Executive Summary

In the Energy Policy Act of 2005 (EPAct), Congress directed the U.S. Department of Energy (DOE) to conduct a study every three years on electric transmission congestion and constraints within the Eastern and Western Interconnections. The American Reinvestment and Recovery Act of 2009 (Recovery Act) further directed the Secretary to include in the 2009 Congestion Study an analysis of significant potential sources of renewable energy that are constrained by lack of adequate transmission capacity. Based on this study, and comments concerning it from states and other stakeholders, the Secretary of Energy may designate any geographic area experiencing electric transmission capacity constraints or congestion as a national interest electric transmission corridor (National Corridor).

In August 2006, the Department published its first National Electric Transmission Congestion Study. In 2007, based on the findings of that study and after considering the comments of stakeholders, the Secretary designated two National Corridors, one in the Mid-Atlantic area and one covering Southern California and part of western Arizona.

This document identifies areas that are transmission-constrained, but as in 2006, this study does not make recommendations concerning existing or new National Corridor designations. The Department may or may not take additional steps concerning National Corridors at some future time.

Transmission Congestion

Congestion occurs on electric transmission facilities when actual or scheduled flows of electricity across a line or piece of equipment are restricted below desired levels. These restrictions may be imposed either by the physical or electrical capacity of the line, or by operational restrictions created and enforced to protect the security and reliability of the grid. The term "transmission constraint" can refer to a piece of equipment that restricts power flows, to an operational limit imposed to protect reliability, or to a lack of adequate transmission capacity to deliver potential sources of generation without violating reliability requirements. Because power purchasers typically try to buy the least expensive energy available, when transmission constraints limit the amount of energy that can be delivered into the desired load center or exported from a generation-rich area, these constraints (and the associated congestion) impose real economic costs upon energy consumers. In the instances where transmission constraints are so severe that they limit energy deliverability relative to consumers' electricity demand, such constraints can compromise grid reliability.

The 2009 study documents (to the extent publicly available data permit) where electricity congestion and transmission constraints occur across the eastern and western portions of the United States' bulk power system. Congestion varies over time and location as a function of many factors, including energy use and production patterns across the grid and changes in the availability of specific assets (such as power plants or transmission lines) over time. This analysis indicates general patterns of congestion—broad areas where the transmission congestion reflects imbalances between electric supply and demand that create significant costs, perhaps including adverse impacts on reliability.

Transmission congestion and the existence and impacts of transmission constraints can be measured according to three broad sets of metrics—high levels of transmission usage, the economic costs and electricity prices that result from transmission constraints, and, occasionally, the reliability consequences of transmission limits. These metrics and the results of their application are discussed in detail in Chapters 2, 4 and 5.

The 2009 study identifies regions of the country that are experiencing congestion, but refrains from addressing the issue of whether transmission expansion would be the most appropriate solution. In

some cases, transmission expansion might simply move a constraint from one point on the grid to another without materially changing the overall costs of congestion. In other cases, the cost of building new facilities to remedy congestion over all affected lines may exceed the cost of the congestion itself, and, therefore, remedying the congestion would not be economic. In still other cases, alternatives other than transmission, such as increased local generation (including distributed generation), energy efficiency, energy storage and demand response may be more economic than transmission expansion in relieving congestion.

Thus, a finding that a transmission path or flowgate is frequently congested should lead to further study of the costs and impacts of that congestion, and to a careful regional study of a broad range of potential remedies to larger reliability and economic problems. Although congestion is a reflection of legitimate reliability or economic concerns, not all transmission congestion can or should be reduced or "solved."

Study Approach and Input

Chapter 2 presents the 2009 study's approach and methods. The 2009 study differs methodologically from the previous study in that in 2006 the Department worked with analysts and consultants to develop independent projections of future congestion in the Eastern and Western Interconnections. In planning for the 2009 study, the Department determined that it would not conduct or sponsor congestion projections specifically for the 2009 study, but would draw instead upon the many studies prepared by others through independent, credible planning entities and processes.

The Department conducted extensive public outreach and consultation relating to the 2009 study. Department staff reached out to stakeholders within state governors' offices, public utility regulators, electric utilities and grid operators, electricity producers, demand-side resource providers, environmental organizations, and the general public to invite input on transmission congestion and constraints, and their consequences. Department staff conducted seven regional and technical public workshops to collect information. The Department reviewed comments submitted in connection with the 2006 congestion study about the conduct of future studies, and reviewed more than 40 comments filed as inputs to the 2009 study. Department staff met or spoke with all stakeholders requesting such contact. All of these views have been considered carefully in preparing the analyses that follow.

For the 2009 study, the Department revisited each of the congestion areas identified in 2006 and reassessed the 2006 study's conclusions for each area in light of currently available information on present conditions and expected high-probability developments. The Department reviewed more than 325 documents, independent studies, and analyses containing relevant information, as well as analyses of both historical and projected grid conditions; all of those reference materials are listed in Appendix C.

Renewable Resource Development, Transmission Availability, and the Concept of a Conditional Constraint Area

The Recovery Act expanded the scope of the 2009 Congestion Study by requiring the Department to include an analysis of the significant potential sources of renewable energy that are constrained in accessing appropriate market areas by lack of adequate transmission capacity, and explain why adequate transmission capacity has not been developed. Chapter 3 addresses these issues after reviewing the areas with the greatest potential for wind, solar and geothermal resource development as identified by the National Renewable Energy Laboratory (NREL).

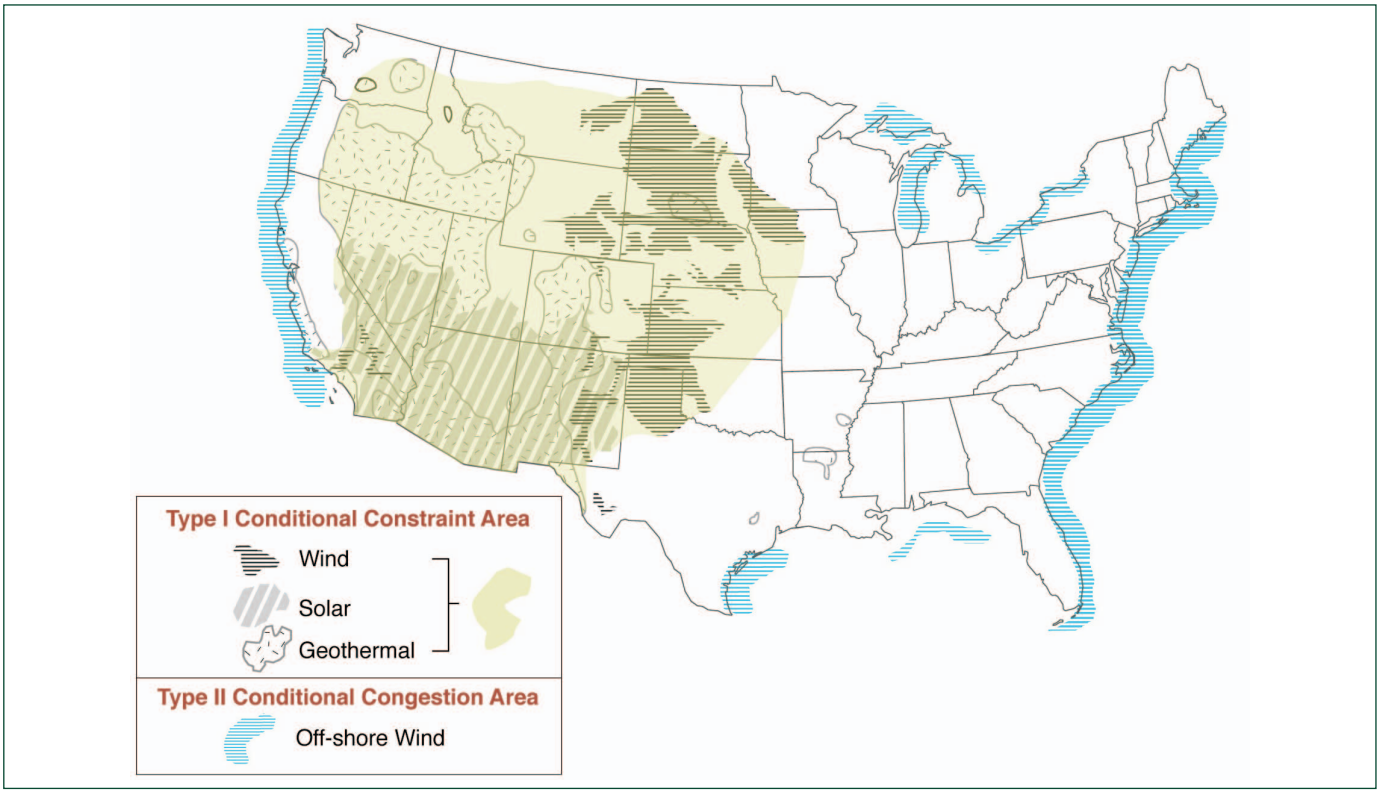
In this study, the Department defines and identifies two types of Conditional Congestion Areas, Type I and Type II. A Type I Conditional Congestion Area is an area where large quantities of renewable resources could be developed economically using existing technology with known cost and performance characteristics—if transmission were available to serve them. Because many of the nation's rich onshore renewable resources are located in adjacent or overlapping areas, the Department has determined

that it is appropriate to identify a single very large Type I area, rather than to call out technology-specific congestion areas (as was done in the 2006 study). By contrast, a Type II Conditional Congestion Area is an area with renewable resource potential that is not yet technologically mature but shows significant promise due to its quality, size, and location. If such resources become technologically mature (through additional R&D and sufficient experience with commercial-scale projects) they could then be limited chiefly by transmission availability, and if so the affected area would qualify for Type I status. A very large onshore Type I area and several offshore Type II areas are shown in Figure ES-1.

It is important to recognize that the economics of renewable resource development can vary widely from region to region, and that the characteristics of the resources are very location-specific. In many cases transmission access makes the difference between an economic and uneconomic project or development area; such economic and geographic granularity must also consider the cost of the transmission to access the resource, and cannot be determined or conveyed accurately in a national-scale study. Several states and regional organizations are conducting highly detailed analyses to identify preferred locations for development of renewable energy resources and their associated electric transmission needs—including efforts by the Western Governors' Association (WGA), Midwest Governors' Association, Southwest Area Transmission (SWAT) Forum, California, Arizona, and several other states. The Department recommends that resource development economic and policy decisions should be guided by these efforts. The Department also notes that there appears to be a wealth of commercially viable renewable resources outside the Type I Conditional Constraint Area; identification of the Area is not meant to suggest that it is not appropriate to develop additional transmission to serve new renewable (and other) resources elsewhere in the nation.

The Recovery Act also directed the Department to analyze the extent to which legal challenges filed at the State and Federal level are delaying the construction of transmission necessary to access renewable energy. Review of numerous transmission projects, including those intended to serve primarily renewable resources, suggests that most large-scale transmission projects are subject to legal challenge,

Figure ES-1. 2009 Type I and Type II Conditional Constraint Areas



regardless of any relationship to renewable resources; the Department concludes that while renewable-associated transmission projects face many challenges, they do not appear to suffer from legal challenge or delay to a greater or lesser extent than other transmission projects.

Transmission Congestion in the Eastern Interconnection

Because transmission congestion occurs when the flow of electricity from one point to another is limited below desired levels, transmission congestion can be evidenced in at least three ways—as heavy electrical usage of the equipment, as price differentials or economic cost differentials between different parts of the grid, and in extreme conditions, as a reliability problem that results from the inability to deliver enough electricity to meet consumers' electricity demand. Each of these measures can be expressed in quantitative metrics, discussed below, but the amounts of publicly available data to quantify and evaluate congestion are limited.

The Department hired a consulting firm to conduct a first-ever assessment of publicly available data on historical transmission congestion in the Eastern Interconnection.[1] The study was based solely on data for 2007. Information on actual electricity flows and on some aspects of scheduled flows in the Eastern Interconnection is not publicly available. Accordingly, the study collected and assessed information on three core elements that affect how transmission is managed—and how congestion can be measured with publicly available data—in the Eastern Interconnection: transmission reservations, transmission schedules, and real-time operations. The available data on 2007 historical transmission confirm the findings of the 2006 study with respect to the principal transmission congestion locations in the East. However, the Department concludes that the Eastern data—and more broadly, information on electric transmission usage generally in the U.S.—need significant improvement in scope and quality.

Reviewing the Congestion Areas identified in 2006, the Department concluded that the Mid-Atlantic Critical Congestion Area (extending from mid-state New York down to mid-Virginia) continues to experience high levels of transmission congestion. The region is making significant progress in reducing loads and improving reliability through the use of aggressive energy efficiency and demand response programs, and has added new generation since 2006. However, little new transmission has been built in the region in the past three years, although many new backbone and expansion projects are nearing construction; therefore it is likely to be several years before current congestion levels ease. This will lead to continued price differentials across the region and could compromise continued reliability in the Washington, Baltimore, New Jersey and New York City areas over the coming years. In addition, as long as New York's electric reliability and economics depend to a significant degree on electricity imports through New Jersey, Pennsylvania and neighboring states, tensions will remain over how to balance the needs and costs across the region. The Department finds that the Mid-Atlantic area continues to exhibit major transmission congestion problems and should continue to be identified as a Critical Congestion Area. This identification—as is the case with the others that follow in this document—is based on consideration of the totality of the various kinds of information presented, rather than on whether specific congestion metrics have been met or exceeded.

In 2006 the Department identified New England as a Congestion Area of Concern due to high electricity price differentials across the region and congestion-related reliability problems in Boston, southwest Connecticut, and other sub-areas. Over the past three years, however, transmission congestion within New England has fallen significantly. This is due to years of sustained effort and achievement on several fronts—new utility-scale and distributed, small-scale supply resources have come on-line, primarily in the locations where they were most needed and valuable; aggressive demand response programs have made load reduction into a geographically targeted resource that can be used to reduce peak loads and mitigate the effects of temporal transmission constraints; and energy efficiency is

[1]Open Access Technology International (OATI) (2009*). Assessment of Historical Transmission Congestion in the Eastern Interconnection*, at http://www.congestion09.anl.gov/.

reducing total loads. Further, the area has a strong queue of new generation projects, as well as a diverse set of new reliability- and economics-oriented transmission projects completed or sitting in its interconnection and transmission system study queues. These developments have eased the significant reliability and economic differentials affecting the Boston metropolitan area and southwest Connecticut.

Although New England still faces a potential resource shortfall under extreme load conditions over the next few years, most of the significant transmission constraints have been eliminated by the region's multi-faceted approach. The region has shown that it can permit, site, finance, cost-allocate and build new generation and transmission, while encouraging new demand-side resources as well. New England faces some near-term reliability challenges, but is working aggressively to address them. For these reasons, the Department no longer identifies New England as a Congestion Area of Concern.

The Department also reviewed transmission congestion and grid conditions across the rest of the Eastern Interconnection and concludes that although there are numerous locations where transmission constraints cause economic congestion and occasional operational reliability problems, at present there are no other large areas that would justify formal identification as a congestion area.

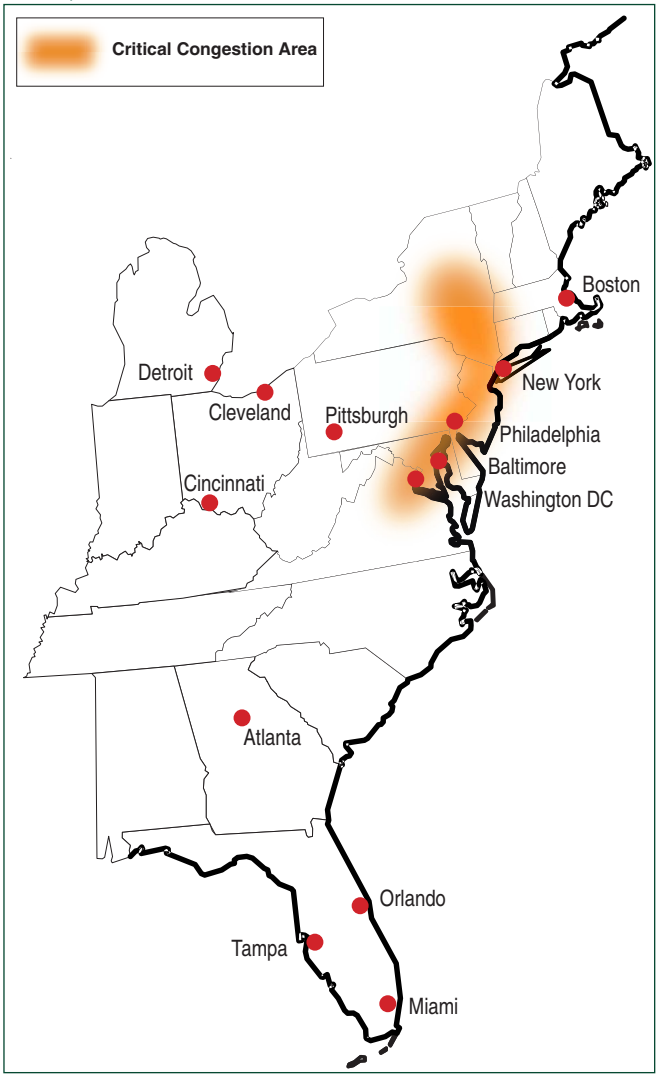
Figure ES-2 shows the Mid-Atlantic Critical Congestion Area, the only congestion area identified by the Department in the Eastern Interconnection in 2009.

Transmission Congestion in the Western Interconnection

For 2009, the Department examined congestion and constraints in the Western Interconnection in general and reviewed the status of the areas it identified in its 2006 study. The Transmission Expansion Planning and Policy Committee (TEPPC) of the Western Electricity Coordinating Council (WECC) conducted both historical analysis of 2007 transmission data and forecasts of transmission needs for 2018. The TEPPC work found that although electricity flows vary from season to season and year to year as a function of changes in electricity demand, fuel costs and availability, new generation additions and losses, and other factors, the patterns reflected in this one-year snapshot still correspond generally to the broad patterns of past historical congestion. In fact, viewed with the same congestion metrics used in the 2006 Congestion Study, the grid congestion patterns for the 2007 data are consistent with the results of TEPPC's analysis of 2004 data (which was reported in the 2006 study).

The Western grid differs from the Eastern grid in that the Western grid system covers larger distances with a higher proportion of transmission lines linking distant generation sources to large, concentrated load centers. This means that Western system electricity data are more geographically aggregated and less granular—across physical geography and

Figure ES-2. Mid-Atlantic Critical Congestion Area, 2009



transmission assets and paths—than in the East. Another difference between West and East is that the West is dominated by vertically integrated utilities, with no centrally organized wholesale electric markets outside California; therefore, there are no data about the historic costs of congestion or electricity prices to measure the economic dimensions and consequences of transmission congestion in the (non-California) West.

The West has developed a strong, transparent regional transmission planning and analysis process over the past several years. This process is now yielding a wealth of proposals to build new backbone transmission across the interconnection, with at least 51 major projects being considered from British Columbia and Alberta down to southern California. Many of these projects are intended to enable concentrations of new renewable generation capacity in regions including southern California, Montana, Wyoming, Washington, and Oregon to deliver their output to coastal and southern load centers.

The Department's 2006 study identified Southern California (spanning the metropolitan areas of Los Angeles and San Diego) as a Critical Congestion Area, given the area's persistent transmission congestion problems, large population, and important economic role within the nation. Factors influencing the identification as a Critical Congestion Area included the area's growing electric demand, heavy dependence upon electricity imports, and difficulty in building new power plants and transmission lines.

In the 2009 study, the Department concludes that although the state of California has shown national leadership in moderating electric load growth and increasing distributed generation, the Southern California region remains challenged. New transmission and generation in Southern California have barely kept pace with load growth over the past few years. Although many promising generation and transmission projects are now in the planning or regulatory approval stages, experience shows that few such projects become operational on schedule in California. Slow development of new generation and transmission facilities could compromise near-term grid reliability in Southern California, despite growing demand response and smart grid capabilities. For these reasons, the Department concludes that Southern California remains congested, and that it should retain its status as a Critical Congestion Area.

In 2006 the Department identified the San Francisco Bay Area as a Congestion Area of Concern because of the reliability challenge posed by serving the area between San Jose and San Francisco with a single set of lines across the San Francisco Peninsula. The area had high local generation costs due to local high-cost reliability-must-run requirements, and little in-area generation. Instead—then and now—the San Francisco City and Peninsula depend upon import capabilities and the level of electricity demand and generation dispatch in the East Bay and South Bay.

A combination of supply and demand relief measures will be needed to reduce congestion and maintain reliability on the San Francisco Peninsula, but only a few of the needed measures will be completed over the near term. Until there is a clearer picture of how and when all the needed supply and demand-side elements will materialize, and materially improve conditions on the San Francisco Peninsula, the Department will continue to identify the San Francisco Peninsula as a Congestion Area of Concern.

The 2006 study identified the area from Seattle south to Portland as a Congestion Area of Concern with both reliability and economic implications. This reflected both high loading in winter and summer and increasing wind generation to the east, combined with new generation that had been built within the congestion path. Current development of rich wind resources to the east of the area is exacerbating the congestion problems over the near term, despite aggressive operational mitigation efforts by the local grid operator.

Several major backbone transmission projects are now being evaluated for the area; their completion would probably solve most of the Seattle-Portland congestion problems. Such completion, however, appears several years away. Until then, the Department will continue to identify the area as a Congestion Area of Concern.

Last, the 2006 study identified the Phoenix-Tucson region as a Congestion Area of Concern because this metropolitan region was experiencing explosive population and load growth with significant transmission loading and congestion. Numerous new transmission and generation projects have been given regulatory approval, however, and are now coming into service in the region, with the result that the existing and planned transmission systems appear adequate to meet the local energy reliability needs of the area for much of the coming decade. Although not all of the transmission and demand-side projects that will resolve current congestion problems have been completed, the recent history of transmission development in Arizona indicates that projects developed through the state's Biennial Transmission Assessment process receive swift regulatory approval and are built on schedule with limited complications or uncertainty due to permitting, routing or cost recovery. Therefore, the Department considers it likely that most of these projects will become operational by their scheduled dates in 2009 and 2010. Based on the progress in addressing congestion issues, the Department no longer identifies the Phoenix-Tucson area as a Congestion Area of Concern.

Figure ES-3 shows the 2009 Transmission Congestion Areas for the Western Interconnection.

A wealth of new backbone transmission is being considered for development in the Western Interconnection. This new transmission will affect western congestion patterns, as will efforts to develop new renewable resources to meet state renewable portfolio requirements and increased energy efficiency to meet resource and carbon emissions management goals. The Department will continue monitoring these developments, and the paths and congestion areas identified above, to determine whether levels of congestion and usage are becoming better or worse as load, generation and transmission infrastructure change over time.

Public Comments, Next Steps and Recommendations

The Department invites public comments on all aspects of this study. The comment period will be for 60 days, beginning with the day a notice of the availability of the study for public comment is published in the *Federal Register*. As soon as the closing date has been determined, the Department will post the closing date on its Congestion Study web site, congestion09@anl.gov. Comments must be submitted in writing to the Department no later than 5:00 p.m. EST on the closing date, if possible by e-mail to congestion09@anl.gov.

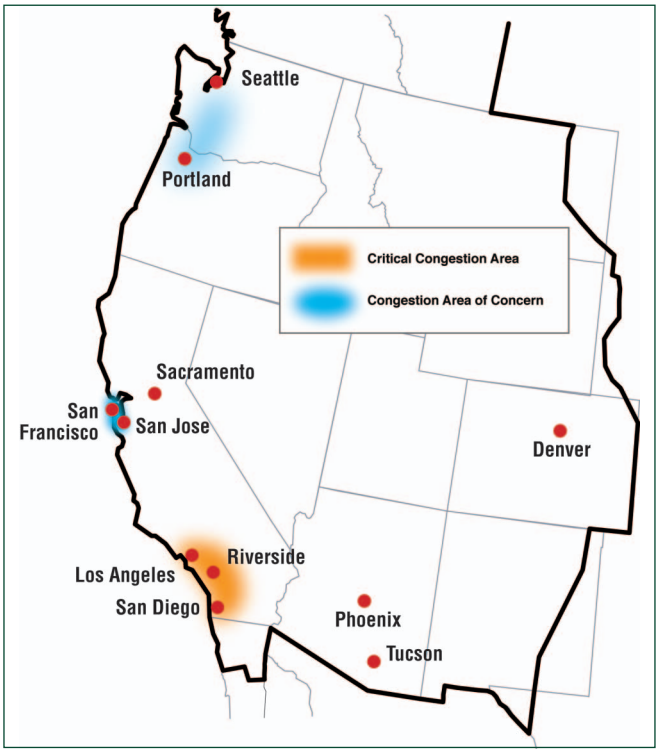
Comments may also be submitted by conventional mail to this address:

Comments on DOE 2009 Transmission Congestion Study
c/o Adriana Kocornik-Mina
Office of Electricity Delivery and Energy Reliability (OE)
U.S. Department of Energy
1000 Independence Avenue SW
Washington DC 20585

All comments received will be made publicly available on the website DOE has created for this study, www.congestion09.anl.gov. The Department will consider all comments received and take them into account in making decisions based in part on the findings of this study.

Several important activities and analyses are pending or already under way that are likely to show

Figure ES-3. 2009 Congestion Areas in the Western Interconnection



more clearly where the case for building additional transmission capacity is especially strong. The Recovery Act provided funds with which the Department intends to support these activities and analyses. These include:

1. *Stronger and more inclusive regional and interconnection-level transmission analysis and planning.* The Department believes that analytical entities in each of the Nation's interconnections should develop a broad portfolio of possible electricity supply futures, and identify their associated transmission requirements. These analyses will address, for example, the extent to which energy efficiency programs can reduce or forestall the need for additional transmission capacity, the merits of developing high-potential renewables in remote areas, as well as the merits of developing other renewable resources closer to load centers.

   After these analyses have been developed and made available for public review, transmission experts from the electricity industry, the states, federal agencies, and other stakeholder groups will collaborate in the development of interconnection-level transmission plans. Thus, to the extent feasible these plans will identify a coherent core set of transmission projects regarded by a diverse group of experts as needed under a wide range of futures.

2. *Designation by states of geographic zones* with concentrated, high-quality renewable resource potential, or other physical attributes especially relevant to reducing overall carbon emissions at reasonable cost. See, for example, *Western Renewable Energy Zones—Phase 1 Report,*[2] which identifies renewable resource "hubs." These hubs are the approximate centers of high-value resources areas that have also been screened to avoid park lands, wilderness areas, wetlands, military lands, steeply sloped areas, etc. DOE has announced that it seeks proposals from eastern state-based organizations to undertake similar analyses in the eastern United States. Identification of zones of particular interest for the development of additional low-carbon electric generating capacity will be very important as input to the long-term planning processes described in the preceding paragraph.

3. *Regional or sub-regional renewable integration studies.* The output from wind and solar generation sources is inherently variable, at least over shorter periods of time. Therefore, in a given region, transmission planners must determine how higher levels of renewable generation could be used in combination with other generation sources, demand-side resources, and storage facilities while maintaining grid reliability. Completion of these integration studies, along with careful transmission planning, is essential to enable planners to make informed decisions about how to integrate large amounts of new renewable generation effectively, economically and reliably.

Determining what will constitute future transmission "adequacy," however, is no simple matter. It is becoming technically feasible to drive transmission systems harder and obtain more services from them, without endangering reliability—provided certain critical conditions are met. These include:

1. The availability of detailed, near-real-time information about second-to-second changes in the operational state of the bulk power supply systems.
2. The availability of effective control devices that will respond extremely quickly to correct or avert potentially hazardous operating conditions.
3. The availability of appropriately trained workforces that will be able to design, build, operate, and maintain such complex systems.

The Department has plans to address these challenges, again through funds provided by the Recovery Act.

Given the rising importance of electric infrastructure planning, however, there is a clear need to facilitate better and more transparent planning and policy decisions by improving the quality and availability of data concerning the use of existing transmission facilities. More systematic and

[2]Western Governors' Association (WGA) and U.S. Department of Energy (DOE) (2009). "Western Renewable Energy Zones – Phase 1 Report," at http://www.westgov.org/wga/initiatives/wrez/.

consistent data are needed on several transmission subjects, such as:

1. The prices and quantities of short- and long-term transactions in wholesale electricity markets.
2. Scheduled and actual flows on the bulk power system. At present, Open Access Same-Time Information System (OASIS) data are scattered across many websites, are neither edited nor archived, and not presented in a consistent format. Clearer direction from the Federal Energy Regulatory Commission (FERC) on how such data are to be presented would be very helpful. Special attention is required to depict more clearly the flows across inter-regional seams.
3. The economic value of curtailed transactions.

The Department looks forward to being able to draw upon both improved data and the results of a wide range of relevant studies in its 2012 Congestion Study.