micro POWER CONNECT

Connecting MicroPower to the Grid

A status and review of
micropower interconnection issues and
related codes, standards and guidelines in Canada

2nd Edition

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Table of Contents

Executive Summary

There is an accelerating world demand for environmentally friendly power, generated with photovoltaic arrays, wind turbines, fuel cells and microturbines. There is a huge potential market among homeowners and small business operators for these "green" micropower sources.

Micropower generators have the potential to improve air quality, reduce environmental damage related to coal or oil-fired generation, and provide greater security in the event of energy shortages.

Also, the connection of small, privately-owned electricity generators to the public power system has many benefits for Canada's economy. However, the challenge for governments and regulators is to allow this new industry to grow in a way that is both safe and efficient.

To that end, Canadian provinces and territories must have appropriate technical standards in place. Such standards allow for consistent manufacturing and installation practices, and reduce the costs, paperwork and safety problems that now prevent many people from using these new technologies. In this respect, this document summarizes the state of four micropower sectors, namely: photovoltaics, fuel cell, wind turbine and microturbine, by identifying the safety and power quality standards and related codes that now exist, those that are lacking in Canada, as well as those in the international community that can serve as references for Canada.

Photovoltaic (solar) panels are a well-established technology, but rules that were designed for large capacity generators often constitute a huge barrier to the marketing of small rooftop systems. Requirements (code and standards) need to be reviewed to cope with the new reality of small residential systems application.

Sommaire

La demande mondiale pour les sources d'énergie propre est en forte hausse, que ce soit l'énergie photovoltaïque, les éoliennes, les piles à combustibles ou les microturbines. Le marché potentiel de ces sources de microproduction d'énergie est particulièrement évident dans les secteurs résidentiel et de la petite entreprise.

La microproduction d'énergie offre d'intéressantes perspectives pour atténuer le recours qu'a le Canada aux énergies produites à l'aide de combustibles fossiles; elle permet aussi d'atténuer les inconvénients environnementaux engendrés par les centrales activées au charbon ou au pétrole, notamment en matière de qualité de l'air, tout en donnant de meilleures garanties de sécurité en cas de pénurie d'énergie.

De plus, l'addition d'énergie électrique au système public d'approvisionnement par de petits producteurs privés présente de nombreux avantages pour l'économie canadienne. Le défi des gouvernements et des organismes de réglementation demeure toutefois de permettre la croissance de cette industrie naissante dans le respect d'une pratique sécuritaire et efficace.

À cette fin, les provinces et les territoires canadiens doivent se doter de normes technologiques bien définies. De telles normes permettront d'établir des règles d'installation et de production uniformes, tout en réduisant les coûts, la paperasse et les risques inhérents à la sécurité; autant de facteurs qui nuisent au développement de ces nouvelles technologies. Dans cette optique, le présent document fait un survol de quatre méthodes de microproduction, soit : la technologie photovoltaïque, les piles à combustible, les éoliennes et les microturbines; on y fait état des codes et des normes existants en matière de sécurité et de qualité de l'énergie ainsi que des normes manquantes au Canada en plus d'identifier les normes sur la scène internationale qui peuvent servir de points de repère à l'industrie canadienne.

La technologie photovoltaïque est désormais bien connue mais les règles établies pour la production à grande capacité deviennent souvent un obstacle important à la mise en marché d'appareillage destiné aux applications résidentielles. Les exigences (réglementations et normes)

Fuel cells are known for their potential in powering vehicles, without hydrocarbon pollution. Their high efficiency also opens up opportunities for large-scale industrial generation and residential / portable applications, producing both electricity and heat. Standards must keep pace with new fuel cell technologies that are beginning to be commercialized. The fuel cell standards are being developed with an international focus in order to support the export of products from Canada to other countries. Those same international standards will be adopted in Canada to support local application of the technology.

As for wind energy, standards do exist in Canada, but they have not kept pace with rapid changes in the technology. There is a need to harmonize them to international standards and ensure that cold-weather wind turbine installations issues are addressed.

Microturbines are now commercially available in sizes from 30-250 kW. They emit significantly less NOx emissions and operate with much lower noise and vibration than reciprocating engines.

While these four micropower technologies have to deal with specific requirements, they also share common issues when it comes to interconnection to the grid. Regardless of the electricity generation method, they all use static inverters, which serve as the interface with the utility grid. Hence, MicroPower Connect has, through one single initiative, addressed the issues pertaining to the interconnection of such micropower generators to the grid. Also, the existing standard on the static inverter itself must be upgraded to suit new grid-connected applications and power generation technologies.

doivent être révisées pour s’adapter à cette nouvelle réalité.

Les piles à combustible sont reconnues pour leur application dans le monde du transport, éliminant les désavantages de la pollution par hydrocarbures. Leur grande efficacité met en lumière des occasions d’utilisation à grande échelle en milieux industriel et résidentiel, produisant à la fois l’électricité et le chauffage. Les normes doivent suivre le rythme d’évolution des nouvelles piles à combustible qui se retrouvent sur le marché. Les normes des piles à combustible sont d'abord développées en gardant le volet international en tête afin de faciliter l'exportation des produits canadiens, puis adoptées au Canada de façon à faciliter l'application des cette nouvelle technologie en milieu résidentiel.

En ce qui a trait aux éoliennes, le Canada a des normes mais celles-ci n’ont pas suivi le rythme rapide d’évolution de cette technologie. Ainsi il y a nécessité de les harmoniser aux normes mondiales tout en s’assurant que les problèmes potentiels associés aux températures froides sont dûment considérés.

Les microturbines sont maintenant disponibles commercialement dans des capacités variant de 30 à 250 kW. Parmi les avantages marqués qu'elles offrent, on note particulièrement leurs émissions de NOx et de bruit beaucoup mois élevées que celles produites par des génératrices conventionnelles.

Bien que ces quatre technologies de microproduction d’énergie ont leurs propres exigences à rencontrer, elles font aussi face à un défi commun en matière d’interconnexion au réseau de distribution; toutes ces technologies de production d’électricité utilisent un onduleur électronique à titre d’interface avec le réseau principal. Ainsi, MicroPower Connect a pu solutionner, par une seule action, la problématique se rapportant à l’interconnexion de tels microproducteurs d’électricité au réseau public. De plus, les normes actuelles couvrant les onduleurs même doivent être rehaussées pour satisfaire aux exigences de ces technologies de microproduction d’électricité et de leurs nouvelles applications reliées au réseau.

Photovoltaic

Microturbine

Fuel Cell

Wind Turbine

1.0 Introduction

A vision of a not so distant future of the electrical network may very well sound like this: An international network of electricity generators based in homes, farms, factories, office buildings and small community facilities. The power devices would be cost-effective and easy to install. The owners would enjoy greater energy security, and receive credit for their excess power.

While this may sound futuristic today, one must admit that deregulation of electricity markets and new products now developed and refined are taking us down a road that is leading us this way. The current issues with the development of this network are not the methods of generating electrical power, as there are a number of micropower options that already exist today, but the mechanisms for sharing it.

The deregulation of the electricity sector in North America provides an opportunity to establish guidelines and policies that will support the widespread use of small renewable energy power and distributed generation sources. Initiatives that are aimed at increasing the market for small renewable and distributed generation have been supported by governments because of three main reasons:

- new technologies often offer cost-effective and efficient solutions with significant environmental benefits;
- there is a huge market potential worth billions of dollars and thousands of jobs; and
- distributed generation has the potential to improve the reliability of electricity power at the site and delay infrastructure upgrades to the existing network.

Micropower will not replace the need for power generation at large installations by traditional utilities. But it is clear that power needs will continue to grow and in regions where the expansion of nuclear or coal-burning plants is constrained, efficient and clean on-site power generation may provide an alternative. However, a number of issues need to be covered to assure a coherent and safe development of this industry. To that extent, safety and power quality standards are an important element of the solution.

Since one of the most important barriers to the adoption and deployment of these new technologies is the lack of harmonised standards and guidelines, Canadian manufacturers and distributors have asked Natural Resources Canada[1] and Industry Canada[2] to support the establishment of MicroPower Connect[3] to facilitate the development of such an approach.

Created in 2001, MicroPower Connect has evolved into a broader initiative called Power Connect that now addresses issues pertaining to the interconnection of larger systems and includes other related issues such as net metering and contractual agreements. However, MicroPower Connect remains a subset of Power Connect focusing on interconnection standard for inverter-based distributed generation Technologies.

1. The CANMET Energy Technology Centres and Renewable Energy and Electricity Division at Natural Resources Canada work with the Canadian industry and associations to remove barriers to the deployment of renewable energy technologies. (www.nrcan.gc.ca/es/ <http://www.nrcan.gc.ca/es/>)
2. Industry Canada has completed a study entitled *Canadian Electric Power Industry Technology Roadmap: Forecast* and supports the Standards Council of Canada (SCC) in an effort to remove international trade barriers that are caused by lack of international standards. (www.ic.gc.ca)
3. MicroPower Connect is an industry lead initiative managed by Electro-Federation Canada (EFC). EFC's members represent key players in the electrical, electronics, appliance and telecommunications industries. As a broadly based association, EFC stages a dialogue on issues affecting the electro-technical businesses, including standards. (www.powerconnect.ca)

About this report

This second edition was prepared to provide a status on codes, standards and guidelines as well as issues relevant to the interconnection of inverter-based Distributed Generation with the grid to stakeholders collaborating on the various standards processes in Canada. Industry experts from four micropower technologies (photovoltaic, wind, fuel cell, and microturbines) contributed to the update of this review. The goal of the report is to identify areas where there are significant overlaps in the needs identified and common barriers that the industry must overcome.

Section 2 of this report describes the safety, power quality, and interconnection issues that are common to most on-site generator systems. Sections 3 to 6 provide a review of photovoltaic, fuel cell, microturbine and wind turbine technology standards and codes. Section 7 lists a series of interconnection requirements applicable in various regions of Canada. Section 8 provides a compilation of the standards and codes of the four technologies for comparison. Finally, Section 9 concludes with common issues and provides an overview of the principal barriers.

2.0 Safety, Power Quality and Interconnection Issues[4]

In Canada, all electrical and gas products installed must be certified for intended use. For that reason there exists a number of safety and performance standards according to which the products are certified. Similarly, there exist standards and codes that specify the requirements for the installation and interconnection to the grid of electrical systems. The following explains some of the technical issues addressed by the standards and codes covering the safety, power quality and interconnection aspects of micropower technologies.

2.1 Islanding

The first safety issue that comes to everyone's mind for small customer-sited systems is a condition called islanding. Islanding is where a portion of the utility system that contains both loads and a generation source is isolated from the remainder of the utility system but remains energised. When this happens with a distributed power system, it is referred to as supported islanding. The safety concern is that if the utility power goes down (perhaps in the event of a major storm), a distributed generation system could continue to unintentionally supply power to a local area. While a utility can be sure that all of its own generation sources are either shut down or isolated from the area that needs work, an island created by a residential system can be out of their control.

There are a number of potentially undesirable results of islanding. The principal concern is that a utility line worker will come into contact with a line that is unexpectedly energised. Although line workers are trained to test all lines before working on them, and to either treat lines as live or ground them on both sides of the section on which they are working, this does not remove all safety concerns because there is a risk when these practices are not universally followed.

Fortunately, static inverter technology developed for grid-interactive systems is now specifically designed so that there is practically no chance of an undesired supported island stemming from an interconnected residential or small commercial systems. This feature is referred to as anti-islanding. Grid-tied inverters monitor the utility line and cease to deliver power to the grid as quickly as necessary in the event that abnormalities occur on the utility system. Such performance requirement is generally described in both the inverter and the interconnection standards.

2.2 Manual Disconnect

An external manual lockable disconnect switch ("manual disconnect") in the interconnection context is a switch external to a building that can disconnect the generation source from the utility line. The requirement for a manual disconnect, stems from utility safe working practices that require disconnecting all sources of power before proceeding with certain types of line repair.

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4. Adapted from "Connecting to the Grid - A Guide to PV Interconnection Issues", IREC Third Edition 2000, by Chris Larsen, Bill Brooks and Tom Starrs.

Whether a manual disconnect for small systems, such as photovoltaic (PV) systems, using certified inverters should be required has been the source of considerable debate. In strict safety terms, a manual disconnect is not necessary for most modern systems because of the inverter's built-in automatic disconnect features as discussed in the previous section. Both the Canadian Electrical Code (CE Code) and the National Electrical Code (NEC) in the United States, refers to the need for an additional switch that is (1) external to the building, (2) lockable by utility personnel, and (3) offers a visible-break isolation from the grid. As such, a manual disconnect is an additional means of preventing an islanding situation. And, the key from the utility perspective is that the switch is accessible to utility personnel in the event of a power disruption when utility line workers are working on proximate distribution system lines. In addition, in many situations, utility line workers can provide redundant protection against islanding by removing a customer's meter from the meter socket. Still, many utilities require a separate, external manual disconnect.

While the cost of installing such a switch is not large relative to the overall cost of a micropower system, a PV system for example, when compared to expected energy savings from the system, such a switch is relatively expensive. Also, for systems located on the top of tall buildings, such a switch becomes very expensive. In the USA, some state-level net metering and interconnection rules require that the utility pay for the installation of a manual disconnect. In New Mexico, use of the meter is an optional alternative to a separate switch while in many other states a manual disconnect is not required, at least for small systems; that is the case of California, New Jersey, Washington, and Nevada. Also, some utilities, such as those owned by the New England Electric System, have established their own interconnection guidelines that do not require an external manual disconnect for small systems.

2.3 Power Quality

Power quality is another technical concern for utilities and customer-generators. In North America, residences receive alternating current (AC) power at 120/240 volts at 60 cycles per second (60 Hz), and commercial buildings typically receive either 120/240 volts or three-phase power depending on the size of the building and the types of loads in the building. Power quality is important because electronic devices and appliances have been designed to receive power at or near these voltage and frequency parameters, and deviations may cause appliance malfunction or damage. Power quality problems can manifest themselves in lines on a TV screen or static noise on a radio, which is sometimes noticed when operating a microwave oven or hand mixer. Noise, in electrical terms, is any electrical energy that interferes with other electrical appliances. As with any electrical device, an inverter, which converts the DC power from the generation side into usable AC power for a house, potentially can inject noise that can cause problems.

In addition to simple voltage and frequency ranges, discussions on power quality include harmonics, power factor, DC injection, and voltage flicker. Harmonics generically refers to distortions in the voltage and current waveforms. These distortions are caused by the overlapping of the standard waves at 60 Hz with waves at other frequencies. Specifically, a harmonic of a sinusoidal wave is an integral multiple of the frequency of the wave. Total Harmonic Distortion (THD) is summation of all the distortions at the various harmonic frequencies.

Another indication of the power quality is the power factor. Certain load types cause voltage and current waveform to be out of synch, forcing the generator to supply apparent power in excess of the active power required. Power factor is the ratio of the active power, as measured in watts, to the apparent power, as measured in volt-amperes (VA). The power factor can range from a low of zero when the current and voltage are completely out of synch to the optimal value of one when the current and voltage are entirely in synch. The terms "leading" and "lagging" refer to whether the current wave is ahead of or behind the voltage wave. Although not strictly the case, low power factor situations can be thought of as contributing to utility system inefficiencies.

DC injection occurs when an inverter passes unwanted DC current into the AC or output side of the inverter. Voltage flicker refers to short-lived spikes or dips in the line voltage. A common manifestation of voltage flicker is when lights dim momentarily. It is important to note, however, that grid-interactive inverters are tested to limit THD and generally do not create DC injection or voltage flicker problems.

2.4 Interconnection

Perhaps the number one interconnection barrier for small renewable systems has been the lack of uniformity in interconnection standards from utility to utility. This is a result of the traditional discretion given to utilities to deal with their own generation, transmission, and distribution systems.

To be more accurate, it is a problem of many utilities not having any standards at all for small grid-tied generators. A survey done in the USA showed that only a limited number of large utilities had any small generator interconnection standards; this is also true for Canada. In the case where a utility has no small generator standards, interconnection is addressed on either a case-by-case basis or through existing standards usually used for larger industrial systems. However, it is beyond the means of most prospective residential or small commercial system owners to hire a professional engineer and attorney for the interconnection of a small grid-tied system that is intended simply to offset a portion of the owner’s electricity use.

A 5 kW system on the Mississauga campus of the University of Toronto

Photo courtesy of Sol Source Engineering

Photovoltaic modules convert solar radiation directly into electricity (DC power) through light sensitive semiconductor devices. This electricity can be used as DC power, stored in batteries for later use or, converted to AC power. In the latter case, a central inverter (power conditioner) or several PV array string inverters are used to tie the PV array to the utility grid.

3.0 Photovoltaic Technical Issues: Safety, Power Quality, and Codes

Overview

In Canada there are a limited, though increasing, number of grid-tied photovoltaic (PV) systems installed to date. However, in the long term there is a large potential for such systems. In Japan, over 230 000 PV rooftop systems had already been installed on residences by the end of 2004. This represents a capacity of 860 MW of on-site power generation. Germany also has an aggressive PV rooftop program which added 65 700 systems representing 345 MW of installed PV power capacity between January 1999 and December 2003.

When thousands of systems are installed every year, it is too costly and time consuming for utilities to conduct case-by-case analysis of each grid-tied system. An important step to developing the distributed generation market in North America is therefore the development of simple and uniform standards; this is particularly true for the installation of small PV systems (less than 10 kW).

An important part of the installation issues relates to the lack of experience of electricians and electrical inspectors who do not regularly deal with DC circuits and emerging technologies such as PV systems. Furthermore, emerging technologies, as such, are not always properly dealt with by existing codes and standards that support the installation and inspection of safe distributed generation systems. The status on current and under development Canadian codes and standards provided below is intended to show the progress being made as well as to identify remaining gaps in these areas.

3.1 Fuel Source and Storage

In the case of PV systems, the energy source comes from the sun in the form of light. Therefore there are no special requirements or standards that apply to the fuel, nor are there any issues regarding the storage of the fuel used by such systems.

3.2 DC Generation

3.2.1 Equipment Standards

PV modules

There are two standards applicable to PV modules in Canada. The first one “CAN/CSA - C61215:01 Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval” is an international standards adopted by Canada in 2001 to cover the performance aspects relating to crystalline modules. This standard was since reviewed by IEC and the second edition should get adopted in Canada in 2006.

The second document is an ORD (Other Recognized Document) “ULC/ORD C1703-01 — Flat plate PV modules and panel” based on a UL standard which covers the safety aspects of modules. In absence of a Canadian standard, this was adopted as an interim solution until the international standard “IEC 61730 — Photovoltaic module safety requirements (Part 1 and 2)” gets developed and adopted. This IEC document was completed in 2005 and is expected to be adopted in Canada by 2007.

Power conversion equipment

Power conversion equipment for use in Photovoltaic Systems is partially covered in CSA C22.2 No 107.1. The PV industry initiated a project to revise this standard in 1998. As a result, the latest edition (CSA C22.2 No.107.1-01) includes several new clauses. Clause 14 - "Power Conversion Equipment for Use in Photovoltaic Systems” applies to electrical power conversion equipment (on the DC side) designed to be connected in a PV system. Clause 15 - “Utility-Interconnected Inverters” in this CSA standard is discussed in Section 3.3.1.

Other equipment, such as switches, fuses, and breakers, are covered by existing codes.

3.2.2 Installation Requirements

There is a specific section in the Canadian Electrical Code, Part 1 (CEC) dealing with photovoltaics. Section 50 - Solar Photovoltaic Systems was introduced into the CEC in the 1994 edition. Important amendments to update Section 50 have been approved by the Section 50 sub-committee and the CEC Part 1 Committee. Changes to bring Section 50 in line with modern practices were published in the CEC 2006 edition.

In Europe many of the installation requirements are developed within the IEC TC64. This technical committee has produced an international standard “IEC 60364-7-712 : Electrical installations of buildings - Requirements for special installations or locations - Photovoltaic power supply systems”. In the US, the National Electrical Code (NEC) Section 690 provides requirements for PV system installation.

3.3 DC to AC Conversion

3.3.1 Equipment Standards

Static Inverters

Standards covering static inverters exist at all Canadian, American and international levels. Section 10 of CSA C22.2 No. 107.1-01 covers stand-alone inverters. As stated earlier, this standard was reviewed in 2001 and several new sections were added. Clause 14 was added to cover static inverters used specifically for PV applications.

Clause 15 of CSA C22.2 No. 107.1-01 deals with utility-interconnected inverters. This section specifies anti-islanding protection as well as the limits of harmonic distortion. The Technical Subcommittee is now revising and evaluating further changes that may be required on CSA 22.2 No. 107.1-01 standard to ensure it is harmonized with the requirements found in the new interconnection standards CAN/CSA C22.2 No. 257-06 and to the extend possible with the American standard for inverters, UL 1741, also under review. CSA C22.2 No 107.1-01 standard covers grid-tied static inverters. However, though the applicability of this standard is not explicitely limited in terms of size, in practice this standard is really usable only for inverter up to about 50 kVA. While this is not a major issue for PV grid connected systems installed in Canada at this time as systems are rarely that large, and normally composed of paralleled smaller sub-systems, in the future, there may be a need for a standard on static inverters larger than 50 kVA.

Canadians are currently participating in the development of an international standard project - IEC 62109, Electrical Safety of Static Inverters and Charge Controllers for use in Photovoltaic Systems. This project was initiated and is managed by a UL expert and a Canadian manufacturer (Xantrex) as well as safety testing associations, such as CSA (Canada), TUV (Germany), KEMA (Netherlands) and JET (Japan). These national safety associations intend to move towards the adoption of international standards for static inverters when approved and published.

3.3.2 Installation Requirements

The installation of static inverters is covered by the General Clause of the CEC Section 1-12, and 26. These sections cover grounding, wiring methods and general rules regarding installation of electrical equipment. PV specific requirements are covered in section 50 of the CEC.

3.4 Customer-side Interconnection

3.4.1 Equipment Standards

Canadian Electrical Code Part II includes a number of standards that cover the accessory equipment, namely most of those found under the following categories: General Requirements, Wiring Products and Industrial Products.

3.4.2 Installation Requirements

For the installation of grid connected PV systems, a clause (50-020) has been included in the CEC Section 50 in order to specify requirements for installation of PV.

In the United States, this is covered by the National Electrical Code under sections 690-54 to 690-64.

In complement to Part I of the Canadian Electrical Code, the Canadian standard “CAN/CSA C22.2 No. 257-06” stipulates a number of requirements that must be met by the owners of interconnected PV systems in order to ensure a safe operation of inverter-based systems that also complies with utility requirements.

3.5 Utility-side Interconnection

3.5.1 Equipment Standards

Although the equipment used for interconnection is generally regular equipment, the interconnection of distributed generation systems has raised an issue about net metering, specifically for meters that can be operated backward. However, the issue is not really a safety issue as meters approved for measuring back-fed electricity do exist. Therefore, it is more a commercial policy and regulation issue, which entails to the selection of the appropriate type of meters by the parties involved (to meet regulation).

3.5.2 Installation Requirements

In Canada, the requirements for the interconnection to the utility are covered in the Section 84 of the CEC. A very general requirement in Clause 002 of Section 84 states that the interconnection arrangements must be in accordance with the requirements of the supply authority. As a consequence, specific interconnection requirements can be imposed by the local utility.

One issue with some existing utility rules is that these rules were often designed for large multi-megawatt capacity generators, which represents a huge barrier to the market introduction of small PV rooftop systems in Canada. There is a general consensus that exceptions are needed for very small residential systems (under 10 kW) and for small commercial systems.

In North America, IEEE Std 929 - Recommended Practice for Utility Interface of Photovoltaic Systems and IEEE Std 1547 series - Standard for Distributed Resources Interconnected with Electric Power Systems are the best known references for interconnection. The IEEE Std 929-2000 is a published standard that is used in most of the net-metering PV programs in the USA, and is good example of different requirements for PV systems below 10 kW. Similarly, the IEC 61727 (Edition 2) is the international standard that lists the requirements for interconnection of PV systems.

In Canada, MicroPower Connect has developed a national consensus document (Guideline) which has been finalized through a CSA process and approved as a National Standard of Canada (CAN/CSA C22.2 No. 257-06) in early 2006. This standard focuses on the lower range of inverter-based systems (connection below 750V) and contributes to minimizing variances that can exist throughout various Canadian jurisdictions.

		HAVE IN CANADA	NEED IN CANADA	OTHERS (US OR INTERNATIONAL)
FUEL SOURCE / STORAGE	Equipment			
	Installation			
DC GENERATION	Equipment	ULC 1703 CSA C22.2 No. 107.1-01		IEC 61730
	Installation	CEC Section 50-004 – 50-020		NEC 690-4 to 690-53
DC-AC CONVERSION	Equipment	CSA C22.2 No. 107.1-01 Clause 15	Larger scale inverter safety standard	UL 1741 and IEC 62109 (draft)
	Installation	CEC general requirements (Sections 1-12, 26)		
CLIENT-SIDE INTERCONNECTION	Equipment	CEC Part II relevant standards (Eg.: wiring equip., etc.)		
	Installation	CEC Section 50 Clause 020 CAN/CSA C22.2 No. 257-06		NEC 690-54 to 690-64
UTILITY-SIDE INTERCONNECTION	Equipment			
	Installation	CEC Section 84 CAN/CSA C22.2 No. 257-06 Other local requirements		IEEE 929 IEEE 1547 IEC 61727

Photo courtesy of Ballard Power Systems

In January 2003, Ballard's jointly-owned company, EBARA BALLARD, unveiled its first generation pre-commercial 1 kW stationary combined heat and power proton exchange membrane (PEM) fuel cell generator for the Japanese residential market.

The system includes a fuel cell, a reformer, pumps and blower, and a hot water storage tank. This generator has total system efficiency (heat and electricity) of 92 percent (lower heating value).

4.0 Fuel Cell Technical Issues: Safety, Power Quality, and Codes

Overview

Stationary fuel cell generators that are interconnected with an electrical distribution system fall into the categories of either base-load or intermittent power. A base-load power application is one in which the generator operates continuosly, at or near maximum electrical power rating, with few interruptions. An intermittent generator, in contrast, is one that is intended to dynamically follow either a heat or electrical load.

Base-load operation requires an unlimited fuel supply, such as that provided by the natural gas distribution network (or a sufficiently large liquid fuel tank). With these generators, electricity is the primary product with the excess heat being captured for use in residential, commercial or industrial applications. Ideally, all waste heat will be utilized, however, when that is not possible, a portion of the heat must be rejected to the environment.

Intermittent operation is suited to fuel cells with a fast response time and is associated with two types of application:

1) The fuel cell is supplied by natural gas and follows the heat load of a building, supplying electricity as a by-product to the grid. Since excess heat is never rejected to the environment, this mode of operation can lead to very high energy efficiencies and CO_2 emissions reduction. This is a mode of fuel cell operation used for residential fuel cells in countries such as Japan.
2) The second intermittent application follows an electrical load, operates only during peak periods, or is used as emergency backup. In these applications, hydrogen for the fuel cells may be derived from a natural gas stream, or, hydrogen may be generated through electrolysis, during a stand-by power mode, and stored as a compressed gas in tanks.

For both the base-load and intermittent power applications, Industry standards for fuel cell technologies are being developed through the IEC TC-105 Fuel Cell Technical Committee. These international standards are being written with input from the Canadian Fuel Cell Technical Committee and its members. All of the IEC TC 105 Fuel Cell standards carry the 62282 series designation. Those standards related to stationary power applications are listed in Table 1.

Table 1 - Relevant IEC Fuel Cells Standards

Designation	Title	Status/Estimated publication date
IEC/TS 62282-1	Terminology	Published (2005)
IEC 62282-2	Fuel cell modules	Published (2004)
IEC 62282-3-1	Stationary fuel cell power plants - Safety	2006-07
IEC 62282-3-2	Stationary fuel cell power plants - Test methods for performance	2006
IEC 62282-3-3	Stationary fuel cell power plants - Installation	2007-08

In addition to the international standards, there are three published fuel cell standards in the U.S. that may be used by Canadian companies preparing fuel cell technology for export to that country. The first is the standard for stationary fuel cell product safety, known as ANSI/CSA AMERICA FC 1 “Standard for Stationary Fuel Cell Power Systems.” The IEC 62282-3-1 standard listed in the table above can be thought of as the international version of ANSI/CSA AMERICA FC 1.

The ASME PTC-50, “Performance Test Code for Fuel Cell Power Systems,” provides guidance for evaluation of fuel cell power system performance, including power output and efficiency. The International standard that serves a similar purpose is IEC 62282-3-2. These performance standards are intended to be used as a contract reference between buyer and supplier and, as such, are voluntary in their application.

The NFPA 853, “Standard for the Installation of Stationary Fuel Cell Power Plants” addresses ventilation and fire protection requirements for fuel cell power plants in and around buildings. The IEC 62282-3-3 standard will serve a similar purpose to NFPA 853, only with an international scope.

In Canada, the Canadian Standards Association is responsible for the development of national fuel cells standards and/or adoption of available international and the U.S. standards for use in Canada.

4.1 Fuel Source and Storage

The International Organization for Standardization (ISO) Technical Committee 197, "Hydrogen Technologies" is developing a set of international standards that are relevant to intermittent fuel cell generators using hydrogen stored in tanks. The standards from that set that are most applicable to stationary fuel cell applications are listed in Table 2.

Table 2 - Relevant ISO Hydrogen Standards

Designation	Standard Title	Estimated Publication Date
ISO/TR 15916	Basic considerations for the safety of hydrogen systems	Published (2004)
ISO 14687	Hydrogen fuel – Product specification Note: ISO/TC 197 WG12 has been developing ISO14687-2 Technical Specification for PEM FC for road vehicles. It is expected that more fuel specifications for other PEM FC applications will be developed.	Published (1999)
ISO/CD 16110-1	Hydrogen generators using fuel processing technologies – Part 1: Safety	2006-09
ISO/CD 16110-2:	Hydrogen generators using fuel processing technologies – Part 2: Procedures to determine efficiency	2007-06
ISO/CD 22734-1:	Hydrogen generators using water electrolysis process – Part 1: Industrial and commercial applications	2006-07
ISO/CD 22734-2:	Hydrogen generators using water electrolysis process – Part 2	2007-06

In the United States, the National Fire Protection Association (NFPA) has published NFPA 55, “Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks.” That standard was recently updated to incorporate the previous NFPA 50, 50A and 50B standards as Chapters 9 - 11 respectively.

In Canada, the Bureau de normalisation du Québec (BNQ) is currently working on the development of the Canadian Hydrogen Installation Code. The publication of this code will be an important tool for industry and regulators for the installation and approval of hydrogen generation, utilization and related equipment in Canada.

4.2 DC Generation (fuel cell module)

IEC 62282-2, “Fuel cell technologies - Part 2: Fuel cell modules” is the first published international standard from the IEC 62282 series. This standard, published in 2004, provides the minimum requirements for safety and performance of fuel cell modules that are intended for integration into end-use equipment. The IEC safety standard for stationary end-use applications (IEC 62282-3-1) is being written to reference this standard.

In order to allow for the use of automotive fuel cell modules in stationary applications, it will be necessary to revise the fuel cell module standard such that it is consistent with the Society of Automotive Engineers (SAE) standards for fuel cell modules. This will include requirements for piping, flammability of materials, leakage rates and electrical testing, among others.

4.3 DC-AC Conversion (inverter)

Inverters are used in fuel cell systems to convert fuel cell direct current to an alternating current at a desired utilization voltage. In the United States, the requirements are provided in UL 1741, "Inverters, Converters, and Controllers for Use in Independent Power Systems." In Canada, CSA C22.2 No. 107.1-01 standard for General Use Power Supplies is used for the design of static inverting equipment. Both the UL and CSA documents are currently under review.

4.4 Customer-Side Interconnection

For natural gas fed generators, guidance for interconnection with the gas distribution system can be found in CSA B149.1, "Natural Gas and Propane Installation Code." These fuel cells may be connected to the gas mains using installation practices similar to other natural gas appliances, such as residential furnaces or hot water heaters.

The room ventilation and exhaust requirements may, however, be different between a fuel cell and a conventional natural gas appliance. The manufacturer's instructions should be followed, along with the guidelines in NFPA 853, Installation of Stationary Fuel Cell Power Plants or the upcoming standard IEC 62282-3-3, "Stationary fuel cell power plants - installation."

The installation requirements for client side electrical interconnection with the building system are given in Part I, Section 84 of the Canadian Electrical Code. That document provides guidance for the sizing of conductors, electrical protection and general wiring practices up to the site electrical service entrance.

4.5 Utility Interconnection

In Canada, each electric utility maintains their own practices for the interconnection between service entrance equipment and the grid when a generator is present on the client side of the service entrance. General recommended practices (guideline) for utility interconnection have been developed with MicroPower Connect and this guideline has recently become a National Standard of Canada developed by the Canadian Standards Association (CAN/CSA C22.2 No. 257-06).

In the United States, the IEEE 1547, "Standard for Distributed Resources Interconnected with Electric Power Systems," provides a similar set of guidelines for interconnection with electric utility grids.

4.6 Conformity Assessment and Certification

IEC 62282-3-1, “Stationary fuel cell power plants - safety,” is a product safety standard being developed to aid in obtaining international certification of stationary fuel cell generators. That standard is expected to be adopted by both Canada and the United States once it has been published by the IEC in the 2006/2007 time frame.

Until that standard is available, production fuel cell power plants, destined for export to the US market, must be certified to the product standard ANSI/CSA FC-1 “Fuel Cell Power Systems.”

For prototypical, or field-trial equipment that is still in development in either Canada or the US, some form of field certification is normally used. This field approval is typically a responsibility of a local authority having jurisdiction. In this case, each unit is examined to ensure it meets the intent of the safety requirements of the ANSI/CSA FC-1 standard, after giving consideration to specific site preparation or the manner in which the equipment is operated. For example, a field trial unit normally employs additional monitoring equipment, is operated by specially trained personnel and is located in a restricted (fenced off) area. CSA International and Underwriters Laboratories Canada (ULC) are among accredited agencies in Canada that can provide these field evaluations. The agency will provide a temporary marking that is valid for a specific unit and the conditions in which it was originally installed.

		HAVE IN CANADA	NEED IN CANADA	OTHERS (US OR INTERNATIONAL)
FUEL SOURCE / STORAGE	Equip.		ISO TC 197 - adopt standards applicable to stationary applications	
	Installation	CSA B149.1 (natural gas and propane installation) *Draft* CAN/BNQ 1784-000 Canadian Hydrogen Installation Code	ISO TC 197 - adopt standards applicable to stationary applications	NFPA 54 (natural gas) NFPA 55 (hydrogen)
DC GENERATION	Equip.	CSA Component Service No. 33 for Proton Exchange Membrane Fuel Cells	Adoption of IEC 62282-2 and its revision so that it is consistent with the automotive SAE fuel cell standards	
	Ins.			
DC-AC CONVERSION	Equip.	CSA C22.2 No 107.1-01 (power supplies)		UL 1741, "UL 1741, Inverters, Converters, and Controllers for Use in Independent Power Systems"
	Ins.	CEC Section 84 (interconnection)		
CLIENT-SIDE INTERCONNECTION	Equip.		Adoption in Canada of IEC 62282-3-1, Stationary fuel cell power plants - Safety	ANSI/CSA America FC-1, "Standard for Stationary Fuel Cell Power Systems"
	Installation	CSA B149.1, Natural Gas and Propane Installation Code CEC Section 84 (interconnection)	Adoption in Canada of IEC 62282-Part 3-3: Stationary fuel cell power plants - Installation	NFPA 853, Installation of Stationary Fuel Cell Power Plants
UTILITY-SIDE INTERCONNECTION	Equip.			
	Installation	CAN/CSA C22.2 No. 257-06		IEEE 1547, "Standard for Interconnecting Distributed Resources with Electric Power Systems"

Photo Courtesy of Antoine Lacroix, CANMET Energy Technology Centre

A 65 kW Windmatic wind turbine at Atlantic Wind Test Site, PEI

A wind turbine extracts the kinetic energy of a moving air mass (wind) and converts it into useful energy, most often in the form of electricity. The electricity is produced by a generator that is driven by the rotor of the turbine. Such a generator produces AC power that is either rectified (DC) or synchronised with the grid.

5.0 Wind Technical Issues

Overview

Since the revival in the 1970s of interest in the wind as a potential source of energy to supplement or replace petroleum for the production of electricity, electric power produced by modern wind turbines has become the fastest growing source of new electrical generation worldwide. In many places where there are good wind resources, large wind turbines in arrays called wind farms have become a very economic, reliable and environmentally attractive means of producing electrical energy. In recent years the desire of many countries to reduce emissions of carbon dioxide and other harmful pollutants is driving the rapid development of wind generation and the implementation of policies, incentives and regulations to encourage investment in wind energy generation. Today a very competitive wind energy industry is producing and supplying wind turbines ranging in size or ratings from 100 watts to over 5 megawatts.

In the first few years of this reawakened technology wind turbine equipment was expensive, small, generally unreliable and experimental in many aspects. As time passed however the interest and concern regarding the cost and security of future energy supply in many nations enabled the wind energy industry to design and develop the large, reliable and economically attractive wind turbines available today. A major accomplishment has been the development by industry associations, government and research and development agencies of wind technology modeling tools, design codes, standards and guidelines for almost all aspects of modern wind energy technology. The documentation of these is voluminous with many similarities and yet many differences in content and emphasis on requirements.

The documents so far developed are generally specific to technical areas of wind technology such as:

- wind resource monitoring and assessment practices
- site selection and assessment
- structural and mechanical design safety
- assembly, installation and erection
- electrical, control and protection safety
- operational safety
- performance testing and measurement practice
- structural and mechanical loads determination
- electromagnetic interference
- acoustic noise measurement practice
- failure reporting
- safety of electrical interconnection with utilities

While many of these may be considered as independent documents dealing with a specific issue, the reality is that there is a great deal of overlap because of the inter-relation of many of these technical areas. Safety and performance of the electrical interconnection is however relatively independent.

There are many technical issues that must be considered in the design and operation or use of wind turbine equipment. Many of these are common for both wind turbine systems intended for stand alone operation such as battery charging for remote facilities and for those connected to an electric utility distribution or transmission system. The former equipment, while required to be safe by regulatory and inspection agencies is not generally considered to represent a direct safety risk or issue to other than the owner or operator. The utility connected system, however, by simple fact of involvement and connection to other users and the operators of the utility system, raises the concern or at least the interest of electric utilities and agencies responsible for electrical safety system operation, performance, reliability and quality.

Besides the Islanding and Power Quality issues, other performance matters include:

- Controls of quality and performance. This matter relates to the protection devices used in the wind systems control system to sense power parameters and act to prevent islanding and operation at levels of unacceptable power quality.
- Interaction with scheduling and dispatch of utility generation resources. This concern relates to the circumstance where the wind generation may, from time to time, represent a significant portion of the generation required to meet the load. While this situation is rare it may occur in certain remote areas where small diesel generators are used to supply electric power.

Some of the key sources of documents are the International Electrotechnical Commission (IEC), the Association of International Electrical and Electronic Engineers (IEEE), the American Wind Energy Association (AWEA), the Canadian Standards Association (CSA) and the American Society of Mechanical Engineers (ASME). A listing of these with a summary of content is found in the section 5.1 to 5.5. It should be noted that some of these standards date back a number of years. Efforts are currently undertaken at CSA, with support from NRCan, to update or adopt the desired standards in Canada.

5.1 Fuel Source and Storage

Standards relating to worldwide wind energy resources include energy assessment (meteorological wind speed measurement, turbulence, gusts, wind shear). The safety component of energy assessment relates to the sizing and mounting of turbines with regard to the wind regime in which they will operate. This is important since wind turbine performance - and power quality - depends on the effective matching of the turbine to the site wind regime. Existing Canadian and American standards for wind turbine siting include the following:

CSA F428-J *(Site Assessment for Wind Energy Conversion Systems - Meteorological Aspects)*, is a "recommended practice" published in 1993 that describes procedures for evaluating the wind speed climatology of a site being considered for the operation of a wind energy conversion system so that its mean annual energy output and its uncertainty may be measured. Descriptions of other relevant meteorological elements such as turbulence and atmospheric icing are included.

AWEA 8.1 *(Standard Procedures for Meteorological Measurements at a Potential Wind Turbine Site)* provides procedures and methods for obtaining meteorological measurements at a site that has been proposed for wind energy use. Standards are provided for meteorological measurement systems and installation, operation and calibration of equipment. Guidelines for sampling strategies, data processing and site evaluation practices are given in the appendices.

AWEA 8.2 *(Guidebook for the Siting of Wind Energy Conversion Systems)* is a document providing guidelines for the proper siting of a wind turbine or group of turbines. These guidelines are recommended both for siting programs that begin with large scale land assessments as well as for site-specific applications where optimized wind turbine placement within a given parcel of land. This standard addresses such siting topics as meteorological measurements at candidate sites, instrumentation and wind flow modeling.

5.2 DC Generation

5.2.1 Equipment standards

A wide range of standards relating to electric generators exist outside of the wind industry standards and simply apply to wind generators. These are not specific for wind turbine generators and, therefore, not listed here.

5.3 DC to AC Conversion

In the majority of wind micropower grid connection projects, the interface will be a static inverter. Such inverter must then meet CSA C22.2 No 107.1-01. In the US, a similar standard UL 1741 is being revised to apply to all static inverters (as opposed to those used for PV applications only, per its original release).

In the case of wind, unlike PV, inverters in size above 50 kVA can be expected and the use of CSA C22.2 No. 107.1-01 could be difficult (practical testing capabilities). A standard covering inverters above that size would then be needed.

5.4 Customer-Side Interconnection

5.4.1 Design, Installation and Performance Standards

The safety and performance of a wind turbine system depends to a significant degree on the adequacy of the installation and adherence to accepted electrical standards and practice for industrial electrical equipment. No amount of good practice will however make up for faulty design and manufacture of equipment.

While wind energy system installation does not have a dedicated section in the Canadian Electrical Code there are a few domestic and international standards that relate to wind turbine installation practices. Listed below are the standard that cover the design and installation aspect of wind turbines.

CSA F416 *(Safety, published in 1987)* This standard specifies the requirements for the safety of wind energy conversion systems, including design and operation under specified environmental conditions. It is concerned with all subsystems, including protection mechanisms, supporting structures and foundations. It is concerned with the components and materials supplied by the manufacturers, with the adequacy of the assembly, installation, maintenance and operation instructions, and with the safety of the system after assembly when operated in accordance with those instructions.

CSA F417 *(Performance, published in 1991)* This standard specifies methods for determining and reporting performance characteristics for wind energy conversion systems. It applies to systems having mechanical, electrical or thermal output.

AWEA 2.1 *(Measurement of Acoustic Noise Emissions - 1989)* This standard, provides the basis for uniform measurement and reporting of the noise produced by an operating wind turbine.

AWEA 1.1 *(PerformanceS93-700, 1988)* This standard, comprising five sections, describes a standard method of determining and reporting primary performance characteristics of wind energy conversion systems. Sections include general information, field test method, noise treatment method, formulation of parameters, and system performance test reports

AWEA 3.1 *(Design criteria, S93-702, 1988)* This document describes the criteria to be used for the design of wind energy conversion systems. It consists of eight sections: scope and application of the document, applicable reference publications, significance and use of these criteria, general design criteria for wind energy systems, environmental and service condition design criteria, system design considerations, component design criteria, and mechanical, structural and electrical attachment conditions with other systems.

IEC 61400-1 *(Wind Turbine Generator Systems - Safety Requirements, second edition, 1999)* This standard deals with safety philosophy, quality assurance and engineering integrity, and specifies requirements for the safety of wind turbine generator systems, including design, installation, maintenance and operation under specified environmental conditions. Its purpose is to provide the appropriate level of protection against damage from all hazards from these systems during their planned lifetime. This standard applies to turbines with a swept area equal to or greater than 40m2, and is concerned with all subsystems such as control and protection mechanisms, internal electrical systems, mechanical systems, support structures and the electrical interconnection equipment.

IEC 61400-2 *(Safety of Small Wind Turbines, 1996)* This standard deals with safety philosophy, quality assurance and engineering integrity, and specifies requirements for the safety of small wind turbine generator systems, including design, installation, maintenance and operation under specified environmental conditions. Its purpose is to provide the appropriate level of protection against damage from all hazards from these systems during their planned lifetime. This standard applies to turbines with a swept area equal under 40 m^2, and is concerned with all subsystems such as control and protection mechanisms, internal electrical systems, mechanical systems, support structures and electrical interconnection equipment.

IEC 61400-12 *(Wind Turbine Power Performance Testing, 1998)* This standard specifies a procedure for measuring the power performance characteristics of a single wind turbine generator system, and applies to the testing of all types and sizes of wind turbines connected to the electric power network. It is applicable both for the absolute power performance characteristics of a wind turbine and of differences between the power performance characteristics of various wind turbine configurations.

IEC 61400-13 *(Measurement of Wind Turbine Structural Loads)* This standard defines methods for measuring operational loads in wind turbines.

IEC 61400-23 *(Wind Turbine Blade Structural Testing)* This standard defines methods for wind turbine blade structural testing.

ASME PTC42, and **ASTM E1240** are two additional US standards dealing with wind turbine performance and safety issues.

CSA F-429 *(Recommended Practice for the Installation of Wind Energy Conversion Systems, 1990)* This standard provides recommended installation practices and procedures, and outlines the required specifications for the installation of wind energy conversion systems.

AWEA 6.1 *(Recommended Practice for the Installation of Wind Energy Conversion Systems, S93-704, 1989)* This document presents recommended practices for the installation of wind energy conversion systems, with regard to safety of installation personnel and the public. It is a general guide to be used with manufacturers' installation manuals and is organized to follow the installation process.

Lightning protection IEC 61400-24 *(Lightning Protection for Wind Energy Conversion Systems)* This document to be soon published as a standard describes lightning protection guidelines.

5.4.2 Installation

In terms of electrical code, a wind turbine installation must comply with the CEC in general and, as far as the interconnection goes, with Section 84 specifically. This Section 84 deals generally with interconnection to utility grid, but specifically notes the authority of the individual utilities to apply their own requirements. The CEC 2006 includes recent change made to this Section with respect to inverter based systems.

5.5 Utility-Side Interconnection

The technical requirements and standards for utility interconnection vary widely by utility and country and there is a need and demand for standards specifically addressing interconnection of the increasing number of small (industrial and residential-scale) private wind power systems.

In the United States, two such standards are available, one of which was designed primarily for interconnection of photovoltaic systems, but nonetheless applicable to small wind power systems. It is apparent that there are significant variances in the generation and control technologies used by the small wind turbine industry and thus a need for a wide ranging by comprehensive standard or guideline for safe and acceptable interconnection.

Fortunately, there is a significant effort to try to harmonize these requirements and practices both within Canada and with the rest of the world.

CAN/CSA C22.2 No. 257-06 This standard covers the interconnection of inverter-based micro-distributed resources to distribution systems up to 750 V.

CSA F-418 *(Interconnection to the Electric Utility):* This standard was published in 1991 and specifies technical requirements for (a) the interconnection of a wind turbine to an electric utility; (b) the installation and operational specifications to be provided to the utility by those proposing interconnection to the utility; (c) the system protection including manual and automatic disconnect switches, transformers, fault protection devices, relays and other equipment for the safe interconnection to the utility; (d) isolation, startup and restart, and requirements related to the quality of power, e.g. limitations of harmonics, lamp flicker and power factor; (e) the installation of wind turbines in accordance with the requirements of the Canadian Electrical Code. This document has not been updated since its publication.

AWEA *(Interconnection recommended practice 1988)*. Similar to CSA F-418.

IEEE 929 is a standard for the interconnection of photovoltaic systems, which can also be applied to small (inverter-based) wind power systems.

IEEE 1547 is a standard for the interconnection of distributed resources to the electrical grid for systems up to 10 MVA.

IEC 61400-21 is a standard covering interconnected power quality measurement techniques.

	HAVE IN CANADA	*NEED IN CANADA*	*OTHERS*
SOURCE / STORAGE	CSA F-428J (Siting)	Updated Wind Measurement Standard	AWEA 8.1 (Wind measurement) AWEA 8.2 (Siting)
DC GENERATION			
DC-AC CONVERSION	CSA C22.2 No. 107.1-01	Larger Inverter Standard	UL 1741
CUSTOMER SIDE INTERCONNECTION	CSA F-416 (Safety) CSA F-417 (Performance) CSA F-429 (Installation)	Cold Weather Installation Guidelines	IEC 61400-11.1 (Safety) AWEA 1.1 (Performance) IEC 61400-12 (Performance) AWEA 3.1 (Design) IEC 61400-2 (Small turbines) AWEA 6.1 (Installation) IEC 61400-11 (Noise) IEC 61400-24 (Lightning)
UTILITY-SIDE INTERCONNECTION	CAN/CSA C22.2 No. 257-06 CSA F-418 (Interconnection) CEC Section 84		IEEE 1547 (Distributed Generation) IEC 61400-21 (Power quality)

Photo courtesy of Minto Energy Management

Capstone microturbine installation at Minto Suites Apartments in Ottawa.

A microturbine is a turbine powered electric generator that can use natural gas, light fuel oil or waste gas such as landfill gas. This turbine also produces a significant amount of heat that can be recovered, which greatly improves the economics of the system.

6.0 Microturbine Technical Issues: Safety, Power Quality, and Codes

Overview

The microturbine industry is a growing enabling technology throughout the world. As of March 2006, there are three major manufacturers, Capstone, Ingersoll Rand and Elliott, all located in the United States (U.S.). Unlike other technology manufacturers the microturbine industry has yet to form an umbrella organization or association to speak as one voice in such areas as standards/codes development and for the industry as a whole. The microturbine manufacturers participate in various standards and codes committees that are particular to their needs. They also keep abreast of the various state microturbine regulations.

Of the three microturbine manufacturers, two use a static inverter-based design, while the third one uses a single shaft design which couples the engine, gearbox and synchronous generator to directly produce AC power. Each of these two basic designs applies somewhat different standards for their respective approvals. Microturbine technology, although mainly an inverter based technology, has been able to use codes originally developed for the stationary engine generator market.

To further and strengthen the standards and codes in Canada, the industry has focused on two broad activities:

The first activity by the Microturbine Codes and Standards Group (MCSG) is reviewing the CAN/CSA B149.1-05 (Natural Gas and Propane Installation Code). The intent is to review the document to see what changes would be required to reference microturbines specifically for installations. MCSG also investigates the possibility of linking U.S. or European standards to the document. The objective would be to submit the changes for consideration in accordance with timing required by CSA to make the proposed 1997 updates for CAN/CSA B149.1-05. This is on going with the changes going out for balloting in 2006.

The second activity is being carried out by a CSA Technical Committee in developing interconnection requirements other than those provided by Section 84 of the CEC Part I, for the safety of the interconnection of inverter-based distributed generation systems to local electricity systems have rated voltage not exceeding 750 volts. This work was completed in 2005 and now published as a national standard.

It should be noted that in this section update, additional references have been added, particularly from the European Standards Community to reflect the excellent work they have done in promoting safety through their documents. It also promotes the idea of developing and implementing international standards with the multi-lateral stakeholders.

6.1 Fuel Source and Storage

The standards which apply to the fuel storage, oil, propane or natural gas are those that apply to the supply of these fuels to existing stationary engine sets. The one standard of particular interest is the UL 2200. Work is underway to adopt this standard in Canada. It is expected that, once this document is adopted, it will be of great assistance for the approval of microturbine equipment in Canada. A recent development on the gas safety side is that Technical Standards and Safety Authority has released an advisory that allows the installation of microturbines in Ontario without special permission from TSSA.

6.1.1. Equipment Standards

There are numerous equipment safety standards that apply to fuel source equipment in microturbine systems. The following list includes Canadian, U.S. and International listings:

- CSA B51-03 Boiler, Pressure Vessel and Pressure Piping Code (all components over 15 psig), boosters compressors
- ULC S643 - Aboveground, Shop Fabricated Steel, Utility Tanks
- ULC/ORD-C404 - Pressure Indicating Gauges for Compressed Gas Sources
- ULC/ORD-C25-92 Meters for Flammable and Combustible Liquids and propane
- ULC S620 - Valves for Flammable and Combustible Liquids
- CSA C22.2 No199 -M89 Revised 2004 Combustion Safety Controls and Solid-State Igniters for Gas- and Oil-Burning Equipment
- Ontario Electricity Restructuring Act 2004 (Bill 100)
- ULC/ORD C441.3-98 Gas Vent Connectors
- UL 1998 (98) Standard for Software in Programmable Components
- UL 372 (94) Standard for Primary Safety Controls for Gas- and Oil-Fired Appliances
- UL 508 (99) Standard for Industrial Control Equipment
- UL 795 (99) Standard for Commercial-Industrial Gas Heating Equipment
- EN 60730-1; Automatic electrical controls for household and similar use - Part 1: General requirements Includes amendment A11: 2002 and A12: 2003
- EN 61508 (1 & 2); Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems Part 1: General Requirements IEC 61508-1: 1998 + Corrigendum 1999; Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems 2000
- ANSI Z21.20-2000; Automatic Gas Ignition Systems and Components
- Directive PED, 97/23/EEC; Pressure Equipment Directive
- Directive GAD, 90/396/EEC; Gas Appliance Directive. It is a third party directive and a notified body is required which will conduct product surveillance. Scope of this directives is safe use of gas which includes the construction, gas technical aspect (emission, efficiency), safety of electronics - internal fault behavior, immunity of electromagnetic radiation and electrical safety.
  - Essential requirements (90/396/EEC) (Standard)
  - Parts of UGE/UP/p Gas fired turbines (Standard)
  - Part of Gas unit (10/93) Gas Fired Gas Turbines (Standard)
- IEC 60079-0; 2004; Electrical apparatus for explosive gas atmospheres - Part 0: General requirements

6.1.2. Installation Requirements

With the current review of CAN/CSA B149.1 underway for the next issuance in 2007, it is hopeful more specific references will be made to microturbine installations and could also reference other international standards. There is also an IEC standard being drafted on microturbine installations.

The microturbine manufacturers have taken great strides in implementing annual training, testing and re-certification for their Authorized Service Providers. For example, both Capstone and IR offer multi year service agreements. This helps to strengthen the service industry in providing good safe, technical services.

The following codes and standards apply to the installation of the equipment:

- CSA B149.1-05- Natural Gas Installation Code
- CSA B149.2-05- Propane Installation Code
- CSA B149.3-05-Code for the Field Approval of Fuel-Related Components on Appliances
- CSA B105 Code for Digester Gas and Landfill Installation
- IFGC 2003 - Code for Installation of Fuel-gas piping systems, Utilization Equipment and Related Accessories
- ANSI Z223.1-02; National Fuel Gas Code (same as ANSI/NFPA 54)
- NFPA 58 - Standard for Storage and Handling of Liquefied Petroleum Gases
- NFPA 30 - Flammable and Combustible Liquids Code
- NFPA 54 - National Fuel Gas Code
- ANSI/NFPA 37: Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, 2002 Edition. Covers the installation and operation of stationary combustion engines and gas turbines.

6.2 DC Generation

In the case of some microturbines, the generator provides high frequency AC which is rectified to DC. Others use normal rotating generators to directly produce AC power. A number of standards were found that might be applicable but the principal ones would be UL 2200 and CSA C22.2 No. 107.1-01. General Use Power Supplies. CE Code 28-900 Protection and Control of Generators might also be used in this area. Also, Canada should be adopting or adapting UL 2200, and other UL standards. These need to be universally accepted across all jurisdiction as uniformity of codes and their application is as important as their existence.

6.2.1 Equipment Standards

These are the Canadian and International standards known to be applicable for equipment standards with respect to DC generation:

- ANSI/CSA C22.2 No107.1 -01; Commercial and Industrial Power Supplies
- ANSI/UL 2200-04 Section 68; Standard for Safety for Stationary Engine Generator Assemblies
- IEEE 1159;- Recommended Practice for Monitoring Electric Power Quality
- Council Directive 73/23/EEC on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits
- EN50165; (Standard) Electrical Equipment of non electric appliance for household and similar purposes
- Directive 98/37/EC of the European Parliament and the Council on the approximation of the laws of the Member States relating to machinery
- EN60204-1; (Standard) Safety of machinery. Electrical equipment of machines. General requirements. EN 60204 provides requirements and recommendations relating to the electrical equipment of machines so as to promote: (1) safety of persons and property; (2) consistency of control response; and (3) ease of maintenance.
  This standard applies to the application of electrical and electronic equipment and systems to machines not portable by hand while working, including a group of machines working together in a coordinated manner but excluding higher level systems aspects (i.e. communications between systems). The equipment covered by this standard commences at the point of connection of the supply to the electrical equipment of the machine. Part 1 of BS EN 60204 is applicable to the electrical equipment or parts of the electrical equipment that operate with nominal supply voltages not exceeding 1,000 V for alternating current and not exceeding 1,500 V for direct current, and with nominal frequencies not exceeding 200 Hz
- Council Directive 92/31/EEC amending Directive 89/336/EEC on the approximation of the laws of the Member States relating to electromagnetic compatibility. It is applicable to appliance that is capable of generating electromagnetic disturbance or can be influenced by external electromagnetic disturbances.
- EN50165; (Standard) Electrical Equipment of Non-Electric Appliances for Household and Similar Purposes - Safety Requirements Includes Amendment A1: 2001
- EN61000-6-2; (Standard) Electromagnetic Compatibility (EMC); Generic Standard-Immunity for Industrial Environments. Immunity testing
- EN61000-6-3; (Standard) Generic Standard. Emission Standard for residential, commercial and light-industrial environments Emission testing

6.2.2 Installation Requirements

With respect to the installation requirements, while the installation of the whole unit must comply with the CEC, the generator normally comes pre-packaged with the inverter so the installer does not have to address the installation of the DC side as a separate piece of equipment.

6.3 DC to AC Conversion

A single recognized inverter standard covering a large range of size would be useful. However, there are other codes and standards which might be called upon by utilities and safety authorities. The main references are as follows;

CSA C22.2 107.1-01; General Use Power Supplies
UL1741 standard; Inverters, Converters and Controllers for Use in Independent Power Systems

6.3.1 Equipment Standard

The following are the Canadian and U.S. standards related to the equipment standard of DC to AC power converters.

- CSA C22.2 No. 107.1-01; General Use Power Supplies
- CSA C22.2 No. 100-04 - Motors and Generators
- UL 1741 - Inverters, Converters and Controllers for Use in Independent Power Systems
- ANSI C84.1 - American National Standards for Electric Power Systems and Equipment Ratings
- IEEE Std.493 - Recommended Practice for Design of Reliable Industrial and Commercial Power Systems
- IEEE Std.519 - Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
- ANSI/IEEE C37.20.1 - Standard for Metal-Enclosed Low-voltage Power Circuit Breakers Switchgear

6.3.2 Installation Requirements

The installation of static inverters is covered by the General Clause of the CEC Section 1-12, and 26). These sections cover general rules, grounding, wiring methods and general rules regarding installation of electrical equipment. There are no specific requirements for microturbine specified in the CE Code Part I.

- CEC Section 1-12, and 26

6.4 Customer-Side Interconnection

Numerous safety and power quality codes and standards were originally developed for the installation of emergency power plants now apply to the installation of stationary power sources. However, most of the safety and control issues referenced in these codes refer to rotating generation not static inverter based technology.

6.4.1 Equipment Standards

Following are equipment standards for consideration;

- CSA C22.2 No.229 - Switching and Metering Centres
- IEEE 902 - Guide for Maintenance, Operation and Safety of Industrial and Commercial Power Systems
- UL 1008 - Transfer Switch Equipment
- ANSI/NEMA C37.54 - Standard for Switchgear-Indoor Alternating-Current High-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclose Switchgear Assemblies-Conformance Test Procedure

- UL 1012-1996; Power Supplies Cover portable, stationary, and fixed power units having an input rating of 600 volts or less, direct- and alternating- current, with at least one output not marked Class 2, and that are intended to be employed in ordinary locations in accordance with the National Electrical Code, ANSI/NFPA 70.

6.4.2 Installation Requirements

Following are installation related standards for consideration:

- CEC Section 84 - Interconnection of Electric Power Production Sources (installation of consumer-owned electric power generation)
- ANSI/CSA C282-- Emergency Electrical Power Supply for Buildings
- NFPA 37 - Standard for the Installation and Use of Stationary Engines and Gas Turbines
- ASME B133.8 Gas Turbine Installation Sound Emission
- NFPA 110 - Standard for Emergency and Standby Power Systems
- NFPA 70 National Electrical Code, Article 705 - Interconnected Electric Power Production Sources
- NFPA 101, Chapter 5 - The Life Safety Code
- IEEE C37.95 - Guide for Protective Relaying of Utility Consumer Interconnections
- IEEE C62.92.4 - Guide for the Application of Neutral Grounding in Electrical Utility Systems, Part IV - Distribution
- ANSI C12.20 - Electricity Meters 0.2 and 0.5 Accuracy Classes
- ANSI/NECA/EGSA 404-2000 Recommended Practice for Installing Generator Sets
- UL 1012.6 -94 Standard for Power Units Other Than Class 2
- UL 1310-R96 Standard for Class 2 Power Units

6.5 Utility-side Interconnection

There are a sizable number of Canadian utilities who have technical interconnection guidelines developed for their service area. It is considered important that we move towards standardizing interconnection guidelines so that suppliers do not have to deal with many different varieties of interconnection standards. CSA has recently completed and issued a new National Standard of Canada (CAN/CSA C22.2 No. 257-06) addressing the interconnection of inverter-based distributed generation system connected to local distribution system (up to 750 volts).

In addition, UL has indicated that the sections of its UL 1741 standard specific to electrical interconnection protection can be applied to rotating generator based microturbines and their associated protective equipment.

6.5.1 Equipment Standard

Section 84 of the CE Code Part I - Interconnection of Electric Power Production Sources stipulates that the interconnection shall be in accordance with the requirements of the supply authority (Clause 84-002).

- Section 84 of the CE Code Part I - Interconnection of Electric Power Production
- UL 1741 - Inverters, Converters and Controllers for Use in Independent Power Systems

		HAVE IN CANADA	***NEED IN CANADA***	***OTHERS (US OR INTERNATIONAL)***	
FUEL SAFETY	**Equip.**	CSA B51-03 ULC S643-00 ULC/ORD C404 ULC/ORD C25-92 ULC S620 CSA C22.2 No.199-04 Ontario Energy Act, Section 10 ULC/ORD C441.3 -98	Current development of ULC/ORD C2200.	UL 1998 (98) UL 372 (94) UL 508 (99) UL 795 (99) EN 60730-1 EN 61508-1	ANSI Z21.20-2000 PED 97/23/EEC GAD 90/396/EEC IEC 60079-0
	Installat.	CAN/CSA B149.1-05 CAN/CSA B149.2-05 CAN/CSA B149.3-05 CAN/CGA B105	Currently reviewing CAN/CSA B 149.1 to clarify installations for microturbines and engines Lower requirements for installer licence	IFGC 2003 ANSI Z 223.1-02 NFPA 58 NFPA 30 NFPA 54 ANSI/NFPA 37	
DC GENERATION	**Equip.**	ANSI/CSA C22.2 No.107.1-01	Canadian standard equivalent to ANSI/UL2200 -04 Section 68	ANSI/UL 2200-04 Section 68 IEEE 1159 LVD, 73/23/EC EN50165	MD, 98/37/EC EN60204 EMC-D 92/31/EEC EN50165 EN61000-6.2 & 6.3
	Installat.	CEC 28-900		IEEE 665 EGSA 100G EGSA 101P EGSA 100F	
DC-AC CONVERSION	**Equip.**	ANSI/CSA C22.2 No107.1 -01 CSA C22.2 No.100-04		UL 1741 ANSI C84.1 IEEE Std.493	IEEE Std. 519 ANSI/IEEE C37.20.1
	Installat.	CEC Section 1-12, and 26			
CLIENT-SIDE INTERCONNECTION	**Equip.**	CSA C22.2 No.229		IEEE 902 UL 1008	ANSI/NEMA C37.54 UL 1012-1996
	Installat.	CEC Section 84 ANSI/CSA C282		NFPA 37 ASME B 133.8 NFPA 110 NFPA 70 NFPA 101, Chapter 5 IEEE C37.95	IEEE C62.92.4 ANSIC12.20 ANSI/NECA/EGSA 404-2000 UL 1012.6 -94 UL 1310 R96
UTILITY-SIDE INTERCONNECTION	**Equip.**	CEC Section 84		UL 1741	
	Installat.	CAN/CSA C22.2 No. 257-06 Multiple Provincial Guidelines listed in document (See Section 7)		IEEE 1547-03 IEEE C37.95	

7.0 General Installation Requirements

Following is a number of existing Canadian Interconnection Guidelines/Requirements.

- **National Standard of Canada**
  Interconnecting inverter-based micro-distributed resources to distribution systems (CAN/CSA C22.2 No. 257-06) http://www.csa.ca

- **ATCO Electric, Alberta**
  Standard for the Interconnection of Generators
  http://www.atcoelectric.com/B_PowerProd/generator_interconnect_guide.pdf

- **BC Hydro Interconnection Requirements:**
  Generator Interconnection for Net Metering Projects to 50 kW, BC Hydro,
  http://www.bchydro.com/info/ipp/ipp8842.html

  Distribution Interconnection Requirements for Rotating Machines,
  http://www.bchydro.com/rx_files/info/info2154.pdf

  Generator Interconnection to the BC Hydro Transmission System at 69 kV and Up,
  BC Transmission Corp.,
  http://www.bctc.com/NR/rdonlyres/8FA9A050-8973-4E78-821F-6B6524189D79/0/interconnection_reqs_69500kv.pdf

- **ENMAX Power Corporation**
  Interconnection Guideline:
  http://www.enmax.com/Power/Our+Services/Technical+Specs+and+Guidelines/Generator+Guidelines.ht

- **Hydro Québec**
  Réseau de distribution et transmission:
  http://www.hydroquebec.com/transenergie/fr/commerce/producteurs_prives.html

- **Manitoba Hydro**
  Information on generator interconnection:
  http://oasis.midwestiso.org/documents/Mheb/queue.html

- **Ontario Distribution System Code**
  Minister of Energy's Directive to the Ontario Energy Board about connection of new generation to distribution systems: http://www.oeb.gov.on.ca/html/en/industryrelations/archivedinitiatives/licences/ministersdirective_connection.htm

- **Hydro One, Ontario**
  Technical Requirements for Generators Connecting to Hydro One's Distribution System
  http://www.hydroonenetworks.com/en/electricity_updates/generation/RFP_External_Tech_Reqt.pdf

- **SaskPower**
  Information to power producers under 100kW:
  http://www.saskpower.com/powerandenvironment/transmission/ppunder.shtml

  Information to power producers over 100kW:
  http://www.saskpower.com/powerandenvironment/transmission/ppover.shtml

8.0 Summary

This table provides a summary of existing safety codes, standards and guidelines relevant to the installation of static inverter-based micropower systems in Canada. Also, since international references are commonly considered, they have been included here.

	PV		Fuel Cell	
	Domestic	**International**	**Domestic**	**International**
SOURCE / STORAGE			CSA B149.1	NFPA 54 NFPA 55
DC GENERATION	CEC 50-004 to 50-020 CSA C22.2 No. 107.1-01 ULC-1703	NEC 690-4 to 690-53 IEC 61730	CSA 33	
DC-AC CONVERSION	CEC 1-12, 26 general requirements CSA C22.2 No. 107.1-01 Clause 15	IEC 62109 (draft) UL 1741	CSA C22.2 No. 107.1-01 CEC 84	UL 1741
CLIENT-SIDE INTERCONNECT	CEC Part II relevant standards CEC 50 Clause 020 CAN/CSA C22.2 No. 257-06	NEC 690-54 to 690-64	CEC 84 CSA B 149.1	NFPA 853
UTILITY-SIDE INTERCONNECT	CEC 84 Local Requirements CAN/CSA C22.2 No. 257-06	IEEE 929 IEEE 1547 IEC 61727	CAN/CSA C22.2 No. 257-06	IEEE 1547

Wind		Microturbine		
Domestic	**International**	**Domestic**	**International**	
CSA F-428J	AWEA 8.1 AWEA 8.2	CSA B51 CSA 199 Ontario Energy Act RSO-Section 10 CSA B149.1 CSA B149.2 CSA B149.3 CAN/CGA B105 ULC S643-00 ULC/ORD C404 ULC/ORD C25-92 ULC S620 ULC/ORD C441.3-48	NFPA 30 NFPA 54 NFPA 58 UL 1998 (98) UL 372 (94) UL 508 (99) UL 795 (99) EN 60730-1 EN 61508-1 ANSI Z21.20-2000 PED 97/23/EEC GAD 90/396/EEC IEC 60079-0 IFGC 2003 ANSI Z 223.1-02 ANSI/NFPA 37	**SOURCE / STORAGE**
		CSA C22.2 No. 107.1-01 CEC 28-900	IEEE 665 IEEE 1159 EGSA 100F EGSA 100G EGSA 101P ANSI/UL 2200-04 Section 68 LVD, 73/23/EC EN50165 MD, 98/37/EC EN60204 EMC-D 92/31/EEC EN50165 EN61000 -6.2 & 6.3	**DC GENERATION**
CSA C22.2 No. 107.1-01	UL 1741	CSA C22.2 No. 107.1-01 CEC Section 1-12 & 26	ANSI C84.1 ANSI/IEEE C37.20.1 UL 1741 IEEE Std.493 IEEE Std. 519	**DC-AC CONVERSION**
CSA F-416 CSA F-417 CSA F-429	AWEA 1.1 AWEA 3.1 AWEA 6.1 IEC 61400-2 IEC 61400-11 IEC 61400-11.1 IEC 61400-12 IEC 61400-24	CEC 84 CSA C282-00 CSA 229	ANSI C12.20 ANSI C37.54 ASME B 133.8 NFPA 37 NFPA 70 NFPA 101, Chapter 5 NFPA 110 UL 1008 IEEE C37.95 IEEE C62.92.4 IEEE 902 UL 1012-1996 ANSI/NECA/EGSA 404-2000 UL 1012.6 -94 UL 1310 R96	**CLIENT-SIDE INTERCONNECT**
CEC 84 CSA F418 CAN/CSA C22.2 No. 257-06	IEEE 1547 IEC 61400-21	CEC 84 CAN/CSA C22.2 No. 257-06	IEEE C37.95 IEEE 1547	**UTILITY-SIDE INTERCONNECT**

9.0 Conclusion

From a general perspective, micropower technologies share a number of common issues, and these can be addressed regardless of the generation method. Among all those listed in the Summary Table (section 8.0), the one that stands out as common to all is the need for a static inverter standard covering larger (industrial) inverters.

For practical reasons (testing), the existing CSA standard (C22.2 No 107.1-01) is only usable for inverters up to about 50 kVA. As distributed generation becomes more and more popular and economically attractive, there will likely be a need for a different standard for larger (industrial) static inverters (larger than 50 kVA). For these industrial inverters, an access to the controller input/output is normally possible, allowing for testing with a different procedure. Such inverters are closer to an assembly than they are from a fully integrated unit with no access to intermediate stages. Nevertheless a single label can be provided for the entire assembly which can be sold as a product, assuring that specific safety aspects, with respect to interconnection for instance, have been considered. On that basis, authorities can then recognize a product carrying the relevant label as safe and acceptable. By nature, photovoltaic technology is modular and lends itself to the use of multiple small inverters. In contrast, wind turbine and microturbine can easily exceed the 50 kVA size. The need for an inverter standard covering larger units could therefore be driven by these technologies.

One common trend for all of these technologies is the interest in adopting international standards, namely IEC's, as opposed to the development of domestic standard, whenever possible.

Much like the computer industry, which started out using mainframes that were huge, expensive, complex and limited in function and resulted in the evolution of computers that are now available as small, inexpensive, easy-to-use devices with amazing capabilities, distributed generation will only become more popular and accessible through the development of safe, standard products. In other terms, standards play a key role in addressing many of the needs for safety, power quality, lower cost, uniform regulation and education. The following reviews their importance with respect to these specific aspects.

Safety: Generators and connections must present no greater risk of fire or electrical shock than other devices already approved for use in homes and businesses. Requirements for equipment, wiring, installation and inspection must relate to the size and inherent risks of the system. Standards intended for large industrial units may be unreasonably strict and more appropriate requirements may be needed in some instances.

Interconnection devices must stop the supply of electrical current from micro generators to the main grid in the event of a loss of utility power. This is essential to protect utility workers from unexpected live wires while making repairs. Utilities must be aware of micropower sources and develop safety procedures to protect workers in the event power enters the grid due to equipment malfunction. Regulators must decide whether it is worth the cost for each generator to have an outdoor manual disconnect switch, allowing utility workers to lock out unwanted current.

Power Quality: Standards will ensure that different manufacturers and different generation technologies all produce consistently high-quality AC current. This will avoid damage to other electrical devices at the site, and disruption of power quality on the grid.

Lower costs: Manufacturing standards must be set to ensure safety and reliability, while not erecting unreasonable barriers to commercial production. Uniform installation standards will allow for better market penetration, higher volumes, more research and more competition, all of which will drive costs down.

As more systems are installed, it will become more time-consuming and expensive for utilities to inspect, analyze and approve individual sites. Standards will simplify installation and reduce the cost of inspections.

Uniformity of Regulation: While a national Canadian strategy is being pursued, and consistent international standards are desirable, legal authority for regulation of the micropower industry rests primarily at the provincial level. It is important that provincial regulators understand the importance of adopting national or international standards, and enforcing consistency within their jurisdictions.

Education: Many electrical and building inspectors are not familiar with micropower and interconnection issues, and may be reluctant to approve some installations. Once standards have been harmonized, there should be a significant effort to inform front-line workers throughout the industry.

Finally: Global demand for small, environmentally friendly power systems is rapidly accelerating. In Canada, there is a huge potential market among homeowners and small business operators. The opportunity exists for Canada's economy to benefit substantially through the connection of these systems. Small power systems have the potential to reduce Canada's dependence on fossil fuels as well as reduce environmental damage related to coal or oil-fired generation, and provide greater security in the event of energy shortages. In addition, the micropower market could provide thousands of jobs and billions of dollars in revenue.

The challenge now is for the governments and industry regulators to allow this new, evolving industry to grow in a way that is both safe and efficient.

Acronyms used in this report

AC	Alternating Current
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWEA	American Wind Energy Association
BNQ	Bureau de normalisation du Québec
CANMET	Canada Centre for Mineral and Energy Technology
CEC	Canadian Electrical Code, Part I
CETC	CANMET Energy Technology Centre
CSA	Canadian Standards Association, now CSA International
DC	Direct Current
EFC	Electro-Federation Canada
EGSA	Electrical Generating Systems Association (U.S.A.)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFGC	International Fuel Gas Code
ISO	International Organisation for Standards
JET	Japan Electrical Testing
NEC	National Electric Code (U.S.A.)
NFPA	National Fire Protection Association (U.S.A.)
NSSN	National Standards System Network (U.S.A.) see ASME, ASTM, IEEE
NRCan	Natural Resources Canada
ORD	Other Recognised Document
PV	Photovoltaic
SCC	Standards Council of Canada
TSSA	Technical Standards and Safety Authority
TC	Technical Committee
THD	Total Harmonic Distortion
TUV	Technical Inspection Association (Germany)
UL	Underwriters' Laboratory (U.S.A.)
ULC	Underwriters Laboratory of Canada

Units

W	watt
Hz	hertz
kW	kilowatt
VA	volt-ampere
MW	megawatt
psig	pounds per square inch gauge

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