IS PV GOING TO GROW UP?

John Wiles

From time to time we must go back and examine where we are and how we got there. This is one of those times. The National Electric Code is just that-- a national code for all electrical power systems. It has evolved over the last 100 years or so and is in effect throughout the entire United States. In some areas even more stringent codes are in use. These codes are safety oriented and do not specify how the requirement is to be achieved or what equipment is to be used. The National Fire Protection Association who publishes the NEC is not in the equipment development business so the NEC is not the proper place to discuss implementation of the requirements.

These Code Corner columns are being written to achieve one objective: The Widespread Use of Cost Effective, Safe, Reliable, and Durable Photovoltaic Power Systems.

The material presented here is a distillation of over 18 months of research carried out under contract to the U. S. Department of Energy. This material has been reviewed by over 300 persons in the PV industry and revisions and comments from nearly 60 manufacturers, distributors, dealers and installers have been incorporated. Feedback from workshops to the general public, dealers, electric utilities, and electric inspectors has also been used in determining the contents of this column. The techniques discussed to meet the NEC and those that don't are based on PV systems being installed today and on tests and evaluations of more than 200 PV systems and nearly a quarter million PV modules in systems over the last decade.

History

Although most commercial power in the U.S. is alternating current (ac), the NEC was initially developed in the days when Edison was still around and direct current (dc) power systems were far more common than ac systems. Even now, some industries such as mining and ore reduction still use dc power. High current battery systems abound as uninterruptible power systems (UPS) are used to keep computers on line when the grid power goes down. The NEC covers all of the systems in use for alternate energy including back up generators, batteries, hydro, wind, PV, etc. It also deals with low voltage, high power systems. The people who write and constantly revise the NEC are "hands on" professionals in various segments of the electric power industry who don't rely on "feelings" to get the job done. Most have been designing, building, and installing electric power equipment and systems for far longer than the terrestrial PV power industry has been in existence. If you own a copy of the NEC, you will know that there is a straight forward procedure for submitting proposed changes -- changes which must be based on cold, hard facts and test data -- not guesses and suppositions.

Current Events

In August in New Haven, CT an electrician/electrical contractor was sentenced to five years imprisonment and an additional five years probation after being found guilty of second-degree manslaughter due to an electrical fire that claimed the life of a 12 year old boy. No, it wasn't a PV system, but the investigation revealed that 19 sections of the local/National Electrical Code had been violated.

Safe or Sorry?

Who will pay the piper when a PV system which is not factually and demonstrably safe, burns up a house or kills someone? Who will pay when little Timmy tries to help Daddy and drops a wrench across the inverter terminals on a system you "felt" was safe without fuses between the battery and the inverter? It is going to take just one major PV accident for the insurance industry or the electrical inspectors to put us all out of business.

Recent Problems, Understanding, and Solutions

Much attention has been recently directed toward the problem of excessive voltage drop between the battery and inverter when the guidelines in the NEC are followed with respect to overcurrent protection and disconnects. The specific facts and connection arrangements used at SEER 90 are not available, but consider the following: All provisions of the NEC in this particular case can be served by a single circuit breaker between the battery and the inverter. The circuit breaker can provide the disconnect for the inverter, the overcurrent protection for the wiring to the inverter, 30 times rating inrush protection, and 10 times rating surge protection. The circuit breaker can interrupt 25,000 amps on systems with less than 65 volts. A circuit breaker of this type has a terminal to terminal resistance of less than 0.001 (one milliohm). Of course, the circuit breaker must be connected to the circuit.

Utility companies routinely make crimped connections to terminals and breakers like this with much less than one milliohm resistance-- and they don't use solder! At 1000 amps, even a 0.001 ohm connection would loose 1000 Watts of power and not even the utility companies can afford that. The added (for NEC requirements) resistance is less than 0.003 ohms (connections plus internal resistance of the circuit breaker) which yields 0.3 volts drop at 100 amps and 0.6 volts drop at 200 amps. During 1000 amp surges, the added drop is 3 volts, but the inverter manufacturer should take this into account in their designs. The circuit breaker mentioned in sizes up to 110 amps costs less than $50 in quantity buys.

There will always be voltage drops due to cable length and size, less than ideal connections, and disconnect and overcurrent devices. As PV systems spread, the inverter manufacturers are going to have to acknowledge these real-world conditions and requirements. They will add remote battery sensing leads for the low voltage cut-off function and a few extra turns in the transformer to deal with the sagging output voltage under surge conditions. They may even be more creative in their solutions and some manufacturers have already addressed the surge issue. Remember they are part of our industry and part of the problem as well as potentially part of the solution.

The PV industry is very small when compared with even the UPS industry. The UPS people deal routinely and effectively with 100's of amps of current and meet UL and NEC requirements so I suspect

we in PV will not be able to generate much enthusiasm for low cost, ultra low loss equipment. It is already available -- if you have $$$$, but there are much easier and cheaper solutions within our own PV/inverter industry.

Incidentally, those of us who remain at 12 volts with inverters which draw more than 100 amps at full output will find that disconnect and overcurrent equipment prices increase by a factor of three or more as we go past 100 amps. After all, we are demanding low, low contact resistance, aren't we?

The Choice Is Yours

Code Corner is written to present solutions to the PV user that meet the legally mandated, existing requirements of the National Electric Code. I make every attempt to find available, low cost, reliable solutions to the perceived problems we face, since I too am paying the bill for my alternate energy system. You don't have to implement any safety considerations in your system if you choose not to, but you must also be willing to stand responsible for the consequences of your actions.

Access

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The Wizard Speaks…

Solar Power

It's time to stop beating around the bush. Global warming, acid rain, and pollution are and will continue to be major problems. Solutions must begin to be implemented to address these dire problems of the biosphere. We, the human race, must take action soon or we may not be able to take any action at all. In fact, we may not even be here to take any action. Them's the facts folks. It's up to us to act on them.

So you ask "What can be done?" It's really simple. Begin immediately to replace all fossil and nuclear power plants with photovoltaics, using hydrogen, hydrides, or hydrogen fuel cells as storage media. Replace gasoline and other fossil fuels with these same hydrogen agents. The only argument against these measures is cost. Costs can be reduced greatly by using energy efficient appliances, especially lighting, refrigeration, and electronics. Conservation can also reduce costs. Besides, there is no choice. What's the earth to you? Do it now!

(The present crisis in the Middle East brings this all home now. Oil will not last forever. It is better to replace it now, than to wait until it is all gone. WIZ)