THE NETL Modern Grid Initiative
Powering our 21st-Century Economy

BARRIERS TO ACHIEVING THE MODERN GRID

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DISCLAIMER

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EXECUTIVE SUMMARY

Our national electric grid is troubled. Utility and technology experts agree that there's an urgent need for major improvements in the nation's power delivery system.

Robust trends in the power industry point out this need. Some of these trends include:

- Increasing business losses from grid issues
- Increasing transmission curtailment actions
- Increasing number of small generators on the grid
- Increasing number of small business and residences divorcing from the grid
- Fewer young engineers entering the power field
- Limited deployment of modern grid technologies

These trends suggest the grid is in trouble and are related to the issues that make the news – another blackout costing society millions, rising prices of electricity, increasing transmission costs due to congestion, increased dependence on foreign oil, impacts on global climate, reduced capital spending by utilities, and poor reliability of service in general. These issues are significant yet only symptomatic of deeper issues affecting today's grid.

Significant barriers exist that threaten our progress in grid modernization. At one time America's grid was a state-of-the-art system. It helped bring a level of prosperity to the United States unmatched by any other nation in the world. But a 21st-century U.S. economy cannot be built on a 20th-century electric grid. Today's grid must be modernized. It must meet increasingly higher standards in reliability, security, cost of service, efficiency, environmental impact and safety. But, a number of barriers must be addressed before modernization can be accelerated to the level needed to successfully support our national security and our growing economy.

What are some of these barriers? Many of the technologies needed for grid modernization are available today. Widespread deployment of these technologies, however, is limited because barriers diminish the incentives for stakeholders to invest. These barriers fall into the following general areas:

- Regulatory & Legislative
- Culture & Communication
- Industrial
- Technical

How will these barriers be resolved? The Modern Grid transition plan will define the logical sequence for achieving the seven principal characteristics (PC's) that define its vision. But, before these PC's can be realized, the barriers that impact their achievement must be resolved. The resolution of some barriers will address national issues, and those issues should be addressed as a priority. The resolution of other barriers may occur gradually and at different priorities based on the unique differences among regions. Figure 2 illustrates how the barriers of the modern grid will be addressed as the transition to the Modern Grid occurs.

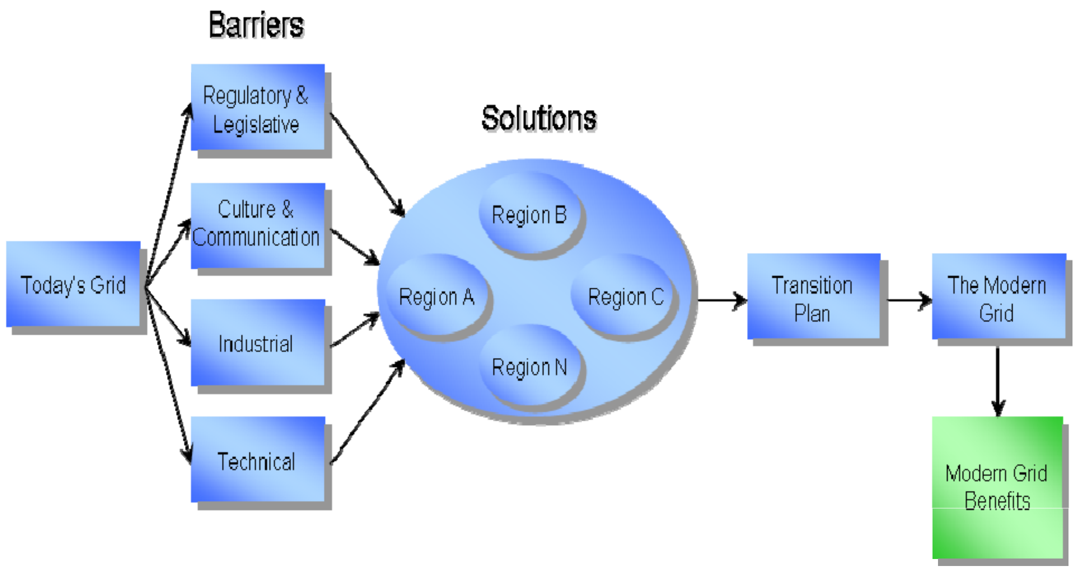

Figure 1: Resolution of Modern Grid Barriers

The purpose of this document is to present the most significant barriers to achieving the principal characteristics of the Modern Grid and to offer some suggestions for addressing them so its vision can be realized.

REGULATORY AND LEGISLATIVE BARRIERS

The Energy Policy Act of 2005 was a good first step in addressing barriers to grid modernization, but more is needed.

Legislators and regulators have not yet taken a strong leadership role in support of grid modernization. A clear and consistent vision for the Modern Grid has not been adopted by legislators or regulators. Much has been said about individual technologies such as renewables and about specific energy issues such as environmental impact, but little has been said about the overall vision for a modernized grid – a vision that integrates the appropriate technologies, solves the various grid related issues and provides the desired benefits to stakeholders and society.

In addition to aligning around a common vision, policy makers need to understand what the specific, individual actions are that they can take to accomplish the vision. Modern Grid advocates need to work with policy makers by presenting detailed policy proposals. Additionally, a Modern Grid transition plan is needed to help all stakeholders understand the intermediate milestones for achieving the Modern Grid vision.

Current rate designs limit progress in grid modernization. Real time rates that reflect actual wholesale market conditions are not yet widely implemented, preventing the level of demand side involvement needed in the Modern Grid. Net metering policies that provide consumers full retail credit for energy generated by them are also not widely deployed, reducing the incentive for consumers to install DER. Also, policies and regulations to encourage investment in power quality (PQ) programs, including those that provide pricing related to grades of power are not in place.

Some regulatory policies penalize utilities for supporting and investing in modern grid technologies. For example, from a strictly financial perspective, utilities are motivated to address system peak issues by investing in new generating facilities – which increases their revenue requirement -- rather than supporting consumer-side demand response (DR) opportunities – which reduces their revenues. New methods are needed to provide the incentive for marketers and utilities to invest in technologies that benefit society and are consistent with grid modernization even when those investments negatively impact their revenue stream. New regulatory models that decouple profit from revenue may be a solution to this conflict.

Incentives to stimulate modern grid investments that provide societal benefits are lacking. Regulatory policies often do not give credit to utilities for investments that provide substantial societal benefits (e.g. improvements in reliability and national security, reduction in our dependency on foreign oil, reductions in environmental impacts, etc.). Financial incentives at both the federal and state levels would enable such projects to pass financial hurdles that they otherwise could not -- enabling the projects to proceed.

Deployment of modern grid technologies is costly, and without such incentives, utilities and energy providers are reluctant to invest in these needed technologies when they would bear all of the costs but where many of the benefits would accrue to other parties or to society as a whole. And the absence of regulatory certainty inhibits technology deployments, as utilities and energy providers are left to weigh the risks of advanced technology investments with little assurance that the investment will be recoverable.

In addition to regulatory changes, changes in the tax law should be considered to make modern grid investments tax-preferred. Tax incentives have been in place for many years for other preferred areas such as energy efficiency and renewable energy. Investment tax credits and incentives tied to more efficient operation of the grid and/or reduction in electricity costs might be helpful.

Regulations that support integrated electricity markets are needed. Federal and state regulations should support and not interfere with the development of large integrated wholesale electricity markets, which meet the needs of consumers and system operators. In the transition to fully enabled markets, there may be individual dissatisfaction along the way, but consumers, and society as a whole, will win. Regulations should support the ability of the Modern Grid to enable markets where they are appropriate.

Inconsistent policies among the states and with federal regulators prevent effective collaboration across a national footprint. Differing regulations among states that are electrically interconnected present challenges to the operation of a larger interconnected network and to the development of one that is even more integrated and dynamic. The optimal model for the electric industry has not been found and the lack of a consistent solution is a barrier to grid modernization. Coordination among local, state and federal agencies on this issue is needed.

Alignment of regulatory policies to support grid modernization is generally weak. In general, regulatory policies were not designed with grid modernization in mind. Consequently, various specific policies need to be reviewed and updated. Some examples include:

- State legislatures and regulatory commissions currently focus on protecting consumers from the risks of consumer choice. Regulatory policy does not currently support the transition of consumers from passive protected users to proactive informed users as has occurred in other industries such as telecommunications and transportation.
- A significant reduction in R&D expenditures by utilities is an unintended drawback of deregulation and should be addressed to support grid modernization.
- Some existing utility assets are technologically obsolete and are incompatible with new modern grid technologies. Regulatory policies are needed for addressing the replacement or modification of these assets so that modern grid technologies can be integrated with them. Recovery of remaining book value of retired obsolete equipment is needed.
- Current policies often penalize consumers rather than utility shareholders for ineffective management decisions.

- The consequences of such actions as Renewable Portfolio Standards (RPS), carbon tax, cap and trade, and carbon capture and sequestration will impact how the grid evolves and performs. Climate change legislation and regulations should be developed in the broader context of grid modernization so that both objectives can be effectively and efficiently met.

CULTURE AND COMMUNICATION BARRIERS

More work is needed to communicate the concepts and benefits of the Modern Grid to a wide variety of stakeholders and the general public and to encourage them to embrace the changes that will be needed to achieve the modern grid vision.

Modernization of the national electric grid is a complex endeavor. Successfully achieving its vision depends on the involvement of a diverse group of stakeholders educated in its vision, technologies, benefits and opportunities and united to accomplish it.

Stakeholders do not see a "burning platform" or a case for change. The societal consequences of inaction (i.e. not modernizing the grid) have not been clearly articulated to our diverse group of stakeholders. A lack of understanding of the fundamental value of a modern grid, and of the societal and economic costs associated with an antiquated one, has created the misperception that today's grid is good enough or at least not worth the sacrifices involved in improving it. Even the inconvenience and cost of infrequently occurring large scale blackouts are quickly forgotten. More effort is needed to communicate and educate our citizens in the following areas:

- Today's grid is vulnerable to attack.
- An extended loss of the national grid would be catastrophic to our nation's security, economy and quality of life.
- Today's grid will not address the security and economic challenges of the 21st century.
- A modern grid will be the platform, system and network that will enable clean technologies, demand side management and other options for addressing climate change to be deployed.
- A modern grid will help the US become less dependent on foreign energy.
- A modern grid will be a more efficient and less costly grid.
- The performance of today's grid may lead to loss of jobs in the future as work is transferred to countries with more reliable and economic grids.

Effective consumer education is lacking. The benefits of a modern grid have not been made clear to consumers. Some potential components of the consumers' value proposition include:

- More effective monitoring and control of energy consumption to reduce overall electricity costs.
- Participation in future electricity markets for demand response, spinning reserve, energy, etc.
- Enjoyment of future value added services that may be enabled by a modern grid.

Consumer involvement is a required ingredient for grid modernization and consumer education is the first step in gaining their involvement. Much remains to be done in the area of consumer education.

The not in my backyard (NIMBY) philosophy must be resolved to reduce the excessive delays experienced today in deploying needed upgrades to the grid. Solutions are needed to reduce the concerns of citizens who object to the placement of new facilities near their homes and cities. New ideas are needed to make these new investments desirable rather than objectionable to nearby citizens. Communication of the Modern Grid vision with its goals of improving efficiency and environmental friendliness may help address this issue.

INDUSTRIAL BARRIERS

A broad consensus for the Modern Grid vision throughout the power industry is gaining momentum but has not yet been institutionalized. A greater understanding of the advantages and benefits of the Modern Grid is needed. And once consensus is reached, a transition plan defining the pathway for transforming today's grid into the Modern Grid is needed.

Electric utility executives do not see a burning platform that would motivate them to change. Most say that their customers are happy, their reliability is good, and their customers want lower rates not higher ones. They are hesitant to make major investments in their systems. In fact, the financial markets are driving them to minimize investments and there is no force on the horizon to make them do otherwise. However, the consequences of "doing nothing" should be considered:

- Increasing number of major blackouts
- More local interruptions and power quality events
- Continued vulnerability to attack
- Less efficient wholesale markets
- Higher electricity prices
- Limited customer choice
- Rising product prices
- Greater environmental impact

More cooperation among utilities is needed. The free exchange of information among the approximately 3,000 diverse utilities is needed to successfully achieve the Modern Grid vision. Some industry observers believe that, as a result of deregulation, the industry's corporate culture has moved from cooperation and coordination to competition and confrontation. Relationships among utilities need to shift to a more collaborative model.

Business cases for investing in modern grid processes and technologies are often incomplete and therefore not compelling. It is often easier to demonstrate the value of the end point than it is to make a sound business case for the intermediate steps to get there. Societal benefits, often necessary to make investments in modern grid principles compelling, are normally not included in utility business cases. Additionally, lack of protection from inherent investment risks such as stranded investments further impacts the ability of these investments to pass financial hurdles. Meanwhile, the increased number of players and extent of new regulation has complicated decision making. Credit for societal benefits in terms of incentives and methods for reducing investment risks might stimulate the deployment of modern grid processes and technologies.

Incompatible equipment must be replaced if it cannot be retrofitted to be compatible with modern grid technologies. Unlike many of today's other technologies such as the personal computer and the cell phone which are upgraded frequently, grid technologies are rarely upgraded -- advanced meters are an example. Early retirement of grid assets to incorporate new technologies needed by the Modern Grid may become an issue with regulators since keeping equipment beyond its depreciated life minimizes the capital cost to consumers. Recovering the cost of retired obsolete equipment that has not been fully depreciated should also be addressed.

Industry executives are reluctant to change processes and technologies. Some utility cultures are resistant to change and operate in “silos” organizationally. As a result, processes and technologies that are based on long standing practices and policies are difficult to change. Additionally, senior managers today may be more focused on marketing and legal issues, rather than the technical aspects of power systems. The result may be an over reliance on markets to address grid modernization issues rather than proactive investment in new processes and technologies. Integration of change management techniques into utility organizations might stimulate change in their culture.

Industry technical staffs are reluctant to change planning and design traditions and standards. Utility planning and design traditions and standards generally focus on the traditional model of the electric grid – centralized generation, legacy technologies, and little reliance on the consumer as an active resource. Modern grid principles have generally not been incorporated into technical policies and standards which limit the deployment of new processes and technologies that exist today. A significant change management effort is needed to encourage technical staffs to modify their current approach.

Resources at many utilities (both human and financial) are limited and stressed. The amount of resources available to look beyond day-to-day operations is limited. As a result, only slow progress is being made in the area of grid modernization.

Little exposure and priority is given to conducting regional and national demonstrations. These demonstrations would bring the needed exposure of modern grid principles to energy company executives. Through such projects, the substantial value of integrating suites of technologies rather than deploying multiple, often redundant ones in isolation can be demonstrated. This would create interest, excitement, and the societal, political, and economic stimuli needed to accelerate the deployment of the successful integrated suite of technologies demonstrated. Regional and national demonstrations would also provide the data needed by regulators to assist them in crafting policies and regulations.

Investments in security upgrades are difficult to justify. A standard approach is lacking for conducting security assessments, understanding consequences, and valuing security upgrades. Additionally, limited access to government-held threat information makes the case for security investments even more difficult to justify. When examined independently, the costs and benefits of security investments can seem unjustifiable. It is difficult to place a value on preventing a cyber or physical attack through implementation of security measures.

The level of R&D spending in the utility sector is amazingly low. Utilities are among the lowest of all industries in R&D as a percent of revenue (less than 1%). Competitive high tech industries are 5-10 times higher. Yet the move to make electricity competitive has not spurred more industry R&D. R&D costs are often not explicitly stated as a line item in rate cases. As a result these costs are often the first to be cut when less than favorable rate case decisions are made.

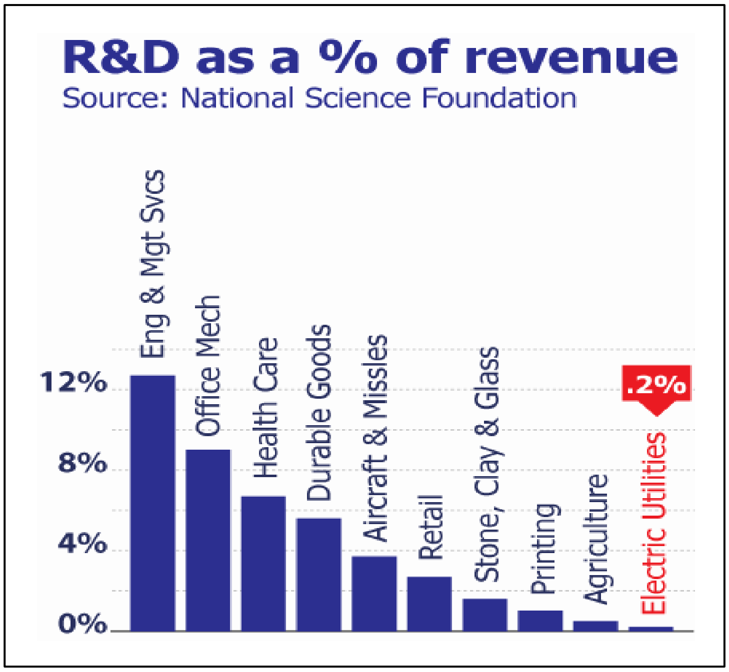

Figure 2: Research and Development as a Percent of Revenue

TECHNICAL BARRIERS

The speed of technology research, development and deployment in the power industry has been slower than in other industries. Technology development and deployment needs to be accelerated.

Needed codes and standards are lacking. New ones need to be created and existing ones updated to support wide-scale deployment of modern grid technologies. For example, universal communications standards and a common architecture that promote interoperability and enable the various communication technologies to work as an integrated suite are needed. Interoperability will enable data from virtually any source to be utilized by virtually any application.

Open communication and operating systems may be vulnerable to security issues. Although open systems are more flexible and improve system performance, they are not as secure as proprietary systems. The increasing use of open systems must be met with industry approved and adopted standards and protocols that ensure system security.

The integration of multiple key technologies has not yet occurred. The benefit realized from the integration of suites of technologies normally exceeds the sum of the benefits of the individual ones. For example, the deployment of integrated communication systems, including supercomputers, is needed to support the processing and analysis of the large data volumes that will be supplied by advanced technologies of the modern grid. Deployments of individual technologies often fail because they have not been adequately integrated with other needed technologies.

The price of many new technologies is currently not competitive with traditional alternatives and should be reduced to stimulate the level of deployment needed to achieve the Modern Grid. As the price ultimately is reduced, technical performance is proven and societal benefits recognized, the demand for these technologies will increase leading to further reductions in prices. Economies of scale and design innovation are needed to drive costs down.

Distributed system behavior is not well understood. Further study is needed to understand how various distribution systems interact when DER of many types and designs are broadly deployed (particularly their behavior during upset conditions).

The growing number of participants in the electric system increases the complexity of security issues. Security measures, both physically and cyber related, must be built into the functions that support distributed energy resource (DER) owners, Independent Power Producers, and consumers active in demand response and automated metering programs. Security of supervisory control and data acquisition (SCADA) and protective relaying systems must also be guaranteed.

A declining infusion of new thought is occurring. The technical experience base of utilities is graying. The talent pool is shrinking due to retirements and a shortage of new university graduates in the power engineering field. Additionally, fundamental knowledge and understanding of power system engineering principles is being lost as more and more of the technical analysis is done by computers rather than by human resources.

Our ability to store electrical energy remains limited. One of the most fundamental and unique limitations of electricity is that it can not easily be stored for use at a later time. Although incremental progress is being made in energy storage research, the discovery of a disruptive storage technology would greatly accelerate grid modernization.

SUMMARY

There are many reasons the Modern Grid is not emerging more quickly. Fundamentally, no single business owns or operates the grid. Individual players have little incentive to risk major change. With so many players in the grid system, finding a common interest in or vision for change is difficult but imperative.

The benefits are so broad and far reaching that perhaps only government can account for the cumulative societal value. Longer term financial incentives are needed to enable the larger infrastructure investments needed for grid modernization.

Many barriers exist today and more will arise before the vision is realized. These challenges are daunting, but they can be overcome. With a clear vision, we can generate the alignment needed to overcome the barriers discussed in this document as well as those yet to be identified. Some options include:

- **Regulatory and Legislative barriers** – change statutes, policy, and regulations to eliminate those that inhibit progress and create those that encourage progress and create a "win-win" scenario for all stakeholders. For example:
    - Capture and include the full set of societal benefits when addressing the costs of grid modernization.
    - Provide regulatory certainty that modern grid investments will be recovered.
    - Establish grid modernization goals, metrics and coordination mechanisms to better manage the transition to the Modern Grid.
    - Provide enhanced returns on modern grid investments.
    - Modify the model that links utility profit to sales volumes.
- **Culture and Communication barriers** – increase the understanding and awareness of stakeholders on the value of the Modern Grid and encourage them to embrace the needed changes within their organizational cultures.
- **Industrial barriers** -- define the case for change, the "burning platform", and provide the necessary incentives to engage industry on grid modernization. Industry will respond when it understands there is a profitable market for grid modernization technologies and services.
- **Technical barriers** – increase the speed of research, development and deployment.
    - Increase funding to support research, development and deployment for those technologies that are needed for grid modernization.
    - Work more closely with academia to develop the human resources with skills needed for the modernized grid.
    - Apply more priority and resources to the development of needed standards.

– Clarify the pathway to the Modern Grid by developing a transition plan that shows the intermediate milestones for achieving its vision.

Creating the Modern Grid will require a significant effort by many stakeholders. Through the Modern Grid Initiative, the OE and NETL are working objectively with stakeholders -- federal, state, and local government, utilities, vendors, policy and regulatory agencies, advocacy groups, consumers, academia and others -- to develop solutions to many of these barriers. Your input is needed to assist in the resolution of these barriers and to help identify new ones as they arise. By working together we can resolve the many barriers that impact a smooth transition to the Modern Grid.

A collection of documents regarding related aspects of the Modern Grid has been prepared and is available for free download at NETL's Modern Grid website. For additional information regarding the Modern Grid please use the resources listed below:

Website: www.netl.doe.gov/moderngrid

Email: moderngrid@netl.doe.gov

Phone: (304) 599-4273 x101

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