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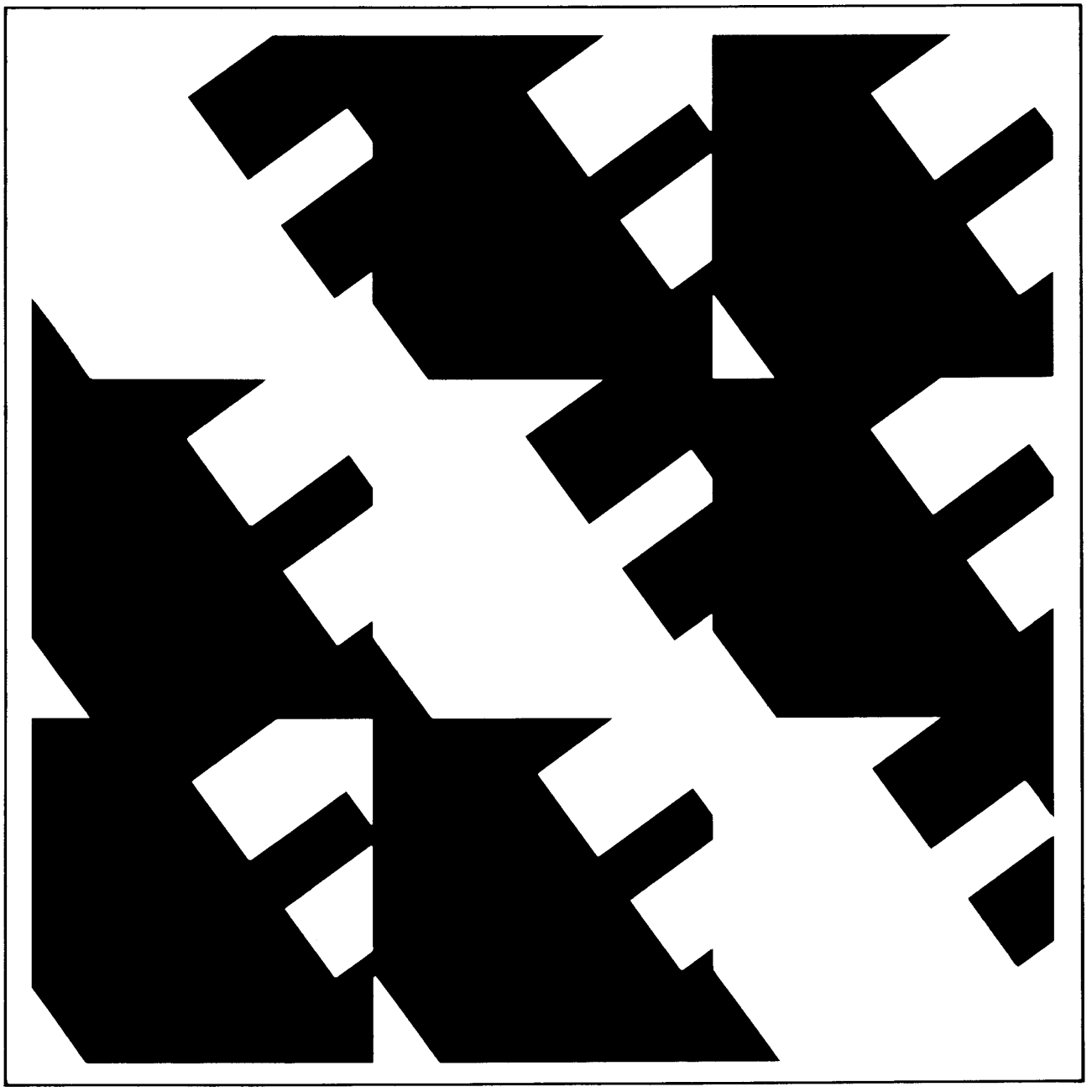
IEEE Recommended Practice for Utility Interconnection of Small Wind Energy Conversion Systems



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IEEE Recommended Practice for Utility Interconnection of Small Wind Energy Conversion Systems

Sponsor

IEEE Standards Coordinating Committee 23, Dispersed Storage and Generation

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 1021-1988, IEEE Recommended Practice for Utility Interconnection of Small Wind Energy Conversion Systems.)

This recommended practice was prepared by a working group comprised of both IEEE and ASTM members. The ASTM draft document, which was revised by the working group, was originally prepared by the electric subsystem standards subcommittee of the American Wind Energy Association.

The principle value of this recommended practice will be realized if it fosters a better understanding of responsibilities and requirements among those involved with interconnecting a small wind energy conversion system (SWECS) with an electric utility.

At the time this recommended practice was approved the members of the working group of the Standards Coordinating Committee on Dispersed Storage and Generation of the IEEE Standards Board were as follows:

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* Alternate

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Contents

An American National Standard

IEEE Recommended Practice for Utility Interconnection of Small Wind Energy Conversion Systems

1. Purpose

The purpose of this recommended practice is to provide a small wind energy conversion system (SWECS) user, owner, or installer with interface guidelines and operating procedures necessary to connect and operate a SWECS in parallel with an electric utility system.

2. Scope

This recommended practice contains application guidelines and procedures for the interconnection and compatible operation of a SWECS with electric utilities. It addresses the interface between the wind system and the utility and the factors relating to equipment protection, power quality, and the safety of operating personnel and the general public.

3. Definitions

interconnection point. Unless otherwise specified, this point is at the utility's meter(s). It is at this point that the electrical parameters (voltage, current, frequency, power factor and harmonics) are measured.

SWECS. For the purposes of this recommended practice, a SWECS is a wind energy conversion system, with a generating capacity of 100 kW or less, a rated voltage of 600 V or less, and interconnected with a utility.

utility. An electric service organization such as an investor-owned, privately owned, rural electric cooperative, or government-owned electric system to which the SWECS is interconnected.

4. Installation and Operation Guidelines

4.1 SWECS Specifications. The SWECS owner / user is responsible for obtaining one-line diagrams, operation and maintenance manuals, and electrical system characteristics from the manufacturer. This information is essential to the utility to understand how the characteristics of the SWECS will affect the operation of the utility with respect to safety, reliability, and power quality.

4.1.1 Each SWECS owner / user requesting interconnection should provide the interconnecting electric utility and other governing authorities with the following information:

(1) A one-line diagram (see Fig 1)

(2) Type of generator and number of phases

(3) Type of inverter (if applicable) and number of phases

(4) A description of any electrical protective systems supplied or incorporated in the controls of the SWECS, such as overcurrent, over / undervoltage, and over / underfrequency. This should also include the setpoints and timing of

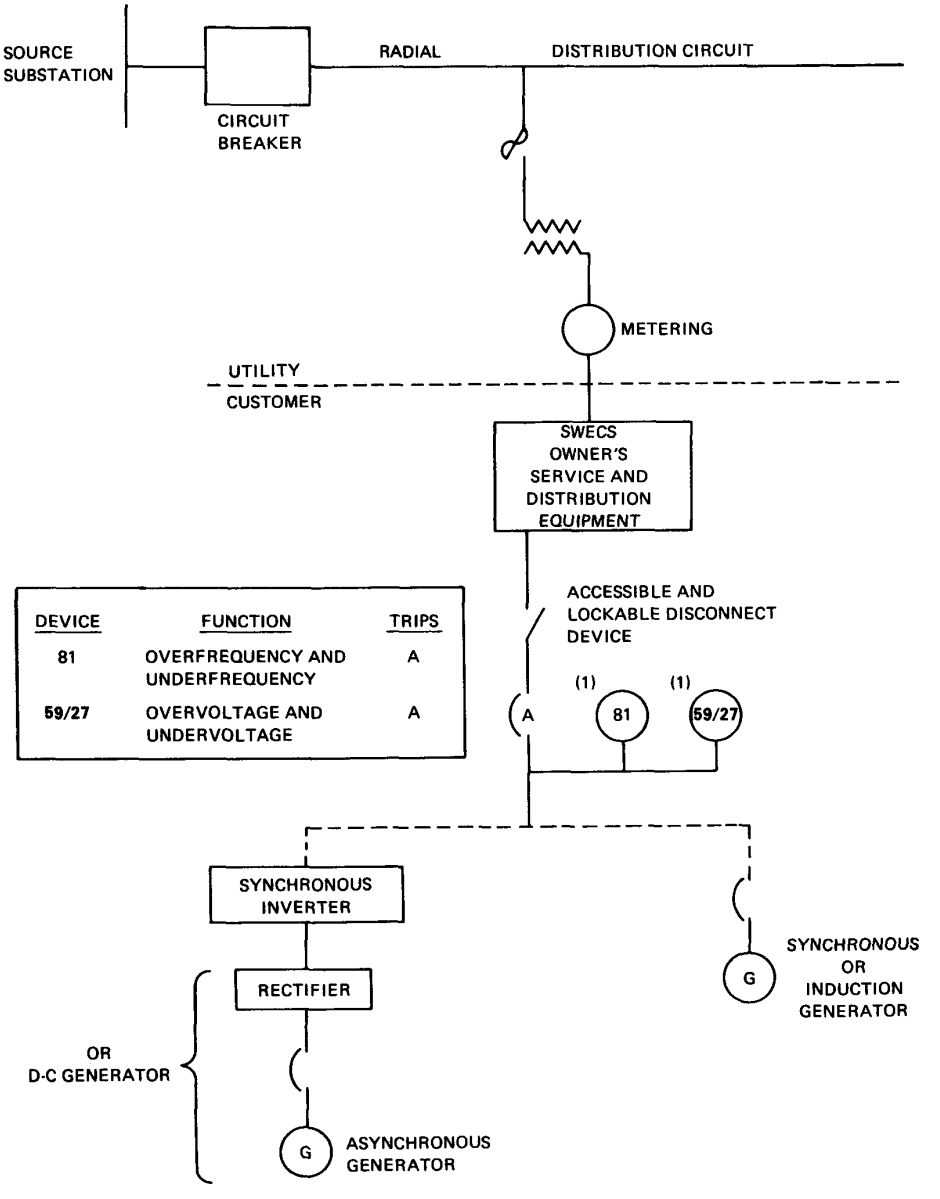

Fig 1
Typical One Line Diagram
(Showing Various Types of Generators)

the protective functions, if factory set, and the range of adjustment, if field adjustable.

(5) A table of SWECS electrical characteristics including, but not limited to

(a) Rated and maximum output, kVA

(b) Rated voltage

(c) Rated current

(d) Maximum available short-circuit current

(e) Maximum inrush current (that is, locked rotor current), magnitude and duration

(f) Rated frequency

(g) Reactive power requirements (power factor) at no load (zero output) and at 25%, 50%, 75%, and 100% of rated power output

(h) Amount of power factor correction capacitors, kvar

(i) Voltage/current harmonic characteristics at 25%, 50%, 75%, and 100% of rated power output

This information is useful in determining possible effects on the utility system, protection requirements, and possible restrictions. As multiples of a particular model are installed on a utility system, some standard data may not be required by the utility; however, site-specific information will continue to be necessary.

(6) The following information may also be requested by the interconnecting utility.

(a) Generator impedances (subtransient (X''_d), transient (X'_d), and synchronous (X_d) direct axis impedances for synchronous machines)

(b) Generator electrical time constants

4.1.2 The owner/installer is responsible for providing site-specific information and drawings indicating the physical location of the SWECS and of the lockable disconnect device (see 4.3.2).

4.2 Utility Outages. Since utility line configurations and impedances cover a very broad range, reliable, cost-effective and enforceable methods for preventing the SWECS system from energizing the utility line will require proper design engineering and testing by the manufacturer, and review of field-operating experience by the manufacturer and the utility.

The interconnection and protection requirements that may be required to ensure reliable de-energization or disconnection from the utility during utility outages can vary with location, different utilities, utility systems, and SWECS characteristics. The ability of SWECS to self-excite or energize the utility line is a function of the characteristics of the SWECS electrical system, the equipment protection and safety protection devices installed, and the electric utility line impedance characteristic.

The ability of an interconnected SWECS to de-energize or disconnect from the electric utility service after a utility outage is probably the most important SWECS electrical system characteristic. This characteristic directly affects the safety of utility maintenance personnel, the safety of the SWECS owner, protection of utility equipment, protection of paralleled connected loads, and protection of the SWECS electrical system.

Though a number of careful investigations have been conducted, conflicting opinions exist concerning how different types of interconnected SWECS (that is, those using synchronous generators, induction generators, or inverters) will react after a utility outage occurs. There is no consensus of opinion nor has there been sufficient field experience to provide a basis for specific recommendations that will ensure 100% reliable de-energization or disconnection of a SWECS during a utility outage. For the most part, the uncertainty and differences of opinion are related to the reactions that may occur when a number of SWECS are concentrated in a small area of an electric utility system.

4.2.1 The interconnected SWECS may be required to provide a means to prevent energizing or attempting to energize a de-energized utility line.

4.2.2 The SWECS system should be de-energized or disconnected from the utility system in less than one second upon occurrence of sustained abnormal voltage or frequency. Abnormal voltage is defined as voltage outside the operating range permitted at the interconnection point by the local utility regulatory authority. Abnormal frequency is defined as frequency less than 59.0 Hz or greater than 61.0 Hz. Utility technical considerations may require tighter tolerances.

Sustained overvoltages may cause utility or customer equipment failure in much less than one second. If the characteristics of the SWECS and the utility system are such that high overvoltages may occur, overvoltage protection with no intentional time delay may be required.

4.2.3 The SWECS electric system should have start-up controls that provide safe operation for personnel and equipment under normal operating conditions and upon resumption of service following a utility interruption. Loss of synchronism due to momentary outages could potentially damage SWECS generators. Synchronism controls or delayed restart operation of the SWECS should be considered to protect the equipment from damage.

4.3 Disconnect Requirements

4.3.1. For safety, each interconnected SWECS owner/user may be required to bear the cost of installing a visible-break disconnect, as shown in Fig 1, that is accessible to utility personnel at all times and capable of being locked in the

open position. Location of this visible-break disconnect is subject to prior approval by the utility. The purpose of this disconnect is to satisfy utility safety rules that require utility personnel to work between visible open breaks.

4.3.2 Depending on size, the SWECS installation may also be required to contain a disconnect device capable of operating under load, such as a shunt trip circuit breaker or contactor, which will permit the utility to disconnect the SWECS from the electric supply system. It may also be permissible to use the visible break safety disconnect as the load disconnect device if rated for switching under load conditions.

4.3.3 The owner/user may be required to disconnect or allow disconnection of the generator from the utility system if, for any reason, the utility determines that the continuation of the SWECS interconnection is, or may be, detrimental to the safety or operation of the utility system. This may include opening the disconnect device(s) with or without prior notice to the SWECS owner for any of the following reasons.

(1) Utility system emergency

(2) When inspection of the SWECS interconnection equipment and protection devices reveals a hazardous condition or lack of maintenance

(3) When abnormal sectionalizing must take place on the utility system

5. Installation Approval

5.1 Utility Review. The potential SWECS owner/user is encouraged to contact the utility as early as possible prior to purchasing a SWECS. The utility can then determine the interconnection requirements and cost estimates before the SWECS owner proceeds. Supplying the information itemized in 4.1.1 will help the utility to determine if the proposed equipment poses any safety problems or jeopardizes the quality of service to other utility customers. The utility should also provide the various metering options available and discuss the rates available.

Review of the requested information provided to the utility is not to be construed as an approval of the performance, reliability, or quality of the proposed SWECS installation. Compliance with local-, state-, and federal-agency requirements, and the construction, operation, and maintenance of the generating facility are the responsibilities of the SWECS owner/installer.

5.1.1 The utility should review the information provided by the SWECS owner/user to ensure that the proposed installation conforms to 4.2 and 4.3 and other utility requirements, considering the characteristics of the utility system.

5.1.2 If the utility finds that the proposed SWECS installation does not meet all of its requirements, it may require the installation of additional protective measures. These may include, but are not limited to

(1) Over and undervoltage relays

(2) Over and underfrequency relays

(3) Overcurrent relays

(4) Overpower relays

(5) Synchronism checking relays

(6) A dedicated transformer serving the SWECS owner

(7) An electrically operated disconnecting device such as a shunt-trip circuit breaker or a contactor

5.1.3 The utility should review the existing service connection provided to the SWECS to determine if sufficient capacity exists for both steady-state and starting conditions.

5.2 Public Authority Review. Prior to initial operation of the interconnected SWECS, written approval by the authorized inspection agency that the installation conforms to national safety codes and local codes must be obtained by the SWECS owner.

The utility will only be responsible for inspecting and accepting those items specified in the interconnection requirements. These may include protection and control devices, circuit breaker controls, instrumentation, and communications equipment.

5.3 Review of Modifications. The initial approval and interconnection requirements of an interconnected SWECS is based on the information in Section 4. Proposed modifications to the installation affecting the electric system must be brought to the attention of the utility and the appropriate regulatory authority or authorities. Written approval should be obtained prior to making any changes.

6. Power Quality

The quality of power is governed by established practices that cover voltage, flicker, frequency, power factor, and harmonics. Deviation from these practices represents out-of-bounds conditions and may require disconnection of the SWECS from the utility. Abnormal voltage and frequency conditions are covered in 4.2 of this recommended practice.

6.1 Service Voltage. The utility service voltage and the SWECS voltage should be maintained within local utility regulatory authority limits.

6.2 Flicker. The operation of the SWECS should not cause excessive voltage flicker on the utility. Since national consensus standards are not presently available concerning voltage flicker, allowable flicker limits are generally established by individual utilities.

6.3 Frequency. Basic electrical principles dictate that the frequency of the SWECS match the utility frequency so that the two systems can operate in synchronism.

6.4 Harmonics. The operation of the SWECS should not cause excessive distortion of the utility voltage waveform or result in excessive injection of harmonic currents into the utility distribution system. Since national consensus standards are not presently available concerning voltage and current harmonic distortion, allowable limits are generally established by individual utilities.

6.5 Power Factor. Power-factor correction may be required to compensate for the reactive characteristics of SWECS. Technical, economic, utility, or regulatory considerations may govern the implementation of power-factor correction.

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