complaints of low frequency noise that came from three of the five farms with complaints out of 126 wind farms in the UK. The study concluded that:

- Infrasound associated with modern wind turbines is not a source which will result in noise levels that are audible or which may be injurious to the health of a wind farm neighbor.
- Low frequency noise was measureable on a few occasions, but below DEFRA criteria. Wind turbine noise may result in indoor noise levels within a home that is just above the threshold of audibility; however, it was lower than that of local road traffic noise.
- The common cause of the complaints was not associated with low frequency noise but the occasional audible modulation of aerodynamic noise, especially at night. Data collected indoors showed that the higher frequency modulated noise levels were insufficient to awaken the residents at the three sights; however, once awake, this noise could result in difficulties in returning to sleep.

The UK Department of Trade and Industry, which is now the UK Department for Business Enterprise and Regulatory Reform (BERR), summarized the Hayes McKenzie report: "The report concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines." [BERR (2007)]

5.6 Howe (2006)

Howe performed extensive studies on wind turbines and infrasound and concluded that infrasound was not an issue for modern wind turbine installations – "while infrasound can be generated by wind turbines, it is concluded that infrasound is not of concern to the health of residences located nearby." Since then Gastmeier and Howe (2008) investigated an additional situation involving the alleged "perception of infrasound by individual." In this additional case, the measured indoor infrasound was at least 30 dB below the perception threshold given by Watanabe and Moeller (1990) as presented in Table 4.3-3. Gastmeier and Howe (2008) also performed vibration measurements at the residence and nearest wind turbine, and concluded that the vibration levels were well below the perception limits discussed in ISO 2631-2.

5.7 Branco (2004)

Branco and other Portuguese researchers have studied possible physiological affects associated with high amplitude low frequency noise and have labeled these alleged effects as "Vibroacoustic Disease" (VAD). "Vibroacoustic disease (VAD) is a whole-body, systemic pathology, characterized by the abnormal proliferation of extra-cellular matrices, and caused by excessive exposure to low frequency noise." Hayes (2007, 2008) concluded that levels from wind farms are not likely to cause VAD after comparing noise levels from alleged VAD cases to noise levels from wind turbines in homes of complainers. Noise levels in aircraft in which VAD has been hypothesized are considerably higher than wind turbine noise levels. Hayes also concluded that it is "unlikely that symptoms will result through induced internal vibration from incident wind farm noise." [Hayes (2007)] Other studies have found no VAD indicators in environmental sound that have been alleged by VAD proponents. [ERG (2001)]

5.8 French National Academy of Medicine (2006)

French National Academy of Medicine recommended "*as a precaution* construction should be suspended for wind turbines with a capacity exceeding 2.5 MW located within 1500 m of homes." [emphasis added] However, this precaution is not because of definitive health issues but because:

- sound levels one km from some wind turbine installations "occasionally exceed allowable limits" for France (note that the allowable limits are long term averages)
- French prediction tools for assessment did not take into account sound levels created with wind speeds greater than 5 m/s.
- Wind turbine noise has been compared to aircraft noise (even though the sound levels of wind turbine noise are significantly lower), and exposure to high level aircraft noise "involves neurobiological reactions associated with an increased frequency of hypertension and cardiovascular illness. Unfortunately, no such study has been done near wind turbines." [Gueniot (2006)].

In March 2008, the French Agency for Environmental and Occupational Health Safety (AFSSET) published a report on "the health impacts of noise generated by wind turbines", commissioned by the Ministries of Health and Environment in June 2006 following the report of the French National Academy of Medicine in March 2006. [AFSSET (2008)] The AFSSET study recommends that one does not define a fixed distance between wind farms and homes, but rather to model the acoustic impact of the project on a case-by-case basis. One of the conclusions of the AFSSET report is: "The analysis of available data shows: The absence of identified direct health consequences concerning the auditory effects or specific effects usually associated with exposure to low frequencies at high level." ("L'analyse des données disponibles met en évidence: L'absence de conséquences sanitaires directes recensées en ce qui concerne les effets auditifs, ou les effets spécifiques généralement attachés à l'exposition à des basses fréquences à niveau élevé.")

6.0 REPRESENTATIVE WIND TURBINES

At the direction of NextEra, two types of utility-scale wind turbines were studied:

- General Electric (GE) 1.5sle (1.5 MW), and
- Siemens SWT-2.3-93 (2.3 MW).

Typical hub height for these wind turbines is 80 meters above ground level (AGL).

Sound levels for these wind turbine generators (WTGs) vary as a function of wind speed from cut-in wind speed to maximum sound level. Table 6.0-1 below lists the reference sound power levels of each WTG as a function of wind speed at 10 meters AGL as provided by the manufacturer. This is in conformance with the sound level standard for wind turbines [IEC 61400-11].

Table 6.0-1 Sound power levels as a Function of Wind Speed (dBA)

Wind Speed at 10 meters AGL (m/s)	GE 1.5 sle 80 m hub height; 77 m rotor diameter	Siemens SWT-2.3-93 80 m hub height; 92.4 m rotor diameter
3	<96	ND
4	<96	ND
5	99.1	99
6	103.0	103.4
7	K104	104.9
8	K104	105.1
9	K104	105.0
10	K104	105.0

ND = No Data available

Each wind turbine manufacturer applied the uncertainty factor K of 2 dBA to guarantee the turbine's sound power level. (According to IEC TS 61400-14, K accounts for both measurement variations and production variation.) The results in Section 8.0 use the manufacturer's guaranteed value, that is, 2 dBA above the levels in Table 6.0-1.

One-third octave band sound power level data have also been provided for each turbine reflective of the highest A-weighted level (typically a wind speed of 8 m/s or greater at 10 m AGL). These data are reference (not guaranteed) data, and are summarized below in Table 6.0-2. Cut-in wind speed for the GE 1.5 sle wind turbine is 3.5 m/s while the Siemens wind turbine has a cut-in wind speed of 4 m/s. The last two rows in Table 6.0-2 contain the overall A-weighted sound power levels from Table 6.0-1 and the guaranteed values.

Table 6.0-2 One-Third Octave Sound Power Levels at 8 m/s (un-weighted, dB)

1/3 Octave Band Center Frequency, Hz	GE 1.5 sle 80 m hub height; 77 m rotor diameter	Siemens SWT-2.3-93 80 m hub height; 92.4 m rotor diameter
25	ND	109.0
31.5	ND	105.7
40	ND	105.3
50	106.4	105.3
63	106.1	104.8
80	105.1	104.7
100	103.9	104.8
125	102.8	105.3
160	105.8	103.2
200	101.6	103.7
250	100.6	105.0
315	100.6	102.5
400	99.1	100.2
500	97.0	97.8
630	95.1	95.8
800	94.8	93.5
1000	92.8	92.7
1250	91.7	90.6
1600	90.5	88.2
2000	88.4	87.1
2500	85.8	85.6
3150	83.6	83.9
4000	81.2	82.1
5000	78.1	80.8
6300	76.0	79.9
8000	72.4	79.4
10000	73.3	80.0
Overall - Reference	104 dBA	105 dBA
Guaranteed	106 dBA	107 dBA

ND = No data provided.

7.0 FIELD PROGRAM

Real-world data were collected from operating wind turbines to compare to the low frequency noise guidelines and criteria discussed previously in Section 4.0. These data sets consisted of outdoor measurements at various reference distances, and concurrent indoor/outdoor measurements at residences within the wind farm. Epsilon determined all means, methods, and the testing protocol without interference or direction from NextEra. No limitations were placed on Epsilon by NextEra with respect to the testing protocol or upon the analysis methods.

7.1 GE 1.5sle and Siemens SWT-2.3-93

Field measurements were conducted in order to measure sound levels at operating wind turbines, and compare them to the guidelines and criteria discussed in this report. NextEra provided access to the Horse Hollow Wind Farm in Taylor and Nolan Counties, Texas in November 2008 to collect data on the GE 1.5 sle and Siemens SWT-2.3-93 wind turbines. The portion of the wind farm used for testing is relatively flat with no significant terrain. The land around the wind turbines is rural and primarily used for agriculture and cattle grazing. The siting of the sound level measurement locations was chosen to minimize local noise sources except the wind turbines and the wind itself.

Two noise consultants collected sound level and wind speed data over the course of one week under a variety of operational conditions. Weather conditions were dry the entire week with ground level winds ranging from calm to 28 mph (1-minute average). In order to minimize confounding factors, the data collection tried to focus on periods of maximum sound levels from the wind turbines (moderate to high hub height winds) and light to moderate ground level winds.

Ground level (2 meters AGL) wind speed and direction were measured continuously at one representative location. Wind speeds near hub height were also measured continuously using the permanent meteorological towers maintained by the wind farm.

A series of simultaneous interior and exterior sound level measurements were made at four houses owned by participating landowners within the wind farm. Two sets were made of the GE WTGs, and two sets were made of the Siemens WTGs. Data were collected with both windows open and windows closed. Due to the necessity of coordinating with the homeowners in advance, and reasonable restrictions of time of day to enter their homes, the interior/exterior measurement data sets do not always represent ideal conditions. However, enough data were collected to compare to the criteria and draw conclusions on low frequency noise.

Sound level measurements were also made simultaneously at two reference distances from a string of wind turbines under a variety of wind conditions. Using the manufacturer's sound level data discussed in Section 6.0, calculations of the sound pressure levels as a function of distance in flat terrain were made to aid in deciding where to collect data in the field. Based on this analysis, two distances from the nearest wind turbine were selected - 1000 feet and 1500 feet - and were then used where possible during the field program.

Distances much larger than 1,500 feet were not practical since an adjacent turbine string could be closer and affect the measurements, or would put the measurements beyond the boundaries of the wind farm property owners. Brief background sound level measurements were conducted several times during the program whereby the Horse Hollow Wind Farm operators were able to shutdown the nearby WTGs for a brief (20 minutes) period. This was done in real time using cell phone communication.

All the sound level measurements described above were attended by the noise consultants. One series of unattended overnight measurements was made at two locations for approximately 15 hours to capture a larger data set. One measurement was set up approximately 1,000 feet from a GE 1.5 sle WTG and the other was set up approximately 1,000 feet from a Siemens WTG. The location was chosen based on the current wind direction forecast so that the sound level equipment would be downwind for the majority of the monitoring period. By doing this, the program was able to capture periods of strong hub-height winds and moderate to low ground-level winds.

Ground-borne vibration measurements were made within the Horse Hollow Wind Farm. Measurements were made 400 feet and 1000 feet downwind from both GE 1.5 sle and Siemens 2.3 MW WTGs under full operation. In addition, background vibration measurements were made with the WTGs briefly shutdown.

7.2 Measurement Equipment

Ground level wind speed and direction were measured with a HOBO H21-002 micro weather station (Onset Computer Corporation). The data were sampled every three seconds and logged every one minute. All sound levels were measured using two Norsonic Model Nor140 precision sound analyzers, equipped with a Norsonic-1209 Type 1 Preamplifier, a Norsonic-1225 half-inch microphone and a 7-inch Aco-Pacific untreated foam windscreen Model WS7. The instrumentation meets the "Type 1 - Precision" requirements set forth in American National Standards Institute (ANSI) S1.4 for acoustical measuring devices. The microphone was tripod-mounted at a height of five feet above ground. The measurements included simultaneous collection of broadband (A-weighted) and one-third-octave band data (0.4 hertz to 20,000 hertz bands). Sound level data were primarily logged in 10-minute intervals to be consistent with the wind farm's Supervisory Control And Data Acquisition (SCADA) system which provides power output (kW) in 10-minute increments. A few sound level measurements were logged using 20-miute intervals. The meters were calibrated and certified as accurate to standards set by the National Institute of Standards and Technology. These calibrations were conducted by an independent laboratory within the past 12 months.

The ground-borne vibration measurements were made using an Instantel Minimate Plus vibration and overpressure monitor. A triaxial geophone inserted in the ground measured the particle velocity (PPV). Each measurement was 20 seconds in duration and all data were stored in memory for later retrieval.

8.0 RESULTS AND COMPARISON TO CRITERIA

Results from the field program are organized by wind turbine type. For each wind turbine type, results are presented per location type (outdoor or indoor) with respect to applicable criteria. Results are presented for 1,000 feet from the nearest wind turbine. Data were also collected at 1,500 feet from the nearest wind turbine which showed lower sound levels. Therefore, wind turbines that met the criteria at 1,000 feet also met it at 1,500 feet. Data were collected under both high turbine output and moderate turbine output conditions, and low ground-level wind speeds (defined as sound power levels 2 or 3 dBA less than the maximum sound power levels). The sound level data under the moderate conditions were equivalent to or lower than the high turbine output scenarios, thus confirming the conclusions from the high output cases. A-weighted sound power levels presented in this section (used to describe turbine operation) were estimated from the actual measured power output (kW) of the wind turbines and the sound power levels as a function of wind speed presented in Table 6.0-1 plus an adjustment factor of 2 dBA (correction from reference values to guaranteed values).

Outdoor measurements are compared to criteria for audibility, for UK DEFRA disturbance using equivalent outdoor levels, for rattle and annoyance criteria as contained in ANSI S12.9 Part 4, and for perceptible vibration using equivalent outdoor levels from ANSI/ASA S12.2. Indoor measurements are compared to criteria for audibility, for UK DEFRA disturbance, and for suitability of bedrooms, hospitals and schools and perceptible vibration from ANSI/ASA S12.2.

8.0.1 Audibility

The threshold of audibility criteria discussed in section 4.3.4 is used to evaluate wind turbine sound levels. The audibility of wind turbines both outdoors and indoors was examined.

8.0.2 UK DEFRA Disturbance Criteria

The DEFRA one-third octave band sound pressure level L_{eq} criteria and procedures for assessing disturbance from low frequency noise (see section 4.3.2) were examined. The indoor criteria and equivalent outdoor criteria were compared to measured low frequency noise from wind turbines.

8.0.3 Perceptible Vibration, Rattle and Annoyance – Outdoor Measurements

The ANSI/ASA S12.2 interior perceptible vibration criteria were converted to equivalent outdoor criteria as discussed in section 4.2.3 and compared to the measured low frequency noise from wind turbines. In addition, measured data were compared to ANSI S12.9 Part 4 low frequency sound levels for minimal annoyance and for the threshold for beginning of rattles as described in section 4.2.2.

8.0.4 ANSI/ASA S12.2 Low Frequency Criteria – Indoor Measurements

The ANSI/ASA S12.2 interior perceptible vibration criteria and low frequency portions of the room criteria for evaluating the suitability of noises in bedrooms, hospitals and schools were compared to indoor measurements of low frequency noise from wind turbines. (See section 4.2.3.)

8.1 Siemens SWT-2.3-93

8.1.1 Outdoor Measurements - Siemens SWT-2.3-93

Several periods of high wind turbine output and relatively low ground wind speed (which minimized effects of wind noise) were measured outdoors approximately 1,000 feet from the closest Siemens WTG. This site was actually part of a string of 15 WTGS, four of which were within 2,000 feet of the monitoring location. The sound level data presented herein include contributions from all wind turbines as measured by the recording equipment. The key operational and meteorological parameters during these measurements are listed in Table 8.1-1

Table 8.1-1 Summary of Operational Parameters – Siemens SWT-2.3-93 (Outdoor)

Parameter	Sample #34	Sample #39
Distance to nearest WTG	1,000 feet	1,000 feet
Time of day	22:00-22:10	22:50-23:00
WTG power output	1,847 kW	1,608 kW
Sound power	107 dBA	106.8 dBA
Measured wind speed @ 2 m	3.3 m/s	3.4 m/s
L_{Aeq}	49.4 dBA	49.6 dBA
L_{A90}	48.4 dBA	48.6 dBA
L_{Ceq}	63.5 dBC	63.2 dBC

8.1.1.1 Outdoor Audibility

Figure 8.1-1 plots the one-third octave band sound levels (L_{eq}) for both samples of high output conditions. The results show that infrasound is inaudible to even the most sensitive people 1,000 feet from these wind turbines (more than 20 dB below the median thresholds of hearing). Low frequency sound above 40 Hz may be audible depending on background sound levels.

8.1.1.2 UK DEFRA Disturbance Criteria – Outdoor measurements

Figure 8.1-2 plots the one-third octave band sound levels (L_{eq}) for both samples of high output conditions. The low frequency sound was “steady” according to DEFRA procedures, and the results show that all outdoor equivalent DEFRA disturbance criteria are met.

8.1.1.3 Perceptible Vibration, Rattle and Annoyance – Outdoor Measurements

Figure 8.1-3 plots the 16, 31.5, and 63 Hz octave band sound levels (L_{eq}) for both samples of high output conditions. The results show that all outdoor equivalent ANSI/ASA S12.2 perceptible vibration criteria are met. The low frequency sound levels are below the ANSI S12.9 Part 4 thresholds for the beginning of rattles (16, 31.5, 63 Hz total less than 70 dB), and the 31.5 and 63 Hz sound levels are below the level of 65 dB identified for minimal annoyance in ANSI S12.9 Part 4, and the 16 Hz sound level is within 1.5 dB of this level, which is an insignificant increase since the levels were not rapidly fluctuating.

8.1.2 Indoor Measurements - Siemens SWT-2.3-93

Simultaneous outdoor and indoor measurements were made at two residences at different locations within the wind farm to determine indoor audibility of low frequency noise from Siemens WTGs. In each house measurements were made in a room facing the wind turbines, and were made with either window open or closed. These residences are designated Homes “A” and “D” and were approximately 1,000 feet from the closest Siemens WTG. Both homes were near a string of multiple WTGS, four of which were within 2,000 feet of the house. The sound level data presented herein include contributions from all wind turbines as measured by the recording equipment. The key operational and meteorological parameters during these measurements are listed in Table 8.1-2.

Table 8.1-2 Summary of Operational Parameters – Siemens SWT-2.3-93 (Indoor)

Parameter	Home “A” (closed / open)	Home “D” (closed / open)
Distance to nearest WTG	1,060 feet	920 feet
Time of day	7:39-7:49 / 7:51-8:01	16:16-16:26 / 16:30 -16:40
WTG power output	1,884 kW / 1564 kW	2,301 kW / 2299 kW
Sound power	107 dBA / 106.7 dBA	107 dBA / 107 dBA
Measured wind speed @ 2 m	3.2 m/s / 3.7 m/s	9.6 m/s / 8.8 m/s
L_{Aeq}	33.8 dBA /38.1 dBA	35.0 dBA / 36.7 dBA
L_{A90}	28.1 dBA / 36.8 dBA	29.6 dBA / 31.2 dBA
L_{Ceq}	54.7 dBC / 57.1 dBC	52.8 dBC / 52.5 dBC

8.1.2.1 Indoor Audibility

Figure 8.1-4a plots the indoor one-third octave band sound levels (L_{eq}) for Home “A”, and Figure 8.1-4b plots the indoor one-third octave band sound levels for Home “D”. The results show that infrasound is inaudible to even the most sensitive people 1,000 feet from these wind turbines with the windows open or closed (more than 20 dB below the median thresholds of hearing). Low frequency sound at or above 50 Hz may be audible depending on background sound levels.

8.1.2.2 UK DEFRA Disturbance Criteria – Indoor Measurements

Figure 8.1-5a plots the indoor one-third octave band sound levels (L_{eq}) for Home "A". The low frequency sound was "steady" according to DEFRA procedures, and the results show that all outdoor equivalent DEFRA disturbance criteria are met. Figure 8.1-5b plots the indoor one-third octave band sound levels (L_{eq}) for Home "D". According to DEFRA procedures, the low frequency sound was not "steady" and therefore the data were compared to both criteria. The results show the DEFRA disturbance criteria were met for steady low frequency sounds, the DEFRA criteria were met for unsteady low frequency sounds except for the 125 Hz band, which was within 1 dB, which is an insignificant difference.

8.1.2.3 ANSI/ASA S12.2 Low Frequency Criteria – Indoor Measurements

Figure 8.1-6a plots the indoor 16 Hz to 125 Hz octave band sound levels (L_{eq}) for Home "A", and Figure 8.1-6b plots the indoor 16 Hz to 125 Hz octave band sound levels (L_{eq}) for Home "D". The results show the ANSI/ASA S12.2 low frequency criteria were easily met for both windows open and closed scenarios. The ANSI/ASA S12.2 low frequency criteria for bedrooms, classrooms and hospitals were met, the spectrum was balanced, and the criteria for moderately perceptible vibrations in light-weight walls and ceilings were also met.

8.2 GE 1.5sle

8.2.1 Outdoor Measurements - GE 1.5sle

Several periods of high wind turbine output and relatively low ground wind speed (which minimized effects of wind noise) were measured outdoors approximately 1,000 feet from the closest GE 1.5 sle WTG. This site was actually part of a string of more than 30 WTGS, four of which were within 2,000 feet of the monitoring location. The sound level data presented herein include contributions from all wind turbines as measured by the recording equipment. The key operational and meteorological parameters for these measurements are listed in Table 8.2-1.

Table 8.2-1 Summary of Operational Parameters – GE 1.5sle (Outdoor)

Parameter	Sample #46	Sample #51
Distance to nearest WTG	1,000 feet	1,000 feet
Time of day	23:10-23:20	00:00-00:10
WTG power output	1,293 kW	1,109 kW
Sound power	106 dBA	106 dBA
Measured wind speed @ 2 m	4.1 m/s	3.3 m/s
L_{Aeq}	50.2 dBA	50.7 dBA
L_{A90}	49.2 dBA	49.7 dBA
L_{Ceq}	62.5 dBC	62.8 dBC

8.2.1.1 Outdoor Audibility

Figure 8.2-1 plots the one-third octave band sound levels (L_{eq}) for both samples of high output conditions. The results show that infrasound is inaudible to even the most sensitive people 1,000 feet from these wind turbines (more than 20 dB below the median thresholds of hearing). Low frequency sound at and above 31.5 - 40 Hz may be audible depending on background sound levels.

8.2.1.2 UK DEFRA Disturbance Criteria – Outdoor measurements

Figure 8.2-2 plots the one-third octave band sound levels (L_{eq}) for both samples of high output conditions. The low frequency sound was "steady" according to DEFRA procedures, and the results show the low frequency sound meet or are within 1 dB of outdoor equivalent DEFRA disturbance criteria.

8.2.1.3 Perceptible Vibration, Rattle and Annoyance – Outdoor Measurements

Figure 8.2-3 plots the 16, 31.5, and 63 Hz octave band sound levels (L_{eq}) for both samples of high output conditions. The results show that all outdoor equivalent ANSI/ASA S12.2 perceptible vibration criteria are met. The low frequency sound levels are below the ANSI S12.9 Part 4 thresholds for the beginning of rattles (16, 31.5, 63 Hz total less than 70 dB), and the 16, 31.5, 63 Hz sound levels are below the level of 65 dB identified for minimal annoyance in ANSI S12.9 Part 4.

8.2.2 Indoor Measurements - GE 1.5sle

Simultaneous outdoor and indoor measurements were made at two residences at different locations within the wind farm to determine indoor audibility of low frequency noise from GE 1.5sle WTGs. In each house, measurements were made in a room facing the wind turbines, and were made with window either open or closed. These residences are designated Homes "B" and "C" and were approximately 1,000 feet from the closest Siemens WTG. Operational conditions were maximum turbine noise and high ground winds at Home "B", and within 1.5 dBA of maximum turbine noise and high ground level winds at Home "C". Home "B" was near a string of multiple WTGs, four of which were within 2,000 feet of the house, while Home "C" was at the end of a string of WTGs, two of which were within 2,000 feet of the house. The sound level data presented herein include contributions from all wind turbines as measured by the recording equipment. The key operational and meteorological parameters during these measurements are listed in Table 8.2-2.

Table 8.2-2 Summary of Operational Parameters – GE 1.5sle (Indoor)

Parameter	Home "B" (closed / open)	Home "C" (closed / open)
Distance to nearest WTG	950 feet	1,025 feet
Time of day	9:29-9:39 / 9:40-9:50	11:49-11:59 / 12:00-12:10
WTG power output	1,017 kW / 896 kW	651 kW / 632 kW
Sound power	106 dBA / 105.8 dBA	104.7 dBA / 104.6 dBA
Measured wind speed @ 2 m	6.2 m/s / 6.8 m/s	6.4 m/s / 5.9 m/s
L_{Aeq}	27.1 dBA / 36.0 dBA	33.6 dBA / 39.8 dBA
L_{A90}	23.5 dBA / 33.7 dBA	27.6 dBA / 34.2 dBA
L_{Ceq}	47.1 dBC / 54.4 dBC	50.6 dBC / 55.1 dBC

8.2.2.1 Indoor Audibility

Figure 8.2-4a plots the indoor one-third octave band sound levels (L_{eq}) for Home "B", and Figure 8.2-4b plots the indoor one-third octave band sound levels for Home "C". The results show that infrasound is inaudible to even the most sensitive people 1,000 feet from these wind turbines with the windows open or closed (more than 20 dB below the median thresholds of hearing). Low frequency sound at and above 63 Hz may be audible depending on background sound levels.

8.2.2.2 UK DEFRA Disturbance Criteria – Indoor Measurements

Figure 8.2-5a plots the indoor one-third octave band sound levels (L_{eq}) for Home "B", and Figure 8.2-5b plots the indoor one-third octave band sound levels (L_{eq}) for Home "C". The results show the DEFRA disturbance criteria were met for steady and non-steady low frequency sounds.

8.2.2.3 ANSI/ASA S12.2 Low Frequency Criteria – Indoor Measurements

Figure 8.2-6a plots the indoor 16 Hz to 125 Hz octave band sound levels (L_{eq}) for Home "B", and Figure 8.2-6b plots the indoor 16 Hz to 125 Hz octave band sound levels (L_{eq}) for Home "C". The results show the ANSI/ASA S12.2 low frequency criteria were met for both windows open and closed scenarios. The ANSI/ASA S12.2 low frequency criteria for bedrooms, classrooms and hospitals were met, the spectrum was balanced, and the criteria for moderately perceptible vibrations in light-weight walls and ceilings were also met.

8.3 Noise Reduction from Outdoor to Indoor

Simultaneous outdoor and indoor measurements were made at four residences within the Horse Hollow Wind Farm to determine noise reductions of the homes for comparison to that used in the determination of equivalent outdoor criteria for indoor criteria, such as ANSI/ASA S12.2 and DEFRA. Indoor measurements were made with windows open and closed. Tables 8.1-2 and 8.2-2 list the conditions of measurement for these houses.

The outdoor sound level data at Home "D" was heavily influenced by high ground winds – the measured levels were higher due to the effect of the wind on the microphone or the measurement of wind effect noise; therefore the data from Home "D" was not used in the comparison of noise reduction, since it would over estimate actual noise reduction.

Figures 8.3-1a and 8.3-1b present the measured one-third octave band noise reduction for the three homes with windows closed and open, respectively. Also presented in these same figures are the one-third octave noise reductions used in Section 4 of this report to obtain equivalent outdoor criteria for the indoor DEFRA criteria ("Table 4.3-1 Noise Reduction - Open Window"). It can be seen that for the window closed condition in Figure 8.3-1a, the measured noise reductions for all houses were greater than that used in our analysis as described in Section 4. For the open window case, the average of the three homes has a greater noise reduction than used in Section 4 and all houses at all frequencies have higher values with one minor exception. Only Home "A" at 25 Hz had a lower noise reduction (3dB), and this difference is not critical since the measured indoor sounds at 25 Hz at each of these home was significantly lower than the indoor DEFRA criteria. Furthermore, the outdoor measurements for both Siemens and GE wind turbines at 1000 feet under high output/high noise levels met the equivalent outdoor DEFRA criteria at 25 Hz.

Table 8.3-1 presents the measured octave band noise reduction for the three homes with windows closed and open, respectively. Also presented in Table 8.3-1 are the octave band noise reductions used in Table 4.2-2 of this report to obtain equivalent outdoor criteria for the indoor ANSI/ASA S12.2 criteria for perceptible vibration. It can be seen that for the window closed condition, the measured noise reductions for all houses were greater than that used in our analysis as described in Section 4. For the open window case, the average of the three homes has a greater noise reduction than used in Section 4 and all houses at all frequencies have higher values with one minor exception. Only Home "A" at 31 Hz (which contains the 25 Hz one-third octave band) had a lower noise reduction (3dB), and this difference is not critical since the measured indoor sounds at 31 Hz at each of these homes was significantly lower than the indoor ANSI/ASA S12.2 criteria. Furthermore, the outdoor measurements for both Siemens and GE wind turbines at 1000 feet under high output/high noise levels met the equivalent outdoor ANSI/ASA S12.2 criteria at 31 Hz.

Table 8.3-1 Summary of Octave Band Noise Reduction – Interior Measurements

Home	Wind Turbine	Windows	16 Hz	31.5 Hz	63 Hz
A	Siemens SWT-2-3-93	Closed	5	6	16
A	Siemens SWT-2-3-93	Open	4	3	12
B	GE 1.5 sle	Closed	20	22	22
B	GE 1.5 sle	Open	13	17	18
C	GE 1.5 sle	Closed	13	14	19
C	GE 1.5 sle	Open	8	13	17
Table 4.2-2 Noise Reduction		Open	3	6	9

8.4 Ground-Borne Vibration

Seven sets of ground-borne vibration measurements were made from Siemens 2.3 and GE 1.5sle wind turbines. The maximum ground-borne vibration RMS particle velocities were 0.071 mm/second (0.0028 inches/second) in the 8 Hz one-third octave band. This was measured 1000 feet downwind from a GE 1.5sle WTG under maximum power output and high wind at the ground. The background ground-borne vibration RMS particle velocity at the same location approximately 20 minutes beforehand was 0.085 mm/sec. Both of these measurements meet ANSI S2.71 recommendations for perceptible vibration in residences during night time hours. Soil conditions were soft earth representative of an active agricultural use. These vibration levels are nearly three orders of magnitude below the level of 0.75 inches/second set to prevent damage to residential structures. No perceptible vibration was felt from operation of the wind turbines. Measurements at the other sites and as close as 400 feet were significantly lower than the above measurements under high wind conditions.

Figure 8.1-1 Siemens SWT-2.3-93 Wind Turbine Outdoor Sound Levels at 1000 feet compared to Audibility Criteria

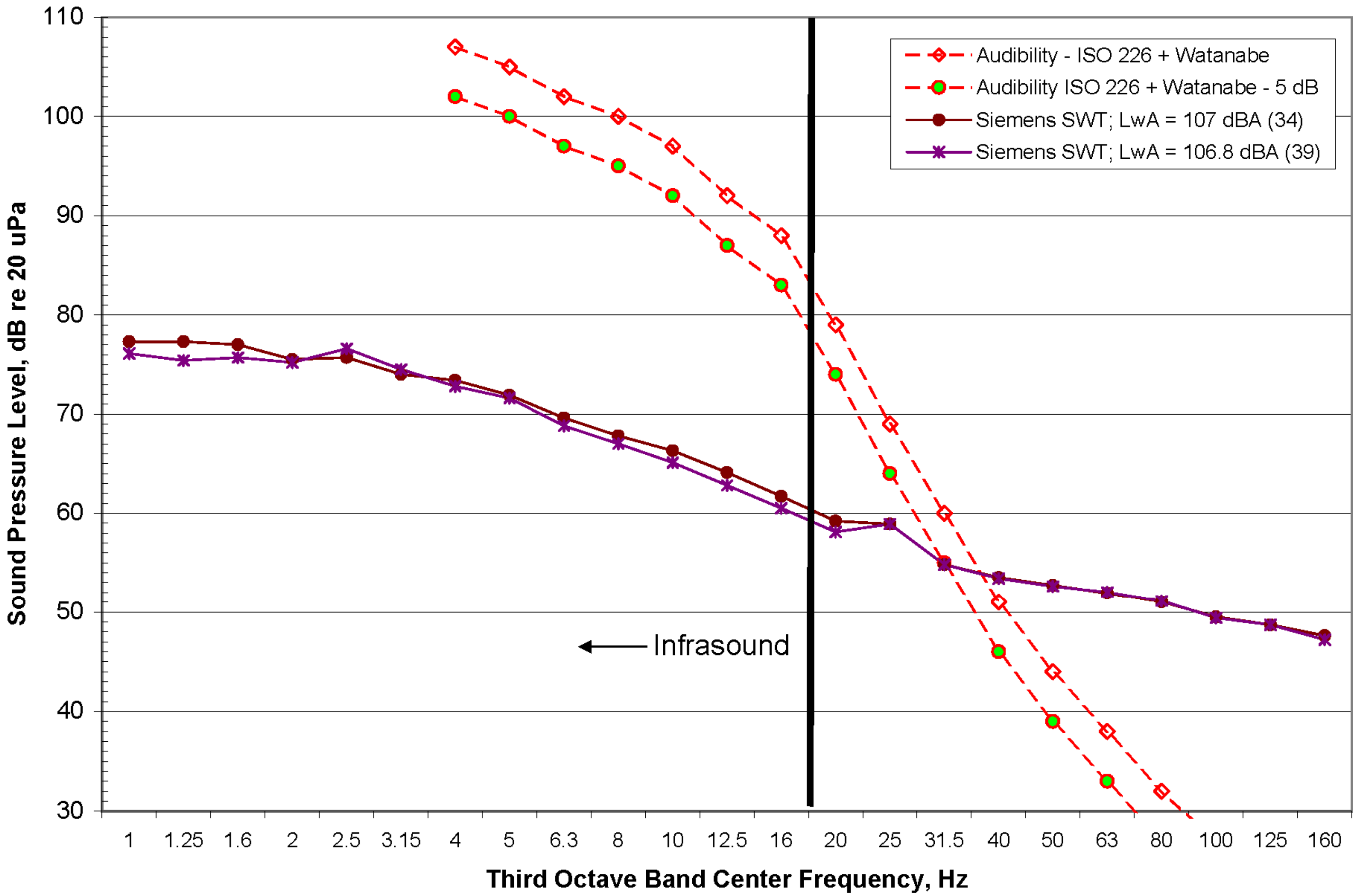


Figure 8.1-2 Siemens SWT-2.3-93 Wind Turbine Outdoor Sound Levels at 1000 feet compared to outdoor equivalent DEFRA Criteria

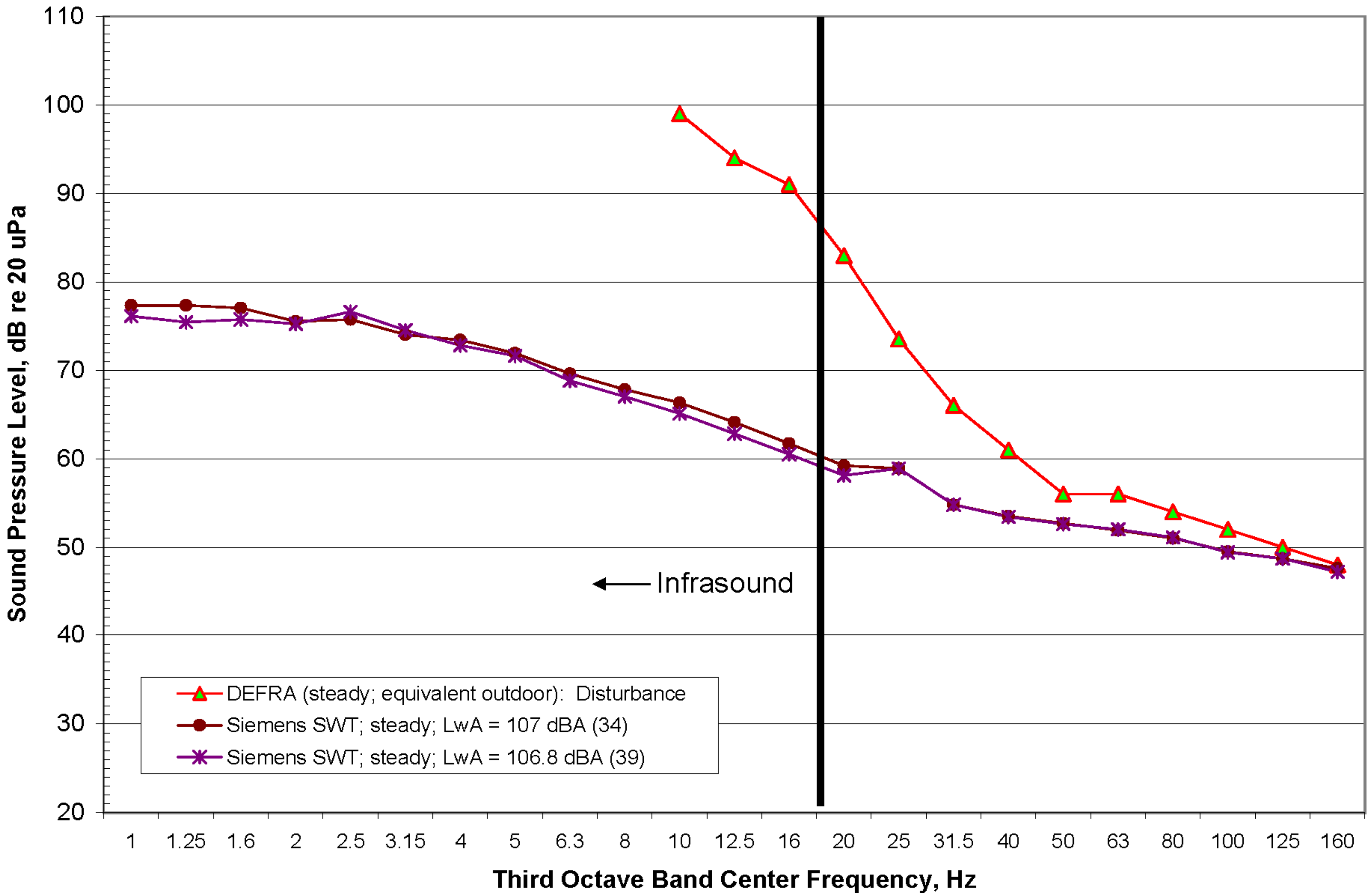


Figure 8.1-3 Siemens SWT-2.3-93 Wind Turbine Outdoor Sound Levels at 1000 feet compared to ANSI Criteria

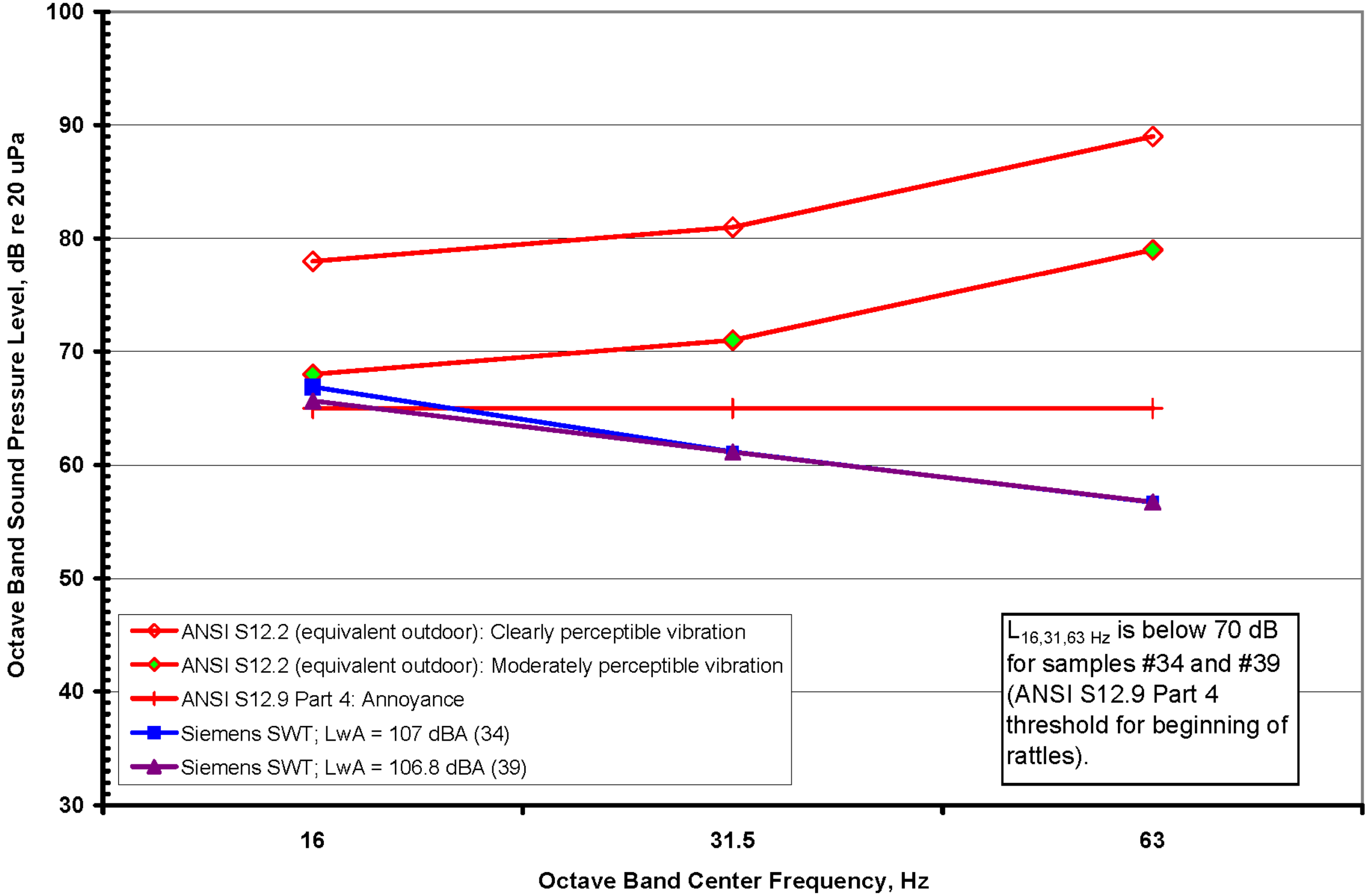


Figure 8.1-4a Siemens SWT-2.3-93 Wind Turbine Indoor Sound Levels at 1060 feet compared to Audibility Criteria (Home "A")

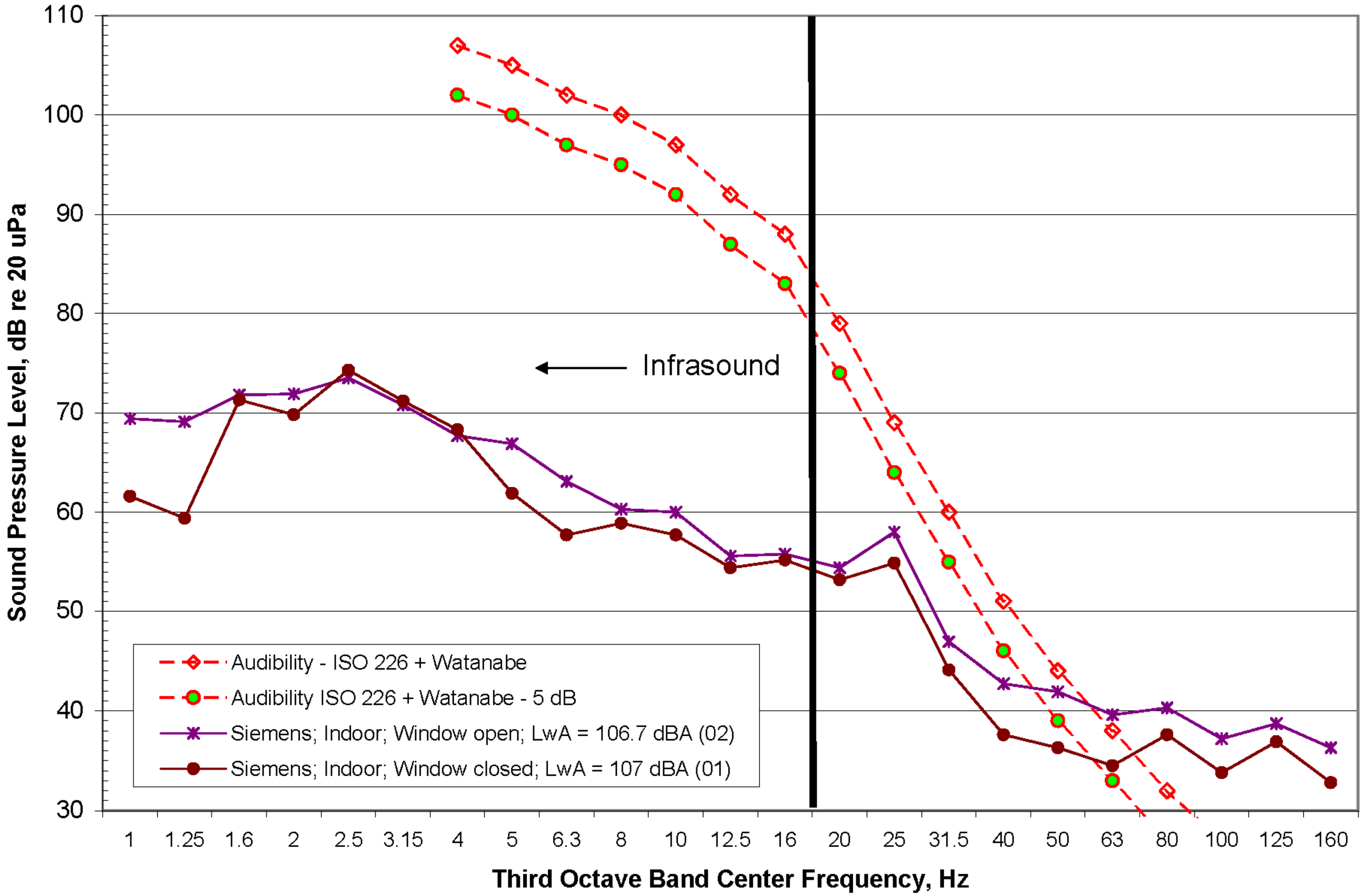


Figure 8.1-4b Siemens SWT-2.3-93 Wind Turbine Indoor Sound Levels at 920 feet compared to Audibility Criteria (Home "D")

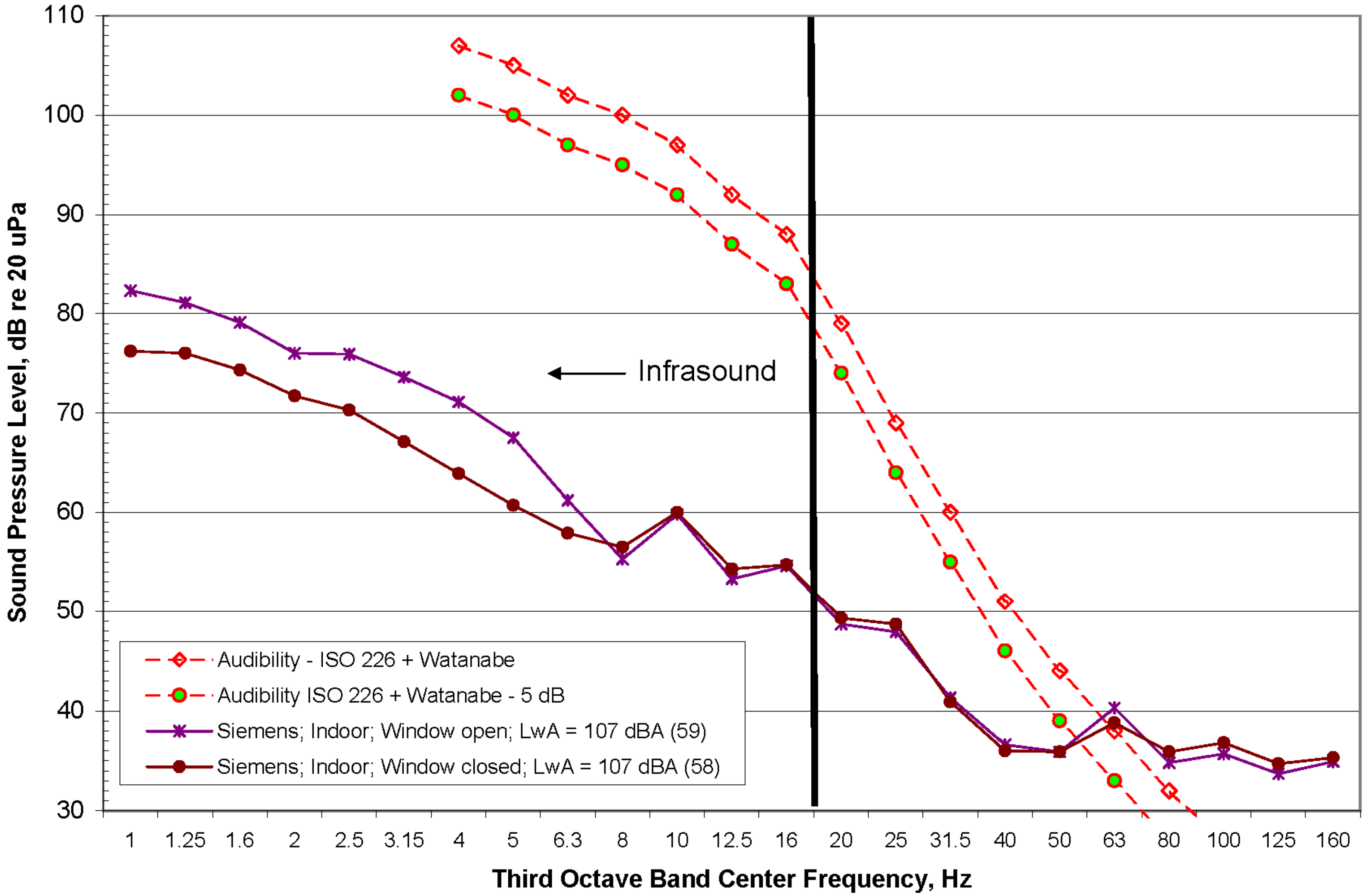


Figure 8.1-5a Siemens SWT-2.3-93 Wind Turbine Indoor Sound Levels at 1060 feet compared to DEFRA Criteria (Home "A")

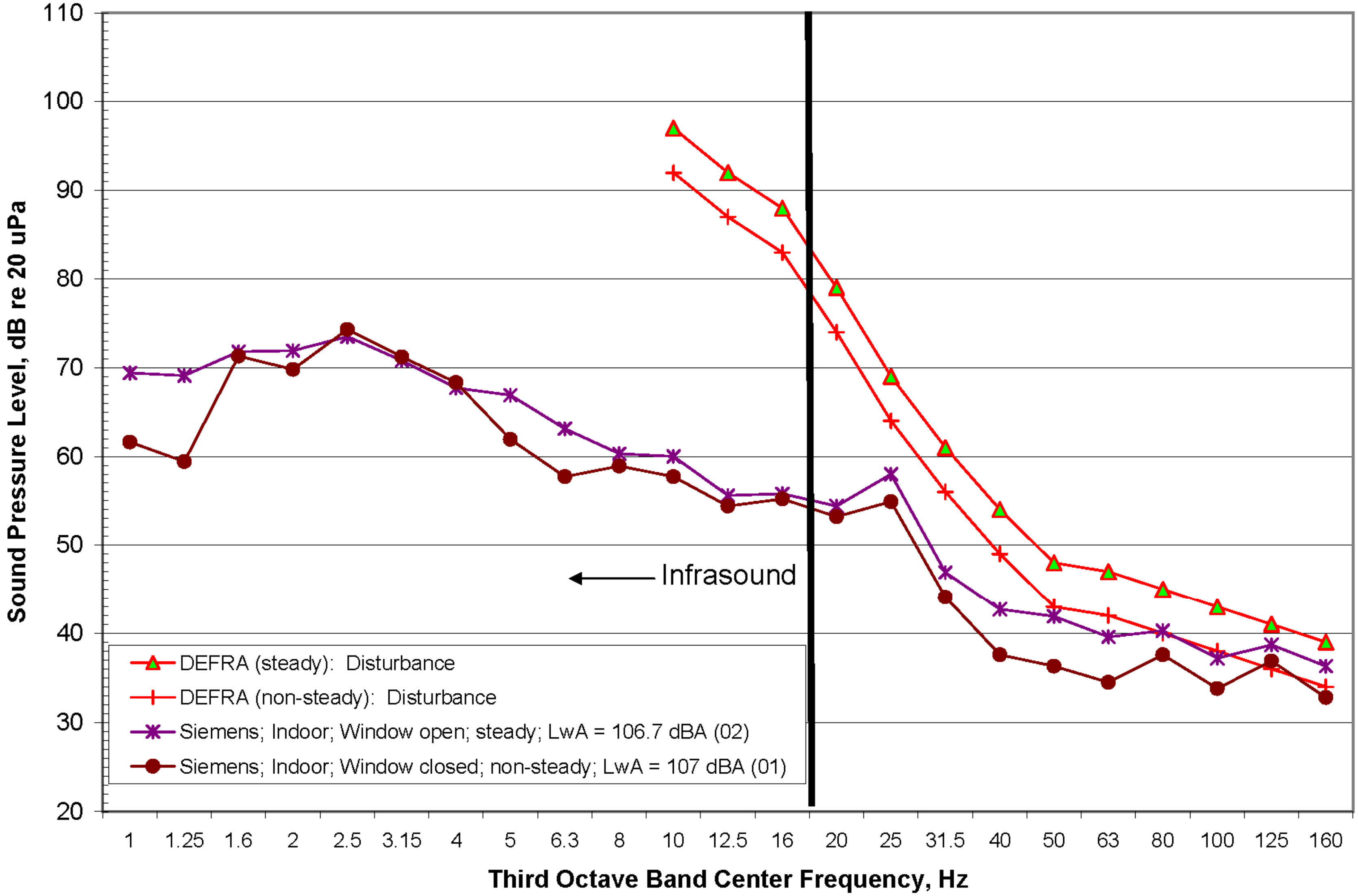


Figure 8.1-5b Siemens SWT-2.3-93 Wind Turbine Indoor Sound Levels at 920 feet compared to DEFRA Criteria (Home "D")

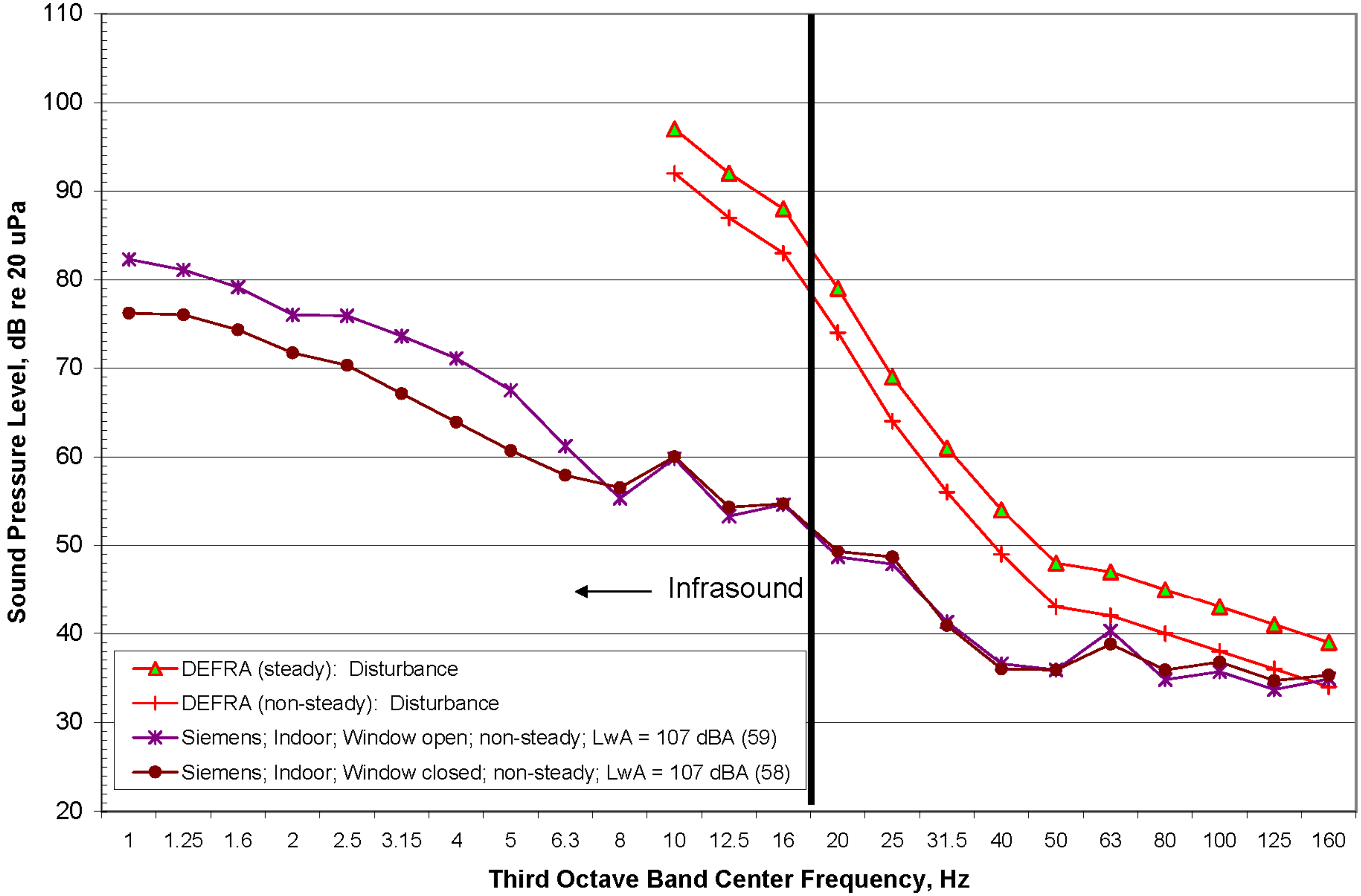


Figure 8.1-6a Siemens SWT-2.3-93 Wind Turbine Indoor Sound Levels at 1060 feet compared to ANSI 12.2 Criteria (Home "A")

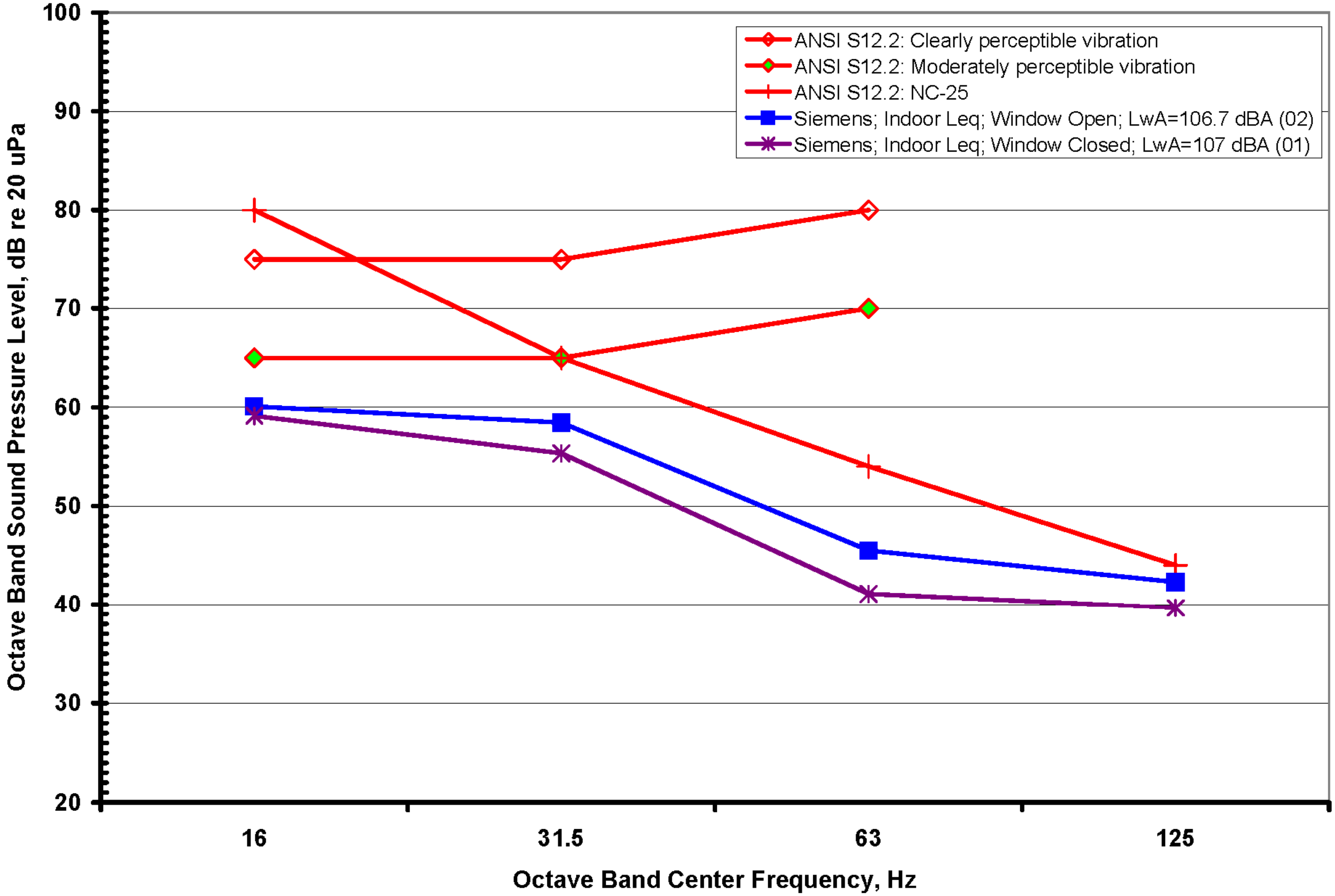


Figure 8.1-6b Siemens SWT-2.3-93 Wind Turbine Indoor Sound Levels at 920 feet compared to ANSI 12.2 Criteria (Home "D")

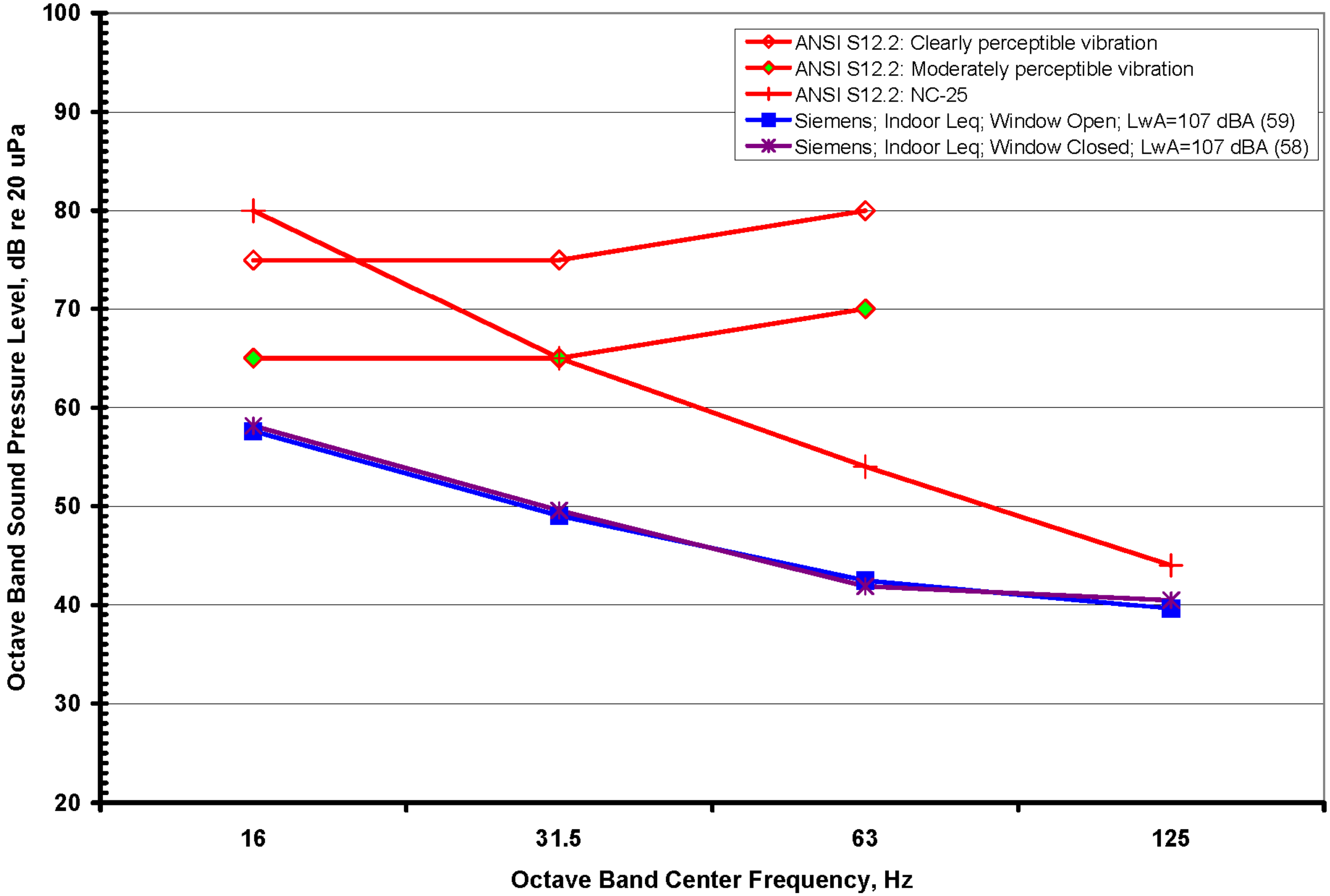


Figure 8.2-1 GE 1.5sle Wind Turbine Outdoor Sound Levels at 1000 feet compared to Audibility Criteria

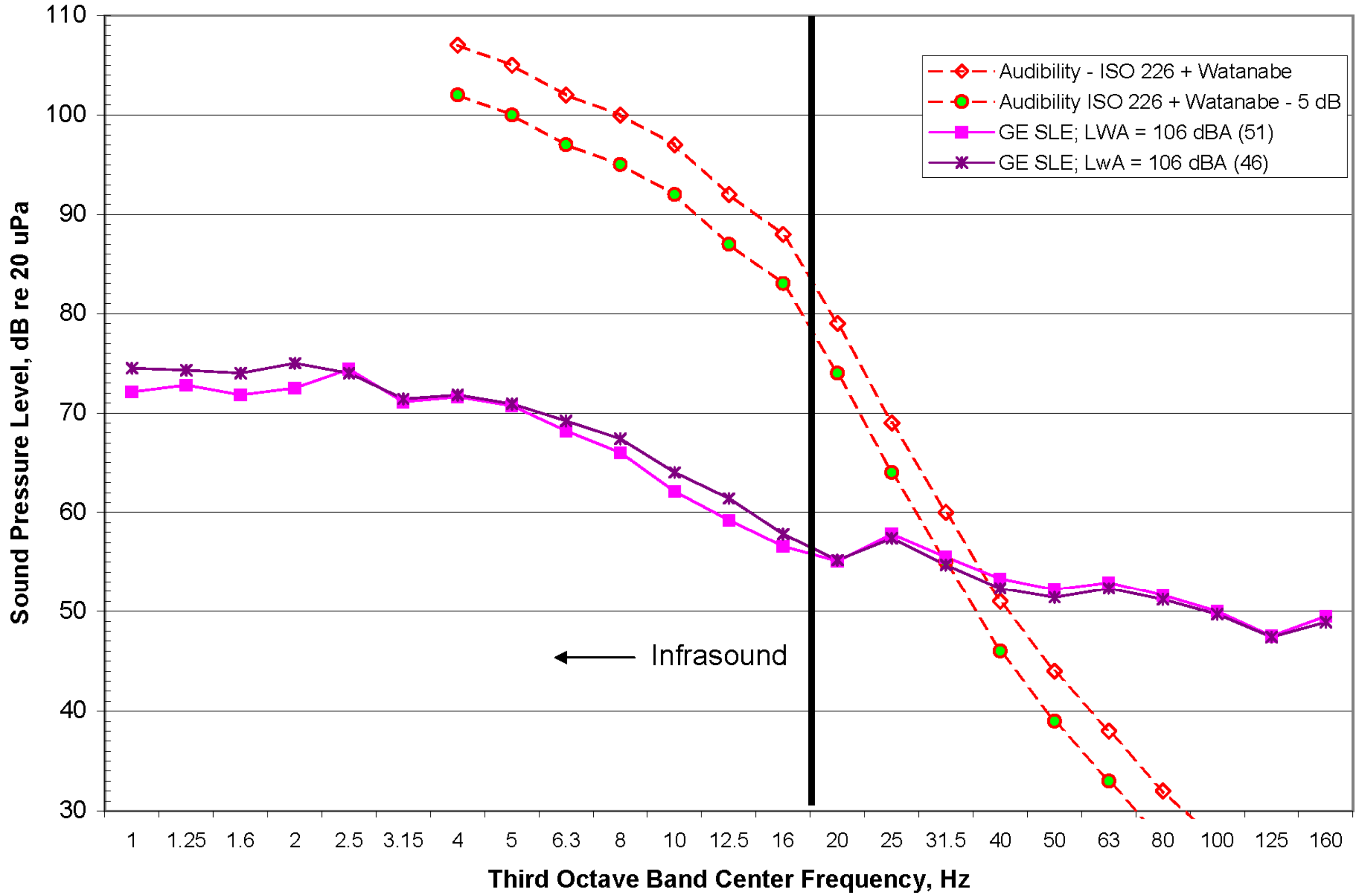


Figure 8.2-2 GE 1.5sle Wind Turbine Outdoor Sound Levels at 1000 feet compared to outdoor equivalent DEFRA Criteria

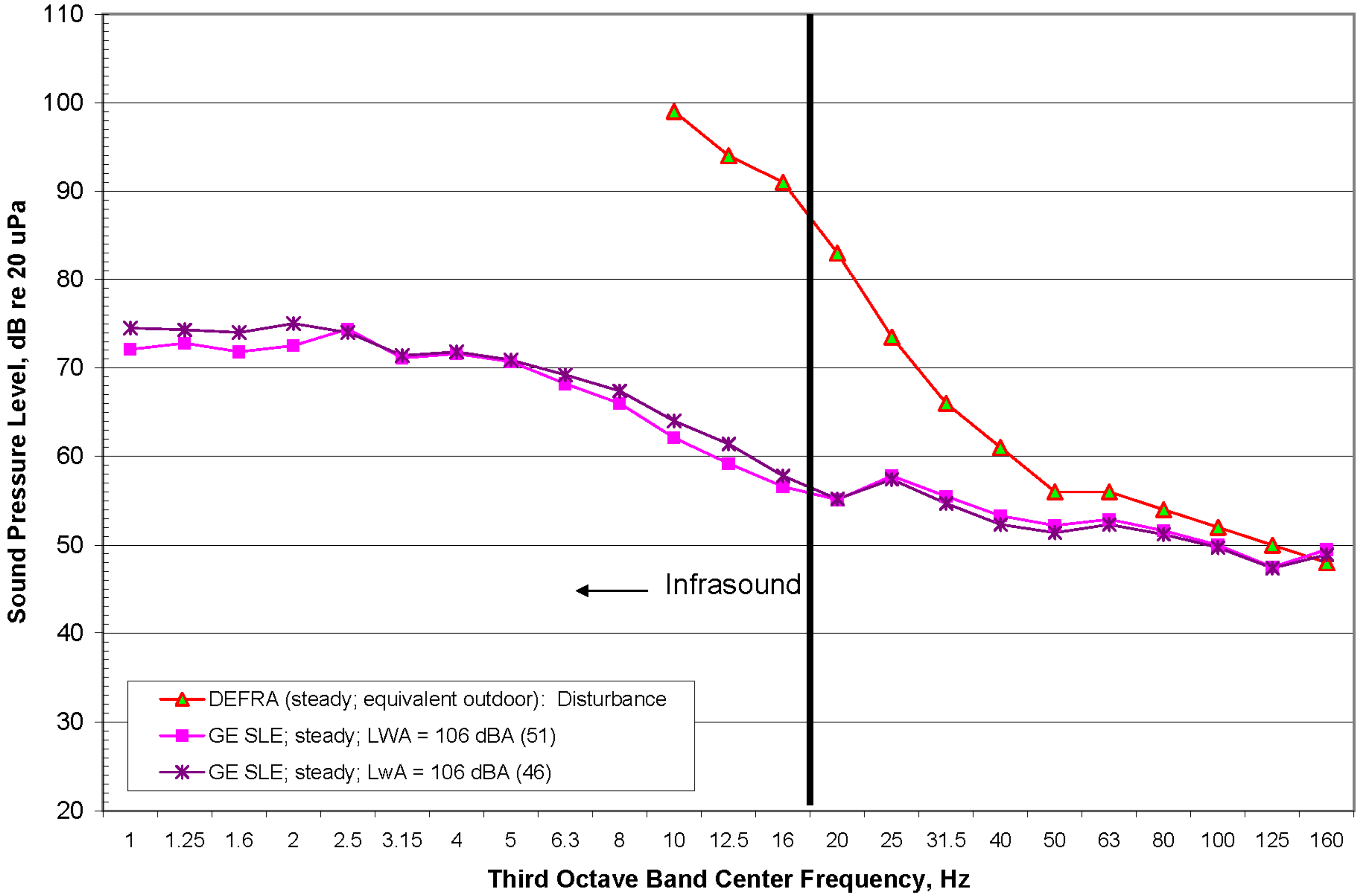


Figure 8.2-3 GE 1.5sle Wind Turbine Outdoor Sound Levels at 1000 feet compared to ANSI Criteria

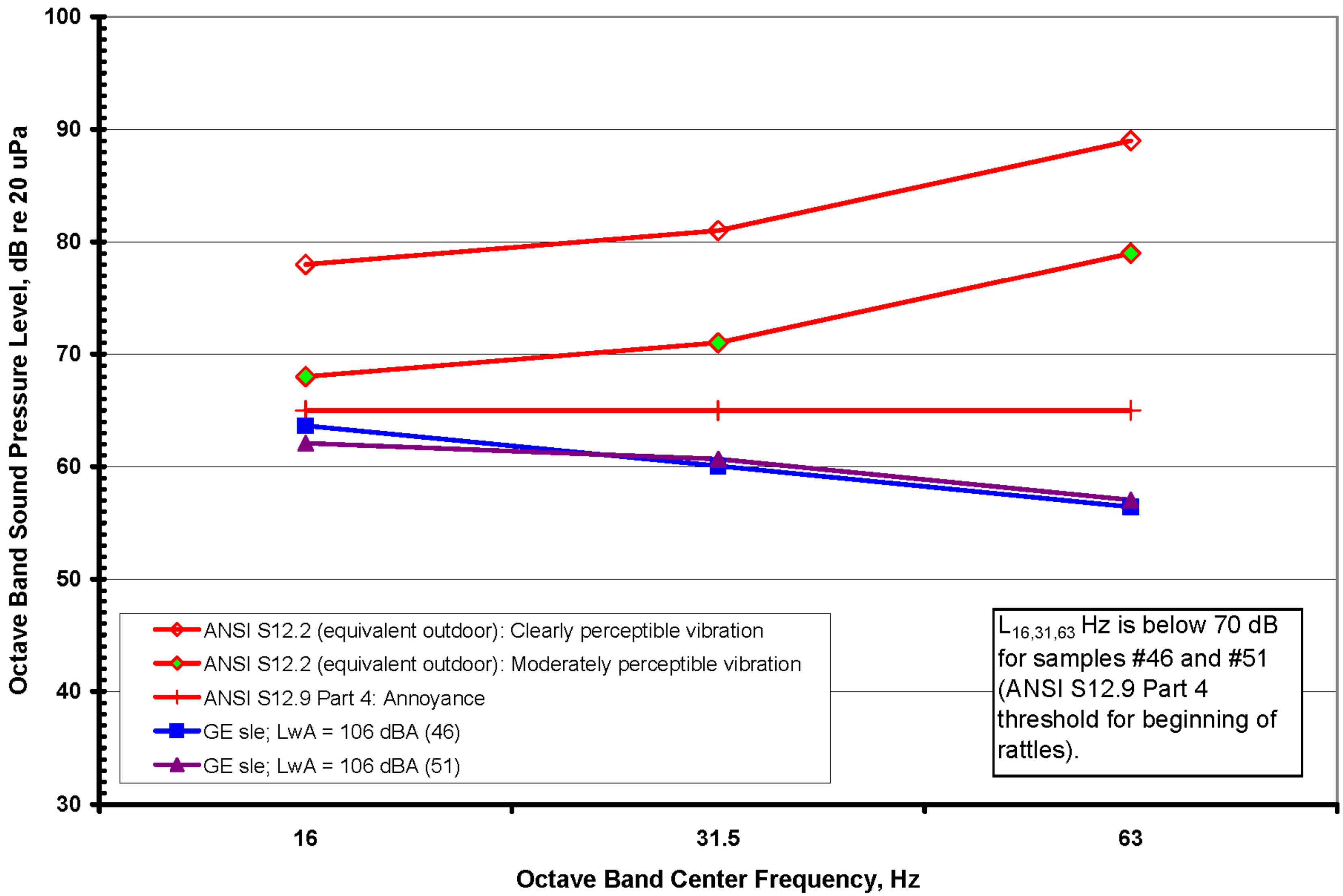


Figure 8.2-4a GE 1.5sle Wind Turbine Indoor Sound Levels at 950 feet compared to Audibility Criteria (Home "B")

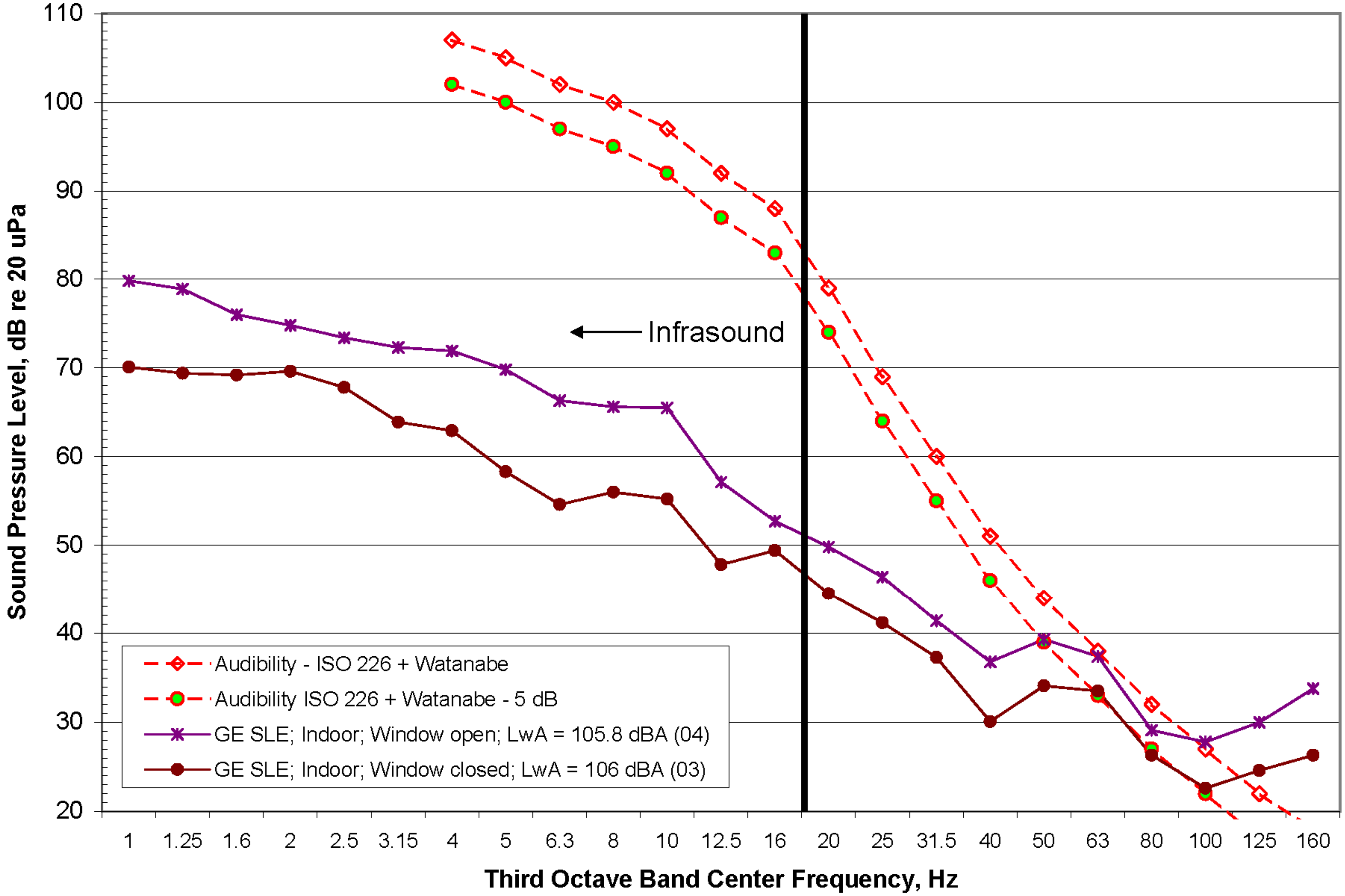


Figure 8.2-4b GE 1.5sle Wind Turbine Indoor Sound Levels at 1025 feet compared to Audibility Criteria (Home "C")

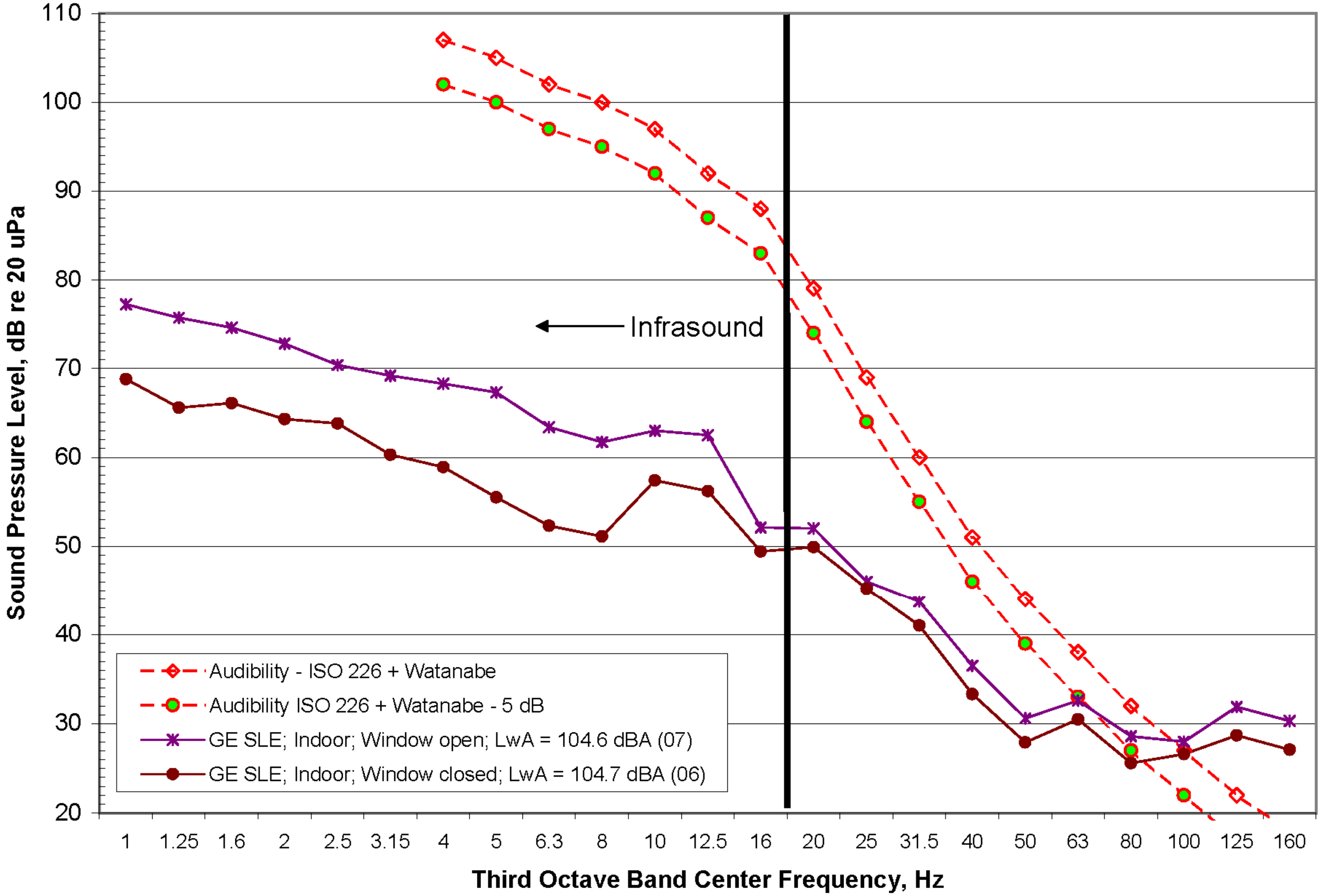


Figure 8.2-5a GE 1.5sle Wind Turbine Indoor Sound Levels at 950 feet compared to DEFRA Criteria (Home "B")

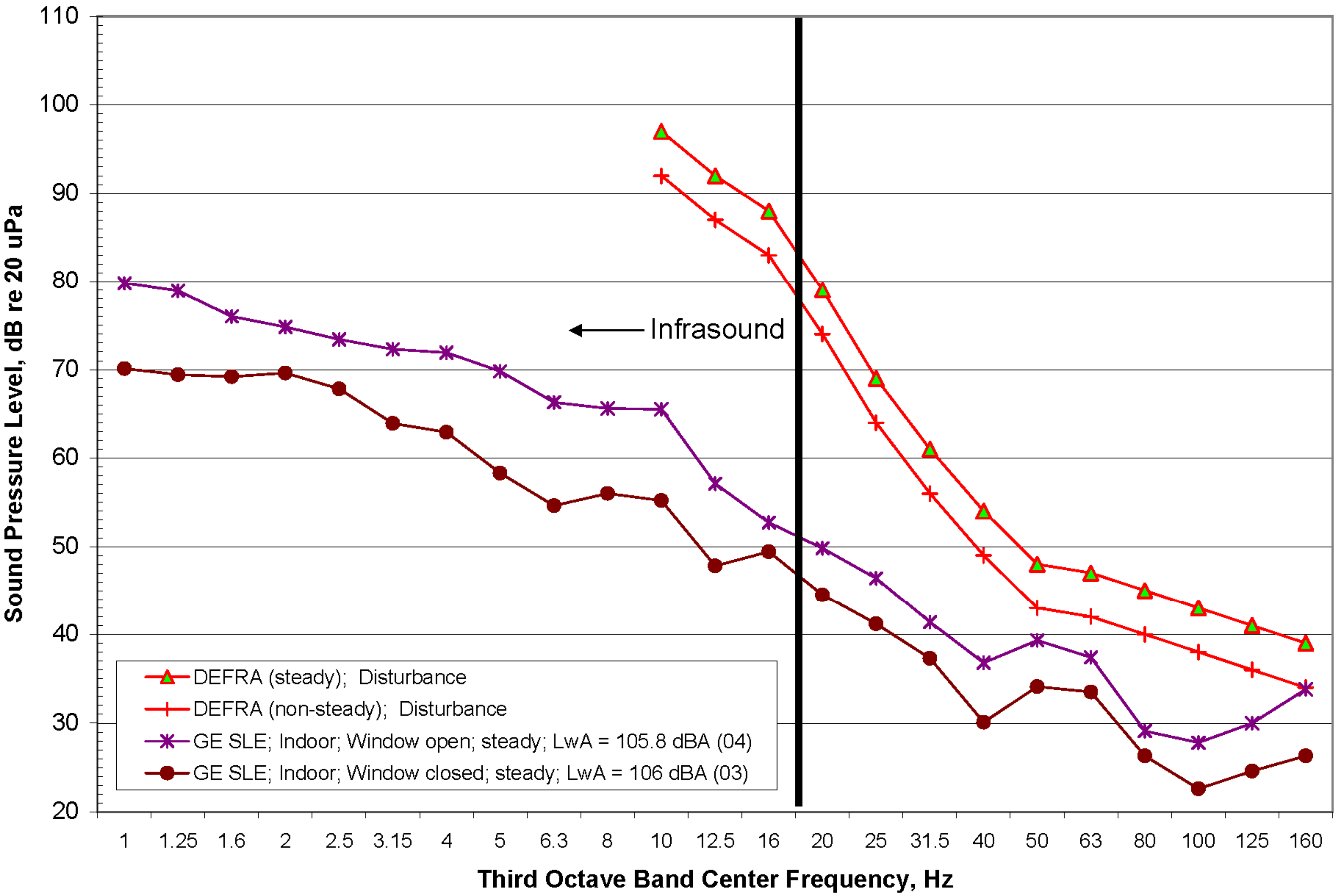


Figure 8.2-5b GE 1.5sle Wind Turbine Indoor Sound Levels at 1025 feet compared to DEFRA Criteria (Home "C")

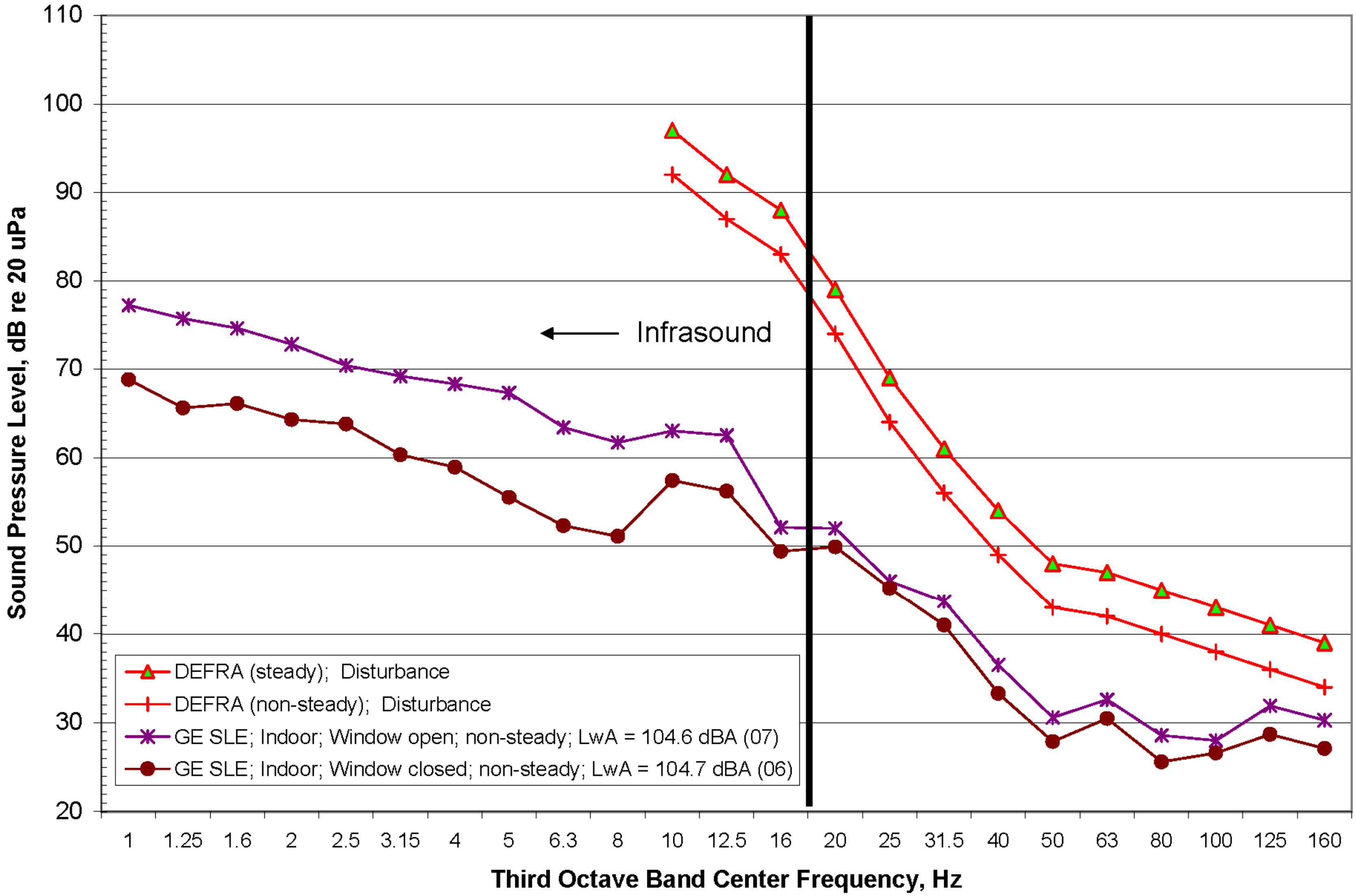


Figure 8.2-6a GE 1.5 sle Wind Turbine Indoor Sound Levels at 950 feet compared to ANSI 12.2 Criteria (Home "B")

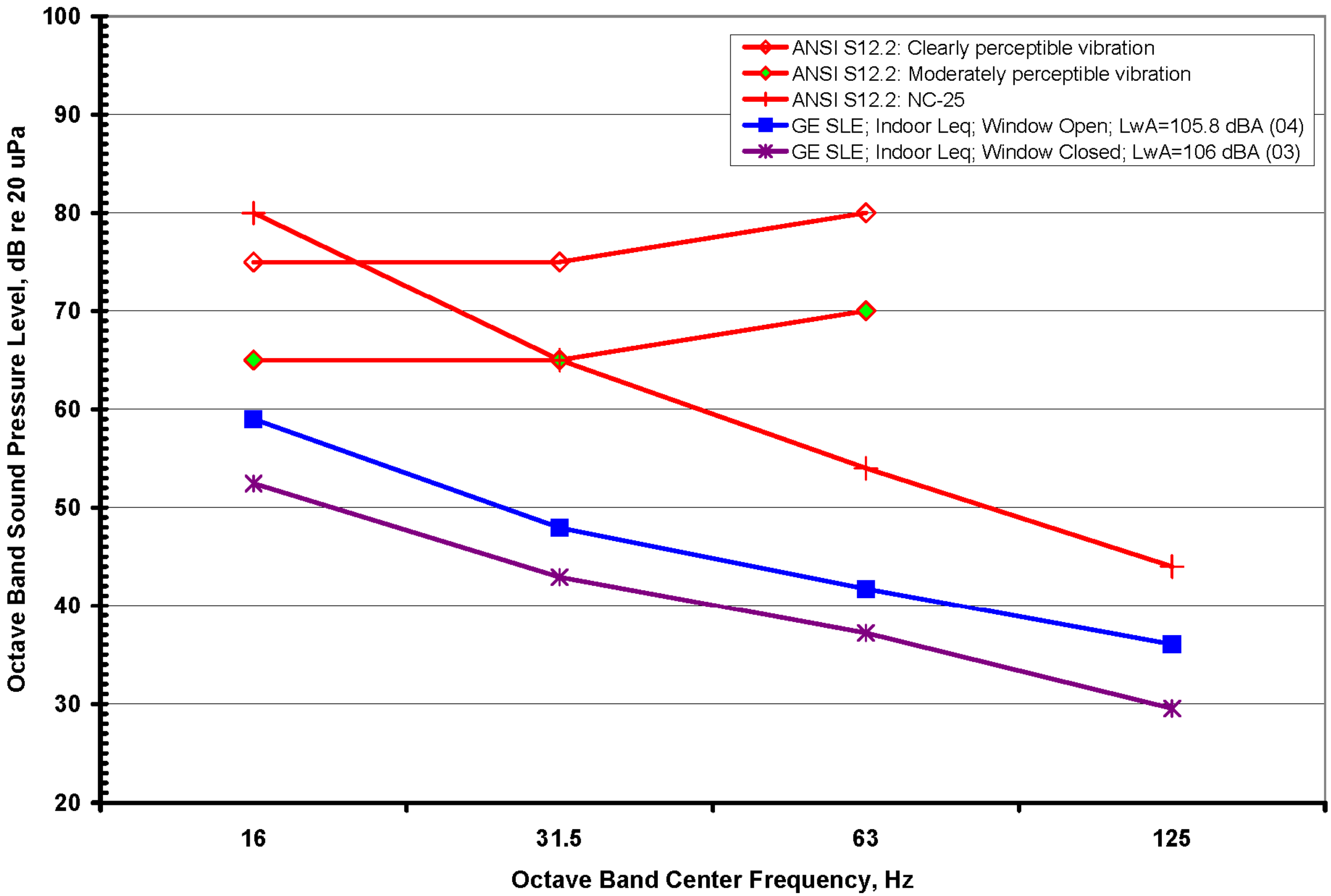


Figure 8.2-6b GE 1.5 sle Wind Turbine Indoor Sound Levels at 1025 feet compared to ANSI 12.2 Criteria (Home "C")

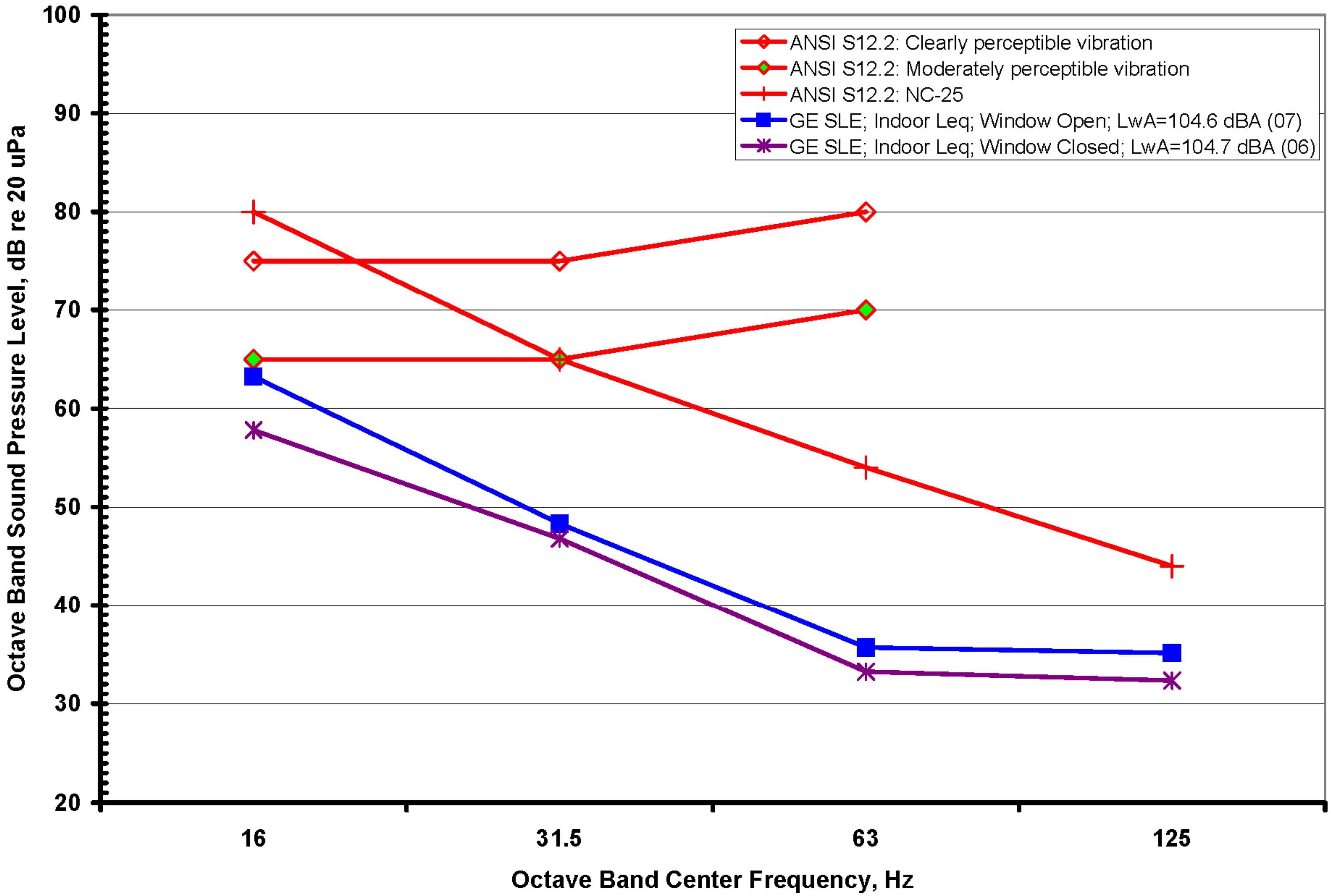


Figure 8.3-1a One-Third Octave Band Interior Noise Reduction – Windows Closed

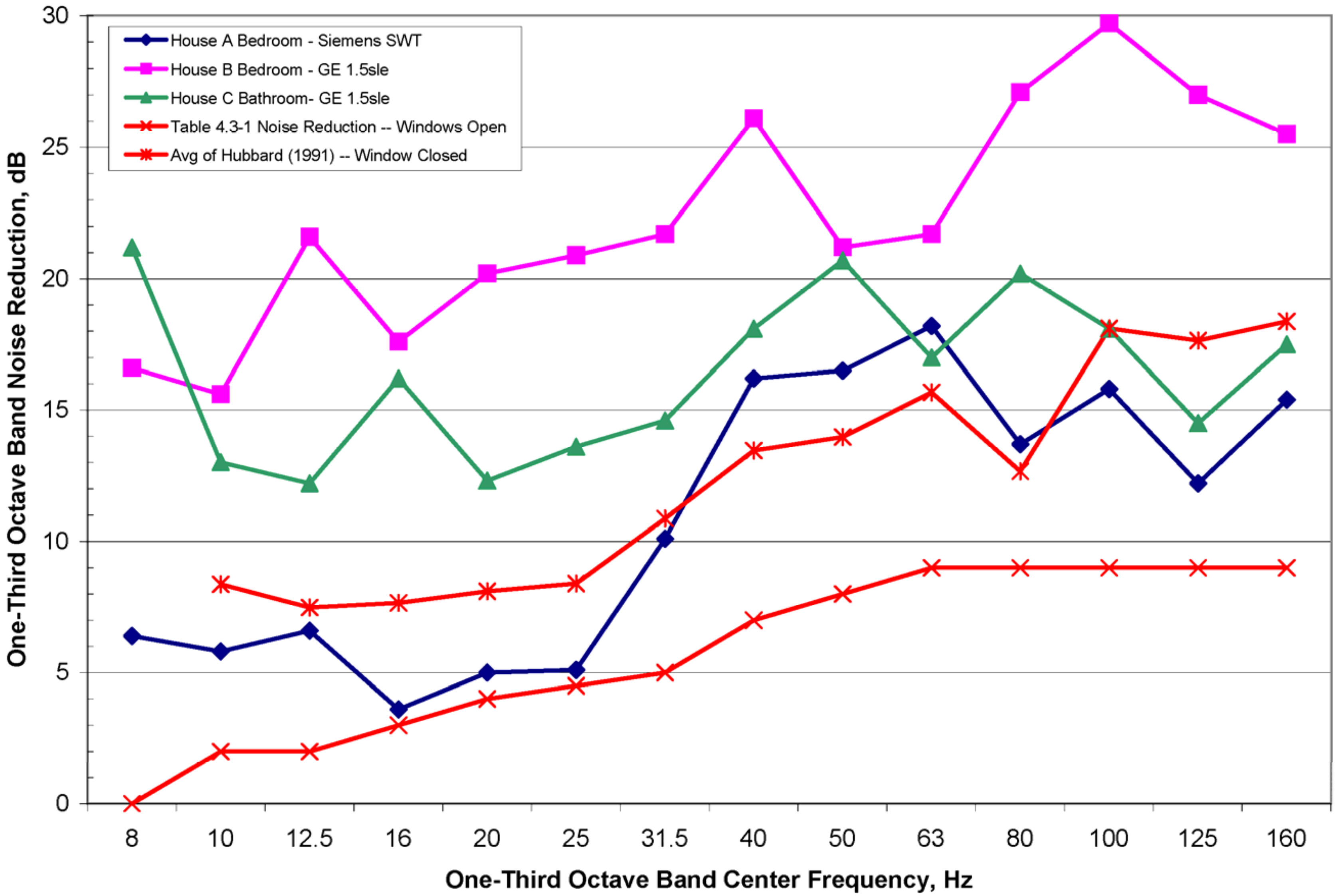
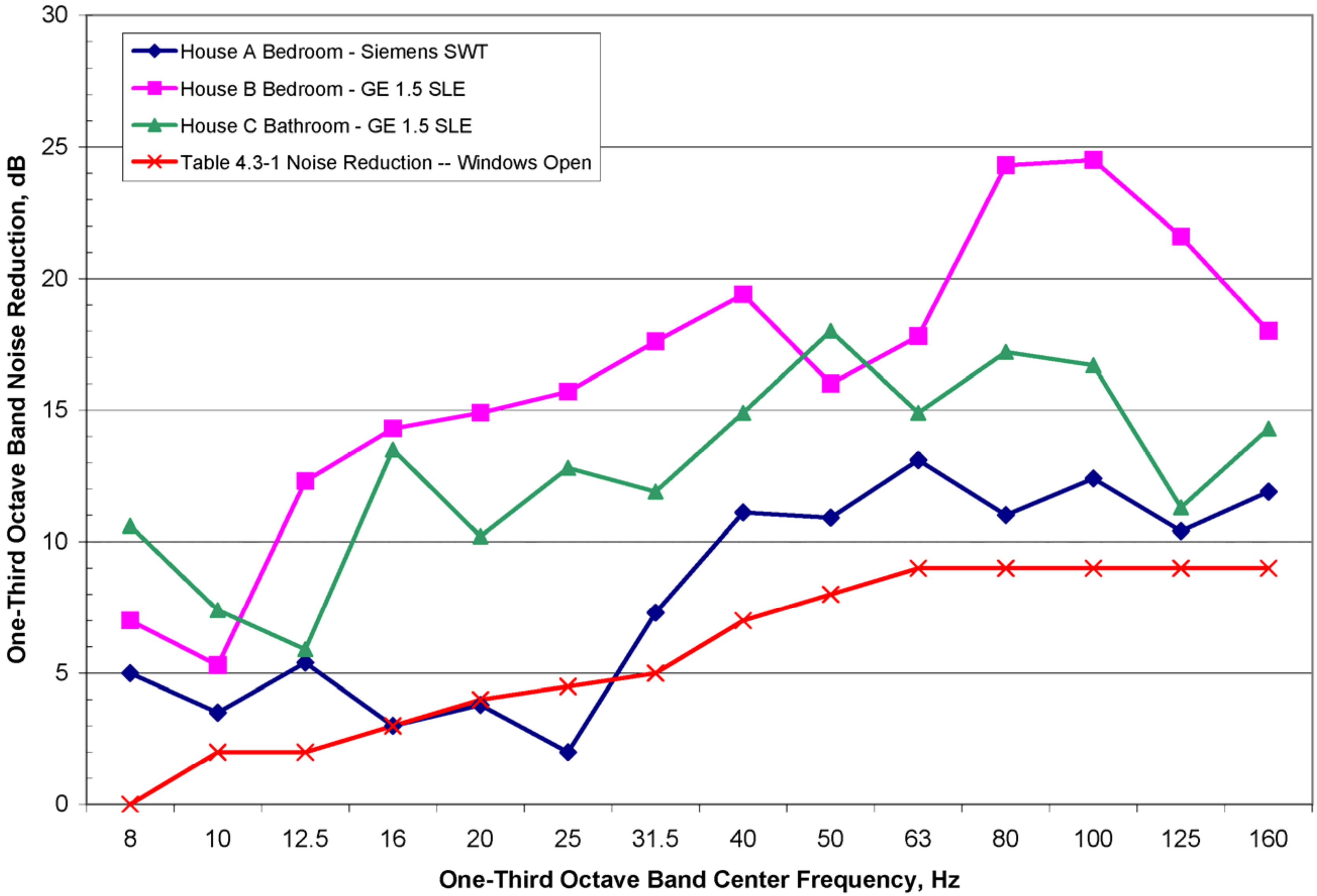


Figure 8.3-1b One-Third Octave Band Interior Noise Reduction – Windows Open



9.0 CONCLUSION

Siemens SWT 2.93-93 and GE 1.5sle wind turbines at maximum noise at a distance more than 1000 feet from the nearest residence do not pose a low frequency noise or infrasound problem. At this distance the wind farms:

- meet ANSI/ASA S12.2 indoor levels for low frequency sound for bedrooms, classrooms and hospitals;
- meet ANSI/ASA S12.2 indoor levels for moderately perceptible vibrations in light-weight walls and ceilings;
- meet ANSI S12.9 Part 4 thresholds for annoyance and beginning of rattles;
- meet UK DEFRA disturbance based guidelines;
- have no audible infrasound to the most sensitive listeners;
- might have slightly audible low frequency noise at frequencies at 50 Hz and above depending on other sources of low frequency noises in homes, such as refrigerators or external traffic or airplanes; and
- meet ANSI S2.71 recommendations for perceptible vibration in residences during night time hours.

In accordance with the above findings, and in conjunction with our extensive literature search of scientific papers and reports, there should be no adverse public health effects from infrasound or low frequency noise at distances greater than 1000 feet from the wind turbine types measured by Epsilon: GE 1.5sle and Siemens SWT 2.3-93.

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Misperceptions about Wind Energy

1. Wind farms cause stray voltage that can harm people, equipment or livestock.

Fact: Stray voltage is caused when a change occurs in current patterns on the electrical distribution line and has been an issue in Ontario long before the development of wind energy. It is not caused specifically by wind turbine operation but is commonly attributed to aging electrical lines.

The Electrical Safety Authority (ESA) is responsible for public electrical safety in Ontario as designated by Ontario Regulation 89/99, and is responsible for enforcing the Electricity Act and Regulations, including the Ontario Electrical Safety Code, Ontario Regulation 164/99. Each wind turbine installed in Ontario must meet strict ESA standards and be certified by the Ontario Electrical Board by passing an electrical completion test. This stringent testing requires that all electrical components of the wind turbines are working safely.

For More Information: Call the Hydro One hotline: 1-888-664-9376 or visit their website: http://www.hydroone.com/MyBusiness/MyFarm/Pages/StrayVoltage.aspx

2. The sound made by wind turbines cause health problems in people who live near them.

Fact: Reviews of peer-reviewed scientific literature have consistently found no evidence linking wind turbines to human health concerns. There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects. The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans. There are several recent studies that have been released to support this which are available online.

For More Information: Visit the Canadian Wind Energy Association's website: http://www.canwea.ca/media/release/release_e.php?newsId=71

3. Property value will decrease if a wind farm is built nearby.

Fact: There is no evidence that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distances of the home to those facilities.

For More Information: Download the complete report by Berkeley National Laboratory at: http://eetd.lbl.gov/EA/EMP

4. Wind turbine failure is common and represents a hazard to the public.

Fact: With over 121,000MW of wind turbines in operation globally there is no known recorded incident of any member of the public ever having been harmed by a wind turbine failure. All wind turbine designs have to comply with rigorous international design codes produced by the International Electrotechnical Commission (IEC). Furthermore, all wind turbine designs need to be independently certified, by companies such as Germanischer Lloyd, prior to being made available for sale. As a further precaution, wind turbines are sited with suitable setbacks to avoid damage to property or persons in the very rare event of a failure occurring.

For More Information: Please visit the IEC website at http://www.iec.ch/ and the Germanischer Lloyd website at http://www.gl-group.com/en/renewables.php

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