Distributed Generation Impact on Distribution Automation Planning and Implementation

George V. Fantozzi
S&C Electric Company
Chicago, IL

Presented at the panel session on
"Distributed Generation: The Challenges of Value, Standardization, Protection, and Data Management"

DistribuTECH® 2000
Conference & Exhibition
Miami Beach, FL March 1, 2000

Introduction

Fuel cells, wind turbines, gas turbines big and small, diesel engines, batteries, photovoltaic arrays, and other types of energy sources will, at some time, become an indispensable part of the landscape of our electric distribution system, alongside ever-more ubiquitous distribution automation systems. Distributed generation (DG) will become an ever-more important tool, enabling distribution service companies of the future to meet customers' power needs. Proponents of DG further suggest that it will enable utilities to expand into new markets, minimize investment in existing infrastructure, increase flexibility, increase reliability and power quality, optimize asset utilization, and reduce the overall cost of providing power to end users. From the end user's perspective, DG offers opportunities for cogeneration to reduce overall power cost, to provide backup and standby power for increased reliability and improved power quality as well as peak shaving, and a means for exporting power into the utility's distribution system.

Standards for interconnection of DG units to existing utility networks are currently being drafted by the IEEE. The P1547 Working Group of the IEEE's SC221 Standards Coordinating Committee is currently in the process of drafting a document titled, "Standard for Interconnecting Distributed Resources with Electric Power Systems." Efforts are well underway for completion of this standard by March 2001. In many cases, local utility commissions are in the process of establishing guidelines for the safe and economic deployment of DG.

Today's distribution systems and their associated operating systems would have trouble coping with a sudden flood of DG. Distributed generation will ultimately put new challenges in the path of utility engineers and their quest to run an efficient, safe, and effective electric system.

Challenges introduced by distributed generation

The challenges introduced by DG cover a broad spectrum, ranging from technical to business-related issues. The following discussion highlights some of these challenges.

System stability and regulation

DG must be managed effectively to ensure that power is dispatched to the distribution system in a controlled manner to maintain system stability and acceptable voltage regulation. Utility planners have been dealing with the scheduling of large generation plants for many years — but there are relatively few large plants compared to the large numbers of distributed generation systems that will someday appear. This means that utilities must utilize computerized, automated systems to control the DGs, many of which will be feeding power into the distribution system.

Protection and coordination

On the protection end of things, DG upsets the traditional applecart. Traditionally, power flowed in one direction — from the source (the big generators) to the load (our homes and businesses). In the future, currents will routinely flow in indeterminate directions depending on the size, placement and operational status of multiple power sources — the DG units. The magnitude of currents available from DG units will vary according to their capacity. All of this will present a tremendous challenge in protecting the distribution system from intermittent faults affecting its safe and reliable operation. In order to meet these particular challenges, protection engineers will need accurate information on DG dispatch and what the contribution to system fault currents will be at any given point in time to ensure that equipment is properly rated and that coordination between protective devices is maintained. More computing power and better ways to present and track the multitude of data points will be crucial to ensure that systems run effectively.

Operation and control

Clever new controls to ensure a proper interface between the DGs and the electric utility system will be essential if DG is to be used efficiently and safely. Such controls will need to communicate with the utility to provide the information described above. Most importantly, they must be fast and smart to ensure the system runs safely — enabling local interruption of the DG power to the utility system based on constantly updated system parameters. Due to the propagation speed of disturbances and the sophistication of protection issues imposed by variable sources of supply, an "expert system" composed of autonomous intelligent controls in high-speed communication with each other will, in all likelihood, be the logical platform to address this level of technological complexity.

Energy management and planning

DG will affect many of the energy-management and planning functions in today's utility structures. Such functions will be affected by the location and availability of DG units, combined with the reduction in losses brought about by the application of these resources. Expected advantages of DG, including optimization of equipment and deferment of capital expenditures, will influence long-term planning decisions. The availability of effective energy- management systems with advanced data acquisition and control functions, planning tools, and business models which take into account the effects of DG, will allow utility executives and planners to make decisions needed to succeed in the competitive power delivery market.

In short, the advent of widespread distributed generation units will require a new way of thinking for utility system engineers, planners, marketers, and business executives.

Impact on distribution automation planning and implementation

The expected growth in DG will significantly affect the operation and control of today's distribution system. It is expected that the requirements for safe and effective operation and control of the distribution system with DG will provide an even-better business justification for distribution automation (DA). The following discussion highlights some of the areas of DA that will be impacted by DG.

Increase in number of IEDs and RTUs

The single most significant impact of DG on DA is the expected increase in the number of intelligent electronic devices (IEDs) and remote terminal units (RTUs) associated with the operation and control of DG units and their interconnection with the distribution system[1]. A large number of IEDs and RTUs will be required to interface effectively with the rest of the DA system to effect proper operation and control, providing such functions as protection, auto-sectionalizing, capacitor switching and voltage regulation, automated meter reading, and load control.

In their "1999 Interconnection Guidelines for Distributed Generation in Texas," the Texas Public Utility Commission specifies the use of an isolating device to isolate the source of generation from the utility system. Such devices must be able to be controlled on-site and may have the capability for remote control. The IEDs and/or RTUs associated with this requirement (as well as other interconnection requirements) form the basis for the growth expected in the number of these devices.

More sophisticated IEDs and RTUs

More sophisticated IEDs and RTUs — with the ability to enable real-time reconfiguration of protective relay settings, capacitor controls, etc. — may be required to enable proper and safe operation of the distribution system. IEDs and RTUs with "smart" onboard controls will be required to enable local interruption of DG units based on constantly updated distribution system parameters. Furthermore, demands for additional Distribution System Management (DSM) features may contribute further to the need for more sophisticated IEDs and RTUs.

Relay manufacturers today offer multifunctional relays with communication features to provide DG interconnect protection as well as unit protection features, including time-overcurrent, overload, undervoltage and overvoltage, and over- and under-frequency protection. Communication ports typically provide RS-232, RS-485, or fiber-optic connections. More development of these relays will be needed to meet the requirements mentioned above.

Increased integration of IEDs into equipment

DA equipment suppliers and integrators will have to develop innovative interface, control, and automation systems to account for the unique system conditions created by DG. The integration of IEDs into equipment may be further driven by the demands for improved DSM. A good example of such integration is the power meter offered by Siemens. This device

---

[1] Based on the expected increase in number of applications due to reduction in cost of DG technologies. For example, over the last decade, production of thin-film photovoltaic cells has increased more than 300 percent, and more efficient motors and new lightweight materials have reduced costs for wind turbines by 90 percent ["Unleashing Innovation in Electricity Generation," by Dick Munson and Tina Kaarsberg published in "Issues in Science and Technology" by the National Academy of Sciences, Spring 1998].

includes a billing meter, revenue meter, power quality analyzer, IED, mechanical loss compensator, transducer, and a small RTU. The same integration trend is demonstrated by the multifunctional relays discussed in the previous section; in addition to the protection and communication features, these devices offer "plug and play" capability, intuitive software for configuration and programming, extensive diagnostics and monitoring functions, GPS time synchronization, and PLC automation or programming capability.

Increased data-handling capabilities

The more widespread use of sophisticated microprocessor-based IEDs on distribution systems will require increased data-handling capabilities by RTUs, PLCs, controllers, and the backbone communication system.

In the substation automation environment, the need for increased data handling is being addressed through the use of distributed processing. This design is based on the philosophy that data capture and processing should occur as close as possible to the source. The distributed processing unit (also referred to as a "cell" or "bay") contains an IED responsible for the control and monitoring of its primary equipment and communicates back to the substation controller via serial connection or LAN. The same concept could be implemented in DG applications where distributed processing units may be called upon to handle local control and monitoring in areas where a large number of DG units are employed.

More wideband-based communications

The increase in available data from IEDs and RTUs, coupled with the large increase in the number of IEDs and RTUs, will drive the installation of high-bandwidth communications technologies, including radio, fiber-optic cable, and satellite. Furthermore, data-compression techniques may be streamlined to increase data handling capability.

A high-capacity fiber-optic network has recently been installed at Foote Creek Rim, a new "green power" project consisting of 69 wind-turbine units. Each of these units has the capacity to generate 600 kW of energy, for a total capacity of more than 40 MW. Each of the turbines has a controller at the base of its tower, which controls all aspects of the turbine's operation and also performs the functions of an RTU, providing important operating parameters to a SCADA master computer in a 34.5/230-kV substation. The SCADA system enables operation and maintenance personnel to monitor wind and generation conditions from an off-site facility. The fiber network consists of a self-healing redundant main loop and two sub-loops. Four virtual fiber channels are available but only two are used, allowing for future expansion.

Increased complexity in communication protocols

The increase in the sophistication of IEDs and RTUs and corresponding data-handling issues will undoubtedly lead to the development of even more communication protocols. Protocols for improved data management, peer-to-peer communications, and increased transmission rates are expected to evolve.

The latest version of the Utility Communications Architecture (UCA Version 2) is reported to include Internet compatibility and a common interface standard for electric, gas, and water utility systems. It is also expected to provide an integrated, open system for real-time information exchange among all major utility data communication systems. There is plenty of room for more standardization in protocol usage, open architecture design, and translation.

Increased complexity in managing data

The large increase in the volume of data and different types of IEDs and RTUs driven by DG and improved DSM will result in increased complexity in data management. This will necessitate more powerful and diverse device interfaces, gateways, and data-management software.

Increased complexity in operation and control

As a result of the increased sophistication of equipment and control possibilities with DG, distribution operation and control will become increasingly more complex. The flexibility allowed by utility control of end-user DG will help to simply things a bit, but economics will play a significant role in determining such flexibility.

The recent pilot project involving the installation of a Remote Intelligent Gateway (RIG) system from Hathaway Corporation for the two control centers of California's ISO, permitting their interfacing with generators at five plants, is a good example of a solution to a complex operational and control problem. This system provides a secure network for the transport of real-time operational and meter data from the generators, and enables the ISO to measure and control the output of the five generators as required. Before January 1999, the ISO issued its generation orders to the power plants through dispatch operators working at the three California investor-owned utilities. The equipment consists of single-bay, seismic-rated NEMA 4 cabinets filled with electronic and computer equipment.

New standards for safe and effective operation and control

Standards for DA in a system with DG are expected to evolve in order to address issues such as communication and control of DG resources, communication protocols, safety, reliability, power flow measurements, etc.

As mentioned earlier, the P1547 Working Group of the IEEE's SC221 Standards Coordinating Committee is currently in the process of drafting a document titled, "Standard for Interconnecting Distributed Resources with Electric Power Systems." Various recommendations are being formulated for interconnection of DG units to utility systems, including the guidelines of the Texas Public Utility Commission referred to earlier. The primary focus of these documents remains the establishment of clear standards and guidelines for safe and effective operation of DG in parallel with utility systems.

Conclusion

Distributed generation on a widespread basis is the latest of new challenges facing today's utility engineers, planners, marketers, and business executives in the ever-changing power delivery market. DG brings with it new challenges, including issues involving system stability and regulation, protection and coordination, operation and control, and energy management and planning.

Distributed generation will largely impact distribution automation through the expected explosion in numbers and sophistication of IEDs and RTUs associated with the operation and control of DG units and their interconnection to the distribution system. DA equipment suppliers and integrators will have to develop innovative interface, control and automation systems to account for the unique system conditions created by DG. End users will need to stay actively involved in the evolution of DG applications, standards, product development, and energy services to ensure that they derive maximum benefit from the anticipated growth in this technology. End users may need to defer to the expertise of distribution automation equipment and service suppliers for help in efficiently integrating DG into their distribution systems