

**IEEE P1547.6 Working Group
August 2007 Meeting Report**



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TECHNOLOGY
COLLABORATIVE

RENEWABLE ENERGY TRUST

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Disclaimer

The IEEE P1547.6 working group session is a closed meeting. No names or company affiliations will be mentioned in this report. This report is general in nature, covering the major issues discussed in the meeting.

By IEEE definition and nomenclature P1547.6 is an IEEE standard, but it is a member of the subcategory of standards referred to as a "Recommended Practice." A Recommended Practice document is one in which IEEE *preferred* procedures and positions are presented (should). This is a lower level than a "Standard" standard document with *mandatory* requirements (shall), but of a higher level than the *suggested* practices of an IEEE "Guide" (may).

IEEE P1547.6 August 7 & 8 Meeting

The meeting started with introductions. There were 13 utility/distribution company representatives, two DG manufacturer representatives, one IEEE chair and one vice chair (former and current utility personnel), one NREL administrator and myself present. The minutes from the February 2007 meeting were accepted by voice vote. The ground rules for civil discourse were stated. Throughout the two day meeting, as issues were discussed, writing tasks were assigned to participants.

The primary purpose of the meeting was to review and debate the language of the IEEE P1547.6/D1 Draft Recommended Practices for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks. This draft resulted from the writing assignments allocated to selected participants at the February 2007 IEEE P1547.6 working group meeting. There are, at present, eight sections to the document. Those sections are:

1. Overview
2. References
3. Definitions and acronyms
4. Existing requirements for the interconnection of distributed resources with networks
5. Overview of network distribution systems: design, components and operation
6. Primary concerns of operating DR on networks
7. Interconnection of DR to networks: current practices/solutions
8. Recommendations for future DR-network interconnections

There was some discussion that the basic IEEE 1547 standard has been adopted by most states. Some people mentioned that the standard has been adopted by some other countries like Korea and is being asked to go international. There is uncertainty whether 1547 has been accepted by the International Electrotechnical Commission. Reports in the meeting claimed that the EU does not have an interconnection standard. Individual countries in

Europe have interconnection standards but not the EU. One participant made the claim that they have secondary network distribution but do not permit interconnections. (England may permit interconnections to secondary network distribution.) Some participants expressed the preference that 1547 not become an international standard because of the resulting complexity of the consensus process. The concern was also expressed that the IEEE 1547 standard remain in its current form long enough for the technical community to evaluate it within a range of different scenarios. This observation acknowledges the possibility that understanding all of the potential issues surrounding DR interconnection to secondary network distribution may take years of operational experience.

This meeting dealt with both system distribution secondary spot and grid networks.

Discussion

The two days of discussions focused on the last three sections of the proposed standard:

- 6) Primary concerns of operating DR on networks
- 7) Interconnection of DR to networks: current practices/solutions
- 8) Recommendations for future DR-network interconnections

These topics might be paraphrased as:

6 → Concerns of utilities and distribution companies regarding DR on secondary networks.

7 → Current practices of DR manufacturers and installers for interconnecting to secondary networks.

8 → Possible new solutions for interconnection of DR on secondary networks that will address utility concerns and facilitate some level of interconnection of DR on networks.

Section 6: Primary concerns of operating DR on networks

There was a range of issues of concern to utilities and distribution companies discussed over the course of the two day meeting. Some of these concerns were very specific and the discussions of these dealt with explicit details such as the number of cycles required for different types of network protectors to open under a reverse power condition or the problem of impedance matching for spot network transformers. Other topics were much more general in nature and dealt with broader industry issues such as the original intent of the design of secondary network distribution equipment or the increasing demands upon shrinking engineering workforce within utilities and distribution companies. All of the concerns reflected reservations regarding installing modern DR on secondary networks, much of which are populated by legacy electromechanical equipment. Questions arose regarding the design philosophy underlying DR in the context of the original design reasoning of the secondary network distribution. All of these issues were considered both in the context of the current levels of penetration and in anticipation of the potential breadth of DR deployment.

Much of the discussion over the details and wording of specific sections of the draft dealt with formulating the document as a performance standard or crafting it in performance language. In many cases the writing of specific sections or sentences was deferred and writing assignments were given to key participants. The fundamental concern of the group was that the addition of DR should not decrease the reliability, power quality or safety of system operations. What follows is a brief description of the key technical elements of the concerns regarding the operation of DR on secondary networks.

- **Dependence upon customer protective equipment**

One very specific concern that was discussed both in this and in the February 2007 meeting was the issue of maintenance of protective equipment on the customer's side of the point of common coupling (PCC). Should the utility rely on one customer's relay equipment to protect the utility's equipment and the equipment and quality of service of neighboring customers? Maintenance is a problem because it is never clear whether or not the customer will perform the necessary maintenance. Maintenance should be performed every four years. Some customers send in reports but the utilities and distribution companies do not have enough resources to verify that the reports are accurate.

- **Network protector delay and timing coordination with DR tripping**

Over the two day meeting much of the discussions centered on the coordination of tripping of the network protectors and the customer DR. The issue has to do with the timing of the responses of the network protector and the customer's protective relaying to abnormal conditions. The strong consensus was that it is preferable for the DR to trip off line before the network protector. During these discussions no mechanism was proposed to achieve this coordination and the

concern of group was that the network protector would trip off before the DR and, potentially, isolate an entire building from the network.

- Differentiating low-level faults (reverse power flow) from high current faults
Low-level faults can be similar to reverse power flow cause by the regenerative braking of elevators. In some service territories network protectors are set with short delays to accommodate the power generated by elevators. Single line to ground faults may cause DR to backfeed at low levels and, to the extent that a DR installation mimics the range of power that would be supplied by an elevator, this it may be able to be tolerated. In the case of high level, phase to phase faults, the network protector must respond instantaneously and older, electromechanical network protectors may not be able to differentiate between the two.

- Opening of network protector due to non-fault conditions
Under light loads, when a building is served by a spot network, it is possible for network protectors to open unnecessarily without the presence of DR. DR can exacerbate this problem simply by lowering the local load.

- Inhibition of network protector re-closing by DR
The reduction of load by DR can prevent proper closing of network protectors. This issue is associated with that of unnecessary opening of network protectors under light loads. It is possible for network protector cycling or “pumping” to occur in some instances where a differential voltage threshold is continually crossed and this may result in premature failure of the device.

- Improper closing of network protectors
For machine-based DR, if close synchronization is not achieved prior to re-closing the network protector, voltages in excess of the network protector rating can occur at the moment the two systems are paralleled. Some network protectors are not designed to tolerate such voltages and may be damaged in such a scenario.

- Frequency issues
Network protectors are not designed to measure frequency and so can not be used to synchronize separate systems. Some microprocessor-based network protectors may have the ability but no data are available.

- Arc flash issues
Reduction of arc flash energy is a major concern. This is a personnel hazard while workers are in the network protector vault. Concerns exist regarding whether the DR will contribute to the arc flash should it occur.

- Calculation of minimum load (for an area or for a single building)
The determination of minimum load for a region or for a single building is essential in assessing the impact of DR on either a grid or spot network. One

participant described his company's calculates the minimum load levels. For their "Trailblazer" program two criteria are used. For a single building the inverter capacity must be less than 50% of the minimum load of the facility. For a region the aggregate generating capacity must be less than 2% of the area/region estimated minimum load. In the future this company plans to have smarter metering. The question was asked if the utility should be looking at the aggregate or the loading on each transformer. One participant said that the minimum load on the transformer should it be 2% or greater or they should do load flow studies. The value of less than 1/2 of the error in measurement was selected to get the 2%.

- Network protector knowledge base

One issue that was not a part of the formal draft standard but which was discussed throughout the meeting is that of the diminution of the utility engineering workforce and, in particular, the resident expertise in secondary network distribution system technology. The design of secondary network distribution systems may be something of a lost art. Much of the institutional memory is no longer available. The first secondary networks were designed 75 or more years ago. Much of the expertise in design, operation and maintenance has retired. Some of the institutional pressures associated with deregulation and restructuring have led to a shrinking of distribution company engineering support and secondary network distribution systems expertise –partly because of the stability and reliability of the systems and partly because of the natural workforce attrition-- has been a casualty of this trend. The problem of succession that is presently hitting the utility industry generally appears to be even more acute in the area of technical expertise in secondary network distribution systems.

Ironically one very real weakness of these secondary network distribution systems is their robustness and enduring reliability itself. In an earlier meeting the claim was made that the grid network in Worcester, Massachusetts has not had a distribution related outage in forty years. As a consequence when network related expertise retires the positions often are not backfilled. It is for this reason that the concern has been expressed that any change to secondary network distribution not occur too rapidly in order to allow time for current utility and distribution company engineering staff to fully evaluate the range of circuit implications.

Section 6 will be revised by the utility and distribution company group that produced the original draft.

Section 7: Interconnection of DR to networks: current practices/solutions

The discussion of current practices for interconnection of DR to secondary networks differentiated between three categories of generation sources: inverter-based systems, induction generation, and synchronous generation. The focus of discussions for this section was on operational considerations and strategies, and local practices. Most of the work done in this section dealt with rotating machinery as apposed to inverter systems.

Several protection strategies were discussed. One approach discussed entailed coordination to be incorporated in the DR design. It was pointed out that it is not possible to clear a network protector in any less than 3 cycles for a single line to ground fault. The generator could be set to trip in less than 3 cycles before the network protector can trip. The claim was made that for synchronous and induction generation protective relaying can typically disconnect the DR within 1.5 to 5 cycles.

To address the issue of low-level faults DR can be set to contribute no more than 1 per unit before disconnecting. This approach limits the capacity of the DR to no more than its nameplate rating. In addition, load flow studies can be preformed and DR operation can be limited based on time of day or weekend considerations.

One estimate of the cost of protection for some DR systems was between \$100,000 and \$500,000.

Section 8: Recommendations for future DR-network interconnections

Discussions under this section focused on possible new recommendations for DR interconnections to grid and spot networks in the future. The questions dealt with in this section had to do with the IEEE recommended design practices DR interconnection for networks. Design practices may require a certain minimum level of load on the network protector transformers. It was pointed out that presently there are no IEEE standards for minimum transformer loading, though there may individual utility practices requiring minimum loads.

The question of what was the “normal” load variation over the course of a year was discussed. It was suggested that a 1 to 4 ratio may be typical. This consideration then goes to what is “normal” network protector behavior over the course of a year. Some utilities and distribution companies take the proactive step of monitoring the open/closed state of network protectors and even change out transformers to achieve a situation where all protectors are closed most of the time.

- De minimus criterion

One recommendation provide in section 8 is the “de minimus” criterion. The maximum allowable capacity of the DR, under this criterion, is one fifteenth of the minimum building load. $1/15^{\text{th}}$ is proposed as a fairly conservative value. The task of determining the annual minimum load is still present. It may require special metering or monitoring, monitoring for an entire year.

- Secondary spot network modifications

Another option proposed is to design a separate bus within a facility that supplies only a portion of the facility load. Under system fault or reverse power condition the second bus can be separated from the main building distribution system to island the segregated portion of the facility.

- Use of high-speed solid-state switching

The possibility of employing a high-speed solid-state switching device between any form of DR and the grid was discussed. The suggestion was made that such a device might be able to achieve disconnecting times of $1/8^{\text{th}}$ to $1/4$ cycle.

- Use of high-speed communications

This proposal relates closely to the solid-state switch configuration. The system would open a circuit breaker in what was referred to as a “transfer trip” scheme. Though there few details in the present draft version of P1547.6 this approach appears to have much in common with the NPEG concept.

- Connection of DR to radial circuit

A alternative to all interconnections to grid and spot secondary network distribution systems is to bypass the interconnection to the network all together

and extend the service, or at least the DR interconnection portion of the service, to the nearest radial distribution point.

Overall the discussions seemed to indicate that microprocessor-based network protectors were the preferred hardware platform for DR interconnections because of their flexibility capable of multiple set points. When reverse current are low and temporary these microprocessor-based devices can be set to delay tripping. When fault currents are high the microprocessor-base units can be set to trip fast.

Presentation of NPEG performance specification

Jim Bing presented a brief description of the NPEG performance specification. Feedback was limited but most of the working group seemed generally open to the process. Several participants requested copies of the presentation and asked to be kept informed regarding the initiative in the future. All of the attendees were invited to participate in future NPEG conference calls.

Meeting Summary

At present the IEEE P1547.6 standard is still in a formative stage. A number of very serious concerns regarding the safety, reliability and security of distribution secondary networks, when interconnected to DR, have been articulated by participants. The standard describes some mechanism presently being used to achieve limited interconnection of DR to networks. A variety of new options have been developed as possible recommended practices within the standard. Overall the development of the document is proceeding through a consensus processes marked by a cautious and studied debate.

With regard to the NPEG process, it appears as though a Network Protector Enable Generation approach could address many of the “concerns” expressed in section 6 of the draft standard. In an NPEG system configuration issues such as customer maintenance of equipment, DR and network protector trip coordination, threshold control of directional power flow, frequency/voltage synchronization of DR and network before network protector closing, and arc flash prevention (DR lock out function) could be addressed directly. The general impression given by the participants to the presentation of the NPEG performance specification appeared to be one of guarded interest and a willingness to at least keep informed of the technical developments.

It should be noted, however, that there is a serious deficiency in the NPEG work to date.¹ That deficiency is the absence of any reference to tariff considerations. Under the present tariff structure, where utility and distribution companies are compensated based upon the volume of energy delivered, any facilitation of DR could have the result of decreasing company revenue. This is what one participant on a recent NPEG conference call referred to as a “perverse disincentive” to DR adoption. In principle this tariff consideration applies to both radial or network distribution systems, however for the safe deployment of DR on secondary networks significantly more distribution company engineering time must be applied. In an environment of shrinking engineering resources –both in workforce size and network-related institutional expertise— this may represent a very serious burden.

While the NPEG concept *may* be gaining traction on a conceptual technical level, given the apparent pressures on utility and distribution engineering resources, progress in this area may eventually be limited. Tariff considerations are outside of the technical scope of NPEG research; however they are an influential component of any eventual adoption of the technology.

¹ The issue of financial disincentives for distribution company investment in DR is addressed in detail in reports that are available at:

- <http://masstech.org/dg/EPRI-STAC.htm>
- <http://masstech.org/dg/winwin.htm>

Post Script

- IEC Public Available Specifications

During the meeting I had the opportunity to speak with Joseph Koepfinger, the Chair of the P1547.6 working group. Mr. Koepfinger is veteran of more than forty years in the utility industry experience and is active on standards making bodies in both the IEEE and the IEC (International Electro Technical Commission). Mr. Koepfinger made an observation regarding possible adoption of NPEG performance specification as an IEC Public Available Specification (PAS). A PAS is like an open source standard or specification and would be published and available for use by any person or company. He said that there is a similar sort of specification form being discussed by the IEEE, but that at present they do not have such a process. In either case this format would be a document that would not be subject to the consensus process that standards normally go through. Mr. Koepfinger suggested we contact Richard Schomberg of Électricité de France (EDF) who is presently a representative to EPRI. Mr. Schomberg is the chair of IEC Technical Committee 8. According to Mr. Koepfinger the IEC is actively seeking standards to publish. I would recommend that this avenue be explored as it may provide a ready mechanism for involvement by more stakeholders in the industry.

- Intentional Islanding

Concurrent with the standards development being done by the 1547.6 working group on DR interconnection to secondary networks, work is going on in the area of intentional islanding under the heading of “IEEE P1547.4 Draft Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems.” P1547.4 is a standard intended to develop recommendations and best practices of systems that include “the ability to separate from and reconnect to part of the area EPS while providing power to the islanded local EPSs.” This standard is presently in the development stage. The meeting of this working group was held concurrently with that of 1547.6 in Atlanta, in February and also in Las Vegas this month. While this standard does not relate directly to concerns of DG on secondary networks it does deal with some of the “ride-through” issues and concerns articulated in the MTC DG Collaborative workshops. Ben Kroposki of NREL is the chair of this working group and Tom Basso is the secretary.