



**CEEPR**

**Center for Energy and Environmental Policy Research**

Electricity Sector Restructuring And Competition: Lessons  
Learned

by  
Paul L. Joskow

03-014 WP

August 2003

**A Joint Center of the Department of Economics, Laboratory for Energy  
and the Environment, and Sloan School of Management**

August 2003

**ELECTRICITY SECTOR RESTRUCTURING AND COMPETITION:  
LESSONS LEARNED**

Paul L. Joskow<sup>1</sup>

**ABSTRACT**

We now have over a decade of experience with the privatization, restructuring, regulatory reform, and wholesale and retail competition in electricity sectors around the world. The objectives and design attributes of these reform programs are reviewed. The improvements in sector performance that have been achieved are discussed. The nature and sources of performance problems are also reviewed. Several lessons learned from this experience are identified and their implications for successful ongoing electricity reform initiatives presented. Electricity sector restructuring, regulatory reform and competition initiatives can yield significant consumer benefits when these reforms are designed and implemented well. Applying the lessons learned from recent experience can yield larger consumer benefits in the future.

Key words: electricity, regulation, deregulation, networks, market power

JEL: L9, L5, L1

---

<sup>1</sup> Professor of Economics, Department of Economics, E52-271D, MIT, 50 Memorial Drive, Cambridge, MA, USA. Phone: 617-253-6664, Fax: 617-258-7070, [pjoskow@mit.edu](mailto:pjoskow@mit.edu). I am grateful for comments from Juan-Pablo Montero and for research support from the MIT Center for Energy and Environmental Policy Research.

## **INTRODUCTION**

During the 1990s, many developed and developing countries began to restructure their electric power sectors to improve their performance. The restructuring programs have included privatization of state-owned enterprises, the separation of potentially competitive segments (generation and retail supply) from natural monopoly segments (distribution and transmission), the creation of competitive wholesale and retail markets, and the application of performance-based regulatory mechanisms (PBR) to the remaining regulated segments. While these restructuring initiatives are ongoing, there is much to learn from both the successes and problems associated with the experience to date. This paper provides a brief review of the performance of the reforms, lessons learned and the implications for future reforms.

## **WHY RESTRUCTURING AND COMPETITION?**

Electricity sectors almost everywhere on earth evolved with (primarily) vertically integrated geographic monopolies that were either state-owned or privately-owned and subject to price and entry regulation as natural monopolies. The primary components of electricity supply --- generation, transmission, distribution, and retail supply --- were integrated within individual electric utilities. These firms in turn had de facto exclusive franchises to supply electricity to residential, commercial and industrial retail consumers within a defined geographic area. The performance of these regulated monopolies varied widely across countries. In many developing countries, the sectors were characterized by low labor productivity, poor service quality, high system losses, inadequate investment in power supply facilities, unavailability of service to large portions of the population, and

prices that were too low to cover costs and support new investment (World Bank 1994, Bacon and Besant-Jones 2001, Besant-Jones 1993). Industrial customers sometimes had to respond to frequent system outages by building their own isolated generating facilities, increasing their costs of doing business. Sector performance in developed countries was generally much better, but high operating costs, construction cost overruns on new facilities, costly programs driven by political pressures, and high retail prices required to cover these costs stimulated pressures for changes that would reduce costs and retail prices (Joskow 1998a, 2000).

The overriding reform goal has been to create new governance arrangements for the electricity sector that provide long-term benefits to consumers. These benefits are to be realized by relying on competitive wholesale markets for power to provide better incentives for controlling construction and operating costs of new and existing generating capacity, to encourage innovation in power supply technologies, and to shift the risks of technology choice, construction cost and operating “mistakes” to suppliers and away from consumers. Retail competition, or “customer choice,” is supposed to allow consumers to choose the retail power supplier offering the price/service quality combination that best meet their needs. Competing retail suppliers were then expected to provide an enhanced array of retail service products, risk management, demand management, and new opportunities for service quality differentiation to better match individual consumer preferences.

It has also been widely recognized that significant portions of the total costs of electricity supply --- distribution and transmission --- would continue to be regulated. Accordingly, reforms to traditional regulatory arrangements governing the distribution

and transmission networks have generally been viewed as an important complement to the introduction of wholesale and retail competition to supply consumer energy needs. Privatization of distribution and transmission companies combined with the application of PBR regulation imposes hard budget constraints on regulated network firms and provides better incentives for them to reduce costs and improve service quality (Joskow 1998b). In addition, the efficiency of competitive wholesale and retail markets depends on a well functioning supporting transmission and distribution network infrastructure.

### **BASIC ARCHITECTURE FOR RESTRUCTURING AND COMPETITION**

While a number of variations are potentially available (Hunt 2002, Joskow 2000, 2003), the basic architecture for restructuring and the development of competitive markets for power involves several key components:

- a. Privatization of state-owned utilities.
- b. Vertical separation of competitive segments (e.g. generation, marketing and retail supply) from regulated segments (distribution, transmission, system operations) either structurally (through divestiture) or functionally (with internal “Chinese” walls separating affiliates within the same corporation).
- c. Horizontal integration of transmission and network operations to encompass the geographic expanse of “natural” wholesale markets and the designation of a single independent system operator to manage the operation the network, to schedule generation to meet demand and to maintain the physical parameters of the network (frequency, voltage, stability).

- d. The creation of public wholesale spot energy and operating reserve market institutions to support requirements for real time balancing of supply and demand, to respond quickly and effectively to unplanned outages of transmission or generating facilities consistent with the need to maintain network voltage, frequency and stability parameters within narrow limits, and to facilitate economical trading opportunities among suppliers and between buyers and sellers.
- e. The application of regulatory rules and supporting network institutions to promote access to the transmission network by wholesale buyers and sellers in order to facilitate efficient competitive production and exchange, including mechanisms efficiently to allocate scarce transmission capacity among competing network users.
- f. The unbundling of retail tariffs to separate prices for retail power supplies and associated customer services to be supplied competitively from distribution and transmission services that would continue to be provided by regulated monopolies. This makes it possible for retail consumers eligible to choose their power suppliers competitively to purchase their power supplies from competing retail suppliers. The competitive retail suppliers in turn must buy their power in wholesale markets, or own generating facilities to support their retail supply commitments, and then deliver the power for a fee over the regulated distribution network to meet their retail customers' demand for electricity.
- g. Where retail competition is not available (e.g. for domestic and small commercial customers), distribution companies would continue to have the responsibility to supply these customers by purchasing power in competitive wholesale markets or, if they choose, to build their own generating facilities to provide power supplies. Hoiwever, in

the latter case the associated charges for power would be subject to wholesale market-based regulatory benchmarks.

- h. Independent regulatory agencies with good information about the costs, service quality and comparative performance of the firms supplying regulated network services, the authority to enforce regulatory requirements, and an expert staff to use this information and authority to regulate effectively the prices charged by distribution and transmission companies and the terms and conditions of access to these networks by wholesale and retail suppliers of power, are also an important but underappreciated component of successful reforms. Regulators should rely on well-designed PBR mechanisms that meet budget balance, rent extraction and efficiency criteria, given the information available to them (Joskow 1998b) and must create a stable and credible regulatory environment that will support the attraction of the capital needed to improve the performance and expand the regulated network platforms upon which competition depends.

### **ELECTRICITY'S UNUSUAL COMBINATION OF ATTRIBUTES**

Electricity has an unusual set of physical and economic attributes that significantly complicate the task of successfully replacing hierarchies (vertical and horizontal integration) with decentralized market mechanisms. These attributes must be recognized and incorporated into the successful design of competitive market and regulatory institutions (Joskow 2003) to avoid performance failures. These attributes include:

- a. Electricity cannot be stored economically and demand must be cleared with “just-in-time” production from generating capacity available to the network at (almost) exactly the same time that the electricity is consumed. Physical laws governing

electricity network operations in real time to maintain frequency, voltage and stability of the network, along with network congestion and physical losses, interact with non-storability to require that supply and demand be cleared continuously at every *location* on the network. Network congestion, combined with non-storability, may limit significantly the geographic expanse of competition by constraining the ability of remote suppliers to compete, further enhancing market power problems. Creating a set of complete markets that operate this quickly, at so many locations, and without creating market power problems is a significant challenge.

- b. The short-run demand elasticity for electricity is very low and supply gets very inelastic at high demand levels as capacity constraints are approached. As a result, spot electricity prices are inherently very volatile and unusually susceptible to the creation of opportunities for suppliers to exercise market power unilaterally.
- c. Loop flow, resulting from the physics of power flows on AC networks, introduces additional complex interactions between generators at different points on the network, creating unusual opportunities for suppliers to take actions unilaterally to affect adversely market prices, complicating the definition of property rights, and creating coordination and free riding problems.
- d. The combination of non-storability, real time variations in demand, low demand elasticity, random real time failures of generation and transmission equipment, the need to continuously clear supply and demand at every point on the network to meet the physical constraints on reliable network operations, means that some source of real time “inventory” is required to keep the system in balance. This “inventory” is generally provided by “standby” generators that can respond very quickly to changing



supply and demand conditions, though demand side responses can also theoretically provide equivalent services as well. Compatible market mechanisms for procuring and effectively operating these “ancillary services” are therefore necessary but difficult to design.

These attributes affect the design of efficient market and regulatory institutions. The failure to carefully integrate these attributes into the design of regulatory and market institutions has created market performance problems.

### **RESTRUCTURING AND COMPETITION HAS IMPROVED PERFORMANCE**

When electricity restructuring and competition programs are designed and implemented well, electricity sector performance can improve significantly. The performance improvements come from a *combination* of institutional reforms: privatization of state-owned enterprises, vertical and horizontal restructuring to facilitate competition and mitigate potential self-dealing and cross-subsidization problems, PBR regulation applied to the regulated transmission and distribution segments, good wholesale market designs that facilitate efficient competition among existing generators, competitive entry of new generators, and retail competition, at least for industrial customers. The evidence is compelling:

- a.** Privatization and the application of high-powered regulatory mechanisms has led to improvements in labor productivity and service quality in electric distribution systems in England and Wales, Argentina, Chile, Brazil, Peru, New Zealand and other countries (Newbery and Pollitt 1997, Rudnick and Zolezzi 2001, Bacon and Besant-Jones 2001, Estache and Rodriguez-Pardina 1998). Sectors that had experienced

physical distribution losses due to poor maintenance and antiquated equipment, as well as resulting from thefts of electric service, have generally experienced significant reductions in both types of losses. Penetration rates for the availability of electricity to the population have increased in those countries where service was not already universally available and queues for connections have been shortened. Distribution and transmission network outages have declined. Improved performance of regulated distribution (and sometimes transmission) systems has accompanied privatization and the application of high-powered PBR mechanisms almost everywhere it has been implemented.

- b.** The performance of existing generating plants that have been privatized and required to operate in competitive wholesale markets has generally improved dramatically (Newbery and Pollit 1997, Rudnick and Zolezzi 2001). Old inefficient and uneconomic generating facilities have been retired. Costly political preferences for using domestic fuels and equipment have been undercut by the need for private generating companies to reduce costs to compete successfully.
- c.** Substantial amounts of capital have been mobilized to support construction of new efficient generating capacity in many countries that have implemented reforms. In the U.S., about 150,000 Mw of new generating capacity, most of it merchant capacity, has begun operating in the last five years. About 40% of the stock of generating plants in service in England and Wales has been replaced with modern efficient combined-cycle gas turbine (CCGT) technology as old coal-burning generators have been closed and expensive dirty coal plants have been displaced by cheaper and cleaner CCGT capacity (Newbery and Pollitt 1997). Many other

countries implementing reforms have also attracted significant investment in both distribution infrastructure and existing and new generating capacity (Jamash 2002). However, generation and transmission investment incentives remain an issue in many developed countries, as I shall discuss presently, and the poor financial experience of foreign investors in Latin America, East Asia, India and Pakistan has led to a significant decline in foreign investment in these countries' electricity sectors since the late 1990s.

- d. Wholesale electricity prices in England and Wales, in much of Europe, in Australia, and in several Latin American countries have fallen (controlling for fuel price changes) as competitive wholesale markets have developed and entry of new generating capacity has expanded supplies and increased competition.
- e. Retail electricity prices have become better aligned with electricity supply costs as a consequence of better regulation of distribution and transmission charges and the diffusion of retail competition, especially for larger industrial customers. In some countries this has meant increasing retail prices that previously had been too low, but especially developed countries, retail prices have generally fallen to reflect reductions in costs (Jamash 2002, Chisari, Estache, and Romero 1997).

#### **THERE HAVE ALSO BEEN PERFORMANCE PROBLEMS**

Electricity restructuring and competition initiatives have also exhibited to a number of performance disappointments and problems, making ongoing reforms necessary. These problems include:

- a. Market power in spot wholesale power and operating reserve markets. Significant wholesale market power problems have been identified empirically in a number of countries using both ex post empirical evidence and ex ante simulation models (Wolfram 1999, Borenstein, Bushnell and Wolak 2002, Joskow and Kahn 2002). The problems can be attributed to the interactions between the attributes of electricity networks noted above, too few competing generating companies, wholesale market design flaws, vertical integration between transmission and generation that creates the incentive and opportunity for exclusionary behavior, excessive reliance on spot markets rather than forward contracts, and limited diffusion of real time prices and associated communications and control technology that facilitates the participant of demand in wholesale spot markets. As a result, market power mitigation strategies have become an important component of wholesale market reforms. However, efforts to mitigate market power with restrictions on bidding behavior and price caps, rather than with structural remedies (e.g. divestiture of generating plants by firms with market power, mandatory forward contracts, and market design improvements), may have caused more harm than good and adversely affected investments in new generating capacity.
- b. The most efficient design of spot wholesale energy markets continues to be a subject of dispute among interest groups and independent experts (Joskow 2003, Hunt 2002, Stoft 2002). Should the market be built around a pool or rely on bilateral contracts? Should there be locational pricing of energy and operating reserves? How should scarce transmission capacity be allocated? Should transmission rights be physical or financial (Hogan 1992, Joskow and Tirole 2000)? While there is some room for

flexibility, and some of the disputes reflect the self-serving arguments of interest groups that expect to benefit from inefficient markets, I believe that the experience to date supports the desirability of several basic wholesale market design features. These basic design features include the creation of voluntary public spot markets for energy and ancillary services (day-ahead and real time balancing) that accommodate bilateral contracts and self-scheduling of generation; locational pricing reflecting the marginal cost of congestion and losses at each location; the integration of spot wholesale markets for energy with the efficient allocation of scarce transmission capacity; auctioning of (physical or financial) contingent transmission rights that are simultaneously feasible under alternative system conditions to hedge congestion, serve as a basis for incentives for good performance by system operators and transmission owners, and partially to support new transmission investment; an active demand side that can respond to spot market price signals (Borenstein, Jaske and Rosenfeld 2002). The allocation of transmission rights can affect the incentives of firms to exercise market power and this should be taken into account in the design of rights allocation mechanisms and restrictions on the entities that can purchase these rights (Joskow and Tirole 2000, Gilbert, Neuhoff and Newbery 2002).

- c. No market design will work well if there are not an adequate number of competitive suppliers of generation service or the market power of dominant firms has not been mitigated in some way (i.e. with regulated forward contracts). There should be a large number of competing suppliers of generation service and deep liquid bilateral forward wholesale markets for physical and financial contracts for power.

- d. Independent market monitors are necessary to identify behavior by market participants that distorts market prices from competitive levels and market design flaws that create opportunities for market participants to profit from inefficient strategic behavior.
- e. Retail competition initiatives have often worked well for large industrial and commercial customers. But the benefits for residential and small commercial customers are yet to be demonstrated compared to alternative procurement arrangements that retain distribution company responsibilities for supplying smaller customers by procuring power in competitive wholesale markets (Green 2000, Joskow 2003). Providing electricity supplies competitively to small customers is relatively costly and these customers have proven to be quite “sticky,” creating potential market power problems. Developing and applying viable models to deliver the benefits of wholesale market competition to smaller customers is an ongoing reform challenge.
- f. Stimulating performance improvements in the operation of transmission networks and, especially, attracting adequate investment to reduce congestion and to increase the geographic expanse of competition to reduce market power and the associated need to regulate wholesale markets to mitigate it, has been a challenge. The transmission systems that have exhibited the best performance are organized with a single independent transmission company that spans a large geographic area, integrates system dispatch, congestion management, network maintenance and investment under PBR regulation (e.g. NGC in England and Wales). Fragmented transmission ownership, separation of system operations from transmission

maintenance and investment, and poorly designed incentive regulation mechanisms reduce performance (Joskow 2003). Relying primarily on market-based “merchant transmission” investment, that is where new transmission investments must be fully supported by congestion rents (the difference in locational prices times the capacity of a new link) is likely to lead to inefficient investment in transmission capacity (Joskow and Tirole 2003).

- g. Creating appropriate investment incentives for new generating capacity is a growing problem in many countries. The environment for financing new generating investments has changed dramatically in the last two years as a result of financial problems for merchant trading and generating companies in Europe, the U.S. and Latin America as well as macroeconomic instability (Joskow 2003, Jamasb 2002, De Araujo 2001). Investors are looking for stable market rules and longer term contractual commitments before they will commit capital. Financing investments in peaking capacity, which relies heavily on wholesale market prices creating “rents” to support fixed investment costs in a relatively small number of hours is especially problematic. A number of countries are considering imposing resource adequacy or forward contracting commitments on the entities that provide retail service to overcome imperfections in wholesale spot markets to restore incentives for investments in generating capacity and demand response capabilities consistent with traditional reliability levels (Joskow 2003).
- h. Regulatory institutions that are independent, are well staffed and have access to necessary information about costs, prices, and service quality continue to be an important linchpin of successful electricity reform programs. Inadequate attention

has been paid to create good regulatory institutions in many countries, especially developing countries.

## **CONCLUSION**

Structural, regulatory and market reforms have been applied to electricity sectors in many countries around the world. Significant performance improvements have been observed in many countries as a result of these reforms, especially in countries where the performance of state-owned monopolies was especially poor. Privatization and PBR mechanism applied to regulated distribution companies has generally yielded significant performance improvements. Wholesale markets have also stimulated improved performance from existing generators and helped to mobilize significant investments in new generating capacity in several countries.

However, efforts to create well functioning competitive wholesale and retail markets have revealed many significant challenges and the restructuring and competition reforms remain a work in progress in most countries. The California electricity crisis (Joskow 2001), scandals involving energy trading companies like Enron, the failure of poorly designed reforms in countries such as Brazil, macroeconomic problems undermining investments in generally well designed systems as in Argentina, and ongoing political interference undermining private sector investments as in India and Pakistan, have certainly made policymakers more cautious (but not necessarily more thoughtful) about electricity sector reforms. The challenges associated with successful reforms have sometimes been underestimated. However, these problems and challenges do not imply that restructuring, regulatory reform, and promoting the development of



competitive wholesale and retail markets for power, are ill-advised. The problems that have emerged are now much better understood and solutions to many of them are at hand. The electricity sector reform program should go forward taking account of the lessons that have been earned. The primary question is whether governments properly can choose between competing solutions and have the political will to resist interest group pressures and pursue reforms that will lead to more efficient markets and better performance of the network platforms upon which competition depends.

## REFERENCES

- Bacon, R. W., and J. E. Besant-Jones. 2001. "Global Electric Power Reform, Privatization and Liberalization of the Electric Power Industry in Developing Countries." *Annual Reviews of Energy and the Environment* 26: 331–59.
- Besant-Jones, J. E., ed. 1993. "Reforming the Policies for Electric Power in Developing Countries." Washington, D.C.: World Bank.
- Borenstein, S., J. Bushnell and F. Wolak, 2002 "Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market," *American Economic Review*, December, 92(5), 1376-1405.
- Borenstein, S., M. Jaske and A. Rosenfeld, 2002. "Dynamic Pricing, Advanced Metering and Demand Response in Electricity Markets," Center for the Study of Energy Markets Working Paper, University of California at Berkeley, October.
- Chisari, O., A. Estache, and C. Romero. 1997. "Winners and Losers from Utility Privatization in Argentina: Lessons from a General Equilibrium Model." World Bank Working Paper No. 1824, World Bank, Washington, D.C.
- De Araujo, J. L. R. H. 2001. "Investment in the Brazilian ESI — What Went Wrong? What Should Be Done?" Institute of Economics, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.
- Estache, A. and M. Rodriguez-Pardina, 1998. "Light and Lightning at the End of the Public Tunnel: The Reform of the Electricity Sector in the Southern Cone," World Bank Working Paper, May.
- Gilbert, R. , K. Neuhoff, and D. Newbery, 2002. "Allocating Transmission to Mitigate Market Power in Electricity Networks, Cambridge-MIT Electricity Project Working Paper, October.
- Green, R., 2000, "Can Competition Replace Regulation for Small Utility Customers?", Centre for Economic Policy Research, Discussion Paper 2405.
- Hogan, W., 1992, "Contract Networks for Electric Power Transmission," *Journal of Regulatory Economics*, 4: 211–242.
- Hunt, S. 2002, *Making Competition Work in Electricity*, New York, Wiley.
- Jamasb, T., 2002, Reform and Regulation of The Electricity Sectors in Developing Countries, June 2002, Department of Applied Economics, University of Cambridge.
- Joskow, P. L., 1998a. "Electricity Sectors in Transition." *Energy Journal* 19:25–62.

\_\_\_\_\_, 1998b. "Regulatory Priorities for Reforming Infrastructure Sectors in Developing Countries." The 10<sup>th</sup> Annual Bank Conference on Development Economics, April 20-21, World Bank, Washington, D.C.

\_\_\_\_\_. 2000. "Deregulation and Regulatory Reform in the U.S. Electric Power Sector." In Sam Peltzman and Clifford Winston, eds., *Deregulation of Network Industries: What's Next?* Washington, DC: Brookings Institution Press.

\_\_\_\_\_, 2001, "California's Electricity Crisis," *Oxford Review of Economic Policy*, 17,(3), 365-388.

\_\_\_\_\_, 2003, "The Difficult Transition to Competitive Electricity Markets," MIT Center for Energy and Environmental Policy Research Working Paper, May.

\_\_\_\_\_ and E. Kahn, 2000. "A Quantitative Analysis of Pricing Behavior in California's Wholesale Electricity Market During Summer 2000," *The Energy Journal*, 23(4),1-35.

\_\_\_\_\_ and J. Tirole, 2000, "Transmission Rights and Market Power on Electric Power Networks," *Rand Journal of Economics*, 31(3), 450-487 .

\_\_\_\_\_ and J. Tirole, 2003, "Merchant Transmission Investment," CMI Electricity Project Working Paper, May 2003. <http://web.mit.edu/pjoskow/www/>

Newbery, D., and M. Pollitt, 1997. "The Restructuring and Privatization of Britain's CEGB – Was it Worth It?" *Journal of Industrial Economics*, 45(3), 269-303.

Rudnick, H. 1996, "Pioneering Electricity Reform in South America," *IEEE Spectrum*, August, 38-45.

Rudnick, H., 1998 "Market Restructuring in South America," *IEEE Power Engineering Review*, June, 3-6.

Rudnick, H., and J. Zolezzi. 2001. "Electric Sector Deregulation and Restructuring in Latin America: Lessons to be Learnt and Possible Ways Forward." In *IEEE Proceedings Generation, Transmission and Distribution* 148: 180-84.

Stoft, S., 2002, *Power System Economics*, Wiley Interscience.

Wolfram, Catherine, 1999. "Measuring Duopoly Power in the British Electricity Spot Market," *American Economic Review* 89(4), 805-826.

World Bank, 1994. *Infrastructure for Development: World Development Report 1994*.