Connecting the Grid to Distributed Generation

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As published in the August 2011 issue of PowerGrid International

Now that the initial smart grid hype is beginning to fade, utilities, regulators, politicians and other stakeholders are closely examining the real opportunities that smart grid solutions provide. Distributed generation (DG) represents a viable benefit area. As utility-scale and smaller renewable DG systems become more popular, cost-effective and widespread, utilities can no longer regard the installation and operation of these assets as one-off, specialized engineering efforts.

Many reasons exist for encouraging inclusion of DG assets into the distribution network, and with opportunities come challenges for providing safe and reliable power. Although the generation source may be owned and managed by a customer or third-party operator, the utility ultimately remains responsible for the overall system operation. This raises questions about interconnectivity between DG resources and the grid. The smart grid provides answers to some of those questions, and areas related to safety impacts, islanding scenarios, power quality impacts, infrastructure asset management, and system planning and operations requirements can be positively addressed with smart grid solutions.

DISTRIBUTED GENERATION REPRESENTS A PERMANENT FACTOR IN GRID OPERATIONS.

No longer should utilities view distributed generation as one-off engineering efforts. Instead, utilities should look to smart grid technologies to help address questions related to tying DG resources to the grid.

SAFETY

In the event of a fault condition, DG systems must ensure safety for utility system operations, personnel, customers and other third parties. Utilities employ a variety of protection schemes at distribution substations and on the distribution system itself —fuses, reclosers, sectionalizers, etc. — that are predominantly designed to operate in a radial power flow fashion. Although DG resources can introduce a remote source that negatively impacts standard protection scheme operations, new low cost monitoring devices help address the problem. By leveraging smart meter communications networks, private or public Wi-Fi and WiMAX solutions, or cellular telecommunications networks, smart grid devices can detect reverse power flow, abnormal operating conditions and the status of the DG resource. Smart grid communication solutions, combined with standards-based controls and monitoring devices, thus help protect operations' integrity by providing valuable system information and insight that was not previously available.

ISLANDING SCENARIOS

Because islanding scenarios typically prevent the utility from ensuring the delivery of adequate voltage and proper power frequency, utilities seek to prevent situations where a DG asset serves an isolated load and operates in an islanding capacity. Therefore, utilities need additional protection schemes to ensure prompt and reliable disconnect of DG resources. Transfer trip solutions,

which send a signal from a remote initiating device to the DG asset, have long been used to address islanding scenarios, but their dependence on dedicated high-reliability communication circuits incur high costs. The advent of smart grid networks presents reasonably priced and available communication solutions. As an example, utilities deploying service area-wide private WiMAX solutions can use this high-speed channel to support transfer trip at a fraction of the cost of traditional solutions.

POWER QUALITY IMPACTS

DG sources can create voltage fluctuations (high and low), excessive harmonic content, transient disturbances and other conditions that detrimentally affect power quality and impact customers adjacent to the DG source. Additionally, older DG devices have been identified as the root cause of negative impacts to utility devices including voltage regulators that operate outside their normal range then prematurely fail. The transient nature of DG devices—devices that do not possess their own power factor correction—forces utilities to examine other fast acting solutions such as D-VAR, SVC or STATCOM devices.

SMART GRID CAN HELP THE TRANSITION FROM REACTIVE TO PROACTIVE PROBLEM RESOLUTION.

Remote monitoring devices – including smart meter service quality monitoring capabilities – can enable utilities to proactively eliminate the impact of DG resources and encourage better follow through on service commitments.

Additionally, utilities have traditionally relied on a combination of advanced engineering studies to identify potential system impacts and subsequent customer complaints to gauge the existence and severity of those issues. With remote monitoring devices, including the service quality monitoring capabilities of smart meters, utilities can monitor and detect negative impacts from DG resources. Proactive attention and remediation eliminates the impact on adjacent customers and better enables utilities to maintain service commitments. Evolving technology solutions also provide tools for the utility to identify and support issue resolution at problem generation facilities.

INFRASTRUCTURE ASSET MANAGEMENT

Although most utilities have some level of distribution automation or substation SCADA solutions that provide high-level indications of system load flows and status, problems can arise when a DG resource is installed on lesser monitored portions of the grid. Output from the DG source may result in an overloaded infrastructure during minimum or maximum generation conditions. Under maximum load conditions, when load generation more closely matches local loads, the impact may be smaller. However, understanding the impact on local infrastructure is difficult without the granularity of local measurements and status information. As more renewable DG resources are installed, the interaction and combination of the individual generation sources may aggravate the impact. Smart grid sensing and monitoring solutions applied on top of a telecommunications network can provide the information necessary to understand these impacts and interdependencies.

Utilities are also investing in intelligent smart grid distribution management systems (DMS) for their control centers. DMS provides intelligent alarm processing and load management applications that better enable the safe

operation of grids with high quantity of DG resources. DMS also help optimize a heterogeneous mix of connected DG resources, such as wind, solar, bio-mass, fuel cell, etc.

Energy storage technologies can potentially match the generation capability of DG resources with system load serving requirements. Storage solutions, such as compressed air energy storage (CAES) or battery technologies, which have the ability to "charge or discharge" at variable levels and rates, can act as either a source or a load. These devices store energy obtained during off-peak, then distribute the energy back onto the grid during peak conditions. As the distributed resources multiply, the impact of data inputs from smart grid and other technologies will need to be examined from both the load and generation perspectives, requiring more complex planning studies in the future that examine multiple contingencies.

SYSTEM PLANNING AND OPERATIONS REQUIREMENTS

The increasing penetration of DG resources heightens the significance of scheduling, dispatching, availability, capacity factor, spinning reserve, and voltage and frequency support. Renewable, solar or wind DG has an additional complexity in that most systems have a higher degree of variability in generation output, requiring more insight into real-time status and generation output. Performing long-term generation planning, substation and distribution system upgrade design and routine load flow analysis requires insight into all available DG resources. This in turn requires that these sources provide real-time information to the utilities that can be fed into the new generation of DMS power flow applications for both planning and system operations. This provides the information that utilities need to plan and operate the grid—safely and reliably.

MOST WIND AND SOLAR DG HAVE HIGHER DEGREE OF VARIABILITY IN GENERATION OUTPUT.

This will generate a need for better insight into all DG resources, which will impact long term planning, substation and distribution system upgrades, and load flow analysis.

A key enabler for effectively integrating, monitoring and managing DG sources within the smart grid lies with the utility's ability to ingest, route, process and act upon the increased levels of instrumentation data from DG sources and the larger grid. With the increasing deployment of information technology solutions such as enterprise service buses (ESBs) and stream processing tools, the latency between "sensory" and "actionable" information has the ability to be dramatically compressed, consequently reducing the time between grid stimulus and effective utility response.

SUMMARY TABLE

	CHALLENGES OF DG	ADDRESSING WITH SMART GRID SOLUTIONS (EXAMPLES)
Safety	DG can impact the ability of the normal protection scheme to function optimally	Leverage new low-cost remote monitoring devices to detect reverse power flow, abnormal operating conditions and DG status

	CHALLENGES OF DG	ADDRESSING WITH SMART GRID SOLUTIONS (EXAMPLES)
Islanding Scenarios	Potential for non-utility DG to operate in an islanding fashion, with utility unable to ensure adequate voltage and proper power frequency	Utilities deploying service area-wide private WiMAX solutions can support transfer trip at a fraction of the cost of traditional solutions
Power Quality Impacts	DG can have detrimental impacts on adjacent utility customers re voltage, harmonic content, and transient disturbances	Use the monitoring capabilities of Smart Meters to monitor and detect negative DG impacts
Infrastructure Asset Management	DG output can result in overloaded distribution network conductors, distribution transformers, fuses, etc.	Distribution management systems (DMS) provide intelligent alarm processing and load management applications, allowing safe operation of a distribution grid with large numbers of DGs installed and optimization of the mix of connected DGs Energy storage solutions, such as CAES or battery technologies, provide a tool to match the DG generation capability with the system load serving requirements
System Planning and Operations Requirements	Increasing penetration of DG (and especially renewable) brings significant system planning and operations issues and complexity	Enterprise Service Buses (ESBs) and stream processing tools enable the utility to ingest, route, process and act upon the increased levels of instrumentation data from DG sources and the larger grid

DISTRIBUTED GENERATION WILL CONTINUE TO GROW IN POPULARITY.

Utilities need to prepare themselves through the proactive investigation and application of smart grid solutions.

Distributed generation, and especially renewable based technologies, will continue to gain in popularity due to technology advances, environmental benefits, political support and growing energy awareness. Utilities need to prepare themselves for this increased penetration of renewable DGs through the investigation and application of smart grid solutions such as smart metering, smart communications solutions, distributed monitoring and control, and DMS applications (see table). These solutions have far-reaching value beyond supporting DG. By proactively embracing these changes, utilities can begin to shape the myriad of planning and operating approaches that maximize the potential long term benefits to the utility and its customers.

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