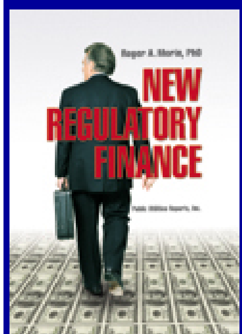

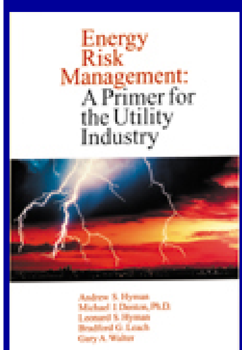

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Ancillary Services: A Call for Fair Prices

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By Eric Hirst, and Brendan Kirby

A case study shows how today's typical tariffs can force some industrial electric customers to subsidize others.

There ought to be a better way for electric utilities to set prices for ancillary services - so that customers pay rates that fairly reflect the needs they impose on the bulk power system. However, while federal officials seem to agree with this point, so far they have done little to turn the idea to action.

Last spring, in its notice of proposed rulemaking on regional transmission organizations (RTOs), the Federal Energy Regulatory Commission appeared to encourage innovative pricing for ancillary services. At that time it wrote, "The Commission believes that, whenever it is economically feasible, it is important for the RTO to provide accurate price signals that reflect the costs of supplying ancillary services to particular customers."[Fn.1]

Several years earlier, in Order 888, the FERC had warned against the simple solution of charging for ancillary services through transmission rates: "Because customers that take similar amounts of transmission service may require different amounts of some ancillary services, bundling these services with basic transmission service would result in some customers having to take and pay for more or less of an ancillary service than they use. For these reasons, the Commission concludes that the six required ancillary services should not be bundled with transmission service."[Fn.2]

Nevertheless, in spite of the FERC's fine words, almost all utilities today charge for ancillary services on the basis of customer demand (in megawatts) or energy (in megawatt-hours). Likewise, the existing and proposed independent system operators use billing determinants that have little or nothing to do with the services being provided.

By contrast, we believe that in competitive electricity markets the prices set for each ancillary service should track two ideas: (1) charge the costs to those that cause the costs to be incurred; (2) collect the costs to reflect the factors that contribute to these costs.

As an example of the first point, operating reserves are required to protect bulk-power systems from potential adverse effects associated with major forced outages at a power plant or transmission facility. For a plant outage, the costs of operating reserves should be assigned to generators, and should reflect the frequency and severity of forced outages. Although these costs ultimately are paid by retail electricity consumers, charging them to generators encourages generation owners to maintain equipment to reduce the frequency of forced outages.

As an example of the second point, the amount of generating capacity assigned to the regulation service is a function of the short-term volatility of system load. Therefore, the charges for regulation should be related to the volatility of each load, not to its average demand.

In this article we discuss the economic efficiency and equity benefits of assessing charges on the basis of customer-specific costs (rather than the traditional billing determinants, megawatt-hour or megawatt). We focus on two key real-power ancillary services - regulation and load following. We determine the extent to which individual customers and subgroups of customers contribute to the system's generation requirements for these two services, in particular whether some customers account for shares of these services that differ substantially from their shares of total electricity consumption.

A Case Study: Definitions and Method

These two ancillary services (regulation and load following) are similar in that each follows temporal variations in system load and helps the control-area operator meet its Control Performance Standards, as set by the North American Electric Reliability Council. Nevertheless, they differ in important ways:[Fn.3]

* Regulation is the use of online generating units that are equipped with automatic-generation control (AGC) and that can change output quickly (megawatts per minute) to track the moment-to-moment fluctuations in customer loads and unintended fluctuations in generation. In so doing, regulation helps to maintain Interconnection frequency, minimize differences between actual and scheduled power flows between control areas, and match generation to load within the control area. This service can be provided by any appropriately equipped generator that is connected to the grid and electrically close enough to the local control area that physical and economic transmission limitations do not prevent the importation of this power.

* Load following is the use of online generation equipment to track the intra- and inter-hour changes in customer loads. Load following differs from regulation in three important respects. First, it occurs over longer time intervals than does regulation, 10 minutes or more rather than minute to minute, and is therefore likely to be provided by different generators. Second, the load-following patterns of individual customers are highly correlated with each other, whereas the regulation patterns are largely uncorrelated. Third, load-following changes are often predictable (e.g., because of the weather dependence of many loads) and have similar day-to-day patterns. Alternatively, the customer can inform the control center of impending changes in its electricity use; as a consequence, these changes can be captured with short-term forecasting techniques.

These differences between regulation and load following have strong commercial implications. Regulation is a higher-value service than load following because of the need for higher generator speed and maneuverability. Therefore, regulation is likely a more expensive service. Similarly, individual customers differ in the amount of regulation and load-following services they require, and should pay accordingly.

Curiously, the FERC did not discuss load following in the section of its Order 888 defining six distinct ancillary services. Perhaps because of this omission, most utilities and ISOs have not included load following in their tariffs. (The Mountain West Independent Scheduling Administrator, in Nevada, is the only U.S. entity we know of that has proposed to create an explicit load-following service.[Fn.4]) The absence of this service requires the California ISO to acquire much more regulation (as well as other services, such as replacement reserves and supplemental energy) than it otherwise would.[Fn.5] Specifically, the California ISO buys regulation in amounts equivalent to about 5 percent of daily load, compared with about 1 percent for most vertically integrated utilities. Thus, the ISO is substituting an expensive service (regulation) for an inexpensive one (load following). The ISO is considering the addition of an explicit load-following service.

To develop and test methods for customer-specific assignment of the costs of regulation and load following, we obtained detailed data from a U.S. control-area operator. Specifically, we obtained 30-second data on generation and system loads, as well as the loads for several large industrial customers. These data cover a 12-day period in February 1999. Figure 1 shows the industrial, nonindustrial and total system loads for three weekdays and the weekend (with industrial load defined as the sum of the large, individually metered loads). The data for total system and nonindustrial loads show the expected winter patterns with morning and evening peaks, and loads lower (by about 10 percent) on the weekend days. The industrial load, on the other hand, remains relatively constant from hour to hour. Its volatility is about half that of the nonindustrial load.

The next step required us to separate regulation from load following.[Fn.6] To do that, we compared the volatility of system load and generation at the one-half-, one-, two- and four-minute levels. We found that the two sets of patterns were roughly similar with the two-minute averages of load and generation. We defined load following on the basis of the 30-minute rolling averages of these two-minute data and regulation on the basis of the difference between the two-minute load averages and the 30-minute rolling average. Based on this split between the two services, we set the following definitions:

* Load Following. The difference (in megawatts) between the maximum and minimum values within each hour of the 30-minute rolling average of these two-minute load data.

* Regulation. The standard deviation of the 30 individual regulation values in each hour.[Fn.7]

Case A (Regulation):

Volatility, Not Size

Our case study illustrates how the need for regulation is a function of load volatility, not size of load, indicating that demand-based methods are inappropriate for billing this ancillary service.

After reviewing several possible metrics, we focused on the standard deviation (in megawatts) of the 30 values in each hour to measure system-level regulation using the two-minute regulation values noted above. Figure 2 shows the hour-to-hour patterns in regulation magnitude for weekdays. This graph shows that the industrial loads have much greater volatility than do the nonindustrial loads. Indeed, as a share of total load, the industrial loads require about six times as much regulation as do the nonindustrial loads. Overall, the regulation standard deviation is 1.3 percent of the total load.

In our study, the correlation coefficients between load itself and regulation are very low for total load, nonindustrial load, and industrial load, suggesting that load is a poor predictor of regulation requirements. Therefore, load is a poor billing determinant to use in assessing charges for regulation.

We next developed a method to allocate fairly the total regulation requirement between any two loads (and, by extension, among several loads). Such an allocation method should meet certain objectives. First, it should yield results that are independent of any subaggregations. In other words, the assignment of regulation to load L should not depend on whether L is billed independently of other loads for regulation or is part of a larger group of loads. In addition, the allocation method should reward (pay) loads that reduce the total regulation burden. A third criterion for choosing an allocation method could be one that is independent of the order in which loads are added to the system; this objective overlaps with the first one discussed above. In other words, the method should treat loads equitably, regardless of whether their standard deviations are positively or negatively correlated with each other, or independent of each other.

The regulation-allocation method we developed uses the two-minute data for each load whose regulation requirement is to be individually measured and the two-minute data for the total system. Overall system regulation requirements are then calculated with and without the load of interest. That allowed us to develop a simple method that accounts for correlations among the regulation burdens of different loads, as well as their magnitudes. It is not necessary to meter the regulation requirements of all loads. (The regulation burden of non-metered loads can be allocated assuming that the regulation burdens of these non-metered loads are uncorrelated.)

The allocation method assigned the large industrial customers an average share of regulation equal to 93 percent of the total, almost triple their 34 percent share of system load. As shown in Figure 3, there were several hours during this period when the industrial customers were assigned more than 100 percent of the regulation requirement. During the hours the industrial share exceeded 100 percent, the nonindustrial customers would have received a credit for regulation, offsetting their regulation costs during the other hours.

These results show that large, volatile loads can require a control area to acquire significant amounts of capacity for regulation. This capacity could otherwise be sold into energy or contingency-reserve markets. The results also show that most loads have much smaller effects on overall regulation requirements and therefore do not merit separate metering for regulation purposes. The method developed here applies to both types of loads.

Case B (Load Following):

Peaks, Not Volatility

Our case study shows that the need for load following is tied to regular repeating patterns in customer load profiles. Load following, like regulation, should not be billed on the basis of peak demand or size of load.

We defined the load-following magnitude (in megawatts) as the difference between the maximum and minimum values of 30-minute rolling-average load during each hour. Unlike regulation, load following is a signed quantity, positive if it is rising during the hour and negative if it is falling. Also unlike regulation, there is a clear diurnal pattern, reflecting the morning and early evening peaks and the late evening dropoff shown in Figure 1. The nonindustrial loads track closely this diurnal pattern, while the industrial load is much more erratic in its load following.

As with regulation, the correlation coefficients between load and load-following magnitude are very small, suggesting that load itself is a poor predictor of load-following requirements. Again, this implies that load-following costs should not be collected on the basis of hourly demand.

We calculated each customer's (or each group of customers') share of load following as the ratio of the customer's coincident load-following amount to the total load-following amount. The use of coincident load following, rather than noncoincident load following, is important because not all loads reach their intra-hour minimum and maximum values at the same time. A customer with noncoincident load following should be charged less than a customer whose load-following requirement is coincident with the system's requirement. Generally speaking, high load-following hours have load changes that span the full 60 minutes.

Figure 4 shows the absolute value of system load following and the coincident contributions from the two components. This figure shows the importance of the industrial load during the hours of mild load-following changes. In particular, during hours 0 through 4, 7 through 17, 19, 20, and 24, the industrial load accounts for more of the total load-following requirement than does the nonindustrial load. (It is likely that the cost of load following is modest during these low system-load-following hours.) Unlike the nonindustrial load, the industrial load's load-following pattern is not predictable from day to day.

Because of the pattern shown in Figure 4, the industrial loads account for more of the load-following requirement than we had initially anticipated: 56 percent, far above their 34 percent share of total load. (Correspondingly, the nonindustrial shares of load-following and energy are 44 percent and 66 percent.) Given this substantial difference between shares of load and load following, customer-specific assignment of load following is probably warranted for these large industrial customers.

Implications

Our study shows that charging customers for these two ancillary services (regulation and load following) on the basis of average loads can be inequitable. In particular, we found that certain large industrial customers with volatile loads use these services disproportionately, and in an unbundled environment they likely would not pay their fair share under traditional rate structures used in most FERC-approved transmission tariffs.

In our study, the proposed billing method would reduce the regulation and load-following charges otherwise assigned to nonindustrial customers by 75 percent and increase the charges to industrial customers by 140 percent. These sorts of subsidies, inherent in today's pricing methods for ancillary services, cannot and would not be sustained.

Indeed, customers who operate certain industrial processes with near-time-invariant loads, such as aluminum smelters and paper mills, justifiably will claim they require none of these services and, therefore, should not have to pay for them.

Eric Hirst and Brendan Kirby are consultants in electric-industry restructuring in Oak Ridge, Tenn. They thank Gregory Pakela for his very helpful comments on a draft of this article.

1 Docket No. RM99-2-000, May 13, 1999 (F.E.R.C.).

2 Order 888, Docket Nos. RM95-8-000, RM94-7-001, April 24, 1996 (F.E.R.C.).

3 Hirst, E. and B. Kirby, "Unbundling Generation and Transmission Services for Competitive Electricity Markets: Examining Ancillary Services," NRRI 98-05, National Regulatory Research Institute, Columbus, Ohio, January 1998.

4 See FERC Docket No. ER99-3719, filed July 23, 1999.

5 Wolak, F., R. Nordhaus, and C. Shapiro, "Preliminary Report on the Operation of the Ancillary Services Markets of the California Independent System Operator," Market Surveillance Committee, California Independent System Operator, Folsom, Calif., Aug. 19, 1998.

6 Additional detail on the methods we developed and applied to split regulation from load following are in a forthcoming Oak Ridge National Laboratory report, "System and Customer-Specific Metrics for Regulation and Load Following," by Brendan Kirby and Eric Hirst.

7 The amount of generating capacity provided for regulation is a multiple of the regulation standard deviation to ensure sufficient probability of meeting these temporal variations in load. Multiplying the standard deviation by two provides 95 percent coverage, and multiplying by three provides 99 percent coverage.

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