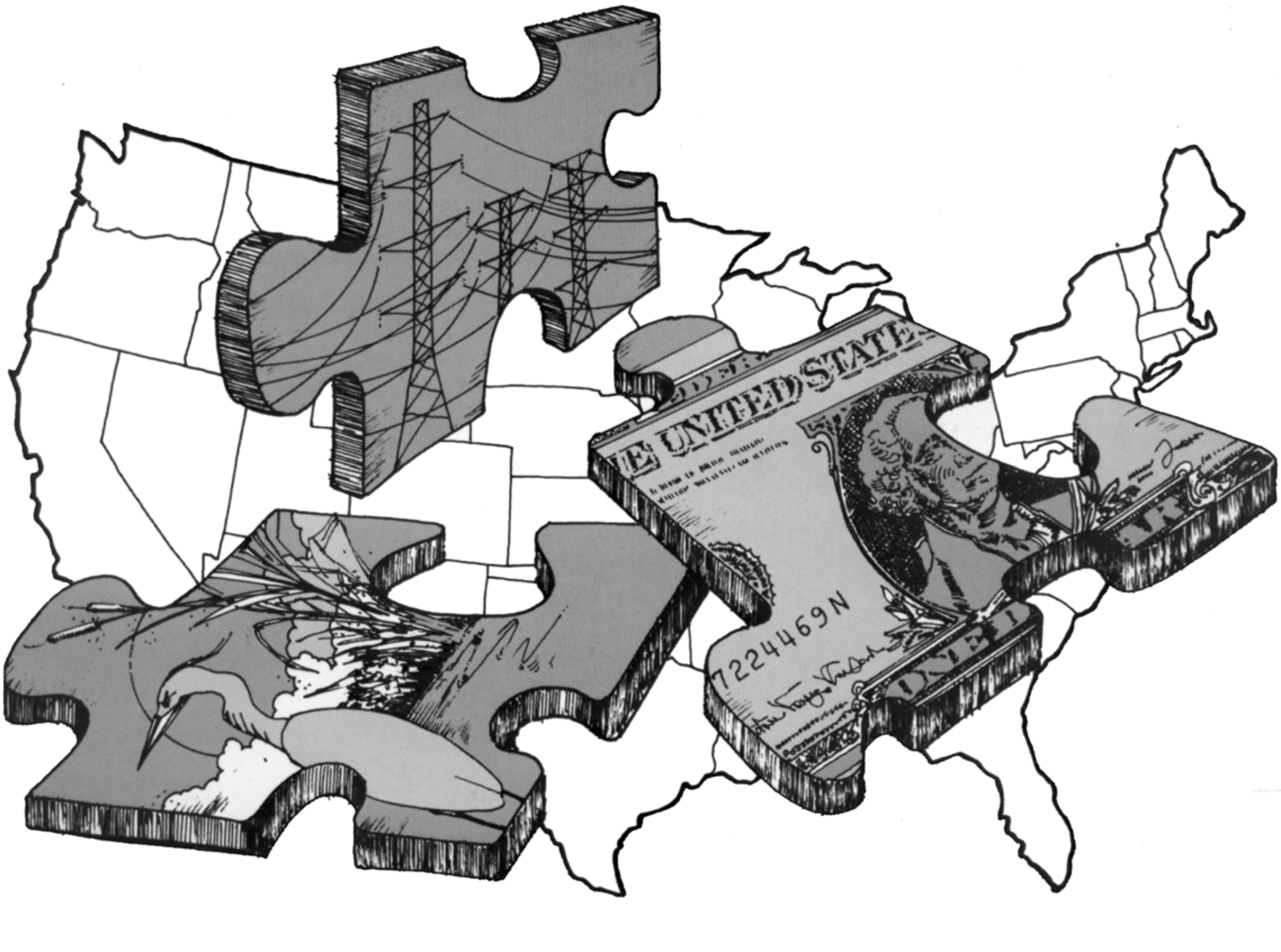
# Dimensions of Reliability:
## Electric System Reliability For Elected Officials




**ELECTRIC INDUSTRY RESTRUCTURING SERIES**

National Council on Competition and the Electric Industry

# Dimensions of Reliability: A Paper on Electric System Reliability For Elected Officials

**The Electric Industry Restructuring Series**

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# The Electric Industry Restructuring Series

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**National Council Steering Committee Members**




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# EXECUTIVE SUMMARY

Electric reliability is a constant priority in a changing industry. It is a public good. It is vital to the public interest in many ways. Policymakers want electric reliability to be maintained or improved as markets and new business models emerge.

For many, reliability is easy to evaluate. The lights are on. The lights are off. The lights are off too often. Policymakers looking for a more robust way to appreciate reliability and to assess what influence they can have over the outcome will find help in this report, *Dimensions of Reliability*.

"Dimensions" of reliability is a way to convey the form and substance of the subject. Good reliability policy should be broader and deeper than just assuring that there is enough power, or just preparing plans sufficient to address operating failures and contingencies. There are many other considerations. These are discussed in section 1.

There are many actors that influence the reliability of the power system, and how much it costs. A significantly increased interest in a vibrant market to trade electricity among power wholesalers over a wide region has broadened the focus of all the institutions that govern reliability. The responsibilities of organizations of the public (state and federal) and the private sectors weave together. The tapestry is not perfect. It functions well, and the product, the U.S. electric power system, sets a global standard. Yet it could be better. States in particular have been relatively passive participants with potential to force, push and prod the industry and federal regulators to seize opportunities for improved performance. The reliability institutions playing these roles are reviewed in section 2.

Reliability would be managed with relative ease if nothing ever changed. Change, along with uncertainty, is a fact of the universe, however, and the nation's electric power system is not exempt. As the demands on the power system change, decision-makers have the opportunity to keep up, improve the system, or allow some degradation in performance. Section 3 examines some of the key sources of change facing the electric system, natural and human-made; as well ways institutions react to these uncertainties.

Responding to the changes and uncertainty that describe the electric power system over time, governing institutions (utilities, government and quasi-private standard setters and system operators) have a range of options to deploy to assure adequate reliability. These options range from large blocks of investment in power lines and generating stations to investments of smaller increments in power system devices and customer resources. Section 4 reviews the contributions that each category of investment makes to reliability.

Another category of options reviewed in section 4 is regulatory incentives. Incentives offered by regulation to the industry directly affect what utilities do. Likewise, incentives offered to customers can lead them to act in ways that will enhance or reduce the reliability of the electric system. Clearly, enhancements are preferred. Efforts to make use of markets and to give customers opportunities to react to real time prices are growing areas of interest. More efficient use of society's resources should lead to a more reliable electric system.

Initiatives that policymakers can implement to address reliability are discussed in section 5. Characteristic of all of them as a group is a goal to maximize the effectiveness of markets where markets can work and maximize the effectiveness of regulation for services that are public goods. There already appears to be ample impetus to build more generating stations. It would be wrong to assume that the only thing left to do to address reliability in a cost-effective way is to accelerate the construction of transmission lines. Some new lines are surely needed. Investments in working markets and active, efficient customers, however, can also make a very significant impact on the reliability and economic performance of the grid.

The electric industry is restructuring. The many elements of work that add up to delivered electric service are under scrutiny to assess how management and delivery of service can be improved. Improvements can be measured in quality gains (i.e. fewer outages, less polluting) and cost reductions. There is no more important task for electric industry policy makers today, however, than to re-establish clear lines of responsibility to maintain grid reliability. All the good ideas in the world will be wasted if there is confusion about who should implement them.

Restructuring will continue and it will be influenced by new federal and state legislation to guide state and federal regulators. This paper is intended to guide policymakers, notably legislators, about the restructuring issues affecting reliability in all its dimensions so that the outcome of these changes is an improvement in the nation's overall reliability performance.

# INTRODUCTION

Electric system reliability is a classic public good. The essential elements, adequate generation, and stable voltage and frequency, are available to all connected users. As one prominent electricity marketer put it, "I tell my prospects, as long as you're connected to the power grid, your reliability will be just the same as your neighbors', no matter who you buy your power from." Like the textbook examples of lighthouses and national defense, most aspects of electric reliability are provided to everyone, or no one, and everyone is required to pay for it.

Public policies of government and its agents, utilities and reliability organizations, determine the costs of reliability and the means of paying for it. Policies that promote comprehensive, least-cost thinking are likely to provide substantial benefits to the public and the economy.

New markets for electric power, growth in electric demand, especially in the summer, and an emerging reliance on natural gas for power generation are revealing gaps in the nation's reliability fabric. Early efforts at restructuring perhaps did not give reliability the attention it deserved and is now receiving.[1] Policymakers are considering actions to assure system reliability, recognizing that the public interest does not always coincide with market interests.

Adding new generation and transmission facilities are obvious and traditional responses to growth. Significant reliability benefits are also available from customers' energy resources. Energy efficiency, demand management, customer-owned generation, customer demand response to real time, reliability-based prices, and wholesale market improvements that support these measures offer significant benefits and costs competitive with generation and transmission options.

There are alternative models of governance and ownership of transmission facilities. There is no one perfect or correct solution. Solutions that are consistent with the public interest will tend to assure that an entity is overseeing the overall transmission system, including generation owned by others, with a comprehensive long-term view that includes sensitivity to public concerns.

This paper will review what reliability is, and encourage broad thinking about how to achieve the levels of reliability society expects in sensible ways that limit both cost and risk.

The National Council on Competition and the Electric Industry has commissioned this paper to assist policymakers, notably elected officials, in appreciating the issues that will affect reliability as they consider changes in utility statutes and oversee regulatory processes in their jurisdictions.

This paper is indebted to a paper commissioned by the National Association of Regulatory Utility Commissioners by Richard H. Cowart, *Efficient Reliability,* published in June 2001. It can be obtained at http://www.rapmaine.org/rely.html.

[1] David Cook, General Counsel to the North American Electric Reliability Council has said, "Not dealing with the reliability side of the business as the industry restructures would be like the airlines switching to jet airplanes without increasing the length of the runways." June 28, 2001.

# 1. DIMENSIONS OF RELIABILITY[2]

This paper discusses challenges to electric system reliability and offers responses to them. Americans have grown accustomed to high quality service, and expectations are increasing. First, however, it is important to appreciate the dimensions of reliability. How do we measure whether we are getting sufficient reliability?

Electric systems have two distinct characteristics:
1) There is a continuous and virtually instantaneous balancing of generation and load. This requires metering, computing, telecommunications, and control equipment to monitor loads, generation and the transmission system and to adjust generation to match load; and
2) The transmission system is primarily passive; there are few controls to regulate flows on individual lines.

These two characteristics lead to these four outcomes:
1) Every grid event can affect all other activities on the grid. Therefore, the actions of all bulk-power participants must be coordinated;
2) Cascading effects of a system fault must be avoided – failure of a single system element (a power line or generator) can, if not managed properly, cause the subsequent rapid failure of many additional elements, disrupting the grid over an enormous area[3];
3) Preparation for the next contingency, or unexpected event dominates the design and operation of bulk-power systems[4];
4) Actions are often required instantaneously, requiring computing, communications, and automatic controls designed based on sound modeling and planning.

When lightning strikes a power line, or a large generator suddenly shuts off, the system frequency drops from its standard 60 cycles per second. Automatic actions throughout the region in the transmission system, in generation running at less than full load, and some customer loads that are responsive to system frequency struggle to stabilize the frequency in a fraction of a second or a few minutes, depending on the event. The objective is to avoid cascading events, and voltage sags sufficient to disrupt sensitive loads like computer chip manufacturers. A graphical picture of an event of this nature, in this case the sudden shutdown of a large power generator, appears in Figure 1 on the following page.

[2] This section is indebted to the Final Report of the Task Force on Electric System Reliability to the Secretary of Energy Advisory Board, September 1998.
[3] Discussed later, the July 1996 power outages in the Western States are recent examples of a cascading outage.
[4] Actual power flows are often at levels far below the physical capacity of a power line so that the contingent flow resulting from a significant failure or outage will not overwhelm the circuit.

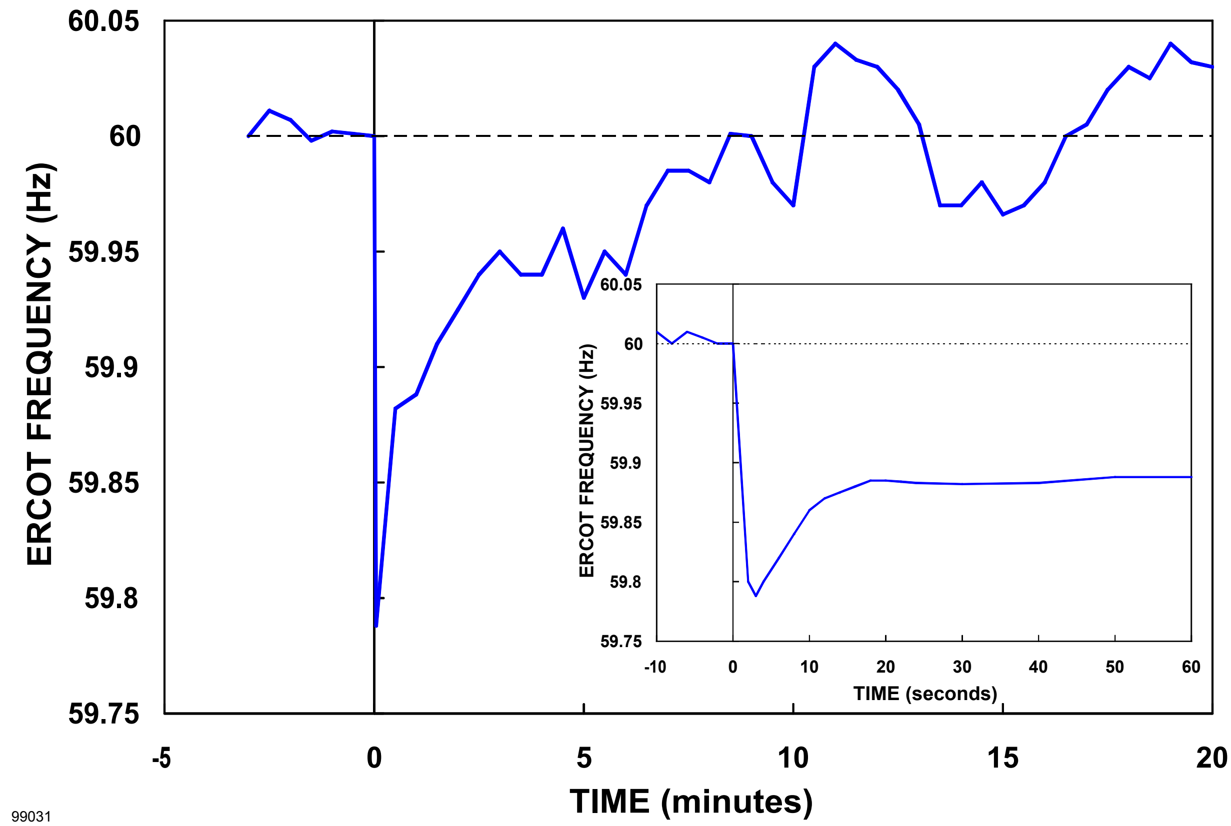


**Figure 1: Interconnection frequency before and after the loss of a 653-MW generator. The inset shows frequency for the first minute after the outage, and the larger figure shows frequency for the first 20 minutes after the outage.**

There are three **dimensions of reliability.** They are **adequacy**, **security** and **quality**. They have elements in common. All require significant on-going investment in maintenance and capital. All require planning to assure that this investment is well spent. All can be accomplished in different ways. Grid managers must make choices about how best to secure a reliable grid. Not all investment is required by the utility. Consumer have a role in reliability also in that add equipment to improve their own reliability, and can offer resources to the grid, as we will see, to enhance reliability for all in an economically efficient way.
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## A. ADEQUACY

Electric reliability requires that there is adequate power generation to meet customer demand requirements in a geographic region. Simple enough. There are some other important facets of the adequacy dimension.

Some generation is always out of service, whether for planned maintenance, or due to the inevitable but unplanned event which forces a plant off-line or to endure a significant reduction in maximum output. So there must be enough generation in place to deal with planned and unplanned outages. [5,6]

Second, it is not easy to predict the amount of electricity that customers will demand, and too much reliance on long term energy forecasts is unwise. Because generation takes an uncertain amount of time to build, and because customer demand can be affected by efficiency and the state of the economy, some margin of uncertainty is necessary in forecasts of adequacy. In addition, if demand is allowed to fully participate in the wholesale power market, as we will discuss later, forecasts of actual peak electric demand are further complicated.

Third, state boundaries mean nothing to electricity. Adequacy from a reliability perspective is regional. Yet regional governance of reliability is unformed at best.[7]

Finally, in places where transmission capacity is limited, there could be a local problem of inadequate generation, even though a region has the capacity it needs to meet total demand.[8]

A fundamental adequacy concern is whether incentives are adequate to assure construction of needed generation. A twist on this concern is whether incentives are adequate for equivalent consumer actions, either to avoid using energy or to add generation capacity locally.

## B. SECURITY

The electric power grid has been called the most complex machine ever created. Because there is very limited storage capacity, nearly every kiloWatt-hour is consumed as it is made. It would be tough enough to operate a homogeneous grid under these perfect theoretical conditions, but the reality is far more challenging. The power system is a network of a variety of facilities using many technologies with many owners and manufacturers built over many decades that must maintain a delicate balance all the time, even as customer loads rise and fall, as supplies enter and leave service, and as transmission components fail.

The question the system operator is constantly asking is: what happens if one or two of the largest generators or the most heavily-loaded power lines suddenly fails? In such events, a huge "rebalancing"

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[5] California experienced the unusual occurrence of available generation from independent power producers being withheld from the market due to concerns about the credit of distribution companies. Hopefully, this is an anomaly that will rarely if ever be repeated. There have also been charges that available generation has been withheld intentionally from the market in order to increase the spot market clearing price for energy. FERC will be investigating. Even if there is adequate installed capacity, consumers may not have access to adequate generation for commercial reasons, a very new phenomenon and one that policymakers may wish to address.

[6] Customer-owned generation, a small but increasing part of the generation mix, adds a manageable but real complication to the task of predicting how much generation will be needed at a future time. Some intermittent generation sources, like wind and photovoltaic solar have similar effects.

[7] While NERC and the regional reliability councils oversee reliability in the United States, Canada and parts of Mexico, they have no real authority. The promise of the Regional Transmission Organization is that it will fill this gap.

[8] A "load pocket" is the term often used to describe a densely populated area with insufficient local generation to meet local demand, and therefore with a reliance on power lines. In cases where the term is used, there is usually a concern that the capacity of the power lines may be approached, especially in the event some key part of the grid fails. Service should always survive any failure from a single cause.

must occur without the customer noticing. Spare capacity in power lines and ready generation must be instantly available and capable of being synchronized or else the system could become unstable and collapse resulting in a blackout that could cascade across a wide region. Maintaining security requires significant generating and transmission capacity in excess of peak demand needs to be available.

**What Are Ancillary Services?**

The system operator controls the grid by constantly balancing loads and generation. Ancillary services are the controls and are very important elements of reliability. Here are eight ancillary services that end-users may want to sell.

**Reactive Supply and Voltage Control from Generation:** Injection and absorption of reactive power from generators to control transmission voltages

**Regulation:** Maintenance of the minute-to-minute generation/load balance to meet NERC's Standards

**Load Following:** Maintenance of the hour-to-hour generation/load balance

**Frequency Responsive Spinning Reserve:** Immediate (10 second) response to contingencies and frequency deviations

**Supplemental Reserve:** Response to restore generation/load balance within 10 minutes of a generation or transmission contingency

**Backup Supply:** Customer plan to restore system contingency reserves within 30 minutes if the customer's primary supply is disabled

**Network Stability:** Use of fast-response equipment to maintain a secure transmission system

**System Blackstart:** The capability to start generation and restore an area's power grid to service without outside electricity supplies after a total system collapse

Recent acts of terrorism have raised the broader issue of security in many categories of infrastructure, and the electric grid is no exception. This is a sensitive topic. It is important for policymakers to have an appreciation for the capacity and readiness of the power system to withstand foreseeable contingencies, including intentional acts to disrupt service. Yet a detailed discussion could unwisely suggest to the public elements of the system that are more or less vulnerable to sabotage.

To address this dilemma, the following information will be helpful. First, each state has an emergency management office. This office with help from the utility-owners is aware of the electric system and its key elements. Regional offices of the Federal Bureau of Investigation also maintain information of this nature. Second, while the power system is made up of long transmission lines that are impossible to monitor visually, it is also made of a finite number of significant power stations and control facilities. These latter facilities are guarded. Third, the U.S. Department of Energy maintains an Office of Critical Infrastructure with its Office of Policy. This office studies the national energy facilities and evaluates whether there are vulnerabilities that should be addressed through federal actions. Finally, the normal analysis of the transmission system by its operators is fundamentally about preparing responses for when system elements fail. Acts of nature, equipment aging, chance and humans (accidentally or on purpose) are all considered. It is likely, however, that there will be a reassessment of intentional human contingencies by system operators throughout the United States due to the events of September 11, 2001.

## C. QUALITY

Quality is a dimension that has grown in importance with the emergence of sensitive electronics on customers' premises. The waveform of the electricity matters to this equipment. Brief interruptions that are easily tolerated by incandescent lights may force cutting edge manufacturing tools and information systems out of service with potentially catastrophic financial and health results. Computer chip manufacturers and Internet server-farms are "poster children" for customers like these. For these "high end" end uses, the standard for reliable service has changed.[9]

This new and higher level of power quality is expensive and could be achieved by grid investments paid for by customers at large. Instead, individual customers are choosing to build the needed power quality into their structures, systems and processes at their own cost.[10]

Reliability can be generally described by the weakest link in the chain of delivery from generation to customer. Reviews of actual system outages generally identify the particular link that failed. Taking pressure off these weaker links is one perspective on efforts to maintain and improve system reliability. We'll now discuss some policy dimensions that relate to reliability.

## D. 'RELIABILITY' IS NOT 'COST'

An important public policy dimension that is often blurred with reliability is cost. Certainly it is important that consumers pay only what they must to receive the service they expect. Regulation plays its traditionally pivotal part in achieving this standard. Generally, transmission costs represent approximately 10% of the total electric bill.

In recent years, electric consumers have faced volatile prices brought on by various causes, including ill-formed wholesale markets, and perhaps some abuses of the rules. As important as these market issues are, they are distinct from reliability.[11]

Since the incentives to build new generation and transmission ultimately affects reliability, some words about these incentives are appropriate. Investors in generation and transmission say that market prices of electricity are an indicator that affects their decisions on whether to green light projects. In this context, market prices are really surrogates for an assessment of market need.

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[9] A common standard for system reliability is delivery of 99.9% (three 9s) of energy demanded by consumers. Customers with "high" reliability needs may look for 99.9999% (six 9s) or even higher.

[10] The Energy Innovations Institute, an affiliate of the Electric Power Research Institute focused on public interest R&D, is launching the Consortium for Electric Infrastructure to Support a Digital Society (CEIDS). CEIDS will look at how consumers and the electric industry together can most effectively meet this challenge.

[11] The rolling blackouts in California in recent months demonstrate that commercial market failures can cause reliability problems as discussed in footnote 5.

Transmission is distinct from generation. While a regional electricity price increase signals a need for more generation, transmission rates are often fixed by tariff. System operators may experience congestion but unless there is a congestion-based pricing system or other comparable pricing signal, incentives to build new transmission may not be sufficient.[12]

Reliability and cost do come together in uplift costs. An uplift charge is imposed by the system operator in some regions, and socializes the costs to assure reliability in the short and long term. In the short term, uneconomic generation may be run to assure grid security in a local area. The excess costs are spread among all consumers in the system area. A long term example is the construction cost of a transmission project located in one utility service territory while benefiting reliability throughout the region. The cost of such a project is also spread among all consumers.[13]

## E. LONG LIVED ASSETS AND EMINENT DOMAIN

Transmission assets are designed to last decades, and consumers pay for them over similarly long periods. This simple observation supports efforts to assure that monopoly utilities and their customers commit to these assets only after a rigorous assessment of need, including an assessment of alternatives.

The public interest importance of these assets has led to laws that grant the power of eminent domain to the certified builders. Effected land owners have rights to participate in the siting process, but must agree to provide necessary rights to the property for a reasonable price once the asset is certified to be in the public interest.

## F. TRANSMISSION SUPPORTS WHOLESALE MARKETS

The transmission system was primarily designed by utilities to bring their generation to their customers. It was fortified to withstand failure of any component (single contingency). It has been enhanced to allow trading of energy and reserves among utilities. The decision to promote competitive wholesale electricity markets in the U.S. has presumed that the transmission system can handle the job. This has proven to be a stretch for the system operators and transmission owners. The number of transactions being handled over the transmission system has increased significantly.[14] Information systems and planning assumptions have had to be overhauled. Some are concerned that the traditional reliability mission of transmission system operators may be losing focus in the effort to create robust inter-state electricity markets.

Transmission congestion refers to the situation in which it is not possible to complete all the proposed transactions to move power from one location to another on the grid, due to thermal, voltage, or stability limits on transmission lines or other facilities. Congestion is often not related to physical limits. Rather, for security concerns, capacity is reserved for responses to contingent outages. Operations are adjusted to

[12] Transmission owners also suggest that the return on equity used to set transmission rates should be higher to promote transmission line construction while many consumer advocates assert that existing return policies should be sufficient. Traditional ratemaking strives to provide a reasonable rate of return on utility investments.

[13] This is not a trivial process where a regional institution (i.e. power pool, ISO, RTO) is not in place.

[14] The NYISO, for example, reports in FERC Docket No. ER00-3591-000 in September 2000 that energy imports of 1000 MW or greater into the NYISO from PJM were scheduled approximately 56 percent of the time during the year 2000. NYISO exports to New England of at least 500 MW or more were scheduled approximately 37 percent of the time, and NYISO scheduled imports from ISO-NE approximately 12 percent of the time. Some question, however, whether data of this type is padded by "churn," the selling of power many times before it is delivered. There is at this time no reliable data on the influence of churn.

avoid a failure if a specific contingency occurs, assuring that system operators retain control of the grid at all times.

In some places, congestion occurs frequently. Locations like these are said to be transmission bottlenecks.[15] The clearing price for energy can be significantly different on either side of the bottleneck.

It is likely that some fundamental changes in the design of electric transmission will be necessary to fully accommodate the increased importance of commerce in addition to reliability. For example, equipment that can control otherwise free-flowing power, like DC lines and FACTS devices[16], will promote the commercial use of the transmission system while providing effective solutions to reliability weaknesses.

## G. TRANSMISSION VS. DISTRIBUTION

To appreciate the subject of reliability, keeping transmission and distribution distinct is helpful.

Functionally, transmission moves bulk power and delivers it to distribution systems. The distribution systems deliver power to consumers. Many find it helpful to use a numerical standard. NERC identifies the bulk power, or transmission, system as 100 kiloVolts or higher in its standards.[17]

Most outages that consumers experience are caused by problems in the local distribution system. Components fail, poles are struck by cars, animals short-circuit equipment in substations, human error, weather– these are common causes of distribution outages. In some isolated cases, unchecked or unexpected demand growth leads to utilities under-investing in the distribution system. Resulting outages are frustrating because they are avoidable.[18]

Utilities balance the cost of equipment and staffing to achieve an acceptable but not perfect record of distribution system reliability. While these distribution problems are intrusive and potentially serious or even life threatening to those customers affected, no widespread regional effects are associated with these outages. State regulatory processes can and should help utilities strike the right balance between cost and distribution reliability.

Transmission outages are rare, but unless the system is designed and operated properly, the effects of these outages can cascade over very large areas. In 1996, an enormous part of the Western Interconnection, including parts of Canada and Mexico, were without service due to an uncontrolled system fault. The potentially enormous economic and public safety effects of a widespread blackout

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[15] Two examples of bottlenecks occur in Maine and California. In Maine, the availability of natural gas from Nova Scotia has led to construction of low cost generation. There is insufficient capacity on the transmission system to allow the power to move to the Boston area when it is could be used economically there. In California, the notorious Path 15, which connects the northern and southern parts of the state limits the movement of power that is economically needed.

[16] DC lines can bring power from one point to another hundreds of miles away, or more, with low losses, bypassing the AC network. Flexible AC Transmission System (FACTS) are sophisticated solid state electronic switches that provide operators with control that can allow or limit flow on certain power lines.

[17] *NERC Planning Standards*, September 1997, pg 8. Functionally, facilities with voltages as low as 34.5 kV may be transmission.

[18] The writer has in mind cases within recent years in Chicago, New York City, and Boston.

provide ample reason for efforts to minimize transmission outages and to contain their effects when they do occur.[19]

We will now look at the institutions charged with preserving electric system reliability and some of their decision-making criteria.

[19] Readers interested in a broad perspective on reliability can read the Report of the Reliability Task Force to the Secretary of Energy Advisory Board, Maintaining Reliability in a Competitive U.S. Electricity Industry: Final Report of the Task Force on Electric System Reliability, date, http://vm1.hqadmin.doe.gov/seab/ESRFINAL.pdf. An excellent report on the 1996 outage is The Electric Power Outages in the Western United States, July 2-3, 1996: Report to the President from the U.S. Department of Energy, August 1996. According to the report, "The cause of the short circuit (the initiating event on a 345 kV line connecting Wyoming and Idaho) was a tree growing too close to the sagging line. The second line tripped because of a faulty protective relay, causing two generators to trip off line. Operating conditions should not have allowed a cascading failure, but they did. The cascading failure indicates a problem with the modeling and allowable operating conditions of the transmission system.

# 2. RELIABILITY INSTITUTIONS

The excellent record of electric reliability in the United States is the result of a long term commitment to rules, traditions and organizations. These go well beyond the noble tradition of mutual aid among utilities when combating a storm-related outage. Confidence in these institutions was shaken in 1996 when much of the west coast was plunged into darkness by a cascading transmission fault. Subsequent close calls have kept pressure on policymakers to examine reliability closely.

Several different types of organizations oversee, operate and participate in bulk-power markets and reliability. These entities, some of which did not exist a few years ago, range from private companies to government agencies, and some quasi-public organizations that exist to operate the grid in the public interest. Keys among these are the Federal Energy Regulatory Commission, FERC, and the North American Electric Reliability Council, NERC.

## A. NERC, RELIABILITY COUNCILS, AND INTERCONNECTIONS

The United States electric system is divided into three Interconnections: Eastern, Western, and most of Texas. Within each interconnection, all the generators operate as essentially one machine connected to each other and to customer loads primarily by AC lines. The interconnections are connected to each other by a few DC links. These DC links are operator controlled and act as “air locks” between interconnections. Because these DC connections are limited, the flow of electricity and markets is much greater within each interconnection than between interconnections.

A level below the Interconnection is the Reliability Councils. Regional reliability councils were organized after the 1965 Northeast Blackout to coordinate reliability practices and avoid or minimize future outages. They are voluntary organizations of transmission-owning utilities, power cooperatives, power marketers, and non-utility generators. Membership rules vary from region to region. There are ten major regional councils plus the Alaska Systems Coordinating Council. Please see Fig. 2 for a map.

Serving the reliability councils is the North American Electric Reliability Council, NERC. Electric utilities established NERC in 1968 as a voluntary membership organization as an alternative to government regulation of reliability. NERC develops standards, guidelines and criteria for assuring system security and evaluating system adequacy. NERC is funded by the ten reliability councils, which adopt NERC rules to meet the needs of their regions. NERC and the regional councils have succeeded in maintaining a high degree of transmission grid reliability throughout North America.

Historically, the reliability councils have functioned without external enforcement powers, depending on voluntary compliance with standards. FERC does not regulate NERC.

NERC has responded to increasing commercial pressures in the wholesale electricity market and is converting its organization from one in which mutual interest and peer pressure encouraged compliance with voluntary reliability-driven standards into a self-regulating one in which management is independent, compliance is mandatory and violations are subject to penalties (including fines). Absent federal legislation requiring compliance with reliability standards, NERC has limited ability to enforce reliability rules. Legislative proposals pending in Congress assign FERC the task of backing up NERC’s authority to impose its judgment concerning reliability on wholesale market participants.

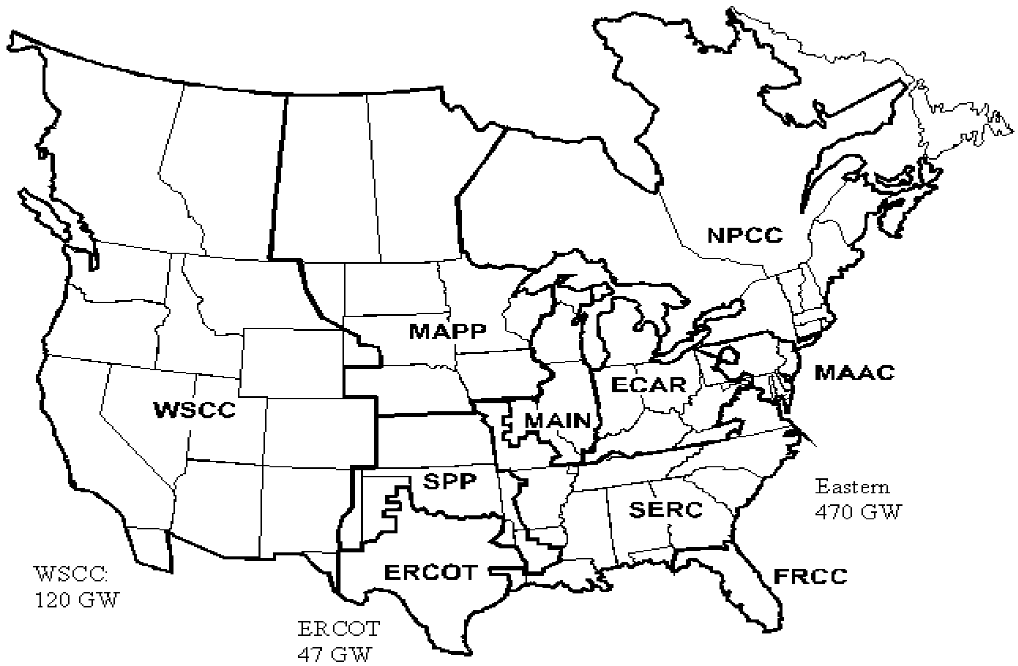


**Figure 2: U.S. map showing the locations of the 10 regional reliability councils, and the customer load of the three Interconnections. The Eastern Interconnection is composed of all eight councils west of WSCC and ERCOT.**

NERC is also expanding greatly the representation from all industry sectors[20] on its committees and it recently converted its Board membership to one that is not affiliated with any market sector. At some point in the future, NERC plans to change its name to the North American Electric Reliability Organization, NAERO, to demonstrate the extent of the council's transformation.[21]

[20] Beyond transmission owning utilities, stakeholders include owners of generation only, customers, and utilities that own no transmission and yet depend on it to get power. Public power is also sometimes thought of as a distinct category.

[21] This change is generally expected to accompany passage of prospective federal legislation that would authorize creation of a self-regulating reliability organization, NAERO, under FERC supervision. Details remain controversial

## B. FERC, ISOS, AND RTOS

As bulk-power markets become competitive, the institutions that oversee and manage reliability and commerce are changing. Historically, utilities, and only utilities or their power pool aggregations,[22] owned generation and transmission and therefore operated control areas. Within the last few years, Independent System Operators, ISOs, that own neither generation nor transmission, have taken over these functions in California, New England, New York, and the mid-Atlantic (PJM) region. An ISO operates the system of assets owned by others for the benefit of reliability and markets under FERC regulation. Transmission asset owners receive regulated returns on investment, as before, but are less able to use their transmission ownership for their own strategic purpose. Other ISOs are now under development in other parts of the US.

CHARACTERISTICS AND FUNCTIONS OF REGIONAL TRANSMISSION ORGANZATIONS AS ENVISIONED IN FERC ORDER 2000

**Characteristics**

Independence from stakeholders (governance, stakeholder committee and advisory processes)
Broad scope and regional configuration
Broad operational authority, including over interconnections
Control over short-term reliability

**Functions**

Administer FERC tariff (includes rates), design improvements, apply to FERC for changes
Manage congested transmission lines
Manage issues related to contract flows diverging from actual power flows
Assure adequate ancillary services (reserves and frequency control capacity)
Determine available transmission capacity
Monitor market for inappropriate commercial behavior
Plan for transmission expansion
Cause expansion of transmission system when needed
Coordinate with other regions

Another trend is to form large transmission-owning utilities, or Transcos. Unlike the ISO, the Transco can be both a system operator and a market participant. The ability of the Transco to use its transmission assets for wholesale market gain is controlled, but not eliminated, by federal regulation.[23]

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at this time. FERC authority will have to be tempered by the prospective NAERO's reliability role in Canada and Mexico.

[22] Utilities in some regions formed "power pools" to coordinate reliability more locally than the reliability councils, and to use generation available in a region more economically efficiently. NEPOOL is an example.

[23] The idea of a Transco has been with us for some time. The Vermont Electric Power Company (VELCO) has been a Transco since the late 1950s and was formed to connect Vermont to and access power in surrounding states. It

In December 1999, FERC issued a major rule, known as Order 2000, which urged the creation of a new type of entity, the Regional Transmission Organization, or RTO. The order required utilities to file with FERC proposals for joining an RTO or an explanation of why the utility cannot join such a regional organization. The box on the previous page lists the main features of the RTO that FERC envisions.

In Order 2000, FERC is trying to make the wholesale market for electricity as functional as possible, making it normal to trade power over the largest possible area. Potentially, all generation within the RTO borders would be operated centrally with resulting reliability and system-wide economic benefits. A practice FERC is trying to eliminate is one where each successive owner of transmission facilities on a path between a power seller and a buyer charges a separate fee for the use of the wires. This practice, called "pancaking," discourages economic transactions by the way transmission users pay for the service. A "postage stamp" rate facilitates commerce by eliminating distance and the number of intervening systems from the way the price is calculated. The regional rate is calculated to assure that transmission owners receive a reasonable return on investment, as determined by regulators. If the system has a congestion bottleneck, a separate pricing structure can be applied to the particular transactions causing the congestion.

Another important objective for Order 2000 and RTOs is to assure that transmission systems are planned in harmony with load growth, new generation and real system needs and in ways that do not add unnecessary cost to consumers' bills. The corporate break-ups of utilities through divestiture and retail competition risks fragmenting a planning process that already needed improvement.

Order 2000 represents a significant change in the role of the FERC. FERC is now responsible for assuring that owners of transmission facilities under its jurisdiction provide non-discriminatory service to all power suppliers in wholesale power markets.

A major public policy concern is whether the system operator, under FERC's direction, will interrupt wholesale power commerce if reliability standards are threatened. So far, the existing ISOs have rejected power trades that threaten reliability, though there remains disagreement on whether the ISOs have been aggressive enough in monitoring the market and questioning trades. The number of times these actions occur is a modest indicator of the robustness of the transmission system to meet its traditional function, reliability, and its increasingly important function, bulk power commerce.[24]

operates the high voltage grid in Vermont under a FERC tariff that allocates transmission costs among all 22 distribution companies in Vermont and other users of the system. Vermont distribution companies own VELCO. VELCO has accepted a modest rate of return, and has effectively operated as a service organization to the Vermont distribution companies. While involved with generation contracts in its early years, VELCO has settled into its primary role of operating the Vermont high voltage system.

[24] Transmission Load Relief (TLR) procedure calls also are a signal of competitive activity. There is risk in relying too heavily on TLR statistics to measure congestion or to evaluate the state of grid reliability since competitive behavior of wholesale power traders is another reason for high TLR rates.

Historically, FERC has not had to involve itself with regulating reliability functions. With reliability issues increasingly intersecting with commercial issues, FERC is being called on to exercise its authority in areas like market power and other reliability and non-reliability-related issues.[25]

FERC issued in July 2001 a series of orders in its RTO dockets. In these orders, FERC makes clear its intention to cause the creation of the fewest number of RTOs necessary to cover the contiguous 48 states.[26]

## C. RELIABILITY STANDARDS

Before turning to the challenges to reliability, a few words about reliability standards are in order. 100% reliability is impossible to achieve, and the closer a system is to this standard, the more money must be spent for redundant systems, back-up systems and stand-by resources. NERC establishes reliability standards and the procedures to assure that reasonable reliability expectations of the general public are met.

To assess the probability of a system collapse, various key power lines and generators are modeled and key elements are assumed to fail. Operators want to know how they would stabilize the system when these contingencies occur individually, and in groups.

In isolated cases, different standards are used. For example, the State of New York assigns a very high value to reliability in New York City. Their challenge is heightened by limited transmission capacity into the city coupled with challenges siting new generation in the midst of the electric demand. The state imposes special standards on utilities to provide reliable service into New York City that affect how the utilities operate the grid during vulnerable periods.[27]

Normal system operation includes a safety margin. Generators can produce a bit more power. Power lines can carry a bit more current. Customers will curtail some demand when asked, more if there is a financial incentive. Neighboring regions may have excess power deliverable over available transmission capacity. Reserves are a subset of ancillary services, which were discussed earlier. It is likely that some imposition of requirements to assure reserves at level adequate to maintain reliability will continue to be the job of the system operator. Creating markets for efficient acquisition of reserves is a subject that has great potential for improvement and is discussed later in this report.

In the event available resources cannot match customer demand, the system operator has procedures that are designed to assure that the grid does not fail in a catastrophic, uncontrolled way. This is the lesson of the Northeast Blackout of 1965.[28] After using all available resources, the system operator begins cutting

[25] Proposed federal law would clarify FERC's role concerning reliability. FERC would be assigned back-up authority to resolve any disputes arising from actions by the prospective NAERO.

[26] These orders were issued July 12, 2001 and are available on the FERC web site at http://www.ferc.gov/Electric/RTO/post_rto.htm

[27] Western states are examining the value of reliability standards specific to the west due to nature of the existing power system, which is designed to transmit large amounts of power great distances.

[28] This West was insufficiently prepared for the July 1996 outage. Post-outage assessment of why the outage occurred only proves the high value of measures designed to prevent a cascading blackout.

service to distribution circuits for an hour to two hours at a time. If high demand persists, these communities are brought back on line, and a different set of communities are taken out of service until the high demand dissipates. This practice, known as a "rolling blackout," has been demonstrated painfully in recent months in California, but would be implemented anywhere similar circumstances occurred.

## D. STATE REGULATION

State regulation affects reliability. One way is through the siting statute in each state. In many states, some assessment of need is required by the state siting authority to determine if the transmission facility will be built. The criteria from state to state are different. Some require a more involved evaluation of alternatives than others. Some limit consideration of costs and benefits that arise in other states. The weight of environmental impacts in the siting process varies from state to state. Some see the importance of local issues and argue for continued state jurisdiction over transmission siting, while others view the same facts and, citing inconsistencies among states in regional electricity systems, argue for national jurisdiction. What is clear is that electric siting matters are not FERC-jurisdictional today.[29]

Some have expressed openness to a new kind of process of shared responsibility between state and federal regulators for electric facilities siting.[30] A great deal of work on this idea is necessary before it could be implemented.

Still others suggest that states should join together to review regional projects. This could be as formal as a Congressionally approved inter-state compact, or as informal as collecting evidence one time for all effected states on a case by case basis. Again, a great deal of effort, including trust among states, will be necessary to structure such a siting review process.

At least one state, Ohio, has as siting statute that explicitly authorizes its siting authority to collaborate with other states to review inter-state transmission projects. In the absence of a law of this kind, siting officials will tend to be reluctant to depart from the normally prescribed siting review process.

## E. BUILDER OF LAST RESORT

Who is responsible to bring on line generation needed to support reliability? The traditional answer is easy: the utility has this responsibility. Attached to this public service responsibility is the expectation that the utility would recover prudently incurred costs for useful facilities from consumers.

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[29] FERC does have jurisdiction for siting inter-state natural gas pipelines. Some use this fact to argue that a similar jurisdiction for electric transmission makes sense. A good resource for state siting regulations is *Electric Transmission Line Siting Regulations: State-level Directory*, Edison Electric Institute, 2001. The absence of FERC does not mean federal authority is absent. The federal power marketing administrations (i.e. BPA, TVA) have their own authority to site transmission. In addition, transmission proposals that cross land controlled by a federal agency must secure its permission. In some parts of the country, this aspect of siting is almost unavoidable.

[30] For a deeper discussion of this topic, see *Maintaining Reliability*, pgs 34-36. http://vm1.hqadmin.doe.gov/seab/ESRFINAL.pdf

With restructuring and divestiture, the traditional role of the electric utility has been changed in many states. Increasingly, generation-owning companies carry the market-driven burden of building and operating new generation. In some of these states, the utility is not expected to build or acquire new generation, but it can if the generation is needed. In other cases, regulatory or statutory transition rules restrict the utility from owning generation for any reason. Some have suggested that a state government could be the "builder of last resort" if no utility or market act sufficiently to prevent a generation adequacy problem.

As for transmission, restructuring has led to ambiguity here also. The vertically integrated utility operates, plans and constructs new facilities for captive customers. The creation of wholesale markets and the Independent System Operator, led to a disconnect. While some suggested that an ISO could cause transmission facilities to be built in a kind of "open season" process, ISOs have been cool to this idea. Many asked how transmission owning companies would decide when to add facilities to meet regional grid needs. The Regional Transmission Organization model advanced by FERC is clearly intended to address these issues, bringing all functions back within one structure.

As with generation, government can find itself in a position to act to build needed transmission if no one else would. An example is the effort of the Western Area Power Administration, WAPA, an extension of the federal government to solicit proposals to add transmission capacity in Central California, at the so-called "Path 15."[31]

A lingering question is whether "last resort" builders on behalf of and funded by consumers will also consider distributed resources to meet grid needs. In some states, distributed resources have been viewed as transmission project alternatives in siting dockets due to the demonstrated potential of energy efficiency and local generation to address more efficiently the needs presented by the power grid.[32] Later, this paper will look at the differences in the ways these alternatives are paid for by consumers.

## F. WHAT STATES CAN CONTROL

With a host of policy areas affecting reliability, it is important for state policy makers to stay focused on the ones states can control. Fortunately, the influence of state government on reliability performance can be significant.

The most obvious area of influence is performance of the franchise electric distribution utility. Regulation is intended not only to control the rates of the utility, but also to assure that it is providing adequate customer service, including reliability.

In practice, this can mean assuring that there is sufficient investment in distribution facilities and right of way maintenance, as well as developing load control and efficiency programs that reduce pressure on the grid. Regulatory engineers can examine the specific projects planned by a utility and assess whether the utility's plan is likely achieve acceptable reliability outcomes. The objective should not be micro-

[31] See http://www.wapa.gov/SN/path15links.htm

[32] A transmission project in New Mexico, designed to improve power transfers from Four Corners to Albuquerque was rejected in favor of a commitment to deploy distributed resources locally.

management, but rather an understanding between the state and utility of how to sustain a reliable system. Specific policy-related options are reviewed later in this paper.

In most of the United States, distribution companies are also responsible for transmission. States can assure through regulation that the companies are investing in their systems to assure adequate reliability. Regulators can order that adequate money is devoted to reliability, and can apply quality standards that measure whether reasonable expectations are being met.

Other areas states can control include:
*The permit process* – Generation and transmission needed for generation should be considered in a process that gives all sides a chance to present evidence and that will render a decision in a reasonably expeditious timeframe, recognizing that once a need is identified, it is in the public interest to address it.
*Interconnection Standards* – Customer-sited generation can contribute to reliability. If the rules governing interconnecting this generation to the grid are onerous to the newcomer, however, these resources will remain under-utilized. States can adopt interconnection standards in law or by regulatory commission rule.
*Planning* – For states to be able to evaluate the efforts and performance of the utilities in the area of reliability, it should have independent planning capabilities. This may reside in the state commission or the energy office. Planning results should give the state an opportunity to evaluate utility proposals and offer alternative plans as appropriate.
*Energy Efficiency* – Base load energy efficiency programs serve to slow load growth, maintaining reserve margins and delaying the need for new grid investments to support reliability. States can assure that stable energy efficiency programs are delivered to consumers.
*Regulatory Incentives* – All regulation broadcasts incentives. Attention to these incentives, implicit and explicit, is important is the objective is to make the utility a partner in achieving a reliable network in a way most consistent with other public policy.

There are several detailed policy options in section 5 of this paper that provide more ways for states to exercise its authority to promote reliability.

Finally, effective state advocacy at the FERC can be very important. FERC is a focal point for resolving many wholesale market issues that will affect reliability and how it is assured. The main events at this time are the several Regional Transmission Organization dockets. The future will present more occasions where FERC decisions will affect reliability outcomes. The states are often the only voices among many commercial interests that are advocating for the public interest. The FERC has relied on the states for sound advice and is likely to do so in the future.

An area of uncertainty concerns the future of the standard setting organization, NERC. Until more is clear about the evolution of NERC and the parallel evolution of FERC's authority over it, the effect of NERC on state authority over transmission is uncertain.

There is an impressive array of reliability institutions that have produced excellent results though there is certainly room for improvement. The next section looks at the challenges that face these reliability institutions.

# 3. CHALLENGES TO RELIABILITY

Change challenges the reliability of the electric grid. Yet change is inevitable. There is significant excess capacity built into some parts of the grid while other parts are stressed now and are vulnerable in the event of contingencies. But if nothing ever changed, system operators would have little trouble maintaining high reliability performance. The many changes that accumulate in society in the ways we use electricity affect electric reliability, and force the industry and regulators to find ways to maintain reliability at acceptable levels.

## A. WEATHER

Before reviewing the anthropomorphic causes of reliability events, it is appropriate to note that unusual weather is a leading cause of reliability problems for customers. Storms take out facilities; heat and cold waves heighten demand intensity prompting unusually great demands for power. The electric grid gives the appearance of long term solidity, but the variability of weather (without consideration of any climate change effects) suggests that there is always the potential of a "most extreme ever" weather event that could strain the electric system.

It is important when listening to projections of short-term reliability to take into account the risk of extreme weather. Sometimes, projections are based on average weather, while others are based on just a ten percent chance of more severe weather. These projections have very different meanings, and the latter is more useful as a reliability assessment.

It is also useful to note that many of the solutions appearing later in this paper help the system operator cope with unusual weather just the same as other contingencies.

## B. GROWTH

Economic growth is a sign of societal success. As policymakers know, however, growth does not come without cost.

One cost, generally hidden, is the erosion of margins of error for reliable electric system operation. In high growth communities that rely on power lines and remote power generation rather than local resources to supply electrical needs, the risk from growth is highest.
Waiting too long to address demand growth surely leads to degraded reliability. It is easy to find examples of this scenario since building generation in populated areas faces many barriers, as we will see in the next section.[33]

[33] An arcane but rich source of examples are utility commission dockets addressing proposals to build transmission lines. In many of these, the alternative of building generation close to the customer growth area is rejected for reasons such as air quality and inadequate sites.

## C. BARRIERS TO CONSTRUCTION

If reliability is so important, why are there numerous anecdotes of apparently important power lines and key generation gone un-built? For many, the answer seems obvious: local opposition is often an immovable barrier to building power lines and generation. In fact, there are several reasons for the gap between the facilities we have and the system that has an efficient margin of reliability everywhere.

Clearly, building a bulk power transmission or generation facility is often an expensive and intrusive process. A great deal of land is used, air and water quality can be significantly affected, and the visual character of a place can be significantly altered. The fact is, however, that many deficient proposals can be cured with money. Air pollution mitigation, sound reduction, cooling of water discharge, site adjustments other specific design changes: all these impose upfront or operational costs on a project. Yet these are part of the balance of making these facilities acceptable, and reflect the real cost of these proposals. Ignorance of these costs reflects hopefulness by developers that expensive project elements can be avoided and is based more on wishful thinking than on a proper assessment of local needs and preferences. The real cost of turbines and wires solutions to reliability concerns accent the need to consider demand side alternatives. Following is a more focused look at some barriers to construction of power facilities.

### Cost

The most obvious barrier to some transmission projects is cost. The most graphic way to see this is to note the many projects where interveners propose undergrounding as an alternative. Since undergrounding is roughly ten times the cost of a comparable above ground project, cost forms a very real barrier to this choice.

Environmental imperatives also turn up in project costs. These costs are often higher than originally anticipated. This difference, however, is often as much a reflection of insufficient preparation of a proposal. The next section focuses on the environment.

Designers of wholesale electricity markets, regulators and market participants, are working to improve market efficiency. Expectations are that technology improvements will reduce the cost of power. Yet, environmental standards and fuel commodity markets are pushing back. With the Clean Air Act driving efforts to meet 1990 levels of various emissions, it is becoming apparent that efficiency alone will not avoid the need for additional pollution controls. Emphasis on natural gas as the dominant fuel of new generation adds long run cost risk through the reduction in fuel diversity even as present costs appear to be reduced. Realistic project costs make consideration of alternatives a more promising activity.

Before leaving the subject of cost, it is important to add that maintenance of power line rights-of-way and power generators, capital replacements of worn out poles and wires and generation components, and automatic controls and communications systems are important parts of reliability.[34] These elements are less publicized than building new projects, yet they are critical to preventing breakdowns and in dealing with breakdowns when they occur. Regulators should scrutinize cost cutting proposals in these categories

[34] Transmission and distribution components have expected lives of 30-40 years. So even with no growth, 2.5-3% of T&D facilities must be replaced each year.

in response to pressure to reduce electric rates or increase profits. Performance based regulation can incorporate standards that promote sound power line maintenance, improving performance in this area if that is a desirable outcome.

The unavoidable truth is that maintaining reliability is expensive.

## Environment

Sometimes, irreplaceable environmental treasures stand in the way of a promising project that would improve system reliability. Colloquially, these are called "stoppers." In these cases, unless some adequate mitigation plan can be developed, no project will be built, and a choice among second-best options is necessary.

Environmental rules already limit air emissions in growing cities plus other limitations related to aesthetics, noise, or traffic tend to stifle building local power stations.

It is important that the utility grid and the natural environment co-exist to the maximum degree. With sufficient money to add transmission line miles to avoid habitats and scenic viewsheds, for example, co-existence is achievable. In many ways, environmental standards are evolving, and there are many locations where projects built forty years ago would be built with more stringent standards today.[35] Any changing standard can be hard on developers and puts a high premium on communication to clarify current requirements. Environmental regulators need to do their part by assuring that their rules are clear, and are applied consistently.

In many cases, however, money, creativity and openness to alternatives can solve problems and enable reliability standards to be maintained. In situations where these options are not proposed, opponents are criticized for obstructing progress when it is really a breakdown in communications and trust at the root of the dispute.

## Public Attitudes

"Not In My BackYard" has been the expected public reaction to major power projects, even though the vast majority of siting dockets in state PUCs end up approving the proposal.[36] Where opposition is strong, some of this behavior can be traced to numerous prior proposals that were insensitive to local needs and concerns, or which disregarded viable and favorable alternatives. The expectations of many are that the future will be no different than the past. There is a lack of trust in response to some proposals. Industry and regulators will see good projects stifled unless this trend is reversed.

Another perceived reason for this level of negative public reaction is a lack of appreciation by the public of the connection between the level of service they expect and the facilities needed to deliver it. In cases

[35] One might hope that the reverse will become typical; that projects thought to be impossible to build will utilize new technologies and methods and get built.

[36] In addition to NIMBY, no utility siting vocabulary is complete without BANANA, which means, "Build Absolutely Nothing Anywhere Near Anything."

where approvable projects are fought, there is often a lack of an appreciation of the importance of the upgrade. This disconnect on information is a chronic barrier.

Some observers suggest that government should provide more comprehensive information to the general public about where electricity comes from and why generation and transmission facilities are needed.

## Limited Use of Demand Side Resources

The solution menu for electric reliability and market improvements should be as long as possible. Yet the actions of many in the industry suggest that the traditional solutions of building large transmission project and generation projects get most of the attention. Reflecting on the barriers already discussed, this attitude can end up hurting reliability if lower cost solutions are ignored, or even if the public and its elected representatives think there are lower cost solutions.

Resources on the customer side of the meter, as well as small-scale generation in the distribution system, are important options to supporting reliability that are not sufficiently deployed.

One reason for this deficiency is the training of system planners. They have grown in their jobs with demand resources being peripheral in their thinking, if they were there at all. The system is relatively simple if customer load is considered static, rather than dynamic and changeable. Corporate expectations tend to not sufficiently drive a more comprehensive approach. Reasons and policy solutions are explored later. Suffice to say here that regulation has tended to offer utilities directives rather than incentives to efficiently reduce customer demand.

Another reason is that the cost effectiveness of demand resources is still not fully understood. There are many flavors of demand resources, including price responsive load, real time prices, interruptible contracts, on-site generation (of several types) and energy efficiency investment programs. Some lack a long record of costs and benefits. A root issue is whether customers can be trusted by the system operator to cut load when needed and promised, or operate on-site generation such that it will be there when called, or maintain an energy efficiency measure for its expected life. A willingness by system operators to understand these customer behaviors is necessary to take advantage of this sea of opportunities.

A symptom of this barrier is the way reliability improvements to the grid are paid for. In ISO-New England, for example, the cost of reliability-related projects (designated by ISO using a standard method) is paid pro rata by the utilities in the region. The projects that are supported by this practice are mostly power lines and some generation. Yet demand side resources and others that may be equally beneficial for system reliability (or even superior) are not eligible for this regional financial support.

## Utility Incentives

A great deal of attention is focused on utility investment incentives as part of electric restructuring. Incentives affecting transmission siting are no exception. The factors already mentioned influence the attitude of the prospective builder of transmission. A few other factors are discussed here

*Venue* – Obtaining regulatory approval for a project is easier to conceive when there are fewer decision-makers. Local governments, state governments (in multi-state projects), and federal land managers all

may have a hand in approving a transmission project, depending on its location. The more complex the approval process is, the less motivated the transmission builder will be.
*Time* – Transmission projects are complex, and due process demands a reasonable opportunity to review them. Worry about reviews stretching over a period of years, however, leads to reluctance to make proposals
*Local Politics* – Major utility projects can become highly politicized. Where there is a track record of this, prospective builders of transmission are more likely to be reluctant to try again.
*Cost Recovery* – Restructuring the power industry has introduced uncertainty in the financial status of utilities in many states. There is disagreement about stranded cost policy. Inter-state projects may face disparate cost recovery treatment among the states. Some companies are not sure they want to remain in the transmission business. Commitment of large blocks of capital for transmission investment may appear to be riskier than it has in the past.

Giving due consideration to all of these, it remains the responsibility of the utility to provide reliable service and to make investments necessary to assure that result.

## D. FUEL DIVERSITY

The nation's energy history is marked by several love affairs with certain fuels for electric generation, even since our early reliance on hydroelectric power. At various times, nearly all new generation planned in the U.S. was fueled by coal (pre Clean Air Act), oil (pre-Arab Oil Embargo), and nuclear (pre-Three Mile Island).

Today, natural gas is "the fuel of choice" for new generation, offering a modest (though somewhat volatile) commodity cost, modest construction costs, plant efficiencies far higher than existing units and compatibility with pollution control equipment leading to low emissions of criteria pollutants.

With all the positives of natural gas, there are some inevitable concerns. The most distant is that at some point, supplies of natural gas will be tougher to extract, multiplying the price we now see.

Many suggest that natural gas should be considered a "transitional fuel," bridging the gap to a time when technologies converting hydrogen and renewable fuels to electricity are ready for broad use. Long before that time, policymakers should consider other matters.

In considering electric system reliability, study of failure contingencies of the natural gas system has not been typical. Continuing this electric-gas bifurcation is a barrier to reliability. As more power generators with gas fuel are sited around the U.S., an assessment of the capacity to deliver gas to them is essential to know of the power supply available at peak winter periods, when retail gas use is also peaking.[37]

Another matter of importance, at least in northern states, relates to fossil fuel storage practices. This breaks down in two ways. First, gas companies store natural gas so that it is available during peaks. Power stations relying on gas must have that gas actually available. Yet natural gas storage levels have

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[37] Levitan & Associates has produced a preliminary study for the New England ISO along these lines. The results suggest that there are weaknesses in the reliability fabric when both electricity and gas are examined together. http://www.iso-ne.com/Special_Studies/Gas_Study/

declined recently out of fear that buying in advance will be more expensive that a "just in time" gas supply strategy. While this concern may be cyclical, reliability suffers when this fear takes hold, as it has in 2000 and 2001.

The other fuel storage concern is about back-up fuels. Many gas-fired generators have fuel oil in the event gas is interrupted. This is helpful for electric reliability, but policymakers should be aware of the potential effects on availability of fuel oil to retail customers. Power generators use fuel oil at very high rates, and can stimulate a shortage in the event of an extended cold snap.

It is standard practice in the gas industry that if there is contention for gas between electric uses and retail gas uses, that the electric use is curtailed. Policymakers wanting to be risk averse can look for ways to assure that contention for critical end uses does not occur.[38]

Some observers are concerned that a rush to natural gas a dominant fuel for new electric generation will give license to suppliers to raise commodity process. While this is less a reliability issue than a consumer cost issue, reliability could be affected if generation owners idle their units during high cost periods.

## E. INCREASINGLY TWO-WAY AND NETWORKED SYSTEM MORE COMPLEX

The transmission system is being asked to work in new ways, largely addressing new commercial demands. Wholesale markets for power are far more active, and customer generation is increasingly flowing into the grid. Network power flow patterns are changing, and radial lines are being networked. In addition, devices are under development that promise better operator control of the transmission system, including the ability to control flows, and provide more efficient peaking energy storage systems. Communications systems are straining to keep up with remarkable improvements in the responsiveness of hardware – systems that are necessary to get the full capability from these silicon-based devices. And demand-side alternatives to transmission promise both reliability and economic advantages.

The technology and design ideas that will be necessary to adapt fully to the complex commercial needs of tomorrow's transmission system require more research and development, and will also require system engineers and owners willing to deploy these new systems. System designers and operators will be faced with new system configurations in which more generation is proximate to the customer, and they will need to adapt to fully realize the benefits of these resources.

## F. TRADITIONS (THE WAY WE'VE ALWAYS DONE IT)

A generic barrier to innovation (not just regarding reliability and the electric industry) is the attitude that a system must resemble the way it has always been. While change tends to erode reliability, in change also are the new solutions in technologies, processes, and corporate and regulatory behavior. These innovations, some of which we will discuss in the next section, suggest that reliability can be maintained at current levels or better even as the electric industry is changing significantly.

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[38] The State of Massachusetts guaranteed price levels for fuel oil placed in storage before the winter of 2000-01 to stimulate the use of storage by fuel oil dealers and reduce the likelihood of contention.

The barrier of tradition is at work as much in regulation as in utility offices. It was John Rowe, then CEO of New England Electric Systems who said that utilities' behavior is analogous to rats smelling the cheese offered by regulators. What are the regulators telling utilities to do by the implications of their decisions? By the rate designs generally in use that link utility profits to sales, utilities are getting a message that even with the risk associated with sales growth,[39] sales growth is what utilities must have. A close look at the incentives of utilities reveals significant opportunities for regulatory reform, as we will see later.

Another significant tradition is state jurisdiction over transmission siting. Frustration by some concerning the pace of siting new transmission facilities has led to suggestions to adopt regional or federal siting jurisdiction. On the other hand there is room for improvement in the quality of siting proposals and the compatibility between the proposal and the need being addressed.

## G. PLANNING

Planning is almost never easy, and it is nearly always a good idea. The Introduction to the NERC Planning Standards opens, "Electric system reliability begins with planning." Through the 1980s and early 1990s, the virtues of planning were debated in many states and regions. In many instances, elaborate planning processes were implemented.

With electric industry restructuring, companies and regulators turned away from planning as a priority in favor of markets. Many states governments allowed their energy planning capacities to atrophy. With divestiture of generation, many parts of the country lacked any coordinated planning capacity that could evaluate the net result on reliability of the many generation and transmission proposals being placed before siting boards. When problems emerge and political leaders ask for options, it is planning that allows competent assessments to be ready.

NERC and The Energy Information Administration with the U.S. DOE do maintain robust planning capacity. The scale and purpose of these efforts are not sufficient, however, to meet the needs of policy makers addressing a regional reliability issue.

While there is a random chance that reliability will not be adversely effected by this trend toward less comprehensive planning, it is more likely that without some replacement of the planning capacity which formerly existed, grid reliability will decline, or at best, customers will pay more than they need to for the reliability they receive.

[39] Short term power market price volatility, construction cost overruns, public rejection of construction plans, for example.

# 4. RELIABILITY RESOURCES OPTIONS

There are many ways utility managers and planners can approach the mission of maintaining system reliability and many possible solutions. From the public policymaker's point of view, it is important that the outcome is based on public interest criteria and includes consideration of all options in a process that does not bias the selection of what to do. The question is whether there will be a process at the front end that enables sound, timely choices, especially concerning the use of ratepayer funds.[40] To be avoided is routine reliance on regulators to sort out blame and cost responsibility from unguided or mis-guided utility decisions that are inadequate or worse.

## A. POWER LINES

High Voltage power lines are clearly important for reliability. According to the U.S. DOE Energy Information Administration, there were 154,503 miles of high voltage transmission running at 230,000 Volts or higher in the United States in 1999. A close look at what they actually do will contribute to an understanding of reliability options.

First, they deliver power to the grid from generating sites. A significant portion of transmission in place today was built to enable the successful commissioning of a generating station without adversely affecting reliability.

Second, a network of power lines delivers power from rural or remote areas to high concentrations of customers, or load centers, where building sufficient generation is problematic. Transmission congestion results when load growth in the load pocket outpaces mitigating steps.

Third, high voltage lines connect regions together, enabling regions to share resources, lowering costs for all while maintaining high reliability.

Fourth, high voltage lines become the common carrier network by which trades are settled in the rapidly growing wholesale power trading market.

These four illustrations depict AC (alternating current) lines. Power is free flowing over the AC power network, governed by physics and determined by the sources, uses and paths of electricity at any moment. In some cases, DC (direct current) lines are used to transmit a specific amount of power from one point to another. DC lines are useful when connecting interconnections, or for transmitting power over great distances without the losses of a comparable AC line.[41] Expensive converters are needed to turn AC power into DC power and back again.

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[40] The distinction here is that some parts of the grid, specifically a significant portion of generation, will be outside the scope of regulation, and ratepayer funds will not be involved. So the good news is that any significant cost exposure stops with the owner. On the down side, reliability-related generation investments will not be required by regulators, and there will be little incentive for the owner to disclose reliability/cash flow trade-offs.

[41] DC is used to transmit a specific amount of power across an interconnection. So, for example, power can be moved from the Western Interconnection to Eastern Interconnection (Colorado to Kansas, for example) up to the capacity of the DC facilities. A recent proposal would deliver power generated by coal in Wyoming to Chicago and Los Angeles with 2000 miles of DC lines.

Now that we have reviewed the uses for power lines, what are the options for improving reliability? The most direct answer is to build more power lines. "Widening the highway" to allow greater flows where they are needed does improve reliability.[42]

As we have seen, there are significant barriers to power line construction, yet some lines are built every year.[43] Most of these projects use existing rights-of-way. They generally either replace the existing circuit with one operating at a higher voltage, or add a new circuit to the one already there. Often these projects require a widening of the right-of-way or an increase in the height of poles. Where investments are needed, these practices are often superior to options that involve a new right-of-way.[44] In addition to the cost of the new circuit, new transformers are also generally required.

As we will see later, there are other enhancements to the grid that are less noticeable than adding power lines.

A great deal of the nation's transmission is owned by regulated utilities.[45] Despite the ownership of the grid by multiple companies, the grid is thought of collectively as a monopoly. The investor-owned companies that own transmission are regulated by FERC, and receive a return on book value investment set by FERC. Regulators routinely adjust allowed returns based on traditional ratemaking methods.

Energy companies are considering new ownership models. Unregulated companies that set their own transmission rates based on market prices and are fully at risk for profits can own power lines. This model is especially suitable for DC lines, where flows can be controlled with precision. It is too early to tell whether this model will actually generate investment and operate alongside the traditional utility-owned facilities. The trend, however, is for a market-based system to address reliability needs with market-based solutions. It is likely that such a system would require congestion pricing (see below) to send the proper price signals to prompt sound investment.

## B. POWER ELECTRONICS AND STORAGE

Progress in microelectronics has heralded the creation of new devices that can significantly improve the performance of the power grid. Power flows can be more easily directed with these devices to greater degrees than previously thought possible. While expensive, these devices are often substitutes for large

[42] The analogy with transportation includes a caution. In many instances of widening highways, more traffic resulted and congestion was not mitigated.
[43] The Electric Power Research Institute points to data showing that the rate of transmission line construction in the 1990s did not keep up with the rate of electric load growth over the same period. EPRI concludes that the siting process for transmission facilities must be improved to correct this imbalance. Another explanation is possible. Since transmission investments are "lumpy," transmission additions often create significant excess capacity. The decline in the rate of transmission construction may be effectively working down that excess. Also, other explanations for a diminished rate of transmission investment aside from the siting process are possible. Regardless of which explanation for the record of the 1990s is correct, a process to support reliability-based investments is needed now to assure both a reliable and a cost-effective utility system in the future.
[44] Placing power lines underground for aesthetic purposes is an option local siting authorities have when facilities are needed in populated areas. Cost concerns suggest a careful analysis of trade-offs is inevitable.
[45] Publicly-owned companies in a monopoly position own most of the rest.

power line upgrades, or can delay the need for other grid investments for many years.[46] Technology breakthroughs are also providing options for storage of power using magnets or flywheels to mitigate frequency drops of fractions of seconds. The small space assigned to this topic here is out of proportion to its likely importance as a reliability option in the future.

## C. CENTRAL STATION GENERATION

Traditional generating stations will be a critical element to maintaining the reliability of the grid. Not all generation is equal in this regard, however. Generation built in proximity to high customer demand is very helpful in stabilizing the grid, unloading transmission lines, and improving reliability. Generation built in remote areas tends only to make congestion worse, and leads to the need for facilities to counter-balance the negative reliability effects.

Complicating the prospects for central station generation proposals are their environmental aspects. It is a well known that places with high customer loads are often also places with air quality problems. Even burning relatively clean fuels can hurt efforts to attain Clean Air Act standards. New generation in these places will use clean technology. Existing generation with inferior environmental performance will be under increasing pressure to close or clean up.

While nuclear stations may be on the verge of getting a second look as a new generation option, the fact is that there have been no new U.S. orders for decades. The future could change if solutions to investment risk, security and nuclear waste storage are resolved. New nuclear generation is at best a wild card in future planning.[47]

Large scale renewable generation may be unusual because of the resource needs of such facilities. More typical may be smaller scale generation facilities that fit into distribution systems or buildings. This topic will be covered in detail in the next section.

In considering central generating facilities and their effect on reliability is that planning must take into account the big grid picture, including environmental constraints, as generation proposals are considered by siting authorities. With most new generation advanced by generating companies, policymakers cannot presume that this big picture planning has been done unless a regional entity (an RTO, for example) assumes this responsibility.

[46] In TVA, AEP, New York and Vermont, Flexible AC Transmission Systems (FACTS) have been installed to give operators more control of the grid, creating more capacity without power line upgrades. These are among the first deployments of these devices in the U.S.
[47] Existing nuclear facilities remain controversial. Despite their recent operating record, which is good, and their market value, which appears to be rising based on recent asset sale agreements, the possibility of significant numbers of these facilities shutting down remains one that planners should assess. Generic problems have plagued the industry before and the licenses of many are scheduled to expire in the next decade, though it appears likely that many of these licenses will be extended. Adequacy of generation in some regions could be dramatically affected by a swift decline in power available from existing nuclear stations.

## D. DISTRIBUTED GENERATION

Distributed generation usually means generation resources that are located downstream of the distribution transformer.[48] The generation could be in a strategic location to support a distribution circuit, or it could be an accumulation of many customers with generation on their property.

What the utility sees is a reduced demand on its substation, increasing capacity upstream on the transmission grid. In many cases, these generation additions will be less costly and more effective at enhancing grid reliability than other alternatives.

Distributed resources accrue reliability benefits in at least five ways[49]:
*Lower Reserve Margins*. The level of reserves required to deliver a given level of reliability varies with the size of generating units and the forced outage rate of those units. The larger the unit size and the higher the forced outage rate, the greater the level of reserves required to deliver a given level of reliability. Distributed resources, because of their very small size, will almost always reduce the amount of reserve capacity needed to meet a given level of reliability. Resources with low forced outage rates would further reduce required reserves.[50]
*Reduced Transmission Loading*. Reliability is also influenced by the capability of transmission facilities. If located in the right place and operated at the right time, distributed generation can increase reliability by freeing transmission lines to serve reliability purposes. Closely related is the ability of strategically located distributed resources to reduce or eliminate load pockets and provide local voltage support.
*Reduced Outages*. The extent of outages and the time needed to restore service can be reduced by the deployment of distributed resources.
*Improved Customer Reliability*. An individual customer's reliability can be improved when distributed generation is located on site and sized to meet all or at least the essential portion of load. This provides the customer with the opportunity to continue to receive electric service when the remainder of the electric system is down.
*Improved Neighborhood Service*. It is possible that improved control and communications technology installed in the distribution system will make it safe and economical to "island" parts of the system. A whole neighborhood or large subdivision might be able to temporarily disconnect from the grid and receive service from distributed resources within the area. This would increase reliability to customers in the island and if the problem was supply related, could help customers who continue to be grid connected by "freeing up" electricity.

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[48] Examples include at customers' home or business facility, or in the community.
[49] David Moskovitz. *Profits and Progress through Distributed Resources*, 2000. NARUC. pg 8.
[50] The small size of distributed resources reduces the consequences of the failure of any particular unit to start and provide the expected service, making them collectively a more reliable source of contingency reserves. Take, for example, the case of a system operator purchasing 100 MW of supplemental operating reserves from a 100 MW fast-start combustion turbine. This turbine might start within the required time on 90% of its attempts. The statistical expected value of the output is 90 MW, but once out of ten attempts, the system operator in 100 MW short. A collection of 11,250 10 kW distributed resources that start 80% of the time makes a better aggregated resource. In this case, 20% of the sources can be expected to fail, but the system operator will see around 90 MW at any time.

There is no doubt that there are some complex issues associated with operating the grid with an increasing amount of local generation. It will take some time, however, before distributed generation represents a significant percentage of total generation, and so there is time to research solutions to any operational challenges that emerge.[51]

In the meantime, many states lack rules that support interconnection of distributed generation with the distribution grid, and there is no national standard on this subject. Texas and New York are two states that have adopted rules, and work is underway by the IEEE to develop a standard interconnection rule.[52] States could go further and offer incentives for customers energy systems exceeding a certain efficiency level.[53]

Following is a brief survey of types of distributed generation.

## Combined Heat and Power (CHP)

Customers live and work in buildings with energy systems. In many of these buildings, the energy system could use fuel more efficiently, especially if some power generation element is included. Consider a cheese manufacturing facility with a need to make steam and hot water. Low grade heat can be collected after manufacturing needs are taken care of and used to make electricity. Or the system can work in reverse, with generators producing power, and the waste heat may be used for space heating, hot water, or drying. System efficiencies exceeding 80% of energy input demonstrate the worth and potential of CHP in new, expanded and refurbished buildings.

Another category of CHP projects showing promise is district energy. Communities can provide district heating and cooling service with a central energy plant what can also produce electricity. The most prominent example of this system at work is in St. Paul, Minnesota.

## Community Projects

There are opportunities in some communities to produce energy from indigenous resources, like biomass, geothermal deposits, animal wastes, or land fills. The community can benefit, especially if these generators are sited near significant loads, such as sewage treatment plants. These plants themselves have the potential to produce energy. Since projects such as these may be best sited on the utility side of the meter, utilities may be more interested in supporting them.

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[51] The Department of Energy Distributed Power Program is supporting important research in this area.

[52] IEEE is the Institute for Electrical and Electronics Engineers. IEEE sets many standards concerning electricity. For a longer discussion of the barriers to Interconnection, see Thomas Starrs, Brent Alderfer, and Monica Eldridge. *Making Connections* 2000. National Renewable Energy Laboratory. http://www.eren.doe.gov/distributedpower/barriersreport/

[53] Some system operator practices, like day ahead scheduling, have the effect of handicapping intermittent resources, like wind and solar generation. Improved wholesale market rules will address some of these concerns.

### Stand-Alone Generators

Individuals or large customers may choose to place photovoltaic panels or fuel cells in their homes and buildings, use the energy they want to, and dump the rest into the distribution grid. A large membership-only retail store with large stand alone stores with flat roofs has put PV panels on the roof expressly to sell renewable energy to this niche market.

A practice that is concerning policymakers today is the use of diesel engines for low cost stand alone power generation in modes beyond emergency back-up. Especially in parts of the U.S. where retail electric prices have been volatile, customers are tempted to run their back-up generators to offset expensive power. System operators too see back-up generators as a way to avoid cutting power to a community for an hour or two, instead of as a tool to keep the lights on for a few customers. Yet these units are often permitted only because of the original intent to run them extremely infrequently. Rules governing the operation of back-up generators will be a point of contention in many states in the next few years if they are not already.[54]

Fuel cells offer the promise of a reliable and clean stand along energy source, but remains expensive for most applications.

## E. CUSTOMER EFFICIENCY

The investment option that addresses reliability, the environment and rates most effectively is demand side management. DSM is, itself, really a portfolio of different initiatives that influence the way customers use electricity.

### Energy Efficiency

Energy efficiency programs work to overcome barriers customers experience when they have the opportunity to invest in cost effective energy uses. These barriers, generally, relate to poor information in the hands of customers and vendors, high first cost, and negative cash flow. The more energy that is not required on the system in any hour, the more margin of reliability is built into the grid. Avoiding air emissions from the fossil fueled generators, and delivered savings at less than three cents per kiloWatt-hour are additional compelling advantages to system-wide energy efficiency programs[55].

Energy efficiency has keen advantages compared with capital-intensive alternatives because the pace of investment can be fine-tuned to the needs of the system and the desired balance between short-term rates and long term savings. Investment intensity can be directed to areas with growth-driven reliability concerns (provided planning identifies these areas) to provide years of cushion before new power lines are needed.

[54] The Texas rule offers a useful guide to assuring that high polluting distributed generation does not inhibit the development of cleaner systems. It offers a streamlined permitting process for distributed generation that does not exceed certain emissions thresholds.
[55] With robust wholesale markets, even utilities with excess contract capacity can free power for sale with energy efficiency. Increasingly, utilities are viewing their power supply as a portfolio of long and short term. To extent this is so, efficiency operates to reduce short term needs.

Methods to compare energy efficiency programs with generation and transmission proposals remain controversial, largely due to the differing incentives facing utilities and other industry stakeholders, but it is clear that energy efficiency is a substitute for capital assets.

## Demand Response and Load Management

At critical hours, the next energy unit used can cost an enormous amount, hundreds of times the average generation cost, and may be generated by environmentally inferior systems. Even worse, generators can use the shortage of available generation options to "game the system," hoping to get away with driving up prices further than is just and reasonable.[56] At times like these, the ability of the system operator to be able to call on customers for more economic resources - demand reductions - can provide great value.

Here is what NERC has to say about demand response and load management,
"(Demand-side management) now has the prospect of becoming a more widely used resource in the routine operation of an electric power system. Within certain limits, the system operator can use DSM as though it were a generation source for both real and reactive[57] power.

"Resourceful system operators, working in conjunction with customer accounts representatives and rate design personnel, are designing direct DSM options for selected customers to cover a wide range of operating situations. Direct DSM can provide utilities new ways to provide for operating reserve, system control, and load following. This is in addition to DSM's classical use during system emergencies. Direct DSM can provide customers with lower energy costs by allowing the utility to control when electricity is used."[58]

There are operational issues remaining to be resolved in securing demand resources in real time when they are needed by the grid, including the degree of control the operator must have over the customers' load, and the ability of the operator to verify the load reduction. Some policymakers also question the value of demand response that leads to the shutdown of a factory shift, or which leads to the use of polluting back-up generation.

It is clear, however, that there is a large reservoir of demand response resources. Importantly, a modest response can have a very significant and beneficial effect on the market. After studying the California

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[56] California events have led to a boom in analysis of the spot prices a working wholesale electricity market would produce. These prices are thought to include the commodity cost, a cost that reflects the scarcity of the product, and costs associated with environmental compliance. Even with these components accounted for, actual California prices were apparently higher in many hours. FERC and others are investigating whether generators withheld generation at times when the supply-demand balance was so sensitive that resulting prices would multiply. Some refunds have already been ordered by FERC and more are being considered.

[57] Power systems produce two types of power, real and reactive. Real power, measured in Watts, does the real work of producing light, heat and motion. Reactive power, measured in VARs, provides the magnetic fields required by motors, generators and transformers. The voltage of transmission systems is very sensitive to the amount of reactive power that it transports.

[58] North American Electric Reliability Council Interconnected Operations Subcommittee *Demand-Side Management: The System Operator's Perspective* 1993.

energy market, EPRI found that reducing high peak demand by 1% would reduce market clearing prices by 10% with significant total summer season power cost reductions. EPRI has found similar results elsewhere.

Figure 3 demonstrates that the high loads demanding the most expensive resources and significant incremental capacity for power lines and transformers occurs in very few hours during the year.

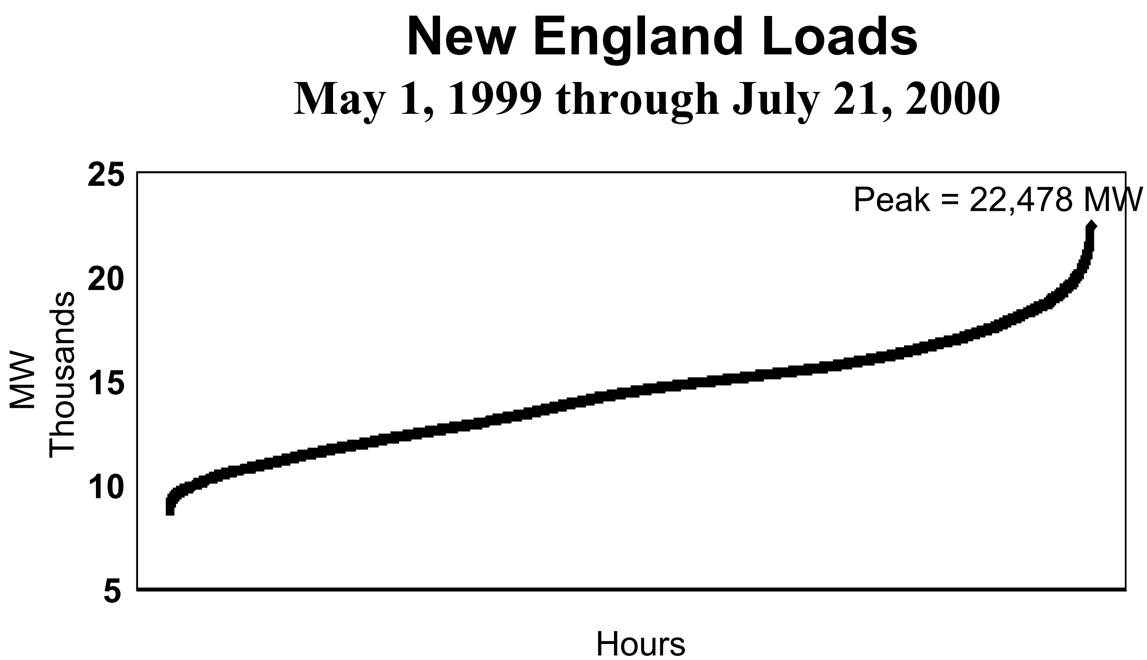


**Figure 3: Load Duration in New England**

## Market Power Mitigation

While demand response is helping improve reliability, it is also working on another infirmity of the wholesale market: market power. Generator owners are thought to have the opportunity in some circumstances to effectively dictate the market price of power. They have this power in part because there are limited alternatives, and customers are not encouraged to value their need for electricity, nor are they financially encouraged to consider doing without grid electricity for all or part of their needs. Demand response programs put a critical mass of customers in the position of being a system resource and competing with the generators to supply that resource in a given hour. With sufficient customer participation, the generators ability to dictate prices will be diminished.[59]

[59] There are several models for how small customers can aggregate their demand response potential to make a meaningful contribution to the grid. Here are two. They could be grouped by the distribution utility by end use, air

There is a direct effect on reliability. One of the key strategies for exercising market power is to withhold power from the system operator until prices move. It is not necessarily the case that the generator adds the withheld power once prices are high. Unfortunately, if this behavior is occurring, there is incentive to hide it from reviewers, so making the withholding appear to be a maintenance outage would be consistent with this strategy. Reliability is threatened if withholding is a promising profit-making strategy. If withholding is unnecessary, all the resulting shenanigans do not happen. Then the consumer can more reliably count on all available generation to be ready to go, as the system needs it.

### Codes and Standards

While the continual updating of building, appliance and equipment efficiency standards falls outside the regulatory arena, they are firmly in the policymaker's ambit. The less energy used to provide the same service for the consumer, the greater the reliability margin is. Technology is continually improving, and getting this technology into wide use takes pressure off electric ratepayers to fund new power lines, power generators, and energy efficiency programs.

## F. RATE DESIGN AND REGULATION

Improved rate design can promote reliability and better functioning markets. An important key is to give consumers the opportunity to see marginal cost. Another is to focus the utility's incentives to provide services customers need and want.

### Rates

Rate design offers a dilemma. Prices reflecting marginal cost are the best way to encourage efficient use of society's resources. This is consistent with good reliability policy because efficient use of the system's resources means they will be more likely available in the event of a threatening contingency. Reliability is all about probability.

Imposing marginal cost rates on all customers is practically flawed, however. Based on current rate design practices throughout the U.S., moving to marginal cost rates would increase fixed customer charges and reduce usage charges[60]. The result is a large percentage increase to the bottom line electric bill for low use customers. The regressive nature of this result, and the apparent incentive to use more electricity despite clear policy motivations to the contrary, makes this kind of rate shift an unlikely outcome.

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conditioning with radio controllers, for example. Energy service companies, which may provide special metering and controls for affected customer loads could recruit them.

[60] Some suggest that the cost of environmental damage and other externalities from electric power production not otherwise included in electric rates should be calculated and added to electric rates. The author ignores the possible effects of this change in rate setting policy.

An option that bridges the dilemma is to offer customers real time prices. A small percentage of customers choosing a real time price tariff can have a significant effect at peak times.[61] Demand reduces as prices rise as customers find lower cost alternatives, enabling existing resources to withstand higher overall customer demands. The corollary effect of reduced peak hour prices is also good news. The optional nature of this policy means consumers uninterested in real time price management will not be forced to accept large bill increases, while consumers that do select this option will receive the primary economic benefits.[62] Economic benefits accrue to all customers to the extent that some new expensive power generation and transmission facilities are no longer needed, and therefore not paid for by consumers.

A less radical approach is to offer consumers time of use rates. Since the peak demand times can be predicted with some accuracy, prices can be raised in these hours, and reduced in the low demand hours. In fact, many states employ this practice, which does require some enhanced metering to assure that each increment of usage is priced properly.

An approach that has been getting a close look recently by California uses an inclined block rate structure. This is based on the presumption that usage sufficiently in excess of an average imposes a burden on society that should be reflected in the rates charged for that excess usage. Usage over a certain threshold costs more. While there are questions about how the averages and thresholds are set, this method does protect low use customers, generally attaches the higher cost of peak power to the causers of the usage, and no new metering is required.

## Utility Incentives

A second important issue in the union of rate setting and reliability addresses utility incentives. A utility conventionally regulated is highly dependent on sales for its bottom line profits. This fundamental relationship[63] occurs because sales growth causes revenues to go up faster than costs.[64]

Changing the way the utility earns profits, in conjunction with performance based regulation, can make a big difference in the utility's attitude about demand side management and distributed generation. If sales become a non-issue for the utility, it will be more interested in and less conflicted about investments that promote the consumers' interests though potentially reducing sales. One way to create this relationship is

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[61] According to EPRI, a 1% reduction in load in California during 2000 would result in a 10% reduction in peak prices; a 5% load reduction grows the expected price effect to –19%. EPRI made similar conclusions concerning the Midwest after its power shortage and price spikes in 1998.

[62] It is reasonable to expect larger C&I customers to be most interested in real time prices since they have the staff of devote to managing real time energy decisions. Restructuring could offer such surprises, however, as aggregated residential customers agreeing to real time prices in exchange for promised total bill reductions while counting on the aggregator to manage the details, like curtail certain household and building energy uses and adding lower cost off-grid peaking energy systems.

[63] David Moskovitz, *Profits and Progress through Distributed Resources*. NARUC. 2000 pgs 10-14.

[64] Many observers of electric utilities know that the dollar return on investment allowed in rates in a rate case is based on the net book value of the company's assets, the utility's cost of debt and the return on equity investment allowed by the regulator. It is less well-understood but no less true, however, that after the rate case is over, the actual profit the cost-of-service-regulated utility sees is based on sales volume. This effect is explained in more depth in Profits and Progress.

to adopt a revenue cap form of regulation. The utility would be compensated based on a fixed amount per customer.[65]

More aggressive regulatory options are available that serve to promote reliability. For example, by identifying areas that may require investment in distribution facilities through planning, regulators can use rate design to create incentives to site distributed resources. In such a distributed resource development zone, the customer can reap the benefit of a making a reliability-enhancing investment.[66]

We will now turn to a discussion and summary of the leading policy options for assuring and enhancing electric system reliability.

[65] Moskovitz, supra
Frederick Weston, Charging for Distribution Utility Services: Issues in Rate Design. NARUC. 2000.
[66] David Moskovitz, *Distributed Resource Distribution Credit Pilot Programs: An Idea Whose Time Has Come*, National Renewable Energy Laboratory July 2001.

# 5. POLICY SOLUTIONS

There is no "silver bullet" to achieving reliability in the most efficient way. Traditional standards for reliability provide an excellent foundation, but recent experiences make clear that active policy management is needed to protect reliability, and more can be done. The public looks to industry and political institutions to assure reasonably reliable service. An array of sound policies addressing each segment of the electricity market is necessary. Solutions to reliability problems should address the following questions:

Could reliability be served at lower cost or lower risk through demand side resources? Is there sufficient incentive to invest in grid reliability? And how can we organize this market or structure this rule to ensure that high-reliability, low-cost solutions are deployed.

There are several venues for discovering and deploying cost-effective efficiency resources:

- Wholesale Markets should invite demand side resources to bid against supply, and should permit demand side resources to compete with transmission and generation investments to meet system needs. Regulators should provide accurate price signals to customers and load serving entities and remove barriers to demand side resources
- Legislatures and regulators should create funding mechanisms for efficiency and load management investments, recognizing their reliability benefits, as well as the significant market barriers that block their efficient deployment.
- New technologies beneficial to reliability should have a clear path from concept to deployment. Industry practices in planning and siting should be comprehensive and should consider all alternatives, including energy efficiency. More sophisticated methods that look further into the future to see load growth trends and predict grid needs will enable energy efficiency to be more responsive in meeting these needs with energy efficiency.

## A. WHOLESALE MARKETS

### Efficient Reliability Standard

**Demand-side resources should receive equal attention with supply and transmission options in RTO and power pool initiatives that use uplift and other "socialized" support mechanisms.**

Electric resource adequacy and system reliability are public goods. Costs to support them are recovered in broad-based rates charged to all interconnected users of the grid. Efficiently constructed wholesale electricity markets, including adequate demand-side bidding systems, can moderate volatile markets. Nevertheless, reliability managers, power market managers, utilities, ISOs and RTOs are increasingly finding it necessary to take administrative actions to promote reliability. These administrative actions take many forms, including:

- Requiring the provision of specified ancillary services, by market participants by rule; and/or purchasing them on behalf of all market participants (and then imposing a tariff to pay for them);

- Socializing congestion costs, supported through uplift charges, so that customers in load pockets do not pay higher prices for power behind a constrained interface;[67]
- Entering the market directly through an RFP for the provision of reliability services, such as the emergency generators and dispatchable load contracts sought to be deployed in several power pools in recent summers[68];
- Identifying needed transmission links and supporting their construction through broad-based transmission tariffs or other forms of "uplift" assigned to users throughout the pool[69];
- Canceling power trades in order to relieve unacceptable loading on the transmission system.[70]

System operators have focused on supply-side resources in meeting reliability requirements for electric networks. There is, however, a demand-side corollary that could perform that same service at lower cost, provided that market rules were defined to include such resources, and broad-based funding were made available to support them on the same basis as the more traditional solutions. Energy efficiency, load management, demand-side bidding, and distributed resources are all potentially cost-effective means of meeting reliability needs identified by system operators and power pool managers. Customers are an important reliability resource.

So long as vertically integrated utilities were basing their investment decisions on the principles of integrated resource planning, many reliability-enhancing decisions were governed by least-cost decision-making. With the breakup of the franchise, the demise of IRP, and the assumption of new responsibilities by RTOs and other regional organizations, there are now numerous occasions where broadly-funded interventions may be taken without serious consideration of less expensive and more reliable alternatives based on distributed resources and demand-side alternatives.

For this reason, the following Efficient Reliability Standard for the efficient provision of reliability should first test reliability rules and investment decisions that will, by administrative action, impose costs on consumers and other market participants:

Before "socializing the costs of a proposed reliability-enhancing investment through tariff, uplift, or other cost sharing requirement, FERC, the state PUC, and the relevant RTO should first require a finding that:
**The relevant market is fully open to demand side as well as supply side resources;**

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[67] This has been the practice in New England for many years.

[68] For example, in the summers of 1999 and 2000 the New England and California ISOs proposed collecting pool-wide uplift charges to bring in and operate emergency generators on barges anchored in the Connecticut River and San Francisco Bay. Several pools have launched programs to acquire demand interruptions from customers who will agree to load controls directly from the ISO.

[69] In 2000, the New England ISO accepted a recommendation to support the construction of several transmission upgrades throughout the region, as "Pool Transmission Facilities" because they would relieve transmission congestion in certain areas, and improve the resilience of the transmission system. In NE-ISO parlance, the cost of these upgrades will be "socialized" -- that is spread among all users of the regional transmission system through a regional "uplift" charge. More than $120 million in capital costs will be raised, under a NE-ISO tariff, for this purpose.

[70] Transmission load relief (TLR) actions have increased markedly in recent years.

**The proposed investment or standard is the lowest cost, reasonably-available means to correct a remaining market failure; and**
**Benefits from the investment or standard will be widespread, and thus appropriate for support through broad-based funding.**

If this standard were adopted as a screening tool by FERC and the nation's RTOs when considering proposed reliability-enhancing rules and investments, it would provide a much-needed discipline in situations where expensive wires and turbines solutions are proposed to address reliability problems, and more robust, less expensive, distributed solutions are overlooked.[71]

There are at least two other reasons why the Efficient Reliability Standard is compelling. First, big transmission system investments will be delayed until they are absolutely needed. Second, the public can have confidence that when a big transmission investment is approved, there are no better alternatives available in terms of cost and environmental effects.

Opportunities to adopt and apply this principle arise in numerous circumstances. Congress and state legislatures have seen bills relating to reliability; statutory revisions should adhere to the principle that demand-side and supply-side reliability options should be considered equally when addressing reliability needs. FERC should also take the initiative on this point. Numerous state PUCs have long understood that least-cost principles should govern utility decisions to make investment decisions that they plan to recover from ratepayers. Increasingly, those decisions are being made by RTOs, ISOs Transcos and wholesale power pools, subject to FERC jurisdiction. FERC should require RTOs to ensure that decisions to socialize reliability improvements have been disciplined by a hard look at distributed and demand-side alternatives.

## Demand-Side Bidding: There is a Demand Curve for Electricity

Every effort should be made to expose the value of demand response in the wholesale and retail markets to as many participants as possible.

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[71] A standard of this sort has been under discussion in at least one of the nation's ISOs. The Advisory Council to the Board of ISO-New England recently addressed this issue, concluding that "it should be the responsibility of the ISO, as New England's RTO, to analyze feasible alternatives to transmission investments for reliability, and to present them as part of a regional reliability planning process. The ISO should develop a regional plan for transmission, with updates and modifications as market participants provide market-driven proposals to relieve reliability and economic congestion conditions; this plan should identify high-value energy services and reliability needs that should be addressed, and which could be remedied through either a transmission, generation, distributed-generation, or demand reduction approach."

In addition, the Advisory Council concluded that the ISO should analyze alternatives to transmission, and make those analyses available in the public decision-making process on socialization proposals: "In situations where the ISO-NE is called upon to analyze transmission proposals whose costs are proposed to be socialized (that is, recovered through a broad-based mechanism paid for by captive ratepayers, as opposed to proposals to recover merchant transmission investments through market mechanisms), the ISO-NE should have a heightened duty to make sure that its analyses consider the impacts of the proposal and a broad array of practical transmission and non-transmission alternatives to it. These analyses should be designed to analyze whether the proposed transmission facility is needed and least-cost."(ISO-NE Advisory Committee, Comments to the ISO – New England Board Regarding the Design of a Regional Transmission Organization for New England, October 11, 2000.)

In traditional regulation there has been little financial relationship between electric demand and supply. Peak period costs were rarely reflected in peak period prices. With prices averaged over time and location, customers simply use the product regardless of its cost and without a thought to society's trade-offs, presenting essentially a vertical demand curve.

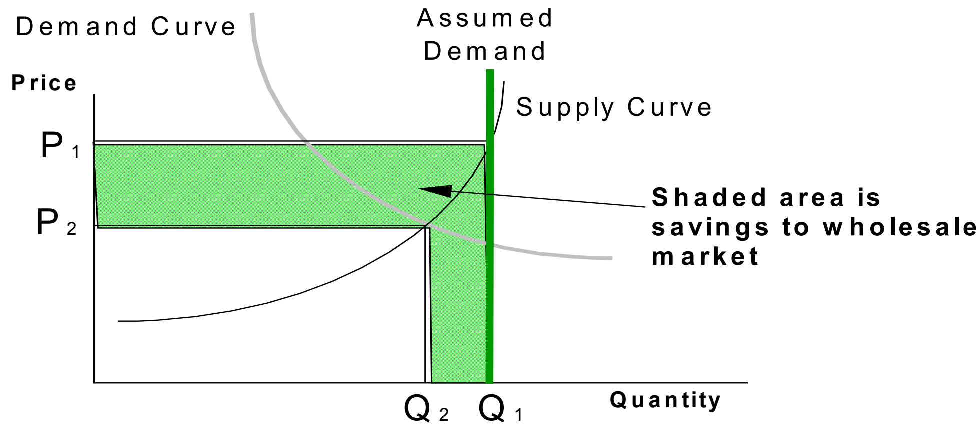


**Figure 4: Assumed vs. Actual Demand Curves for Electricity. Revealing the actual demand curve would lower price and peak loads in the market.**

Efficient energy markets cannot be built in this foundation. There is ample evidence that many customers will adjust their demand based on market conditions, either by reducing overall use, or shifting use to less expensive hours. Revealing the customers' real demand curve is now a critical challenge for the nation's policymakers. Markets will clear at lower quantities of energy and lower prices when the demand curve is exposed. Figure 4 demonstrates this in graphical form.

Fortunately, a relatively modest demand response during just a few hours of the year make a substantial reduction in peak demand, enhancing reliability and lowering costs. Even more promising is the fact that a small fraction of customers account for a disproportionate fraction of demand. Nationwide, industrial customers are 0.4% of total customers, and 30% of total demand.[72]

[72] Edison Electric Institute, *Statistical Yearbook of the Electric Utility Industry, 1999 Edition*

For those constructing wholesale markets, the lessons suggested by these data are straightforward. As Hirst and Kirby conclude:

These results show that large benefits can likely be achieved by offering dynamic pricing and related programs to a tiny fraction to the nation's electricity consumers. In other words, your grandmother need not worry about responding to real-time pricing.[73]

Bidding rules on the wholesale trading floor must be organized to reveal the customers' demand curve. The first step in this process is to require customers or their load serving entities to place bids into the market under the same general conditions as generators placing supply bids. Bidding rules should permit load to bid at multiple price points, stating how consumption will vary with different market prices. When market managers clear the market, both demand and supply bids will be involved in setting price and quantity in the settlement.[74]

## Demand-Side Bidding Works for Ancillary Services

As discussed earlier, ancillary services help utilities maintain the balance between load and supply. FERC ordered the unbundling of ancillary services from generation and transmission service to promote competitive markets, which should improve efficiency and lower prices. These markets should be open to any technology capable of providing the service. More supply of ancillary services will reduce any market power that may be held by generators, and more reserves from demand resources will free generation capacity to generate electricity.

Demand resources can supply many of these services if there is a market mechanism to deliver them in return for compensation. For example, customers can agree to curtail loads within ten minutes, and this service can compete with marginally priced fossil-fuel units running at partial load with higher than average emissions. This scenario presents an environmental opportunity as well. Since that partly loaded generator is operating very inefficiently, substitutable demand resources enable significant emissions reductions.

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[73] Hirst and Kirby, *Retail-Customer Participation in Bulk-Power Markets.* Oak Ridge National Laboratory. 2000. at 30-31.

[74] In states that have adopted competition and default or standard offer service, load profiles are generally used to assign load responsibility among the load serving entities. Load profiles are based on average usage patterns of customers in a particular class. Load profiles dampen out the motivation of customers to respond to varying wholesale prices. Customers who reduce electricity use in high-cost hours will not see the benefits of the change in their bills, and neither will the load serving entity.

Real time meters are an expensive solution. A simpler way to address the problem would be to require multiple load profiles, sub-classifying customers by key distinguishing characteristics, notably keyed to loads that can be controlled. Air conditioning customers and electric water heating customers are examples of two customer groups that are likely to have distinct load profiles. These customers, then, could be targeted for demand bidding programs.

### Multi-Settlement[75] Markets Address Real Time Markets

The positive effects of demand responsiveness can extend from projected market conditions to real time conditions, such as weather, unplanned outages, changed consumer needs, or unanticipated market price changes. **Bidding rules should permit adjustments to commitments made in advance**, and they can. Here is how it works:

- In the day ahead market, bids are taken for loads and supply resources;
- Demand and supply bids are ranked and the market manager clears the market at prices and quantities that are physically achievable;
- Day ahead bids are settled and become firm financial commitments;
- Up to a certain time in the "day of" market, buyers and sellers can seek to modify their commitments in a second settlement in new financially binding commitments.
- Behavior that is contrary to the commitments exposes the bidder to whatever the spot market prices yield.

Day ahead prices are forecast with fairly low confidence[76] and opportunities for supply and demand resources to respond to volatile prices and offer more stability and reliability to the system are quite limited.

A multi-settlement system offers an efficient way for market participants to manage risk, and it has the related benefit of reducing the potential of windfall profits flowing to generators in times of shortage.

### Improved Wholesale Market Administration and Practices

A great deal of attention right now is focused on creating wholesale electricity markets with large regional scale. This is because many observers expect that there are efficiencies in sharing resources and planning over the widest areas. Whatever the outcome of the FERC's efforts to create a minimum number of large RTOs in the U.S., there is significant opportunity for improved practices. These include

- Sharing of reserves
- Compatible market rules
- Compatible tariffs that to not result in pancaked transmission rates.

## B. RATES AND RULES FOR WIRES COMPANIES

### Transmission-Level Congestion Pricing

Transmission congestion has always been a problem, but it seems to be getting worse. One explanation is that the vertically integrated utilities were better able account for and work around transmission constraints in everything they did, whereas the more competitive markets of today lack this overall focus.

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[75] The New England ISO is developing "Multi-Settlements System." PJM ISO has implemented the system described here, which is called the "Two-Settlements" system.

[76] In June of 2000, the New England ISO day ahead load forecasts deviated from actual hourly loads by roughly 3.4% (440 MW). Hourly forecasted prices deviated from actual settlement prices by roughly 20%.

With the added force of more wholesale transactions, the stress is worse. Transmission resource constraints are not fully recognized in averaged wholesale prices. Regardless of the system of utility ownership or regulation, locational pricing reveals the value of all resources, including distributed resources, across constrained interfaces.

Locational-based transmission prices are alternatives to construction of facilities to eliminate the congestion that allow market participants to decide how to utilize limited facilities.[77] They signal the market to focus resources on high cost transmission paths to reduce both cost and congestion. PJM uses locational prices, calculating prices for approximately 2000 nodes in its region. Locational price differences vary from month to month. Between April 1998 and September 1999, prices differed from location to location during 15% of those hours, and the maximum difference in price was nearly 2 cents per kWh. These data also reveal that the direction of congestion sometimes changes.

When congestion costs are assigned to the responsible load, a more accurate price signal is received with the constrained area. If allowed by the market rules, cost-effective means to reduce congestion will have an opportunity to compete to reduce the congestion and improve reliability.

Energy efficiency and load management resources may have great value when they reduce load in particular locations and at the particular times that congestion problems would otherwise arise.

## Enhancing Reliability Through Retail Rate Design

Since the energy crisis of the 1970s, policymakers have been generally aware that retail electric rate design is a tool that can be managed to yield significant efficiency dividends. Yet aside from some use of seasonal differential rates, and limited time-of-use experiments, that potential remains unrealized.

Offering **optional real time pricing** can pay quick dividends by using the motivation of participating customers to reduce usage and extend the capacity of existing resources.

Offering **demand bidding** extends this effect. When motivated consumers can bid to reduce load in favor of higher cost generation bids, those resources remain available to supply reliability benefits.

Where electric demand is growing, taxing existing facilities and causing the need for some investment in electric facilities, regulators can provide incentives to assure that alternatives are considered. In many cases the cost of adding new or upgraded wires to a system is very high, leaving plenty of room for other options to solve the problem.

Today, most demand bidding is offered to large customers with direct-metered connections with the system operator. More customer load would be available for demand bidding if system operators allowed and encouraged statistical representations of wide spread aggregated demand to bid. Appropriate

[77] There is a debate about the best way to apply congestion pricing. The two candidates are "nodal," which assigns values to hundreds or thousands of nodes within a control area, and "zonal," which generally applies values to either side of a congestion interface. This paper takes no side in this debate, though it probably most important that the transmission pricing systems in place are compatible across the nation.

verification methods and allowances for cheaters would be necessary, but the result would strongly promote efficient energy markets, resulting in improved reliability.

One author suggests the creation of **Distributed Resource Development Zones**.[78] These are geographic areas where savings would be expected from the deployment of distributed resources. Utilities would identify DRD Zones based on planning. A DRD Zone would be characterized by high local incremental power costs, perhaps due to the cost of transmission investment that would be necessary is customer electric demand continues to grow without mitigation.

In the DRD Zone, the utility would offer distribution credits to customers. Under a program of geographically **de-averaged distribution credits**, the utility would establish financial credits for distributed resources installed in the zone. These credits would cost the utility less than the amount that would have been paid to build power lines.

## Rules for Distributed Generation

Distributed generation has the prospect of adding value to both customers and utility systems as discussed earlier. The rules governing connecting these systems to the grid often serves to stifle these opportunities while being over-conservative. These rules, hopefully consistent with national standards under development by IEEE, should be adopted by states.

## System Benefits Charge and Public Benefit Programs

Energy efficiency and demand management promote reliability. They allow consumers to meet their needs while applying less stress to the grid. This is one reason among others that state laws and regulators direct a portion of utility revenues to support energy efficiency, and why programs to encourage demand management are becoming increasingly popular. Where customer resources are not looked at in this way, a significant opportunity to promote efficient electricity markets is lost. Energy efficiency is a leading type of public benefit program.[79]

Some states use a system benefit charge (SBC) to collect money from consumers for public benefit programs. An SBC simply breaks out the cost of the public benefit program from the overall utility cost. This device is used most often where a state has adopted retail competition, but it has also been used in retail monopoly states. The advantage of an SBC is that it draws attention to the public benefit programs, assuring they are managed actively.

## R, D, D & D

"Research, development, demonstration and deployment" represent the sequence of bringing a new technology or practice from concept to commercial acceptance. The electric power industry has seen

[78] David Moskovitz *Distributed Resource Distribution Credit Pilot Programs: An Idea Whose Time Has Come*. National Renewable Energy Laboratory2001. http://www.rapmaine.org/DPDeaveragedCredits.pdf
[79] Other leading public benefit programs include R, D, D & D of renewable energy systems, and support of low income electric consumers.

major technology advances over the course of the twentieth century, and especially recently. Yet, the dominant utility infrastructure has not changed much in many decades

It is mysterious why some ideas find the path to deployment straightforward to traverse without policy assistance while others would be nowhere without it. It is evident, however, that government and industry have had a long partnership in technology development, and that this relationship is undergoing some stress with the restructuring of the electric industry. Industry commitment to R,D,D&D appears more focused on payback periods and appears more risk averse. There is a risk that the breadth of new ideas will be narrowed.

For the purpose of this paper, suffice to say that public policy has a role in maintaining a flow of new technology and practices, not just the “best bets” that the private sector supports, but the “dark horses” which may be untraditional but effective at addressing public needs. Demonstration projects and commitment of a small fraction of utility revenues to public interest R,D,D&D are useful public policy answers to this question, where will new ideas come from?

## Planning and Siting

Planning is the process of bringing all the facts of the grid; the generators, wires, customer demand; together with forecasts of the future demands on it and all the options to improve it. The Efficient Reliability Standard would inform the planning process, as would many of the other ideas discussed in this paper.

A solution that merits study would have a more “transparent” planning process for transmission grid enhancements. A transparent planning process is one in which the public is invited to see and understand the problems the grid operator is trying to solve, and is invited to ask questions and make suggestions about possible solutions before decisions emerge as siting proposals.

Such a process would tend to identify areas of the grid that may become problematic based on load growth trends or expected changes in development patterns or other events, and focus a planning conversation on what to do while all options are available. Some options, like the distributed resource development zone designation, and the deployment of geographically de-averaged distribution credits, may take time to achieve the potential and desired effects. Delay in engaging a problem could make the benefits of some options unattainable.

A benefit from a transparent planning process would be siting proceedings where the proposals would be more clearly needed and would be more demonstrably superior to alternatives.

Transparent grid planning is not just for the transmission level. A relatively new practice, called Distributed Utility Planning, is being developed in some states. This approach, which considers small-scale generation and efficiency resources as alternatives to distribution system construction, would be further enhanced by methods to bring the public into the process.

Frustration concerning the pace of siting of new transmission facilities has led many to question the viability of maintaining state jurisdiction over these proceedings. This paper will not enter the debate about whether siting jurisdiction should remain with the states or be moved to a regional or federal level.

Here are indicators of a successful siting process regardless of the outcome of the political jurisdictional debate.

- Transparent (open, inclusive, early) planning process
- Broad array of alternatives considered in answer to a reliability problem
- Clear criteria for approval, including what "need" means
- Clear time frames for considering completed applications
- Accounting for all project benefits and costs, regardless of state boundaries

A sound objective for the siting process is for it to win and maintain the public trust. Such a process will cause investment in and construction of the facilities needed for reliability, without leading to costly and wasteful gold-plated systems.

It is a very fair question to ask who will do the planning described here. As discussed earlier, electric industry restructuring in many regions has disaggregated planning for generation, transmission and customer load that vertically integrated utilities have done. The current direction is to assign the Regional Transmission Organizations to the planning job. The RTO would work under some combination of FERC/NERC direction. Legislatures should assure that state PUCs are participating in RTO planning processes while holding utilities responsible for planning in the states. It remains to the future to reveal if the RTOs adopt the planning philosophy described here or one that is less comprehensive.

# CONCLUSION

Reliability has always been of paramount importance to electric consumers. The U.S. electric industry has taken justifiable pride in its reliability performance. Restructuring has not changed either of these.

What has changed is that there is closer scrutiny than ever of the institutions that make up the electric industry. Responsibilities for maintaining reliability are shifting to new organizations. While it is evident that many of the changes at the state and federal level have not fully considered the effects on reliability, there is much that regulators and the industry can do to improve reliability, or to maintain it in a more cost-effective way.

The excellent electric reliability performance in the U.S. since the 1965 Northeast Blackout is no accident. The industry did an excellent job. Likewise the Western Blackout of 1996 and other close calls over the last five years indicate that policymakers together with the industry should recognize changes in this restructured industry the U.S. now has and focus on how to make targeted changes in regulation and practices to deliver the reliability margins customers want and increasingly count on.

There is no more important task for electric industry policy makers today than to re-establish clear lines of responsibility to maintain grid reliability. All the good ideas in the world will be wasted if there is confusion about who should implement them.

This paper has reviewed electric reliability issues facing the U.S. and has offered policy ideas addressing supply and demand sides of the market that promise significant improvement in the nation's reliability performance. Elected officials will benefit by becoming familiar with the dimensions of reliability and the policy ideas in this paper as discussions of utility rates, utility construction projects and efficiency ebb and flow in capitols across the United States. Those ideas that rely on statutory changes should prompt important policy debates and receive close scrutiny and consideration.

# GLOSSARY

**Access Charge** -- A charge levied on a power supplied, or its customer, for access to a utility's transmission or distribution system. It is a charge for the right to send electricity over another's wires.

**Aggregator** -- An entity that puts together customers into a buying group for the purchase of a commodity service. The vertically integrated investor owned utility, municipal utilities and rural electric cooperatives perform this function in today's power market. Other entities such as buyer cooperatives or brokers could perform this function in a restructured power market. This is opposed to marketer that will be defined as an entity that represents different suppliers.

**Ancillary Services** -- Additional generation and transmission services provided by generating units and some types of transmission equipment that are needed to ensure the reliable operation of the transmission system and facilitate power transfers. Some of these services, include: scheduling, system control and dispatch; reactive power supply, voltage support, and voltage control; regulation and frequency control; energy imbalance (short-term load following); standby generation; operating reserves, including spinning and supplemental reserves; compensation for real power or transmission losses; dynamic scheduling of generation in response to fluctuations in specific loads; and restoration of generation service or black start capabilities.

**Bottleneck Facility** -- A point on the system, such as a transmission line, through which all electricity must pass to get to its intended buyers. If there is limited capacity at this point, some priorities must be developed to decide whose power gets through. It also must be decided if the owner of the bottleneck may, or must, build additional facilities to relieve the constraint.

**Bulk Power Supply** -- Often this term is used interchangeably with wholesale power supply. In broader terms, it refers to the aggregate of electric generating plants, transmission lines, and related-equipment. The term may refer to those facilities within one electric utility, or within a group of utilities in which the transmission lines are interconnected.

**Contract Path** -- The most direct physical transmission tie between two interconnected entities. When utility systems interchange power, the transfer is presumed to take place across the "contract path," notwithstanding the electrical fact that power flow in the network will distribute in accordance with network flow conditions. This term can also mean to arrange for power transfer between systems. (See also Parallel path flow)

**Control Area** -- An electric system bounded by transmission lines that are equipped with metering and telemetry equipment to track and report power flows with adjacent control areas. A control center for each control area controls the operation of generation within its portion of the transmission grid, schedules interchanges with other control areas, and helps to stabilize the frequency of alternating current in the interconnection. Control centers are currently operated by individual utilities, power pools, ISOs or RTOs.

**Demand Charge** -- A fee based on the peak amount of electricity used during the billing cycle.

**Demonstration** -- The application and integration of a new product or service into an existing or new system. Most commonly, demonstration involves the construction and operation of a new electric technology interconnected with the electric utility system to demonstrate how it interacts with the system. This includes the impacts the technology may have on the system and the impacts that the larger utility system might have on the functioning of the technology.

**Distributed Generation** -- A distributed generation system involves amounts of generation located on a utility's distribution system for the purpose of meeting local (substation level) peak loads and/or displacing the need to build additional (or upgrade) local distribution lines.

**Distribution** -- The delivery of electricity to the retail customer's home or business through low voltage distribution lines.

**Distribution Utility (Disco)** -- The regulated electric utility entity that constructs and maintains the distribution wires connecting the transmission grid to the final customer. The Disco can also perform other services such as aggregating customers, purchasing power supply and transmission services for customers, billing customers and reimbursing suppliers, and offering other regulated or non-regulated energy services to retail customers. The "wires" and "customer service" functions provided by a distribution utility could be split so that two totally separate entities are used to supply these two types of distribution services.

**DSM (Demand-Side Management)** -- Programs to influence the amount or timing of customers' energy use.

**Economic Efficiency** -- A term that refers to the optimal production and consumption of goods and services. This generally occurs when prices of products and services reflect their marginal costs. Economic efficiency gains can be achieved through cost reduction, but it is better to think of the concept as actions that promote an increase in overall net value (which includes, but is not limited to, cost reductions).

**Electric Utility** -- Any person or state agency with a monopoly franchise (including any municipality), which sells electric energy to end-use customers; this term includes the Tennessee Valley Authority, but does not include other Federal power marketing agency.

**Eminent Domain** – The process by which rights to land needed for public interest facilities is acquired over the objection of the landowner. Eminent domain is generally enforced by the relevant siting authority that found the facilities to be in the public interest.

**Energy Efficiency** -- Using less energy/electricity to perform the same function. Programs designed to use electricity more efficiently -- doing the same with less. For the purpose of this paper, energy efficiency is distinguished from DSM programs in that the latter are utility-sponsored and -financed, while the former is a broader term not limited to any particular sponsor or funding source. "Energy conservation" is a term that has also been used but it has the connotation of doing without in order to save energy rather than using less energy to do the same thing and so is not used as much today. Many people use these terms interchangeably.

**Federal Energy Regulatory Commission (FERC)** -- The Federal Energy Regulatory Commission regulates the price, terms and conditions of power sold in interstate commerce and regulates the price, terms and conditions of all transmission services. FERC is the federal counterpart to state utility regulatory commissions.

**Grid** -- A system of interconnected power lines and generators that is managed so that the generators are dispatched as needed to meet the requirements of the customers connected to the grid at various points. Gridco is sometimes used to identify an independent company responsible for the operation of the grid.

**Independent System Operator (ISO)** -- A neutral and independent organization with no financial interest in generating facilities that administers the operation and use of the transmission system. ISOs exercise final authority over the dispatch of generation to preserve reliability and facilitate efficiency, ensure non-discriminatory access, administer transmission tariffs, ensure the availability of ancillary services, and provide information about the status of the transmission system and available transmission capacity. Under some proposals, an ISO may make some transmission investment decisions.

**Kilowatt (kW)** -- This is a measure of demand for power. The rate at which electricity is used during a defined period (usually metered over 15-minute intervals). Utility customers generally are billed on a monthly basis; therefore, the kW demand for a given month would be the 15- minute period in which the most power is consumed. Customers may be charge a fee (demand charge) based on the peak amount of electricity used during the billing cycle. (Residential customers are generally not levied a demand charge.)

**Kilowatt-hour (kWh)** -- This is a measure of consumption. It is the amount of electricity that is used over some period of time, typically a one-month period for billing purposes. Customers are charged a rate per kWh of electricity used.

**Load Center or Load Pocket** -- A geographical area where large amounts of power are drawn by end-users.

**Long-Range Planning** -- The process of forecasting long-term loads, determining a reasonable set of potential resources to meet such loads (including reduction of loads through energy efficiency), analyzing the costs (sometimes including externality costs) of several possible mixes of such resources, and identifying the resources to be secured to meet such future needs.

**Monopoly** -- The only seller with control over market sales.

**Natural Monopoly** -- A situation where one firm can produce a given level of output at a lower total cost than can any combination of multiple firms. Natural monopolies occur in industries that exhibit decreasing average long-run costs due to size (economies of scale). According to economic theory, a public monopoly governed by regulation is justified when an industry exhibits natural monopoly characteristics.

**NERC** -- The North American Electric Reliability Council is the coordinating arm of the nine member regional reliability councils. (See also Reliability Councils)

**Non-bypassable Charge** -- Any of a number of charges that would apply to all end-users of electricity, and could not be bypassed except by totally disconnecting from the grid. Includes systems benefits charges, public goods charges, wires charges, access charges, and the like. Typically is a fee of some kind for use of the wires or access to the grid.

**Obligation to Serve** -- The obligation of a utility to provide electric service to any customer who seeks that service, and is willing to pay the rates set for that service. Traditionally, utilities have assumed the obligation to serve in return for an exclusive monopoly franchise.

**Parallel Path Flow** -- As defined by NERC, this refers to the flow of electric power on an electric system's transmission facilities resulting from scheduled electric power transfers between two other electric systems. (Electric power flows on all interconnected parallel paths in amounts inversely proportional to each path's resistance.) This demonstrates that contract transmission paths do not define the way electricity actually flows.

**Peak Load or Peak Demand** -- The electric load that corresponds to a maximum level of electric demand in a specified time period.

**Performance-Based Regulation (PBR)** -- Any rate-setting mechanism that attempts to link rewards (generally profits) to desired results or targets. PBR sets rates, or components of rates, for a period of time based on external indices rather than a utility's cost-of-service. Other definitions include light-handed regulation that is less costly and less subject to debate and litigation. A form of rate regulation that provides utilities with better incentives to reduce their costs than does cost-of-service regulation.

**Power Authorities** -- Quasi-governmental agencies that perform all or some of the functions of a public utility.

**Power Pool** -- An entity established to coordinate short-term operations to maintain system stability and achieve least-cost dispatch.

**Provider of Last Resort** --A legal obligation (traditionally given to utilities) to provide service to a customer where competitors have decided they do not want that customer's business.

**Public Good** -- A good (or a service) that will not be produced and delivered if we rely solely on the free market. Economists call these “public goods” because the public consumes them, and their use cannot be restricted to the benefit of a single buyer or group of buyers. There is no way to produce a public good without producing a value to society at large. This in turn makes it all the more unlikely that an individual would pay out of his own pocket to see that the good is produced.

**Public Interest Goals** -- Public interest goals of electric utility regulation include: 1) inter-and intra-class and intergenerational equity); 2) the equal treatment of equals (horizontal equity); 3) balancing long- and short-term goals that have the potential to affect intergenerational balance; 4) protecting against the abuse of monopoly power; and 5) general protection of the health and welfare of the citizens of the state, nation, and world. Environmental and other types of social costs are subsumed under the equity and health and welfare responsibilities.

**Public Utility** -- A utility operated by a non-profit governmental or quasi-governmental entity. Public utilities include municipal utilities, cooperatives, and power marketing authorities.

**Real-Time Pricing** -- The instantaneous pricing of electricity based on the cost of the electricity available for use at the time the electricity is demanded by the customer.

**Regional Reliability Councils (RRC)** -- Regional reliability councils were organized after the 1965 northeast blackout to coordinate reliability practices and avoid or minimize future outages. They are voluntary organizations of transmission-owning utilities and in some cases power cooperatives, power marketers, and non-utility generators. Membership rules vary from region to region. They are coordinated through the North American Electric Reliability Council (NERC). There are ten major regional councils plus the Alaska Systems Coordinating Council.

**Reliability** -- Electric system reliability has two components -- adequacy and security. Adequacy is the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and unscheduled outages of system facilities. Security is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system facilities.

**Renewable Resources** -- Renewable energy resources are naturally replenishable, but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Some (such as geothermal and biomass) may be stock-limited in that stocks are depleted by use, but on a time scale of decades, or perhaps centuries, they can probably be replenished. Renewable energy resources include: biomass, hydro, geothermal, solar and wind. In the future they could also include the use of ocean thermal, wave, and tidal action technologies. Utility renewable resource applications include bulk electricity generation, on-site electricity generation, distributed electricity generation, non-grid-connected generation, and demand-reduction (energy efficiency) technologies.

**Research and Development (R&D)** -- Research is the discovery of fundamental new knowledge. Development is the application of new knowledge to develop a potential new service or product. Basic power sector R&D is most commonly funded and conducted through the Department of Energy (DOE), its associated government laboratories, university laboratories, the Electric Power Research Institute (EPRI), and private sector companies.

**Reserve Margin** -- Capacity over and above anticipated peak loads, maintained for the purpose of providing operational flexibility and for preserving system reliability.

**Resource Efficiency** -- The use of smaller amounts of physical resources to produce the same product or service. Resource efficiency involves a concern for the use of all physical resources and materials used in the production and use cycle, not just the energy input.

**Restructuring** -- The reconfiguration of the vertically-integrated electric utility. Restructuring usually refers to separation of the various utility functions into individually-operated and -owned entities.

**RTO** – An organization designed to operate the grid and its wholesale power market over a broad region and with independence from commercial interests. An RTO would also have a role in planning and investing in the grid, though how it would conduct these activities remains unresolved. An RTO would also coordinate with other RTOs.

**Spot Markets** -- Any of a number of venues in which purchases and sales, as of electricity, are made by a large number of buyers and sellers, with new transactions being made continuously or at very frequent intervals. Typically, the phrase refers to a market in which the prices, amounts, duration and firmness of the purchases and sales is publicly known, at least shortly after the transaction is completed, if not simultaneously.

**System Benefits Charge** -- A non-bypassable charge imposed to collect funds to cover the above-market costs of providing public goods.

**Taking** -- Reducing the value of someone's property through government action without just compensation.

**Tariff** -- A document, approved by the responsible regulatory agency, listing the terms and conditions, including a schedule of prices, under which utility services will be provided.

**Time-of-Use (TOU) Rates** -- The pricing of delivered electricity based on the estimated cost of electricity during a particular time block. Time-of-use rates are usually divided into three or four time blocks per twenty-four hour period (on-peak, mid-peak, off-peak and sometimes super off-peak) and by seasons of the year (summer and winter). Real-time pricing differs from TOU rates in that it is based on actual (as opposed to forecasted) prices that may fluctuate many times a day and are weather-sensitive, rather than varying with a fixed schedule.

**Transmitting Utility (Transco)** -- This is a regulated entity that owns, and may construct and maintain, wires used to transmit wholesale power. It may or may not handle the power dispatch and coordination functions. It is regulated to provide non-discriminatory connections, comparable service and cost recovery.

**Uplift** – Costs imposed on all wholesale market participants by the system operator to maintain reliability.

**Utility** -- A regulated entity that exhibits the characteristics of a natural monopoly. For the purposes of electric industry restructuring, "utility" refers to the regulated, vertically integrated electric company. "Transmission utility" refers to the regulated owner/operator of the transmission system only. "Distribution utility" refers to the regulated owner/operator of the distribution system that serves retail customers.

**Wholesale Competition** -- A system allowing a distributor of power to buy its power from a variety of power producers, and the power producers would be able to compete to sell their power to a variety of distribution companies.

**Wholesale Power Market** -- The purchase and sale of electricity from generators to resellers (who sell to retail customers) along with the ancillary services needed to maintain reliability and power quality at the transmission level.