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Distributed Generation MONITOR

US Armed Forces Embrace DG

The U.S Military has long been an important source of funding for new technologies. It has become increasingly apparent that military largess may have important consequences for the development of the DG industry. The military already has a great deal of DG in place to provide backup power, remote power and in many other applications, but has expressed interest in and provided support for new DG development and the improvement of existing DG technologies. The military is targeting important development issues such as:

- Fuel flexibility. For security and logistical reasons, military power supply systems must able to operate using military standardized logistics fuels. Flexibility will also make DG technologies amenable to remote and developing country applications without access to fuel infrastructures.
- High efficiency, low emissions and noise levels are critical for DG applications across the board.
- High quality power. This issue is especially important for premium power and security applications.

Military interest in DG technologies is strategic as well as environmental and economic. Some technology applications under scrutiny include:

Stationary Power Applications. Stationary applications are located at fixed facilities and can either be grid connected or stand-alone. The military has encouraged technologies that increase energy efficiency, reduce environmental impacts, meet increasing energy demands, and reduce logistical burdens. Applications of particular interest are combined heat and power generation (cogeneration) and premium power generation. The Department of Defense (DOD) is the largest single owner of district heating systems in the United States, and is a huge potential market for DG cogeneration applications for base

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DG Monitor Takes the Pulse of the DG Market

From July 2001 through the end of the year, the Resource Dynamics Corporation asked visitors to www.distributed-generation.com to participate in a short survey of their interest in DG. In the October/November 2001 edition of DG Monitor, qualitative results from this survey were summarized. Some quantitative results are now reviewed.

As expected, most respondents (who were both surfing for DG information and were willing to spend a couple of minutes to share their perspective) are strongly interested in DG issues. A minority described their interest as moderate, only interested if DG economics improve further, or having limited further interest in the topic. This degree

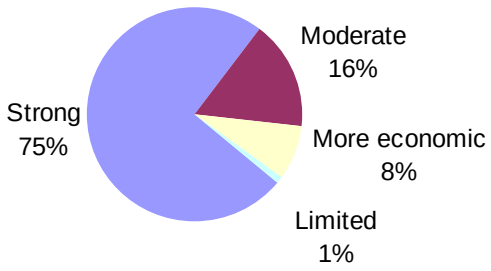

Figure 1: Interest in DG Issues

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RESOURCE DYNAMICS CORPORATION

To view earlier editions of the DG Monitor or to begin receiving the publication via email please visit: www.distributed-generation.com.

About the DG Monitor The DG Monitor is a bi-monthly publication of the Resource Dynamics Corporation covering the many facets of the emerging Distributed Generation marketplace. Articles both report and interpret the most important items. In addition, the Monitor includes special series on DG technologies, applications, manufacturers, and issues providing the reader with a complete picture of these topics over several issues.

Comments or requests for additional information can be addressed to DGMonitor@rdcnet.com, through our website at www.distributed-generation.com, or by contacting Jean Connors at 703/356-1300 x 208.

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Distributed Energy Resources Conference

The Office of Power Technologies at the U.S. Department of Energy sponsored a conference in late November, entitled "Distributed Energy Resources – the Power to Choose: Creating an Expanded DR Industry." This meeting was held November 28th through 30th in Washington, D.C. and was attended by over 200 participants. This conference represented the major public debut of the relatively new Office of Distributed Energy Resources, created by DOE in November 2000 with the mission to develop and integrate distributed generation and combined heat and power technologies and to address regulatory and institutional barriers to DG commercialization.

The major purpose of this conference was to share with the public and a wide range of stakeholders the goals of the Distributed Energy Resource program and to gain the advice and counsel of an esteemed group of peer reviewers, especially invited to attend the meeting. The first day of the conference explored the foundation for a distributed energy resource (DER) goal, and Paul Lemar of the Resource Dynamics Corporation estimated current DER capacity at around 22 gigawatts. This figure did not include backup units, which, if included, would add about another 18 gigawatts to the total existing installed base today. Throughout the second and third day of the conference, a wide range of presenters reviewed DOE-funded DER activity focusing on technology development (gas turbines, fuel cells, reciprocating engines, etc.), technologies and tax assistance for buildings, combined heat and power and industrial distributed generation, and transmission and distribution along with potential DER contributions to energy reliability.

Presentations and a conference summary are available on-line at www.eren.doe.gov/der/conference_01.html

RDC's DG Information Source: Number One

According to the search engine Direct Hit, Resource Dynamic Corporation's www.distributed-generation.com is the most frequently selected website about "distributed generation". A key resource within this website is a library of DG presentations, publications and reports covering DG technologies, applications, markets and regulations, and previous editions of the DG Monitor. The library is accessed by dozens of users each day, and some presentations have been downloaded thousands of times. Check in regularly for library updates, pass on the address to others looking for timely DG information, and thanks for making us number one!

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and operation usage. Premium power is increasingly important to ensure the security of military high-security facilities, communications and data centers, manufacturing process facilities, radar sites, and research and testing facilities.

Mobile Power Applications. Mobile power applications include land-based, marine, and aeronautical vehicular propulsion systems. Fuel cells are being examined for each of these applications. The Army's Tank Automotive Command (TACOM) National Automotive Center (NAC) is investigating using fuel cells to replace existing diesel engine systems in military land-based vehicles. Fuel cells are quiet, have low infrared signatures, and can help increase the range and enhance the stealth of these vehicles. The Navy is also examining fuel cells to provide power aboard ship or for propulsion systems. However, fuel cells must be adapted greatly to compensate for the extreme conditions of the marine environment.

Other Power Applications. The U.S. military has recently increased its emphasis on rapid response and "light, lean and lethal" force deployments. The military must be able to deploy forces quickly and then support both air and land operations anywhere around the world for undetermined periods of time. Currently, portable generators are widely used in U.S. military operations around the globe. Advanced DG technologies are being examined to reduce waste, weight and noise, and decrease maintenance requirements. The military's Soldier Systems Center (Natick Labs) is looking into small-scale Engine-Driven, Thermophotovoltaic (TPV), and Fuel Cell cogeneration to reduce the use of traditional electric generators. The Air Force is also looking at fuel cell technology to replace generators used for base and Air Expeditionary Force operations.

The mobile, flexible, rapid deployment military strategy has implications for the individual soldier as well. The DOD's Defense Advanced Research Projects Agency (DARPA) is developing planar solid oxide fuel cells (SOFC), TPV, and small turbine engines in the 300-500 W range for distributed power generation. These units can provide power to a soldier or group of soldiers. Fuel cells can potentially be used to power communication equipment, sensor suites, battery chargers, and to reduce the weight each soldier must carry. Their modular design means they can be used for a range of applications from portable units to large electric generators.

Current R&D Activities. In general the military, in their efforts to advance DG technologies, has relied on the private sector, funding demonstration projects and R&D efforts. Fuel cells have received a great deal of this attention through programs like the DOD's Fuel Cell Test and Evaluation Center (FCTEC), whose primary goal is to accelerate the development and commercialization of fuel cell power plants. Their Demonstration Program resulted in 30 fuel cell installations between 1994 and 1997 across the Nation.

In the last few months alone:
- With a grant from the U.S. Army Corps of Engineers, DCH Technology will provide three proton exchange membrane (PEM) fuel cells to Brooks Air Force Base in San Antonio, Texas and install a 3 kW DCH Enable(TM) fuel cells at the Ft. Jackson, South Carolina Army post. Both installations will power facilities on base and be connected to the grid.
- FuelCell Energy and PPL Spectrum will supply and install a 250-kW Direct FuelCell power plant for the U.S. Coast Guard Air Station Cape Cod in Massachusetts. It will provide electricity to the station and supply hot water for use in the air station's barracks.
- The U.S. Army awarded a $2.9 million contract to Pittsburgh Electric Engine, Inc. to develop a fuel cell engine combining turbine and fuel cell technologies.
- Proton Energy Systems was awarded $6.2 million by the Naval Research Laboratory to apply PEM fuel cell technology to space propulsion and energy systems.
- Hydrogenics Corp contracted with the U.S. Army for a self-contained regenerative fuel cell system for auxiliary power deployment and to provide power to digital equipment and extended silent watch requirements.
- University of Pennsylvania researchers received $1.8 million from the U.S. Army and DARPA to develop a coffee-can-sized fuel cell capable of generating power equivalent to 50 D-cell batteries.
- The U.S. Army signed Mechanical Technology Inc. and Alliant Techsystems to explore military applications for direct methanol fuel cells (DMFC) in their Objective Combat Weapon program.
- Interest in fuel cells is not limited to the US Military. Defence R&D Canada will examine Energy Visions Inc.'s DMFC technology for use in military applications. Hydrogenics Corporation was awarded a contract to develop its chemical hydride-fueled portable fuel cell.

These and other new and ongoing military projects will have important implications for the development and commercialization of DG technologies and for those in the DG industry.

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of interest shades the results such that figures like willingness to pay a price premium for benefits are likely high estimates.

Nonetheless, the data provide interesting anecdotal information about DG user interests. Most respondents came from companies, not government or regulatory agencies, with a limited number of potential individual DG users. Thus the results can help reflect what the DG industry is thinking.

Each person was encouraged to note all technologies of interest, so a summation of the results far exceeds 100 percent. Fuel cells and microturbines polled the largest interest (over 50%), followed by solar, traditional reciprocating engines, and wind (each over 40%). Small hydropower, hybrid fuel cells/gas turbines and small combustion turbines received the least enthusiastic response (still over 20%), possibly because respondents are less familiar with these technologies. The three most common responses were people a) only interested in reciprocating engines, b) only interested in renewable technologies, or c) interested in a wide range of DG technologies. Based on survey comments, any DG technology that can economically compete with grid-based power is much more likely to be embraced by users.

Similarly, Figure 2 indicates the percent of respondents who expressed an interest in various applications of DG. Again multiple selections were encouraged. The four applications of most interest were cogeneration, selling excess power generation back to the grid, generating power continuously, and peak shaving. The remaining six applications polled less interest and were often aligned with specific technologies, e.g. those interested in renewable technologies generally planned to use DG for green power, residential applications or remote power. Respondents seeking power reliability normally were also interested in power quality.

Most DG users plan to finance their DG units. This financing may come from traditional lending institutions (27%) or via self finance (42%). Alternatively, about one-eighth expect to lease their DG equipment and about one-fifth expect to partner with a third party who will own and finance the equipment with them. Thus there appears to be significant development room for both traditional finance companies and energy companies who wish to own and lease equipment to DG users.

Respondents (see Figure 3) were willing to pay widely varying premiums for potential DG benefits. The survey measured the percent of capital cost (or cents/kWh) that people were willing to pay for environmental benefits, power reliability and quality, and security benefits. While about one-third were unwilling to pay any premium, many are willing to pay an extra 4 percent or higher premium price. Individual respondents often indicated a willingness to pay significantly different amounts for each of these three types of benefits; it is only the aggregate picture that appears similar. Benefits were correlated with technologies and applications of interest. In any event, it is clear that DG can be mareketed for its benefits.

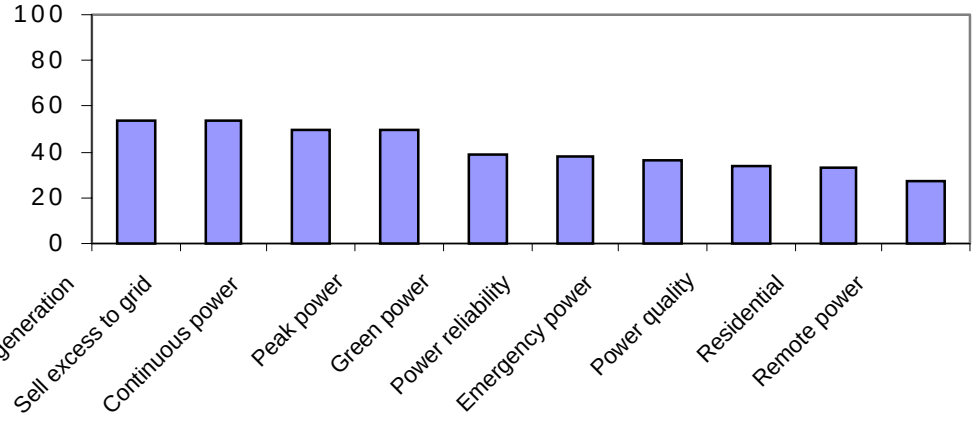

Figure 2: DG Application Interest

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The survey is ongoing, and we plan to periodically evaluate the information to establish trends. To participate in or to view the survey, please go to www.distributed-generation.com/survey.htm.

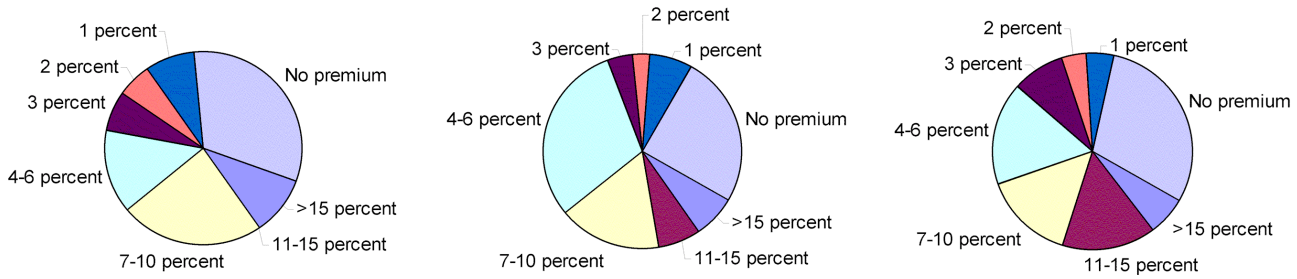

Figure 3: Premium Payment Willingness

RDC DG News

Presentations

"DG Interconnection: Will the 'Black Box' Technology Get the Job Done?" - N. Richard Friedman, at Distributed Generation and On-Site Power, GESI, Atlanta, GA, Mar. 11-13, 2002.

"The Application Guide for Distributed Generation Interconnection. The NRECA Guide to IEEE 1547." - N. Richard Friedman, at 2002 IEEE Rural Electric Power Conference, Rural Electric Power Committee, Colorado Springs, CO, Mar. 5-7, 2002.

"DR Cost Impacts on T&D Systems." - N. Richard Friedman, and a presentation by Paul L. Lemar, Jr. at EPRI's VIIth Distributed Resources Conference and Exhibition, EPRI, Dallas, TX, Mar. 17-21, 2002.

"New Technologies in Generating Electricity and the New Markets they are Creating" – Paul L. Lemar, Jr., at Cyberposium 2002, Harvard Business School, Boston, MA, Feb. 8-10, 2002.

Reports

Resource Dynamics Corporation recently completed a study for the Maine Public Utilities Commission (PUC) called the *Assessment of Distributed Generation Applications*.

This report provides a comprehensive assessment of the strengths and weaknesses of commercial and near-commercial DG technologies in the 5 kW to 5 MW size range. The technologies profiled are reciprocating engines, microturbines, industrial combustion turbines, phosphoric acid and proton exchange membrane fuel cells, photovoltaics, and wind turbine systems. The report examined history and current status, operation, emission control technologies, potential applications, and representative manufacturers for each DG technology.

The report also examines the different applications for DG including Continuous Power; Combined Heat and Power (CHP); Peaking Power; Green Power; Premium Power; Transmission and Distribution Deferral; and Ancillary Service Power. Results from the RDC report were used in the Maine Public Utilities Commission Final Report on Distributed Generation to the Maine Legislature. RDC also provided other DG consulting services to the PUC, including hosting numerous question and answer sessions.

The report is available on-line at: www.state.me.us/mpuc/Electric%20Supplier/dg.htm

DG Notes

Jan 23, 2002 - Mauna Lani Resort dedicated a 250 kW photovoltaic PowerTracker(TM) system that includes a tracker that follows the sun and a data acquisition and monitoring and control system. With this PV system, manufactured and installed by **PowerLight Corporation** of California, Mauna Lani now has the most solar electric generating capacity of any resort in the world- 1/2 MW. The resort projects energy savings of $5 million over the next 25 years.

Jan 17, 2002 - Fuel cell and hydrogen sensor manufacturer **DCH Technology, Inc.** outlined its 2002 business strategy. Top priorities include solidifying their financial position, increasing fuel cell sales with a focus on the earliest fuel cell adopter markets, decreasing the cost of their reformer-based fuel cells systems, and expanding and leveraging strategic business relationships. They also plan to launch their next generation of hydrogen RHS-FET sensors, capable of detecting 50 parts per million of hydrogen.

Jan 8, 2002 - **DTE Energy Technologies'** energy|now(TM) System Operations Center (SOC) offers commercial and industrial customers a way to optimize their distributed generation based on their energy needs. The center includes **Silicon Energy's** EEM Suite Distributed Energy Manager (DEM) software platform for monitoring and control capabilities.

Dec 26, 2001- **FuelCell Energy, Inc.** and **The Marubeni Corporation** will site the first Direct FuelCell® power plant in Asia at Japan's Kirin Brewery Co. The 250 kW DFC® unit will be operated in cogeneration mode, using a digester gas produced from Kirin's brewery process effluent.

Dec 19, 2001 - **UTC Fuel Cells** sold eight 200 kW PC25(TM) fuel cell power plants to the New York Power Authority to produce power for four wastewater treatment plants in New York City. With the addition of these eight units, a total of 17 PC25 power plants will supply electricity for New York City area facilities.

Dec 19, 2001 - A 60-kW unit **Capstone** microturbine unit, previously used at the Oak Ridge National Laboratory, was delivered to the University of Maryland, College Park to replace a 75-kW Honeywell unit at the University's integrated energy systems test facility.

Dec 13, 2001 - Many mid-sized commercial and industrial **Xcel Energy** customers own backup generators that they seldom use. Xcel signed a contract with **Celerity Energy** of Portland, Ore., for up to 5 MW of electricity from this group. Celerity will convert diesel units to mixed-fuel generators, take over generator maintenance, and equip generators to be remotely operated simultaneously as one unit, serving both customers' electricity needs and sending excess electricity to Xcel's system during peak periods if needed.

Dec 13, 2001 - In response to steadily increasing demand, PowerLight Corporation has begun round-the-clock manufacturing of PowerGuard® solar electric roof tiles, and by the first quarter 2002, will have completed equipment upgrades to increase its manufacturing capacity to 20 MW per year.

Dec 11, 2001 - **Ingersoll-Rand's** Energy Systems business unit is taking commercial orders for its PowerWorks™ microturbine. The 70-kW systems have cogeneration capabilities, are designed to operate for 8,000 consecutive hours without maintenance, and produce less than 9ppm of NO_X. IR is also developing microturbine systems that range in sizes up to 250-kW.

Conferences

Distributed Generation and On-Site Power, Problems: Solutions, & Applications for Improving Power, Quality, Reliability & Reducing Energy Costs, 11-13 March, 2002
Atlanta, GA

2002 IEEE Rural Electric Power Conference, Rural Electric Power Committee, 5-7 March, 2002
Colorado Springs, CO

EPRI's VIIth Distributed Resources Conference and Exhibition, EPRI, 17-21 March, 2002
Dallas, TX

Cyberposium 2002, Harvard Business School,
8-10 February, 2002
Boston, MA

2nd Annual Fuel Cell Investor, Strategic Research Institute, 26-27 March 2002
New York, NY USA

DG TECHNOLOGY SERIES: GRID INTERCONNECTION

DG applications are interconnected to the grid for a reason – the DG owner may want to use the generator and the grid, sometimes simultaneously, and may also gain from selling electricity via the grid. Grid operators can increase system redundancy and security with DG interconnections. However, interconnection raises important safety, quality and economic issues both for the DG owner and the grid operator. The owner of the grid must ensure an interconnection that is safe and does not affect the grid power quality while the DG owners hopes to meet these requirements without prohibitively high costs.

For these reasons, the interconnection system is an important technological issue for DG market stakeholders. An interconnection system is the equipment that makes up the physical link between a DG unit and the local electric grid. The interconnection system is the means by which the DG unit electrically connects to the outside electrical power system and provides monitoring, control, metering, and dispatch of the DG unit.

Understanding the interconnection "black box" is important to understanding the future role of and barriers to distributed power. The integrated power electronics technology that provides the foundation of the interconnection package is advancing quickly, with functional performance available today that was not possible even one year ago. Developments in digital design and advanced processors have boosted performance to impressive levels, and a convergence of software and hardware engineering is equipping state-of-the-art digital technology to provide the protection relaying and coordination functions at lower cost and at higher reliability. Hardware companies are moving into the software business and software companies are moving into the supply of interconnection hardware. The new IEEE standard (see text box next page), combined with this advanced hardware/software, should make interconnection less of a barrier in the future.

The complexity of the interconnection system depends on the level of interaction required between the DG unit and the grid. DG units can be interconnected with the following levels of complexity:

- No interconnection,
- Isolated DG operation with automatic transfer between the DG and the grid,
- Parallel operation with grid, no power export, or
- Parallel operation with grid with power export.

Different applications of DG will require different levels of interconnection complexity. The table below shows major DG applications and possible interface configurations.

In addition, some interconnection systems are remotely dispatchable, which adds another level of complexity. Figure 4 shows an interconnection system that is dispatchable with parallel operation to the grid with power export. All of the components within the dotted line are part of the interconnection system.

Table 1: DG Application Interface Configuratiaons

	No Interconnection	Isolated DG Operation With Automatic Transfer To Grid	Parallel Operation To Grid	
			No Power Export	Power Export
Baseload	✓	✓	✓	✓
Cogeneration	✓	✓	✓	✓
Peak Shaving		✓	✓	✓
Emergency/Backup	✓	✓	✓	✓
Premium	✓		✓	✓
Remote	✓			

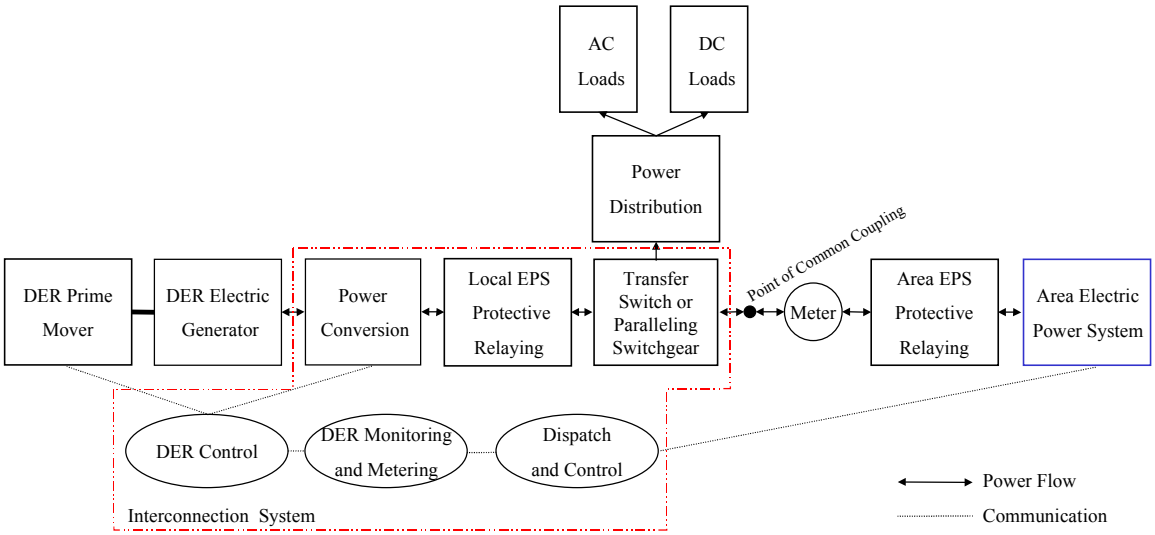

Figure 4: Interconnection System

Each device in the interconnection system is described below:

Power Conversion Subsystem
A device that accepts power from the electric generator (or non-rotating prime mover) and converts it to clean AC power at the required voltage. If the electric generator (or non-rotating prime mover) supplies DC power or very high-frequency AC power, an **Inverter**, or an electronic device used to convert DC into AC, is required. If the electric generator supplies AC power, sometimes a **Transformer**, an electronic device used to convert AC from one voltage to another and/or provide isolation, is required.

DG Control
A device that manages the DG unit and can provide a person/machine interface, a communications interface, power management, monitoring and metering.

Local Protective Relaying
Electrical devices designed to interpret input conditions (which reflect the operation of another piece of equipment) in a prescribed manner, and, after specified conditions are met, to respond by controlling equipment operation to protect an electrical circuit.

Transfer Switch
An **Automatic Transfer Switch** is a self-acting equipment for transferring one or more load conductor connections from one power source to another. A **Static Transfer Switch** is a self-acting solid-state equipment for rapidly transferring one or more load conductor connections from one power source to another.

Paralleling Switchgear
A device that parallels and synchronizes the DG (or multiple DG units) operation with the grid. The objective of paralleling switchgear the ability to seamlessly switch between the DG and the grid, or use both at once. Many utility interconnection guidelines state for DG to be considered parallel, it must operate in parallel for more than 60 cycles.

DG Monitoring and Metering
A device which monitors and meters various functions supplied by the through an interface with the DG control.

Dispatch and Control
Devices and communication equipment that can interface to DG and manage them.

Interconnection Standards

Interconnection standards have been cited as one of the main barriers to the implementation of DG. The Institute of Electrical and Electronics Engineers (IEEE) has been developing the **Standard for Distributed Resources Interconnected with Electric Power Systems**, IEEE 1547, over the past 2 years. The work is nearing completion and has brought together a wide range of stakeholders interested in accelerated implementation of distributed generation (DG). To support this standard, it is necessary to have hardware and software that allows interconnections to occur smoothly, safely and economically.