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ENERGY REGULATION EFFECTS ON CRITICAL INFRASTRUCTURE PROTECTION

by

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U.S. critical infrastructure includes those assets that are vital to maintaining the nation's security, economy, and public health and safety. A reliable supply of electric power provides an essential foundation for the daily operation of all national critical infrastructure as well as most aspects of modern society. A sustained loss of electricity would be significantly detrimental to the economy and the health and security of the nation. Since 1935, the U.S. electric power industry has been heavily regulated in order to address issues such as consumer protection, rate control, conservation, and market competition. However, legislators have not considered the impact of regulations on the resiliency of critical infrastructure. This thesis argues that the energy sector regulatory framework has directly resulted in decreased security and reliability of electric power infrastructure. Energy legislation has created a "tragedy of the commons" situation for power transmission lines where utilities are reluctant to invest in infrastructure needed to ensure the reliable delivery of electricity. The solution to ensuring the resilience of electric power infrastructure is to craft a combination of regulatory improvements, reliability standards, and financial incentives to ensure the electric power industry is able to provide the foundational structure needed for U.S. national security.

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ABSTRACT

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LIST OF ACRONYMS

AC	Alternating Current
BCA	Business Case Analysis
CI/KR	Critical Infrastructure and Key Resources
DC	Direct Current
DHS	Department of Homeland Security
DOE	Department of Energy
EIA	Energy Information Administration
EPAct	Energy Policy Act (1992 & 2005)
ERO	Electric Reliability Organization
EWG	Exempt Wholesale Generator
FERC	Federal Energy Regulatory Commission
HSPD	Homeland Security Presidential Directive
IEEE	Institute of Electrical and Electronics Engineers
IOU	Investor-Owned Utility
ISO	Independent System Operator
NEPOOL	New England Power Pool
NERC	North American Electric Reliability Corporation (as of January 1, 2007; formerly the North American Electric Reliability Council)
NIETC	National Interest Electric Transmission Corridor
NIMBY	Not In My BackYard
PUHCA	Public Utility Holding Company Act (1935)
PURPA	Public Utility Regulatory Policies Act (1978)
QF	Qualifying Facility
RTO	Regional Transmission Organization
SEC	Security and Exchange Commission
TLR	Transmission Loading Relief

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I. ENERGY SECTOR REGULATIONS AND ELECTRIC POWER INFRASTRUCTURE SECURITY

In recent years the rise in energy prices has been a recurring high interest topic as it increasingly impacts many aspects of our daily lives. As fuel prices have risen, the prices of goods and services have correspondingly increased in order for businesses to recoup their expenses. Although not as rapidly as oil and gasoline, the cost of electricity has been increasing steadily as well. The price of electricity increased dramatically in the 1970s during the oil crisis, but then remained fairly constant from 1982 to 2000, only increasing about 1% per year which was well below the level of inflation. From 2000 to 2006, though, the price of electricity increased an average of 4.4% per year with a large jump of 10% in 2006.[1] By comparison, inflation has averaged 2.7% during this same time period.[2] The price of energy has been drastically impacted by the global political and economic environment, but energy prices are also significantly affected by the regulatory environment that constrains the energy industry's decisions about operations and investments. For example, the huge spike in electricity prices in California between 1999 and 2000 was affected more by the regulatory environment and local market manipulation by the energy industry than by the market prices for fuel used to generate electricity.[3] As the energy sector is scrutinized as a result of ballooning prices, attention should also be focused on the infrastructure which is essential to meeting national energy needs. If the infrastructure is not properly maintained and protected from damage, not only will energy prices likely spike higher, but the ability to maintain a reliable supply of electricity will be at risk of widespread regional or national disruption.

Both the economy and U.S. national security are dependent on the foundation provided by a reliable supply of electricity. The infrastructure that enables the

[1] Electricity price percentages calculated from average retail prices of electricity in Energy Information Administration, *Annual Energy Review 2007* (Washington, DC: 2008), Table 8.10.

[2] Inflation percentage calculated from Consumer Price Index-Urban (CPI-U) Urban in U.S. Bureau of Labor Statistics, "Consumer Price Index," Washington, DC, August 14, 2008, http://www.bls.gov/cpi/home.htm (accessed August 16, 2008).

[3] Matthew Waldron, "Exploring Failed Electricity Deregulation: Lawyers' Role in Supporting a Healthy Marketplace," *The Georgetown Journal of Legal Ethics* 19, no. 3 (Summer 2006), 1007-8.

transmission and distribution of electricity is identified as one of the vital national assets that must be protected and preserved. The *National Infrastructure Protection Plan* describes the importance of protecting electric power and other national critical infrastructure assets:

> Protecting the critical infrastructure and key resources (CI/KR) of the United States is essential to the Nation's security, public health and safety, economic vitality, and way of life. Attacks on CI/KR could significantly disrupt the functioning of government and business alike and produce cascading effects far beyond the targeted sector and physical location of the incident.[4]

Modern society is dependent on electricity to turn on the lights, conduct banking transactions, run manufacturing facilities, and communicate via the phone or internet. Businesses, hospitals, schools, factories, and government facilities are forced to shut down when the power goes out. Because power must be provided for people to work, some of the most essential facilities have backup generators to provide electricity during a power outage. Most facilities cannot continue to function, though, beyond a few hours without the return of electricity supplied by the power grid. The focus of the research for this paper will be on the need to preserve national security and protect the economy by improving the security and reliability of electric power critical infrastructure.

Improving the operation of electric power infrastructure is a responsibility shared by industry and government. Regulations established by federal and state governments significantly affect decisions made by utility companies about investing in power grid infrastructure. The electric power industry has been subject to a number of restrictive regulations since the 1930s. In the 1970s, the government began to shift its oversight of the electric industry from strictly regulating the structure of utilities to following more of a market-based approach.[5] Power outages in recent years demonstrate that the government regulatory approach has not been sufficient to ensure adequate reliability and security measures are implemented by the power industry to protect and maintain their

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[4] U.S. Department of Homeland Security, *National Infrastructure Protection Plan* (Washington, DC: 2006), 1.

[5] Amy Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements* (Washington, DC: Congressional Research Service, 2006), 1-2, 9.

infrastructure assets. Some power companies have established internal efforts to learn from past mistakes and document their lessons learned, and yet still the lessons have been ignored and government oversight has failed to ensure consistent reliability for the electric power grid.[6] The regulatory environment has actually resulted in the opposite effect, causing the power grid architecture to be less reliable and secure. Government energy policy has led, for example, to electric utilities limiting their investment in transmission line infrastructure.

Major power failures such as the widespread blackout in August 2003 indicate that existing infrastructure is not able to withstand significant outages, whether resulting from component failures, natural disasters, or deliberate sabotage. In an environment of significant energy regulations, why are incidents like the August 2003 blackout still able to occur? Why has U.S. energy policy failed to ensure the electric power grid is secure and reliable? This paper argues that energy regulatory policy has weakened the power grid by focusing on goals that were intended to address consumer prices and environmental conservation without considering the detrimental effects it would have on the security of electric power critical infrastructure. To correct the failures in U.S. energy policy, the solution is for Congress to establish strong reliability standards, provide regulatory and financial incentives to invest in infrastructure, and foster the use of innovative technologies that will create a more resilient electric power grid.

A. CRITICAL INFRASTRUCTURE PROTECTION

The definition of critical infrastructure in Homeland Security Presidential Directive 7 (HSPD-7) is "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or

[6] For example, Con Edison established a seminar titled "Lesson Learned from the 1977 Blackout" that was made available to the electric industry and lessons are also documented at the "Blackout History Project," a web-based site maintained by George Mason University at http://www.blackout.gmu.edu/. See Philip E. Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability* (Cambridge: Cambridge University Press, 2006), 169.

safety, or any combination of those matters."[7] Critical infrastructures are divided into a number of sectors, but many of them are interconnected, meaning damage to one asset can have far-reaching impacts in other sectors.[8] This paper will focus on the energy sector, specifically the electric power industry, which is one of the most interconnected and foundational sectors that our society depends on for all aspects of daily life.[9] Any significant failures or shortfalls in the energy sector would severely damage or halt the ability of the national economy to function, putting our safety and security at risk until the infrastructure was returned to service. In the interest of preserving national security, the country cannot accept the risk of devastating national impacts as a result of cascading effects from the destruction of foundational energy infrastructure assets.

Existing electricity infrastructure analysis emphasizes the inadequacy of market incentives to encourage infrastructure investment as well as the effect of regulatory reform on limiting investment in electricity infrastructure. The electric power industry has been significantly affected by several major Congressional regulatory actions: the Public Utility Act of 1935, which is made up of two components, the Public Utilities Holding Company Act of 1935 (PUHCA) and the Federal Power Act; the Public Utility Regulatory Policies Act of 1978 (PURPA); and the Energy Policy Acts of 1992 (EPAct 1992) and 2005 (EPAct 2005).[10] These energy regulations have defined the structure of companies in the electric industry as well as the level of investment in power generation and transmission infrastructure throughout the U.S. The regulatory emphasis has shifted from strict regulation initiated in 1935 to leveraging market-based dynamics beginning in

[7] George W. Bush, "Homeland Security Presidential Directive 7: Critical Infrastructure Identification, Prioritization, and Protection," Washington, DC, December 17, 2003, citing 42 U.S. Code sec. 5195c(e).

[8] The full list of critical infrastructure/key resource sectors includes: agriculture and food; defense industrial base; energy; public health and healthcare; national monuments and icons; banking and finance; drinking water and water treatment systems; chemical; commercial facilities; dams; emergency services; commercial nuclear reactors, materials, and waste; information technology; telecommunications; postal and shipping; transportation systems; and government facilities. See U.S. Department of Homeland Security, *National Infrastructure Protection Plan*, 3.

[9] Ted G. Lewis, *Critical Infrastructure Protection in Homeland Security: Defending a Networked Nation* (Hoboken, NJ: Wiley-Interscience, 2006), 56-57.

[10] Amy Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992* (Washington, DC: Congressional Research Service, 1998); Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements*.

the 1970s. The regulatory limits placed on the electricity industry, even with a shift to some market-based approaches, may be a contributing factor to the current vulnerabilities in electricity infrastructure. While existing analysis addresses the limited effectiveness of market-based incentives on improving electric infrastructure security, there appears to be a gap in research into whether or not regulations have been a direct contributing factor in creating electricity infrastructure vulnerabilities. The impacts of the regulatory environment will be examined along with potential improvements to the market environment and opportunities for partnership with industry to improve the reliability and security of electric power infrastructure.

B. LITERATURE REVIEW

The *National Strategy for Homeland Security* and the *National Infrastructure Protection Plan* assign responsibility for protecting critical infrastructure to government agencies as well as to private industry, agencies and citizens.[11] The government and private entities responsible for infrastructure security, and the actions taken to protect the infrastructure, vary with the type of infrastructure. Establishing a national perspective on the best actions to protect critical infrastructure is complicated by several factors. Many critical infrastructures are interconnected, meaning damage to one asset can have far-reaching impacts in other sectors of critical infrastructure. Since most critical infrastructure crosses state boundaries, the overall operation of the infrastructure is regulated at the federal level.[12] As a result, state and local governments and the private sector do not have the perspective to adequately assess interstate and national impacts of damage to infrastructure assets. However, approximately 85% of national critical infrastructure assets are owned and operated by the private sector.[13] While expertise on infrastructure vulnerability is primarily in the private sector, the federal government has an integrated national view of the highest priority infrastructure sectors and assets as well as access to national intelligence assessments which are essential to determining what

[11] Homeland Security Council, *National Strategy for Homeland Security* (Washington, DC: 2007), 4; U.S. Department of Homeland Security, *National Infrastructure Protection Plan*, 2.

[12] Lewis, *Critical Infrastructure Protection in Homeland Security: Defending a Networked Nation*, 10.

[13] Homeland Security Council, *National Strategy for Homeland Security*, 4.

threats are likely to impact critical infrastructure. HSPD-7 appropriately assigns the responsibility for coordinating the national effort and creating a national plan for critical infrastructure protection to the Secretary of the Department of Homeland Security (DHS).[14] DHS has the necessary perspective to provide direction on critical infrastructure protection, unifying the efforts of federal, state, local, and private protection efforts. DHS does not, however, have regulatory authority over the critical infrastructure sectors. While DHS can set strategy and facilitate investment in infrastructure security, the department will have to work with Congress and other regulatory authorities, such as the Department of Energy (DOE), to address security requirements that are impacted by the regulatory environment of the infrastructure sectors.

There are several areas of general agreement on the topic of critical infrastructure protection. Most authors agree that the allocation of resources and efforts for protecting critical infrastructure should be based on a prioritization methodology which is characterized by some form of a risk-based assessment.[15] How the risk assessment is done and how well it is currently being implemented is heavily debated, but the general principle of needing an objective prioritization criteria is commonly accepted. The magnitude of the protection task is enormous, for example there are 2,800 power plants, 66,000 chemical plants, 590,000 highway bridges, and 2 million miles of pipelines.[16] There are simply not enough resources available to protect all assets that are classified as critical infrastructure, so it is essential to have some method of prioritization. Since approximately 85% of critical infrastructure is owned and operated by the private sector, another area of agreement on the treatment of critical infrastructure is that representatives from private industry need to be integrally involved in critical infrastructure protection

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[14] Bush, "Homeland Security Presidential Directive 7: Critical Infrastructure Identification, Prioritization, and Protection," par. 12-15, 27.

[15] See for example Todd Masse, Siobhan O'Neil and John Rollins, *The Department of Homeland Security's Risk Assessment Methodology: Evolution, Issues, and Options for Congress* (Washington, DC: Congressional Research Service, 2007); Henry H. Willis et al., *Terrorism Risk Modeling for Intelligence Analysis and Infrastructure Protection* (Santa Monica, CA: RAND Corporation, 2007); Lewis, *Critical Infrastructure Protection in Homeland Security: Defending a Networked Nation.*

[16] George W. Bush, *The National Strategy for the Physical Protection of Critical Infrastructures and Key Assets* (Washington, DC: 2003), 9.

planning.[17] The owners and operators of these assets know their most important components and associated vulnerabilities and they have the knowledge required to recommend security measures to protect the critical infrastructure from an attack or natural disaster. Without integrated private sector involvement, any protection planning would be woefully inadequate. Within the energy sector, most authors agree that companies have not invested sufficiently in infrastructure capability and security.[18] As a result of deregulation through the Energy Policy Act of 1992 (EPAct 1992) and subsequent regulatory changes by the Federal Energy Regulatory Commission (FERC), competition in the industry has pressured companies to reduce expenditures on their infrastructure in order to maintain their competitive position in the market.[19] Recent legislation included in the Energy Policy Act of 2005 (EPAct 2005) has been designed to expand the options for electric power companies to finance investments in electricity infrastructure.[20] Although there are questions about the ability of recent changes to sufficiently increase infrastructure investment to meet current and future requirements, most authors agree that investment is needed and should be encouraged. When analysis turns to the specific details of how to protect and improve critical infrastructure, though, there are disagreements on who is primarily responsible and what the best methods are to address the shortfalls.

A significant debate on critical infrastructure protection revolves around the approach to government and private sector roles. The *National Infrastructure Protection*

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[17] See for example Joe D. Whitley, George A. Koenig and Steven E. Roberts, "Homeland Security, Law, and Policy through the Lens of Critical Infrastructure and Key Asset Protection," *Jurimetrics* 47, no. 3 (Spring 2007), 259-79; Alane Kochems, *Who's on First? A Strategy for Protecting Critical Infrastructure* (Washington, DC: The Heritage Foundation, 2005); Arjen Boin and Denis Smith, "Terrorism and Critical Infrastructures: Implications for Public-Private Crisis Management," *Public Money & Management* 26, no. 5 (November 2006), 295-304.

[18] See for example Joshua P. Fershee, "Misguided Energy: Why Recent Legislative, Regulatory, and Market Initiatives are Insufficient to Improve the U.S. Energy Infrastructure," *Harvard Journal on Legislation* 44, no. 2 (Summer 2007), 328-330; Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements*, 5-6; American Society of Civil Engineers, "Report Card for America's Infrastructure: Energy," Reston, VA, 2005, http://www.asce.org/reportcard/2005/page.cfm?id=25 (accessed June 1, 2008).

[19] Christopher W. Johnson, "Public Policy and the Failure of National Infrastructures," *International Journal of Emergency Management* 4, no. 1 (2007), 26-27.

[20] Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements*, 2.

Plan places the responsibility on the private sector to protect critical infrastructure assets that they own and operate.[21] The central question is, will the private sector spend the resources required to secure critical infrastructure from terrorist attacks and natural disasters? One side of the debate emphasizes the primary role for the federal government is to prevent terrorist attacks, while the private sector is primarily responsible for protecting their infrastructure assets. They argue that the government should facilitate critical infrastructure protection by partnering with the private sector and providing incentives and voluntary guidelines.[22] Some authors in the limited government involvement camp argue that market economics provide sufficient incentives to the private sector to improve security. In the energy market, competition is advocated as the best method to reduce consumer costs as well as increase industry profits which can then provide capital to invest in infrastructure.[23] Additionally, authors note that the government needs to partner with the private sector because they have the best knowledge of vulnerabilities inherent in their infrastructure assets. On the other side of the debate are advocates for direct government involvement through funding or regulatory standards for critical infrastructure protection.[24] They argue that market forces will not provide sufficient motivation to allocate enough resources to adequately protect critical infrastructure. Additionally, in the electricity sector there is concern that deregulation has limited access to system operations data for electricity transmission as a result of it being classified by companies as competition sensitive information. Increased

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[21] U.S. Department of Homeland Security, *National Infrastructure Protection Plan*, 26-27.

[22] For an emphasis on government as facilitator see Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability*; Steven Roberts, "Critical Infrastructure Protection and Homeland Security," *Perspectives on Preparedness*, no. 15 (July 2003), 1-12; Kochems, *Who's on First? A Strategy for Protecting Critical Infrastructure*; Mark Sauter and James Jay Carafano, *Homeland Security: A Complete Guide to Understanding, Preventing, and Surviving Terrorism* (New York: McGraw-Hill, 2005).

[23] See for example Jason Makansi, *Lights Out: The Electricity Crisis, the Global Economy, and what it Means to You* (Hoboken, NJ: John Wiley & Sons, 2007); Robert Peltier, "PUHCA Still Stifling Industry Growth," *Power* 149, no. 5 (June 2005), 4.

[24] For an emphasis on government regulation see Clark Kent Ervin, *Open Target: Where America is Vulnerable to Attack*, 1st ed. (New York: Palgrave Macmillan, 2006); Ted Lewis and Rudy Darken, "Potholes and Detours in the Road to Critical Infrastructure Protection Policy," *Homeland Security Affairs* 1, no. 2 (Fall 2005), http://www.hsaj.org/?article=1.2.1 (accessed November 4, 2007); Chris Logan, "How Willing is Private Industry to Identify its Vulnerabilities and Protect Critical Infrastructure?" In *Homeland Security, the Reference Shelf*, eds. Norris Smith and Lynn Messina, Vol. 76, no. 1 (Bronx, NY: H.W. Wilson Company, 2004), 155-59.

regulation is argued as necessary to make the data available to determine needed infrastructure improvements and expansion requirements.[25] The regulation camp also argues that only the government has a complete national-level security perspective sufficient to prioritize security measures for the most important infrastructure assets.

There is a tendency in the debate to heavily emphasize one side of the argument or the other, with no consideration of a middle ground. In the government facilitation versus regulation debate, some authors have an overly wide focus on deficiencies in critical infrastructure security, arguing that emphasis needs to be placed on a comprehensive plan to fix almost every identified shortfall.[26] That assessment is idealistic, requiring significantly increased funding that would need to be supported by a significant restructuring of funding allocations in the federal budget. For example, Clark Kent Ervin says in the conclusion of his book, “We should … spare no expense to defend our nation here at home, now that we’re under a continuous threat of attack on our own soil … Our priorities are misplaced when the budget of the Department of Defense is almost exactly ten times larger than that of the Department of Homeland Security.”[27] He implies that homeland security should be given a blank check, with the funding coming at the expense of other national security priorities. On the other side of the debate are advocates for limited regulatory action with a focus on government partnering with the private sector to facilitate their efforts in protecting the critical infrastructure assets they own and operate. There is not much analysis focused on a mix of methods, including government regulation as well as partnership and incentives, where appropriate, to provide a balanced approach to protecting privately owned and operated critical infrastructure. The outcome of the debate over how to improve critical infrastructure security would benefit from research into an effective balance of government interactions with the private sector.

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[25] Jack (John) Casazza, "Blackouts: Is the Risk Increasing?" *Electrical World* 212, no. 4 (April 1998).

[26] See for example Ervin, *Open Target: Where America is Vulnerable to Attack*; Roberts, "Critical Infrastructure Protection and Homeland Security," 1-12.

[27] Ervin, *Open Target: Where America is Vulnerable to Attack*, 226.

C. OPTIONS TO IMPROVE INFRASTRUCTURE SECURITY AND RESILIENCY

The government has a number of potential avenues available to facilitate improvements in the security of electric power infrastructure. One area to address is the impact of regulations on industry's level of investment in critical infrastructure. The regulatory environment has evolved over time to address governmental concerns without necessarily considering the implications on infrastructure security or resiliency. Many regulations that impact critical infrastructure were passed to address issues such as conservation, the environment, price stability, and shared access to infrastructure.[28] Security has generally not been a significant factor in many infrastructure policy decisions. As the impacts are assessed now, though, the implications can be seen that some regulations favor less resilient designs such as ones that use shared common infrastructure assets rather than parallel or redundant architectures. The recent EPAct 2005 legislation has reduced some barriers to investment in electric power infrastructure, but while some restrictions have been reduced at the federal level, investment approval has instead shifted to the states. The legislation also does not appear to have significantly increased incentives for private industry to improve infrastructure security.[29] This paper will examine options for changing regulations to potentially create incentives for innovative approaches to improving electricity infrastructure security.

Another method the government can use to improve infrastructure security is to provide more direct incentives rather than relying primarily on a market-based approach. In the thirty years from 1975 through 2005, the demand for electricity has doubled but annual investment in infrastructure has decreased. While demand is expected to continue to increase steadily, infrastructure is currently not adequate to meet peak requirements.[30] While assessing the reliability of electric power infrastructure leading up to the summer of 2008, the president of the North American Electric Reliability Corporation (NERC)

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[28] Lewis, *Critical Infrastructure Protection in Homeland Security: Defending a Networked Nation,* 253-55.

[29] Fershee, "Misguided Energy: Why Recent Legislative, Regulatory, and Market Initiatives are Insufficient to Improve the U.S. Energy Infrastructure," 338-39.

[30] Ibid., 328-29.

noted some progress in the previous year, but also commented that “increasing demand and limited infrastructure improvements over the long term are still very much a concern.”[31] Companies in the energy sector apparently do not consider returns on investments from improving infrastructure security to be sufficient to justify the costs. When companies consider the potential impacts of large infrastructure damage or loss, they have alternative recovery options through insurance claims or bankruptcy laws if their operational capability is reduced or destroyed. On a national scale, however, the loss of energy infrastructure could have a devastating impact depending on the duration of the outage. Due to the importance of energy critical infrastructure to national security, the government could investigate providing industry with more direct incentives to invest in security. This paper will assess potential incentive options the government could use, such as tax breaks, cost sharing, grants, or more indirect methods such as establishing benchmark requirements to receive reduce rates for risk insurance for terrorist attacks or natural disasters.

A third government approach could be to work with standard setting organizations, such as the Institute of Electrical and Electronics Engineers (IEEE), to improve the resiliency of the electric power grid. Electric infrastructure security can be improved, for example, by encouraging the use of parallel transmission and distributed generation and storage capability.[32] Uniform standards do not currently exist for connecting to the power grid.[33] For companies to develop additional or improved infrastructure capability, they need to be able to interface with the existing infrastructure. Uniform standards for components and interconnections could facilitate the development of new technologies or expand the use of existing capabilities to meet customer’s demand for electricity in a more robust manner. This paper will investigate areas where the

[31] North American Electric Reliability Corporation, "Electricity Projected to be Reliable Throughout North America in Coming Summer, with Limited Concerns," Princeton, NJ, May 14, 2008, ftp://ftp.nerc.com/pub/sys/all_updl/docs/pressrel/summer-assessment-pr-FINAL.pdf (accessed June 6, 2008).

[32] Lewis, *Critical Infrastructure Protection in Homeland Security: Defending a Networked Nation*, 283.

[33] Jessica Morrison and Diane Broad, "Wind Interconnection: Bridging the Divide," *Electric Light and Power* 84, no. 3 (May/June 2006), 32-33.

government can facilitate setting standards that will enable potential enhancements to electric power infrastructure security.

D. RESEARCH OVERVIEW

First this paper will assess the status of energy infrastructure security and the current government approach to dealing with the energy sector. Recent reforms will be addressed in the context of the overall regulatory environment for energy infrastructure. Then the paper will examine the benefits of each of three alternatives to improving infrastructure security and the challenges that could be faced in implementing them. The alternatives include modifying regulations to create incentives for innovative approaches to infrastructure security, providing direct incentives instead of relying on a market-based approach, and setting standards to facilitate a more resilient electric power grid. Finally, the research will conclude with an assessment of the political and practical challenges inherent in implementing these changes.

The government has available a number of approaches that can more effectively improve energy infrastructure security. Analysis of the tradeoffs for these approaches will be compared with the current strategy for protecting critical infrastructure. Some of the approaches may require significant effort to overcome political opposition, but the assessment of potential benefits will demonstrate that some of the alternate strategies should be pursued to better protect energy infrastructure. By weighing the benefits and costs of alternative policy options, this paper will provide a framework to assess the range of choices available to improve the reliability of electric power infrastructure.

II. ENERGY SECTOR REGULATORY REFORMS

A. INITIAL ADOPTION OF ELECTRICITY

The U.S. electricity market owes much of its early structure to Thomas Edison who in 1879 invented a light bulb that could compete with gas lamps. To light those bulbs, he had to create an entire supporting infrastructure, including generators, distribution lines, sockets to hold the bulbs, and switches to turn them on and off.[34] The structure he created became the basis for the concept of electric power utilities being considered a natural monopoly, including within one corporate entity all of the components required to create, distribute, and make practical use of electricity.[35] In 1881, Edison hired Samuel Insull to help him run the business he was in the process of creating.[36] As it turned out, Insull took Edison's inventions and early forays into the electric utility business and made a much broader application, establishing a business that prior to its collapse in 1929 with the onset of the Great Depression was the largest provider of electricity in the country.[37]

For a number of decades, Insull worked with state and local governments to create an environment that was very friendly to his vision for providing electricity to as many customers as possible. His quest for reaching more customers led him to break with Edison's preference for direct current (DC) electricity that was limited in the distance that it can be transmitted efficiently. Insull was quick to adopt George Westinghouse's use of alternating current (AC) motors and transformers, which enabled the transmission of electricity over long distances. Using a series of holding companies that owned a number of electric utility companies as well as tiers of holding companies that owned other holding companies, Insull was able to expand his broad control of the electricity market

[34] Gordon L. Weil, *Blackout: How the Electric Industry Exploits America* (New York: Nation Books, 2006), 2-3.

[35] Energy Information Administration, *The Changing Structure of the Electric Power Industry 2000: An Update* (Washington, DC: 2000), 5.

[36] Weil, *Blackout: How the Electric Industry Exploits America*, 5.

[37] Ibid., 17-18.

into thirteen states while avoiding federal monopoly legislation. His close relationship with state and local governments, combined with the confusing array of tiered holding companies, prevented his companies that controlled much of the electricity industry from being regulated at the federal level.[38] However, his practices began to draw concern from several important national politicians who ultimately dismantled the empire Insull had created. With the passage of the Federal Utility Act of 1935, the ability to own electric utilities in multiple states was eliminated and regulations were applied to the transmission of electricity across state lines.[39]

The success of Insull, and others who ran utility holding companies in the early 1900s, led to the widespread use of electricity across the United States, but his greed led to the breakup of his empire and the federal regulation he had worked hard to avoid. In the process, Insull's reputation was destroyed as well and he narrowly escaped ending up in jail, to the chagrin of many investors whose equity had evaporated. Insull's tiered holding companies had applied tactics, which unfortunately were repeated in similar fashion by Enron a number of decades later, that used investments in other industries to hide the true financial condition of the companies. When the Great Depression cut back electricity usage nationwide, the debt that was financing Insull's holding companies came due and they couldn't pay off their creditors.[40] The change in law that regulated the industry followed a few years later in 1935 under the leadership of Congressman Sam Rayburn (Democrat-Texas) and Senator Burton Wheeler (Democrat-Montana), with the strong endorsement and ultimately the signature of President Franklin D. Roosevelt.[41]

B. ELECTRICITY MEETS REGULATION

The Public Utility Act of 1935, which included the Public Utility Holding Company Act (PUHCA) and the Federal Power Act, established a regulatory

[38] Weil, *Blackout: How the Electric Industry Exploits America*, 9-12.

[39] Ibid., 26-30.

[40] Ibid., 18-22.

[41] Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992* (Washington, DC: 1993), 8.

environment that persisted until the energy crisis of the 1970s.[42] A series of legislation impacting the energy sector followed the collapse of Insull's and other utility holding companies, to include laws establishing the Tennessee Valley Authority in 1933 and the Bonneville Power Administration in 1935. These government-run electric power agencies, along with several others that were established to serve regions in the mid-west, extended the reach of the electric industry to rural areas that investor-owned companies such as Insull's did not consider profitable enough to justify providing electric service. The Rural Electrification Administration was established in 1935 as well to oversee the extension of electricity's reach to rural areas.[43] Congress and the President wanted to prevent another utility holding company monopoly as well as to ensure electricity was available to everyone in the nation, not just urban areas with large numbers of customers.

The Public Utility Act of 1935 was aimed in large part at the damage that had been done by large utility holding companies through underhanded corporate dealings that hid the true nature of their financial transactions from customers, investors, and public officials.[44] The similarities to the type of hidden transactions made by Enron, to prevent public knowledge of the corporation's financial condition, are striking. It is unfortunate that lessons learned in the 1930s had to be relearned at the turn of the 21st century.[45] In spite of thousands of pages of regulations established by the Federal Energy Regulatory Commission (FERC) that address the operations of the electricity industry, Enron demonstrated it is difficult to prevent willful, deliberate fraud, especially when there is collusion with other companies, in the case of Enron with their financial auditors, to provide cover for criminal behavior.[46] Once it was implemented, PUHCA did improve protections for consumers and investors by significantly limiting the likelihood of utility holding companies putting large regions of the country at risk. By

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[42] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 2.

[43] Weil, *Blackout: How the Electric Industry Exploits America*, 28-29.

[44] Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 1-9.

[45] Amy Abel and Larry Parker, *Electricity: The Road Toward Restructuring* (Washington, DC: Congressional Research Service, 2004), 9-10.

[46] Jack (John) Casazza, "Engineering, Ethics & Electricity," *IEEE Spectrum* 40, no. 7 (July 2003), 11-12.

breaking up the large holding companies, the legislation made it a much simpler task to oversee the more limited scope of utility companies.

The primary provision established through PUHCA was the regulation by the Security and Exchange Commission (SEC) of interstate operations conducted by the gas and electric industries. The SEC was charged with requiring large holding companies to sell off assets in order to reduce their span of operations to a limited geographic region. As a result, many of the utility holding companies were reduced to operating within a single state and were therefore regulated at the state level.[47] For utility holding companies that continued to operate across state lines, they were required to provide information about their operations to the SEC and to receive approval for their more important financial transactions. The companies were required to maintain accounting records that were to be available for review by the SEC. They were required to obtain authorization from the SEC before raising capital through securities. They were also prohibited from levying high management fees on their utility companies, which resulted in electricity rate increases, and from taking loans from their utility companies, which had been used by holding companies like Insull's to hide their true financial status. Holding companies were also limited to controlling only one integrated utility. Their organizational structure was limited to no more than two separate corporate tiers and their utility assets were required to be located in areas that were geographically connected.[48] The end result was a significant drop in the number of interstate holding companies and a more limited scope of operations for those that remained. The number of holding companies had peaked in the thousands in the 1920s, with the top three controlling almost half of the electricity market. But by the 1990s, a total of about 160 holding companies existed, with only a dozen subject to SEC regulation and these interstate holding companies only served about 18% of the market.[49]

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[47] Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 9.

[48] Amy Abel, *Electricity Restructuring Background: Public Utility Holding Company Act of 1935 (PUHCA)* (Washington, DC: Congressional Research Service, 1999); Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 10-11.

[49] Weil, *Blackout: How the Electric Industry Exploits America*, 18, 27.

C. ADJUSTING UTILITY REGULATIONS – ADDRESSING THE ENERGY CRISIS

Regulation of the electric power industry was gradually expanded during the decades after PUHCA was implemented, but the next major legislation was not implemented until more than forty years later when world events drove Congress to pass another significant change to utility industry operations. The energy crisis which began in October 1973 as a result of the OPEC oil embargo shocked the U.S. into a realization of how dependent it had become on foreign oil and the electricity that it fueled.[50] As electricity technology had improved, generation efficiency increased, national coverage expanded, and electricity prices dropped. Utility companies had enjoyed a long period of expansion and profitability following World War II. People had come to rely on electricity's widespread availability and low cost.[51] The shortage of oil, though, drove up costs for electricity generation and many states began to allow "fuel adjustment clauses" to allow utility companies to recover their increased costs from rising fuel prices.[52]

President Jimmy Carter was highly focused on conservation as a result of the energy crisis and he supported the efforts of the Democratic Congress to reduce U.S. dependence on external energy sources. Congress passed the Public Utility Regulatory Policies Act (PURPA) in 1978 which required electric utilities to buy electricity from other generating companies called Qualifying Facilities (QFs). These QFs included "small power producers" that used renewable energy sources and "cogenerators" that used steam in their industrial processes as well as to produce electricity. PURPA had effectively ended the expectation that utilities were natural monopolies that needed to control all aspects of electricity generation, transmission, distribution, metering, and billing.[53] PURPA was part of the National Energy Act of 1978 which included other

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[50] Weil, *Blackout: How the Electric Industry Exploits America*, 37-38.

[51] Energy Information Administration, *The Changing Structure of the Electric Power Industry 2000: An Update*, 113-14.

[52] Weil, *Blackout: How the Electric Industry Exploits America*, 38.

[53] Ibid., 40-41.

conservation-minded legislation as well, including the Powerplant and Industrial Fuel Use Act that prevented utilities from building new natural gas and oil-fueled generators, although QFs were exempted, and the National Energy Conservation Policy Act, which mandated utility companies help their customers in an effort to conserve energy.[54]

To facilitate the competitive capability of the new electricity generation facilities, PURPA allowed QFs to be exempt from the regulatory requirements of PUHCA. Especially for cogenerators, it was essential to allow an exemption from the PUHCA restriction on utilities investing in other sectors, since the cogenerators' core business was in the industrial sector, with electricity generation possible from what was previously a wasted byproduct.[55] PURPA made a significant change in the landscape for electric utilities, opening the door for smaller companies to enter the generation market and for industrial plants to sell power that was created from steam generated in their manufacturing operations. As a result of PURPA, QFs expanded to provide a significant amount of electricity generation, cementing their role in the electricity sector. In the 1980s, QFs added generation capability that supplied over 20,000 megawatts according to the Department of Energy (DOE), which accounted for roughly 13% of the electricity generation capacity added from all sources in that time period.[56]

PURPA established the pricing method which allowed Qualifying Facilities to determine the profitability of building additional generating capacity. Utilities were required to pay QFs for electricity according to a rate equivalent to what it would have cost them to produce the electricity directly, called the "avoided cost." The calculation did not take into account the expense incurred by QFs to produce the electricity, only the calculated cost that the electric utility company would have incurred to generate it. In some regions of the country, avoided costs calculated by state regulators were higher than they should have been, leading to QFs building more electricity generation capacity than

[54] Energy Information Administration, *The Changing Structure of the Electric Power Industry 2000: An Update*, 35.

[55] Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 31-32.

[56] Generation capacity percentage for 1980s calculated from Energy Information Agency table for capacity added from 1979-1989, Energy Information Administration, *Annual Energy Review 2007*, Table 8.11a; Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 32.

needed.[57] California and New England were focused on improving conservation and ended up setting avoided costs too high, while in Southern regions where electricity costs were already low, states set avoided costs low, which prevented sufficient profit margin to justify building QFs in those regions. [58] After seeing the impacts of PURPA and QFs on the utility industry, in the mid-1980s some regions began to adjust their approach to setting avoided costs. Starting in Maine and later spreading throughout the country, states changed to a market-driven approach that allows QFs to bid for the price at which they would be willing to sell electricity to utilities, rather than having the states establish the rates directly.[59] The bidding process shifted the basis for the cost of electricity closer to the QFs' actual generation costs. The change marked a move in the direction of establishing a true market for purchasing electricity, which was furthered by another change in legislation in the early 1990s.[60]

D. MARKET APPROACH ATTEMPTED WITH UTILITIES

The breakup of the long-held structure of natural monopolies, through the introduction of Qualifying Facilities, was found to be a successful model and the utilities were interested in benefitting from the regulatory flexibility provided to QFs.[61] Electricity's cost to consumers continued to decline as technology improved and the power industry was interested in expanding their investment options. The benefits of exempting QFs from PUHCA requirements through PURPA, which was designed to promote energy conservation after the oil crisis, were seen as a starting point for further expansion of a market-based approach to the sale of electricity. Utilities began to call for access to the same flexibility available to QFs, to be able to invest in electricity generation without the restrictions of PUHCA, with the objective of further increasing the

[57] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 3.

[58] Weil, *Blackout: How the Electric Industry Exploits America*, 44-45.

[59] Energy Information Administration, *The Changing Structure of the Electric Power Industry 2000: An Update*, 32.

[60] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 3-4.

[61] Ibid., 2-4.

benefits of competition seen under PURPA. Some companies were interested in investing in electricity generation, but those companies that were not yet subject to PUHCA were reluctant to risk having their non-utility business impacted.[62] Additionally, a number of electric utility companies were upset that states' regulations hindered them from profitably investing in new generation capacity, while QFs were able to avoid regulatory burdens and more easily take advantage of improved, more efficient generation technology. The Department of Energy became convinced as well that competition would further the goals of conservation and reducing consumers' electricity rates.[63]

Senator J. Bennett Johnston (Democrat-Louisiana), the chairman of the Committee on Energy and Natural Resources, became an advocate of improving the operation of the electricity industry by expanding exceptions to PUHCA. In 1989 he introduced a bill that defined a new category of generation capability called Exempt Wholesale Generators (EWGs), which were so named because the generating facilities would be exempt from the restrictive requirements of PUHCA. EWGs were defined as electricity generating facilities that were solely in the business of selling electricity in wholesale transactions to utilities, not to individual consumers.[64] By removing the regulatory requirements, EWGs could be owned by companies that were invested in other industries without conflicting with the PUHCA requirements. Utility holding companies whose primary business was regulated by PUHCA were also permitted to own EWGs, with those specific facilities' operations being exempt from PUHCA.[65] The ideas introduced by Senator Johnston were debated and adjusted for three years, but finally becoming law when the Energy Policy Act (EPAct) was signed in 1992 by President George H. W. Bush.

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[62] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 4.

[63] Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 32-33.

[64] Ibid., 33-34.

[65] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 5.

President Bush's administration advocated several changes to Senator Johnston's bill that provided additional protections for consumers from utilities attempting to limit competition. The additional provisions ensured oversight of electricity market transactions would be provided at the federal and state level.[66] Protections were also provided to ensure EWGs had equal access to transmission lines owned by utilities, regardless of who owned the generating facilities.[67] Utilities were required to divide their generation and transmission portions of their business so the prices set for all EWGs to use the transmission lines would be fair. These changes to the generation and transmission of electricity were designed to increase competition and reduce electricity rates for consumers. The legislation was not, however, received well by the utility companies. When the regulations to enforce EPAct 1992 were implemented by the Federal Energy Regulatory Commission (FERC) through Order 888, which was numbered 888 to match the Washington, DC street address of the commission, industry fought its implementation in the courts for a number of years until the Supreme Court ruled in 2000 that FERC was appropriately implementing the law.[68]

While EPAct 1992 was designed to improve competition and reduce the cost of electricity, the implementation of FERC Order 888 actually drove electricity prices up when it was implemented in 2000. Electricity prices had declined for much of the 1990s, but the price spiked in 2001 by 4.1% over the price in 2000, going up 1.3% more than the increase in the inflation index. The price of electricity dropped the following year, but then increased steadily for the next few years along with the increasing price of oil (see Figure 1).[69] The jump in electricity prices in 2001 was partially corrected in 2002, indicating it may have been a short-term industry adjustment to the new regulations as a result of uncertainty about the impacts of the rules changes, rather than a sustained

[66] Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 57.

[67] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 5.

[68] Weil, *Blackout: How the Electric Industry Exploits America*, 57; Eric J. Lerner, "What's Wrong with the Electric Grid?" *The Industrial Physicist* 9, no. 5 (October/November 2003), 10.

[69] Electricity prices calculated from Table 8.10, "Average Retail Prices of Electricity, 1960-2007," in Energy Information Administration, *Annual Energy Review 2007*, Table 8.10; Inflation calculated from U.S. Bureau of Labor Statistics, "Consumer Price Index."

inefficiency in the market. The continuing increase in the price of electricity after 2002 could be related to the increase in the price of oil more so than the effects from EPAct 1992. A longer term trend will need to be established before the effects of the legislation can more readily be determined.

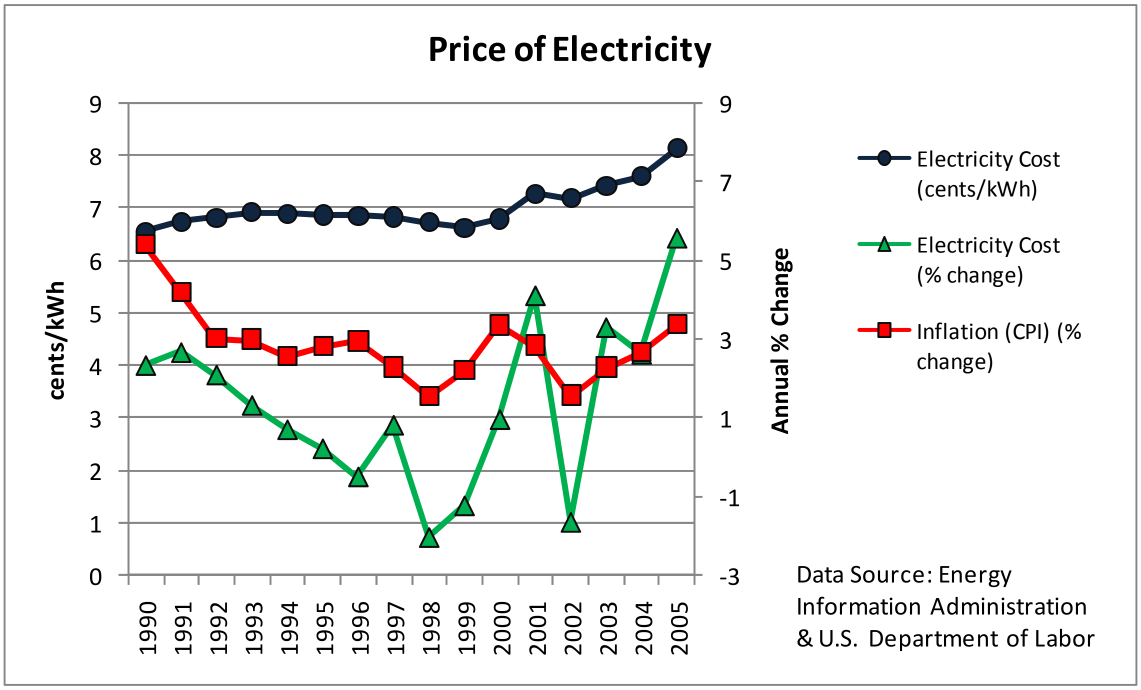

Figure 1. Price of Electricity, 1990-2005.

An area of potentially higher concern than the relatively small spikes in the price of electricity is the level of utilities' investment in transmission capacity. The electric grid was designed over the years to support the natural monopoly structure of the electric power sector. Transmission lines were designed to carry power generated in facilities designed by the same company. With the addition of Qualifying Facilities, there was only a slight increase in the amount of power that was carried by transmission lines. There was a significant change in transmission requirements, though, under EPAct 1992 with an expansion of the range of companies that could build Exempt Wholesale

Generators and the opening of utilities' transmission lines to carry EWG power without discriminating against any of the generating facilities.[70]

The transfer of power under the new scheme has been compared to the way commodities are handled in the stock market. Power is bought and sold in a competitive market and then transferred to the purchaser across the existing transmission lines, a transaction which is referred to as wheeling. The concern with the commodity analogy is that the electric grid was not designed to support long-distance transfers of power that take place with wheeling. The physics do not support a change in the use of the grid and as a result wheeling places tremendous stress on the transmission infrastructure. An indication of the level of stress on the grid can be found in the frequency of Transmission Loading Relief (TLR) procedures which restrict the use of transmission lines when they are overly congested. Within two months of the Supreme Court ruling approving FERC Order 888, TLRs had spiked to a level six times the number in the previous year.[71] The number of required TLRs has continued to increase since 2000 and may very well get much worse as a result of an anticipated ten-year growth rate of 20% in generation demand as compared to a projected growth rate of 6% in the miles of transmission line infrastructure. While investment in infrastructure has begun to trend upward since 1999, with an annual investment increase in real 2003 dollars of 12%, it follows on the tails of a declining level of transmission investment from 1975 through 1998. The recent increase in transmission lines is a positive step, but the decades of investment below the level of growth in demand has resulted in a number of areas in the country with problematic congestion on the transmission lines.[72]

E. A SECOND ENERGY POLICY ACT

Shortfalls in the electricity sector have become evident, with congestion on a number of transmission lines and the major regional blackout experienced in August

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[70] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 4-5.

[71] Lerner, "What's Wrong with the Electric Grid?" 10-11.

[72] Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements*, 5-6.

2003 in the Midwest and Northeastern U.S. and Ontario, Canada. Another round of legislation was assembled to address some of the shortfalls identified in the existing regulations controlling the operations of the electric power grid. Similar to the rationale behind the passage of PURPA following the OPEC oil embargo, the Energy Policy Act of 2005 (EPAct 2005) was driven in large part by runaway increases in oil prices and the detrimental impact of increasing energy costs on the U.S. economy.[73] The energy bill was sponsored by Senator Pete Domenici (Republican-New Mexico) and Congressman Joe Barton (Republican-Texas) and received bipartisan support in both houses of Congress, gaining yes votes from roughly 3/4 of the Senate and 2/3 of the House, before being signed by President George W. Bush in August 2005.[74]

The 2005 legislation makes a number of significant changes to the energy regulatory environment. Some limitations in the law's ability to sustain U.S. energy security were highlighted, though, when Hurricane Katrina caused a significant reduction in domestic oil production and refining capacity as a result of storm damage a few weeks after the bill was signed into law.[75] In spite of unfortunate timing that negatively affected assessments of EPAct 2005, it did significantly alter the electricity sector landscape, addressing competition, reliability, and infrastructure investment. One of the most significant changes was the full repeal of the Public Utility Holding Company Act of 1935. In place of PUHCA, EPAct 2005 does sustain the SEC's role in approving mergers proposed for utility holding companies and any investments made outside of the utility industry. The shift in the law allows flexibility in the investment portfolio of utility companies as long as the decisions are approved by the SEC. Some additional requirements from PURPA, which had mandated that utilities purchase electricity from QFs, were also repealed by EPAct 2005.[76]

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[73] Mark Holt and Carol Glover, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions* (Washington, DC: Congressional Research Service, 2006), 1.

[74] Bill sponsors and status available from The Library of Congress, "H.R. 6: Energy Policy Act of 2005," Washington, DC, 2005, http://thomas.loc.gov/cgi-bin/query/D?c109:6:./temp/~c109CEMDue:: (accessed September 9, 2008).

[75] Holt and Glover, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions*, 1.

[76] Ibid., 2.

To address the reliability of the electric grid, EPAct 2005 gave FERC the authority to establish an Electric Reliability Organization (ERO) with the responsibility to establish obligatory reliability standards. The reliability of transmission lines is to be addressed by DOE through a study conducted every three years that addresses the congestion of transmission lines. Regions that are determined to be congested can in some cases be approved for construction of new transmission infrastructure through the direct granting of building permits from FERC as well as the potential to have eminent domain granted through U.S. District Court.[77] These direct effects on the electricity industry are also supplemented by regulations affecting the larger energy sector, to include tax incentives, conservation guidelines, and renewable fuel goals.[78]

The impact of federal legislation which set the regulatory environment for the electric power sector has created a number of opportunities for improvements in the operations of the power grid and the security of its infrastructure. With states also playing a regulatory role, there is a fair amount of ambiguity in the path the electricity sector will take in the next few years.[79] The goals for strategically developing the electric power sector need to continue to be refined to build a clear path toward a more resilient infrastructure that is less reliant on foreign sources of fuel and less susceptible to disruptions from attacks or natural disasters.

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[77] Holt and Glover, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions*, 1-2.

[78] Ibid., 2-5.

[79] Amy Abel, *Electric Transmission: Approaches for Energizing a Sagging Industry* (Washington, DC: Congressional Research Service, 2007), 25.

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III. IMPROVING ELECTRICITY INFRASTRUCTURE SECURITY – LEGISLATIVE MEASURES

The regulations, guidelines, standards, and requirements that impact the electric power industry are rather extensive. EPAct 2005 repealed PUHCA, which controlled the structure of utility companies for seventy years, but at the same time it added 550 pages of new regulatory guidance.[80] Wading through the legislation in EPAct 2005 took a nineteen-person Congressional Research Service staff 152 pages to summarize the main provisions.[81] Even with the extensive length of the recent energy legislation, there are still a number of uncertainties that remain in the electric power industry about congressional intensions for the electricity market environment, the level of infrastructure investment, and the areas that will receive further regulatory action.[82] Several provisions in EPAct 2005 should work well to improve the reliability of the electric power grid, but there is also room for improvement in the regulatory framework that affects the electric power industry. For example, Congress could provide clarification about their intension for the division of responsibilities in the overlapping roles of state and federal regulatory agencies in the siting of transmission line infrastructure. Congress will need to resolve some of the areas where there is a lack of clarity and where shortfalls have been discovered in existing energy legislation in order to guide federal, state, and electric power industry actions to create a more resilient electric power grid.

A. ELECTRIC RELIABILITY ORGANIZATION (ERO)

Over the years the focus of energy regulation has been on the organizational structure of the industry and the rates that customers are required to pay. EPAct 2005 began to shift some of the focus to improving the reliability of the power grid. The legislation addressed a number of other areas as well, such as expanding the diversity in fuels used for generation, improving generation efficiency, reducing electricity retail

[80] *Energy Policy Act of 2005, U.S. Statutes at Large* 119 (2005): 594-1143.

[81] Holt and Glover, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions.*

[82] Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements,* 13.

rates, and providing tax breaks that focused on reducing U.S. dependence on foreign energy.[83] The congressional focus after the August 14, 2003 blackout, though, was on legislating the implementation of mandatory reliability guidelines that had previously been left to industry to handle independently.[84] Some regions in the U.S. had already been successful in establishing reliability guidelines that resulted in fairly robust regional grid architectures, but the integrated nature of the electric power grid means that a weak link in one area can rapidly affect many other areas of the grid as well. The 2003 blackout began with only a few generation and transmission line outages in Ohio, but once the localized troubles in Ohio reached a critical level, outages cascaded through the power grid infrastructure blacking out the Midwest and Northeastern U.S. and Ontario, Canada.[85] The mistakes made by one utility company in Ohio, FirstEnergy, were a result of shortcuts that had been taken to reduce operating expenses and improve profit margins. These actions ran counter to the lessons learned from previous blackouts and to the voluntary reliability guidelines established by NERC. FirstEnergy failed to trim trees along transmission lines, train their operators on emergency procedures, and maintain reliable system monitoring capability to allow operators to identify grid problems as they occurred.[86] The failure of voluntary reliability guidelines to prevent the root causes of the 2003 blackout resulted in a renewed interest in making reliability measures mandatory in order to improve the overall security of the power grid.

The reliability legislation in EPAct 2005 provided a good start toward necessary reform that emphasizes the importance of U.S. electric power critical infrastructure. EPAct 2005 did not establish specific reliability standards, nor did it require a federal agency to write standards, but instead it provided FERC with the authority to designate an Electric Reliability Organization (ERO) which would have the expertise needed to

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[83] Denise Warkentin-Glenn, *Electric Power Industry in Nontechnical Language*, 2nd ed. (Tulsa, OK: PennWell Corporation, 2006), 136-42.

[84] Weil, *Blackout: How the Electric Industry Exploits America*, 133.

[85] U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations* (Washington, DC and Ottawa, ON: U.S.-Canada Power System Outage Task Force, 2004), 1-2.

[86] Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability*, 168.

make the grid more reliable. The ERO was intended to implement reliability standards with FERC's approval. Once the standards were approved by FERC, Congress provided the ERO with the authority to enforce the standards and impose penalties on utilities that do not follow them.[87] The legislation gave sufficient authority to the ERO to make the standards meaningful. In the 2003 blackout, the problems that led to the cascading power outage were not a result of a lack of knowledge about what steps were required to maintain a reliable power grid. Rather the shortfalls were due to a clear disregard for reliability guidelines and lessons learned from previous blackouts.[88] A number of the contributing factors to the blackout were apparently due to an interest in saving money to boost company profits. At the time of the blackout in 2003, the industry reliability guidelines were published by NERC which was a voluntary industry organization guided by the interests of member utilities.[89] The most recent major federal energy regulation in EPAct 1992 was focused in part on building a competitive market in the electric utility industry, not on the reliability of the power grid.[90] In its analysis of the reasons for the 2003 blackout, the joint U.S.-Canada Power System Outage Task Force's first recommendation was to "make reliability standards mandatory and enforceable, with penalties for non-compliance."[91] EPAct 2005 provided the framework needed to implement this task force recommendation.

After EPAct 2005 was signed into law, it took almost a year for FERC to designate the ERO that would be responsible for establishing electricity industry reliability standards. Providing continuity in the role that NERC had played in

[87] Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements*, 2.

[88] Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability*, 168.

[89] U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, 22.

[90] Weil, *Blackout: How the Electric Industry Exploits America*, 124.

[91] U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, 140.

establishing voluntary reliability guidelines, FERC designated NERC[92] as the U.S. Electric Reliability Organization on July 20, 2006.[93] Another eight months passed before FERC approved 83 reliability standards out of 107 that had been proposed by NERC. While FERC noted that "many of the reliability standards 'need significant improvement,'" at least there was finally an initial set of reliability standards in place that had FERC's backing and carried the threat of penalties for non-compliance.[94]

The NERC reliability standards cover a number of aspects of the operation of the electric power grid, including load balancing, infrastructure protection, emergency preparedness, training, and communications.[95] The recommendations made by the U.S.-Canada Power System Outage Task Force in April 2004 were finally beginning to be implemented, although it had been almost three years since they had been proposed.[96] Now it is up to FERC and NERC to ensure that adequate funding and personnel are devoted to the effort required to evaluate utilities for compliance against the reliability standards and to impose appropriate penalties when violations occur. NERC will also need to refine and improve the reliability standards to ensure they are not ambiguous and that utilities are able to interpret and implement them consistently. One of the critiques about the NERC voluntary reliability guidelines at the time of the August 2003 blackout was that they were vague, leaving considerable room for differing interpretations.[97] In

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92 The North American Electric Reliability Council was renamed the North American Electric Reliability Corporation on January 1, 2007. The "Corporation" was created by the "Council" during the ERO certification process, but the two entities were combined in 2007. The distinction between the two is not material to the discussion in this paper and as such both are referred to in this paper as NERC. See North American Electric Reliability Corporation, "Company Overview: History," Princeton, NJ, 2008, http://www.nerc.com/page.php?cid=1|7|11 (accessed October 14, 2008); North American Electric Reliability Corporation, "Company Overview: FAQ," Princeton, NJ, 2008, http://www.nerc.com/page.php?cid=1|7|114 (accessed October 14, 2008).

93 Federal Energy Regulatory Commission, "NERC Certified as Electric Reliability Organization; Western Region Reliability Advisory Body Accepted," news release, July 20, 2006.

94 Federal Energy Regulatory Commission, "Commission Approves 83 NERC Reliability Standards; Proposes Rule to Eliminate QF Reliability Exemption," news release, March 15, 2007.

95 North American Electric Reliability Corporation, "Standards: Reliability Standards," Princeton, NJ, 2008, http://www.nerc.com/page.php?cid=2|20 (accessed October 11, 2008).

96 Federal Energy Regulatory Commission, "Commission Approves 83 NERC Reliability Standards; Proposes Rule to Eliminate QF Reliability Exemption."

97 U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, 21.

approving the new mandatory standards, FERC noted that a significant amount of effort was still required and the commission held back a number of the proposed standards for later approval, requesting NERC provide additional details.[98] As the standards are reviewed and improved, individual examples of utility operations around the U.S. should be examined to ensure the lessons learned, from previous blackouts and more than a century of electricity industry operations, are applied appropriately to improve the reliability of the electric power grid. It will be important for NERC to ensure utility companies throughout the country are consistently implementing the standards in their internal operations. In addition to documentation of the standards, NERC should implement training to be conducted by industry reliability experts in order to facilitate an equal understanding of best practices across the various electric power regions. While additional infrastructure will need to be built in a number of congested regions to ensure continued reliable operations, the consistent application of appropriate reliability standards with existing infrastructure will certainly help to prevent major outages like the regional blackout in 2003.

B. INDUSTRY SELF-REGULATION AND GOVERNMENT EXPERTISE

Reliance on industry representative organizations, such as NERC, to enforce reliability standards has a number of advantages since the members have access to internal technical expertise on the operational details of the electric power system. As the Electric Reliability Organization, NERC is a “self-regulatory” institution that has the authority from FERC to establish rules and standards with input from industry experts.[99] Due to the breadth of expertise available in its designated role as the ERO, NERC has the potential to significantly improve the resilience of the electric power grid. However, there will always be some reluctance for industry representatives to voluntarily set stringent standards that are important from a reliability perspective, but are costly and do not improve the profitability of the utilities’ operations. Self-regulated governance can work well in a market environment where true competition forces the industry to meet

[98] Federal Energy Regulatory Commission, "Commission Approves 83 NERC Reliability Standards; Proposes Rule to Eliminate QF Reliability Exemption."

standards to improve their chances at gaining market share. But in the utility industry, the significant expense involved in constructing transmission and generation assets and the technical knowledge required to operate the power grid set formidable barriers to the formation of a truly competitive environment. The establishment of Qualifying Facilities (QFs) and Exempt Wholesale Generators (EWGs) has introduced some competition to the electricity industry, but the impact on the overall electricity market has been limited. EPAct 2005 further reduced competition potential by allowing utilities to expand their ownership into those generation areas through the repeal of PUHCA and modifications to PURPA. With SEC approval, utilities can expand their generation and transmission infrastructure holdings beyond the boundaries of a single state without being subject any longer to the highly restrictive regulations from PUHCA. Utilities are also not required to purchase power from QFs at avoided cost rates that had been set arbitrarily high in a number of regions. There is a general expectation that the repeal of PUHCA will lead to further consolidation of utility asset ownership throughout the industry.[100]

The electricity market is already dominated by large corporations that have been able to consolidate their holdings and expand the breadth of their control under legislative changes, starting with EPAct 1992, that deregulated portions of the industry and pushed it toward a market approach.[101] Although the electric power industry is no longer considered to be made up of "natural monopolies," the defining characteristics of natural monopolies still mostly apply as a result of the high costs and technical expertise required to operate the power grid and its components.[102] Congressional efforts have so far failed to establish true competition in the electricity retail market. The initial widespread enthusiasm about the electricity markets started by Enron and other power marketers came crashing down in 2001 when it was revealed that much of the market was a sham, with power marketers creating the perception of competition by lying to customers, hedging bets on future rate changes, and falsifying records to maintain an appearance of

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[99] North American Electric Reliability Corporation, "Company Overview: FAQ."

[100] Warkentin-Glenn, *Electric Power Industry in Nontechnical Language*, 134-35, 144-46.

[101] Weil, *Blackout: How the Electric Industry Exploits America*, 137-38.

[102] Abel, *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992*, 2.

profitable operations.[103] Enron and other power marketers were able to fool state and federal regulators into believing what they wanted to believe, that market competition was lowering rates and that electricity could be bought and sold like any other commodity. The reality was that high fixed infrastructure costs, increasing fuel prices, and the physics of the operation of the power grid make it very difficult to have a truly competitive market in the electricity industry.

EPAct 2005 included requirements for state and federal regulators to be able to access utilities' records and the legislation prohibited deceptive tactics that had been used by Enron and others, such as making false statements about electricity prices and artificially manipulating the market to change rates.[104] A number of the provisions in EPAct 2005 that require market transparency and enforcement of legitimate business operations, though, will only be effective if the regulators have the expertise to catch attempts by electric power companies to use deceptive or illegal tactics. California and other state and federal regulators were fooled by the deception of Enron, at least partially due to their limited knowledge about the technical aspects of electric power market operations as well as their willingness to trust at face value the apparent expertise of the power marketers.[105]

Having robust technical knowledge cannot necessarily prevent government regulators from being fooled by a company that is determined to break the law and to use deception to cover its tracks, but a number of the tactics used by Enron and other power marketers should have raised flags that, if investigated, would likely have uncovered the widespread illegal activity. For example, if the incredibly large swings in market electricity rates had been investigated, it should have been apparent that generators were being artificially shut down and transmission line usage was being falsified to drive up rates by fictitiously scheduling transmission requirements so they appeared to have reached the transmission lines' congestion limits. Enron and other power market traders were even willing to talk about their obviously illegal tactics on recorded trading phone

[103] Weil, *Blackout: How the Electric Industry Exploits America*, 91-95, 100-101.

[104] Holt and Glover, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions*, 84-87.

[105] Weil, *Blackout: How the Electric Industry Exploits America*, 101-104.

lines.[106] The regulators need to have sufficient personnel with technical expertise who are able to identify areas of concern and investigate them to determine if there is in fact any wrongdoing. To adequately regulate the electricity industry, as well as to force it to move toward a more resilient design, FERC and state regulators need to have sufficient numbers of internal electric power technical experts who are able to keep track of the almost 400,000 personnel working in the electric power industry at over 3,100 electric utilities.[107] This is a significant oversight burden, in addition to FERC's role in regulating the transmission and sale of oil and natural gas. To accomplish it properly, FERC needs to have staff with the right expertise to monitor electricity industry operations and ensure utilities are not unjustifiably driving up rates or taking actions that will inhibit the reliable operation of the power grid.

Over the years, FERC has been heavily influenced by partisan politics. The five FERC commissioners are appointed by the President and historically Republican commissioners have favored policies that benefit investor-owned utilities and Democratic commissioners have favored publicly-owned utilities.[108] The distinction in party biases was indicated clearly when Republican Ronald Reagan succeeded Democrat Jimmy Carter. The FERC staff under President Carter had assigned preference to publically-owned utilities in the process of bidding for the right to operate hydro-electric projects when the license came up for renewal. Investor-owned utilities took FERC to court to get the position overturned and the Eleventh Circuit Court of Appeals ruled in favor of FERC's assignment of preference. However, President Reagan appointed commissioners who quickly reversed the course set by the previous FERC commissioners and staff and asked the Supreme Court to overrule the Circuit Court which had supported the original FERC position under President Carter's administration. The Supreme Court refused to overturn the Circuit Court in that case, but the impact of partisan politics on the operation

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106 Weil, *Blackout: How the Electric Industry Exploits America*, 97-101.

107 Industry-Specific Occupational Employment Estimate from U.S. Bureau of Labor Statistics, "NAICS 221100 – Electric Power Generation, Transmission and Distribution," Washington, DC, May, 2007, http://www.bls.gov/oes/current/naics4_221100.htm (accessed October 14, 2008).; Electric utilities total from Energy Information Administration, "Form EIA-861 Database," Washington, DC, 2006, http://www.eia.doe.gov/cneaf/electricity/page/eia861.html (accessed October 14, 2008).

108 Weil, *Blackout: How the Electric Industry Exploits America*, 185-90.

of the power grid can be seen in this example of the decisions made by FERC that were focused primarily on political objectives, in spite of the recommendations and experience of the FERC staff that had supported the initial FERC position. During the Reagan administration, there were several changes which ultimately led to the elimination of the preference for publicly-owned utilities in taking over the operations of hydro-electric generators. The FERC approach was able to be modified as a result of changes in the composition of the Circuit Court, continued lobbying by investor-owned utilities, and strong support from a number of state regulators who sided with investor-owned utilities.[109] While publicly-owned utilities have continued to operate successfully in spite of the turn of events in this example, instability in regulatory policy due to partisan biases is not beneficial to the overall security of the operations of the electric power industry. To minimize partisanship in FERC, Congress should extend commissioners' terms beyond the current five years and maintain the staggered replacement of commissioners so subsequent administrations are not able to quickly replace all or a majority of the commissioners. Additionally, longer terms would provide more stability in the regulatory approach taken by the commission. Continuity in the leadership of FERC would certainly be beneficial by providing a more stable platform that utilities could count on as they determine their long-term operational and investment strategies.

In addition to political party biases, a number of the commissioners have developed significant personal connections with the electric power industry. The closeness of the relationships with industry has been evidenced in a number of examples where commissioners have transitioned directly from working for FERC to working in senior executive positions in the electricity sector.[110] A collegial relationship between regulators and electric utilities can be beneficial by ensuring regulatory decisions do not unnecessarily impose detrimental requirements that may negatively affect the operation of the power grid. However, close relationships that result in significant monetary compensation immediately following service in the regulatory agency will almost certainly cloud the judgment of the regulators. Congress should establish a waiting

[109] Weil, *Blackout: How the Electric Industry Exploits America*, 188-90.

[110] Ibid., 109.

period of at least one year before FERC commissioners are able to work for the companies that are directly affected by FERC's regulatory decisions. To preserve an ethical standard that focuses on the reliable operation of the electric power grid rather than on industry and personal profits, a clear restriction should be placed on the ability of commissioners to profit monetarily from their role in FERC.

The background of the current commissioners is heavily weighted toward experience in law and energy policy at both the state and national level.[111] The commissioners do not have technical experience in the operations of the electric power grid and much of their staff as well does not have a technical background based on electric power industry experience. As a result, FERC is often put in a position of relying on the industry's recommendations for policies that affect the operation of the grid.[112] The limited technical background of the commission, and the tendency at times for partisan bias, was clearly demonstrated during the California energy crisis when the commission under the Republican administration of President George W. Bush initially ignored calls for help from the Democratic governor of California. FERC was initially biased in its assumption that the problems in California were self-inflicted as a result of environmentally conservative policies implemented by the state that had limited generation and transmission infrastructure from being built. Even after it became apparent that Enron had been illegally manipulating the electricity market to increase its profits, at the expense of California consumers, FERC appeared to determine that it did not have the authority to intervene and help resolve the crisis.[113] EPAct 2005 has since clearly assigned FERC the authority to obtain information from utilities and to prevent the abuse of the electricity market.[114] But the lack of any effective action taken by FERC against the abusive actions of Enron, and other power marketers, calls into question how much more effective FERC will be now that it has been legislatively

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[111] See commission member biographies in Federal Energy Regulatory Commission, "About FERC: Commission Members," Washington, DC, August 4, 2008, http://www.ferc.gov/about/com-mem.asp (accessed October 14, 2008).

[112] Weil, *Blackout: How the Electric Industry Exploits America*, 172.

[113] Ibid., 176-77.

[114] Holt and Glover, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions*, 86-88.

assigned the authority to intercede in the market. FERC needs both the legal authority as well as the technical expertise necessary to take effective action. Changes in the law to provide authority will not change the regulation of the market until the technical capability is also present to enable the commission to successfully wield that authority.

To correct the technical shortfalls in the administration of FERC, Congress should require technical expertise be mandated, if not for the commissioners, at least within the direct supporting staff. Obtaining the necessary expertise may require a more closely integrated relationship with the power industry, through NERC or other industry representatives. Expertise may also already be available within some portions of the FERC organizational structure, but not necessarily at the level where it can provide the best effect on policy actions and oversight of the industry. To facilitate the acquisition of personnel with technical operational experience, Congress could allocate funding marked specifically for hiring additional technical staff or consultants as an addition to the existing FERC budget.[115] FERC is a large organization with over a thousand employees, many with apparently solid technical qualifications. However, without the proper strategic guidance at the senior staff and management level where organizational policies are decided, the effectiveness of FERC's industry oversight will continue to be limited, in spite of the changes made in EPAct 2005.

C. REGULATIONS' EFFECTS ON INFRASTRUCTURE

FERC is responsible for regulating the operation of the electric power industry and overseeing the efforts of NERC to establish and enforce reliability standards. Both organizations can improve the resiliency of the power grid as it is currently structured and operated, however they cannot require the utilities to build more transmission and generation infrastructure to increase the safety and operating margins of the grid. NERC reliability standards focus on two concepts to ensure the reliability of the existing power grid: adequacy and security. Adequacy is a measure of the ability of the power grid to supply all of the power required to meet the demand of electricity customers at all times. Security focuses instead on the ability of the power grid to continue to operate after a

[115] Weil, *Blackout: How the Electric Industry Exploits America*, 208.

component outage, such as a transmission line or a generation facility that goes off-line and is no longer able to serve electricity customers.[116] When the two concepts are maintained together, the result is a reliable power grid. When utilities keep up with maintenance, such as trimming vegetation along the transmission line corridors, and ensure monitoring equipment is operating properly, the grid is and has been secure and reliable for most of its history. The operating margin that determines the adequacy of the grid, though, has been declining over much of the last thirty years. Congestion in the power grid has increased significantly, especially since the EPAct 1992 legislation opened the power grid to the addition of much more generation capacity through Exempt Wholesale Generators (EWGs). The additional generation capacity has unfortunately not been matched by equivalent investments in transmission capacity.[117] EPAct 1992 required utilities to provide the use of their transmission lines to all EWGs, as well as to Qualifying Facilities (QFs) established under PURPA, at the same transmission rate that they charge their own generation facilities.[118] The result of EPAct 1992 and PURPA was to create an environment where the "tragedy of the commons" applied to transmission line infrastructure. The utility owners of the transmission lines are required to provide the benefits from their investment to all wholesale generators, while generation owners do not have to invest in transmission infrastructure. As a result of the low overall cost for transmission being around 10% of the cost of providing electricity, there is not a significant portion of utility revenue generated from the operation of transmission lines.[119] Utilities are reluctant to increase nonessential investments in transmission because all owners of generation will benefit and the overall impact on total revenue will be small. This results in a tragedy of the commons situation since the common transmission infrastructure that is used by all parties provides little or no incentive for the owning utilities to invest in maintenance, upkeep, or expansion of the assets.

[116] Warkentin-Glenn, *Electric Power Industry in Nontechnical Language*, 147.

[117] Abel, *Electric Transmission: Approaches for Energizing a Sagging Industry*, 2.

[118] Weil, *Blackout: How the Electric Industry Exploits America*, 56-57.

[119] Abel, *Electric Reliability: Options for Electric Transmission Infrastructure Improvements*, 9.

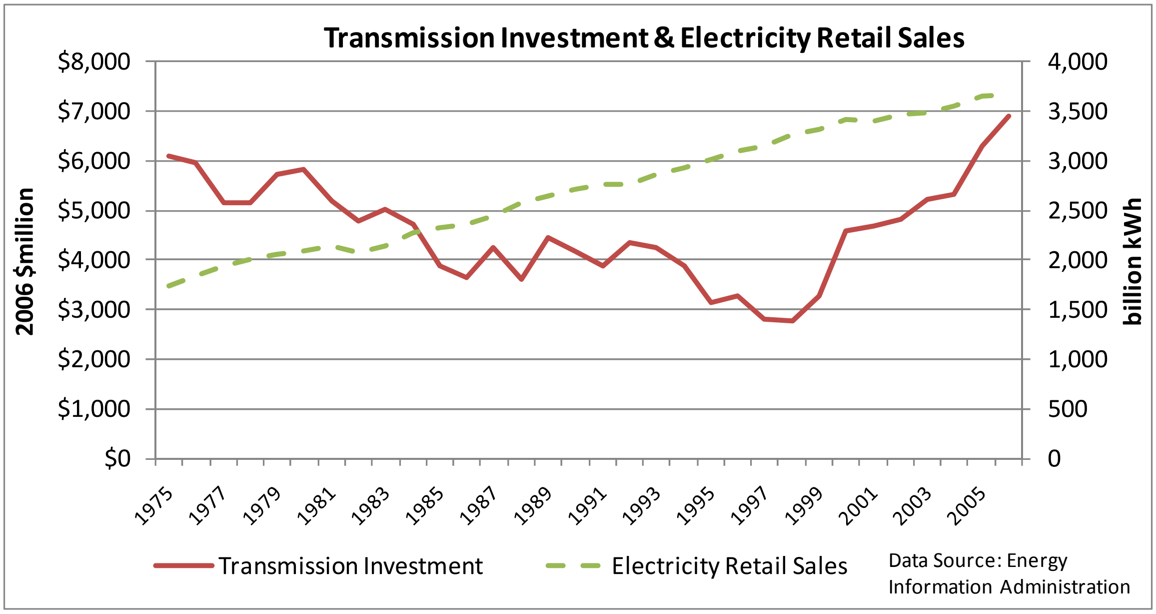

Figure 2. Transmission Investment and Electricity Retail Sales, 1975-2006.

As a result of limited incentives to invest in transmission infrastructure and an emphasis on increasing generation capacity, especially through renewable energy and cogeneration sources, investment in transmission infrastructure in real dollars declined from 1975 through 1998. Although investment has increased by roughly 12% per year since 1998, there have been more than two decades of inadequate investment in transmission (see Figure 2).[120] Some regions of the country are worse off than others, with significant congestion on the transmission infrastructure providing regular constraints to the reliable operation of the power grid. Corrective actions taken to prevent excessive loading on transmission lines when they are congested are called Transmission Loading Relief procedures (TLRs). The number of TLRs required each year provides an indication of the increasing congestion on transmission line infrastructure. TLRs have increased steadily each year since the implementation of

[120] Edison Electric Institute, *EEI Survey of Transmission Investment: Historical and Planned Capital Expenditures (1999-2008)* (Washington, DC: Edison Electric Institute, 2005), 3.; Transmission investment calculated from Table 9.1, "Construction Expenditures for Transmission and Distribution: Shareholder-Owned Electric Utilities," in Edison Electric Institute, *Statistical Yearbook of the Electric Power Industry: 2006 Data* (Washington, DC: Edison Electric Institute, 2007).; Electricity retail sales calculated from Table 8.1, "Electricity Overview, 1949-2007," in Energy Information Administration, *Annual Energy Review 2007*, Table 8.1.

EPAct 1992, from 305 TLRs in 1998 to 1,494 in 2002 and to 1,901 in 2006.[121] The continued growth in the number of TLRs indicates the recent increases in transmission infrastructure investment since 1998 will need to continue to grow for a significant number of years or grow at a faster rate before transmission capacity will begin to reverse the trends of a couple decades of insufficient investment. In the 2006 *National Electric Transmission Congestion Study*, the Department of Energy (DOE) identified two significantly congested areas, called National Interest Electric Transmission Corridors (NIETCs), on the East Coast in the mid-Atlantic region and in Southern California. EPAct 2005 requires DOE to conduct congestion studies every three years and provides FERC with the authority to approve construction of transmission lines in a NIETC if it determines states have not acted on permitting requests for over a year.[122] After the designation of the two NIETCs, though, U.S. Senators from those identified areas were quick to raise objections to the designation of locations in their states where FERC has the authority to overstep the role of state regulators and directly approve transmission line construction.[123] The congressional response gives an indication of the difficulty of addressing the not in my backyard (NIMBY) sentiment that makes it hard to site transmission lines in areas where congestion is a problem.

Due to the NIMBY political opposition to siting transmission lines in the areas where they are most needed, additional congressional action appears to be required to go beyond the EPAct 2005 authorization for FERC to directly approve permits for construction of transmission lines in NIETCs. One approach Congress should consider is to implement a requirement that transmission siting locations must be approved prior to the construction of any generation capability. Since growth in electricity demand is forecast by the Energy Information Administration (EIA) to continue to increase by 1.5% each year through 2030, generation facilities will need to continue to be constructed to meet the increasing demand as well as to replace older generation capacity as it reaches

[121] Abel, *Electric Transmission: Approaches for Energizing a Sagging Industry*, 11.

[122] Ibid., 13.

[123] Matthew Wald, "Wind Energy Bumps into Power Grid's Limits," *The New York Times*August 27, 2008, http://www.nytimes.com/2008/08/27/business/27grid.html (accessed August 27, 2008).

the end of its service life and is taken off-line.[124] By forcing a linkage of transmission siting and investment with generation siting and investment, both necessary to reliably meet growing electricity demand, states will be required to identify areas where additional transmission lines can be constructed. This approach would serve to reduce the congestion on existing lines and improve the reliability and resiliency of the overall electric power grid. There are other technological improvements that could also reduce the level of congestion on transmission lines, but ultimately additional transmission lines will need to be built to meet the projected growth in electricity demand. Congress should act soon to ensure the long-term planning and investment in additional transmission infrastructure will accelerate to make up for decades of neglect.

D. RECOMMENDATIONS - LEGISLATION

Regulatory action has the potential to both benefit and harm the security of U.S. critical infrastructure. The establishment of an Electric Reliability Organization that is responsible for establishing and enforcing reliability standards was a much needed step in protecting the reliability of the electric power grid. EPAct 1992, though, provides an example of harmful effects from government regulation. The legislation contributed to a less secure architecture by reducing the incentive for utilities to invest in transmission infrastructure that must be made available for use by all wholesale electricity generators. Congress has significant room to improve the resiliency of the electric power infrastructure by expanding on some of the successes in EPAct 2005, adjusting the structure of regulatory agencies, and establishing robust requirements for planning for and investing in power grid infrastructure.

1. Summary of Recommendations

- Adequately fund and staff the ERO to train, evaluate, and enforce reliability standards; and continue to refine and improve those standards.

[124] Kevin L. Kliesen, "Electricity: The Next Energy Jolt?" *The Regional Economist* (October 2006), 7.

- Mandate technical expertise for a sufficient number of FERC personnel; and provide funding for the expert staff needed for rigorous oversight of the electric power industry.

- Extend FERC commissioners terms to provide continuity in regulatory policy; and mandate high ethical standards by establishing a waiting period of at least one year before commissioners are able to profit from their prior role in FERC.

- Mandate the designation and approval of needed transmission line siting before construction begins on new generation facilities.

IV. IMPROVING ELECTRICITY INFRASTRUCTURE SECURITY – INCENTIVES & STANDARDS

Long-term infrastructure construction planning is ultimately tied to the anticipated effect it will have on the corporate bottom line. The federal government has different objectives for infrastructure, taking into account the impact of investment decisions on national security objectives in addition to effects on the overall health of the economy. Establishing regulatory requirements aimed at improving the security of critical national infrastructure has an essential place in the government's role of influencing electric power industry investment decisions, but there are also other non-regulatory tools available to the government to create an environment that pushes industry toward achieving national security objectives. Taking a multifaceted approach to improving electric power critical infrastructure protection should have a much greater impact on security and reliability than focusing solely on regulation.

A. INDUSTRY INCENTIVES TO IMPROVE SECURITY

A combination of government incentives will likely be necessary to address the cumulative shortfall in transmission infrastructure investments over the last three decades and to correct the conditions that led to a tragedy of the commons situation.[125] As a result of the EPAct 1992 requirement to provide equal transmission line access to Exempt Wholesale Generators (EWGs), the benefits of owning transmission line infrastructure have been significantly decreased. The profit incentive of owning transmission infrastructure was reduced by being required to share the benefits of transmission line ownership with companies that do not have to expend their own capital up front on high cost transmission lines and then depreciate those assets over many years. The construction costs to build transmission lines, depending on the voltage level, for above ground lines can range from $130 thousand per mile for 115 kilovolt lines up to $840 thousand per mile for 230 kilovolt lines and the costs can reach almost $4 million per

[125] Abel, *Electric Transmission: Approaches for Energizing a Sagging Industry*, 9.

mile for underground 230 kilovolt lines.[126] Construction costs for higher voltage above ground transmission lines, up to 765 kilovolts, can also range into the multiple millions of dollars per mile.[127] These capital expenditures for transmission infrastructure, which must be amortized over a number of years, need to be compared to other investment areas that can potentially lead to more consistent expectations of greater returns on investment, such as the construction of new generation facilities.

The return on investment for transmission line infrastructure is complicated by the overlap of rate setting authority between state regulators that set rates for utilities' base customers and federal regulation by FERC that sets rates for wholesale electricity sales. The rates of return for transmission lines are thus affected by two separate regulatory agencies, making it more difficult to determine the expected rate of return, what level the electricity retail rates will be, and what events may lead to increases or cuts in the rates. For example, in a couple cases in California, the decision on the allowed rate of return was transferred from the state to FERC. The expected rate of return of 12.5% initially set by CA regulators was then reduced in the FERC approved rates for these two cases to 9.7% and 9.8%.[128] In the assessment of capital investment options, the allowed rates of return on investment is a concern, especially as the ratings of credit worthiness for utilities has declined sharply in recent years since the electricity market crash in 2001 due to abuses by Enron and other power marketers.[129] The uncertainty in investment returns and declining credit ratings negatively impacts the decisions to consider new transmission infrastructure investment.

The overlap in rate setting between states for retail sales and FERC for wholesale sales of electricity typically results in utilities' base customers paying for most of the infrastructure investment costs. A credit is returned to base customers which is

[126] Warkentin-Glenn, *Electric Power Industry in Nontechnical Language*, 167.

[127] American Electric Power, "Interstate Transmission Vision for Wind Integration," Columbus, OH, 2008, http://www.aep.com/about/i765project/docs/windtransmissionvisionwhitepaper.pdf (accessed November 10, 2008).

[128] Eric Hirst, *Expanding U.S. Transmission Capacity* (Oak Ridge, TN: Consulting in Electric-Industry Restructuring, 2000), 14-15.

[129] Gregory Basheda et al., *Why are Electricity Prices Increasing? An Industry-Wide Perspective* (Washington, DC: The Edison Foundation, 2006), 81-82.

equivalent to the income utilities receive for wholesale transmission of electricity to other regions. The result is that utilities may not receive any financial benefit from meeting the requirements of the law to provide equal access to their transmission infrastructure for wholesale electricity transfers because the payment for wholesale transfers is used to reduce base customers rates.[130] The wholesale transfers, though, may increase congestion and require additional effort by the utilities to control the operation of the grid without providing additional financial benefit to the utility. This undermines the incentive to expand and improve infrastructure since it limits potential gains from the investments. The complications of dealing with multiple rate setting agencies and the limitations on potential returns on investment are likely to push transmission infrastructure investment down in priority in long-term planning by electric utilities.

Additionally, when EWGs have equal access to transmission lines, the available market share can be decreased for utilities' own generation facilities if the lines begin to approach congestion limits. Transmission line owners would ideally seek to use the maximum capacity of their lines to deliver their own generated electricity, either to their base customers or to sell to other utilities, so they can maximize the available profit from their generation assets. Since adding transmission capacity can provide an increased market for EWGs, utilities may also be reluctant to expand transmission infrastructure that would benefit their competitors. If relieving local congestion through expanding transmission capacity will provide increased opportunity for competitors to transmit power from newer, less expensive generation facilities, then utilities will be inclined to maintain the current transmission infrastructure level, rather than expand, in order to protect the profits from their retail base.[131] The resulting environment creates a significant disincentive to invest in transmission infrastructure and instead to rely on existing transmission lines or look to other companies to shoulder the risk of building additional transmission infrastructure.

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[130] Ross Baldick et al., *A National Perspective on Allocating the Costs of New Transmission Investment: Practice and Principle* (Washington, DC: Working Group for Investment in Reliable and Economic Electric Systems (WIRES), 2007), 27.

[131] Ibid., 44-45.

To offset the reasons that utilities are reluctant to invest in transmission infrastructure, government incentives can be developed to reduce the risks and improve the potential rates of return. Incentives will need to be designed to provide a long-term effect due to the need for utilities to amortize construction costs over many years. Incentives that will only be in place for a few years will be unlikely to provide sufficient incentive to convince utilities to build new infrastructure. To be effective, utilities will need to be assured that the incentives will be in place long enough for the utilities to justify the high up-front capital expenditures required for construction of new infrastructure.

Several options can be provided to offset the risk to utilities for transmission investment. The incentives could be in the form of direct monetary provisions, such as through government grants or cost sharing arrangements, designed to reduce the level of industry investment and associated risk required to build transmission lines. It will be difficult to gain political support for this approach since it would expand government expenditure in an area of the economy that is fairly stable. While the costs of other energy sources such as oil and gas have suffered significant price volatility, electricity rates have been fairly steady for several decades. Adjusted for inflation, the rates for electricity have actually declined most years since the early 1980s (see Figure 3).[132] A potentially more palatable government approach would be to allocate funding for construction of government-owned transmission lines such as the ones currently owned by municipal utilities in a number of states. However, the large majority of customers are served by investor-owned utilities and expanding the government role as an electricity service provider is also unlikely to receive a high level of political support.[133]

[132] Energy price data from Energy Information Agency, in real 2000 $; Residential electricity prices from Table 8.10, "Average Retail Prices of Electricity, 1960-2007;" Natural gas prices from Table 6.8, "Natural Gas Prices by Sector, 1967-2007;" Crude oil prices from Table 5.21, "Crude Oil Refiner Acquisition Costs, 1968-2007" in Energy Information Administration, *Annual Energy Review 2007*.

[133] In 2005, investor-owned utilities generated 43%, non-utilities generated 35%, government-owned utilities generated 17%, and cooperatives generated 5%. See Edison Electric Institute, *Statistical Yearbook of the Electric Utility Industry: 2005 Data* (Washington, DC: Edison Electric Institute, 2006), Table 3.3.

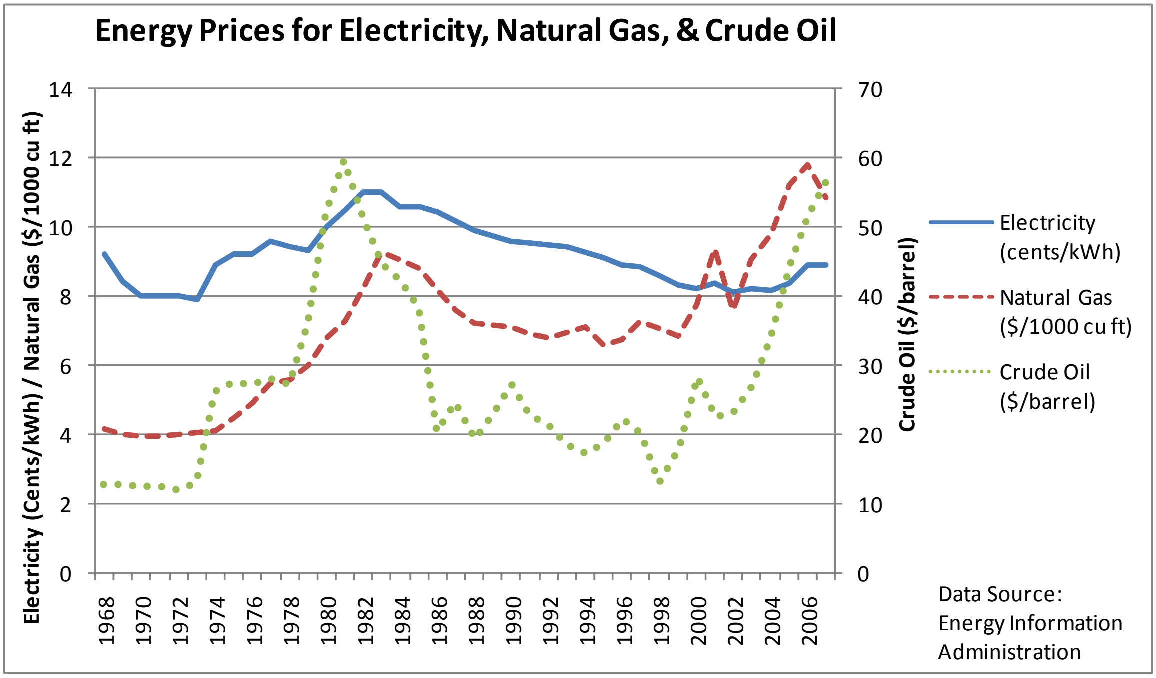

Figure 3. Energy Prices for Electricity, Natural Gas, and Crude Oil, 1968-2007.

It would be potentially much better received to use tax breaks for construction expenditures like has been done for some energy tax relief in the EPAct 2005 legislation. EPAct 2005 focused tax breaks primarily on increasing domestic energy sources and improving energy efficiency. There is only one provision that addresses transmission infrastructure, decreasing the depreciation timeline for transmission investments from twenty years to fifteen years. The only tax breaks specifically for infrastructure investments are for environmentally cleaner generation, both for clean coal and nuclear generation facility construction.[134] To improve the reliability of the electric power grid, tax breaks need to be directed toward reducing the cost of investing in transmission infrastructure, making construction decisions more attractive to industry. These tax breaks would need to be extended over the full amortization period of the costs for the infrastructure, to provide sufficient justification for the utilities to approve the expenditures. While short-term tax incentives may spur some investment, they will have

134 Holt and Glover, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions*, 3, 89-93.

a limited effect on the long-term planning required for most infrastructure investment. Any sunset clauses for tax incentives should be aligned with time frames that will allow industry to count on them in their long-term planning. This may require committing to fifteen or more years of tax breaks for infrastructure investments, in line with the allowed depreciation timeline for transmission line construction costs. The increased time span will be more difficult to gain congressional support, but it is essential to making the tax breaks a realistic tool to expand infrastructure investment. Shorter term tax breaks may support political rhetoric on improving the reliability of energy sources, but they will not have the long-term effects that the nation needs to build resilient critical infrastructure.

In addition to providing incentives for transmission line investments, the resiliency of the electric power grid can also be improved by supporting efforts to expand the use of distributed generation. When electricity is generated close to where it is consumed, it reduces the need for transmission infrastructure. Distributed generation can be provided with conventional fossil fuel powered generation facilities and it can also be accomplished with renewable energy sources. For example, projects have been undertaken to construct solar power generation in sunny regions to provide local, long-term renewable sources of power generation. A 15 megawatt project at Nellis Air Force Base in Nevada was implemented in 2007 under an arrangement between the local power company, two renewable energy companies, and the base to provide more than a quarter of the base power needs from a solar array located on base property, minimizing the need for additional transmission infrastructure.[135] Since distributed generation will most often not be as efficient as large centralized power plants, a focus on renewable energy sources that are cheaper than fossil fuels can help to offset the decrease in efficiency from using smaller distributed generation sources. The high construction costs for many renewable energy sources will make long-term incentives even more important to encourage investment. Government incentives to construct distributed renewable generation facilities can provide multiple benefits through reductions in the use of fossil fuels, an associated decrease in environmental impact, and improvements in the security of electric

[135] Seamus O'Connor, "Solar Panels at Nellis could be Win-Win," *Air Force Times*November 19, 2007, http://www.airforcetimes.com/news/2007/11/airforce_nellis_solar_071119w/ (accessed November 11, 2008).

power critical infrastructure as a result of reducing dependence on large, centralized generation facilities and long-distance transmission lines.

No matter which method is selected to provide incentives for infrastructure investment that will improve the resiliency of the electric power grid, it will only have a significant effect if it is designed to be stable for a number of years. Utilities will need to be able to rely on the incentives to plan their investments. A lack of consistency in the rate of return on investments and uncertainty in the ability to recover costs reduces utilities' willingness to build new infrastructure.[136] Government approaches to improve infrastructure security need to take into account the timeline of industry planning and ensure incentives are extended for maximum effect.

B. ESTABLISH STANDARDS TO IMPROVE SECURITY AND RELIABILITY

In addition to providing financial incentives to increase the resiliency of the electric power grid, governmental authorities can mandate the implementation of standards designed to improve the reliability and security of critical infrastructure. EPAct 2005 gave FERC the authority to designate an Electricity Reliability Organization (ERO) which it did in 2006, assigning the responsibility to NERC. NERC has established a number of reliability standards that focus primarily on procedural requirements, including analysis, planning, maintenance, and operations of the power grid as well as requirements for training, operating safely, preparing for emergencies, and providing physical and cyber security.[137] These standards are an excellent basis for improving the day-to-day operations of the electric power system and preparing for emergencies and component failures. The legislative changes that allow the ERO to enforce the reliability standards is a great step toward improving the reliable operation of the electric power system and preventing a large regional blackout like the one that occurred in August 2003.

[136] Bob Shively and John Ferrare, *Understanding Today's Electricity Business* (San Francisco: Enerdynamics, 2007), 59-61.

[137] North American Electric Reliability Corporation, "Standards: Reliability Standards."

There is room, however, to move beyond the existing procedural reliability standards and several requirements for security and safety measures to also address some specific design requirements that can improve system reliability. The standards established by the ERO will work well to ensure the system operates reliably based on the current system design and associated operating procedures. If the NERC standards had been followed in Ohio in 2003, they could have prevented the August 2003 blackout. Procedures such as ensuring adequate vegetation management along transmission lines and verifying full operational capability of the emergency monitoring systems would likely have prevented the 2003 blackout.[138] These procedural reliability standards are not designed, though, to take advantage of new technology or to force changes to the design of the power grid to make it more resilient to multiple sources of failure.

Some regions have implemented power grid design standards very successfully that have improved system reliability, such as the New England Power Pool (NEPOOL) which required that generators could not be constructed until a power system analysis demonstrated the generation capacity could supply all of New England customers even when all existing generation facilities were also operating. In some cases this forced the construction of additional transmission lines to ensure the existing lines were not overloaded by the new generation facilities. The design standard provides for a much more robust power grid in New England that was able to avoid any significant impacts from the cascading outages during the August 2003 blackout.[139] Design standards such as this one implemented by NEPOOL shift the focus toward designing a more resilient grid during the planning for new infrastructure construction.

Another example of a change in system design standards that would be more resilient to component failures would be to expand the use of distributed generation so power is generated in close proximity to where it will be used. Distributed generation reduces dependence on congested transmission lines and limits cascading failures throughout the power grid since any failure of distributed generators would have a

[138] Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability*, 168.

[139] Weil, *Blackout: How the Electric Industry Exploits America*, 114.

localized impact on the customers for that facility. To increase the use of distributed generation, standards need to be developed for interconnection to the power grid for independently operated distributed generation facilities. There are no existing standards that define how to connect to the power grid.[140] Congress would not need to specify the details of the grid interconnection standard, but rather they could mandate that the standard be developed and enforced. Standard setting organizations such as IEEE could develop the standard with industry input and then the ERO could be authorized to enforce the implementation of the standard. Standards such as this example for connecting distributed generation facilities to the power grid will likely require government backing to force industry to accept the standard since there is a potential for utilities to lose profits from their existing centrally located, large generation facilities. Independently run distributed generation facilities could decrease the customer base for utilities, while still requiring a connection to the power grid for emergency backup and potentially to meet local peak demand requirements.

There is nothing to prevent utilities from benefiting from the distributed generation approach, however, by entering into agreements to construct and maintain distributed generation facilities. Many communities that consider building a reliable local power source would be interested in accessing the technical and management expertise provided by electric utility companies. Since growth in demand for electricity generation is expected to increase significantly in the next five to ten years, distributed generation could be a profitable enterprise for utilities.[141] Urban areas will still need to maintain large, centralized generation facilities and some regions will not be interested in the up-front expense to build distributed generation. For those areas that are willing to spend the capital, though, the interconnection standards would enable a more resilient overall design for the electric power grid. The initiative could also be linked to conservation measures that focus on developing distributed generation facilities that operate using renewable energy sources. These potential benefits alone are unlikely to be sufficient to push many utilities into investing in distributed generation, though, until a

140 Morrison and Broad, "Wind Interconnection: Bridging the Divide," 32-33.

141 Shively and Ferrare, *Understanding Today's Electricity Business*, 160.

mandatory interconnection standard is adopted that guarantees the consistent ability for small generation facilities to be connected to the power grid and opens a competitive environment for local communities to develop reliable local generation capability.

An additional area where government mandated standards could improve the resiliency of the power grid is the establishment of a design standard for large transformers. Transformers are an essential component of the electric power grid, allowing electricity to be stepped up to a high voltage level that can be efficiently transmitted from where it is generated, the source, to where it will be consumed, the load, and then stepped down to a lower voltage that can be used by the utilities' customers. Transformers are also used to change voltage levels at intermediate points in the power grid to meet the requirements of different industrial, commercial, and residential customers. Additionally, they are used to enhance safety when electricity is transferred to lower voltage distribution lines to complete the circuit as electricity is provided to smaller commercial or residential customers. High voltage transformers are very expensive, costing as much as $6 million each, and they can take as long as a year to manufacture. Many of these high voltage transformers are individually made to custom specifications according to utilities' requirements for the unique design of their generation, transmission, and distribution infrastructure.[142] The grid designs are often not built around the design of high voltage transformers, but rather the transformers are designed to meet the needs of the unique grid configuration.

Transformers are components of the grid that regularly fail for any of a number of reasons, including lightning strikes and other voltage spikes, manufacturing defects, overloading, and deterioration over time.[143] Transformers can also be fairly easily damaged or destroyed by an individual. Sabotage can even be accomplished from a distance with small arms fire. With the establishment of standard design criteria for transformers, the resiliency of the grid can be improved by maintaining a spare stock of

[142] Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability*, 208.

[143] William H. Bartley, "An Analysis of Transformer Failures, Part 2 – Causes, Prevention and Maximum Service Life," Hartford, CT, 1997, http://www.hsb.com/thelocomotive/Story/FullStory/ST-FS-LOTRANS2.html (accessed November 9, 2008).

standard transformers that can be used throughout the country to replace transformers when they fail. Some regional electricity organizations, such as PJM Interconnection in the Mid-Atlantic area, have proposed the design of a standard transformer for some applications, but industry has not yet widely adopted the approach of designing standard, interchangeable transformers.[144] Congressional direction can redirect the debate over the concept and focus industry efforts on developing and implementing a common design. Legislation could assign NERC, the ERO, with the responsibility of coordinating the design effort with industry and standard setting organizations. NERC's focus is on improving the reliability of the electric power grid and its membership includes electric utilities with industry technical expertise that will be essential to guiding the design standard effort.[145] The structure exists in the electric power industry for standards to be developed and implemented, but it appears that government intervention is required to expand the scope of ERO reliability standards to include grid interconnections and electric power component designs in order to incrementally improve the security and reliability of the power grid.

C. FOSTER INNOVATION TO IMPROVE SECURITY

The regulatory environment affecting the energy sector has seen multiple changes in recent years through the implementation of EPAct 1992, EPAct 2005, and several implementation orders released by FERC. As a result of uncertainty about future changes in energy regulations, the environment is not very conducive to significant investment in innovative designs that could improve the operations of the electric power industry. A number of ideas have been proposed, for example, under the Smart Grid concept. The U.S. National Energy Technology Laboratory provides a description of the concept as including: self-healing capability, consumer participation in the operation of the grid, resilience to attack, consistent power quality, accommodation of various generation technologies, competition in power markets, and optimized infrastructure assets (see

[144] Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability*, 209.

[145] North American Electric Reliability Corporation, "NERC: About NERC," Princeton, NJ, 2008, http://www.nerc.com/page.php?cid=1 (accessed November 9, 2008).

Table 1 for a comparison of the existing grid to the Smart Grid concept).[146] The government should actively encourage the continued design, development, and testing of these and other innovations which have the potential to improve the resiliency of the electric power grid. Some of the ideas will require further research which could be taken on by government research laboratories as well as through government sponsored research at universities and collaboration with industry research and development efforts.

The Smart Grid of the Future

20th Century Grid	21st Century Smart Grid
Electromechanical	Digital
One-way communications (if any)	Two-way communications
Built for centralized generation	Accommodates distributed generation
Radial topology	Network topology
Few sensors	Monitors and sensors throughout
"Blind"	Self-monitoring
Manual restoration	Semi-automated restoration and, eventually, self-healing
Prone to failures and blackouts	Adaptive protection and islanding
Check equipment manually	Monitor equipment remotely
Emergency decisions by committee and phone	Decision support systems, predictive reliability
Limited control over power flows	Pervasive control systems
Limited price information	Full price information
Few customer choices	Many customer choices

Table 1. The Smart Grid of the Future.[147]

One area that has the potential to considerably improve the reliability and capacity of existing infrastructure is the use of solid state power control devices to handle transmission line monitoring, switching, and control tasks. These solid state devices have the potential to replace existing traditional electro-mechanical power control components such as switches, controllers, and capacitors. Their design allows electric power to be

[146] Global Environment Fund and Center for Smart Energy, *The Emerging Smart Grid: Investment and Entrepreneurial Potential in the Electric Power Grid of the Future*, 2nd ed. (Washington, DC and Redmond, WA: Global Environment Fund and Center for Smart Energy, 2006), 2.

[147] Table 1, The Smart Grid of the Future, see Global Environment Fund and Center for Smart Energy, *The Emerging Smart Grid: Investment and Entrepreneurial Potential in the Electric Power Grid of the Future*, 2.

controlled quickly and accurately as it is transferred to high voltage transmission lines. Solid state high voltage and high current devices can also improve reliability, increase infrastructure capacity, and respond quickly to changes in electric loads. They have the potential to handle higher congestion on transmission lines and respond quickly to many changes in the configuration of the power grid. There are concerns, though, about the long-term reliability of these new power electronic devices and in the ability to adequately and reliably control them in distributed locations throughout the grid. The ability for distributed devices to automatically respond to changes in the power grid, maintaining its balance and stability, has not yet been tested and proven to be as reliable as the current centrally managed and controlled design using electro-mechanical components.[148] Power electronic devices have the potential, though, to increase the capacity, reliability, and control capability of the electric power grid if they can be properly tested and shown to be as safe and secure as existing power control devices. The government can invest in verification of the newer technology, fostering the continued development and application of design improvements.

The government can also encourage the development of storage capacity options which would increase the reliable operation of the power grid during times of peak demand and in cases of infrastructure outages. Industry is looking into options such as large battery storage and systems that can provide short term power capability to bridge gaps during a power outage, such as flywheels and compressed gas. One concept that has so far only been analyzed and tested on a small scale is the potential for electric and hybrid vehicles to use the stored energy in their batteries to provide power back to the power grid. The supply from car batteries could be especially useful during peak load periods in the middle of the day when many of the cars would be parked at office buildings. If the concept was further researched and tested, it has the potential to improve the reliability of the grid by handling some of the load during high demand periods, effectively increasing the available electricity supply.

[148] Warkentin-Glenn, *Electric Power Industry in Nontechnical Language*, 77, 79; Basheda et al., *Why are Electricity Prices Increasing? An Industry-Wide Perspective*, 60.

As more cars with large rechargeable batteries are purchased, the available battery capacity increases significantly each year. A number of issues would need to be addressed to make the concept viable, such as how to transfer the power from the car batteries back into the power grid and then distribute it to where it is needed as well as how to compensate the car owners for the use of their batteries. EPAct 2005 encouraged states to consider the use of net metering which would allow for electric utility customers to sell power back to the grid. Most states have some level of approval in place for the use of net metering, largely to account for electricity generated by renewable energy sources, such as wind or solar, that are able to provide some excess power to the grid.[149] Net metering capability could be applied to the use of vehicle batteries as a source of energy for the power grid. There are also a number of potential solutions to compensate owners for the use of their batteries. The utilities could guarantee the proper function of the batteries for a set number of years, they could establish an agreement to replace the vehicle batteries when their storage capability declined below an acceptable threshold, or they could financially compensate the owners for the amount of power provided back to the grid through net metering.

The potential exists for a significant amount of power to be available from vehicle batteries, with estimates that if 25% of cars on the road were hybrid or electric vehicles, they could supply enough power to be roughly equivalent to the entire current U.S. power generation capacity. It would require fewer than 100 vehicles, out of this large potential source of electricity, to provide utilities with an economically useful amount of power of one megawatt.[150] Vehicle batteries provide a significant potential to improve the resiliency of the grid and facilitate leveling of the fluctuation in the power demand during the day. The government has the opportunity to encourage and support research into new applications of technology to improve the operations of the electric power grid. A number of innovative concepts and technologies have been around for many years and are ready to be put into use. Government advocacy and direct support for research could

[149] Basheda et al., *Why are Electricity Prices Increasing? An Industry-Wide Perspective*, 49.

[150] Willett Kempton and Jasna Tomić, "Vehicle-to-Grid Power Implementation: From Stabilizing the Grid to Supporting Large-Scale Renewable Energy," *Journal of Power Sources* 144, no. 1 (June 1, 2005), 281-82.

provide the additional boost required to bring some of these ideas to the point of implementation in the electric power industry.

D. RECOMMENDATIONS – INCENTIVES AND STANDARDS

A combination of approaches should be considered by federal and state regulators to improve the resiliency of electric power infrastructure. Investor-Owned Utilities (IOUs) account for the large majority of power supplied in the U.S. and making a consistent profit is the primary incentive for IOU investment decisions. Industry is interested in ensuring the power grid operates reliably to provide power to their customers, but the government needs to also take into account national security requirements for a power grid that is resilient to many potential disruptions. The various changes in energy legislation provide an indication of the difficulty in getting the right mix of requirements specified that will create stable and secure energy infrastructure. A combination of approaches is more likely to be successful in building resiliency into the power grid, including reducing or eliminating regulatory barriers to infrastructure investment, providing financial incentives for industry to invest in infrastructure security, and setting design standards that will improve reliability as well as take advantage of innovative technologies. No one solution is likely to achieve the level of security required to ensure electricity is able to reliably sustain national critical infrastructure. The critical role of reliable electricity in the modern economic system highlights the need to take all appropriate measures to ensure the proper continued operation of the electric power grid.

1. Summary of Recommendations

- Provide long-term financial incentives, including grants, cost sharing, and tax breaks for infrastructure investments in transmission lines and distributed generation.

- Establish design standards for grid interconnection, large transformers, and other critical infrastructure components.

- Foster innovative designs such as the Smart Grid, solid state power control devices, and grid connection of electric and hybrid vehicle batteries.

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V. POLICY IMPLEMENTATION CHALLENGES AND RECOMMENDATIONS

Addressing the weaknesses in the electric power grid is critically important to achieving U.S. national security objectives. The *National Strategy for Homeland Security* identifies four national focus areas:

- Prevent and disrupt terrorist attacks;
- Protect the American people, our critical infrastructure, and key resources;
- Respond to and recover from incidents that do occur; and
- Continue to strengthen the foundation to ensure our long-term success.[151]

To successfully address the second and fourth focus areas, protecting critical infrastructure and strengthening the foundation of U.S. homeland security, it is essential to maximize the resiliency of electric power infrastructure. The power grid underpins all other critical infrastructure sectors and enables the successful operation of the national economy. Due to the foundational nature of the use of electricity in society and the fact that power is typically delivered reliably every day, it is easy to overlook electric power infrastructure and shift the focus of national efforts to other pressing priorities. Major power outages do not occur frequently. Excluding several outages in areas impacted by hurricanes, it has been more than five years since the last widespread regional blackout. The economic damage from the August 2003 blackout reached into the multiple billions of dollars, though, and it disrupted hospitals, grocery stores, financial markets, and many other essential aspects of the economy in the Midwest and Northeast for one to two days and for several additional days in some of the affected areas.[152]

Despite the infrequent nature of blackouts, the costs are extremely high when they do occur and as congestion increases throughout the power grid and as infrastructure ages, there is an increasing potential for another major outage. Stresses from an environmental disaster or deliberate sabotage would also increase the possibility of an

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[151] Homeland Security Council, *National Strategy for Homeland Security*, 1.

[152] Auerswald et al., *Seeds of Disaster, Roots of Response: How Private Action can Reduce Public Vulnerability*, 121, 166, 212.

extended regional blackout. The best protection for the electric power grid is to make the infrastructure more resilient to potential failures. Sustaining momentum behind infrastructure investments will require reminding regulators and legislators of the risks and potential damages of another widespread blackout and building support behind implementing a number of the options recommended in this paper that can significantly improve infrastructure security.

A. OVERCOMING POLITICAL AND INDUSTRY OPPOSITION TO CHANGE

The historical gap between the passage of major pieces of energy legislation and the years of debate that precede significant policy change provide an indication of how difficult it is to reach a consensus on the appropriate direction for U.S. energy policy. Major energy legislation has been enacted in 1935, 1978, 1992, and 2005. Well over a decade has passed between each of these legislative measures. One example of the lengthy timeline between the introduction of ideas for policy change and the actual implementation of the change is demonstrated with Exempt Wholesale Generators (EWGs). Senator J. Bennett Johnston initially introduced EWGs in a legislative amendment submitted in 1989, but the idea was debated for three more years before it was enacted in EPAct 1992.[153] Similarly, policy changes that were enacted in EPAct 2005, such as establishing an Electric Reliability Organization (ERO) and reforming PUHCA, had been debated since at least the summer of 2003. Pressure to pass a change in energy policy increased after the August 2003 blackout, but it took two more years of debate before the changes became law.[154] Attempting to make additional significant changes to energy policy at this point will be difficult and it will require a focused effort to emphasize the importance of the needed changes and to address the likely objections to further policy changes.

Efforts to improve the security of the electric power grid, as well as the broader energy sector, would benefit from an integrated approach that includes the various

[153] Energy Information Administration, *Public Utility Holding Company Act of 1935: 1935-1992*, 33.

[154] Robert Bamberger, *Energy Policy: The Continuing Debate and Omnibus Energy Legislation* (Washington, DC: Congressional Research Service, 2004), 10.

stakeholders involved in establishing and implementing energy policy, to include DOE, DHS, FERC, NERC, industry representatives, state regulators, and the congressional committees on energy, infrastructure, and homeland security. Complete consensus will not likely be reached between all of the affected agencies, organizations, legislators, and businesses, but the ability for policy to achieve its intended objectives is greatly increased when there is buy-in from as many of the stakeholders as possible. Focusing on the national strategic objectives of protecting critical infrastructure and preserving the foundational infrastructure of the national economy will help to guide the debate over the measures that need to be implemented.

The reliability and security of the electric power grid is one part of the broader responsibility for ensuring the protection of all critical infrastructure sectors. Homeland Security Presidential Directive 7 (HSPD-7) assigns the responsibility to the Secretary of DHS for national planning and implementation efforts related to critical infrastructure protection.[155] Integrating the disparate objectives found at the state and federal levels, as well as between government and industry, is a role that can be appropriately assumed by DHS. The EPAct 1992 requirement for market competition was held up in the courts for eight years. To avoid such lengthy legal battles between government regulators and industry, it would be beneficial to bring industry into the discussion and work to arrive at the best supportable solution that balances national security requirements with industry profit objectives. Whether the leadership on energy infrastructure security falls to DHS or another agency, the objective should be to maximize the benefits of industry expertise combined with a national government perspective on security requirements.

The majority of electric power infrastructure is owned and operated by the private sector. As a result, their expertise will be greatly beneficial to the development of policy changes designed to improve the resiliency of the power grid through the development of realistic objectives, such as expanding the use of distributed generation and standardizing high voltage transformer designs. By giving industry representatives an integral role in designing the objectives for improving infrastructure security, industry should develop a

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[155] Bush, "Homeland Security Presidential Directive 7: Critical Infrastructure Identification, Prioritization, and Protection," par. 12-15, 27.

sense of ownership in the process and it should result in policies that are better able to achieve security goals. With industry collaboration on the policy development, the resulting government requirements will be less likely to be held up in court for years and industry will be less likely to attempt to find ways to circumvent the intent of the regulations.

Industry representatives can also help to focus initial efforts on the most promising technologies that should achieve the biggest improvements in security. Within the Smart Grid concepts there are many areas that can be developed to improve the security of the power grid. Even within a single area of technology application, such as solid state power control devices, there are multiple options to use the devices for switches, controllers, capacitors, and other components that can improve the time response and precision of control over the operation of the power grid.[156] The process of selecting the technologies and applications that will take advantage of mature technologies and achieve the best effects, within the confines of available funding, will appreciably benefit from close coordination with industry representatives. There is a double benefit from an integrated government-industry team. Industry representatives will gain ownership in the infrastructure security improvement process and the policy development team will have access to extensive technical expertise. The use of an integrated team should also facilitate the development of a consensus within Congress on the approach recommended by the government-industry team for implementing policy changes. If industry is lobbying for the recommended policy changes, it will increase the likelihood of sufficient congressional support to implement the changes.

Congressional endorsement of power grid infrastructure security improvements will require bipartisan support. While there is significant partisan debate on the best approaches to achieve energy independence and to protect the environment, it should be a fairly nonpartisan issue to improve the reliable operation of the power grid, even when equipment failures, natural disasters, or sabotage occurs. There may be debate, though, over the particular methods selected, especially if an impression is created that the

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[156] Warkentin-Glenn, *Electric Power Industry in Nontechnical Language*, 77.

electricity industry is receiving preferential government treatment. To address the potential for partisan opposition to security policy improvements, it will be important to work closely with the congressional staff members on the energy, infrastructure, and homeland security committees, as well as with the personal staff for the chairman and ranking minority members on each of these committees. In many cases it is the congressional staff members that define the policy objectives pursued by their congressional committees. Due to the prominence of issues such as volatile fossil fuel prices and the need to protect Americans from terrorist attacks, there will be significant competing priorities vying for the attention of personal and professional staff members associated with the energy, infrastructure, and homeland security committees. Convincing these staff members of the foundational importance of electric power infrastructure will be an essential component of the strategy to implement needed policy changes. The lack of incentives in EPAct 2005 that were focused on transmission infrastructure and power grid technology improvements provides an indication of the difficulty that will be encountered in attempting to implement much needed power grid security policy. To make progress on electric power infrastructure security objectives, it will be essential to invest significant personnel resources from industry and government regulatory agencies into the education of the appropriate congressional committee staff members to gain their support for the needed policy improvements.

To secure the full support of industry for implementing security policy changes, it will take more than just informing industry representatives about the decisions made by the government team. The government leaders on the policy analysis team, likely coming from DHS, will need to work with industry to prioritize the measures that are expected to have the greatest impact on improving the security of electric power critical infrastructure. Although grants and cost sharing for these measures would likely be industry's preferred method for government incentives, as discussed earlier, it is more likely that Congress would support tax breaks rather than direct funding. The best structure for tax breaks should be recommended by industry. Industry should be able to provide an assessment of the impact of different tax incentives on their ability to obtain the funding needed to invest in transmission infrastructure or other security improvements. The policy analysis team should then develop a Business Case Analysis (BCA), or equivalent assessment, of the expected benefit to industry from the proposed tax breaks, given the existing regulatory environment and anticipated market dynamics. The purpose of a BCA is to assess a proposed strategy to determine the expected financial and business impacts of the strategy.[157] In the case of the proposed energy policy, for it to be accepted by industry, the BCA will need to demonstrate how the policy will maintain or increase electric power industry profit margins. The assessment should aim to show that industry can make a reasonable profit, while also supporting national security objectives. Involving industry representatives in the development of the BCA will improve the accuracy of the analysis and help to focus the policy options on those that are most likely to create strong incentives for industry to invest in infrastructure security.

Even with the introduction of government incentives to encourage infrastructure investments, there will likely still be companies in the electricity industry that are not interested in any type of energy policy change. Volatility in the regulatory environment makes it difficult for companies to perform long-term investment planning and it can undermine existing plans that have already been initiated. Some portions of industry are likely to favor the status quo rather than risk the potential that additional policy changes will hurt their business plans. To be successful in winning widespread industry support for new policies, the proposed government approach will first need to be clearly articulated in a BCA. The benefits will then need to be marketed to industry, focusing on the potential for increased profits and expanded market share, for example through increasing the capacity of existing transmission infrastructure with Smart Grid components or through constructing new transmission infrastructure that will solve congestion limitations on existing infrastructure. Although industry leaders may be nominally interested in doing their part to support national security objectives, they also need to address their corporate bottom-line requirement to make a profit. Tax breaks will only lead to increased investment in infrastructure if utilities are able to acquire sufficient investment capital. To obtain the capital, the policy analysis will need to show that there

[157] Kochems, *Who's on First? A Strategy for Protecting Critical Infrastructure*, 6.

is sufficient room to earn a reasonable return on investment while also improving the resiliency of the electric power grid.

B. ASSESSING POTENTIAL UNINTENDED CONSEQUENCES OF POLICY CHANGES

It will be a definite challenge to gain congressional and industry support for changes to energy policy, especially since only a few years have passed since the most recent legislation was enacted and there has not yet been much time to assess the impacts of EPAct 2005. Once an integrated government-industry team has been able to gain support for changing energy policy, the next challenge will be to assess the risk of unintended consequences that could undermine the intended benefits for electric power infrastructure. As with previous energy legislation that focused on issues such as conservation, reducing retail rates, and increasing competition, but resulted in decreased infrastructure security, there is a comparable potential that new energy policies focused on increasing infrastructure security could cause problems in other aspects of the electric power industry. Some of the potential negative impacts may be worth accepting due to the critical importance of ensuring a reliable supply of electricity, but wherever possible, it would be better to anticipate and mitigate those risks while the policy changes are being developed and implemented.

One of the most likely potential consequences of investing in new infrastructure is a resultant increase in customers’ electricity rates. A return on investment for infrastructure construction is factored into electricity rates to ensure utilities are able to attract sufficient investment capital and maintain a reasonable profit margin. A rate increase to pay for capital investments would be offset to some extent by the proposed tax breaks established to encourage infrastructure investment. If a utility’s market share is expanded as a result of constructing new infrastructure, any potential increase in rates would also be spread over a wider customer base, thus reducing the amount of any increase for existing customers. A number of the investments recommended for improving electricity infrastructure security are also targeted toward transmission infrastructure, which accounts for only a small percentage of electricity retail rates.

Investments in transmission lines and solid state power control devices would impact less than 10% of customer's electricity rates. In 2006, electricity on average cost 8.9 cents per kilowatt-hour and the portion of the rate that covers the cost of transmission investment, operations, and maintenance was 0.65 cents per kilowatt-hour, or 7.3% of the overall retail rate for electricity.[158] While investment in transmission infrastructure can have a significant impact on the security of the electric power grid, a resultant increase in the retail rate for electricity should be only a small percentage of what consumers pay for their electricity. When looking at a combination of government tax incentives for infrastructure investment, an expected increase in utilities' customer base, and the limited impact of transmission infrastructure on electricity retail rates, it leads to the conclusion that any small increase in the cost of power should not be a significant impact on electricity customers or the overall U.S. economy.

Another potential consequence of improving the security and reliability of the electric power grid is that it may result in an increase in the use of fossil fuels, further expanding the dependence on foreign sources of fossil fuels and increasing the vulnerability to market price fluctuations. The use of distributed generation can be accomplished with a number of technologies, including, for example, microturbines that operate on natural gas or other fuels. Microturbine designs are efficient and produce lower air pollution emissions when compared to a number of older, centralized generation facilities.[159] Adding additional microturbines and other fossil fuel-powered distributed generators will likely increase the nationwide consumption of fossil fuels. The issue could be mitigated, though, if the move toward distributed generation was combined with incentives to build renewable fuel generation facilities, such as those that use solar energy, wind, or biofuels. In that case, the distributed electricity generation would reduce the load on centralized generation facilities and decrease the overall national use of fossil fuels. Both objectives, to increase conservation and improve

[158] Energy Information Administration, *Annual Energy Outlook 2008 with Projections to 2030* (Washington, DC: 2008), 131.

[159] U.S. Department of Energy, *Advanced Generation: Microturbine Systems* (Washington, DC: 2002).

security with distributed generation, can be accomplished as long as incentives are in place to maximize the use of renewable fuel sources.

Any policy change creates uncertainty in the industry, potentially limiting rather than expanding infrastructure investments due to the uncertainty about energy policy priorities. There is always the potential that future Congresses could repeal the policy change and revert back to the state before the change took effect or pursue another policy objective that becomes a higher priority as a result of changing world events. The potential for continued policy adjustments can never be entirely eliminated, but by conducting the policy analysis and implementation planning with an integrated government-industry team, the mutually agreed to priorities that are designed to support national security objectives should be fairly stable. Major energy policy changes in the past have been made after significant crises, such as drastic increases in oil prices, or after many years of efforts to reform the market structure of the energy industry. The recommended emphasis on national security objectives, though, is not driven by a crisis or by politically motivated goals. The emphasis on infrastructure resiliency is designed to improve the reliable supply of electricity in order to strengthen all other U.S. critical infrastructure sectors. The focus of the policy changes on security objectives should provide a durable support base that will be unlikely to change based on shifting political biases or the occurrence of national or international incidents. Additionally, if the legislation that implements the policy change has an extended duration for the incentives and a focus on new, efficient technologies, it would be difficult for future Congresses or administrations to come up with legitimate rationales to justify overturning the legislation. Even when there have been objections to previous major energy legislation, most often the legislation has been adjusted rather than overturned completely. For example, the 1935 PUHCA legislation held for seventy years before it was overturned. It was modified with PURPA and EPAct 1992, but it wasn't until the effects of those legislative changes were assessed, and after many years of debate, that EPAct 2005 finally eliminated the restrictions in PUHCA and left the oversight of utility holding company acquisitions and mergers up to the SEC.

There may be other consequences that will occur as a result of focusing energy policy on building a resilient electric power infrastructure, but the importance of the national security objectives to protect critical infrastructure and protect the foundations of U.S. homeland security provides a solid justification for accepting any ancillary effects. The modern economy's dependence on reliable electricity provides a vital reason to emphasize resilient power grid architecture. The U.S. government needs to recognize the clear foundational importance of electric power infrastructure and make it a central guiding objective in the next major piece of energy policy legislation.

C. CONCLUDING ASSESSMENT

> Like those who came before us, we must lay the foundations and build the institutions that our country needs to meet the challenges we face. The [National Security Strategy] will focus on several essential tasks. The United States must:…
> • Transform America's national security institutions to meet the challenges and opportunities of the 21st century[160]

> As we face the dual challenges of preventing terrorist attacks in the Homeland and strengthening our Nation's preparedness for both natural and man-made disasters, our most solemn duty is to protect the American people. The National Strategy for Homeland Security serves as our guide to leverage America's talents and resources to meet this obligation.[161]

The National Security Strategy of the United States of America and the *National Strategy for Homeland Security* lay the framework that defines the importance of efforts to protect U.S. national critical infrastructure. Within the context of volatile energy prices, global financial turmoil, and a continuing battle against terrorism, it is important to emphasize the foundational infrastructure that sustains the U.S. economy and the ability to carry out national strategic objectives. The electric power grid is one of the most fundamental infrastructures that supports all other critical infrastructure sectors, including, among others, information and telecommunications, banking and finance,

[160] George W. Bush, *The National Security Strategy of the United States of America* (Washington, DC: 2006), 1.

[161] George W. Bush in preface to the *National Strategy for Homeland Security*. See Homeland Security Council, *National Strategy for Homeland Security*, v.

emergency services, and the defense industrial base. To sustain the modern U.S. economy and support the national security strategy, the recommendations analyzed in this paper should be carefully considered, prioritized along with other important national objectives, and implemented by Congress in the near future. The recommendations can be readily integrated with other high interest areas that are receiving significant attention, such as conservation, environmental protection, and energy independence. Either in entirety or in part, these recommendations will greatly benefit the nation if they are acted upon quickly to preserve the security and reliability of national electric power critical infrastructure.

1. Summary of Recommendations

The following summary captures each of the recommended changes that should be considered for energy policy legislation to construct a solidly resilient electric power grid.

a. Regulatory Changes

- Adequately fund and staff the ERO to train, evaluate, and enforce reliability standards; and continue to refine and improve those standards.

- Mandate technical expertise for a sufficient number of FERC personnel; and provide funding for the expert staff needed for rigorous oversight of the electric power industry.

- Extend FERC commissioners terms to provide continuity in regulatory policy; and mandate high ethical standards by establishing a waiting period of at least one year before commissioners are able to profit from their prior role in FERC.

- Mandate the designation and approval of needed transmission line siting before construction begins on new generation facilities.

b. Incentives and Standards

- Provide long-term financial incentives, including grants, cost sharing, and tax breaks for infrastructure investments in transmission lines and distributed generation.

- Establish design standards for grid interconnection, large transformers, and other critical infrastructure components.

- Foster innovative designs such as the Smart Grid, solid state power control devices, and grid connection of electric and hybrid vehicle batteries.

c. Political and Industry Support

- Establish an integrated government-industry team to focus on improving electricity infrastructure resiliency.

- Conduct a BCA of proposed infrastructure security initiatives to demonstrate industry's ability to achieve national security objectives and make a profit.

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