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STATUS OF THE IEEE P1547 DRAFT INTERCONNECTION STANDARD AND DISTRIBUTED ENERGY RESOURCES R&D

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ABSTRACT

The Department of Energy (DOE) Distributed Power Program (DPP) is conducting work to complete, validate in the field, and support the development of a national interconnection standard for distributed energy resources (DER), and to address the institutional and regulatory barriers slowing the commercial adoption of DER systems. This work includes support for the IEEE standards, including P1547 Standard for Interconnecting Distributed Resources with Electric Power Systems, P1589 Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, and the P1608 Application Guide. Work is also in progress on system integration research and development (R&D) on the interface and control of DER with local energy systems. Additional efforts are supporting high-reliability power for industry, evaluating innovative concepts for DER applications, and exploring plug-and-play interface and control technologies for intelligent autonomous interconnection systems. This paper summarizes (1) the current status of the IEEE interconnection standards and application guides in support of DER, and (2) the R&D in progress at the National Renewable Energy Laboratory (NREL) for interconnection and system integration and application of distributed energy resources.

INTRODUCTION

Interest in using distributed power and storage has increased because of the potential to provide increased reliability, lower costs, and other benefits. The deregulation of the electric power industry, development of small modular generation technologies, increased gas and electric prices, coupled with recent energy shortages, have intensified interest in distributed power. The power industry estimates that distributed power will account for up to 20% of new generation by 2010. The National Energy Policy recognizes the importance of distributed power and includes it in future energy goals.[1]

Distributed energy resources and storage can bring many benefits. But the technologies and the operational capabilities to integrate them properly into the power distribution system must be developed to realize these benefits and avoid negative impacts on power distribution system reliability and safety. The current power distribution system was not designed to accommodate active generation and storage at the distribution level, particularly to supply energy to other customers. Technical issues to allow this type of operation are significant. Electricity regulation, zoning and permitting processes, and other business practices have also been determined without considering the new and developing energy production and storage approaches.

NREL is conducting activities in distributed power systems integration in support of the DOE Distributed Power Program, in collaboration with industry and other national laboratories. NREL is working to develop standards and codes that address safety, reliability, power quality, and interconnection issues. The work also includes research on advanced interconnection systems, including hardware and software for DER interconnected with electric power systems. And NREL is working with industry, state, and local government organizations to eliminate unnecessary barriers to the use of DER. Finally, a DER Test Facility was established at NREL. The progress of this work, including subcontracted research, is presented below under four interrelated headings. The NREL DER Test Facility capabilities and plans are also described. Updated information is also available on the Distributed Energy Resources and Distributed Power Program (DPP) Web sites.[2, 3]

OVERVIEW OF PROGRESS

Interconnection engineering, standards, and system integration testing

Interconnection engineering is key for DER systems integration, which pertains to both the local power system and the utility electric power system. NREL is supporting development of standards and codes, as well as tests that address safety, reliability, power quality, and interconnection issues related to integrating DER with power systems.

The NREL DPP staff members lead IEEE work groups developing standards related to the interconnection of DER to electric power systems. The first of these standards is IEEE P1547, Standard for Interconnecting Distributed Resources with Electric Power Systems. This standard establishes the universal technical requirements for the interconnection of DER with electric power

systems. The technical requirements of the standard fall into the following categories: general requirements, response to area EPS abnormal conditions, power quality, and islanding. The most recent information about the standard is available at the IEEE Web site.[4]

Work has also begun on the related IEEE P1589 standard, entitled Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems. The scope of this standard covers the type, production, and commissioning tests that shall be performed to demonstrate that interconnection functions and equipment of a distributed resource conform to IEEE standard 1547. A separate work group is developing the IEEE P1608 Application Guide, which provides technical background and application details pertinent to IEEE P1547. These details are: network interconnection, monitoring and control; grid/distributed generation impacts determination; and islanding and anti-islanding. Two additional IEEE guides are under consideration–one to address monitoring, information exchange, and control of DER; and the other to address interconnection equipment certification and laboratory accreditation for DER.

Several subcontracts are in progress to assess and resolve interconnection engineering issues. DTE Energy Technologies is determining distributed power and electric power system aggregation models and field configuration equivalency validation testing by studying distributed resources interconnected with the Detroit Edison Electric Company utility grid.

Safety is also an issue for interconnection, and Underwriters Laboratories Inc. (UL) is subcontracted to complete a UL standard for safety for distributed generation. They have completed a survey of the current status of applicable standards and codes and are now working to produce a completed standard. UL will then select test equipment to conduct tests of distributed generation. Finally, UL will validate test facilities for conducting the UL safety tests and conduct witness testing of interconnection configurations.

Additionally, the EPRI PEAC Corporation is developing a pilot effort for equipment certification and laboratory accreditation. The subcontract approach promotes industry-wide acceptance by creating an advisory board, soliciting inputs on testing and reporting procedures, and providing standard test protocols that describe rationale and expected results.

An ongoing activity is the field validation of test procedures from IEEE P1547 at the Nevada Test Site (NTS). NREL is coordinating efforts to facilitate the NTS demonstration project with INEEL, DOE/NV, and Bechtel/NV. NREL defined—and in November 2001, led—testing at the site to validate an interconnection and commissioning test in conjunction with the IEEE P1547 Standard. Testing was conducted on two types of distributed power sources: a 100-kW diesel generator with paralleling control package and one static inverter connected to a photovoltaic system.[5]

Other work related to the NTS is a subcontract with Distributed Utility Associates. They have completed the planning, siting, and design for a Distributed Utility Integration Test in California and developed a long-term test plan at the NTS.[6] This work is designed to meet NREL/DOE needs for interconnection systems integration activities, including determining information relevant to the IEEE SCC21 P1547 interconnection standard.

Interconnection systems and control technologies

Several companies are conducting research on advanced interconnection systems and control technologies, including both hardware and software. General Electric Corporate Research and Development (GE) has conducted analyses and is developing requirements for a distributed power/electric power system interconnection interface. Their work includes determining the (1) impact of the connection to the utility network on the design of power electronics, and (2) impact to the utility network of increased DER penetration relative to existing network hardware.[7]

Another subcontractor, Gas Research Institute (GRI) through its lower-tier subcontractor Encorp, Inc., is conducting research and testing on interconnection systems and communications focusing on key enabling technologies and features incorporated in a system-level integrated solution. Encorp Inc. is developing cost-effective plug-and-play DER grid interconnection products, software, and communication solutions, applicable to improving the economics of a broad range of distributed power systems. A final subcontractor in this category is Orion Engineering Corp. This firm is applying the principles of integrated neural networks to develop a household controller module. Their approach is to develop an option for aggregating a community of small distributed generators into a virtual single large generator to provide power.

Energy management and grid support applications

Several companies are working under subcontract to address the management, analysis, and monitoring of integrated distributed generation systems and grid support applications. New York State Energy Research and Development Authority (NYSERDA) and its lower-tier subcontractor Electrotek are developing backup generator connection and control, as well as the monitoring and communications needed for back-up power units.

NiSource Energy Technologies, Inc., is working to evaluate distributed generator technologies for subsidiary utilities to identify the system integration and implementation issues for distributed generation, and to develop and test potential solutions to these issues to determine solutions for a range of power users, from small industry to residences. Another participant in this category is the National Rural Electric Association, which is evaluating residential fuel cells as an option for rural electricity users.

Another subcontractor, RealEnergy LLC, has developed, installed, and is testing systems to manage DER for commercial applications from the perspective of the distributed energy generator. Their requirements include the automated configuration, metering, alarming, scheduling, and control of distributed energy resource technologies in commercial building applications interconnected to the grid. The University of Wisconsin is conducting subcontracted R&D to establish testing equipment and approaches to address the application of DER for sensitive loads. Finally, EPRI PEAC recently completed work to explore the potential benefits of a distributed power system capability as a fast-response, load-matching system based on a fuel-cell/capacitor hybrid system.

Regulatory and institutional issues

Current utility use tariff and rate designs generally do not price distribution services to account for system benefits that could be provided by distributed generation. In addition, zoning, air permitting, water use permits, comprehensive environmental plan approval, and other regulatory processes can both delay and increase the costs of distributed power projects. These issues typically relate to site-specific concerns. Distributed power technologies are not covered in national building, electrical, and safety codes. In addition, existing business practice and business models often reflect the old regulated electricity industry dominated by vertically integrated utilities and central-station power plants. New business models are needed to capture the full economic values of DER.

Work is in progress to address this range of issues. A recent study reviewed the experiences of distributed energy resources with interconnection. Based on these experiences, certain barriers to interconnection were identified, and the authors developed a list of recommendations to resolve some of the issues.[8] Also under this topic, the Regulatory Assistance Project (RAP) was subcontracted to pursue several issues relating to DER. Four reports review system cost methodologies, DER distribution credit programs, DER in wholesale markets, and the DER impact on electric system reliability.[9,10,11,12] NREL and Energy and Environmental Analysis, Inc., are also completing a report investigating the air-quality permitting barriers to increased commercialization of distributed generation technologies.

NREL DER Test Facility

As summarized above, the Distributed Power Program performs R&D to enable manufacturers, developers, owners, and others to address the difficult system integration issues for DER. To support this effort, the Distributed Power Program established the NREL DER Test Facility. Currently, distributed generation equipment up to 150 kW can be tested in stand-alone and interconnected configurations with a wide range of distributed technologies, including microturbines, wind turbines, photovoltaics, diesel generators, and energy storage. Plans are in progress for a testing capability up to 1 MW with additional distributed technologies. At this facility, scientists and engineers will be able to: (1) characterize, test, and evaluate the performance of interconnection systems to ensure that they operate properly and meet the interconnection, communication, and other standards; (2) develop protocols and procedures for testing and evaluating systems to ensure that they meet performance, safety, and compatibility standards; (3) test advanced designs for grid-connected or stand-alone use, microgrids, and hybrid systems; and (4) coordinate laboratory and industry testing activities, in particular by defining and providing standard testing and evaluation procedures.

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