

# Electricity Transmission: What the Data and Models Show

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## Summary

Federal law and implementing regulations are causing the most significant change in the U.S. electric power industry since the Great Depression. For more than 60 years the industry was characterized by a structure—utilities serving exclusive franchises—and a regulatory strategy—pricing at average prudent cost of service—that is changing in fundamental ways.

Beginning with the Public Utility Regulatory Policies Act of 1978 (PURPA), and continuing with the Energy Policy Act of 1992 (EPACT), Congress allowed certain kinds of generators to enter wholesale power markets. In 1996, the Federal Energy Regulatory Commission (FERC) issued Order 888 requiring:

*. . . all public utilities that own, control or operate facilities used for transmitting electric energy in interstate commerce to have on file open access non-discriminatory transmission tariffs that contain minimum terms and conditions of non-discriminatory service . . . .*<sup>1</sup>

The order “unbundled” electrical energy generation from transmission and other services needed to deliver power to customers.<sup>2</sup>

FERC’s intent was that its own administrative determination of the cost of service would eventually be replaced by competitive markets as the arbiter of just and reasonable rates for wholesale energy and any services that could be supplied competitively. As FERC explained, Order 888 is necessary because:

*The only way to effectuate competitive markets and remedy discrimination is through readily available, non-discriminatory transmission access.*<sup>3</sup>

Transmission, however, remains regulated. FERC’s efforts to bring competition to the electric power industry are collectively referred to as restructuring. In response to Order 888 and other FERC initiatives, the industry has seen a huge increase in the number of independent generators seeking transmission services.

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<sup>1</sup>Federal Energy Regulatory Commission, “Recovery of Stranded Costs by Public Utilities and Transmitting Utilities,” Order No. 888, Final Rule (April 24, 1996), Summary.

<sup>2</sup>Order 888 also identified a number of ancillary services that were considered, from a regulatory point of view, to be part of transmission service and thus subject to regulatory oversight and the potential for market pricing. These ancillary services include voltage regulation, operating reserves, and balancing energy. A companion order, Order 889, required transmission providers to post their available transmission capacity (ATC) on Internet sites called the Open Access Same-Time Information System (OASIS).

<sup>3</sup>Federal Energy Regulatory Commission, “Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities,” Order No. 888-A, Docket Nos. RM95-8-001 and RM94-7-002 (March 4, 1997), p. 11.

Recently the Department of Energy (DOE), the FERC, and the Congress have questioned whether the high-voltage transmission system can support its growing economic role. The agencies were particularly concerned with the grid's alleged technical obsolescence, reliability, lagging investment, low rates of return in transmission, generator siting, and undue discrimination by transmission providers.

Less well recognized is the impact of the industry's structural change on the data supporting public policy. When there is a fundamental change in the way an industry does business, as is now happening in electricity, the basic data needed to describe the industry must also change. Federal agencies charged with collecting industry data must modify their data collection methods and, as needed, acquire new kinds of data. The agencies must also develop new ways of aggregating and disaggregating basic reports to accommodate new organizational and market boundaries.

The Federal Energy Administration Act of 1974 (P.L. 93-275, 15 U.S.C. 761 et seq.) and the DOE Organization Act (P.L. 95-91, 42 U.S.C. 7101 et seq.) require the Energy Information Administration (EIA) to carry out a centralized, comprehensive, and unified energy information program to collect, evaluate, assemble, analyze, and disseminate information on energy resource reserves, production, demand, technology, and related economic and statistical information for use in assessing the adequacy of energy resources to meet near-term and longer term domestic demands and to inform public policymakers. FERC is responsible for regulating the wholesale power market and the high-voltage transmission system that supports interstate trade. Together, EIA and FERC are the major Federal Government sources of transmission information.

The changing structure of the industry and the Federal Government's increasing interest in transmission persuaded EIA to reexamine its official data collections to determine whether they continue to meet the needs of the Government.

### **Restructuring's Impact on Federal Data Collections**

The Federal Government—two Federal agencies and two Departments—collects a great deal of information about electricity transmission. The FERC collects transmission information from investor-owned utilities (IOUs) and other entities it regulates. The EIA collects similar information from entities that are outside FERC jurisdiction: independent power producers (IPPs), cooperatives, municipal systems, Federal power, and Texas. EIA also collects data from generators under FERC jurisdiction. The DOE collects trade data with Canada and Mexico. The Department of Agriculture collects data from cooperatives having loans with the Rural Utilities Service. The Federal Government currently fields 11 major data collection instruments directly relevant to transmission.

Federal data collections were designed to describe and regulate a cost-of-service world dominated by utilities serving exclusive franchises. Compared to generation, transmission was cheap: utilities built whatever they needed to serve their customers. Few utilities relied on power from distant suppliers to meet their customers' needs. In that world transmission was not important.

FERC's restructuring initiatives increase the importance of transmission because of its unique roles in creating markets and in reliability management. For the limited purposes of this report, the basic elements of a restructured market are as follows:

- Energy, reserves, transmission, and various services are unbundled and separately priced. Transmission is to be a standalone enterprise.
- The grid and wholesale markets are open to competitors.
- Markets are used to price wholesale energy and, when possible, related services.
- Transmission tariffs are regional and are based on regional capital recovery and operating costs.
- Additional charges associated with using fully loaded lines, i.e., congestion charges, are signals for transmission use, generator siting, and grid expansion. FERC prefers to price congestion using market prices.<sup>4</sup>
- Grid expansion projects are based on regional plans.

The scope and pace of restructuring have been uneven across the United States. Currently, industry participants are in one of three distinct economic and regulatory systems:

- Independent System Operators (ISOs) in the Northeast and California are operating restructured public markets under formal agreements with FERC.
- In Texas, public power cooperatives and municipal systems continue to operate outside FERC jurisdiction in most respects. Texas has its own market.
- The remainder of the industry is operating in FERC-regulated, private markets that have not been restructured.

In much of the country electricity is unbundled, the grid is at least partially open to competitors, and markets are being used to price wholesale energy. Except for the Midwest ISO, the ISOs have auction markets with publicly reported wholesale market prices. The majority of the country, however, depends on bilateral agreements made in private markets, and wholesale prices are not public. In most of the country transmission rates are not regional, congestion is not separately charged, and regional planning is limited.

Much of the data are predicated on an industrial structure that no longer exists. Official data, especially outside the ISOs, are generally neither compiled nor defined to allow monitoring and analysis of key aspects of the industry, including transmission as a separate enterprise, access to the grid, prices of transmission and wholesale energy, regional costs, congestion charges, and investment.

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<sup>4</sup>Congestion costs, revenues, and system re-dispatch costs all arise from limits on the transmission grid. They are discussed in Chapter 5 in the sections titled "Measuring the Grid's Impact on Wholesale Markets," and "Data Showing the Grid's Support of Markets."

## Federal Interest in Transmission

The Federal Government needs data and models to answer factual questions that are basic to resolving long-standing public policy issues in three broad policy areas:

- Reliability and national security
- Economic regulation
- Economic growth and efficiency.<sup>5</sup>

Factual questions of policy interest include:

- How reliable is the grid? Is reliability improving or deteriorating?
- How much does transmission cost? What are the revenues, prices, and returns of transmission? How do costs, prices, and returns compare regionally?
- What investments are being made to expand, maintain, and modernize the grid?
- Is the grid accommodating economic trade? Is the grid available to all competitors (i.e., is there open access)? How much do customers and generators pay for transmission? What is the quality of transmission service?
- Are markets for wholesale electricity competitive? Is the grid being used to shield firms from competition?

## Purpose of Report

One purpose of this report is to examine the suitability of existing official data for informing Federal policymakers about electric power transmission in interstate commerce. Official data are those produced by the Federal and State governments, their agents and regulated entities such as ISOs. Data that are **routinely** supplied to DOE, EIA, and FERC by the North American Electric Reliability Council (NERC) are also included.

A second purpose of this report is to determine whether needed, but currently unavailable, data could in fact be obtained. Before any agency of the Federal Government can collect or continue to collect data from 10 or more persons, it must obtain approval from the Office of Management and Budget (OMB). Two minimum thresholds for OMB approval of an agency's data collection are that: the data are needed for the Federal Government's legitimate purposes, and the data can in fact be obtained. Those thresholds are the focus of this report.

This report indicates that currently unmet data needs could be satisfied by one of three means: by modifying existing data collections, by coordinating and consolidating information from official and quasi-official entities, or by undertaking new data

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<sup>5</sup>The East Coast blackout of 1965 and subsequent blackouts in the Western United States, the terrorist attacks of September 11, 2001, and the August 14, 2003, East Coast blackout showed the national interest in a reliable, secure transmission grid. The Federal Government's substantial involvement in regulating and in building interstate power transmission and generation goes back to the start of the New Deal. The Federal Power Act of 1935 authorized the Federal Power Commission, now the Federal Energy Regulatory Commission, to regulate utilities involved in interstate transmission and power sales to ensure "just and reasonable" electricity prices. In 1933, the Federal Government chartered the Tennessee Valley Authority to build hydroelectric facilities to promote regional economic development.

collections. It shows that, in principle, the needed data can be obtained; the suggestions do not represent the only or necessarily the best ways of obtaining transmission data.

This report does not compare official data on transmission collected by the U.S. Federal Government with official data collections in other countries.

## Reliability

With restructuring, some utilities have divested generation and all are seeing power flowing across utility and regional boundaries in response to commercial opportunities. That development, together with the entry of independent generators supplying local and distant markets, means reliability is increasingly dependent on building and managing transmission capacity.

Data collections that the Federal Government relies on to monitor reliability have not kept pace with the ascendancy of transmission in a restructuring industry. The Government does not have the electrical models (power flow models) necessary to verify that transmission capacity is adequate to keep the lights on. The industry’s reported plans are not necessarily those imperfectly analyzed in the power flow analyses that industry does submit to FERC. Data for monitoring investments in the high-voltage grid, including those to improve grid control, and indicators of reliability trends are not routinely available to the Government. Neither the industry nor the Government has data adequate to allow rigorous cost-benefit analyses of transmission-related investments to enhance reliability.

Much improvement in the Government’s capability to oversee reliability could be achieved by modifying existing data collections. The forms referred to in Table S1 are described in Chapter 2.

**Table S1. Reliability Data: Modify Existing Forms**

Information Need	Form	Needed Changes	Comment
1.High-quality power flow models.	FERC 715	<ol style="list-style-type: none"> <li>1. Identify load buses by MSA.<sup>a</sup></li> <li>2. Power flow cases of existing system.</li> <li>3. Model planning data for 1, 3, and 5 years in future.</li> <li>4. Provide contingency lists.</li> <li>5. Explain line and voltage violations.</li> </ol>	The quality of reporting is often poor. Submissions often do not use EIA/EPA names and contain serious electrical violations.
2. Data on the recent adequacy, security status of control areas. Data to verify power flow models of existing system.	FERC 714	<ol style="list-style-type: none"> <li>1. Actual hourly demand, generation, inter-control-area power flows experienced in control regions for 715 cases (2 above).</li> <li>2. Experienced line and voltage violations.</li> <li>3. Use EIA/EPA generator names and same line/bus identifiers as on FERC 715.</li> </ol>	

3. A consistent set of reference reliability plans.	FERC 714, EIA 411, and EIA 860	1. Require EIA 411 and EIA 860 data to describe the same plan. 2. Require FERC 714 (Part 111, Schedule 2) and EIA 411 demand projections to be consistent.	These plans should be the basis for the power flow analyses 1, 3, and 5 years into the future.
4. Monitor demand response.	EIA 861	Add a schedule showing total MWh metered hourly (or higher frequency) and MWh billed by time of consumption.	To quantify extent of price responsive demand. See Chapter 6.
5. Quantify investment in the high-voltage grid and in its metering and control.	FERC 1	1. Adopt NIA definition of investment. 2. Report line and associated equipment investment by voltage level. 3. Report investment in metering, communication, software, and control of the high-voltage grid.	See Chapter 4.

<sup>a</sup>MSA stands for Metropolitan Statistical area. An MSA is a geographic entity defined by the U.S. Office of Management and Budget. Qualification as an MSA requires the presence of a city with 50,000 or more inhabitants, or the presence of an Urbanized Area (UA) and a total population of at least 100,000 (75,000 in New England).

## Financial Performance and Investment

FERC collects capital and operating cost data from IOUs to ensure “just and reasonable” electricity prices. EIA complements the FERC collections with less detailed reports from the other generation and transmission owners to produce industry-wide totals. FERC’s Commissioners are concerned with the economics of transmission as a standalone enterprise because of their obligation to ensure just and reasonable prices in a restructuring environment. But FERC’s financial accounts are more appropriate to the circumstances of integrated regulated utilities selling bundled electricity in a cost of service environment.

Apart from a few “transmission only” entities, the FERC Form 1 says little about the economics of transmission. Official data do not capture transmission’s financial performance, in large part because most transmission revenue is bundled with revenue from retail sales and is not separately identifiable. The available data describing transmission operation costs, capital stock, and investment are not comparable across reporters, because the FERC Form 1 does not impose a common definition separating transmission from distribution.

If transmission were fully unbundled, its revenues would be unambiguous. Absent that, FERC could require line-of-business reporting—a fundamental change that would be tantamount to introducing a new data collection form. How useful or valid the resulting estimates would be is a serious question.

Far less dramatic changes to the FERC Form 1, the Form EIA-412 and Form EIA-860 would make the data more useful for cost and investment (but not financial) analysis.

Sharp definitions of transmission would be a logical place to start. Moreover, additions to transmission plant and equipment reflect purchases of existing assets from others, land and other expenditures that, while relevant for some purposes, are not “investment” in the sense of the “National Income Accounts.” The EIA forms that are modeled after the FERC Form 1 share those attributes.

Disaggregating line investment by voltage and identifying investment in grid metering and control would also be helpful. EIA would have to adopt FERC Form 1 conventions, including FERC’s calendar-year convention, to permit calculation of national totals. FERC and EIA could also require that the accounts be segregated by region (ISO or NERC) as appropriate.

The kinds of changes to existing forms that would be required are shown in Table S2.

**Table S2. Financial and Investment Data: Modify Existing Forms**

Information Need	Form	Changes	Comment
1. Consistent separation of transmission from distribution accounts.	FERC 1, EIA 412	Explicitly define transmission in the same way for all utilities and use that definition in assigning costs, revenues, and net capital.	Current data are an “apples and oranges” mix.
2. Ancillary service revenues.	FERC 1, EIA 412	Require reporting as proposed by FERC,	
3. Re-dispatch Costs.	FERC 1, EIA 412	Require reporting.	Only applicable to utilities owning generators. Not necessary for ISOs
4. Utility investment in the high-voltage grid.	FERC 1, EIA 412	1. Adopt NIA definition of investment. 2. Report line and associated equipment investment by voltage level. 3. Report investment in metering, communication, software and control of the high-voltage grid.	Current “additions to plant and equipment” data have very limited use for economic and reliability analysis, although they are important to capital cost recovery.
5. IPP investment.	EIA 860	Collect direct connection and grid reinforcement costs from IPPs on EIA 860.	Some of these investments may not be picked up on the FERC 1. See Chapter 5
6. Merchant transmission investment.	EIA 412	Add to the list of respondents and require them to report transmission investments, as defined above, and to fill out Schedules 10 and 11.	Merchant investment and line data are not currently collected.
7. Consistent aggregation.	EIA 412	Adopt FERC definitions (see above) and require reporting by calendar year.	EIA currently allows reporting by fiscal year.

8. Regional costs.	FERC 1, EIA 412	Require reporters to disaggregate cost, revenue, net capital stock, and investment by appropriate region.	This would allow regional cost comparisons.
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## Transmission and Wholesale Power Markets

Much of the data needed to evaluate the grid's support of markets is already being collected. EIA collects comprehensive data on generators, including those planning to connect to the grid. Those data are indispensable for analyzing the potential supply of electricity and the entry of generators to the market, and for calculating market shares. The OASIS contains data critical to evaluating access, transmission tariffs, and the quality of service. NERC has data on power flows across the high-voltage grid and on curtailments of transmission service. The ISOs are reporting congestion.

The data are not, however, available for policy analyses. The OASIS data are scattered across dozens of websites, are neither edited nor archived, and are not in useable form. NERC's power flow and curtailment data are not routinely available for use by the Government in monitoring wholesale trade. Consolidating, editing, and archiving in a single database all the data that are required to be on individual OASIS sites would substantially improve the Government's ability to evaluate the progress of restructuring. Table S3 indicates how existing forms could be modified and existing data consolidated to fill the gaps in data.

**Table S3. Grid's Support of Markets: Modify Existing Forms and Consolidate Information**

Information Needed	Form/Collection	Needed Changes	Comment
1. Access time series data by provider.	OASIS	Consolidate, edit, and archive all data required on OASIS in a single database.	
2. Transmission service offerings and actual rates.	OASIS	As above.	
3. Cost and time required for generator connection.	EIA 860	Report how much generator paid for grid reinforcements, direct (other) connection costs, and the date of the initial connection request.	For newly activated generators, add questions to Schedule 3, Part B, Line 4.
4. Load-serving entity cost and quality of transmission service.	EIA 861	Report percent of supply covered by long-term contracts, percent covered by firm service (or FTR), transmission service expense, and curtailments (MWh) of firm and non-firm service in past year.	Schedule 2, Part B.
5. Generator cost and quality of transmission service.	EIA 906	Report paralleling that of load-serving entities (see above).	

6. Congestion costs, trade flows and price differentials.	ISO Web sites	FERC and ISOs define data elements the same way across ISOs and report data to FERC.	None of this information is available for analyzing the effect of restructuring policy outside the ISOs.
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Even with these modifications to existing collections, data on congestion, wholesale trade flows, and corresponding wholesale prices would not be available for most of the country. Obtaining those data would require significant research and effort.

### **Wholesale Competition**

The ISOs have all the data needed to assess competition within their areas, but outside the ISOs the Government does not have the data necessary to monitor and evaluate the competitive status of wholesale markets. Government can subpoena data in response to clear behavioral evidence of anticompetitive behavior or as part of a merger approval, but the subpoena is not a reasonable means of obtaining data for ongoing market monitoring.

If Federal regulators and antitrust officials are satisfied with market share analyses, then the critical need is for high quality power flow models to delineate market boundaries. That could be accomplished with power flow models developed for evaluating industry’s reliability plans. If Federal regulators and anti-trust officials require analyses of cost-price ratios (Lerner indices) for non-ISO areas, much more than the currently available data would be needed.

### **Conclusion**

Changing and consolidating existing data collections could greatly enhance the data available to Federal and State policymakers. These changes would require long-term, coordinated effort across EIA, FERC, DOE, OMB, ISOs, and perhaps, NERC. In reviewing any specific proposal, OMB would consider more than the policy relevance of the data and whether it could be collected. OMB would also consider public comments, whether the data are available elsewhere, the likely quality of the data, the cost of collection, the burden on the public, and whether the data should be confidential.<sup>6</sup>

New collections would be needed to describe wholesale prices and trade flows, congestion, regional costs and revenues, and interconnection-wide reliability management. New collections are often controversial and have long gestations.

As markets for energy develop, the grid’s economics and operations are becoming more integrated. Prices, supplies, and reliability are not as closely associated with individual firms as in the past. Neither power flows nor markets begin and end at ownership and jurisdictional borders, and even if they did, individual companies and system operators rarely have complete information on topics of policy interest. Federal and State policymakers are forced to look beyond individual company reports and political boundaries to inform their oversight of the grid.

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<sup>6</sup>The availability and quality of privately collected data vary over time and depend to some extent on what Official sources chose to collect and release. Data quality, costs, collection burden, confidentiality, and similar attributes can only be evaluated relative to a specific collection proposal at a particular time.