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United States Government Accountability Office
Washington, DC 20548

February 1, 2008

Congressional Addressees

Subject: *Transmission Lines: Issues Associated with High-Voltage Direct-Current Transmission Lines along Transportation Rights of Way*

Electricity is central to the national economy and the daily lives of many Americans, powering homes, businesses, and industries. Today, an extensive system consisting of more than 150,000 miles of high-voltage transmission lines[1] works to provide reliable electricity service and transport electricity from power plants to consumers. Federal and state entities share responsibility for regulating the electricity system. On the federal level, the Federal Energy Regulatory Commission (FERC) regulates interstate transmission of electricity and wholesale rates, among other regulatory activities. State public utility commissions are generally responsible for regulating retail electricity sales and, in some cases, planning for new power plants and transmission lines.

However, as studies have shown, growth in electricity demand has strained the nation's transmission system, resulting in less flexibility to respond to system problems and an increased risk of potential blackouts.[2] These issues have led some to suggest that new lines or other investments in the transmission system may be required to increase capacity and accommodate growing electricity demand. Several companies have recently introduced proposals to build new high-voltage direct-current (HVDC) transmission lines.[3] Some of these proposed lines would follow active transportation rights of way, such as railroads, highways, and pipelines. Some stakeholders have raised concerns about the potential economic, safety, and security issues related to collocating new HVDC transmission lines along transportation rights of way, particularly for nearby residents and consumers of electric power.

Given these issues, Congress included a provision in the Implementing Recommendations of the 9/11 Commission Act of 2007 requiring us to assess the siting of HVDC transmission lines along active railroad and other transportation rights of way[4] and report to

[1]High-voltage transmission lines carry currents of usually 230 kilovolts or greater.
[2]See U.S. Department of Energy, *National Transmission Grid Study* (May 2002) pp. 5-6; Congressional Research Service, *Electric Transmission: Approaches for Energizing a Sagging Economy* (Apr. 27, 2007) pp. 1-2; and National Council on Electricity Policy, *Electricity Transmission: A Primer* (June 2004) pp. 6-7.
[3]DC technology is defined as current that flows in one direction through a circuit and requires operator intervention to reverse the direction. The majority (98 percent) of all transmission line miles in North America use alternating current (AC) technology, whereby the current reverses direction at regular intervals without operator intervention. DC can be converted into AC, and vice versa, using a converter station.
[4]Pub. L. No. 110-53, § 1525 (Aug. 3, 2007).

appropriate congressional committees. In response to this requirement and after discussions with the committees, we examined (1) the role of the federal government in siting HVDC electric transmission lines along active transportation rights of way, (2) advantages and disadvantages of adding transmission lines and using HVDC technology, and (3) benefits and risks associated with the siting of HVDC electric transmission lines along active transportation rights of way.

To determine the federal government's role in siting HVDC electric transmission lines along active transportation rights of way, we reviewed applicable laws, regulations, and guidance related to siting new transmission infrastructure, including the Energy Policy Act of 2005, the Federal Land Policy and Management Act, and FERC guidance. To identify the advantages and disadvantages of adding transmission lines and using HVDC technology, we reviewed relevant reports and studies, and we interviewed officials from the Departments of Energy, Homeland Security, and Transportation; officials from FERC, state public utility commissions, and state departments of transportation; and representatives from several other stakeholders, including electricity industry associations and independent system operators. To identify the benefits and risks of siting HVDC transmission lines along transportation rights of way, we reviewed literature to identify frequently cited benefits and risks of siting new HVDC electric transmission lines along active transportation rights of way for nearby residents and consumers of electric power. We also conducted site visits to three states—New York, Utah, and Virginia—where existing HVDC lines currently follow active railroad, highways, or pipelines, or where lines have been proposed that would do so. Finally, we interviewed officials from the Departments of Energy, Homeland Security, and Transportation; officials from FERC, state public utility commissions, and state departments of transportation; and representatives from a number of other stakeholders, such as power companies, transportation industry associations, and environmental and other advocacy groups to obtain their perspective on these issues. We focused our work on transmission line proximity to three types of transportation rights of way: railroads, highways, and pipelines. We conducted this performance audit from August 2007 to January 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. We briefed committee staff on the results of our review (see enclosure I for a copy of that briefing). This report formally conveys the information provided during that briefing.

Results in Brief

Historically, the federal government has had a limited role in siting transmission lines. It has generally only made siting decisions on federal lands. State governments, through public utility commissions and other agencies, traditionally approve transmission line siting. However, the Energy Policy Act of 2005 expanded the federal government's role. Specifically, under certain circumstances, FERC now has the authority to approve and issue siting permits for new transmission lines in areas designated by the Department of

Energy as National Interest Electric Transmission Corridors (NIETC).[5] However, some stakeholders have expressed concerns about FERC's expanded authority in the national corridors, including how the state siting process will be affected and whether states and the public will be involved in FERC's proceedings. FERC officials told us they expect the review of a transmission line proposal in the national corridors would have little impact on the states' existing process. FERC officials also told us that to the extent FERC receives applications, they expect to consider information from the state siting process as part of their federal proceeding and that states and the public will have opportunities to participate in and comment on the federal siting process. Currently, federal statutes as well as federal and state guidance encourage the collocation of new transmission lines along existing transportation and other rights of way. For example, FERC guidance for hydroelectric projects provides that existing transportation and other rights of way should be given priority as locations for additional transmission facilities. FERC may be able to apply the principles from this guidance to transmission lines in the NIETCs. The type of transmission technology—either HVDC or high voltage, alternating current (HVAC)—does not affect how federal or state siting decisions are made.

We identified potential advantages and disadvantages to adding transmission lines and using HVDC technology. According to studies we reviewed and stakeholders we interviewed, adding transmission lines offers potential advantages, including (1) decreased congestion and improved reliability of the electricity system by providing access to additional sources of generation and additional paths for electricity, (2) lower costs for consumers at the end of the line where electricity is received, (3) better utilization of existing power plants and more competitive local wholesale electricity markets, (4) facilitated development of new electricity sources location outside population centers, and (5) facilitated development of renewable energy sources. Stakeholders and studies also identified potential disadvantages of adding transmission lines, including (1) diminished economic or aesthetic values of the land if lines are built above ground, (2) raised electricity prices in areas from where the electricity is being taken, and (3) reduced incentives to identify alternatives that decrease demand (e.g., energy conservation). With respect to the potential advantages of using HVDC over HVAC technology, studies we reviewed and stakeholders we interviewed indicated that HVDC lines generally (1) cost less than HVAC over long distances and (2) allow operators of transmission systems to have more control over the direction and the amount of power flowing over HVDC lines. Potential disadvantages of using HVDC over HVAC technology include (1) higher costs for short-distance lines due to the cost of equipment needed to convert DC into AC electricity used by residents and (2) the lack of electricity benefits to consumers living along these lines—unless converter stations are installed at

[5]As required by the Energy Policy Act of 2005, the Department of Energy established NIETCs in October 2007, within which FERC now has the authority to approve siting of new transmission lines under certain circumstances; that is, if: (1) the state does not have authority to approve siting or consider what the interstate benefits might be; (2) the applicant does not qualify for state approval since it does not serve consumers in that state; or (3) the state entity with siting authority withholds approval for more than 1 year, or conditions its approval such that the project will not significantly reduce interstate transmission congestion or is not economically feasible. See Pub. L. No. 109-58 § 1221(a) (Aug. 8, 2005). FERC issued rules specifying requirements for permit applications. See FERC Order No. 689, Regulations for Filing Applications for Permits to Site Interstate Electric Transmission Facilities. The Department of Energy is reviewing the applications for rehearing of its order designating the two NIETCs.

intermediate locations—because such lines are generally not connected to local electricity lines.

We also identified potential benefits and risks resulting from the collocation of transmission lines along transportation rights of way. According to studies we reviewed and stakeholders we interviewed, potential benefits of collocation may include ease of construction and maintenance of the transmission lines and the reduction of environmental and visual impacts. For example, electricity stakeholders told us that building along rights of way may avoid constructing lines in undisturbed lands. In addition, stakeholders told us that it may be less costly to acquire the right to add a new transmission line to an existing right-of-way from a single owner—such as a pipeline, highway, or railroad—than it would be to acquire the needed rights from multiple property owners. Potential risks of collocation may include the increased likelihood of safety and security incidents due to the proximity of the transmission lines and the transportation infrastructure. For example, train derailments or highway crashes potentially could damage transmission lines and fallen transmission lines could damage transportation infrastructure. In addition, a collocated transmission line and natural gas line may be a more desirable terrorist target than either facility on its own. Federal and state officials told us they have not conducted studies specifically on these risks, but they expect the probability of these occurrences to be low. Several infrastructure owners and other stakeholders that we interviewed said that steps, such as adhering to required clearance distances for infrastructure maintenance and conducting risk assessments, can be taken to mitigate the potential risks associated with collocation.

Agency Comments and Our Evaluation

We provided the Departments of Energy, Homeland Security, and Transportation, and FERC a draft of this report, including the slides, for review and comment. The Departments of Energy, Homeland Security, and Transportation, and FERC provided technical clarifications, which we incorporated as appropriate.

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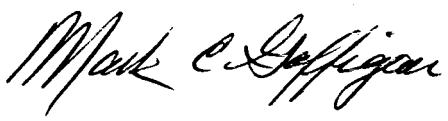
We are sending copies of this report to the Secretaries of Energy, Homeland Security, and Transportation, the Commissioners of FERC, and other interested parties. We will also make copies available to others upon request. In addition, this report will be available at no charge on the GAO Web site at http:// www.gao.gov.

Should you or your staffs have any questions on matters discussed in this report, please contact Mr. Mark Gaffigan at (202) 512-3841 or Mr. David Wise at (202) 512-2834. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in enclosure II.



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Enclosures

The Honorable Daniel K. Inouye
Chairman
The Honorable Ted Stevens
Vice Chairman
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Joseph I. Lieberman
Chairman
The Honorable Susan M. Collins
Ranking Member
Committee on Homeland Security and Governmental Affairs
United States Senate

The Honorable Bennie G. Thompson
Chairman
The Honorable Peter T. King
Ranking Member
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United States House of Representatives

The Honorable James L. Oberstar
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The Honorable John L. Mica
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United States House of Representatives

The Honorable Michael A. Arcuri
United States House of Representatives

Briefing to Congressional Addressees

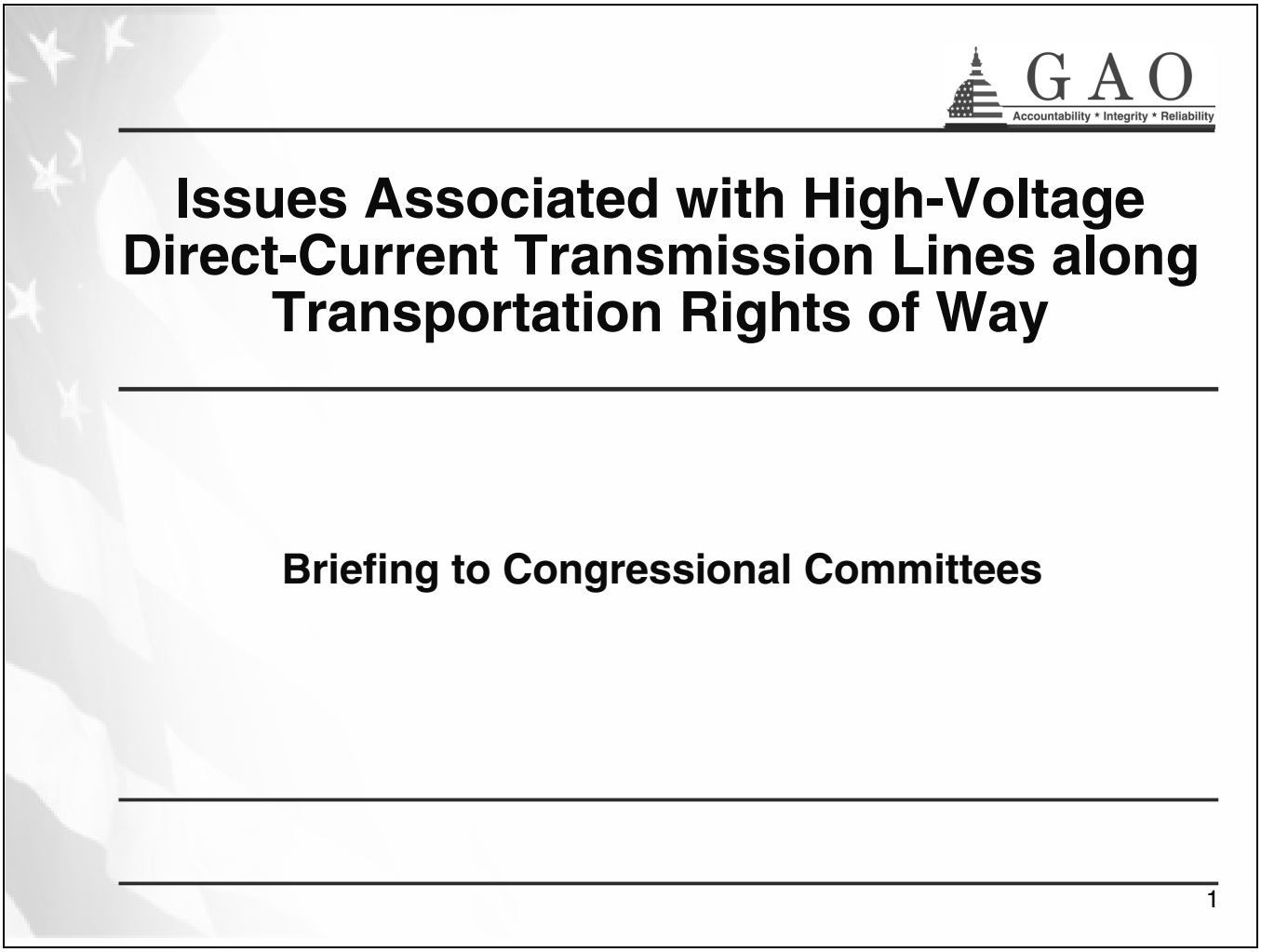

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Figure 1: HVDC Transmission Line along Utah State Highway 174

Source: GAO.

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Objectives

- The Implementing Recommendations of the 9/11 Commission Act of 2007 required GAO to assess the siting of high-voltage direct-current (HVDC) electric transmission lines along active railroad and other transportation rights of way (ROW).

- To meet this requirement and address the interests of committee staff, we examined the following objectives:
  - What is the role of the federal government in siting HVDC electric transmission lines along active transportation ROW?
  - What are the advantages and disadvantages of adding transmission lines and using HVDC technology?
  - What are benefits and risks associated with the siting of HVDC electric transmission lines along active transportation ROW?

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Scope and Methodology

- To answer the objectives, we:
  - reviewed applicable laws, regulations, and guidance to determine the federal government's role in the siting of HVDC electric transmission lines along active transportation ROW;
  - interviewed federal and state officials as well as representatives from other stakeholders, such as electricity industry groups and independent system operators, and reviewed reports and studies to identify the advantages and disadvantages of adding transmission lines and using HVDC technology; and
  - conducted site visits and reviewed literature to understand the benefits and risks of siting HVDC electric transmission lines along existing transportation ROW for nearby residents and consumers of electric power.

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Scope and Methodology (cont'd)

- We focused our work on transmission line proximity to three types of transportation ROW: railroads, highways, and pipelines.
- For our site visits, we selected three states—New York, Utah, and Virginia—where existing HVDC lines currently follow active railroad, highways, or pipelines, or where lines have been proposed that would do so.
- Our findings represent the views of studies we reviewed and stakeholders we interviewed.
- We conducted our work from August 2007 through January 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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Summary

- In most cases, the federal government has a limited role in siting transmission lines:
  - State governments traditionally approve transmission line siting through public utility commissions and other agencies.
  - The Energy Policy Act of 2005 expanded the Federal Energy Regulatory Commission's (FERC) federal role in siting transmission lines, under certain circumstances, within the National Interest Electric Transmission Corridors (NIETC).
  - Some stakeholders have expressed concerns about FERC's expanded authority to site transmission lines, including how states and the public will be involved in the siting process.
  - Federal statues as well as federal and state guidance encourage collocation of new transmission lines along existing transportation ROW.

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Summary

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Summary (cont'd)

- Potential advantages and disadvantages to adding transmission lines and using HVDC technology include:
  - Advantages of adding HVDC or high-voltage alternating-current (HVAC) transmission lines include decreased congestion and lowered costs to consumers; disadvantages include diminished land value if the lines are built above ground and reduced incentives to identify alternatives that decrease demand (e.g., energy conservation)
  - Advantages to using HVDC technology include lower costs over long distances and more system control; disadvantages include a lack of electricity benefits to those along its route and higher costs compared to construction of HVAC for short distances
- Potential benefits and risks of transmission lines along transportation ROW include:
  - Benefits: easier construction and maintenance, and reduced environmental and visual impacts
  - Risks: poses some safety and security risks; studies specifically on these risks have not been conducted, but probability of these occurrences expected to be low; several infrastructure owners and other stakeholders told us that steps can be taken to mitigate these risks

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Background

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HVDC Transmission Lines Are Uncommon in the United States

- Electricity can be transmitted either using alternating-current (AC) or direct-current (DC)
  - AC is an electric current that reverses its direction at regular intervals
  - DC is an electric current that flows in one direction through a circuit
    - DC requires operator intervention to reverse the direction
    - DC facilitates interconnection of AC at different frequencies
- The United States electric grid relies primarily on AC technology
  - There are five long-distance HVDC transmission lines
  - HVDC represents about 2 percent of all transmission line miles
- High-voltage transmission lines are usually 230 kilovolts (kV) or greater
- There are proposals to build additional long-distance HVDC lines in New York and Virginia, among others

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Background

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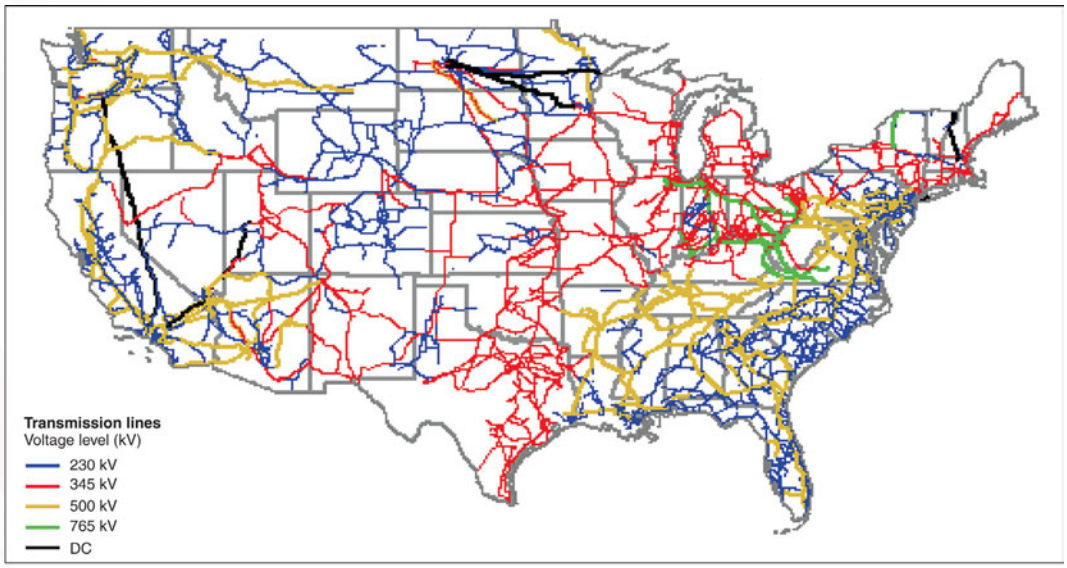
Figure 1: Map of Total AC and DC High Voltage Transmission Lines (≥230kV) in the United States



Source: Federal Energy Regulatory Commission, created using Global Energy's Energy Velocity Suite.

Note: The 230, 345, 500, and 765 kV lines listed are all alternating current lines.

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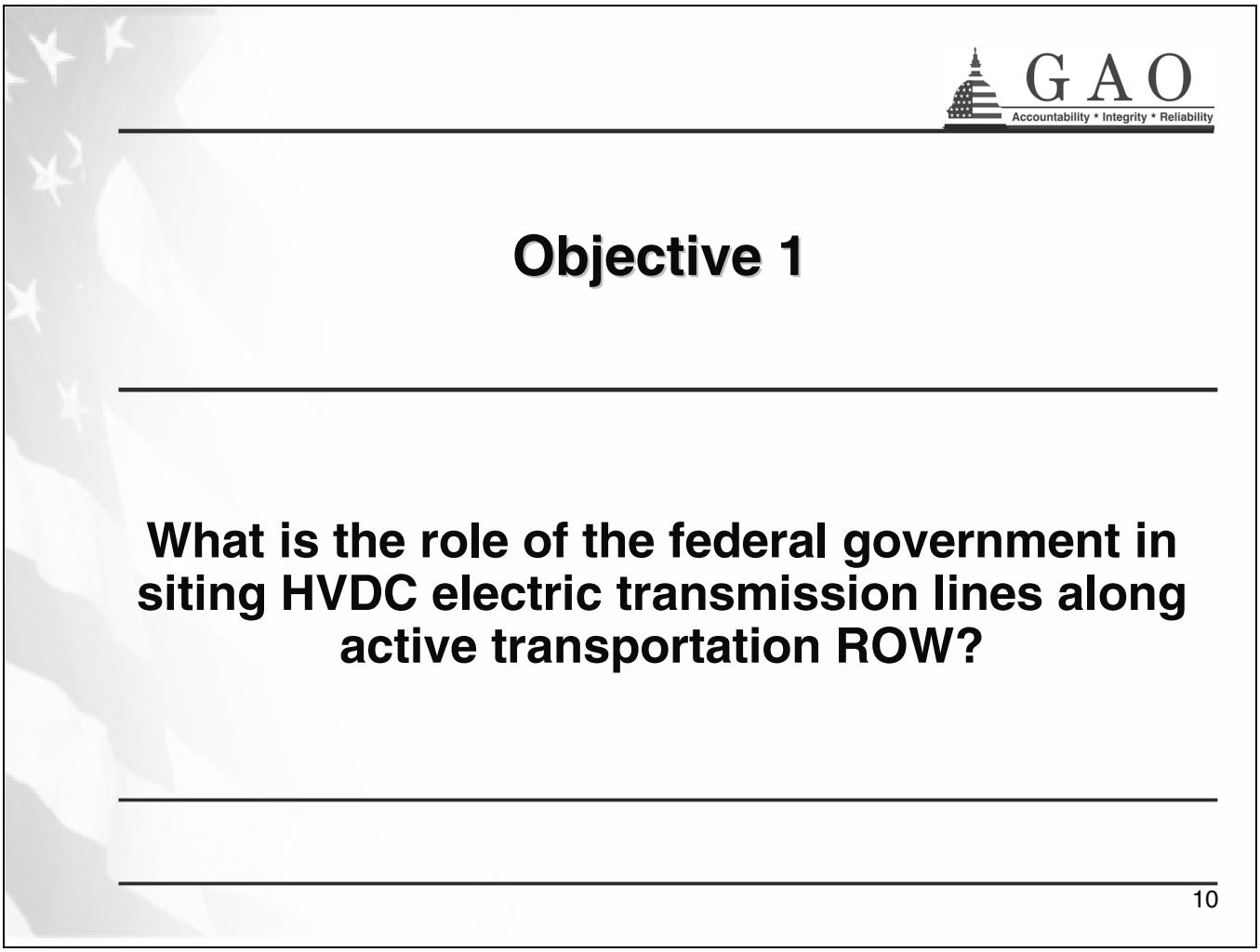
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Objective 1
What is the role of the federal government in siting HVDC electric transmission lines along active transportation ROW?
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Federal Role

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Historically, the Federal Government Has Had a Limited Role in Siting Transmission Lines

- Generally, the federal government only makes siting decisions on federal lands.
- State electricity agencies—such as the Public Utility Commission—traditionally approve transmission line siting within their respective states.
- The type of transmission technology—either HVDC or HVAC—does not typically affect how siting decisions are made.

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Federal Role

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Federal Government's Role in Siting Transmission Lines Has Recently Changed

- The Energy Policy Act of 2005 provided additional federal siting authority:
  - The Department of Energy designated two NIETCs in October 2007.
  - Within the NIETCs, FERC now has the authority to approve siting of new transmission lines under certain limited circumstances; that is, if:
    - The State does not have authority to approve siting or consider what the interstate benefits might be;
    - The applicant does not qualify for state approval since it does not serve consumers in that state; or
    - The state entity with siting authority withholds approval for more than one year or conditions its approval such that the project will not significantly reduce interstate transmission congestion or is not economically feasible.
- FERC issued rules specifying requirements for permit applications.[1]
- The Department of Energy is reviewing the applications for rehearing of its order designating the two NIETCs.

[1]See FERC Order No. 689, Regulations for Filing Applications for Permits to Site Interstate Electric Transmission Facilities.

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Federal Role

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Stakeholders Have Raised Questions about How FERC's Expanded Authority Will Function

- Stakeholders we interviewed raised the following questions about FERC's expanded authority to site transmission lines:
  - What will be the impact on the current state siting process?
  - Will information from the state siting process be considered?
  - Will the state and the public have adequate opportunity to participate in and comment on the federal proceedings?
- In response, FERC officials told us that:
  - They expect their review of a transmission proposal in the NIETCs will have little impact on the state's existing siting process;
  - To the extent FERC receives applications, they expect to consider information from the state process as part of the federal proceeding; and
  - States and the public will have opportunities to participate in and comment on the federal siting process.

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Federal Role

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Federal and State Statutes and Guidance Encourage Collocation with Existing ROW

- Federal statutes and guidance encourage collocation of new transmission lines with existing transportation ROW. Examples include:
  - Federal Land Policy and Management Act (FLPMA) – to minimize adverse environmental impacts on federal land, the use of ROW in common is required to the extent practical
  - Energy Policy Act of 2005 – requires streamlined review and permitting within corridors designated by FLPMA
  - FERC guidance – for hydroelectric projects, existing ROW should be given priority as locations for additional electricity transmission facilities. FERC may be able to apply the principles from the guidance to transmission lines in the NIETCs
- State guidance encourages collocation of new transmission lines. Examples include:
  - New York guidance – utility facilities should be accommodated within the highway ROW when such use and occupancy does not interfere with the free and safe flow of traffic
  - Virginia guidance – cites FERC's guidance

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Objective 2

What are advantages and disadvantages of adding transmission lines and using HVDC technologies?

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Adding Transmission Lines Has Potential Advantages

- Studies we reviewed and stakeholders we interviewed identified the following potential advantages related to adding transmission lines:
  - May decrease congestion and improve reliability of the electricity system by providing access to additional sources of generation and additional paths for electricity
  - May lower costs for consumers receiving the electricity
  - May better utilize existing power plants and make local wholesale electricity markets more competitive (e.g., connecting existing, low-cost power plants to areas with high power costs may increase competition and lower prices)
  - May facilitate development of new electricity sources located outside population centers, which sometimes face air quality and other environmental constraints
  - May facilitate the development of renewable energy sources such as wind, water, solar, and geothermal energy, which may be located outside of urban centers

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Adding Transmission Lines Has Potential Disadvantages

- Studies we reviewed and stakeholders we interviewed identified potential disadvantages related to adding transmission lines:
  - May diminish economic or aesthetic land values if lines are built above ground (e.g., view of landscape may be affected); underground HVDC and HVAC lines are more expensive to construct and maintain than above-ground lines
  - May raise electricity prices in areas from where the electricity is being taken
  - May reduce incentives to identify alternatives that decrease demand (e.g., energy conservation)

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Using HVDC Technology Has Potential Advantages Compared to HVAC

- Studies we reviewed and stakeholders we interviewed identified potential advantages of HVDC technology over HVAC technology:
  - HVDC generally costs less than HVAC over long distances (HVDC has few or no intermediate interconnections)
    - HVDC lines lose less power than HVAC lines
    - HVDC lines may require less ROW width than HVAC (only two lines are needed for HVDC as opposed to three lines for HVAC)
  - HVDC lines can provide transmission operators with more control over the direction and amount of power flowing than HVAC lines

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Using HVDC Technology Has Potential Disadvantages Compared to HVAC

- Studies we reviewed and stakeholders we interviewed identified potential disadvantages of HVDC technology over HVAC technology:
  - Short-distance HVDC lines can be more expensive to construct than HVAC due to the need to convert direct-current into alternating-current electricity used by consumers
  - HVDC lines do not typically provide electricity benefits to residents along their routes, unless converter stations are installed at intermediate locations, because such lines are generally not connected to local electricity lines

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Objective 3

What are benefits and risks associated with siting HVDC electric transmission lines along active transportation ROW?

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Collocation Has Potential Benefits

- Studies we reviewed and stakeholders we interviewed identified potential benefits:
  - **Construction and maintenance**
    - May facilitate access to transmission lines for construction and maintenance
    - May facilitate negotiation of a new ROW agreement
    - May reduce the need to designate a new ROW in residential, commercial, and industrial areas where limited space is available for transmission lines
  - **Environmental and visual**
    - Can avoid impacting undisturbed land and surrounding areas
  - **Economic**
    - Use of existing single ROW may be less costly than acquiring new property rights or property from multiple owners
    - Current owner of ROW may benefit from payment for additional use of ROW

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Potential Benefits and Risks of Collocation

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Collocation Has Potential Risks

- Studies we reviewed and stakeholders we interviewed identified potential safety and security risks
  - **Safety**
    - Accidents from transportation infrastructure users (such as train derailments or highway crashes) could damage transmission lines and fallen transmission lines could damage transportation infrastructure
    - Electromagnetic fields and stray current could interfere with railroad signaling systems and highway traffic operations, and accelerate pipeline corrosion, resulting in accidents
    - Maintenance workers may be more likely to be injured given increased safety risk from close proximity of transmission lines to transportation ROW
  - **Security**
    - Collocation may make the corridor a more attractive target
    - Events that would otherwise be isolated (e.g., a pipeline explosion) could lead to service interruptions on the transmission line or along active ROW
- Federal and state officials we interviewed told us that while they have not conducted studies specifically on these risks, they expect the probability of these occurrences to be low

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Benefits and Risks of Collocation

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Steps Can Be Taken to Mitigate Potential Risks of Collocation

- Various stakeholders, including industry associations and infrastructure owners, reported that steps can be taken to mitigate potential risks associated with collocation
- Examples of approaches for mitigating potential collocation risks include:
  - *Along pipelines* – Ensure electric current emitted from the line will not interfere with cathodic protection (which helps to prevent corrosion) required under Pipeline and Hazardous Materials Safety Administration regulations, or otherwise directly or indirectly accelerate pipeline corrosion
  - *Along railroads* – Ensure line's magnetic fields will not interfere with railroad signal systems; tower design must adhere to required clearances for maintenance
  - *Along highways* – Encourage assessments of potential collocation risks; Ensure transmission towers and lines will not impede traffic operations and the free flow of traffic or possible future expansion of roadway

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Staff Acknowledgments

Key contributors to this report were Nikki Clowers, Assistant Director; Jon Ludwigson, Assistant Director; Vidhya Ananthakrishnan; Allen Chan; Colin Fallon; Philip Farah; Kathleen Gilhooly; Brandon Haller; Dawn Hoff; Tina Won Sherman; and Barbara Timmerman.

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