UTILIMETRICS
The Utility Technology Association

SMART GRID TECHNOLOGY

“An Introduction to the Technology Supporting the Smart Grid”

This handbook is for anyone who wants to better understand the basics, or building blocks, of Smart Grid Technology. It is organized by functional categories. Each category is broken down by the types of equipment used along with their descriptions and functions. Within each section we have also included brief overviews of current issues facing utilities and manufacturers along with technology “road maps.”

Smart Grid Technology Categories:

1. Metering
2. Communications
3. Transmission & Distribution
4. In-Home Devices
5. Generation, Distributed Generation, and Renewables

CATEGORY 1:
METERING

Meters fall into three broad functions for both residential and commercial users. We have made no distinction between equipment types and issues between these two groups, however the C&I category of equipment is far ahead in terms of widespread use of smart devices than the residential area.

Electro-Mechanical Meter: The standard for metering and utilities for the past century has been the electro-mechanical meter. The technology relies heavily on manufacturing quality so that meters run accurately for decades. Mechanical devices are durable but not perfect – meters can run fast or slow. These mechanical issues have resulted in the consumer protection regulations we have today. The largest cause of failures of electro-mechanical meters are physical damage from outside causes including weather, falling objects, animals, insects or tampering.

AMR – Automated Meter Reading. An AMR Meter has built in communications technology broadcasting a meter read within a short range for collection by a meter reader. Traditionally, the communications functions are limited to a one-way broadcast of information from the meter to the collector. AMR has been essential to reducing labor costs associated with meter readers as a single meter reader can collect meter read data from a vehicle with an efficiency of 100 to 1. The labor savings makes for a very simple business case.

> **Technology:** The presence of a transmission mechanism in a meter makes it an AMR meter. The meter itself may be electro-mechanical or a solid state (electronic) device. Some AMR is provided by a retro-fit of a transmission device to an older model meter. In the case of combination gas/electric utilities a battery powered transmitter is frequently attached to the gas meter as well so that both meters can be read simultaneously from a distance.
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> **Roadmap:** AMR devices are not deployed in a true Smart Grid because they lack the two way communications functionality which is needed to support smart applications such as demand response, time of use metering, automatic shut off, automatic notification of power outages, etc. AMR will continue to be enhanced for gas and water applications but is not likely to see new development for electric utilities without being equipped with true AMI functions. Most utilities still using electro-mechanical meters will skip AMR and move directly to AMI equipment even if they do not fully implement AMI functions for years to come.
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> **Issues:** Maintenance and support of the AMR meter is very simple and managed with most existing O&M (Operations and Maintenance) fleets. Most of the increase in O&M problems are reported on the transmitter or battery supporting the transmitter. Battery life and charging or replacement problems are the most limiting factor in deployment of both gas and water AMR and AMI.

AMI – Advanced Metering Infrastructure. An AMI Meter is significantly different from its AMR brethren in that the AMI meter collects meter read data on consistent intervals throughout the day and can broadcast that data either to a nearby vehicle (as with AMR) or a nearby access point to be relayed to the host system. Only AMI meters are capable of reporting usage data suitable for interactive demand-response programs. Many utilities have installed AMI meters without activating the time of use functions because no benefits can be offered to the customer without the installation of a complete communications network and host systems to manage the data.

- AMI Features: In addition to controllable and granular collection of meter read data, AMI meters can also come equipped with features to permit remote disconnect. These switches are used for electric applications and disconnect valves for use in water AMI. Both save utilities the expense and trouble of sending field crew to cut service and provide improved customer response for reconnections and improve utility employee safety.

- Meter Pre-Payment features can be added to AMI Meters.

- Acoustic-analysis tools for identifying water-system leaks: Acoustic analysis tracks the sound of pressure waves vibrating inside water pipes. Based on the frequency of the noise in the pipes, engineers can tell if there is leak, the likely size of the leak, and the location.

Technology: The internal mechanism in an AMI meter is an electronic circuit board with various optional features housed in a meter-like weatherproof housing. This is a major departure from previous meter technologies in that the electronics must function in the field with the same type of useful life and durability as electro-mechanical devices.

Under the meter-like appearance, the AMI meter is a close cousin to a personal computer. It has a circuit board, a processor, solid state storage, LCD display, communications link, and runs a software system which can be updated through its communications function. Joe Rigby, Chairman and CEO of Pepco Holdings put it succinctly when he describes an AMI meter as a "personal computer running metering applications".

Roadmap: AMI meters are recently being deployed in volume and the history of their stability is yet to be written. The pace of change in the electronics industry suggests that many improvements and enhancements will come into the marketplace very rapidly. The challenges for manufacturers and utilities alike are to keep technology backward compatible so that investments in physical equipment are not rapidly obsolete.

Issues: Experience from current field use data already shows that AMI meters will need repair or replacement in the field between 4 and 10 times more frequently than the equipment replaced. This has dramatic operational and maintenance (O&M) cost impacts as each repair must be handled by a dispatch of a repair crew ("truck roll"). The costs to touch a non-functional meter is more costly than then meter itself. Total cost of ownership analysis should include careful planning for managing the increased repair burden.

MDM (Meter Data Management). MDM is the function of utilizing the vast volumes of data flowing from capturing meter data in time intervals during the day. Utilities can develop their own MDM systems, purchase ready-to-use solutions, or outsource to a service provider. The MDM system is crucial to activating any form of demand response or time of use billing. Most meter data management systems are hosted in a data center facility.

CATEGORY 2:

COMMUNICATIONS

Much of the public discussion of the "Smart Grid" has focused on the subject of Smart Meters and their impact on consumer behavior. Less often discussed, but no less important, is the communications technology linking the meter to the utility. None of the expected impacts on load balancing, demand response, conservation, and integration of home-based technologies can begin without the installation of smart meters and associated communications.

Robust and stable communications networks are essential to all parts of utility operations today. Adding additional "smart" functions only increases the requirement for network stability. The flow of information through a network begins at the meter, where a transmission made from the meter goes first to an aggregator. The aggregator captures data from multiple meters and bundles it for bulk transmission to the host system in a function named “Backhaul”. On the return side, dissemination of usage data back to the consumer can take many forms, all of which involve network communications.

The technology leader for providing the metering side of communications has been the RF (Radio Frequency) network. PLC (power line communications) and BPL (broadband over power line) technologies are also widely deployed on the metering side as well as the transmission and distribution side. The choice of communications technology for both metering and additional communications needs is based on considerations of topography, distance, volume of data transfer, and security.

RF (Radio Frequency) Function: This is the most common approach taken with AMI and AMR Deployments. The RF device is attached to the meter as an “End Point”. The other “End Point” of the RF network is a data collector used to capture the RF signal from many locations and relay it to the utility. RF has been the AMI solution of choice for most urban and dense settings since a single data collection end point can handle many meters cost-effectively.

Transmitters and Receivers: All meter endpoints must be equipped with transmitters to send the meter reading to a central collection point. Some endpoints also have receivers that can interact with a “wake-up” signal from the collection device. Endpoints without wake-up capacity are known as “bubble-up” units: They transmit their readings at predetermined intervals.

Data Collectors: The other endpoint in the system is the data collector. These combine data from the individual device (meter or otherwise) and aggregate the transmission of data back to the utility. Most centralized data collectors connect to a broadband network.

> **Technology:** Meters transmit information to a centralized data collector, often located atop power poles, buildings, water towers and other high structures. This is due to the nature of radio signals. Radio signals radiate in a circular pattern if the source of the transmission is at ground level, but the signal propagation takes on the shape of a cone when raised. The higher the apex of the cone, the larger its circumference at ground level, and the wider the signal range.
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> **Issues:** RF transmitters are less useful in locations with underground locations (pits, buried locations, locations block by accumulations of ice etc.) Many gas and water utilities do not use RF for these reasons. Other applications for RF within the transmission and distribution functions are challenged by long distances and signal interference from active devices – such as would be found in a substation.
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> **ZIGBEE** – This is most commonly used communications protocol for AMR. A Zigbee device is one built using a Zigbee chip broadcasting an RF signal in a Zigbee format. Multiple manufacturers produce Zigbee chips which are then integrated into the finished product. There are alternative protocols such as **Bluetooth**, but the battery life of devices using Zigbee is longer than with other options. As a result, the Zigbee design has been preferred.
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> **Wi-Fi** (Wireless Fidelity) is a standard for radio transmissions using IEEE 802.11 Wi-Fi is based on a single router (such as in a home or coffee shop) delivering broadband access into their local area network (LAN).
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> **Wi-Max** (Worldwide Interoperability for Microwave Access) is based on the IEEE 802.16 standard – also known as Broadband Wireless Access. Wi-Max is suitable for providing a broadband connection to the “last mile” as an alternative to wired solutions such as cable and DSL.
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> **Cellular** – Cell services are delivered using a variety of standards including Wi-Max, Wi-Fi, GSM, EDGE and others to deliver internet services and voice over networks. Cell technology is currently in use primarily in the commercial and industrial metering sector due to its low cost of entry. Expanded

use of cell technology for AMI has been debated over concerns that the standards are evolving too quickly to invest in any technology where the product could be obsolete in a very short time.

Wired Telephone and Satellite – Both traditional telephone and satellite communications links are in use and may continue to be useful for particular projects. Neither appears to be the communications format of choice for Smart applications. Wired telephone suffers from the same problems as BPL and PLC systems, with the added cost of paying the wired telephone provider for service. Satellite communications also rely on locally available power and outside costs.

Power-line communications (PLC) systems: This is the oldest form of fixed-network AMR, transmitting a narrow-band signal over a utility's own distribution wires, thereby eliminating the need to build out network infrastructure. Because the system goes anywhere the utility has electricity wires, infrastructure already is in place to reach all sites. Such systems are well suited to distribution-system maintenance chores, such as signal-strength monitoring to find weak signals that might indicate line loss from problems on the distribution network. Rural and low-density locations tend to prefer the PLC solution as being the most cost-effective for their operations.

Technology: Traditional PLC systems don't require line-system upgrades; however, they may require substation add-ons. Some PLC systems require distribution level equipment, while others don't. The physical variations between systems and the ability of lines to carry signals means that no one technology can be applied to all situations.

Issues: Dependency on the power line is the Achilles heel of this approach. Outages cannot be detected if the system is down.

Broadband-over-power-line (BPL) systems: BPL systems are another form of power-line communications. These systems boast data-transmission rates comparable to DSL or cable, making them a viable smart-grid technology capable of providing bi-directional communications and grid-automation power. The enabling technologies are similar to those of PLC systems.

Issues: BPL systems are prone to signal attenuation, which is a reduction in signal strength as the signal travels down the distribution line. Consequently, such systems often need repeaters and regenerators to amplify those waning signals. The FCC has yet to settle the issues over signal interference ("spectrum pollution").

Wide-Area Networks (WAN) for Backhaul: AMI systems only bring the data to centralized collector sites. From there, the utility must move the data back to its data center. This is called "Backhaul". This typically occurs via Internet-based networks, because they offer wide enough bandwidth to carry aggregated readings from thousands of endpoints. Some utilities, though, look at the Internet as too open and insecure and use utility-managed backbone systems instead.

Technology: WAN systems provide the connection from the meter to the utility as backhaul, and are the essential link for the return of information back to the meter. Because of the volumes of data involved – a broadband connection is used. Broadband service is typically provided by some kind of wired connection including Cable, DSL, BPL, and FibreOptic. Wi-Max is the non-wired alternative.

Routers & Switches: Movement of information back and forth within the network is performed by routers and switches. This includes moving data from the collectors through the backhaul function to the main processing center. Security of data is provided by various types of encryption. A special type of router called a Firewall is located at the main data center to prevent unauthorized access into the data center through the network.

Issues: The volume of networking equipment in the field is exploding. Each device deployed has its own failure rate and service needs. In addition to the weather, heat, and durability issues already experienced in the substation automation environment, many of these additional devices must be

> deployed in physically high settings. This will add to the costs of O&M as a network outage will now be consequential to grid stability even if the power lines are unaffected.

General Issues for the Communications Category:

Radio Spectrum Licenses: Many RF systems transmit data over non-licensed frequencies, which adds simplicity and cuts costs. However, it introduces the possibility of "Noise" on the system. Such interference is the same that is audible with radio stations. For RF systems the problem is that noise causes data latency issues, as readings are lost or delayed while the system sends and resends the same information until reception is confirmed.

Some product offerings have primary-use licensing from the Federal Communications Commission. The cost for such a dedicated spectrum is built into the cost of the AMI system, and having a guaranteed frequency means utilities may be able to transmit using a high wattage of power, which increases signal strength and reliability. Transmission power permissions also come under FCC jurisdiction.

Topology: Engineers call the shape or geometry of a network its "topology." In RF communications, two topologies dominate: **star** and **mesh** networks.

Star networks have a single central point of contact that communicates with surrounding endpoints. Endpoints talk only to that centralized tower, not to each other, so each node has only one pathway its transmissions follow. In redundant star networks, repeaters add second layer of communications assurance. Such networks could conceivably get data from the endpoint to the collector in seconds.

> **Issues:** Single point of failure is a large concern for star networks. Networks can be designed to be redundant so that each endpoint is able to communicate with multiple collectors. In this way, the collector is no longer a single point of failure in the system. The system automatically manages which collector is tracking the endpoint device or sorts through redundant transmissions. Redundancy means additional initial cost as well as additional support and maintenance needs because there is more equipment involved.

Mesh networks are arranged such that the endpoints can talk to each other, so if a device cannot get its signal through to the centralized data collector, it can pass the reading on to another device that can get through, making the system self-healing. Often, a single reading may take several such "hops" on a mesh network before the signal finally reaches the backhaul data-collection point.

> **Issues:** While the ability to take varied routes to a data collector gives mesh networks built-in redundancy, it also can take a toll on battery life, which could be an issue with gas or water implementations. That's because the networks require added protocols to manage those multiple communications pathways. The protocols add to the data load of each transmission.

Cyber Security: Cyber security has become the key limiting issue for expanding the use of communications equipment within the electric grid. Much of the effort being made at the Federal level (NIST, FERC, NERC) is directed at supporting the industry with standards that will improve cyber security. Cyber security is of concern not only to protect the privacy of meter data but more critically, to prevent system damage by means of hacking.

CATEGORY 3:

TRANSMISSION AND DISTRIBUTION (T&D)

Equipment in this category is typically located in substations, switchyards, and generating stations. The use of electronic control and monitoring equipment within these locations already meets the definition of a “Smart” grid function. This area is exploding with new and improved devices and software applications. Because much of the electronic equipment is nominally protected from the elements by various housings but not climate controlled, electronics are subjected to extreme variations of temperature and moisture. Access for repair is not usually a problem as Substation Automation and SCADA equipment is usually co-located with the infrastructure equipment or is placed in a nearby building.

Since failures of T&D equipment can have serious impacts, T&D managers have been exploiting electronic technologies to improve operations for a long time. The general functions for T&D equipment are outlined below. SCADA is a method of coordinating and controlling these functions.

Substations: Substations usually have switching, protection and control equipment, and transformers to step up or step down current as it moves around the transmission lines from generation to consumer. Different types of substations perform different functions.

- Transmission substations connect two or more transmission lines. If the voltages from the different lines are not matched, transformers convert voltages so that power can flow smoothly from one line to another. Switching equipment in the transmission substation includes circuit breakers and a large amount of protection and control equipment. Sometimes these substations are also called Switching Substations.

- Distribution substations convert high voltage from generators to voltages suitable for local distribution. These substations are also used to isolate faults on either the transmission or distribution system.

- Collector substations are used where large distributed generation projects, such as wind farms, attach to the grid. They resemble distribution substations but their operation is to control flow of electricity in the opposite direction.

Substation Automation: The differentiation between electro-mechanical equipment in the substation and any electronics comes under the heading of substation automation. The equipment functions described below are all types of substation automation equipment.

Protective Relays: One of the most common functions for T&D is protecting the grid and equipment from failures in operating conditions. For example, if voltage exceeds a pre-set limit for a device, a protective relay will trip a circuit breaker, just as a circuit breaker trips in a home to protect the system. The trend in protective relays is towards electronic devices and away from electro-mechanical devices in order to take advantage of the control possible with an electronic and networked device.

Switching: Connection and disconnecting of transmission lines or other components is done using switches. Switches are essential to being able to isolate and de-energize sections of the grid for maintenance, or to add or remove a new transmission line or transformer. In the case of problems (faults) in the system, being able to remove the faulted section from connection to the grid helps maintain overall grid stability. Electronic switching and remote power switching equipment is a burgeoning area of development and growth for the smart grid. Switchgear is expected to trail only smart meters in terms of revenue growth through 2013.

Transformers: Transformers within a substation are larger versions of the drum style transformers ubiquitous in residential neighborhoods. The function of the transformer is to literally transform (convert) one type of voltage to another. Within the substation, transformers may step up or step down the current depending on the requirement. Transformers are not electronic devices but electronic monitoring equipment is being used now to monitor the status of transformers to determine when (not if) they will need to be replaced. Monitoring has the potential to prevent outages by predictive modeling of life cycle of each device on the grid.

Reclosers: In the case where a disturbance in voltage and current are present, such as from a lightning strike or a tree limb resting on the line, the Recloser is designed to safeguard the electric lines by shutting off power briefly and then immediate "reclose" the circuit to restore power. This action causes lights to blink. Occasionally the disturbance takes more than one try to rid itself of the problem, which causes power to stutter for several seconds. If the fault does not clear at that point the electro-mechanical Recloser will turn itself off until reset by a crew. Newer electronic reclosers are now available with "Smart" functions so that the reset function can be made remotely saving tremendous time in restoring power as well as labor savings.

Arrestors: Lighting arrestors are designed to protect equipment from voltage surges due to lightning strikes. They work as a shunt, allowing the brief high voltage to go around the protected equipment. Usually the arrestor will turn itself off after the high voltage passes through. Sometimes the stresses are too great and the arrestor literally explodes. Arrestors are not technology devices.

Digital Fault Recorders: In the event of a problem event, these devices collect and archive information about power system faults as recorded by the protective relays. This data can then be used for analysis and troubleshooting.

Issues: T&D products must be extremely durable and ruggedized. In order to avoid outages associated with equipment failures, some systems use redundant devices so that there is an automatic fail-over. Repairs can then be made while the system remains active. Utilities pay close attention to the published Mean Time Between Failure (MTBF) for these devices because reliability of the grid depends upon the reliability of these devices.

Transmission Technology:

PMU (Phasor Measurement Unit) Engineers can monitor the quality of the electricity being generated and transmitted around the grid using a device called a Phasor measurement unit (PMU). A PMU can be a dedicated device, or the PMU function can be incorporated into another device such as a protective relay.

Clocks: PMUs need accurate clocking in order to use the data to make comparisons. Most clocks use a common time source such as a GPS radio clock.

Synchrophasor: Phasor measurements that occur at the same time are called Synchrophasors. Synchophasors measure voltages and currents at diverse locations at the same time on a power grid. Because the phasors are carefully synchronized as to time, the comparisons can be used to assess system conditions. This technology has the potential to change the economics of power delivery by allowing increased power flow over existing lines. This is because accurate data regarding the line limit can be collected and less reserve capacity set aside for an unknown worst case limit.

SCADA – Supervisor Control and Data Acquisition: SCADA systems are common in both T&D as well as generation and management functions including EMS (Energy Management Systems), AGC (Automatic generation control), and WAP (Wide area protection). A great deal of the functionality of SCADA is developed and run on host systems in data center environments. The equipment described below are those deployed in the field.

SCADA systems rely on sensors in key parts of the grid to relay their status information back to the control center. Managers can then make supervisory decisions to adjust controls or settings remotely. SCADA equipment is very widely deployed and fall into the functions below. SCADA will continue to be deployed and upgraded as an already "smart" technology.

Actuator: An actuator is a device that converts communications instructions into a mechanical or electrical action. For example, an actuator may control a breaker or a valve.

IED (Intelligent Electronic Device). As the name implies, this is a device with onboard electronics used to provide specific services such as voltage regulation, electronic reclosers, and remote communications. IEDs are widely used in SCADA systems. IED Gateways are controllers for multiple IEDs.

I/O Controllers and Field I/O: I/O means input and output. In the SCADA system the field I/O and I/O controllers are the interface between the control system and the physical devices being monitored.

PLC (Programmable Logic Controller). A PLC is a small processor dedicated to controlling devices at the local site.

RTU (Remote Telemetry Unit/Remote Terminal Unit): The RTU control panel is the communications controller for interface with the network back to the control center. RTUs are most commonly used in the switchyard

Sensor: A sensor is a device that monitors the state of another device in order to report to the control system. For example, a sensor may report on the temperature within a transformer.

Roadmap: Developments in SCADA are focused on improving security with specialized firewall and VPN (Virtual Private Network) functions. Advanced encryption and authentication software is also key to improvements in security.

Issues: Cyber Security remains the largest problem with SCADA systems. In the case of T&D assets, utilities need to protect the control systems from unauthorized access, including hacking as well as common problems such as virus infections. They must also protect their communications systems as with any networked elements of the Smart Grid.

CATEGORY 4:

IN-HOME DEVICES (IHD)

The promise of the smart grid to deliver demand management, enable time of use metering, demand response, and encourage efficiency and conservation revolves around providing consumers with enabling technology to make better decisions on their electric use. The interface between the utility and the residential consumer changes with the implementation of in home devices either directly controlled by the utility or information portals where usage data is provided in real time.

In-Home Devices (IHD) will likely be widely used to provide both external demand management and as an information portal for conservation and consumer choice. There are wide differences of opinion on the degree to which the utility should have active control over the IHD and how privacy can be protected if such offers were to be made. At the passive end of the spectrum the case is being made that utilities should provide time of use data in real time using existing technology portals such as the internet. Regulators and officials will be spending considerable time on these issues.

Home Area Network (HAN) Function: Use of electric usage data at the customer level is likely to be managed by a HAN controller device or portal on a personal computer. The marketplace for such devices is enormous and is being approached by a very wide variety of interests and showing enormous creativity and potential.

Some energy management portals are already being marketed for in-home use that will be sold in consumer electronics outlets such as Best Buy or WalMart. Appliance makers are being encouraged to produce devices that can respond to time of use signals. Most such devices are being standardized around a Zigbee protocol but the landscape of options continues to be wide. It is unclear if the HAN side of the smart grid is going to be a consumer electronics product, an appliance product or a utility provided service.

> **Issues:** Consumers look to the vendor of equipment to support that equipment. If Utilities become the vendor of in-home devices, they will face considerable pressure to support such equipment themselves even if the underlying manufacturer offers a warranty. Integration of complex HAN devices, portals, and meters is likely to result in a heavy load on customer-service programs. Equipment service and replacement issues will need to be resolved. What happens to a customer when the in-home-device needs repair?

Direct Control Devices: Utilities already have experience with the Commercial and Industrial (C&I) users with remote shutoff and thermostatic controls installed in exchange for price or other concessions. Deployments of similar functions at the residential level will likely proliferate.

> **Issues:** Utility control over residential devices has been a lightning rod of controversy. Despite negative media, the technologies exist and can be exploited in appropriate settings to offer considerable advantages to consumers.
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> **Rapid Change**: This area of activity is highly entrepreneurial will likely to shift dramatically over the next decade. Some utilities may stay away from this area entirely, and others may elect to become extensively involved supplying and supporting IHDs devices. Standards for communications will be helpful in removing some of the development risks for new products but care has to be taken at the same time to allow innovation.

CATEGORY 5:

GENERATION, DISTRIBUTED GENERATION & RENEWABLE EQUIPMENT

Generators already use “smart” devices to monitor generation, better match load, model load profiles, and interact with grid managers and oversight organizations. The expansion of the Smart Grid in this area promises improvements and upgrades to the existing generation and T&D systems to reduce the amount of power lost or wasted in the transmission function. Smart Metering and advanced communications equipment is fundamental to being able to more easily integrate distributed generation, including renewables, into the future “Smart Grid”.

Base Load Generation: Base Load generation is of the traditional form where control of generation can be pre-set and manufactured to suit the need. Generators that can run at any time of day are potential base load generation. There is little uniquely “smart” about generation as most systems are already linked in to sophisticated networks for control and monitoring.

Distributed Generation includes equipment which can be operated at will and deliver power to the location or the grid at scheduled times.

- Micro-turbine gas or fuel cell generators are in this category. Most distributed generation of this kind is installed to augment power needs at a particular location instead of generating excess power to return to the grid. Excess capacity of distributed generation can be sold back to the grid at which time it becomes necessary to manage this resource in a manner similar to a solar array or wind farm.

Renewables fall into the intermittent category of generation whereby if the wind isn't blowing or the sun isn't shining the generating capacity of the resource is unavailable. Integration of renewable generation equipment is particularly complex for grid managers since the output can be highly variable and come from a wide variety of end point sources. The Smart Grid is a necessity for integration of more solar into the grid as management of this resource is otherwise impossibly unwieldy.

- Solar. Solar arrays can be located effectively in many locations. Arrays located "behind the fence" are those built for the purpose of electrical generation and are secured and connected in an aggregate. Data about generating capacity from these arrays is easily related to grid managers from a single point. Arrays outside the fence, be they on residential roof tops or other widely distributed settings such as pole mounted, are far more complex to manage. Each individual array must be equipped with communications technology to notify the grid operator of its status in close to real time.

- Wind. Permission to build a wind turbine is considerably more difficult than for a solar panel on a roof top. Wind generation is therefore usually adopted on a commercial scale and data about generating capacity is easily transmitted to the grid operator.

Storage: The dream of many engineers and designers of smart grid and utility technology is to have the ability to store electricity in the same way that reservoirs store water and tank farms store gas and oil. There is no currently functional technology in this area.

Distributed Generation Equipment: Issues: As with other types of generation, transmission, and distribution issues involving technology have much to do with maintaining the communications network and equipment for consistent reliability. In addition, renewable technologies have service issues unique to their location such as harsh weather and geography.

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Utilimetrics is an international trade association bringing together diverse stakeholders from electricity, water and gas distribution utilities to promote and share best practices for smart grid/smart metering, communications, utility automation and data management.

Utilimetrics believes that utilities and consumers must be closely linked to compel efficient and responsible energy and water management.

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