CSA Guide to Canadian wind turbine codes and standards

CANADIAN STANDARDS ASSOCIATION

Disclaimer

This guide was prepared by the Canadian Standards Association (CSA) to communicate general information to its members and any other interested parties regarding codes and standards that may pertain to wind turbines for use in Canada.

This document is not intended to be a detailed guide on what regulatory and other requirements a user may expect to be asked to comply with. Recognizing that Laws and Regulations, and voluntary Standards, are the responsibility of Governments and Consensus Committees respectively, and that they may change over time depending on factors such as environmental conditions and considerations, government policy of the day, etc., CSA takes no responsibility for the accuracy of any documents mentioned herein, particularly the validity or applicability of any regulatory references, nor of the potential application of any standard mentioned herein in relation to possible regulatory requirements or otherwise.

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CSA Guide to Canadian wind turbine codes and standards

Section A — Introduction and general information

1 Introduction and scope

This guide was prepared by the Canadian Standards Association (CSA) to provide general information to its members and any other interested parties on codes and standards pertaining to the approval, design, installation, operation, and maintenance of wind turbines for use in Canada.

Some of the information presented may appear redundant or obvious to a Canadian reader; however, CSA receives questions from all over the world about these subjects and therefore some basic information about Canadian regulatory systems has also been included to serve these readers.

To maintain relevance, the intent is that this guide will be updated and reissued as required and as resources permit to reflect timely information on the state of standards, codes, and related subject matter pertaining to wind turbines. CSA encourages all readers of this guide to contribute to this effort. Please contact Jeff Shikaze (jeff.shikaze@csa.ca) or Sam Loggia (sam.loggia@csa.ca) with any suggested updates or revisions.

2 Abbreviations

The following abbreviations apply in this guide:

AHJ — Authorities Having Jurisdiction
CanWEA — Canadian Wind Energy Association
CEC — Canadian Electrical Code (developed and published by CSA)
CSA — Canadian Standards Association
DNV — Det Norske Veritas
EN — European Union Norm
ESA — Electrical Safety Authority (of Ontario)
GL — Germanischer Lloyd
IEC — International Electrotechnical Commission
ISO — International Organization for Standardization
OBC — Ontario Building Code
WECS — Wind energy conversion systems
WTGS — Wind turbine generator system

3 General background

Over the last decade, the Canadian wind-energy sector has evolved from a scattering of individual installations to one of the fastest growing wind-energy markets in the world. While this growth has been supported and encouraged by various levels of government across Canada, many of the projects have experienced extensive cost overruns, delays, and in some cases cancellation related to confusing or unclear regulatory requirements, which differ considerably throughout the various Canadian jurisdictions. It is very important for the reader to understand that the Canadian regulatory environment is demanding and may be perceived as being complicated. Wind-energy developers are subject to dozens of approval processes involving various federal (national), provincial (state), and municipal (local) authorities. This may be further complicated by the makeup and ownership of the Canadian electrical transmission and distribution systems, which range from locally owned private businesses to fully integrated government-owned systems, with a wide range of regulatory roles and connection requirements.

In lieu of specific and up-to-date Canadian regulations addressing the subject of wind energy, Canadian authorities having jurisdiction (AHJ) and professional engineers have used a range of reference publications to determine how to evaluate and approve the development of wind turbine installations with respect to subjects such as effects on the environment, zoning, power quality, grid integration, performance testing, and electrical, worker, and structural safety. In many cases, these stakeholders have had to undertake costly engineering studies to supplement the available information in order to demonstrate due diligence.

A subset of the subjects described above deals with codes and standards relating to the structural, mechanical, electrical, and operating characteristics of wind turbines. These are the subject areas where CSA input has been sought since the 1980s, when the following National Standards of Canada pertaining to wind energy conversion systems (WECS) were developed:

- CAN/CSA-F416-87, *Wind Energy Conversion Systems (WECS) — Safety, Design, and Operation Criteria*;
- CAN/CSA-F417-M91, *Wind Energy Conversion Systems (WECS) — Performance*;
- CAN/CSA-F429-M90, *Recommended Practice for the Installation of Wind Energy Conversion Systems*; and
- CAN/CSA-F418-M91, *Wind Energy Conversion Systems (WECS) — Interconnection to the Electric Utility* (withdrawn by CSA in 2004). See Clause 10 (Electrical connections — Grid connected) for interconnection information.

Although these standards are still referenced in the Electrical Protection Codes of Nunavut and the Northwest Territories, they were never officially adopted into any Canadian provincial building or electrical codes. However, they have been used as references by some AHJ in recent years to evaluate large modern turbines. CAN/CSA-F416, CAN/CSA-F417, and CAN/CSA-F429 were developed to address 1980s-era wind turbines, which bear little resemblance to most of today's massive and sophisticated power-generating systems. It is widely acknowledged that these standards are significantly out of date with respect to modern wind-energy technology and of little use for current regulatory or engineering purposes, except perhaps for small turbines of 50 kW or less.

CSA and its members have been actively working since 2004 to address the needs of Canadian stakeholders with respect to this rapidly developing technology. These needs primarily focus on the electrical and structural safety aspects of wind turbines, but also involve other subject areas outside the current scope of the various CSA committees.

The approach being undertaken by CSA to update the National Standards of Canada for wind turbines is based on the adoption of the body of knowledge published by the International Electrotechnical Commission (IEC) Technical Committee 88 (TC 88) on Wind Turbines. As of January 15, 2008 there are five IEC TC 88 Standards being adopted by CSA (IEC 61400-1, -2, -11, -12-1, and -24). Three of them in particular (IEC 61400-1, -2, and -24) will contain significant deviations or additional information applicable to Canada. It is expected that the five new wind turbine generator system (WTGS) Standards will be completed and published as National Standards of Canada by the following dates:

- CAN/CSA-C61400-11, *Wind turbine generator systems — Part 11: Acoustic noise measurement techniques* (Published November 2007);
- CAN/CSA-C61400-12-1, *Wind turbines — Part 12-1: Power performance measurements of electricity producing wind turbines* (Published November 2007);
- CAN/CSA-C61400-24, *Wind turbine generator systems — Part 24: Lightning protection* (Technical Report; Published December 2007);
- CAN/CSA-C61400-1, *Wind turbines — Part 1: Design requirements* (Expected publication May 2008); and
- CAN/CSA-C61400-2, *Wind turbines — Part 2: Design requirements for small wind turbines* (Expected publication May 2008).

It is the intent of CSA and its members to support the subsequent adoption of these new National Standards of Canada into any applicable regulatory publications when the regulatory publications are updated.

4 Overview of Section B (Specific regulatory and approval subject areas)

The remainder of this guide addresses 22 specific subject areas related to the development of a typical wind-energy project that currently involves (or could eventually involve) regulatory or equivalent formal approval processes. Specific information on any associated standards or codes known to CSA is provided for each subject area. Likely sources of additional information are also provided.

Section B — Specific regulatory and approval subject areas

1 Zoning

The zoning of a prospective site for a wind turbine installation is determined by the relevant AHJ and is not known by CSA to be addressed by any National Standards of Canada. The reader may wish to contact the specific municipality (or equivalent jurisdiction) concerned for zoning information. The reader may also wish to contact the Canadian Wind Energy Association (CanWEA — www.canwea.ca) and the Ontario Sustainable Energy Association (www.ontario-sea.org) for more information on this subject.

2 Public hearings

The public hearing process associated with a prospective site for a wind turbine installation is determined by the relevant AHJ and is not known by CSA to be addressed by any National Standards of Canada. The reader may wish to contact the specific municipality (or equivalent jurisdiction), aboriginal government, provincial or territorial government, or the Government of Canada for information of this nature. The reader may also wish to contact CanWEA (www.canwea.ca) and the Ontario Sustainable Energy Association (www.ontario-sea.org) for more information on this subject.

3 Power purchase agreements

The right to sell power generated from a wind turbine is granted by the grid owner or other AHJ and is not known to be addressed by any National Standards of Canada. The reader may wish to contact CanWEA (www.canwea.ca) and the Ontario Sustainable Energy Association (www.ontario-sea.org) for more information on this subject.

4 Building permits

The need for building permits in a specific location is determined by the applicable AHJ. The issuing of building permits may be subject to demonstrated compliance with the applicable provincial or local building code. By reference within a code, AHJ may require compliance with any standard referenced in that code. Examples of referenced standards are detailed in Clause 11 (Foundations) and Clause 12 (Towers) of this guide.

It is CSA's understanding that location-specific building permits are required for wind-turbine foundations in most areas of Canada. However, the permitting process for "above-grade" structures or machinery will vary from jurisdiction to jurisdiction. The only specific published requirements known to CSA relating to this subject exist in the province of Ontario. Clause 1.3.1.1 (Designated Structures) of the 2006 Ontario Building Code (OBC) states: "The following structures are designated for the purposes of clause (d) of the definition of *building* in subsection 1 (1) of the Act: … (g) a structure that supports a wind turbine generator having a rated output of more than 3 kW."

The OBC is developed and published by the Ontario Ministry of Municipal Affairs and Housing. Visit www.obc.mah.gov.on.ca for contact information.

5 Electrical plan approval/permitting

The requirements for electrical plan approval and permitting vary widely across Canadian jurisdictions. In many cases, the AHJ are government-owned utilities or similar large utilities. In Ontario, this process is addressed by the Electrical Safety Authority (ESA) (visit www.esasafe.com for contact information). By reference within a code, AHJ may require compliance with any standard referenced in the applicable provincial electrical code. Examples of referenced standards and additional contacts are detailed in Clause 14 (Electrical safety) of this guide.

6 Site suitability

This subject area includes specific site assessments of obstructions (constructed or natural), soil conditions, proximity to persons or property, access, fencing, and support facilities and is not known by CSA to be addressed by any National Standards of Canada. These subjects are addressed by the AHJ and professional engineers familiar with the specific site issues. The reader may also wish to contact CanWEA (www.canwea.ca) and the Ontario Sustainable Energy Association (www.ontario-sea.org) for more information on this subject.

7 Evaluation of impact on water, air, and wildlife

These requirements, which can vary widely depending on the location, are defined by a range of AHJ and are not known by CSA to be directly addressed by any National Standards of Canada. However, some of these evaluation processes may be based on the CSA 14000 series of ISO adoptions or related environmental management system standards. The reader may also wish to contact the Canadian Environmental Assessment Agency (www.ceaa-acee.gc.ca), CanWEA (www.canwea.ca), and the Ontario Sustainable Energy Association (www.ontario-sea.org) for more information on this subject.

8 Acoustic noise

Allowable noise levels for all types of machinery are determined by the local AHJ, based on zoning and proximity to neighbours. The threshold levels and methods of measurement are typically determined by provincial AHJ guidelines and generally make reference to other Standards, including:

- CSA Z107.10-06, *Guide for the use of acoustical Standards in Canada* (which references a number of recently endorsed ISO noise standards);
- CAN/CSA-ISO 1996-1:05, *Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures*;
- CAN/CSA-ISO 1996-2, *Acoustics — Description and measurement of environmental noise*; and
- "National Guidelines for Environmental Noise Control" by the Federal-Provincial Advisory Council on Environmental and Occupational Health, Health Canada, 1989.

In May 2007, the CSA Technical Committee on Wind Turbines approved the adoption of IEC 61400-11, *Wind turbine generator systems — Part 11: Acoustic noise measurement techniques*, and it has just recently been released for publication as a new National Standard of Canada as CAN/CSA-C61400-11. It provides specific requirements on how to correctly perform noise measurements from a wind turbine source. It is compatible with the existing Canadian publications and it is expected that it will be referenced in the applicable provincial regulations during their next revision cycles.

A related but independent subject is that of "infrasound" (very low frequency sound) as it pertains to wind turbines. This has recently been the subject of a number of detailed scientific studies. The reader may wish to contact CanWEA (www.canwea.ca) for more information on this subject.

9 Electrical connections — Off grid

Stand-alone (off-grid) wind-energy installations are not subject to all of the same requirements as grid connected installations, but must still meet the electrical safety requirements of applicable AHJ. In jurisdictions without conventional AHJ involvement (e.g., very remote or temporary sites, marine sites, etc.), the owner may still need to demonstrate conformance with acceptable standards to meet insurance or other liability requirements. The default standard is general installation in accordance with the CSA *Canadian Electrical Code (CEC), Part I*, using components certified to applicable CSA CEC, Part II Standards (e.g., CSA C22.2 No. 100, CSA C22.2 No. 14, etc.). However, it is also possible the AHJ may deem foreign certification to the IEC 61400 series or similar standards as acceptable for a turbine unit as long as it is installed with other electrical equipment in compliance with locally applicable codes. The reader may wish to contact CanWEA (www.canwea.ca) and the Ontario Sustainable Energy Association (www.ontario-sea.org) for more information on this subject.

10 Electrical connections — Grid connected

Grid connected equipment must meet the electrical safety requirements of the applicable AHJ. Applicable AHJ may include the following organizations:

- the grid owner;
- the system operator; and
- the electrical safety authorities.

The reader should contact the appropriate AHJ to confirm specific local requirements.

In most areas of Canada, in lieu of any unique requirements, the default installation and connection standards and codes used by the AHJ may include

- the applicable parts of the CSA CEC, Part I, (in particular, Section 84), or the equivalent provincial code;
- CAN/CSA-C22.2 No. 257, *Interconnecting inverter-based micro-distributed resources to distribution systems*, if within the scope of the Standard (inverter-based distribution resources connected at 600 V or less);
- the regional "Grid Code" and other requirements of the AHJ and/or grid owner(s), which may in turn reference other CSA engineering Standards related to transformers, overhead systems, and the like; and
- the draft standard (not yet published) CSA C22.3 No. 9, *Interconnection of distributed resources and electricity supply systems* (for installations up to 10 MW connected to distribution systems up to 50 kV), which is based on IEEE 1547, *Interconnecting Distributed Resources with Electric Power Systems*, and planned for publication by early 2008.

In addition to the AHJ, the reader may also wish to contact CanWEA (www.canwea.ca), the Ontario Sustainable Energy Association (www.ontario-sea.org), Electro-Federation Canada's Powerconnect Group (www.powerconnect.ca), or the Canadian Electricity Association (www.ceatech.ca) for more information on the subject of interconnection.

11 Foundations

11.1 General

It is the understanding of CSA that apart from Ontario (see the special case in Clause 11.2), there are no regulations or codes in Canada pertaining specifically to wind turbine foundations. In most jurisdictions, foundations for all but the smallest wind turbines are subject to approval and permitting by local AHJ. In most areas of Canada, this process includes the involvement of professional engineers registered in the specific province to provide sealed (approved) design drawings. In addition to applicable building codes, Canadian AHJ and professional engineers are understood by CSA to use a range of references in the course of evaluating wind turbine foundations. These references may include

- the structural design requirements of CAN/CSA-F416 (published 1987);
- the structural design requirements of CSA S37, *Antennas, Towers, and Antenna-Supporting Structures* (published 2001);
- IEC 61400 series Standards and references;
- Germanischer Lloyd (GL) guidelines and certification documents;
- Det Norske Veritas (DNV) guidelines and certification documents;
- various other European standards, codes, and guidelines; and
- supplementary studies from recognized professional engineers.

The only current National Standard of Canada that specifically addresses wind turbine foundations is CAN/CSA-F416. Clause 6.2.6 of CAN/CSA-F416 states: “The design of all anchorages and foundations shall be in accordance with CSA Standard S37-M [1986, *Antennas, Towers, and Antenna-Supporting Structures*] and any other appropriate CSA Standards, and shall consider the cyclic nature of some design load conditions.” However, as previously identified in this guide, CAN/CSA-F416 was developed to address 1980s wind-energy technology and not envisioned for use on turbines larger than approximately 50 kW. It has never been officially referenced in any Canadian building code.

CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008. These documents approach foundation design requirements based on the IEC body of knowledge for specific wind turbine load cases, supplemented with references to national (Canadian) structural codes and standards for materials as directed by the IEC standards. The current drafts of these documents include references to Part 4.3 of the 2005 (Model) *National Building Code of Canada* (which in turn references a range of Canadian design, materials, and fabrication standards), Canadian climate and seismic design requirements, and other aspects of the Structural Commentaries of the 2005 *National Building Code of Canada*.

For further information on Canadian requirements in this subject area and building codes in general, the reader may wish to visit Canada’s National Code website at www.nationalcodes.ca, or contact the appropriate member of the Provincial/Territorial Policy Advisory Committee on Codes (http://www.nationalcodes.ca/ccbfc/PTPACC%20Members%20list2.pdf). The reader should also consider contacting a consulting engineering firm familiar with the jurisdiction.

11.2 Foundations (Province of Ontario)

Clause 1.3.1.1 (Designated Structures) of the 2006 Ontario Building Code (OBC) states: “The following structures are designated for the purposes of clause (d) of the definition of *building* in subsection 1 (1) of the Act: … (g) a structure that supports a wind turbine generator having a rated output of more than 3 kW.”

The OBC is developed and published by the Ontario Ministry of Municipal Affairs and Housing. Visit www.obc.mah.gov.on.ca for contact information.

12 Towers

12.1 General

It is the understanding of CSA that apart from Ontario (see the special case in Clause 12.2), there are no regulations or codes in Canada pertaining specifically to wind turbine towers. However, the AHJ in some jurisdictions throughout Canada have required the involvement of professional engineers registered in the specific province to provide sealed (approved) design drawings before allowing tower erection.

Large wind turbine towers are typically manufactured to the system designer’s specifications by specialized independent fabricators. Until a few years ago, most large towers were fabricated and shipped from Europe. However, large towers are now increasingly being fabricated in the USA and Canada.

Smaller wind turbine towers are correspondingly easier to transport and are available from a wide range of domestic and international sources.

The current National Standard of Canada for wind turbines, CAN/CSA-F416, addresses the subject of wind turbine towers in Clause 6.2.2, stating that "all materials used to construct the support tower shall be in accordance with the [Model] *National Building Code* [of Canada] and with the appropriate CSA Standards." By reference elsewhere within CAN/CSA-F416, this includes CSA S37-M (1986) and any other Standards that are typically used for steel or concrete structural sections, including numerous CSA and ASTM fastening and joining requirements. However, as previously identified in this guide, CAN/CSA-F416 was developed to address 1980s wind-energy technology and not envisioned for use on turbines larger than approximately 50 kW. It has never been officially referenced in any Canadian building code.

CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008. These documents approach tower design requirements based on the IEC body of knowledge for specific wind turbine load cases, supplemented with references to National (Canadian) structural codes and standards for materials as directed by the IEC standards. The current drafts of these documents include references to Part 4.3 of the 2005 (Model) *National Building Code of Canada* (which in turn references a range of Canadian design, materials, and fabrication standards), Canadian climate and seismic design requirements, and other aspects of the Structural Commentaries of the 2005 *National Building Code of Canada*.

For further information on Canadian requirements in this subject area and building codes in general, the reader may wish to visit Canada's National Code website at www.nationalcodes.ca, or contact the appropriate member of the Provincial/Territorial Policy Advisory Committee on Codes (http://www.nationalcodes.ca/ccbfc/PTPACC%20Members%20list2.pdf). The reader should also consider contacting a consulting engineering firm familiar with the jurisdiction.

12.2 Towers (Province of Ontario)

Clause 1.3.1.1 (Designated Structures) of the 2006 Ontario Building Code (OBC) states: "The following structures are designated for the purposes of clause (d) of the definition of *building* in subsection 1 (1) of the Act: … (g) a structure that supports a wind turbine generator having a rated output of more than 3 kW."

The OBC is developed and published by the Ontario Ministry of Municipal Affairs and Housing. Visit www.obc.mah.gov.on.ca for contact information.

13 Markings for aviators

It is CSA's understanding that the Canadian national requirements for markings for aviators are defined by Transport Canada (www.tc.gc.ca). Other provincial or local requirements may apply.

It is CSA's understanding that these specific requirements are currently addressed by Transport Canada's Draft Standard CARS 621.19.12, *Marking and Lighting of Wind Turbines and Windfarms*, which is posted on the Transport Canada website.

CAN/CSA-F416 identifies that "The Wind Energy Conversion System may be required to be marked as an aircraft obstruction. The marking shall be in accordance with CSA S37-M [1986] and any regional Transport Canada regulations." CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008. Neither of these new Standards addresses markings for aviators.

In addition to the AHJ, the reader may also wish to contact CanWEA (www.canwea.ca) for more information on the subject.

14 Electrical safety

14.1 General

This section deals with the electrical safety requirements of all wind turbine components up to the point of connection with a Canadian certified step-up transformer or another similar connection to typical Canadian approved gear.

It is CSA's understanding that the requirements for electrical safety of wind turbine components are not specifically identified by any published Canadian regulations. The recognition of any published documents by the AHJ is based on their interpretation and/or their respective provincial acts relating to electrical safety.

The electrical safety AHJ in Canada have different scopes of authority and interpretations of how their provincial electrical codes are applied. Some AHJ have non-arms-length relationships with grid owners (large private or crown utilities) and have the ability to recognize equipment that has not been certified by a Standards Council of Canada accredited certification (conformity assessment) agency but meets the grid operator's requirements. Other AHJ require owners to allow internal inspections or provide additional documentation or evidence of suitability/compatibility of the equipment. This may include specific modifications for local Canadian climates or to meet particular key code or engineering requirements.

If these unique provincial or local requirements are anticipated and accommodated at the factory, they may not result in any significant cost or delay. It is very important for those involved to become informed about the specific needs of the AHJ for a particular Canadian jurisdiction to avoid expensive field revisions and delays, which have proven to be significant in the past.

There is certainly a desire from all stakeholders to identify and reduce the differences between Canadian and foreign electrical safety codes and standards, though some of these differences in opinion have existed between European and North American electrical safety experts for many decades and will likely continue to exist for years to come.

14.2 Canadian electrical safety standards

The current National Standard of Canada for this subject area is CAN/CSA-F416. CAN/CSA-F416 has never been referenced in any provincial electrical code, although it is referenced in the Northwest Territories and Nunavut codes. CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008. These documents recognize a combination of both existing Canadian electrical safety standards and those international standards or guidelines that are currently supported by international wind turbine certification programs.

14.3 International electrical safety guidelines

To date, most large turbines installed in Canada have been designed in accordance with IEC 61400-1 and its underlying IEC and ISO safety standards. These standards represent the collective requirements that have been deemed acceptable by a consensus of participating member countries (primarily Germany, Denmark, U.K., Sweden, Japan, Spain, Italy, Holland, China, Korea, India, USA, and, since 2005, Canada) and have in turn been adopted by a number of countries with or without national deviations. In some countries, these standards have also been supplemented with extensive structural, material, and worker safety standards. The certification (conformity assessment) processes in these countries differ to some degree within Europe itself, but the differences and the companies involved are considerably different in Canada. Two examples of highly developed international certification guidelines for wind turbines that CSA members have reviewed are published by Germanischer Lloyd (GL) and Det Norske Veritas (DNV). Member delegates from both of these firms play a very active role in updating the IEC 61400 series documents and are very supportive of Canada's intent to update its National Standards to reflect the current state of this technology.

Wind turbine assemblies that arrive in Canada certified by GL, DNV, or others are usually factory certified to IEC standards or the similar adopted national standards of the country of origin (typically Germany or Denmark, but increasingly from the USA, Spain, India, and other countries).

These certifications may include recognition of other certified components, especially electrical components. It is easy to imagine how difficult it is for a Canadian electrical inspector to assess the compatibility (with Canadian electrical codes) of a huge European machine built to different installation standards containing all types of electrical components that are marked by agencies not officially recognized in Canada, or not marked at all. GL and DNV certifications are well known and highly respected in Canada by AHJ involved in selected heavy structural engineering and insurance sectors, particularly with respect to ships and large marine structures. However, these agencies and those who certify the myriad of components are for the most part not integrated into the Canadian or US electrical safety systems.

The harmonization (where possible) of Canadian wind turbine standards (electrical safety) with IEC/European standards will help clarify the range of clearly acceptable, or allowable, solutions for electrical safety. However, the lack of qualified North American registered testing and certification facilities and marking systems is clearly a concern.

14.4 AHJ

This is obviously a subject that some readers will want to pursue further. As noted, the AHJ will vary considerably by jurisdiction. The reader may wish to contact a professional engineer familiar with the jurisdiction. It is the understanding of CSA that the following AHJ may be contacted for guidance on their current and future requirements with respect to electrical safety for wind turbines. This list is not comprehensive.

- Alberta — Alberta Municipal Affairs and Housing (www.municipalaffairs.gov.ab.ca)
- British Columbia — BC Safety Authority (www.safetyauthority.ca)
- Manitoba — Manitoba Hydro (www.hydro.mb.ca)
- New Brunswick — Department of Public Safety (www.gnb.ca)
- Nova Scotia — Nova Scotia Power (www.nspower.ca)
- Ontario — Electrical Safety Authority (www.esasafe.com)
- Prince Edward Island — PEI Department of Communities, Cultural Affairs and Labour (www.gov.pe.ca)
- Québec — Hydro Québec (www.hydroquebec.com)
- Saskatchewan — SaskPower (www.saskpower.ca)

15 Environmental design considerations/external conditions

It is the understanding of CSA that there are no regulations or codes in Canada pertaining specifically to environmental design considerations for wind turbine generator systems. However, there are some jurisdictions in Canada where the requirements of the AHJ may include the consideration of environmental data contained in a provincial building code or other recognized document.

International Standards IEC 61400-1 and IEC 61400-2 (as well as the GL and DNV guidelines) provide great detail on how to evaluate wind loads and assign a class rating using a dynamic approach based on wind speeds. Although the approach to assessment of wind conditions differs from that of the Canadian building codes, it does not appear to conflict and can be reasonably assessed using appropriate conversion factors and supplementary information. Although the IEC standards are up to date, they do not address colder temperature considerations (e.g., colder than minus 20 degrees Celsius) prevalent throughout much of Canada. Additional treatment of colder weather conditions is provided in the GL and DNV guidelines as well as other publications from manufacturers and the International Energy Agency. IEC 61400-1 does not provide much on the subjects of hail, icing, or seismic loads, but these are addressed in some detail by the GL and DNV guidelines.

The current National Standard of Canada for this subject area, CAN/CSA-F416, includes the following environmental design considerations:

- a 100-year return period for worst-case environmental conditions;
- a survival wind speed of 60 m/s at 10 m in lieu of recognized meteorological analysis;

- a wind-shear equation and wind-shear parameter;
- a wind-gust model and a maximum rate of direction change;
- requirements for performance in the 100-year period at –40°C to +40°C and 100% humidity (–60°C north of 60° latitude);
- requirements for withstanding icing of at least 60 mm in lieu of recognized meteorological analysis;
- hail of 20 mm at 20 m/s while operating at full speed;
- lightning strike conditions; and
- seismic loads as defined in building codes.

As previously identified in this guide, CAN/CSA-F416 was developed to address 1980s wind-energy technology and not envisioned for use on turbines larger than approximately 50 kW. It has never been officially referenced in any Canadian building code.

CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008. These publications strike a balance between the approach of the IEC documents and unique requirements based on the realities of Canadian environmental conditions, as detailed in the *National Building Code of Canada*.

16 Load cases

Please see Clauses 11 (Foundations) and 12 (Towers) for information on how building codes may apply in the identification of load cases.

Considerable detail is provided on this subject in Clause 7 of IEC 61400-1 and Clause 7 of IEC 61400-2 and in much greater detail in the GL and DNV guidelines. The application of national or local material codes is recognized in Clause 7.6.1.3 of IEC 61400-1.

CAN/CSA-F416 defines general design load cases and load combinations in Clauses 5.1 and 5.2 but refers to Clause 4.2.1 of the National Building Code (1985) and CSA S37 (1986) for details on survival wind loading. Design methods are based on a life of 20 years. Allowable stress or limit states methods are permitted, but limit states should be as per CSA S37 (1986).

As previously identified in this guide, CAN/CSA-F416 was developed to address 1980s wind-energy technology and not envisioned for use on turbines larger than approximately 50 kW. It has never been officially referenced in any Canadian building code.

CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008. These publications strike a balance between the approach of the IEC documents and the requirements of Canadian AHJ for structural design and approval.

17 Lightning protection

The subject of lightning protection in general, and specifically how it relates to wind turbines, is of great interest to a wide range of stakeholders.

IEC 61400-1 references IEC 61024 for general lightning protection requirements and IEC/TR 61400-24 for wind turbine guidelines. IEC/TR 61400-24 is a Technical Report on wind turbine lightning protection. While technically not a standard, it provides details on the nature of lightning risks as well as guidelines on how to provide reasonable levels of protection to key wind turbine components. It also references a number of other more general IEC documents related to lightning and grounding. The GL and DNV guidelines also provide good coverage of the subject.

CAN/CSA-F416 defines what type of lightning strikes the wind turbine grounding path should be able to withstand, but provides no guidance on how to do so. The CSA CEC, Part I includes numerous clauses containing general requirements for installation of grounding, lightning arrestors, and lightning protection equipment. CAN/CSA-B72, *Installation Code for Lightning Protection Systems* is also a useful general reference.

As previously identified in this guide, CAN/CSA-F416 was developed to address 1980s wind-energy technology and not envisioned for use on turbines larger than approximately 50 kW. It has never been officially referenced in any Canadian building code.

CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008. These publications strike a balance between IEC and Canadian requirements for lightning protection and grounding.

CSA has recently released for publication CAN/CSA-C61400-24, which is the adoption, with Canadian deviations, of IEC/TR 61400-24. It was published in December 2007.

The reader may wish to contact the electrical safety AHJ listed in Clause 14.4 for additional guidance.

18 Blades/rotors

CSA is not aware of any Canadian regulatory requirements for wind turbine blades or rotors.

IEC 61400-1 refers to IEC 61400-23 for the structural requirements of large blades. The GL and DNV guidelines cover this subject in great depth. CAN/CSA-F416 does not contain requirements on blades or rotors.

As previously identified in this guide, CAN/CSA-F416 was developed to address 1980s wind-energy technology and not envisioned for use on turbines larger than approximately 50 kW. It has never been officially referenced in any Canadian building code.

CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008.

19 Mechanical systems

CSA is not aware of any Canadian regulatory requirements for wind turbine mechanical systems. CAN/CSA-F416 does not contain requirements on these subjects.

IEC 61400-1 has a section describing mechanical systems (gearboxes, brakes, bearings, pitch and yaw actuators, etc.) and is supplemented by IEC/TS 61400-13 (on measurement of mechanical loads) and a number of ISO references for bearings. The GL and DNV guidelines also cover these subjects in great depth.

CAN/CSA-F416 will be superseded by the new CSA publications CAN/CSA-C61400-1 and CAN/CSA-C61400-2, both expected to be published before May 2008.

20 Performance measurement

CSA is not aware of any regulatory publications that relate to this subject area. However, this subject area is becoming increasingly important with respect to the commercial aspects of wind turbines and is a very active subject within IEC TC 88. In May 2007, the CSA Technical Committee on Wind Turbines approved the adoption of IEC 61400-12-1, *Power performance measurements of electricity producing wind turbines*, and it has just recently been released for publication as a new National Standard of Canada as CAN/CSA-C61400-12-1.

Several international certification bodies, including GL and DNV, address this subject area in their published guidelines and also offer certification programs based on their guidelines.

CAN/CSA-F417 is not known to be referenced in any official capacity but contains a fairly simple procedure suitable for evaluating the power curve, annual output, and noise generated by a small turbine. Now that CSA has published CAN/CSA-C61400-12-1, CAN/CSA-F417 will be withdrawn.

21 Power quality

In Canada, the AHJ will typically be the grid operators, and the rules will be based on the respective grid codes. There is no applicable National Standard of Canada for wind turbine power quality.

IEC 61400-21 provides details on how to define and measure a number of power quality characteristics such as reactive power, flicker, voltage fluctuations, and harmonics, but is not currently planned for adoption in Canada.

A great deal of research has been carried out on wind turbine power quality around the world, and it is the subject of ongoing work by a number of North American organizations including a joint American Wind Energy Association (AWEA) and CanWEA working group (see www.canwea.ca) and the Canadian Electricity Association (www.ceatech.ca).

22 Worker safety

Each Canadian province has occupational health and safety codes that provide general and specific requirements for a range of work environments. These codes cover personal protective equipment, work platforms, ladders, guarding, confined spaces, etc., and may reference other documents from CSA or other standards bodies. Related CSA Standards include the CSA Z259 “fall arrest” series; CAN/CSA-Z431, *Basic and safety principles for man-machine interface, marking and identification — Coding principles for indication devices and actuators*; CSA Z432, *Safeguarding of machinery*; CAN/CSA-Z460, *Control of hazardous energy — Lockout and other methods*; and the larger range of personal protective equipment standards.

CSA is unaware of any Canadian worker safety regulations or standards specific to wind turbines. An example of a comprehensive worker safety standard for wind turbines is British Standard BS EN 50308, *Wind Turbines — Protective Measures — Requirements for Design, Operation and Maintenance*, which addresses specific risks to workers from falls, slips, fire, electrocution, noise, confined spaces, and ergonomics in the context of a wind turbine. It also references several EN and ISO standards and contains a number of prescriptive requirements.

For more information, the reader may wish to contact the AHJ responsible for enforcement of occupational health and safety regulations in the particular jurisdiction of interest. The reader may also wish to contact the Canadian Centre for Occupational Health and Safety (www.ccohs.ca).

Annex A
CSA Wind turbine committees and members

CSA and its members have been actively working since 2004 to address the needs of Canadian stakeholders with respect to this rapidly developing technology.

The CSA Technical Committee on Wind Turbines is responsible for the direction and approval of all of CSA wind turbine standards projects and reports to the CSA Strategic Steering Committee on Requirements for Electrical Safety (SCORES). The approach being undertaken by the Technical Committee is to update the National Standards of Canada based on the body of knowledge published by the International Electrotechnical Commission (IEC) Technical Committee 88 on Wind Turbines. As of November 16, 2007, there are five IEC TC 88 standards being adopted by CSA and each was reviewed in detail by a specific CSA Subcommittee (Standing Committee) as follows:

IEC Standard reviewed	CSA Wind turbine subcommittee name	Status of adoption
61400-1, Wind turbines – Part 1: Design requirements	Design Requirements	Currently at Technical Committee ballot. Publication expected in May 2008
61400-2, Wind turbines – Part 2: Design requirements for small wind turbines	Small Wind Turbine Design Requirements	Currently at Technical Committee ballot. Publication expected in May 2008
61400-11, Wind turbine generator systems – Part 11: Acoustic noise measurement techniques	Acoustic Noise Measurement	Adopted without deviations and published as a National Standard of Canada in November 2007
61400-12-1, Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines	Power Performance Testing	Adopted without deviations and published as a National Standard of Canada in November 2007
61400-24, Wind turbine generator systems – Part 24: Lightning protection	Lightning Protection	Adopted with Canadian deviations and published as a National Standard of Canada in December 2007

A listing of the current members of the CSA Technical Committee on Wind Turbines and its five Subcommittees at the time of publication are attached.

Technical Committee on Wind Turbines

D. Vandermeer	Satcon Stationary Power Systems, Burlington, Ontario	*Chair*
C. Handler	Natural Resources Canada, Ottawa, Ontario	*Vice-Chair*
R. Abdul	Mitsubishi Power Systems, Lester, Pennsylvania, USA	
P. Andres	Sustainable Energy Link Limited, Kincardine, Ontario	
M. Bourns	TransAlta Wind, Calgary, Alberta	
T. Buchal	Intertek — ETL Semko, Cortland, New York, USA	*Associate*
P. Champigny	GAMESA Wind, Toronto, Ontario	*Associate*
D. Clements	Nova Scotia Power Inc., Halifax, Nova Scotia	
M. De Lint	Ontario Ministry of Municipal Affairs and Housing, Toronto, Ontario	*Associate*
C. Deveau	U.S. Steel Canada Inc., Hamilton, Ontario	*Associate*
S.W. Douglas	Electrical Safety Authority, Cambridge, Ontario	
G.S. Frater	Canadian Steel Construction Council, Toronto, Ontario	
M. Gardner	Alberta Municipal Affairs and Housing, Edmonton, Alberta	
R. Grant	Grantec Engineering Consultants Inc., Hammonds Plains, Nova Scotia	
R. Guillemette	AAER Systems Inc., Verdun, Québec	
G. Holden	Hatch Energy, Niagara Falls, Ontario	*Associate*

B. Howe	HGC Engineering — Howe Gastmeier Chapnik Ltd., Mississauga, Ontario	*Associate*
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D. Krause	Algal & Associates Ltd., Toronto, Ontario	*Associate*
D.R. Luciani	CWB Group - Industry Services, Mississauga, Ontario	*Associate*
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M. Oprisan	Natural Resources Canada, Ottawa, Ontario	*Associate*
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S. Paulsen	Province of New Brunswick, Fredericton, New Brunswick	
K. Polnicky	Vestas Americas Wind Technology Inc., Portland, Oregon, USA	
S. Saylors	Vestas Americas Wind Technology Inc., Portland, Oregon, USA	*Associate*
I. Shaw	Hatch Energy, Niagara Falls, Ontario	
M. Stone	Canadian Welding Bureau/ Bureau Canadien de Soudage, Mississauga, Ontario	
R. Strube	Intertek — ETL Semko, Cortland, New York, USA	*Associate*
D. Timm	Canadian Wind Energy Association (CanWEA), Ottawa, Ontario	

L. Welsh	Environment Canada, Hull, Québec	
S. Whittaker	Canadian Wind Energy Association, Ottawa, Ontario	*Associate*
C. Cortissoz	Canadian Standards Association, Mississauga, Ontario	*Project Manager*
J. Shikaze	Canadian Standards Association, Mississauga, Ontario	*Project Manager*

Subcommittee on Wind Turbine Design Requirements

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G.S. Frater	Canadian Steel Construction Council, Toronto, Ontario	
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R. Storey	Canadian Standards Association, Mississauga, Ontario	*Project Manager*

Subcommittee on Small Wind Turbine Design Requirements

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Subcommittee on Acoustic Noise Measurement of Wind Turbines

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Subcommittee on Wind Turbine Power Performance Testing

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Subcommittee on Wind Turbine Lightning Protection

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