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

MODERN GRID BENEFITS

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EXECUTIVE SUMMARY

The US electrical grid, once the envy of the world, is no longer world-class. Unlike all other industries that have benefited from the past three decades of technology advancement, the US electric power infrastructure remains bogged down with mid-20th century technology. The reasons are many, but the result cannot be acceptable to a society that wishes to prosper in the 21st century.

A modern grid having the following principal characteristics is needed to meet the demands of the 21st century:

- **Self-heals:** The modern grid will perform continuous self-assessments to detect, analyze, respond to, and as needed, restore grid components or network sections.
- **Motivates and includes the consumer:** Consumer choices and increased interaction with the grid bring tangible benefits to both the grid and the environment, while reducing the cost of delivered electricity.
- **Resists attack:** The grid deters or withstands physical or cyber attack and improves public safety.
- **Provides power quality for 21st century needs:** Digital grade power quality avoids productivity losses of downtime, especially in digital device environments.
- **Accommodates all generation and storage options:** Diverse resources with "plug-and-play" connections multiply the options for electrical generation and storage including new opportunities for more efficient, cleaner power production.
- **Enables markets:** The grid's open-access market reveals waste and inefficiency and helps drive them out of the system while offering new consumer choices such as green power products. Reduced transmission congestion leads to more efficient electricity markets.
- **Optimizes assets and operates efficiently:** Desired functionality at minimum cost guides operations and fuller utilization of assets. More targeted and efficient grid maintenance programs result in fewer equipment failures.

The resulting benefits of a grid with these principal characteristics are enormous. They include:

- Virtual elimination of cascading outages, such as occurred August 2003.
- Increased national security through deterrence of organized attacks on the grid and reduced reliance on imported fuel.
- Reduced energy losses and more efficient electrical generation.
- Improved power quality.
- Reduced environmental impact.
- Improved US competitiveness, resulting in lower prices for all US products and greater US job creation.

- New customer service benefits.

This document describes the benefits of a modern grid in the following areas:

- Reliability
- Security and safety
- Economics
- Efficiency
- Environment

The broad scope of these benefits is reflective of the fundamental societal role of electricity. While not free, the collective value of these grid modernization benefits far exceeds their cost.

IMPROVEMENTS IN RELIABILITY

MAJOR REDUCTION IN OUTAGE DURATION AND FREQUENCY

The annual cost of power disturbances to the US economy is enormous (on the order of $100 billion according to EPRI). The modern grid will dramatically reduce this cost.

Distribution circuits will contain new protection, communications, and control elements able to sense circuit parameters, isolate faults, and quickly restore service by employing such tools as automated feeder ties and distributed resources. In addition, effective consumer interfaces will allow the incorporation of demand response and real-time load management as an active factor in grid operations. And advanced decision support systems will "know" when there is a need to quickly reduce load on the electric system.

The real-time acquisition and transfer of data will support the modern grid's ability to detect, analyze, and respond autonomously to adverse conditions. Advanced sensors and new measurement techniques will collect valuable information about electrical conditions throughout the grid.

In response to signals from system operators and smart sensors, distributed energy resources (DER) will respond in real time with corrective actions. A modern grid will also immediately call for increased real and/or reactive support from distributed energy resources to help meet transmission and distribution needs. The combination of distributed generation and storage options, along with a modern grid's advanced communication and control systems:

- Reduces dependency on the transmission system by strengthening the distribution system.
- Increases operational flexibility during routine, emergency, and restoration activities and reduces system restoration time following major events.
- Reduces the risk of a common mode failure affecting overall operation of the entire grid.

FAR FEWER POWER QUALITY (PQ) DISTURBANCES

Power Quality improvements reduce cost and inconvenience of momentary power system disturbances.

Power quality issues represent a large annual cost to society, estimated to be in the tens of billions of dollars. Merely avoiding the productivity losses of poor quality power to commercial and industrial customers can shed billions of dollars of waste from the economy. The costs associated with power quality events at commercial facilities such as banks, data centers, and customer service centers can be tremendous, ranging from thousands to millions of dollars for a single event. The costs to manufacturing facilities can be even higher. Voltage dips that last less than 100 milliseconds can have the same effect on an industrial process as an outage that lasts several minutes or more. EPRI estimates that, by 2011, 16% of the US electric load will require digital-quality power. Data from an EPRI study indicates that sags exceeding acceptable industry standards occur at a typical industrial facility five or more times each year. A modern grid will dramatically reduce such occurrences.

The modern grid will detect and correct power quality issues. Supply-side and demand-side conditions will be monitored to identify both emerging and actual power quality issues. Appropriate corrective actions will be taken to address power quality challenges before they become significant.

At the transmission level, Flexible AC Transmission Systems (FACTS) or superconducting synchronous condensers will provide instantaneous support of voltage to reduce the sags that are the biggest customer power-quality problem. Superconducting fault current limiters will reduce the voltage depressions created by transmission system faults, while synchronous switching will limit transient over-voltages.

At the distribution level, high-speed transfer switches will instantly remove disturbed sources and replace them with clean, backup power supplies. FACTS-like devices (e.g. dynamic voltage restorers), DER, and microgrids will provide voltage support and buffering to minimize power-quality events.

The reduction of power quality problems will produce a proportional reduction in several categories of loss:

- Scrapped materials – This cost can be significant in industries where both the manufacturing process and product quality are extremely dependent on power reliability and quality.
- Customer dissatisfaction – Although difficult to quantify, this factor can create a negative perception that loses clients, revenue, and goodwill.
- Lost productivity – Even if business shuts down, overhead costs continue and compound the resulting loss of revenue.
- Customer safety – In some manufacturing processes, power perturbations can create safety dangers.

Intelligently improving PQ in the nation's power system will offer opportunities to broaden and enrich the commercial bases of struggling communities and regions. Rural communities will be able to support clean, high-tech industries that demand high quality and reliable power. New jobs and higher tax bases will transform regions and communities that once depended solely on agriculture or single industries.

Poor power quality negatively affects the life and efficiency of both consumer equipment and the grid itself. For example, harmonic currents associated with poor power quality produce no useful power yet create electrical losses and heat that must be supplied by increased electrical generation. Since poor power quality leads to shorter electrical equipment life and higher electrical (KWH) losses, economic and environmental benefits accrue to both the consumer and the utility when PQ is improved.

Virtual Elimination of Regional Blackouts

With a modern grid, the probability of regional blackouts can be reduced to near zero.

The societal cost of a massive blackout is estimated to be in the order of $10 billion per event as described in the 'Final Report on the August 14, 2003 Blackout in the United States and Canada'. That blackout left over 28 million people in Michigan, New York, Ohio, and other states without electricity for up to four days. The modern grid will be far less vulnerable to such occurrences. The modern grid will employ multiple technologies to identify threats and immediately respond to maintain reliable service.

With improved human interfaces and decision support, complex and extensive system information will be rendered into formats quickly understood by trained system operators so they can:

- Understand the overall status of the grid at a glance.
- Maintain grid security and integrity by quickly detecting and mitigating threats against it.
- Identify stressed equipment so that relief can be provided or equipment replaced before a breakdown can occur.

Integrated communications will enable the development of new, real-time analytical tools, including wide-area measurements and their interpretation that will assist system operators in predicting and preventing events that impact grid reliability. These tools will also support the post-mortem analysis of such events. Advanced tools will analyze system conditions, perform real-time contingency analyses, and rapidly initiate corrective actions. Power stabilization software will look for the early signs of a cascading blackout and automatically mitigate the event faster than humans can react.

Advanced components (such as flexible AC transmission systems) will give the grid the ability to respond quickly to emerging problems by using strategies like instantly changing flow patterns and voltage conditions, while demand response (DR) tools, including grid friendly appliances that automatically respond to frequency and voltage deviations, will allow corrective load modifications. And advanced protective relaying systems will sense and address regional troubles, rather than just local events.

IMPROVEMENTS IN SECURITY AND SAFETY

SIGNIFICANTLY REDUCED VULNERABILITY TO TERRORIST ATTACK AND NATURAL DISASTERS

A Center for Contemporary Conflict white paper estimates the direct cost of the 9/11 terrorist attack at $27 billion, in addition to the tragic loss of life.

The modern grid is one weapon in a strategy to reduce the risk of such attacks in the future. Intelligent networking and the broad penetration of DER will make the modern grid far more difficult to attack. Sophisticated analytical capabilities will detect and prevent or mitigate the consequences of any attack. Probabilistic analytical tools will also identify any inherent weaknesses in the grid so that they can be integrated into an overall national security plan.

Extensive real-time data acquisition capabilities will immediately detect security challenges, and initiate high-speed corrective steps. The modern grid's integrated communications infrastructure, which overlays the entire electric network will provide detection and mitigation of both cyber and physical threats. It will also provide timely key data needed by rapid response organizations in an emergency. And, as an additional bonus, this tamper-proof grid monitoring and communication system will improve the security of even non-grid infrastructure since the electric grid extends to virtually all other sensitive societal systems.

The deployment of a wide variety of generation options reduces vulnerability:

- Decentralization to the distribution level reduces the impact of a single attack.
- Diversity in DER gives operators more choices in response to a security emergency.
- Diversity in a geographic region provides alternate means to restore the grid following a major event.
- Diversity of fuels at central generating stations (coal, oil, gas, nuclear, hydro) and at decentralized DER (wind, solar, gas, hydrogen for fuel cells, etc.) increases the probability that adequate fuel supplies will be available.

Besides improving the modern grid's inherent resilience, there are some unique side benefits of the modern grid's ability to resist attack. These include deterring an attack in the first place, because it clearly would have little effect, and improving the operational readiness of our defense forces by ensuring security-of-supply for electric power. Meanwhile, the grid's increased resistance to attack makes it better able to cope with natural disasters.

Improved Public and Worker Safety

Electric utility work is among the most dangerous of all occupations. APPA reports that about 1000 fatalities and 7000 flash burns occur annually in the electric utility business.

The self-healing feature of the modern grid includes the intelligence to ensure the safety of grid workers and the general public. Improved monitoring and decision support systems will quickly identify problems and hazards. For example, the ability to identify equipment that is on the verge of failure is certain to save lives and reduce severe injuries. Also, the modern grid creates less unnecessary maintenance, which means less exposure to accident and increased safety of maintenance personnel.

The condition and location of system assets, human resources, portable equipment, and physical landmarks such as roads, bridges, and city streets will be immediately available to system operators, significantly improving the logistical support needed to safely and efficiently complete restoration work.

In addition, by reducing the number and duration of outages, associated public safety and crime issues are proportionately reduced.

Improved Economics

Reduction or Mitigation of Prices

Market efficiencies will reduce, or at least mitigate, the price of energy and capacity.

In a modern grid, access to buyers and sellers of electricity will increase, and the price will be available to both in real time. Energy price signals will allow all consumers to participate in the electricity market, based on current supply-and-demand influences. There will also be a reduction in grid congestion and unplanned outages. Overall, markets will be more efficient, resulting in the economically correct price for electricity. For example, LECG, an economic and financial consultant, determined that the organized wholesale electricity markets of PJM and the New York Independent System Operator (NYISO) together have already reduced average electric rates between $430 million and $1.3 billion a year.

Fully enabled electricity markets will also drive smarter decisions about where to locate grid resources. Examples include the role of locational marginal price (LMP) as an added input to independent power producer (IPP) generation siting in Wisconsin, and added input to the siting of distributed generation in Connecticut.

New Options for Market Participants

More robust electricity markets create new options and revenue opportunities for those who choose to participate.

The modern grid will enable a wide array of new load management, distributed generation, energy storage, and demand-response options. Accommodating this variety of options adds to the modern grid's economic advantages by:

- Eliminating or deferring large capital investments in centralized generating plants, substations, and transmission and distribution lines, reducing overall costs by tens of billions of dollars over a 20-year period according to a 2003 Pacific Northwest National Laboratory report.
- Reducing peak demand and peak prices.
- Increasing the grid's robustness and efficiency, leading to cost savings and lower rates.
- And, as discussed previously, improving system reliability and power quality, leading to a huge reduction in economic losses incurred by business and residential consumers.

Extending electricity market participation to a wider stakeholder group (e.g., distribution companies, distributed generation owners, and consumers) will improve the performance of markets, whether wholesale or retail. Peak shaving and the accumulation of reserves, both of which are commercial products in the energy market, can provide revenue to their owners. And the "transformed meter", in the form of a consumer portal and other DR technologies, will provide a wealth of information to customers and utilities alike.

Demand-response programs will satisfy a basic consumer need - greater choice in energy purchases. As consumers respond to market data about increases in price, electrical demand will be mitigated. This ability to reduce or shift peak demand will allow utilities to minimize capital expenditures and operating expenses, keeping rates lower while also providing substantial environmental benefits by reducing the operation of inefficient peaking power plants. Consumers will become more engaged in determining alternative lower cost solutions, which also spurs new technology development. New customer service benefits will come with the modern grid, such as remote connection, more accurate and frequent meter reads, outage detection and restoration, and tamper detection. All benefit the customer directly or via utility savings that are passed through to customers. Viewed from a higher level, demand response will be a means by which the demand side is dynamically and continually balanced with supply-side resources to produce the most desirable and least costly electricity system possible. Consequently, Independent System Operators (ISOs) are increasing their focus on DR, both as a tool to mitigate emergencies and as a means to realize substantial economies.

DER is another modern grid element that will have a large economic impact. Deployment of DER will benefit the entire value chain of consumers. Simple connections to the grid will accelerate consumer usage of small generation and storage devices. Allowing the consumer to store and generate electricity in a coordinated way will support the grid by providing a wide range of economic and environmental benefits.

Improved electric system efficiency of a modern grid, as discussed in the next section, will also produce major economic savings.

IMPROVED EFFICIENCY

MORE EFFICIENT OPERATION AND IMPROVED ASSET MANAGEMENT AT SUBSTANTIALLY LOWER COSTS

Significant amounts (at least $40 billion in 2005 excluding fuel and purchased power) are spent annually by IOUs to operate and maintain the power system.

Much of the same data acquired to support the self-healing feature of the modern grid will also support improved asset management programs. Real-time data will be used to more effectively load assets and manage their condition. Advanced monitoring technologies which are part of the modern grid will:

- Allow for dynamic (continuous) equipment ratings, enabling greater use of existing assets.
- Enable optimal loading of assets.
- Provide detailed awareness of component and equipment condition.

Equipment condition data will lead to a reduction in failure-related maintenance and outage costs, improve the overall health and reliability of assets, reduce their out-of-service times, reduce the overall cost of maintenance, and improve the repair/replace decision-making process. The result will be a general decrease in operation and maintenance costs, with savings from productivity improvements, such as the elimination of routine tasks and reductions in material use.

With a modern grid, some assets will remain in service longer and have a lower maintenance profile. New advanced components such as fault current limiters will reduce the need to replace entire systems that are unable to handle the increasing fault levels associated with new distributed energy resources and increased power delivery capacity.

Major long-term investments needed to increase system capacity will become more cost effective when asset-utilization data and concepts are integrated into distribution and transmission planning models. The need for new and costly hard assets will lessen as integrated communications technologies provide alternative ways to increase grid reliability, rather than simply adding new and costly hard assets.

MORE ENVIRONMENTALLY FRIENDLY

MUCH WIDER DEPLOYMENT OF ENVIRONMENTALLY FRIENDLY RESOURCES

The modern grid will enable the deployment of all forms of generation and storage, including those that are environmentally friendly.

The modern grid will:

- Encourage the deployment of smaller DER sources, including those based on clean technology and those employing highly efficient combined heat and power. Because of its greater efficiency, emissions of CO2 per unit of useful energy are substantially lower at CHP units than at conventional fossil-fired power generation facilities. As of the end of 2005, CHP capacity in place was 83.5 GW. Department of Energy projections suggest that additional CHP opportunities at large industrial and commercial sites could be as high as 130 GW. The application of CHP for both large and small applications will produce large environmental benefits.
- Encourage greater access to the grid of more centralized hydro, solar, and nuclear power that produces zero emissions. According to a Business Roundtable energy report, current installed wind generation capacity is 9.65 GW and it could increase by 20 GW by 2025, while solar thermal generation is estimated to have the potential to generate an additional 4.5 GW by 2025. These renewables currently represent about 2% of US generation capacity. Various organizations have recommended renewable penetration be raised above 10%, resulting in a significant reduction of GHG emissions.
- Reduce the need for new centralized generating stations and associated transmission lines.
- Allow demand response and energy storage to be coupled with intermittent renewable resources to make such resources more viable and contribute a greater percentage of supply. Advanced metering systems will provide customers with information that will enable them to become more energy conscious consumers.
- Enable many states, through the use of low-emission DER sources , to meet their goals for Renewable Portfolio Standards

Environmental impact will also be significantly reduced by the modern grid's integrated communications and decision support technologies. Integrated communications will enable DER to be dispatched as a system resource, and also lead to increased investment in single DER units as well as larger DER farms. The modern grid’s improved decision support systems will provide a better understanding of the environmental impact of energy resources, allowing operators to balance that impact with economics in the dispatch of centralized generation and DER. Also, improved equipment failure prediction/prevention will reduce the environmental impact associated with such events as transformer fires and oil spills.

The proper application of FACTS devices, dynamic circuit ratings and other transmission technologies will allow the deferral of some transmission line additions. Improved transmission line power-transfer capability means fewer lines are ultimately needed, which also lessens environmental impact.

ELECTRICAL LOSSES REDUCED

Electrical generation is required to provide the energy consumed in electrical losses and by inefficient equipment. Hence efficiency improvements produce a one-to-one reduction in required generation, resulting in a corresponding reduction in CO2 and other plant emissions.

The modern grid is made more efficient by accommodating many generation alternatives. Generation sources, including plants, located near load centers reduce transmission losses. Grid efficiency will also greatly improve as advanced components maximize asset utilization and reduce electrical losses. As an example, superconducting lines and machines will produce major efficiency gains throughout the electric power system, including even at the customers' loads.

Demand response will also play a role in energy efficiency. In addition to the energy efficiency that it will enable and the emissions benefits that will result, demand response will be a key to addressing emissions in other ways. The advanced metering and other technologies put in place will allow more accurate measurement and verification of energy reductions – something that will be increasingly important under climate change policies that monetize greenhouse gas reductions. Beyond CO2, demand response holds promise as a dynamic emissions tool that can be used to address NOX and SOX non-attainment, which is most threatened during times of peak electricity demand.

The modern grid's focus on improved power quality also has environmental benefits. The reduction of harmonics and momentary voltage excursions will reduce electrical losses as well as equipment failures with their associated environmental damage.

SOCIETAL BUSINESS CASE

THE SOCIETAL BUSINESS CASE FOR GRID MODERNIZATION IS COMPELLING

According to EPRI, "The grid of the future will require $165 billion over the next 20 years". The benefits to society will be $638 to 802 billion. The cost-benefit is 4 to 1.

While these benefits to society take a wide variety of forms, some of the most obvious are captured below.

According to the Business Roundtable, the estimated dollar impact of T&D losses is over $25 billion per year. Annual T&D losses account for the equivalent of 226 million barrels of crude oil. Of all energy consumed to produce electricity, only 30% reaches consumers in the form of electricity; 60% is lost in generation and 10% is lost in transmission and distribution.

Transmission congestion costs are over $4.8 billion annually, with some estimates over $50 billion. Distributed generation can significantly reduce this cost. In Denmark, 50% of generation is from distributed energy, versus less than 10% in the US.

A Synapse Energy Economics study found that increasing energy efficiency, renewable energy, and distributed generation would save an estimated $36 billion annually by 2025.

The annual cost of reliability and power quality defects has been estimated to be at least $100 billion. Area blackouts are costing $1 billion and major regional blackouts such as occurred August 2003 cost $10 billion. According to Terry Boston of TVA, the combined cost of blackouts and PQ in 2001 was $119 billion. A nominal scenario developed by RAND placing annual losses at $50 billion shows them reduced by $15 billion annually with a 50% penetration of modern grid technologies in transmission and 25% in distribution. And with a RAND assumption of $100 billion in outage impacts and a slightly higher rate of technology penetration, losses could be cut by $49 billion annually.

Significant amounts (at least $40 billion in 2005 excluding fuel and purchased power) are spent annually by IOUs to operate and maintain the power system. While yet to be quantified, even a 10% savings resulting from grid modernization will be valued at $4 billion.

An indication of modern grid benefits can be found by summarizing the above highlighted areas of savings opportunities:

T&D losses	$ 25B
Congestion	$ 5B
Energy inefficiency	$ 36B
Unreliability/PQ	$ 100B
T&D O&M	$ 40B
Total	**$ 206B**

A conservative estimate of potential savings resulting from grid modernization as discussed throughout this document, even allowing for any possible overlap in the above independent analyses, is 20% (more than $40 billion/year).

AND THE BENEFITS ARE EVEN MORE FAR REACHING

There are additional positive aspects to consider.

Because "bits are cheaper than iron", total capital expenditure requirements will be reduced as a result of grid modernization. For example, Pacific Northwest National Laboratory (PNNL) researchers note that smart (grid friendly) appliances costing $600 million can provide as much reserve capacity to the grid as power plants worth ten times that amount. A PNNL study found that, over 20 years, significant amounts of US power infrastructure additions could be avoided. The net present values of the avoided cost of construction are:

- Generation - $19 billion-$49 billion
- Transmission - $5 billion-$12 billion
- Distribution - $22 billion-$56 billion
- Total - $46 billion-$117 billion

The cost of environmental impact is also large and growing; hence the environmental benefits of a modern grid will generate billions of dollars in benefits each year. Every KWH saved by the efficiencies of the modern grid results in reduced expenditures on pollution controls at power plants.

Studies of the total societal value proposition for grid modernization have not been common, but they are increasing in number. A recent study by the University of San Diego looked at the value of a modern grid to the San Diego area. It found about $1.4 billion in system benefits plus about $1.3 billion in societal benefits, producing an IRR of at least a 26%.

Other countries that have already implemented partial grid modernization programs report very positive results. Italy's ENEL Telegestore Project is a case in point. The largest advanced metering project in the world, with over 27 million meters networked, this project made a 2.1 billion € total investment that is producing 500 million € savings per year and delivering better service at lower cost. Advanced metering and communications, as implemented by ENEL, are important characteristics of a modern grid and lay the foundation for most other aspects of grid modernization. The benefit ratio will further improve when all aspects of grid modernization are implemented.

Additional societal benefits related to a cleaner and safer environment, increased national security, improved US competitiveness, more efficient electricity markets, and new job creation, among others, clearly provide substantial additional support for grid modernization.

In summary, the overall potential savings implied by all of the above easily supports the EPRI estimate of a 4 to 1 societal benefit ratio.

SUMMARY

A MODERN GRID WILL GREATLY IMPROVE THE QUALITY OF LIFE.

The benefits of grid modernization are many and far reaching. They encompass the broad areas of reliability, power quality, health and safety, national security, economic vitality, efficiency, and environmental impact.

More specifically, these benefits include:

- Virtual elimination of cascading outages, such as occurred August 2003.
- Increased national security through deterrence of organized attacks on the grid.
- Improved tolerance to natural disasters.
- Improved public and worker safety.
- Reduced energy losses and more efficient electrical generation.
- Reduced transmission congestion, leading to more efficient electricity markets.
- Improved power quality.
- Reduced environmental impact.
- Improved US competitiveness, resulting in lower prices for all US products and greater US job creation.
- Fuller utilization of grid assets.
- More targeted and efficient grid maintenance programs and fewer equipment failures.
- New customer service benefits such as remote connection, more accurate and frequent meter readings, outage detection, and restoration.

Grid modernization, like any investment in improved quality of life, doesn't come free. But the benefits, from a societal perspective, far exceed the costs. EPRI estimates the benefit ratio as 4 to 1. This is probably very conservative, when all factors, including the national and economic security of America are given appropriate weight.

A collection of documents regarding related aspects of the Modern Grid have been prepared and are available for free download at the National Energy Technology Laboratory Modern Grid Initiative website. For additional information regarding the Modern Grid Initiative, please use the resources listed below:

Website: www.netl.doe.gov/moderngrid

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ACRONYMS

APPA	American Public power association
CHP	Combined Heat and Power
DER	Distributed Energy Resources
DR	Demand Response
ENEL	Italy's largest power company
EPRI	Electric Power Research Institute
FACTS	Flexible AC Transmission Systems
GHG	Greenhouse Gas
GW	Gigawatt
IOU	Investor Owned Utility
IPP	Independent Power Producer
IRR	Internal Rate of return
ISO	Independent System Operator
KWH	Kilowatt Hour
LECG	A global expert services firm
LMP	Locational Marginal Price
MGI	Modern Grid Initiative
NOX	Nitrogen oxides
NYISO	New York Independent System Operator
PJM	Pennsylvania, New Jersey, Maryland
PNNL	Pacific Northwest National Laboratory
PQ	Power Quality
RAND	A nonprofit research and analysis institution
SOX	Sulfur Oxides
T&D	Transmission and Distribution
T&D O&M	Transmission and Distribution Operations and Maintenance
TVA	Tennessee Valley Authority