

Modern Grid v1.0

Powering Our 21st-Century Economy

A Systems View of the Modern Grid **Appendix A5: Accommodates a Wide Variety** **of Generation Options**

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ACCOMMODATES A WIDE VARIETY OF GENERATION OPTIONS

Overview

The modern grid will enable and encourage a substantial increase in investment of new energy sources, types, and configurations and will substantially involve consumers in collaboration with system stakeholders. The grid will accommodate a portfolio of generation types diverse in capacity and interconnected voltages and will facilitate the integration of Demand Response (DR) capabilities to complement the generation portfolio. The effort required to interconnect these generation sources and DR systems will be greatly simplified and will be analogous to “plug and play” in today’s computer environment, particularly at the Distributed Energy Resources (DER) level.

The modern grid must accommodate a wide variety of generation and Demand Response (DR) options to achieve the improvements in reliability, security, economics, power quality, and asset utilization required by its vision. A widespread deployment of diverse energy sources is needed across the following dimensions:

- Decentralized vs. centralized to increase the geographical dispersion
- Distribution voltage interconnections vs. transmission voltage interconnections to provide generation at all voltage levels in the grid
- Many vs. few to increase redundancy
- Diversity of plant and fuel types to increase tolerance to common mode issues
- More low-emission sources to reduce environmental impact
- Diversity of size (MW) to provide flexibility in operations
- Diversity of ramp rates to improve response times
- Introduction of energy storage devices to improve power quality and reliability

The modern grid will accommodate large numbers of DER of relatively small capacity at the residential level including such technologies as photovoltaic (PV), wind, fuel cells, electric vehicles, and energy storage of various types. These devices will normally be connected to the low voltage distribution lines or through a dc micro-grid. A significant increase in the deployment of DER by consumers is expected for the following reasons as today’s grid transforms into the grid of the future.

- DR purposes (to enable the consumer to reduce demand on its side of the meter in response to price signals for demand response resources)
- Back up generation for reliability purposes when system outages occur

- Grid connected generation (to enable the consumer to respond to price signals for generation resources)
- Power quality enhancement

DER investments at the commercial and industrial level will be made by consumers and marketers at an ever-increasing rate. DER will be aggregated and integrated with distribution networks to create larger generation sources that provide a more significant benefit to grid operations. Commercial wind, PV farms, and neighborhood-size DER systems will result. In general, these DER investments will be significantly larger in capacity than those deployed at the residential level and will be interconnected with both the distribution and transmission systems over a wide range of voltages. In addition, since many of the DER are renewable energy sources, the deployment of DER will stimulate the diversity of environmentally friendly fuel types used by the U.S. generation portfolio.

DER deployment is expected to be significant and will complement rather than displace other types of generation sources. A diverse portfolio of generation types will be essential to the modern grid. Figure 1 maps the various DER technology options to the associated market applications.

Technology Options	End User	Utility Grid Support	Energy Supply
	CHP Premium Power Backup Power Peak Shaving	Asset Mgt Reliability Power Quality	In-City Generation Renewable
Reciprocating engine/diesel	X	X	
Combustion turbine	X	X	X
Microturbine	X		
Fuel cell	X		
Photovoltaic	X		X
Wind	X	X	X
Energy storage	X	X	X
Biomass and waste management	X		X

Figure 1: DER options versus market applications

The United States has approximately 30 GW of grid-connected distributed generation (DG) capacity, a small percentage of its 953 GW of electric capability. In all, the nation has an estimated 234 GW of installed DG. But small reciprocating engines, used to supply emergency or standby power, account for

about 81 percent and most are not grid-connected. Combustion turbine technology is the second most widely used approach with 7 percent of the mix, and combined heat and power (CHP) is the second most widely used application at 9 percent.

The future offers several pathways to growth for distributed energy, depending on how technologies and markets evolve. The largest market now and probably through 2015 will be the end-users, where consumers use distributed generation to achieve savings and improve reliability.

In addition to accommodating a wide variety of generation sources, the modern grid will also be friendly to the integration of DR systems and devices. The use of DR on the consumer's side of the meter to reduce load on the grid and the technologies that will enable consumers and grid operators to manage load when needed are examples of how DR can be applied. Effective utilization of DR resources will enable modern grid operators to more effectively and efficiently manage the generation portfolio.

In addition, to consumer investments in DER and DR, investments in Combined Heat and Power (CHP) and non-utility generation facilities will be made by large power consumers and marketers. These generation sources will be larger in capacity than the DER typically deployed by commercial and industrial consumers. Investments in large combustion turbine plants will continue at a rate consistent with fuel costs and will be located closer to load centers than conventional, centralized power stations to reduce the burden on, and the cost of, transmission. New conventional, centralized fossil power stations (coal, oil, and gas) as well as nuclear will be needed in the generation portfolio of the future to meet the expected increase in electrical demand.

The modern grid will provide for and encourage the interconnection of these diverse generation sources and demand response systems. It must accommodate not only the initial interconnection process but also meet the new maintenance and operational challenges that these sources and systems create.

Widespread deployment of diverse energy sources in conjunction with the successful achievement of the other six fundamental characteristics of the modern grid will enable its long-term vision to be realized.

Current State

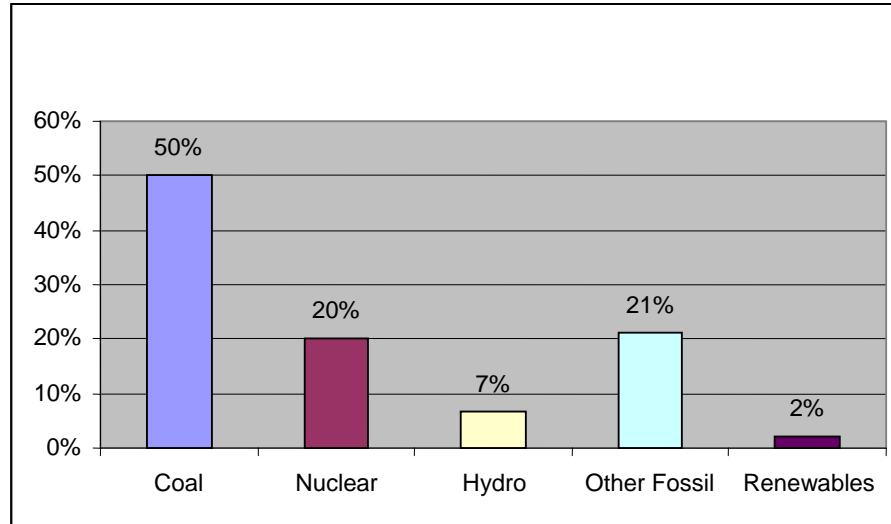


Figure 2: U.S. net generation mix (2004)

In terms of net electrical generation, the current electric grid is dominated by large, centralized generating facilities. Large generators (noted as coal, nuclear, and hydro in Figure 2 above) made up over 75 percent of the net electric generation in 2004. A substantial gap therefore exists between the existing and desired amounts of electricity generated by DER, particularly in the renewables category. Clearly, the modern grid must accommodate new varieties of generation options to be successful at closing this gap.

To achieve the level of deployment needed to support modern grid operations, DER deployment must occur at the consumer level (residential, commercial, and industrial), marketer level, and the electric industry level. The goal for DER deployment should be similar to what has occurred with the deployment of PC's, laptops, and cellular technology. Unfortunately, today's consumers are not adequately motivated to invest in these generation technologies. For example:

- The total cost of ownership (investment, operating, maintenance and fuel, etc.) for DER devices is currently too high and is not competitive with conventional alternatives. Their costs need to be reduced to stimulate the level of investment needed to create widespread deployment.
- Generally, residential consumers are not billed on a real-time basis. Until consumers feel price signals based on real-time system conditions and wholesale prices, they will not be motivated to pursue alternatives like DER. Smart meters need to be deployed and real-time rates need to be developed to provide this price signal to consumers to motivate them to consider investing in DER.
- An integrated communications platform is needed to enable all power system components, smart meters, and demand response assets on the customer side of the meter to intercommunicate on a network basis. The current

communications system of today's grid lacks integration and standardization and does not yet penetrate down to the consumer level.

In addition, other barriers currently prevent today's grid from accommodating a wide variety of generation (and DR) options. Some of these barriers include:

- Advances in research and commercialization of smart sensors, control devices, and gridwide communications are needed to support the level of autonomous control necessary for seamless operation of the modern grid.
- The development of reasonable and consistent interconnection and operation codes and standards for DER is moving too slowly. These codes and standards need to be finalized and adopted industrywide to enable the corresponding research (and commercialization) to be done to support their execution.
- New operating models and algorithms need to be developed to operate a modern grid that utilizes a significant number of decentralized generation sources. Today's operating models are not sufficient for effectively operating this new configuration. Also needed are advanced simulation tools that can provide a more complete understanding of grid behavior where a large number of diverse DER units are deployed.
- National energy legislation and regulations are required that provide financial incentives for investing in DER deployment and usage. These programs should consider the total societal benefits of these programs. Investment incentives should be made available to consumers. Also, some form of financial relief should be provided to corporations who make investments in the modern grid and later experience stranded investment costs.

Future State

To accommodate a wide variety of generation options, interconnection standards will be simplified, standardized, and clarified. Also, methods will be developed to resolve the unique maintenance and operational challenges created by DER, DR systems, and other new generation sources. The convenience of “plug and play” technology, a more competitive price structure for generation options, and the use of real-time price signals felt by consumers and marketers at all levels will motivate them to invest in generation to improve the reliability of their supply. In addition, their participation in the system capacity, energy, and ancillary services markets is expected to increase as well.

New rate designs will be developed to define the real-time pricing process and details.

Advanced real-time pricing technologies (dispatched from transmission and distribution operators) will establish price signals to motivate consumers to invest in DER. Smart meters and information gateways will be developed to receive, process, and act on price signals in real time. Energy management systems on the

consumer side of the meter will monitor and control DER operations and demand response actions in an integrated manner.

In addition to consumers, utilities will also broadly deploy DER. Both storage and local generation will be used to improve load factors, reduce investments in conventional transmission and distribution infrastructure, reduce system losses and emissions, improve power quality, and enhance reliability.

Standard and ubiquitous communications will enable the integrated exchange of data. A standard open architecture for data transmission acceptable to vendors, consumers, and utilities will reduce the concern for stranded investments and stimulate DER deployment.

Advanced system planning tools will integrate the benefits of DER and consider the uniqueness of their operation to optimally site conventional, centralized power stations.

Improved operator visualization techniques and training will be developed to effectively operate the modern grid, which will contain a significant amount of smaller, decentralized DER units providing generation and energy storage.

DER will be connected at all distribution voltage levels (and some transmission levels) and integrated with local AC and DC networks. They will receive price signals to assist the consumer with energy management and commands from the local Distribution Operations Centers to assist modern grid operators response to system reliability concerns.

Besides the conventional types of DER (i.e., wind, solar, micro-turbines, etc.), fuel-cell technologies and energy storage devices will be widely deployed. The use of the electric car for not only transportation but also as an energy storage device will significantly engage the consumer in advancing the robustness of the modern grid.

The modern grid will depend on DER to respond on a real-time basis to optimize the energy cost to the consumer and at the same time enable system operators (both distribution and transmission) to effectively manage the reliability of the system(s).

As a complement to the increased deployment of DER, large combustion turbine (CT) plants and conventional, centralized stations will continue to be added to the grid. CT's will be located closer to load centers, thereby reducing the burden on the transmission system. Increased use of nuclear generation will be accepted as the cleanest source of central generation.

The seamless integration of a variety of generation options provides significant benefits to the modern grid from various standpoints. For example, the integration of DER at all distribution (and some transmission) voltage levels, and with broad geographical diversity, will significantly increase the robustness of the modern grid by strengthening the distribution system and reducing the burden on the transmission system.

The key success factors for achieving the vision of the modern grid drive the need for this characteristic. The modern grid's capability to accommodate a wide variety of generation options will positively influence the key success factors as follows:

Reliability

- Reduces dependency on the transmission system
- Increases operational flexibility during routine, emergency, and restoration activities
- Reduces system restoration time following major events (depends on advanced communications and control systems inherent in the modern grid)
- Reduces vulnerability to common mode failures

Security

- Reduces vulnerability to a single security attack
- Increases operational flexibility in response to security emergency

Economics

- Defers large capital investments in generation, transmission, and distribution
- Enables consumers to participate in the electricity market (and partially fund new generation)
- Reduces system peak demand, transmission congestion, and peak energy prices

Power Quality

- Increases “ride-through” capability and momentary voltage support as energy storage device deployment reaches the needed level

Efficiency

- Increases options for use by the system planners for addressing future demand issues
- Increases options for use by system operators for improving the utilization of grid assets
- Reduces grid electrical losses by locating generation electrically closer to the load

Environment Quality

- Encourages the deployment of smaller DER sources including those based on clean technology.
- Encourages greater use of hydro, solar, and nuclear power that produce zero emissions

Safety

- Provides improved safety features to protect workers and the general public by mitigating any new hazards created by the interconnection of large numbers of diverse types of generating sources and energy storage devices.

Observed Gaps

A substantial gap exists between the existing and desired amounts of electricity generated by decentralized sources including DER. Accommodating large numbers of new and diverse types of generation sources into today's grid is difficult. Several fundamental issues require resolution to enable the modern grid to be successful in this area:

- The motivation of consumers must be significantly increased to drive the deployment of new and diverse generation sources. Energy price signals, consumer portals and lower cost, more efficient "plug and play" DER will help create the needed motivation.
- A standardized, ubiquitous, and integrated communications platform is needed to enable all power system components, smart meters, and demand response assets on the customer side of the meter to intercommunicate on a network. The exchange of energy price signals and dispatch commands from system operators must be part of this network to effectively integrate these new generation sources.
- A clear, consistent vision for the modern grid that clearly identifies the role of generation, DER, and DR needs to be defined and accepted by all stakeholders. Regulatory and legislative reform at both the federal and state levels needs to occur and be consistent with this vision. Policies and statutes may then be put in place that endorse this vision, remove barriers, create incentives for investment, and ensure that the various regulations are aligned with the goal of achieving the vision of the modern grid.
- Conflicting agendas exist among some stakeholders. For example, deployment of DER by consumers negatively impacts utility revenues. Methods to resolve these basic conflicts need to be resolved.
- Today's operating models are not sufficient for effectively operating this new configuration. The transient and steady-state behavior of the modern grid with its many types of widely deployed DER needs to be better understood. New operating models and algorithms need to be developed to assist system operators in safely operating the modern grid. Its behavior is expected to differ substantially from today's grid, which is predominately powered by large, central generating plants. Also, improved simulation tools are needed to assist system planners in designing reliable power systems in this new environment.

Unless the noted gaps are successfully resolved, the rate of deployment of new and diverse generation options will be insufficient to fully realize the benefits of

the modern grid. The positive influences on reliability, security, economics, power quality, efficiency, environmental quality, and safety discussed above will therefore not be achieved.

Design Concept

Consumers, marketers, DER vendors, and suppliers of electric energy will become motivated by real-time and forecasted energy price signals. As a result, the next generation of DER devices will be improved and made cost effective. New instrumentation and control devices, as well as simplified interconnection codes and standards, will enable DER to be easily integrated (“plug and play”) with the modern grid, both from a power generation and communications perspective.

Aggregation and integration of DER beyond the individual consumer level such as energy “farms” will enable DER to have a larger impact on grid operations. New operational models will be developed to enable these decentralized generating farms to be most effectively utilized.

In general, the modern grid will expect DER capacity to be available and to respond on a real-time basis to optimize the energy cost to the consumer and at the same time enable system operators (both distribution and transmission) to effectively manage the reliability of the system(s).

The increased deployment of DER will also increase the use of renewable energy sources since many DER devices use environmentally friendly fuels. This may also be beneficial to the real-time emissions trading market.

Functional Architecture

Accommodating a wide variety of generation options has significant synergistic effects with other modern grid characteristics:

- Increased deployment of decentralized generation sources such as DER and DR systems, effectively integrated with the modern grid’s communication, instrumentation, and control systems, enables it to play a major role in the self-healing feature of the modern grid. DER and DR will respond in real time to preventive and corrective actions from system operators and other smart sensors such that reliability issues are avoided and, if not avoided, mitigated.
- Energy price signals received via the consumer portal coupled with the cost effectiveness of future DER and DR will engage the consumer to invest in DER to improve its reliability and reduce its energy costs.
- Wide geographical distribution and smaller generation capacities of DER inherently provide benefits from a security perspective. Common mode failures from a security attack or equipment failure are reduced as a result.

- Deep penetration of DER and DR systems enables major capital investments (i.e., centralized generating plants, substations, transmission and distribution lines, etc.) to be deferred, significantly reducing system costs.
- DER and DR operation will result in improved asset utilization and improved power quality particularly during times of system stress (i.e., peak load, storms, etc.)
- The continued investment in CT plants located near load centers will also improve asset utilization since the burden on the Transmission System is reduced.

Performance Requirements

As new generating sources of a more decentralized nature (such as DER) are integrated into the modern grid, they will operate seamlessly and perform in a real-time environment. More specifically, these new generating sources will:

- Auto start, load, and shut down in response to price signals and system operator and owner commands
- Provide for safe line crew interaction during maintenance and system restoration operations (in conjunction with smart sensors and control devices)
- Represent a significant amount of capacity, energy, and voltage support on an aggregated systemwide basis and will be utilized by the system operators to manage reliability and congestion
- Integrate safely and reliably with existing distribution topologies (e.g., long radial feeders) and operations

DR devices will also be expected to respond in real time to price signals and system operator requirements.

In addition, new operator visualization techniques and training will be needed to effectively operate and maintain a modern grid that contains a significant amount of smaller decentralized and often intermittently operating generating units.

Metrics should be established in the following areas:

- DER percentage of systemwide capacity, energy, ancillary services
- System and customer reliability (improvements)
- Power quality (improvements)
- Transmission congestion (improvements)
- Energy prices (with and without congestion)
- Capital investments (deferred investments)
- Environmental (reduction in emissions)

Design Constraints

While some penetration of DER technologies is occurring today, several significant barriers remain to full-scale deployment. To achieve the level of deployment needed to support modern grid operations, DER deployment must occur at the consumer level (residential, commercial, and industrial) and marketer level, as well as at the electric system level. The goal for DER deployment should be similar to what has occurred with the deployment of PC's, laptops, and cellular technology. Some of the constraints that currently prevent this level of deployment include:

- Generally, residential consumers are not billed on a real-time basis. Until consumers feel price signals on real-time system conditions and wholesale prices, they will not be motivated to pursue alternatives like DER. This constraint is significant and real. For example, when oil (and gasoline) prices rise significantly (and are felt by the consumer), significant efforts to seek alternative relief (i.e., ethanol-based gasoline, solar heat for residential water heaters, kerosene space heaters, shifts to more gas-efficient vehicles) are observed. Smart meters need to be deployed and real-time rates need to be developed to provide this price signal to consumers to motivate them to consider investing in DER.
- Currently, the total cost (investment, operating, maintenance, and fuel, etc.) for existing DER devices is too high and is not competitive with conventional alternatives.
- Although great strides have been made in DER research and commercialization, much is yet to be done. Stimulation to further improve the DER option portfolio should come from the demand side, i.e., the value proposition for the consumers and marketers needs to be real and depends on energy price signals or perhaps legislation. With assistance from the demand side, further investment in DER research and commercialization will occur. For example, fuel cells for the home and business, energy storage devices, and hydrogen fuel technologies are expected to be components in the future DER portfolio.
- Advances in research and commercialization of smart sensors, control devices, and gridwide communications are needed to support the level of autonomous control necessary for seamless operation of the modern grid.
- The development of reasonable and consistent interconnection and operation codes and standards for DER is moving too slowly. Efforts are underway at the federal level and within individual states (California, Michigan, Minnesota, New York, Texas, and Wisconsin) to develop fair and uniform interconnection standards to help facilitate the deployment of Distributed Energy Resources (DER). These codes and standards need to be finalized and adopted industrywide to enable the corresponding research, commercialization, and deployment of DER to be effective.

- National energy legislation and regulations are required that provide financial incentives for investing in DER deployment and usage. These programs should consider the total societal benefits of these programs. Investment incentives should be made available to consumers. Financial relief should be provided to corporations who make generation investments in the modern grid to help offset future stranded investments costs should they occur.

The ability of the modern grid to accommodate a wide variety of generation (DER) options depends on successfully motivating the residential, commercial, and industrial consumers and marketers to invest in DER. Until this occurs, DER investment will primarily be funded by the electric industry, which will limit its deployment. Ironically, significant demand-side investment in DER by the consumers will drive improvements in the modern grid's ability to accommodate new generation options.

Design Features and Functions

The ability of the modern grid to accommodate a wide variety of generation options depends not only on the demand (desire) to deploy DER but also on the following additional enabling modern grid design features and functions:

- Advanced real-time pricing technologies (dispatched from transmission and distribution operators) are needed to establish price signals to motivate consumers to invest in DER. In addition, new rate designs will be required to define the real-time pricing process and details.
- Smart meters and information gateways are needed to receive, process, and act on price signals in real time. Additionally, energy management systems on the consumer side of the meter will be required to monitor and control DER operations and demand response actions in an integrated manner.
- Smart sensors and protection and control devices are needed to integrate real-time operation of DER with system needs. Lower cost smart sensors and protection and control devices will reduce the installation costs of DER, ensure stable operation of many interconnected DER units, and provide for the safety of line crews and the general public during system maintenance and restoration. In addition, these devices will be needed even more as the demand for autonomous controls increases.
- Standard and ubiquitous communications are needed to enable the exchange of data. A standard open architecture for data transmission acceptable to vendors, consumers, and utilities is needed to eliminate the concern for stranded investments and stimulate DER deployment.
- Advanced system planning tools that integrate the benefits of DER and consider the uniqueness of their operation are needed to optimize the siting of conventional, centralized power stations.
- Improved operator visualization techniques and new training methodologies are needed to effectively operate the modern grid, which contains a significant

amount of smaller, decentralized DER units providing generation and energy storage. These methodologies must also address the integration of large numbers of DER into “farms” as well as the intermittency of operation of some DER, such as wind and solar.

Expected Benefits

The benefits from accommodating a wide variety of generation options will be realized in the following areas:

- Increased diversity of generation and DR capability needed to support the self-healing feature of the modern grid
- Reduction in the need for new centralized generating stations and transmission lines
- Reduction in congestion and transmission demand by siting generation closer to loads
- Improved power quality and reliability due to increased robustness of the grid, leading to cost savings to consumers
- Improved efficiency in grid operations due to more effective economic dispatch and better asset utilization, leading to the lowest possible prices for energy for consumers
- Reduction in vulnerability to security attacks due to decentralization of DER
- Positive impact on the environment as the deployment of green sources, such as wind and solar increases
- Growth of retail electricity markets (capacity, energy, ancillary services) and, potentially, emissions markets

Recommendations

Today’s grid does not currently support the needed rate of deployment of generation options to fully realize the benefits of the modern grid. Some specific actions that would accelerate deployment include:

- Smart sensors and protection and control devices need to be developed that use standard communication protocols to integrate real-time operation of DER with system needs.
- An integrated communications platform using standard communication protocols needs to be developed to enable data to be exchanged among sensors, users, and control centers on a network basis.
- State Public Utility Commissions need to develop tariffs for real-time pricing so that consumers participate in the energy market based on real-time supply and demand pricing.

- Advanced real-time pricing technologies (dispatched from transmission and distribution operators) are needed to establish price signals to motivate consumers to invest in DER.
- Smart meters and information gateways (on customer side of the meter) to receive, process, and act on price signals in real time need further development.
- National energy legislation and regulations are required that provide financial incentives for investing in DER deployment and usage.
- Advances in R&D and commercialization of DER are needed to lower its cost to make it more competitive with conventional sources of generation.
- RTO's need to put a higher priority on the use of DER as a future solution to transmission line congestion.
- State level regional pilots are needed to demonstrate the value and uses of DER technologies coupled with innovations in grid design and automation. These pilots would establish a baseline to encourage follow-on investments in DER-enabled grid infrastructure.
- A consistent vision for the modern grid that clearly identifies the role of generation, DER, and DR needs to be defined and accepted by all stakeholders. Regulatory and legislative reform at both the federal and state levels can then occur consistently with this vision. Policies and statutes need to be put in place that endorse this vision, thereby bringing consistency among the regulators and removing barriers to making progress.

Other Considerations

Security Aspects

The ability of the modern grid to accommodate a wide variety of options can reduce its vulnerability to security attacks and also improve its security during major natural events. Some specific security enhancing features include:

- Decentralization of DER to the distribution level reduces the grid's vulnerability to a single security attack.
- Diversity in a geographic location provides alternate means to restore the grid following a major natural event.
- Diversity of fuels at central generating stations (coal, oil, gas, nuclear, hydro) coupled with the diversity of fuels utilized by decentralized DER (wind, solar, gas, hydrogen for fuel cells, etc.) increases the probability adequate fuel supplies will be available.
- Diversity in DER (and central generation) technologies reduces the chances for a common mode failure to impact overall operation of the modern grid.
- Large quantities of smaller DER, coupled with smaller quantities of large centralized generation, reduce the impact of unit(s) failure on overall grid operation.

Issues and Outstanding Questions

The vision for how generation options will be accommodated into the modern grid is relatively clear. The question is “How do we achieve full-scale implementation”? The answer to this question lies in the resolution of the following issues:

- Deployment of DER is still a supply-driven effort and does not yield the level of participation needed to support a modern grid. The end user (demand side) needs additional motivation to achieve the needed level of DER penetration. This can be done through the real-time pricing of energy or through other financial incentives.
- Technical barriers to successful deployment need to be resolved. A standard communication platform and protocol has not been adopted and causes investors to hesitate for fear their investments will be stranded as technologies change (i.e., beta vs. VHS). Additionally, smart sensors, meters, protective relays, controls, and gateways need to be compatible with the standard communication platform.
- A better understanding is needed of how various distribution systems will behave, particularly during upset conditions, when DER of many types and designs are broadly deployed.
- The total cost of DER is too high and needs to be reduced to make it more competitive with other generation options.
- Deeper penetration of real-time pricing tariff options is needed.
- Conflicting agendas exist among some stakeholders. For example, deployment of DER by consumers negatively impacts utility revenues. Societal benefits desired by government are normally not considered in the business plans of marketers and utilities resulting in some projects not being funded. These are often the projects most important for achieving the vision of the modern grid.

Quality Aspects

Performance standards (in addition to the interconnection and operation standards discussed above) and associated metrics need to be developed to ensure that the DER owners continuously meet their obligations to the operators of the modern grid (i.e., does the unit follow its dispatch instructions within tolerances, etc.) Each owner should be expected to perform his or her own self-assessments to ensure compliance with these standards. Periodic audits should be performed by an appropriate regulatory group and enforcement actions taken when needed.

User Interface

The modern grid with its wide deployment of decentralized and often intermittent (particularly wind and solar) DER must be operated differently than today’s conventional centralized EMS control design. Visualization techniques need to

be developed, consistent with the new operating approach, and made available to the system operators at both the transmission and distribution levels. Better integration between transmission operators and distribution operators in such areas as communications, technologies, and training (normal and emergency operations) will also be needed.

Key metrics need to be developed, standardized, and communicated to the operators, regulators, and other stakeholders to provide the transparency needed to most effectively support the safe operation of the modern grid.

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