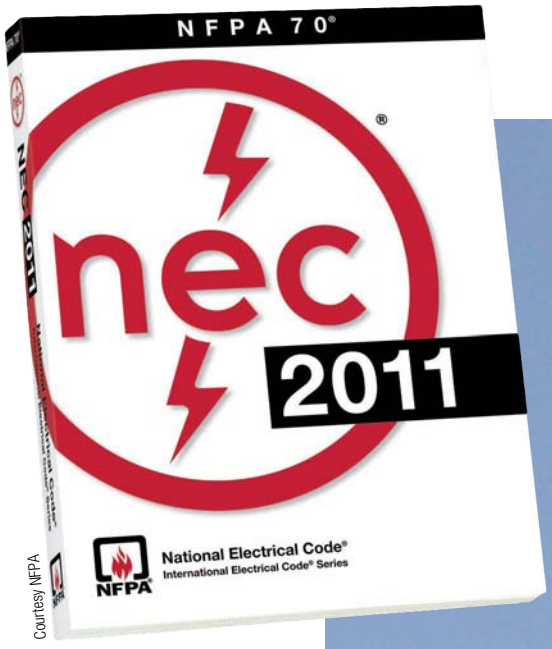
Small Wind Systems & the *NEC*

by Robert Preus



Courtesy NFPA

Courtesy Ian Woofenden

Move over, solar electricity: This year, small wind-electric systems got their own article in the *National Electrical Code*.

The *National Electric Code (NEC)* is a set of rules for the electrical connection and installation of all kinds of electrical equipment, but has lacked specificity for small wind systems (wind turbines rated at 100 kW or less)—until now. In the mid-1980s, PV systems were given their own presence in Article 690 of the *NEC*. Three decades later, small wind systems have earned their own Article—694—too.

In the past, due to the unique character of small wind installations, applying some of the general code was difficult or confusing, and AHJs often attempted to use the PV Article 690 to deal with this. However, PV can be disconnected from the load or short-circuited with no harmful effects. Some wind generators can also—but some cannot. This can result in unsafe conditions when applied to a small wind installations.

Getting to Wind

PV code pioneer and electrical engineer Robert Wills and I were persuaded to co-chair a group of wind industry stakeholders in developing a proposal to amend the 2008 *NEC* for its revision in 2011. In March 2008, we formed a stakeholder group that included input from about 50 participants, including installers, system designers, manufacturers, and incentive program managers with an interest in the small wind industry. The proposal had to be submitted using the rules of the *NEC* style guide. Wills was very familiar with these guidelines since he had been involved in the PV code from the beginning.

In January 2009, the 19 *NEC* code panels met to review and report on the proposals. Wills served as a delegate and I was an alternate. Literally hundreds of amendments to

articles covered by this panel were considered, debated, and voted on. They ranged from our group's proposal for a separate wind article to minor changes in wording of already-existing articles to improve consistency in the formatting and style. The separate article was accepted in principle with the requirement for some modifications, and assigned its own number—694.

In July 2009, the proposals by the panels were published, and the public comment period began. During this period, anyone with interest could comment on any of the proposed actions or changes to the *NEC*. If a proposal was rejected for lack of justification, the author or anyone else could provide justification. If someone objected to a proposed change that was accepted by the panel, they could submit an objection with justification for the objection. The panel responded to all comments.

In December 2009, the panels met to consider the comments and finalize their actions on each proposal. At that point, the new wind article was approved with modifications. The final, official adaptation of the 2011 *NEC* occurred at the June 2010 annual meeting of the National Fire Protection Association (NFPA), the organization responsible for the *NEC*. In September 2010, the 2011 *NEC* rolled out. Some jurisdictions adopt the new version of the *NEC* immediately; some wait longer or make their own modifications. But even if a jurisdiction has not fully adopted a newer version, sometimes parts of the latest versions are allowed or applied.

The process for addressing changes for the 2014 *NEC* will begin again in October 2011. There will be many proposals for modifying the small wind article since it is now included in the code. Many of the proposals will involve consolidation of requirements common to PV, wind, and fuel cell systems into Article 705; battery-related requirements will be consolidated into Article 480.

Section by Section

The format for Article 694 is modeled after the PV code's Article 690. Section I (694.1 through 694.7) establishes the scope of the article and provides definitions for terms specific to small wind systems. It also states that 694 requirements apply anytime they differ from the rest of the code—except for 705, when a small wind system is operated in parallel with primary sources of electricity; and 500 through 516, when a system is installed in a hazardous location.

Section I specifies that small wind systems shall be installed by qualified persons. This issue caused great debate between those who think that the *NEC* should specify only *how* the installation is done—and not by whom. Section I also requires surge protection between the wind turbine system and the loads served, and allows standard plug-in receptacles on the wind turbine branch or feeder circuit for maintenance or data acquisition. (This is not allowed for in PV systems under Article 690.)

Section II (694.10 to 694.18) covers circuit requirements. It defines how to calculate voltage and current for small wind systems and how to derate conductors. 694.15 covers overcurrent protection and, in an exception, does not require overcurrent devices when the conductors' ampacities (sized in accordance with 694.12(B)) exceed maximum current from all sources.

Section III (694.20 to 694.28) relates to disconnecting issues. Section 694.20 provides an exception that exempts a wind turbine that uses an output circuit for regulating speed from having a disconnecting means. Section 694.24 allows a shorting switch or shorting plug to be used as an alternative to a disconnect in this case. This makes sense with the understanding that a small wind turbine is a limited current source and that, for some small wind generators, disconnecting the load produces a dangerous situation. This is one of the prime reasons that small wind needed its own article. Section 694.22 (D) allows the installation of rectifiers, controllers, and inverters in nacelles (wind turbine housings) and other exterior areas that are not readily accessible.

Section IV (694.30) covers wiring methods. It requires that flexible cords comply with Article 400 and be identified as hard service cord, listed for outdoor use and water-resistant. DC output circuits in a building must be in metal raceways, from the point of penetration at the building's surface to the first readily accessible disconnecting means.

Section V (694.40) addresses grounding. It requires that towers and turbine nacelles be attached to an equipment grounding conductor, but exempts attached parts, such as tails, that have no energizing source. Guy wires are not required to be connected to the equipment grounding conductor. Auxiliary electrodes and equipment-grounding conductors are both required for the tower structure. It refers to Article 250, Section III, for most of the details of the grounding requirements.

Section VI (694.50 through 694.56) prescribes signage that is required for various system configurations. It covers grid-interactive systems and stand-alone systems.

Section VII (694.60 to 694.68) pertains to connecting the system to other sources of electricity. This section requires that inverters used in grid-tied systems be listed and identified as utility-interactive, and that these systems comply with article 705. Section 694.66 allows inverters on branch circuits to exceed the normal voltage operating range so long as the voltage at the distribution panel remains within the normal limits. The reason that this is important is this: When inverters are pushing power into the grid, they raise the voltage to do so. If there is a long wire run between the inverter and the utility transformer, it is common to raise the voltage higher than the voltage allowed for the utility. Without this option, wind system owners would be required to install larger-gauge wire to limit the voltage rise.

Section VIII (694.70 to 694.75) covers storage batteries, referencing Article 480 for general battery requirements. But 694.70 spells out the current limiting and other battery-specific safety measures that are required, with an emphasis on systems at 48 volts nominal or greater. Section 694.75 also details requirements for charge controllers. One significant requirement is that a single diversion load control cannot

Courtesy Endurance Wind Power

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be the sole means of regulating battery charging. A utility-connected service does not qualify as a reliable diversion load to meet the second regulating means requirement.

Section IX (694.80 and 694.85) is for systems greater than 600 volts. While there are few, if any, systems in excess of 600 V and, as far as I know, no battery systems over 600 V, serious efforts are made to not have the code limit future developments. So there are avenues left open that are not currently used. Section IX references Article 490 for general requirements, and also establishes the basis for determining battery and other circuit voltage for wire and device ratings.

What's Next

Some AHJs consider the wind turbine alternator as an AC source and are requiring grounding of the center of the three-phase wye for the alternator wiring, under Article 250.20. This does not work for a system that rectifies the output of the alternator and that has one leg of the DC bus grounded. You get a built-in short circuit load that keeps the wind turbine from starting. As 694 is applied, other areas in the code may require clarification as well.

The Code & Consumers

Article 694 for small wind-electric systems provides more consistency in their installation. There will be fewer surprises caused by contractors and authorities having jurisdiction applying different interpretations of the *NEC* for wind turbine system installations. Code-compliant systems also help guarantee that installations meet current safety standards.

Access

Robert Preus (robert@artre.us) is a wind energy systems engineer with experience in managing systems design for small and intermediate wind generators. He is also experienced in obtaining certifications, and in listing and marking wind energy equipment. Robert offers small wind technology training and engineering consulting in small design and certification through his company, Advanced Renewable Technology.