United States General Accounting Office

GAO

Report to the Chairman, Senate Committee on Governmental Affairs

November 2003

ELECTRICITY RESTRUCTURING

2003 Blackout Identifies Crisis and Opportunity for the Electricity Sector

GAO-04-204

Contents

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United States General Accounting Office
Washington, DC 20548

November 18, 2003

The Honorable Susan M. Collins
Chairman, Committee on Governmental Affairs
United States Senate

Dear Chairman Collins:

The August 14, 2003, electricity blackout—the largest in the nation's history—affected millions of people across eight northeastern and midwestern states as well as areas in Canada. In some areas, power was restored in hours, while in others power was lost for several days. The blackout intensified concerns about the overall status and security of the electricity industry at a time when the industry is undergoing major changes and Americans have a heightened awareness of threats to security.

Because of these widespread concerns and the broad institutional interest of the Congress, we (1) highlighted information about the known causes and effects of the blackout, (2) summarized themes from prior GAO reports on electricity and security matters that provide a context for understanding the blackout, and (3) identified some of the potential options for resolving problems associated with these electricity and security matters.

Over the past several weeks, GAO staff briefed numerous congressional staff on its observations. In response to your request, we prepared this overview to accompany the slides used in these presentations. Appendix I presents the latest briefing slides in their entirety. Our briefing is based largely on reports we previously issued on a range of electricity issues along with updated information obtained from the Department of Energy (DOE), the North American Electric Reliability Council, and operators of the transmission system in the blackout region. The information presented is intended to place the electricity blackout in the broader context of long-term issues affecting the sector. The options presented do not encompass a complete set of all possible options but do represent ideas that merit consideration as the nation moves forward to address this important issue.

Summary

While the root cause of the blackout has not yet been conclusively established, a recent DOE report describes a sequence of events that

culminated with the outage. A series of power plants and transmission lines went offline beginning at about noon eastern daylight time because of instability in the transmission system in three states. The loss of these plants and transmission lines led to greater instability in the regional power transmission system, which—4 hours later—resulted in a rapid cascade of additional plant and transmission line outages and widespread power outages. The blackout affected as many as 50 million customers in the United States and Canada, as well as a wide range of vital services and commerce. Air and ground transportation systems shut down, trapping people far from home; drinking water systems and sewage processing plants stopped operating; manufacturing was disrupted; and some emergency communications systems stopped functioning. The lost productivity and revenue have been estimated in the billions of dollars. A joint U. S.-Canadian taskforce is seeking to identify the root cause of the failures and plans to issue an interim report in November 2003.

Over the past several years, our work on the electricity sector has resulted in numerous findings, conclusions, observations, and recommendations. Based on this prior work, we highlight three themes on electricity and security matters in our briefing and lay out some of the potential options to consider in addressing problems in these areas.

Specifically:

- Electricity markets are developing, but significant challenges remain. Our work has shown that while the electricity sector is in transition to competitive markets, the full benefits of these markets will take time and effort to achieve. For example, we found that the separate development of wholesale and retail electricity markets, which is occurring as part of the electricity industry shifts from regulated to competitive markets, limits the industry's ability to achieve the benefits of competition. The separate development of these markets reduces or eliminates retail consumers' incentive or ability to respond to market signals that supplies are tight. Consumers do not respond because the retail prices they see are set by state regulators and do not reflect actual market conditions. This lack of consumer response becomes particularly important during periods of high demand for electricity, such as hot summer afternoons, when total electricity use approaches the total amount of available generation. Efforts to promote various types of demand response, such as those that link customers' electricity consumption with prices, may offer one option for improving this situation. We are exploring this issue in more depth in

response to your request. Other issues raised by our work in this area are presented in slides 14 through 18 of the briefing.

- Oversight of markets and reliability needs more attention. The ongoing transition to competitive markets, or "restructuring" of electricity markets, has dramatically changed how the Federal Energy Regulatory Commission (FERC) needs to oversee these markets and the information it needs to do so. In order to monitor current market conditions to ensure fair competition, for example, FERC needs to access market information on wholesale transactions and the operation of electric generating plants, among other things. Our work shows that FERC's oversight efforts are improving, but it continues to be hampered by a number of challenges. In particular, we noted that FERC had previously not clearly defined its role in monitoring the market, faced gaps in information due to limitations in its jurisdictional authority, relied on third-party data to perform regulatory functions, and had limited enforcement authority. In addition, we pointed out that FERC faced human capital challenges to acquire and develop the staff knowledge and skill it needs to effectively regulate and oversee today's electricity market. Because restructuring has changed the types of information regulators need, we have previously recommended that FERC demonstrate what additional information it needs, describe the limitations it faces without such information, and ask the Congress for authority to collect it. One option for congressional action in this area includes providing FERC with authority to gain access to needed data relating to reliability and markets. Other issues raised by our work in this area are presented in slides 19 through 26 of the briefing.

- Security for critical infrastructure is of growing importance. Our work has shown that a reassessment of the security of the nation's physical infrastructure as well as that of related information technology and control systems should be undertaken. Often, security measures have been added after the infrastructure is in place, which is costly and creates potential conflicts between security and efficiency. Therefore, it may be better to integrate sufficient security measures for these critical systems, particularly in a post-September 11th environment, into the planning for new construction or the upgrading of existing infrastructure, rather than viewing them as later add-ons. Our work has also raised concerns about the increasing reliance on information technology and control systems, which are potentially vulnerable to cyber attack, including the systems used in the electricity sector. As part of our work, we have found that cyber attacks against these systems could be used to cause damage or complicate the response to a physical attack. One option to help address this problem would be to increase the focus on research and development and other related

activities, including the use of currently available technologies and vulnerability assessments, aimed at enhancing national capabilities to respond to cyber-security issues. Other aspects of our work in this area are presented in slides 27 through 29 of the briefing.

Whatever the ultimate cause of the blackout, our work has shown that a number of significant challenges remain for the electricity sector. We recognize that many issues surrounding the restructuring of the electricity industry are complicated and that solutions involve complex policy tradeoffs for the Congress that will undoubtedly take time to fully resolve. GAO stands ready to provide any analytical assistance the Congress may need in this important long-term endeavor.

We conducted our work in accordance with generally accepted government auditing standards.

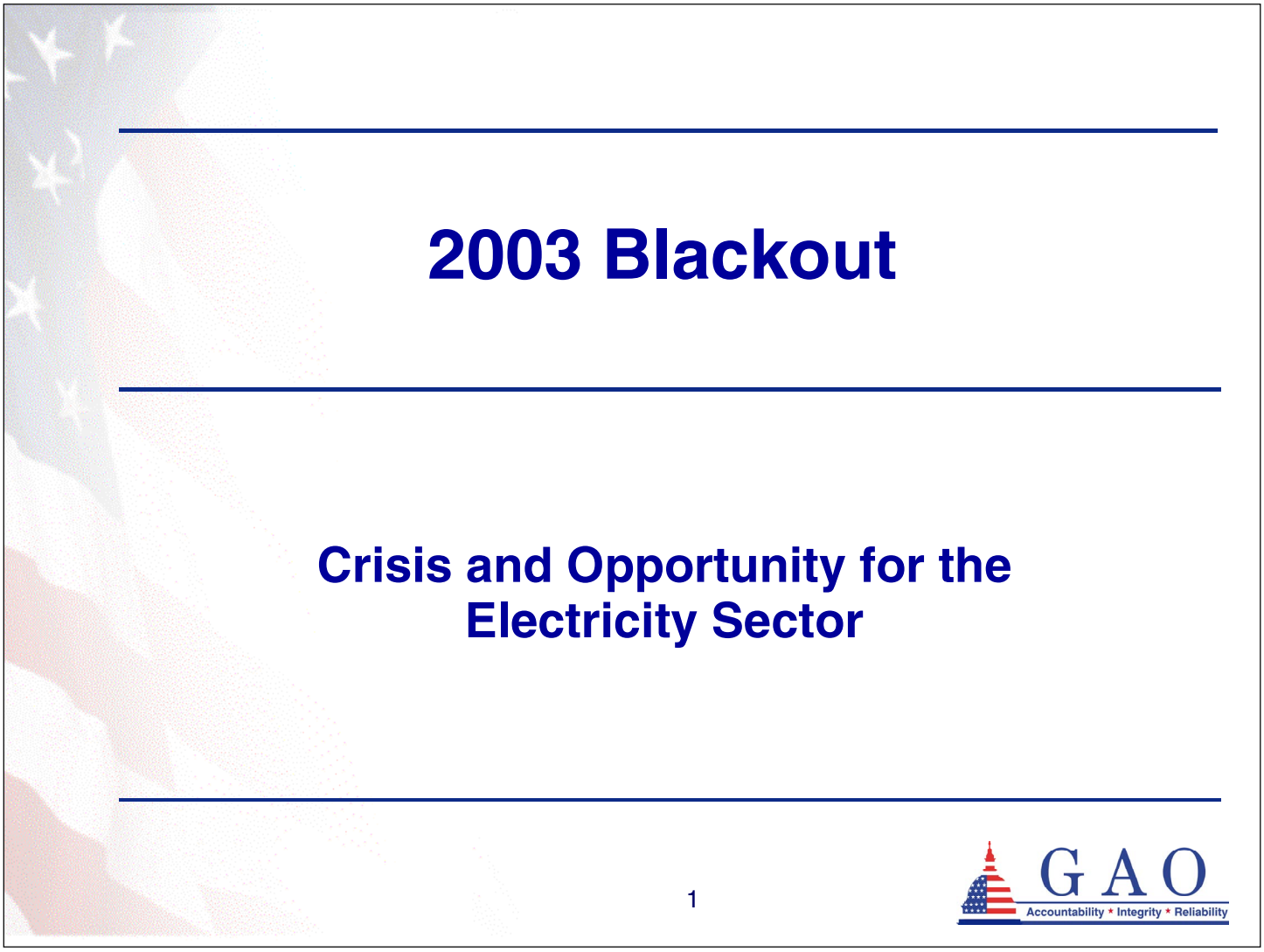
We are providing copies of this report to other appropriate congressional committees as well as DOE and FERC. The report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841. Major contributors to this report included Mary Acosta, Dennis Carroll, Dan Haas, Randy Jones, Mike Kaufman, Jon Ludwigson, and Barbara Timmerman.

Sincerely yours,

Jim Wells
Director, National Resources and Environment

Appendix I: 2003 Blackout Identifies Crisis and Opportunity for the Electricity Sector



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What We Considered in Developing the Briefing

Examined information from NERC, FERC, DOE, several ISOs

Examined prior relevant GAO work (reports, testimony, and briefings) covering a range of areas

- Development of energy markets
- Regulatory oversight of energy sector
- Homeland security and physical security of critical infrastructure
- Information technology and cyber security

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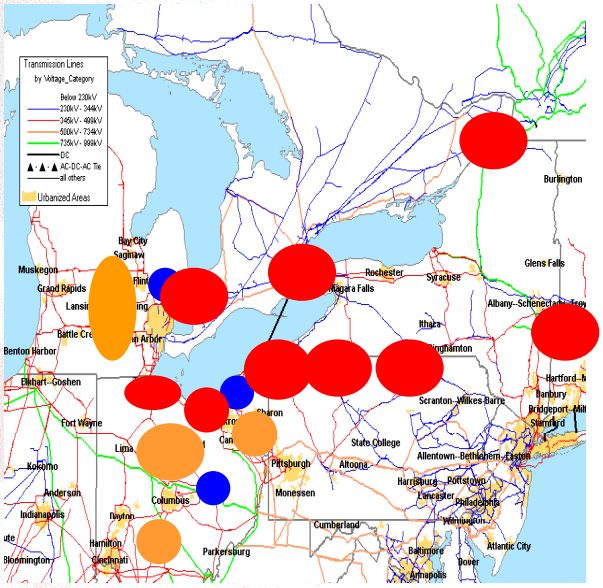
Information on the Blackout

Events Preceding the Blackout



Root cause not known, evaluation ongoing

Current analysis points to a series of line and plant outages (times in Eastern Daylight Time)

- Midday, 3 large power plants go down (Michigan, mid-Ohio, Cleveland)
- 2-3 PM 4 large (345 KV) transmission lines tripped
- Power swings noted in Canada and Eastern United States
- 4:10 many power plants and large transmission lines trip, mostly in Michigan and Ohio
- 4:11 cascade of trips sever New York east and west, PJM and New England separate

Grid operator (Midwest Independent System Operator) experienced significant communication problems during event

Note: Color coded dots depict approximate power line and power plant outage locations.
Source: GAO analysis of data provided by the Department of Energy and Platt's PowerMAP.

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Information on the Blackout

Largest Blackout in U.S. History

Note: Locations and boundaries are approximate.
Source: GAO analysis of information provided by the Department of Energy.

Significant electricity outage

- 8 states and 2 Canadian provinces
- 61,800 MW of demand
- 50 million customers (estimated)
- About 102 plants (22 nuclear plants)

Wide-ranging impacts

- Water systems shut down
- Raw sewage dumped
- Air and ground transportation halted
- Gas stations and refineries closed
- Cellular networks interrupted
- 911 communications interrupted
- Manufacturers shut down

Investigations underway

- US-Canadian team
- U.S. House—Energy and Commerce
- U.S. House—Homeland Security
- State government investigations

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Background

Electricity Sector

Vast infrastructure

- 3 major U.S. systems (East, West, and Texas)
- Vast network (~2,100 large power plants, ~150,000 miles of electricity lines)
- 4 key functions (generation, transmission, distribution, system operations)

Integrated and coordinated system

- Electricity must be produced and consumed at almost the same time
- A change in one area of the grid can affect other areas, almost instantaneously
- Infrastructure (such as power plants and transmission grid) has limited capacity
- Local and regional supply and demand must be balanced to avoid blackouts
- Overall demand increases about 2-3% per year, but can vary widely by region

Regulated sector

- Federally at FERC (wholesale sales, interstate transmission for "public utilities", generally excludes Alaska, Hawaii, and most of Texas)
- States through state commissions (retail sales, intrastate transmission)
- Some entities largely unregulated (cooperative, municipal, and other owner-serving entities)

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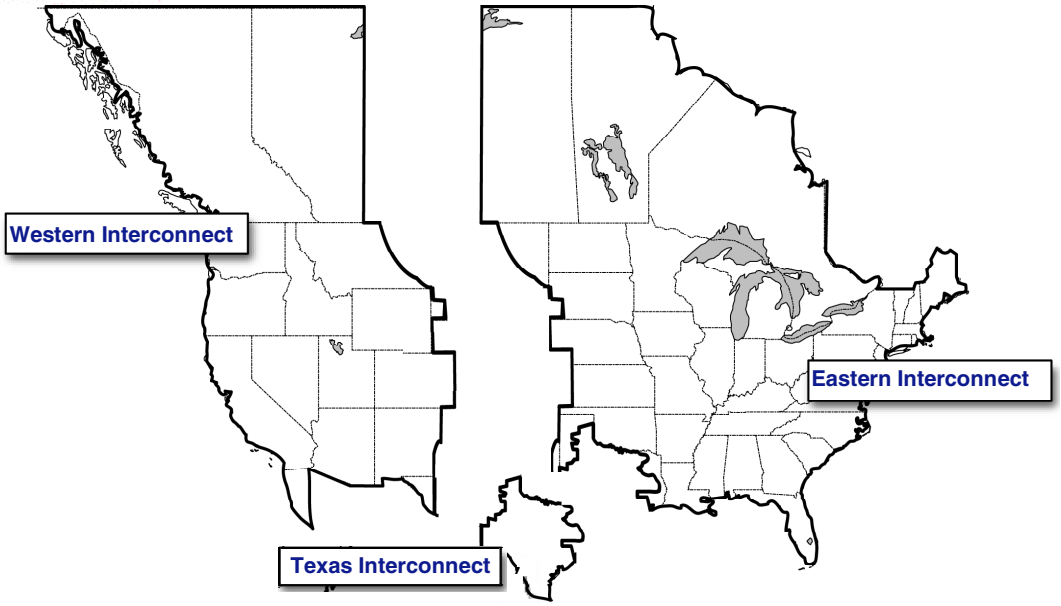
Background

Local Networks Became 3 Synchronized U.S. Systems



Source: North American Electric Reliability Council.

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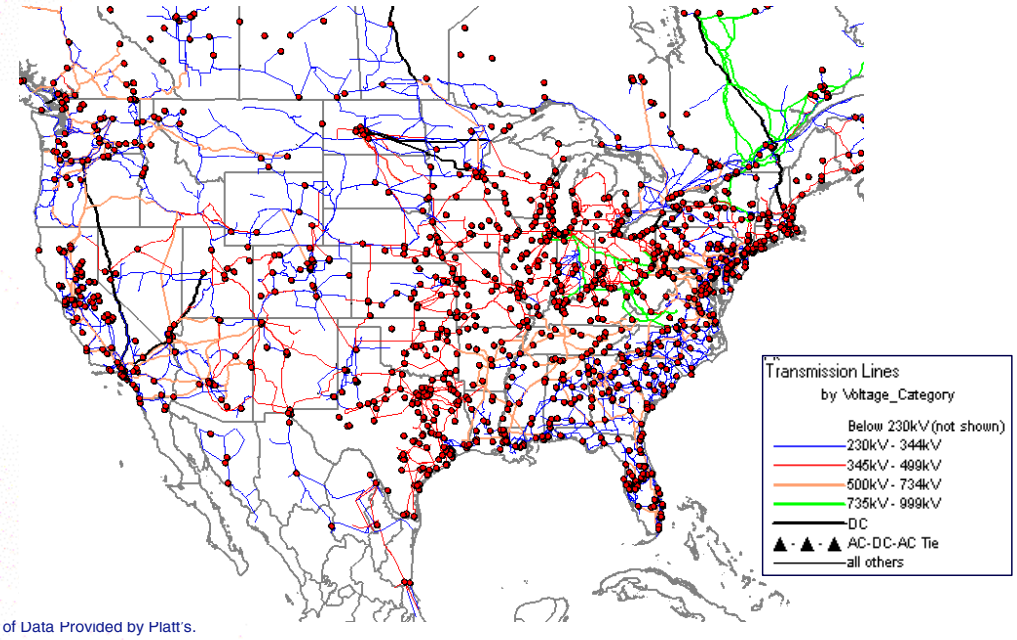
Background

Vast Network of Electricity Lines and Plants



Source: GAO Analysis of Data Provided by Platt's.

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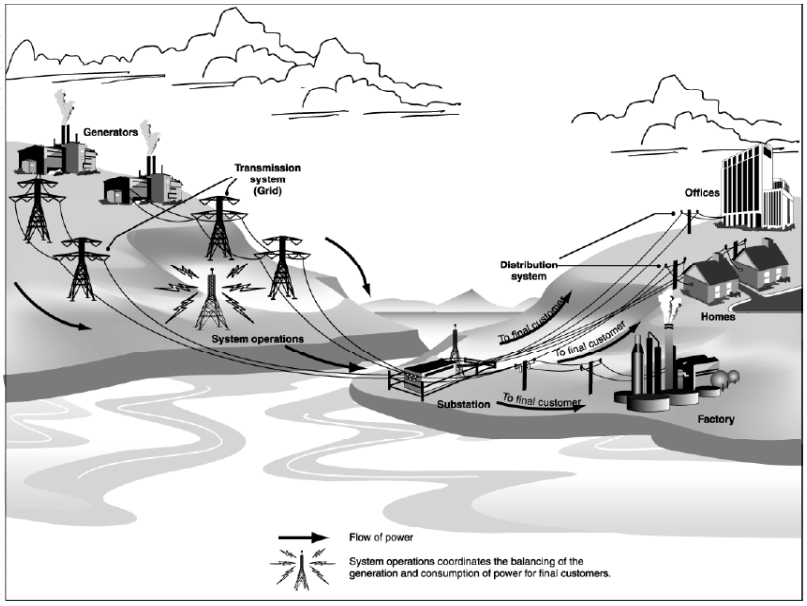
Background

Electricity Sector Has 4 Distinct Functions



Source: GAO.

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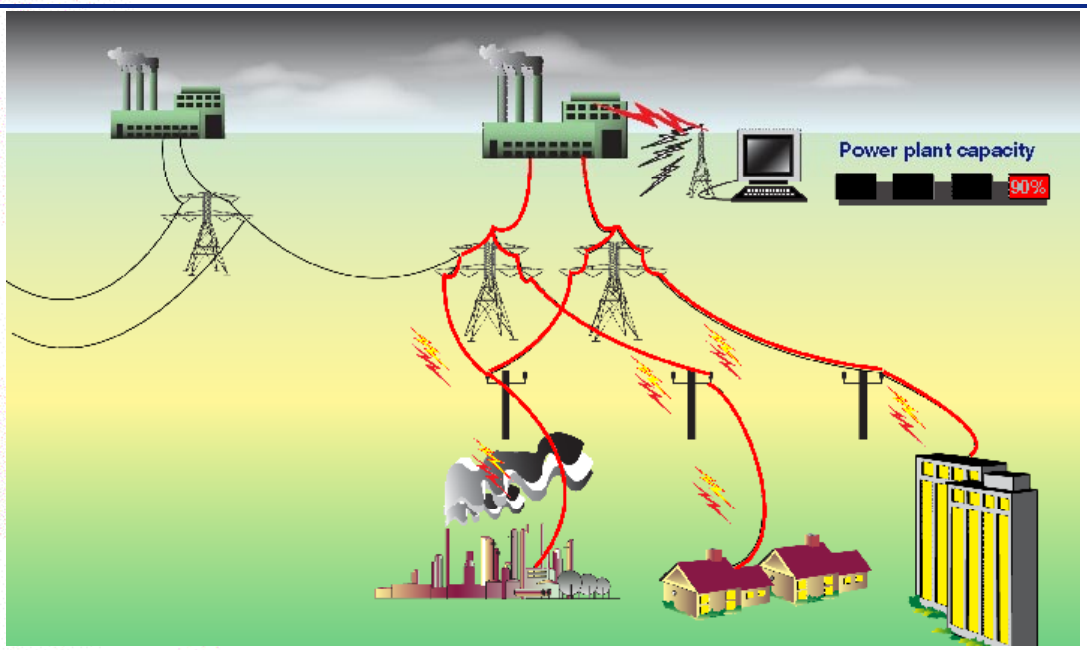
Background

System Must be Balanced Throughout Day



Source: GAO.

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Background

Restructuring Goal: Competition Leading to Benefits

Increase competition

- Increase numbers of buyers and sellers
- Provide information to enable consumers to make choices
- Enable sellers to enter and exit market in response to information

Provide benefits to consumers

- Lower prices
- Access to new services
- Increased efficiency
- More innovation

Maintain or enhance reliability

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Background

Electricity Restructuring Is Changing the Sector

Businesses shifted from emphasizing regulation to emphasizing markets

- Opened generation to competition, 3 other functions remain regulated
- Companies now bear risks previously borne by ratepayers

Physically, opened access to transmission lines to utilities and new entrants

- As a result, multiple entities now interact to perform the key functions needed to deliver electricity to consumers

Regulators shift away from planning system and setting rates

- FERC is shifting from setting rates (reactive) to designing and monitoring markets in real-time (proactive)
- States are moving away from central role in planning and rate setting to leaving private entities to determine what to build and what to charge

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Themes from Prior GAO Work

GAO Work Focused Around Three Key Areas

Electricity markets developing, but challenges remain

Regulatory oversight needs more attention

Security of critical infrastructure increasingly important

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Themes from Prior GAO Work

Electricity Markets Developing, but Challenges Remain

- Adequate infrastructure essential for reliability and competitive prices
- Grid becoming more regional, but key authorities remain with states and localities
- Little understanding of options during market events or emergencies
- Uncertainties limit investment in new infrastructure

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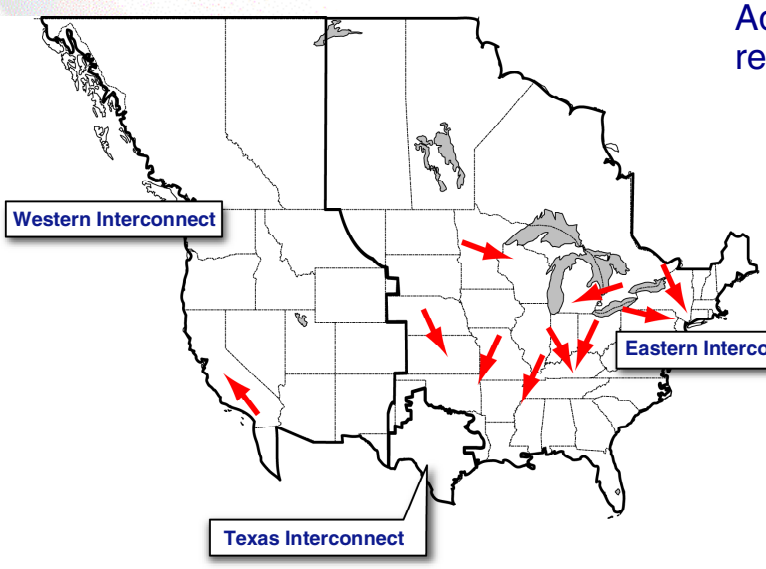
Themes from Prior GAO Work

Electricity Markets Developing, but Challenges Remain



Adequate infrastructure essential for reliability and competitive prices

- Growing electricity demand places pressure on grid and supply sources
- Restructuring increases use of the grid
- Numerous parts of U.S. witnessing increasing congestion of transmission system

Note: Arrows in this illustration show the location and direction of current transmission congestion.
Source: North American Electric Reliability Council.

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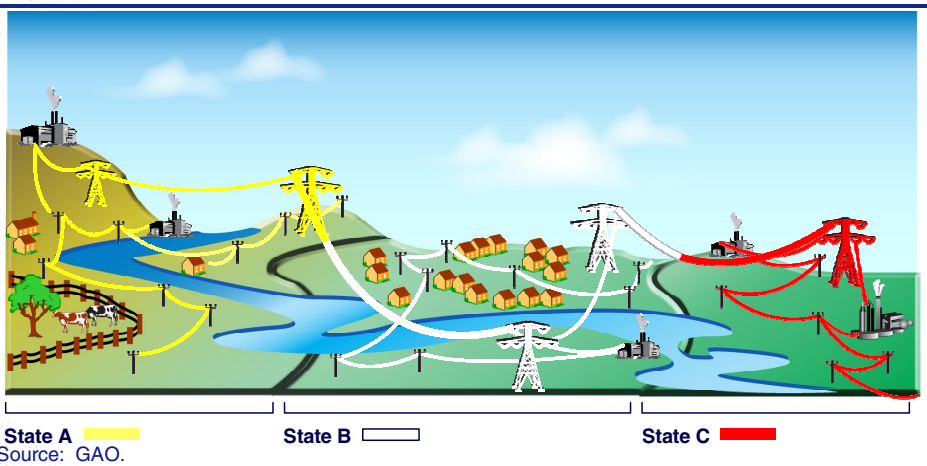
Themes from Prior GAO Work

Electricity Markets Developing, but Challenges Remain



Source: GAO.

Grid becoming more regional, but authorities remain with states and localities

- Infrastructure serves regional needs
- Increasingly, problems in one state affect neighboring states
- Authority to add new infrastructure remains with states

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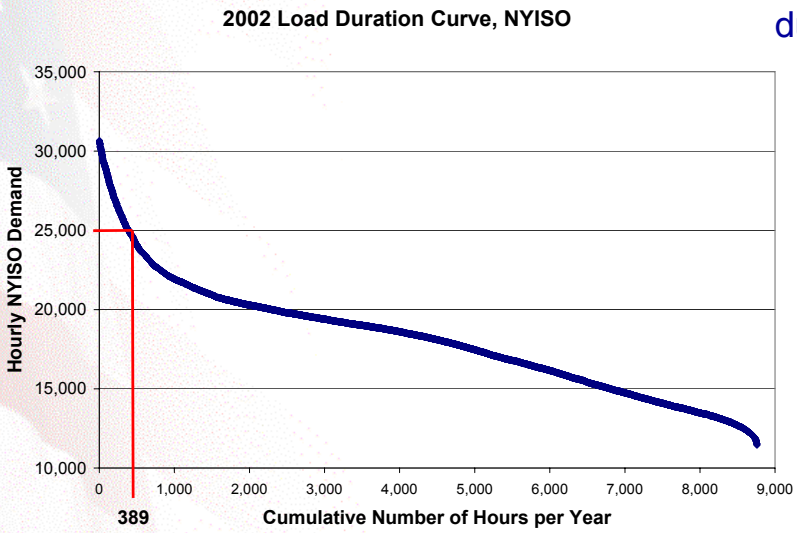
Themes from Prior GAO Work

Electricity Markets Developing, but Challenges Remain



Source: GAO analysis of New York Independent System Operator data.

Little understanding of options during times of shortage or crisis

- Highest levels of demand only reached during a small percentage of the hours of the year
  - For example, the New York ISO exceeds 25,000 MW during <5% of hours
- Consumer response to scarcity, such as when wholesale prices rise, is missing due to lack of information and incentives
- Backup generation not inventoried, limits on use
- Use of emergency power generally involves environmental and other challenges

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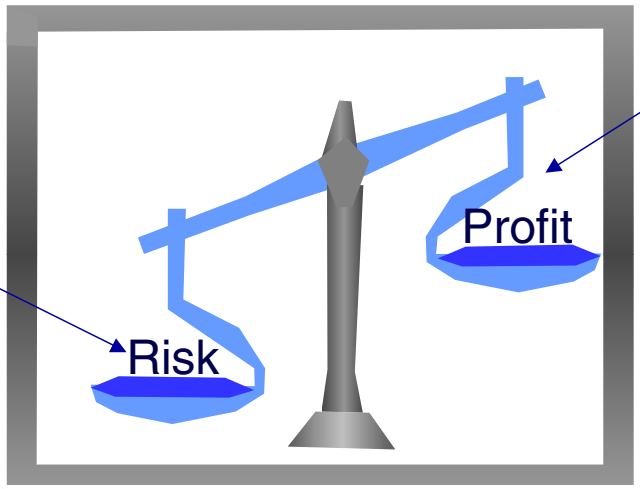
Themes from Prior GAO Work

Electricity Markets Developing, but Challenges Remain

Attracting private investment requires balancing risk and profits

- Market
- Business
- Environmental regulation
- 9/11, terrorism
- Enron, investment
- Federal regulation
- State regulation



- Market prices v. costs
- Higher cost of capital
- Shorter recovery periods

Source: GAO.

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Themes from Prior GAO Work

Regulatory Oversight Needs More Attention

Monitoring of reliability inadequate
Limited jurisdiction and varied rules hinder market development
FERC faces challenges in market oversight

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Themes from Prior GAO Work

Regulatory Oversight Needs More Attention

Monitoring of reliability inadequate

	FERC	States	NERC
Monitoring Authority	Transmission Wholesale Markets	Distribution Retail Markets	**None** (Voluntary Membership)
Reliability Monitoring	**None**	Varies (23 of 40 states*)	Nationally (Voluntary Compliance)

*National Regulatory Research Institute

Source: GAO.

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Themes from Prior GAO Work

Regulatory Oversight Needs More Attention

Limited jurisdiction and varied rules hinder market development

- FERC lacks jurisdiction over some entities resulting in patchwork of restructured and regulated wholesale markets
- Varied wholesale market rules may limit development of a competitive market
- Limited implementation of retail restructuring may limit development of wholesale markets
- FERC protects consumers through its oversight of wholesale markets and through its oversight of fair access to transmission lines

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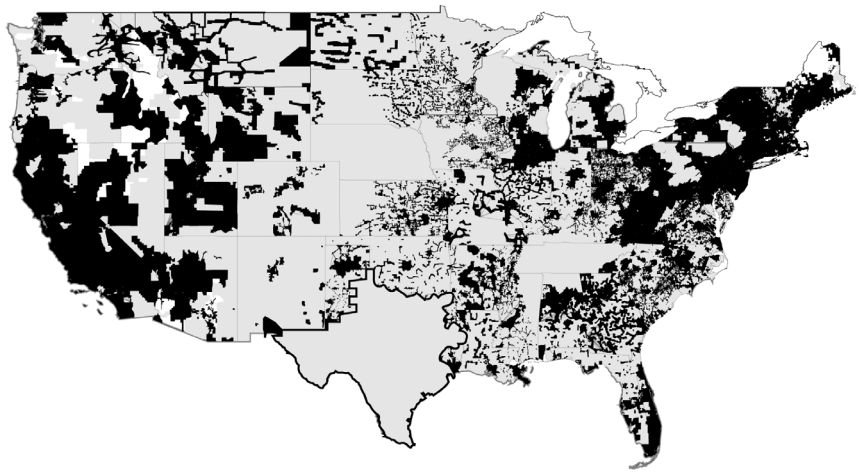
Divided Jurisdiction

FERC Lacks Jurisdiction Over Some Entities



Source: GAO analysis of PowerMap data provided by Platt's/RDI.

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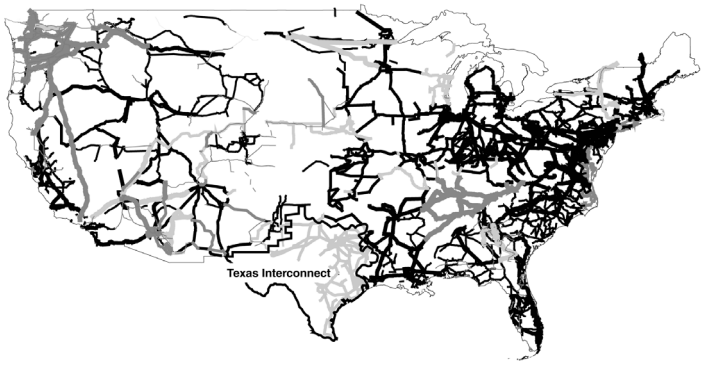
Divided Jurisdiction

FERC Lacks Jurisdiction Over Some Entities (cont.)



Source: GAO analysis of PowerMap data provided by Platt's/RDI.

Notes: Data for transmission lines reflect primary ownership--some lines have multiple owners.

Federal entities include the Bonneville Power Administration, the Tennessee Valley Authority, the Western Area Power Administration, and others."

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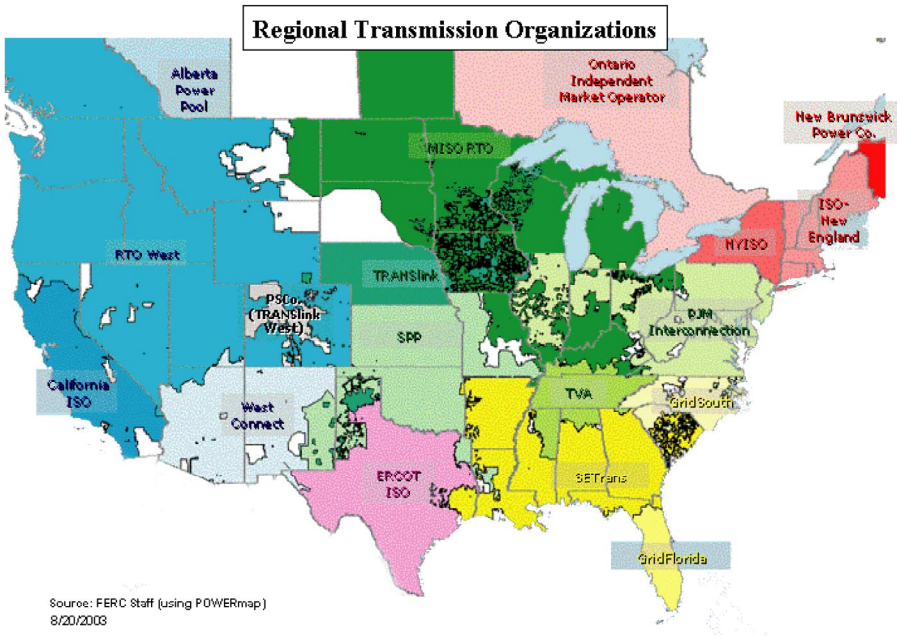
Divided Jurisdiction

Varied Wholesale Market Rules



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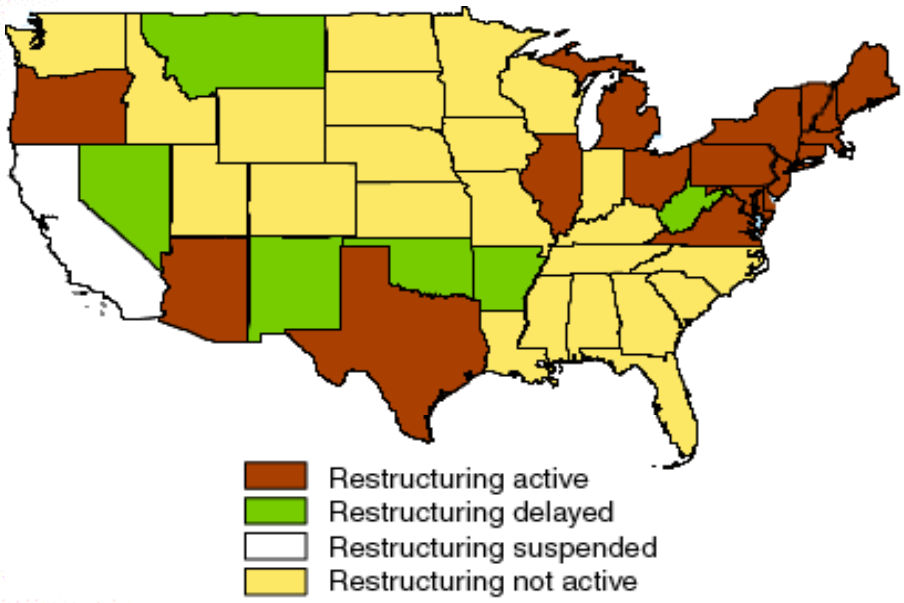
Divided Jurisdiction

Limited Implementation of Retail Restructuring



Source: GAO Analysis of Energy Information Administration data.

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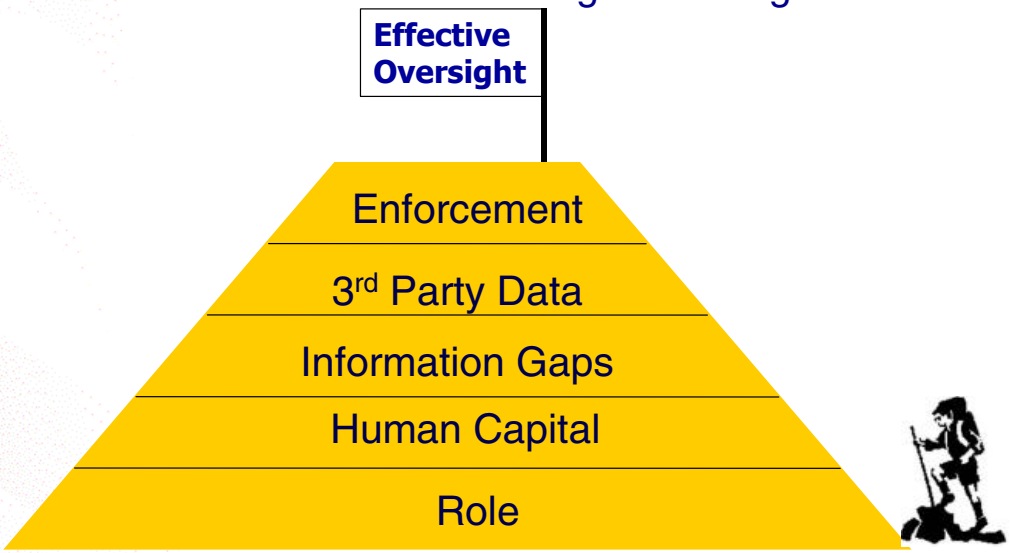
Themes from Prior GAO Work

Regulatory Oversight Needs More Attention

FERC faces market oversight challenges



Source: GAO.

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Themes from Prior GAO Work

Security of Critical Infrastructure Increasingly Important

- Embedding homeland security principles as integral part of investment in infrastructure and business processes is important
- Increasing reliance on information technology requires attention to cyber-security

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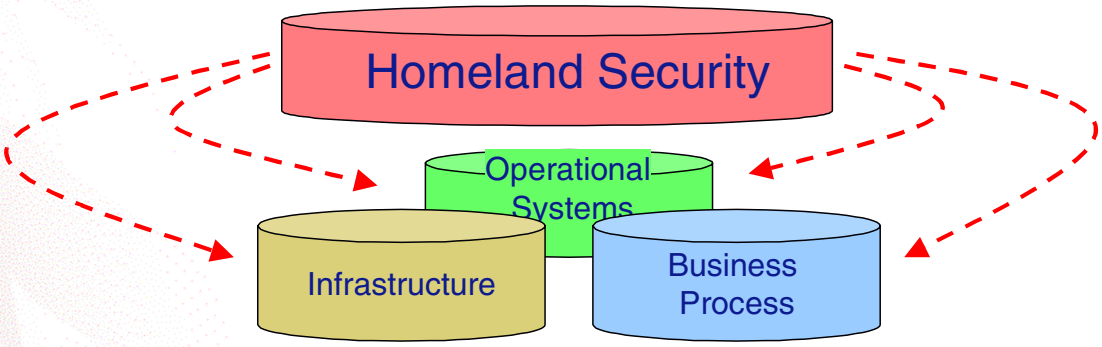
Themes from Prior GAO Work

Security of Critical Infrastructure Increasingly Important

Embedding homeland security principles as integral part of investment in infrastructure and business processes is important

- Designing it in up-front [most cost-effective]
- Not bolting it on afterwards [potential conflicts between security and efficiency]



Source: GAO.

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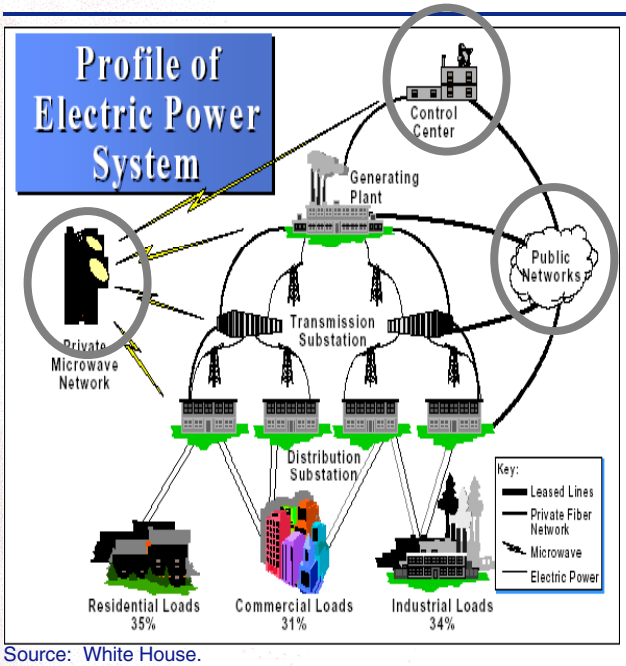
Themes from Prior GAO Work

Security of Critical Infrastructure Increasingly Important



Source: White House.

Increasing reliance on information technology requires attention to cyber-security

- SCADA/control systems perform vital functions in electric power and other industries
- SCADA/control systems and networks are potentially vulnerable to attack, by terrorists or others
- Electricity sector making progress in implementing critical infrastructure protection (CIP) measures

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Potential Options

Issues Needing Resolution and Options to Address Them

Energy markets developing, but challenges remain

- Minimal consumer responsiveness to market
- Lack of "backstop authority" for transmission siting
- Divided regulatory authority
- Lack of uniformity in market rules
- Uncertainty about future of restructuring
- Uncertainty over how to pay for transmission upgrades

Oversight and monitoring needs more attention

- Lack of enforceable reliability rules (NERC or federal reliability organization)
- Limited access to needed reliability and market data for regulators

Security of increasing importance

- Limited incentives for participation in federal critical infrastructure protection activities
- Homeland security concerns not fully considered
- Weaknesses in cybersecurity

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Potential Options for Improving Consumer Responsiveness to Market

Issue—Minimal consumer responsiveness limits the development of markets and reduces reliability

- Infrastructure limited, resulting in scarcity during periods of high demand
- Consumers generally do not respond to this scarcity
- Lack of response increases costs, raises price volatility, and reduces reliability

What FERC has done

- In its standard market design, FERC has proposed to introduce one type of demand response

What GAO has done

- Identified that the lack of demand response limits the benefits of restructuring
- Examining the issue of demand response, release expected 2004

Options for congressional action

- Encourage the use of demand response tools in retail markets
- Promote the development of metering needed to implement demand response
- Educate utilities and consumers about the benefits of demand response

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Potential Options for Providing "Backstop Authority"

Issue—Transmission serves regional needs and is essential to reliability, but varied approaches present challenges for upgrading system

- Reliability and markets depend on adequate infrastructure
- States and localities have regulatory authority over siting plants and lines
- Varied approaches to siting can result in contentious, uncertain, and time-consuming efforts to add infrastructure
- Uncertainty and delays may reduce investment in new infrastructure

What GAO has done

- Described FERC authorities for natural gas pipelines
- Described Colorado backstop statute for transmission lines

Options for congressional action

- Consider empowering regional entity to resolve disputes
- Consider FERC backstop authority (ability to grant eminent domain) if companies and states cannot reach agreement

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Potential Options Addressing Divided Regulatory Authority

Issue—Divided regulatory authority limits development of market and reliability of the system

- Entire network interconnected—points on grid separated by milliseconds
- Lack of coordination between the development of wholesale and retail markets limits the potential benefits
- A patchwork of rules now governs electricity markets
  - Only about 75% of the wholesale market subject to FERC's authority
  - Varied state approaches to regulating/restructuring retail markets
- Lack of consistency limits trade and slows development of competition

What FERC has done

- FERC seeking consensus through outreach with states and regions

Options for congressional action

- Clarify FERC's authority over all wholesale markets and transmission lines
- Determine if FERC should oversee some aspects of retail markets
- Explore how to better link wholesale and retail markets

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Potential Options for Enhancing Uniformity of Market Rules

Issue—Lack of uniformity in market rules limits development of market and places reliability at risk

- FERC has approved different sets of market rules for different areas
- Presence of different rules limits trade, and the development of competition
- Presence of different rules makes investment in new infrastructure more risky

What FERC has done

- In 2002, FERC proposed standard market design that would make all FERC jurisdictional wholesale markets operate under a single set of rules

Option for congressional action

- Make market rules regional and move toward standardization—markets cannot solve this problem

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Potential Options for Reducing Uncertainty About Restructuring

Issue—Lingering uncertainty over the future of restructuring is limiting needed investment and raises costs to consumers/investors

- Long-standing federal debate over future of restructuring creates uncertainty
- Actions on state restructuring of retail markets vary and the future is uncertain
- Uncertainty limits and/or delays investment and raises costs

What FERC has done

- Issued orders restructuring wholesale markets and proposals outlining plans

What GAO has recommended

- FERC should report on the performance of restructured electricity markets, collecting data needed to evaluate both wholesale and retail elements
- FERC should report annually to Congress to identify emerging issues and impediments to reaching goal of achieving competitive wholesale markets

Options for congressional action

- Reduce uncertainty about restructuring's future—identify milestones or timeline
- Increase incentives for investment

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Potential Options for Determining How to Pay for Transmission Upgrades

Issue—Transmission upgrades vital for reliability and market development, but determining who should pay is difficult

- Transmission serves regional needs and promotes reliability
- Electricity often crosses jurisdictions and travels varied paths
- Determining who benefits and who should pay for additions is difficult
- New lines needed; infrastructure old and congestion increasing
- Private investment faces significant hurdles

What GAO has recommended

- FERC should standardize interconnection agreements to reduce uncertainty
- FERC should clarify how costs of transmission upgrades associated with interconnection should be allocated

Options for congressional action

- Increase regulated rate of return for investments in transmission
- Consider providing additional incentives, such as direct tax incentives or accelerated depreciation

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Potential Options for Enhancing Reliability Rules

Issue—Voluntary nature of NERC membership and provision of data leaves gaps in information and threatens reliability

- Many new electricity producers not members in NERC and do not provide comprehensive operations data to it
- Nonmembers are not required to follow NERC guidelines for maintaining reliability

Options for congressional action

- Require mandatory compliance with NERC reliability guidelines
- Consider the creation of a new federal reliability organization

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Potential Options for Improving Regulator Access to Needed Data

Issue—Restructuring changes what types of information regulators need

- FERC has shifted from approving cost-based rates to monitoring market performance
- FERC needs greater access to real-time market data to assess market performance and to identify abuses of market power
- FERC needs data on the operation of power plants to monitor reliability as well as assess performance of markets

What GAO has recommended

- FERC should demonstrate what additional information it needs
- FERC should describe the limitations it faces without having adequate information
- FERC should ask the Congress for authority to collect the information that it needs

Options for congressional action

- Give FERC authority to collect, or have access to, needed market data
- Give FERC access to reliability data

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Previous GAO Recommendations Related to CIP Participation Incentives

Issue—Participation in federal CIP efforts critical

- Federal policy encouraged voluntary industry participation in critical infrastructure protection (CIP) activities, including operation of industry information sharing and analysis centers (ISAC's) and tasked lead agencies to assess the need for incentives for industry participation

What has been done

- Industry progress reported in fulfilling suggested ISAC activities
  - Establishing baseline statistics and patterns
  - Serving as clearinghouse within/among various sectors
  - Providing a library of historical data for private sector and government

What GAO has recommended

- DOE to assess the need for public policy tools (e.g., regulation, grants, tax incentives) to encourage increased industry CIP activities
- Identify additional actions needed to improve the quality and quantity of information being provided by the ISACs,

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Potential Options for Addressing Homeland Security Concerns

Issue—Changing security threat

- Post-9/11
- Who's in charge and who pays?
- Measures to improve resiliency, redundancy, remote monitoring, fail-safe and restoration capabilities promote both greater efficiency as well as security

Options for congressional action

- Consider homeland security as integral and compatible to improving safety and reliability of systems when making investment decisions and designing improvements
- Consider distributed power sources, diversity in energy sources, improved conservation measures and remote sensing as ways to enhance both system safety as well as counter terrorist threats

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Potential Option for Addressing Cybersecurity Weaknesses

Issue—Electricity sector faces increasing cyber threats

- Supervisory control and data acquisition (SCADA)/ control systems, critical to the electric industry, may not have adequate security
- Cyber attacks against these systems could be used to cause damage or complicate the response to a physical attack

What has been done

- A number of federal and private-sector efforts are underway to study cybersecurity issues
  - Including developing standards and performing research and development

Options for congressional action

- Increase focus on research and development and related efforts to address cybersecurity issues

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Prior Relevant GAO Work

Natural Resources and Environment Team

- *Bonneville Power Administration: Long-Term Fiscal Challenges,* GAO-03-918R
- *Energy Markets: Additional Actions Would Help Ensure That FERC's Oversight and Enforcement Capability Is Comprehensive and Systematic.* GAO-03-845
- *Electricity Markets: FERC's Role in Protecting Consumers,* GAO-03-726R
- *Electricity Restructuring: Action Needed to Address Emerging Gaps in Federal Information Collection,* GAO-03-586
- *Lessons Learned From Electricity Restructuring:Transition To Competitive Markets Underway, but Full Benefits Will Take Time and Effort To Achieve,* GAO-03-271
- *Restructured Electricity Markets: California Market Design Enabled Exercise of Market Power*, GAO-02-828
- *Energy Markets: Concerted Actions Needed by FERC to Confront Challenges That Impede Effective Oversight*, GAO-02-656
- *Restructured Electricity Markets: Three States' Experiences in Adding Generating Capacity*, GAO-02-427
- *California Electricity Market Options for 2001: Military Generation and Private Backup Possibilities,* GAO-01-865R
- *Energy Markets: Results of Studies Assessing High Electricity Prices in California,* GAO-01-857

Information Technology Team

- *Critical Infrastructure Protection: Challenges for Selected Agencies and Industry Sectors,* GAO-03-233
- *Information Security: Progress Made, But Challenges Remain to Protect Federal Systems and the Nation's Critical Infrastructures.* GAO-03-564T
- *High Risk Series: Protecting Information Systems Supporting the Federal Government and the Nation's Critical Infrastructures,* GAO-03-121
- *Combating Terrorism: Selected Challenges and Related Recommendations,* GAO-01-822

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