A Critical Issue in Electricity Reliability: Minimizing Regional Economic Losses in the Short Run

By Adam Rose*

Introduction

Since the New York City blackout of 1965, the primary focus of electricity service reliability has been on engineering failures in both small and integrated systems. The recent problems with the electric utility industry in California and elsewhere have dramatized three other issues of service reliability. First, is a lack of capacity for power supply in general to meet customer needs under normal engineering operating conditions. Second, is the problem of having adequate supplies but at exorbitant prices. Third, is the broader negative impact of supply interruptions and related industry problems such as utility bankruptcies.

Below, I focus on several aspects of the third issue, though aspects of the other two come into play. I pass no judgment on the causes of the current California crisis, though an underlying premise of my discussion is that similar situations are likely to develop elsewhere if deregulation proceeds without adequate safeguards. I should also note that much of my insight into the problem comes from what might first seem like a specialized area of the reliability issue, but one which I believe has applicability—the regional economic impact of an electricity service disruption caused by a major earthquake. Except for causation, the implications of a hazard-induced or an institutionally-induced service disruption are similar in nature, as are some of the policy measures to cope with them. In short, both types of events cause ripple or general equilibrium effects whose sum can be a large multiple of the direct profit losses or direct customer sales losses. Also similar are the application of interruptible service discounts or various other mechanisms for rationing electricity services made even more scarce by the adverse situation.[1]

A Broader Perspective on Loss Estimation

Industrial economies are characterized by a high level of economic interdependence, where negative impacts in one sector set off a chain-reaction affecting sales of suppliers and customers, as well as still further losses through decreases in wages and profits and subsequent declines in household spending. In the aftermath of a short electricity disruption, some of these can be made up by overtime work (though at a higher cost), but several sectors, such as hotels, restaurants, and some internet services, cannot do so. The loss of electricity supply can also cause physical damage or high re-start costs that decrease productivity. The irony is that not just those who are without power are affected. Also suffering losses will be businesses physically unscathed and having adequate electricity, but whose suppliers are unable to deliver a critical input or whose customers cancel their orders, anywhere along the supply/demand chain, including many steps removed.

Fortunately, businesses have a number of coping measures that have improved their "resiliency," such as back-up generators, inventories of other critical inputs (electricity is notorious because of its lack of storability), and conservation. Also, a rearrangement of contracting is viable for outages lasting several days, though either impossible or not viable for short blackouts/brownouts associated with the current California crisis. Otherwise, ordinary multiplier effects are likely to be at a maximum here and can accelerate if a key industry, e.g., petroleum refining, is disrupted at a much higher level than others, thereby creating a supply bottleneck. Business failure of a large utility can set off a similar larger than normal shock wave.

Such broader damages to the economy are typically not assessed in evaluating reliability from the perspective of the individual customer or even the system. Losses are much greater than a drop in sales of the utility company or lost production of businesses directly affected. Thus, many of the current estimates of the economic impact of the California electricity crisis are probably far too low. Broader implications are often brushed aside because many believe they are difficult to quantify (which they are not) or subject to exaggeration (they often are, but safeguards exist). The point is that economic damage from an electricity service disruption is much larger than usually measured and hence warrants greater attention to its mitigation before and during the event.

Improved Allocation of Scare Electricity Services

The best long-term solution, of course, is to make sure adequate capacity exists in the system itself or to improve the interaction of larger regional grids to make use of excess capacity elsewhere. Increased capacity comes at a cost, however, and efficiency is best served when it is not standing idle for much of the day. Thus, instruments like time-of-use metering are a valuable supplement to the long-run solution of the problem.

In the meantime, mechanisms exist for promoting the best allocation of scarce electricity. One approach is interruptible service discounts (or non-interruptible service premia). The problem comes in estimating these accurately. Most businesses have very limited experience with actual disruptions and can often make only guesses at what continued service is worth. Also, business conditions change momentarily, and these premia, which would ideally reflect the avoidance of marginal damages from an interruption, remain fixed for long periods. Still, there is a problem in that individual businesses will fail to take into account broader implications of their decisions concerning service interruptibility. However, overcoming the "partial equilibrium" optimizing problem may not be sufficient. For example, a firm may pay the premium but still be forced to shut down if one of its suppliers decides not to pay it. It is not clear that the market can incorporate all these features, especially given the lack of experience and lack of accurate "real time" information. (Of course, angry phone calls from customers to suppliers following recent events will stimulate

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[1] I have been fortunate to have received funding from the U.S. National Science Foundation to study the economic impacts of the actual Northridge earthquake of 1994 (Rose et al., 1997a), from the Multidisciplinary Center for Earthquake Engineering Research to study a hypothetical New Madrid (Memphis, Tennessee) earthquake (Rose et al., 1997b; Shinozuka et al., 1998; Rose, 1999; Rose and Benavides, 1999), and to assist in the development of the Federal Emergency Management Agency's design of an expert system for earthquake impact analysis (FEMA, 1997; Brookshire et al., 1997).

some rethinking of this, including the possibility of side-payments to better approximate an economy-wide efficient use of electricity. Ordinary breach-of-contract provisions may not be sufficient because of *force majure* exclusions.)

What is needed in accurately estimating non-interruptibility premia is an assessment of the contribution to the entire economy, a type of "general equilibrium" solution. Here energy economists have the modeling capability to provide the necessary information that may not be available to individual firms.

Pricing is almost universally supported by economists as the best rationing device for scarce resources, but two problems, from opposite extremes, arise in its application to the current context. The first, pertaining to the California case, is that retail electricity prices may be capped by law and cannot provide this support function. The other is when retail prices go through the roof or are highly volatile, causing an unsettling set of adjustment problems, cost-push inflation, and concerns about the ability of low income families to heat their homes. Almost any shortage can be eliminated if we let price go high enough, but that solution does have its down-sides.

An alternative when prices are actually capped or where there is some concern that the market equilibrium will make them go far too high is to use some form of non-market rationing, the best example of which is surrogate market pricing with some forced demand shifts. Unlike the case of earthquakes, where there is some physical damage to the electricity system that decreases flexibility (e.g., cessation of operation of a large power plant or large transmission line), the necessary infrastructure is in place in this context. The same on-off switching that works for individual customers to implement the standard interruptibility option can be used to make other selections in emergencies. Where this technical capability does not exist, it can be accomplished by decree, through announcements of shutdowns for certain customer classes. Preferably, this prioritization of customers would not be done arbitrarily, but based on market considerations (even shadow prices). Of course, such prioritization of customers is likely to be a highly politically-charged issue. However, it cannot be avoided. Even the across-the-board approach typically used is a type of default prioritization. In other cases, utilities or their regulators have a prioritization, which they often keep under wraps, for emergencies such as natural disasters.

Serious consideration should be given to economic criteria for allocating scarce electricity resources, but again not on a partial equilibrium basis. What should be assessed is a customer's contribution to the overall economy both directly and indirectly. This favors customers who have the highest total employment or sales value contribution to the economy per dollar of electricity utilized. Service sectors typically score high on this indicator if viewed in isolation, but the gap narrows considerably once we consider the energy utilization of all their indirect input demands.

Of course, I am not suggesting that major decision-makers confine themselves solely to economics, since considerations of health and safety are likely to be paramount. Some attention to geographic and socioeconomic distributions (a form of "energy justice") are likely also to be taken into account. Again, economic models exist to assist in such policy evaluations, including the ability to handle non-economic constraints. These models can be set up to provide real-time results so gains from load-shedding are not undercut by fine-turning delays.

Conclusion

How effective might improved measures to reallocate scarce electricity be in the case of California? To the best of my knowledge, no study has been undertaken to estimate this so far. However, I can offer some insights from my own work on electricity disruptions associated with earthquakes. My NSF study of the Northridge earthquake in the Los Angles Department of Water and Power Service Area indicated that unrestricted reallocation of electricity across sectors would have reduced losses of sales and employment in the earthquake aftermath by as much as 50%. This percentage applied to the "resiliency-adjusted" simulations as well. Also, additional gains could be achieved by altering the manner in which service is restored (e.g., rather than basing it on a minimization of restoration costs narrowly defined, a prioritization of customers on the basis of energy efficiency was estimated to be able to decrease economic losses by another 10-15%). Even larger economic savings were projected for a hypothetical 7.5 magnitude earthquake in the New Madrid Earthquake Zone, where supply bottlenecks in other sectors loom large because of their geographic concentration. I should mention that all of the above estimates of regional economic losses exaggerate subsequent reallocation potential because they were done with linear models and, while they allow for input substitution by electricity resiliency measures such as inventories, back-up-generators, and some conservation of electricity, no similar adjustments are incorporated for other inputs. Recent simulations with a more flexible model framework, computable general equilibrium (CGE) analysis, further support the general conclusion on the benefits of optimal electricity allocation. They indicate that normal market adjustments, including broader input substitutions, can significantly reduce economic losses from supply curtailments. CGE model estimates tend toward a lower-bound on loss estimation since they assume an immediate return to equilibrium, which would typically not take place for more than a year. They thus exaggerate the ease of adjustment and hence the cost-savings of reallocations for short-term disruptions. Still, they indicate that for such events, where ordinary market adjustment possibilities are limited, improved non-interruptible service premia and efficient reallocations implemented by decree, on the basis of efficiency prices, can at least expedite the adjustment process for electricity and go a long way to reducing the sizeable regional economic losses that are likely occurring in the current California crisis and potentially in other states.

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