Δ **692.17 Switch or Circuit Breaker.** The disconnecting means for ungrounded conductors shall consist of readily accessible, manually operable switch(es) or circuit breaker(s).

Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and shall have the following words or equivalent:

DANGER
ELECTRIC SHOCK HAZARD.
DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE LINE AND
LOAD SIDES MAY BE ENERGIZED
IN THE OPEN POSITION.

The danger sign(s) or label(s) shall comply with 110.21(B).

Part IV. Wiring Methods

Δ **692.31 Wiring Systems.** In addition to wiring methods included in Chapter 3 of this *Code*, wiring methods and fittings specifically listed and identified for use with fuel cell systems shall be permitted.

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Part V. Marking

692.50 Fuel Cell Power Sources. A marking specifying the fuel cell system, output voltage, output power rating, and continuous output current rating shall be provided at the disconnecting means for the fuel cell power source at an accessible location on the site.

692.51 Fuel Shut-Off. The location of the manual fuel shut-off valve shall be marked at the location of the primary disconnecting means of the building or circuits supplied.

Δ **692.52 Stored Energy.** A fuel cell system that stores electrical energy shall require the following warning sign, or equivalent, at the location of the service disconnecting means of the premises:

WARNING
FUEL CELL POWER SYSTEM CONTAINS
ELECTRICAL ENERGY STORAGE DEVICES.

The warning sign(s) or label(s) shall comply with 110.21(B).

Part VI. Connection to Other Circuits

N **692.60 Connection to Other Systems.** Fuel cell systems connected to other sources shall be installed in accordance with Parts I and II of Article 705.

692.61 Transfer Switch. A transfer switch shall be required in non-grid-interactive systems that use utility grid backup. The transfer switch shall maintain isolation between the electrical production and distribution network and the fuel cell system. The transfer switch shall be permitted to be located externally or internally to the fuel cell system unit. Where the utility service conductors of the structure are connected to the transfer switch, the switch shall comply with Article 230, Part V.

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ARTICLE
694 Wind Electric Systems

Part I. General

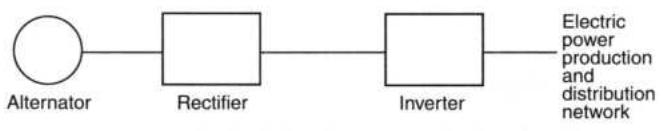
Δ **694.1 Scope.** This article applies to wind (turbine) electric systems that consist of one or more wind electric generators and their related alternators, generators, inverters, controllers, and associated equipment.

Informational Note: Some wind electric systems are interactive with other electric power sources (*see Informational Note Figure 694.1*). Some systems have ac output and some have dc output. Some systems contain electrical energy storage, such as batteries.

Like photovoltaic and fuel cell systems, wind-driven turbines as a stand-alone, or an interconnected power production source, are available for use as part of the premises wiring system. Due to an increased desire for renewable energy, these systems have seen a significant increase in use. According to the U.S. Department of Energy, although the United States reached 10 gigawatts (GW) of wind power capacity in 25 years, it took only 4 years to add an additional 40 gigawatts (2008–2012). As of 2020, the United States' total cumulative wind power capacity of 122 gigawatts was second in the world, as compared to the largest worldwide generator of wind power, China, at approximately 288 gigawatts. Wind power installations often are land based but can also be installed offshore. In 2020 alone, the United States increased its offshore wind power generation capacity over 24%, to roughly 35 gigawatts.

Wind turbine farms are becoming more common. Some are utility owned, while others are owned by private investors. Most wind electric systems consist of a single wind turbine, such as the one shown in Exhibit 694.1.

Many of the requirements in Article 694 are similar to those contained in Articles 690 and 692. The requirements apply to all wind turbines within the scope of the *NEC®*, regardless of the kilowatt rating.



INFORMATIONAL NOTE FIGURE 694.1 *Identification of Wind Electric System Components — Interactive System.*

EXHIBIT 694.1 A wind electric system consisting of a single wind turbine.

Δ **694.7 Construction and Maintenance.** The construction and maintenance, associated wiring, and interconnections shall be performed only by qualified persons.

Informational Note: See Article 100 for the definition of *qualified person*.

Wind-powered systems present some unique hazards, including the danger of working in elevated, confined spaces. Therefore, personnel working on these systems have to be trained to recognize and avoid all hazards associated with the installation and servicing of this type of power generation system.

(A) Wind Electric Systems. A wind electric system(s) shall be permitted to supply a building or other structure in addition to other sources of supply. These requirements apply to both onshore and offshore installations.

Δ **(B) Equipment.** Wind electric systems shall comply with one of the following:

(1) Be listed
(2) Be evaluated for the application and have a field label applied

Wind electric systems undergoing evaluation for type certification and listing shall be permitted to be operated in a controlled location with access limited to qualified personnel.

Informational Note: See UL 6141, *Standard for Wind Turbines Permitting Entry of Personnel*, and UL 6142, *Standard for Small Wind Turbine Systems*, for further information on wind turbine equipment. Ratings for wind turbines could include limitations on installation locations such as onshore or offshore. Testing is typically performed under supervision of a qualified electrical testing organization.

Three documents published by Underwriters Laboratories — Subject 6140, *Outline of Investigation for Wind Turbine Generating Systems;* Subject 6141, *Outline of Investigation for Wind Turbine Converters and Interconnection Systems Equipment;* and UL 6142, *Small Wind Turbine Systems* — provide the basis for certifying (product listing or classification) the overall wind turbine generator and its associated components or individual components, such as inverters and interconnection hardware, that are associated with a wind electric system. Some small wind turbines come listed as a unit, while others are assembled from individual listed components and require a field evaluation and label to assist the AHJ in approval of the system.

(C) Diversion Load Controllers. A wind electric system employing a diversion load controller as the primary means of regulating the speed of a wind turbine rotor shall be equipped with an additional, independent, reliable means to prevent overspeed operation. An interconnected utility service shall not be considered to be a reliable diversion load.

(D) Overvoltage Protection. A listed surge protective device shall be installed between a wind electric system and any loads served by the premises electrical system. The SPD shall be permitted to be a Type 3 SPD on the circuit serving a wind electric system or a Type 2 SPD located anywhere on the load side of the service disconnect. SPDs shall be installed in accordance with Part II of Article 242.

Because the towers associated with wind electric systems will generally be the tallest structures in the vicinity, the use of surge-protective devices covered in Article 242, Overvoltage Protection, is mandatory to help protect the premises wiring systems against the effects of lightning.

See also

694.40(B)(3) and **(4),** which cover grounding of towers and guy wires

Chapter 9 of **NFPA 780,** *Standard for the Installation of Lightning Protection Systems,* for the protection of wind turbines from lightning strikes

(E) Receptacles. A receptacle shall be permitted to be supplied by a wind electric system branch or feeder circuit for maintenance or data acquisition use. Receptacles shall be protected with an overcurrent device with a rating not to exceed the current rating of the receptacle. In addition to the requirements in 210.8, all 125-volt, single-phase, 15- and 20-ampere receptacles installed for maintenance of the wind turbine shall have ground-fault circuit-interrupter protection for personnel.

Receptacles installed for the maintenance of a wind turbine often are installed in areas similar to those required to be GFCI protected in other areas of the *NEC*. The shock hazard to personnel servicing wind turbines is similar, and GFCI protection for personnel is required for 125-volt, single-phase, 15- and 20-ampere receptacles. For example, a receptacle installed in a shed for system maintenance requires GFCI protection similar to that for a receptacle in a dwelling unit garage.

(F) Poles or Towers Supporting Wind Turbines Used as a Raceway. A pole or tower shall be permitted to be used as a raceway if approved in accordance with one of the following:

(1) Be evaluated as part of the listing for the wind turbine
(2) Be listed for the application
(3) Be evaluated for the application and have a field label applied

(G) Working Clearances. Working space shall be provided for electrical cabinets and other electrical equipment in accordance with 110.26(A).

For large wind turbines where service personnel enter the equipment, where conditions of maintenance and supervision ensure that only qualified persons perform the work, working clearances shall be permitted to comply with Table 694.7(G) for systems up to 1000 volts nominal.

TABLE 694.7(G) Working Spaces

Nominal Voltage to Ground	Condition 1	Condition 2	Condition 3
0–150	900 mm (3 ft)	900 mm (3 ft)	900 mm (3 ft)
151–1000	900 mm (3 ft)	1.0 m (3 ft 6 in.)	1.2 m (4 ft)

Part II. Circuit Requirements

694.10 Maximum Voltage.

(A) Wind Turbine Output Circuits. Wind turbine output circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage up to 600 volts.

(B) Direct-Current Utilization Circuits. The voltage of dc utilization circuits shall comply with 210.6.

(C) Circuits over 150 Volts to Ground. In one- and two-family dwellings, live parts in circuits over 150 volts to ground shall not be accessible to other than qualified persons while energized.

Informational Note: See 110.27 for guarding of live parts and 210.6 for branch circuit voltage limitations.

694.12 Circuit Sizing and Current.

(A) Calculation of Maximum Circuit Current. The maximum current for a circuit shall be calculated in accordance with 694.12(A)(1) through (A)(3).

(1) Turbine Output Circuit Currents. The maximum current shall be based on the circuit current of the wind turbine operating at maximum output power.

(2) Inverter Output Circuit Current. The maximum output current shall be the inverter continuous output current rating.

(3) Stand-Alone Inverter Input Circuit Current. The maximum input current shall be the stand-alone continuous inverter input current rating of the inverter producing rated power at the lowest input voltage.

(B) Ampacity and Overcurrent Device Ratings.

(1) Continuous Current. Wind turbine electric system currents shall be considered to be continuous.

(2) Sizing of Conductors and Overcurrent Devices. Circuit conductors and overcurrent devices shall be sized to carry not less than 125 percent of the maximum current as calculated in 694.12(A). The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B) and (C).

Exception: Circuits containing an assembly, together with its overcurrent devices, listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.

694.15 Overcurrent Protection.

Δ **(A) Circuits and Equipment.** Turbine output circuits, inverter output circuits, and storage battery circuit conductors and equipment shall be protected in accordance with 240.4 and 240.5. Circuits connected to more than one electrical source shall have overcurrent devices located so as to provide overcurrent protection from all sources.

Exception: An overcurrent device shall not be required for circuit conductors sized in accordance with 694.12(B) where the maximum current from all sources does not exceed the ampacity of the conductors.

Informational Note: Possible backfeed of current from any source of supply, including a supply through an inverter to the wind turbine output circuit, is a consideration in determining whether overcurrent protection from all sources is provided. Some wind electric systems rely on the turbine output circuit to regulate turbine speed. Inverters may also operate in reverse for turbine startup or speed control.

(B) Power Transformers. Overcurrent protection for a transformer with sources on each side shall be provided in accordance with 450.3 by considering first one side of the transformer, then the other side of the transformer, as the primary.

Exception: A power transformer with a current rating on the side connected to the inverter output, which is not less than the rated continuous output current rating of the inverter, shall not be required to have overcurrent protection at the inverter.

(C) Direct-Current Rating. Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a wind electric system shall be listed for use in dc circuits and shall have appropriate voltage, current, and interrupting ratings.

Part III. Disconnecting Means

694.20 All Conductors. Means shall be provided to disconnect all current-carrying conductors of a wind electric power source from all other conductors in a building or other structure. A switch, circuit breaker, or other device, either ac or dc, shall not

be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state.

Exception: A wind turbine that uses the turbine output circuit for regulating turbine speed shall not require a turbine output circuit disconnecting means.

694.22 Additional Provisions. Disconnecting means shall comply with 694.22(A) through (D).

Δ **(A) Disconnecting Means.** The disconnecting means shall not be required to be suitable for use as service equipment. The disconnecting means for ungrounded conductors shall consist of manually operable switches or circuit breakers complying with all of the following requirements:

(1) They shall be located where readily accessible.
(2) They shall be externally operable without exposing the operator to contact with live parts.
(3) They shall plainly indicate whether in the open or closed position.
(4) They shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment.

Where all terminals of the disconnecting means are capable of being energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and shall have the following words or equivalent:

WARNING.
ELECTRIC SHOCK HAZARD.
DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE LINE
AND LOAD SIDES MAY BE
ENERGIZED IN THE OPEN POSITION.

The warning sign(s) or label(s) shall comply with 110.21(B).

(B) Equipment. Equipment such as rectifiers, controllers, output circuit isolating and shorting switches, and overcurrent devices shall be permitted on the wind turbine side of the disconnecting means.

(C) Requirements for Disconnecting Means.

(1) Location. The wind electric system disconnecting means shall be installed at a readily accessible location either on or adjacent to the turbine tower, on the outside of a building or structure, or inside at the point of entrance of the wind system conductors.

Exception: Installations that comply with 694.30(C) shall be permitted to have the disconnecting means located remotely from the point of entry of the wind system conductors.

A wind turbine disconnecting means shall not be required to be located at the nacelle or tower.

The disconnecting means shall not be installed in bathrooms.

For one-family and two-family dwellings, a disconnecting means or manual shutdown button or switch shall be located at a readily accessible location outside the building.

The general requirement for locating the wind electric system disconnecting means is similar to 230.70(A) for services. For one- and two-family dwelling units, a means must be provided on the outside of the building to disconnect or shut down the wind generation system. This requirement brings wind generation systems into alignment with methods of protecting emergency personnel, such as the requirements for an emergency disconnect for services or rapid shutdown for solar photovoltaic systems. The exception permits the system disconnecting means to be located at any readily accessible location within a building or structure, except a bathroom, provided the wiring method between the conductor point of entry and the disconnecting means is a metal raceway or the conductors are protected by a metal enclosure. Supply conductors are permitted to be installed without a disconnecting means until they reach the building or structure.

(2) Marking. Each turbine system disconnecting means shall be permanently marked to identify it as a wind electric system disconnect.

(3) Suitable for Use. Turbine system disconnecting means shall be suitable for the prevailing conditions.

(4) Maximum Number of Disconnects. The turbine disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchgear.

(D) Equipment That Is Not Readily Accessible. Rectifiers, controllers, and inverters shall be permitted to be mounted in nacelles or other exterior areas that are not readily accessible.

694.23 Turbine Shutdown.

(A) Manual Shutdown. Wind turbines shall be required to have a readily accessible manual shutdown button or switch. Operation of the button or switch shall result in a parked turbine state that shall either stop the turbine rotor or allow limited rotor speed combined with a means to de-energize the turbine output circuit.

Exception: Turbines with a swept area of less than 50 m^2 (538 ft^2) shall not be required to have a manual shutdown button or switch.

(B) Shutdown Procedure. The shutdown procedure for a wind turbine shall be defined and permanently posted at the location of a shutdown means and at the location of the turbine controller or disconnect, if the location is different.

Although the exception to 694.23(A) permits a smaller turbine without a manual shutdown switch, a shutdown procedure is required for all turbines.

Δ **694.24 Disconnection of Wind Electric System Equipment.** Means shall be provided to disconnect equipment, such as inverters, batteries, and charge controllers, from all ungrounded conductors of all sources. If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified.

A single disconnecting means in accordance with 694.22 shall be permitted for the combined ac output of one or more inverters.

A shorting switch or plug shall be permitted to be used as an alternative to a disconnect in systems that regulate turbine speed using the turbine output circuit.

Exception: Equipment housed in a turbine nacelle shall not be required to have a disconnecting means.

694.26 Fuses. Means shall be provided to disconnect a fuse from all sources of supply where the fuse is energized from both directions and is accessible to other than qualified persons. Switches, pullouts, or similar devices that are rated for the application shall be permitted to serve as a means to disconnect fuses from all sources of supply.

694.28 Installation and Service of a Wind Turbine. Open circuiting, short circuiting, or mechanical brakes shall be used to disable a turbine for installation and service.

Informational Note: Some wind turbines rely on the connection from the alternator to a remote controller for speed regulation. Opening turbine output circuit conductors may cause mechanical damage to a turbine and create excessive voltages that could damage equipment or expose persons to electric shock.

Part IV. Wiring Methods

694.30 Permitted Methods.

Δ **(A) Wiring Systems.** In addition to wiring methods included in Chapter 3 of this *Code*, wiring methods and fittings specifically intended listed and identified for use on wind turbines shall be permitted. In readily accessible locations, turbine output circuits that operate at voltages greater than 30 volts shall be installed in raceways.

(B) Flexible Cords and Cables. Flexible cords and cables, where used to connect the moving parts of turbines or where used for ready removal for maintenance and repair, shall comply with Article 400 and shall be of a type identified as hard service cord or portable power cable, shall be suitable for extra-hard usage, shall be listed for outdoor use, and shall be water resistant. Cables exposed to sunlight shall be sunlight resistant. Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14(A).

To provide a greater degree of flexibility, the conductors used in flexible cords and flexible cables are more finely stranded than conductors with Class B or C stranding. Terminals, connectors, and devices used with classes of stranding other than Class B or C are required to be identified for the classes of stranding for which they are suitable.

See also

110.14 and its commentary for more information on conductor terminations

(C) Direct-Current Turbine Output Circuits Inside a Building. Direct-current turbine output circuits installed inside a building or structure shall be enclosed in metal raceways or installed in metal enclosures, or run in Type MC metal-clad cable that complies with 250.118(A)(10), from the point of penetration of the surface of the building or structure to the first readily accessible disconnecting means.

Part V. Grounding and Bonding

694.40 Equipment Grounding and Bonding.

(A) General. Exposed non–current-carrying metal parts of towers, turbine nacelles, other equipment, and conductor enclosures shall be grounded and bonded to the premises grounding and bonding system. Attached metal parts, such as turbine blades and tails that are not likely to become energized, shall not be required to be grounded or bonded.

(B) Tower Grounding and Bonding.

(1) Grounding Electrodes and Grounding Electrode Conductors. A wind turbine tower shall be connected to a grounding electrode system. Where installed in close proximity to galvanized foundation or tower anchor components, galvanized grounding electrodes shall be used.

Informational Note: Copper and copper-clad grounding electrodes, where used in highly conductive soils, can cause electrolytic corrosion of galvanized foundation and tower anchor components.

(2) Bonding Conductor. Equipment grounding conductors or supply-side bonding jumpers, as applicable, shall be required between turbines, towers, and the premises grounding system.

(3) Tower Connections. Equipment grounding, bonding, and grounding electrode conductors, where used, shall be connected to metallic towers using listed means. All mechanical elements used to terminate these conductors shall be accessible.

(4) Guy Wires. Guy wires used to support turbine towers shall not be required to be connected to an equipment grounding conductor or to comply with the requirements of 250.110.

Informational Note: Guy wires supporting grounded towers are unlikely to become energized under normal conditions, but partial lightning currents could flow through guy wires when exposed to a lightning environment. Grounding of metallic guy wires may be required by lightning standards. See NFPA 780-2017, *Standard for the Installation of Lightning Protection Systems*, for information on lightning protection systems.