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Neither Lucky Nor Good: The Case of Electricity Deregulation in California*

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Abstract: We present an integrated summary of the various factors that contributed to shortages of electrical power in California in 2000. Several necessary conditions for the crisis are identified. We conclude that a sufficient remedy may be defined by policies that mitigate the limited incentives to invest in transmission capacity.

I INTRODUCTION

Various factors have been blamed for the electrical power crisis in California – the usual suspects include increased demand for power, reduced hydroelectric capacity, fixed retail prices, restrictions on long-term contracting, insufficient investment in generation, market power, and high natural gas prices. We present an integrated summary of these factors, several of which are identified as necessary conditions for the crisis. We conclude that an insufficient incentive to invest in transmission capacity is the single, most critical factor that must be addressed if reforms are to be successful.

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II ON THE PRODUCTION AND FLOW OF ELECTRICITY

Delivery of electricity from producer to consumer entails three distinct functions: generation, transmission, and distribution. Generation is the process by which mechanical work is converted to electrical power. Transmission refers to the bulk movement of electrical power from points of generation to points of distribution. Distribution refers to the final stage of delivery of electrical power from a system of bulk transmission lines to individual consumers.

An understanding of several technical aspects of electricity production and consumption is important for properly modelling these markets. To begin, all functions of electrical service provision remain relatively capital intensive,[1] in spite of technological innovations that have reduced the minimum efficient scale of generation.[2] Moreover, that electricity cannot be efficiently stored accentuates the capital intensity of supply. Generation and transmission systems must be designed to serve peak demand since electricity producers and consumers have a limited ability to make use of inventories. Finally, current technologies do not permit one to control the path that electricity travels across an interconnected grid. Thus, it is impossible to ensure that electricity will flow to a consumer along any particular "contract path".

The capital intensity of distribution suggests this function will remain a natural monopoly. The capital intensity of generation and the inability to store electricity suggest a short-run supply curve that is relatively elastic at low levels of output but turns highly inelastic as fixed capacity constraints set in. The non-excludable nature of transmission capacity suggests these assets may be under-provided by the private sector.

On the demand side, electricity is an important input in a broad range of production and consumption processes. Moreover, consumers may be unable to find substitutes that are suitable for many applications, at least in the short run. Thus, inelasticity of demand is a feature that distinguishes electricity from many goods.

These four distinguishing features of electricity – high fixed costs of supply, limited storability, inefficient switching technologies, and low elasticity of demand – have important implications for the structure and performance of electricity markets.

[1] Yatchew 2000.
[2] Energy Information Administration 2000.

III ON THE CALIFORNIA EXPERIENCE

The state of California is disproportionately reliant on hydroelectric and natural gas fired generation. In addition to nuclear power, electricity generated from these sources serves approximately 86 per cent of state demand.[3] An additional 4 per cent of demand is served by generation from renewable resources. The balance of demand, a large fraction by national standards, is served by imports from other states and Canada.[4]

California's restructuring efforts were launched with Assembly Bill 1890 which passed unanimously through both houses of the legislature and was signed into law in 1996. This legislation provided for the organisation of an independent operator of California's transmission grid. Utilities were ordered to divest of a majority of their generation assets in order to encourage development of an open wholesale market for electricity.[5] Legislation also provided for the introduction of competitive retail sales of electricity and measures aimed at financing recovery of stranded costs.[6]

Some have argued that California is a victim of its own poorly devised policies. First, the state prohibited retail utilities from long-term contracting for electricity. This provision was intended to hasten formation of the wholesale spot market and market price discovery. It would also expose retailers to spot market volatility. A second apparently ill-advised policy was the temporary fixing of retail prices. This policy was intended to provide retail utilities with an incentive to write off stranded costs so pre-liberalisation investments would not burden customers of the deregulated regime. Now exposed to spot market volatility, this policy would ensure retail utilities would incur operating losses as spot prices increased. Finally, it has been argued that opposition to facility siting by environmental and community groups limited expansion of generation and transmission capacity, further exacerbating California's problems.

Several exogenous events suggest that California was relatively unlucky in 2000, as well. First, the region experienced a significant increase in demand. This occurred not only in California but also in southwestern states that are large exporters of power. On the supply side, the Pacific Northwest received relatively little snow in the winter of 1999 to 2000. This event sharply reduced hydroelectric capacity available in the region. Finally, extraordinarily high natural gas prices increased the cost of electricity generation at newer

[3] Energy Information Administration 2001.
[4] Ibid.
[5] Governor's Office of Communication, State of California 2001.
[6] Stranded costs are capital expenditures by utilities that were approved under the regulated regime but would have been unprofitable in a restructured market.

gas-fired facilities. In combination with the prohibition of long-term contracting, the adverse weather and gas price conditions that developed in early 2000 exposed retail utilities to rapidly rising costs for wholesale power.

IV THE REGULATED MONOPOLY REVISITED

The performance of markets for electrical service in California can be examined using the extended regulated monopoly framework presented in Figure 1. Panels A and B represent the regulated market for retail electrical service in the long and short runs, respectively. The deregulated market for wholesale electricity is presented in panels C and D.

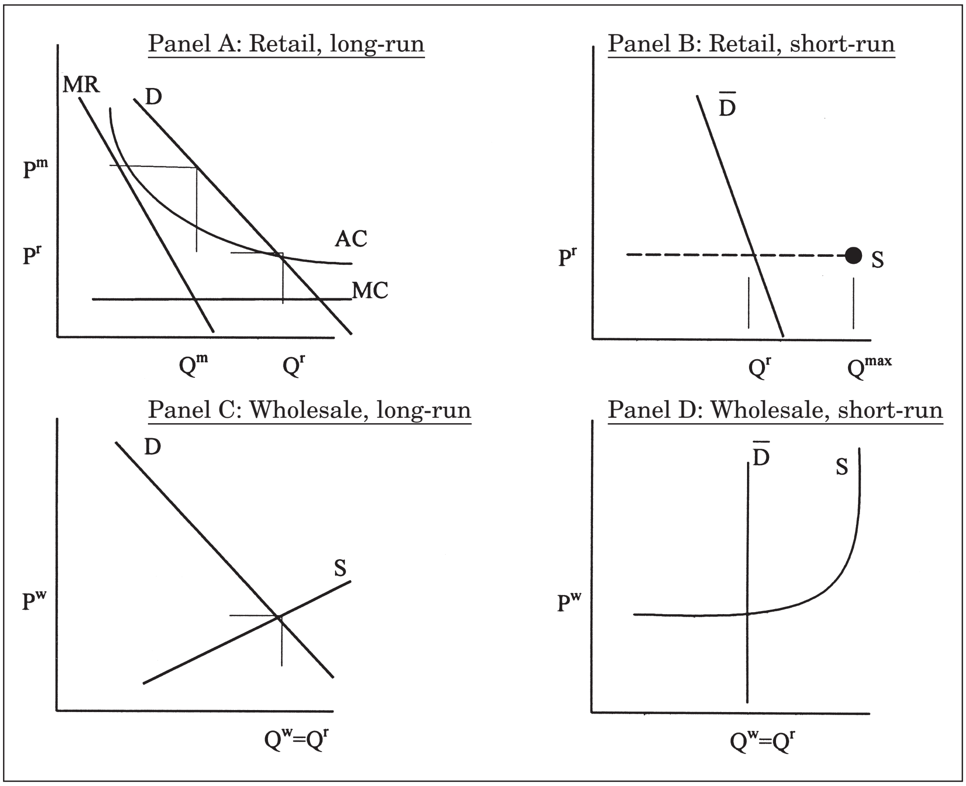

Figure 1: *The Market for Electrical Service*

In panel A, the long-run average demand curve, D, implies a marginal revenue schedule, MR. The retail sector is assumed to be monopolistically competitive since fixed-costs are significant and end users of electricity are captive to a single distribution-system-owning firm. The optimal solution for the monopolist retail service provider is to choose output Q^m and charge a price P^m such that MR is equal to marginal cost, MC. Ruling out income transfers, the regulator will prefer the second-best solution to this pricing problem, P^r, which expands output to Q^r while assuring the utility recovers long-run average costs, AC.

Panel C illustrates the long-run market clearing quantity and price in the unregulated market for wholesale electricity. The demand curve, D, facing wholesalers is that determined in the retail market. In addition to the usual factors of input costs and technology, the wholesale supply curve, S, reflects a particular state of grid capacity. An increase in grid capacity, all things equal, would ensure that entrants in wholesale generation have access to retail markets and would tend to increase supply, driving down the equilibrium wholesale price, P^w.

In the short-run wholesale market depicted in panel D, demand, $\overline{D}$, is completely inelastic, reflecting the must-serve obligation facing retail service providers. The supply curve, S, is highly elastic at low levels of output, reflecting the constant marginal costs of fuel and other variable inputs. Short-run wholesale supply turns completely inelastic as output approaches fixed capacity constraints. This upper capacity constraint defines the maximum possible supply available to the retail market in the short run, Q^{max}.

Panel B depicts the market for retail electrical service in the short run. Demand, $\overline{D}$, is depicted as relatively inelastic as compared to that in the long run, illustrating the difficulty of finding suitable substitutes for electricity over this horizon. In addition, short-run retail demand is understood to be a stochastic function of price as exogenous shocks to factors such as weather or income shift $\overline{D}$. The short-run supply correspondence represented by the dashed line illustrates both the retailer's must-serve obligation defined by the solution to the regulator's pricing problem and the capacity constraint determined by private investment in wholesale generation capacity.

The model presented in Figure 1 can be used to assess the interrelation of the various factors believed to have caused the California power crisis. High natural gas prices and limited rainfall available to recharge hydroelectric facilities shifted back the short-run wholesale supply curve. As a result, maximum deliverability to the retail market, Q^{max}, also shifted back. The regional increase in demand may be viewed as a series of positive realisations of shocks that effectively shifted out $\overline{D}$ in short-run retail and wholesale markets. The result of these exogenous events was that wholesale equilibrium price determination moved into the inelastic regions of the demand and supply schedules. These shifts would cause wholesale prices to spike dramatically as continued shocks to demand and supply were realised. In addition, Puller

(2001), Joskow and Kahn (2001), and Borenstein, Bushnell, and Wolak (2000) suggest pricing power is significant when wholesale power markets operate in the inelastic regions of demand and supply.

V DISCUSSION

Given the foregoing analysis, we now ask, what changes could have been made to avoid the problems of 2000? What changes can be made to improve the long-run functioning of electricity markets in California? While acknowledging that policies can be devised to reduce demand growth and natural gas prices, we take these factors, along with the weather, to be largely beyond the control of energy market regulators.

Some have argued that the problems in California are primarily a consequence of market power by suppliers. The foregoing analysis casts market power as a symptom of more fundamental problems in energy markets. If deliverability were sufficient to keep short-run wholesale price determination on the elastic portion of the supply curve, wholesale suppliers would be unable to exercise market power.

Some have argued that simply eliminating the fixed retail price provision would have avoided the utilities' financial losses since they would have been able to pass the high wholesale prices onto consumers. But the political feasibility of deregulation requires something more for consumers than high and volatile prices. More importantly, floating retail prices would not have avoided the more basic problem of insufficient deliverability of wholesale electricity. A long-term solution to California's problems must increase short-run wholesale supply so that the probability of positive realisations of demand shocks in excess of Q^{max} is unlikely.

Eliminating the prohibition on long-term contracting will increase short-run wholesale supply to the extent that contracting activity increases long-run wholesale supply by reducing the risk of investment in new generation capacity. Other measures to limit the ability of community and environmental groups to hold up wholesale capacity expansions will have similar effects. To the extent that these collective efforts simply reflect local preferences, however, market reforms should allow for localities that may prefer to import their power.

Additional investment in transmission capacity will shift out short-run wholesale supply as such investments provide access to larger markets from which to import.[7] There are reasons to believe, however, that private decision

[7] Borenstein, Bushnell, and Soft 2000.

making will under-provide transmission assets. To begin, recall that the interconnected nature of a transmission grid implies positive externalities to transmission investment. Existing transmission capacity owners are therefore more likely to justify investment as they internalise more of the gains to capacity expansion. If wholesale generators maintain ownership interests in grid assets, however, these same firms may have reduced incentives to upgrade grid capacity as they benefit from pricing power associated with regional capacity constraints in the market for wholesale generation.

VI CONCLUSIONS AND RECOMMENDATIONS

While various causes have been proposed to explain the power crisis in California, little attention has been focused on issues associated with transmission capacity investments. The literature has also avoided an integrated analysis that allows one to consider the full range of causes of the crisis within a single framework. By applying such an analysis, a few previously overlooked issues fall into relief. In particular, it is unclear that efficient expansion of the electrical transmission network can be expected. Market participants may face conflicting incentives for investment in transmission capacity. Efficient expansion of transmission holds the potential to stabilise newly opened generation and retail sectors. Looking forward, adequacy of transmission capacity is a key issue that will need to be resolved as the electricity industry is restructured in California and elsewhere.

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