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USING FIVE-MINUTE DATA TO ALLOCATE LOAD-FOLLOWING AND REGULATION REQUIREMENTS AMONG INDIVIDUAL CUSTOMERS

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Contents

List of Figures and Tables

Figures

Tables

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Abbreviations and Acronyms

min	minute
RM	revenue meter
s	second
SCADA	supervisory control and data acquisition

SECTION 1

Introduction

In an earlier project, we analyzed data on total system load and the loads of eight large industrial customers in terms of system- and customer-specific requirements for the regulation and load-following ancillary services.[1] We conducted these analyses using 12 days of data from February 1999 plus 12 days of data from August and September 1999. These analyses were conducted using data provided by the control area at the 30-s level, which we then aggregated to the 2-min level for subsequent analysis.

The current project analyzes the feasibility of using 5-min revenue-meter (RM) data to allocate load-following and regulation requirements among retail customers. This project does not use the 5-min data to determine the actual ancillary services requirements for individual loads because these requirements depend strongly on the time-averaging period chosen for the load data. In particular, the amount of regulation required declines as the time-averaging period increases. Our earlier project showed that 2 min was a reasonable time-averaging period for this control area.

The reason for examining 5-min data is that supervisory control and data acquisition (SCADA) data, which are available every 4 s, are collected for only eight of this control area's very largest industrial customers. On the other hand, this control area collects 5-min RM data for about 600 customers. Although these customers account for less than 0.2% of the retail customers, they account for 60% of total energy sales and more than 40% of total revenues. Thus, if the allocations obtained with 5-min data for these eight large customers agree well with the allocations obtained with the SCADA data for these customers, the method we developed to allocate regulation costs to individual customers can be applied to many more customers— that is, no additional metering or data collection costs are required to charge individual customers for the regulation service.

In addition, RM data are more accurate than SCADA data. SCADA data are used primarily by system operators to monitor and control the bulk-power system and must therefore be provided frequently (at least once every few seconds). However, SCADA data need not be accurate enough for billing purposes as RM data must be. In addition, the RMs at this utility record demand down to 1 kW, while the SCADA meters can record data to only 100 kW.

The data used in this project consist of 30-s SCADA data (aggregated to the 2-min level) and 5-min RM data for the same eight industrial customers for the same period in February 1999. In addition, we used the same SCADA data on total system load and nonindustrial load as we had used in the earlier project.

The next section of this paper presents a comparison of the SCADA and RM data on an hourly basis for the eight customers. Section 3 compares the load-following results obtained with the two

[1]B. Kirby and E. Hirst, *Customer-Specific Metrics for the Regulation and Load-Following Ancillary Services*, ORNL/CON-474, Oak Ridge National Laboratory, Oak Ridge, Tenn., January 2000.

data sets. Section 4 compares the regulation-allocation results obtained with the two sets of data. The final section presents our conclusions from this analysis.

SECTION 2

Comparison of SCADA and RM Data

We began this project with a comparison of the hourly electricity-consumption values for all 288 hours for 12 days in February 1999 for all eight industrial customers. As shown in Table 1, the two sets of data agree closely for six of the eight customers. For customers 7 and 8, the data diverge. Although we tried to identify with control-area personnel the reasons for these discrepancies, we were unable to do so. In both cases, the RM data probably reflected the actual behavior of the loads, while the SCADA data did not.

Figure 1 compares the two data sets for customer 2; the data for customers 1 through 6 show very similar patterns. For these six customers, the two sets of data agree within about 1% on average. More important for regulation purposes, the up-and-down movements of the two sets of data are quite consistent.

The two sets of data do not agree well for customers 7 and 8. The RM data for customer 7 show both positive and negative values; the negative values reflect hours when this customer operated its generators and produced more electricity than it consumed. The SCADA data, on the other hand, are consistently positive and almost always show higher consumption than do the RM data (by about 130%, on average).

The two sets of data for customer 8 agree well during those hours that the facility consumes large amounts of electricity. However, when consumption drops to about 10 MW or lower, the SCADA system records zero energy consumption. Consequently, the SCADA meters record 16% less energy, on average, than does the RM for this customer.

In spite of the large discrepancies between the SCADA and RM data for two of the eight customers, we decided to proceed with the analysis including all eight customers. This inclusion provides an especially strong test of the load-following and regulation-allocation methods.

Table 1. Comparisons of average hourly energy consumption based on SCADA data vs RM data

Customer	Average hourly use (MW)	Average error	
		(MW)	(%)
1	147.6	0.1	!0.1
2	114.9	1.5	!1.3
3	32.9	!0.1	!0.3
4	76.9	0.4	!0.7
5	53.4	!0.2	0.4
6	224.8	!2.4	1.1
7	4.4	5.7	79.9

8	42.4	!5.5	81.3

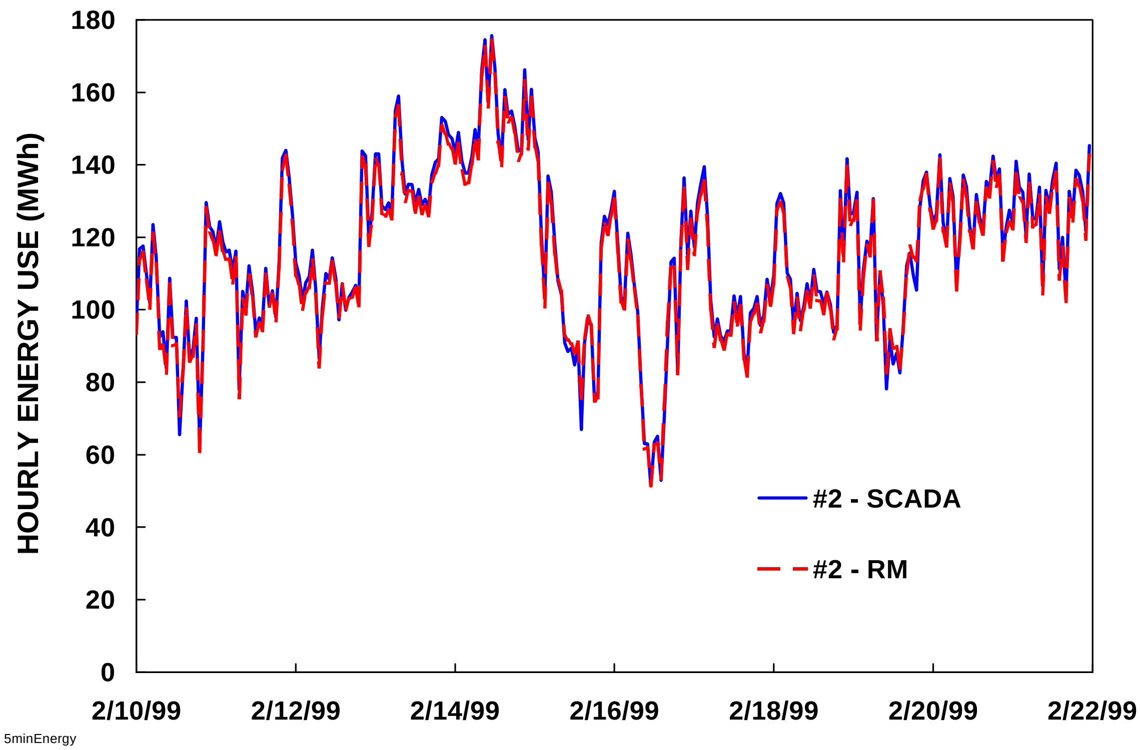

Fig. 1. Comparison of hourly energy values for customer 2 for 12 days in February 1999.

SECTION 3

Comparison of Load-Following Requirements

As explained in our 2000 report, we used a 30-min rolling average to define the load-following component of each load and the total system load. We then calculated the load-following requirement for each load as the customer-specific load following that is coincident with the system's hourly load-following requirement.

For this project, we used exactly the same data, analyses, and results that were developed last year to represent the original load-following results. That is, we did not recompute a 30-min rolling average on the basis of a 5-min aggregation of the original 30-s SCADA data. Rather, we used the original 2-min aggregations to define the load-following requirement with the SCADA data.

To identify the total and customer-specific load-following requirements with the 5-min RM data, we used the prior three values, the current value, and the following two values:

$$\text{Load following}_t = \text{Load}_{\text{estimated}-t} = \text{Mean}\,(L_{t-3} + L_{t-2} + L_{t-1} + L_t + L_{t+1} + L_{t+2})\ .$$

The regulation requirement is then defined as

$$\text{Regulation}_t = \text{Load}_t - \text{Load}_{\text{estimated}-t}\ .$$

Table 2 summarizes the results of this comparison. As expected, defining *load following* on the basis of 2-min data rather than 5-min data leads to larger magnitudes, both for system load and for the individual components. However, the *allocations* of the total to individual customers and to groups of customers (nonindustrial vs industrial) are almost the same across the two data sets. For example, the original 2-min analysis assigned 58% of the total requirement to these eight industrial customers, whereas the 5-min analysis assigned 57%. For individual customers, the percentage assignments are usually within one percentage point.

Figure 2 shows the hourly load-following values for customer 2 for 3 days as calculated with both data sets. The two sets of data produce very similar results on an hourly basis as well as on average.

These results indicate that the 5-min RM data are more than adequate for allocating load-following requirements among individual customers and groups of customers.

Table 2. Comparison of average load-following results (MW and fraction of total) with SCADA data and RM data

Customer	2-min SCADA data		5-min RM data	
	Load following (MW)	Fraction of load following	Load following (MW)	Fraction of load following
All customers	63.9	1.00	57.7	1.00
Nonindustrial	27.0	0.42	24.7	0.43
Industrial	36.9	0.58	33.1	0.57
Eight large industrial customers in this study				
1	14.3	0.22	12.5	0.22
2	6.6	0.10	5.1	0.09
3	4.2	0.07	3.8	0.07
4	5.9	0.09	5.5	0.09
5	0.0	0.00	0.0	0.00
6	0.0	0.00	0.0	0.00
7	0.4	0.01	0.5	0.01
8	5.4	0.08	5.7	0.10

SECTION 4

Comparison of Regulation Requirements

Our original analysis of regulation requirements, using 2-min SCADA data, showed an average hourly requirement of 31 MW and an industrial share of this total of 93%. This 31-MW hourly

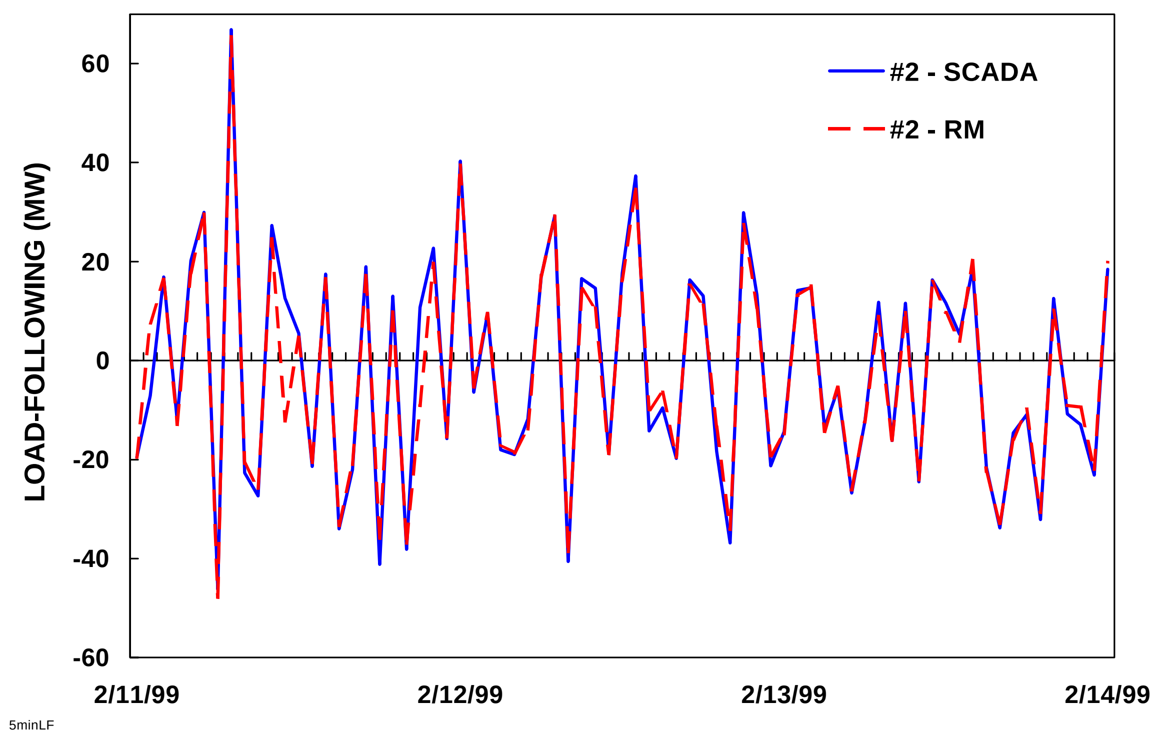

Fig. 2. Load-following requirement for customer 2 as determined by the 5-min RM data and the 2-min SCADA data.

requirement represents the average value of the standard deviation, with the standard deviation calculated from the thirty 2-min values of $\text{Load}_t - \text{Load}_{\text{estimated}-t}$ each hour.[2]

Because the current project uses 5-min data, we first reaggregated the 30-s SCADA data to 5-min averages. Not surprisingly, the total regulation metric declines with the increase in time-averaging period from 31 to 24 MW (Table 3). The longer time period also increases the industrial share, from 93 to 96%.[3]

We reaggregated the SCADA data to 5-min averages so that we could compare SCADA regulation results with those obtained using the 5-min RM data. As shown by the four righthand columns in Table 3, these two sets of 5-min results are in close agreement. (Figure 3 shows hour-by-hour results for customer 1.) The agreement is weakest for the nonindustrial-customer group, for which the RM regulation value is 40% higher than the SCADA value (9.4 vs 6.6 MW). (This lack of agreement is expected because the nonindustrial loads are not measured directly by the RM metering. They are calculated as the residual of the SCADA metering for the entire system and the RM measurement of the industrial loads.) However, the results are quite close for the industrial customers, both as a group and individually. The RM data show higher regulation values for customers 5 and 6, probably because the SCADA meters cannot read small values.

The results agree poorly for customer 7, as expected, because the RM data show much more volatility. The two sets of results are close for customer 8 even though the SCADA data do not capture the fluctuations when the load is below about 10 MW; this agreement occurs because most of the regulation requirement arises when the load is higher.

[2]Typically, a utility might provide an amount of regulation capacity equal to two or three times the standard deviation (e.g., to cover 95 or 99% of the expected load swings). Thus, this control area might carry 60 to 90 MW of regulation capacity to compensate for this aggregated load.

[3]Using 5-min averages provides only 12 observations each hour for calculating standard deviations. Although we were concerned that so few observations would lead to unstable results (relative to those obtained with 30 observations an hour), our fears were unfounded.

Table 3. Comparison of average regulation results (MW and fraction of total) with SCADA data and RM data

Customer	2-min SCADA data		5-min SCADA data		5-min RM data	
	Regulation (MW)	Share	Regulation (MW)	Share	Regulation (MW)	Share
All customers	31.2	1	23.6	1	23.6	1
Non-industrial	10.5	0.07	6.6	0.04	9.4	0.07
Industrial	30.9	0.93	23.6	0.96	23.9	0.93
Eight large industrial customers in this study						
1	19.7	0.38	15.6	0.43	15.7	0.42
2	12.6	0.14	9.4	0.14	8.8	0.12
3	9.5	0.09	6.6	0.09	6.6	0.08
4	14.1	0.20	10.1	0.19	10.2	0.18
5	0.4	0.00	0.3	0.00	0.4	0.00
6	0.4	0.00	0.3	0.00	0.9	0.00
7	4.4	0.02	2.7	0.01	4.4	0.03
8	5.3	0.09	4.5	0.11	4.9	0.10

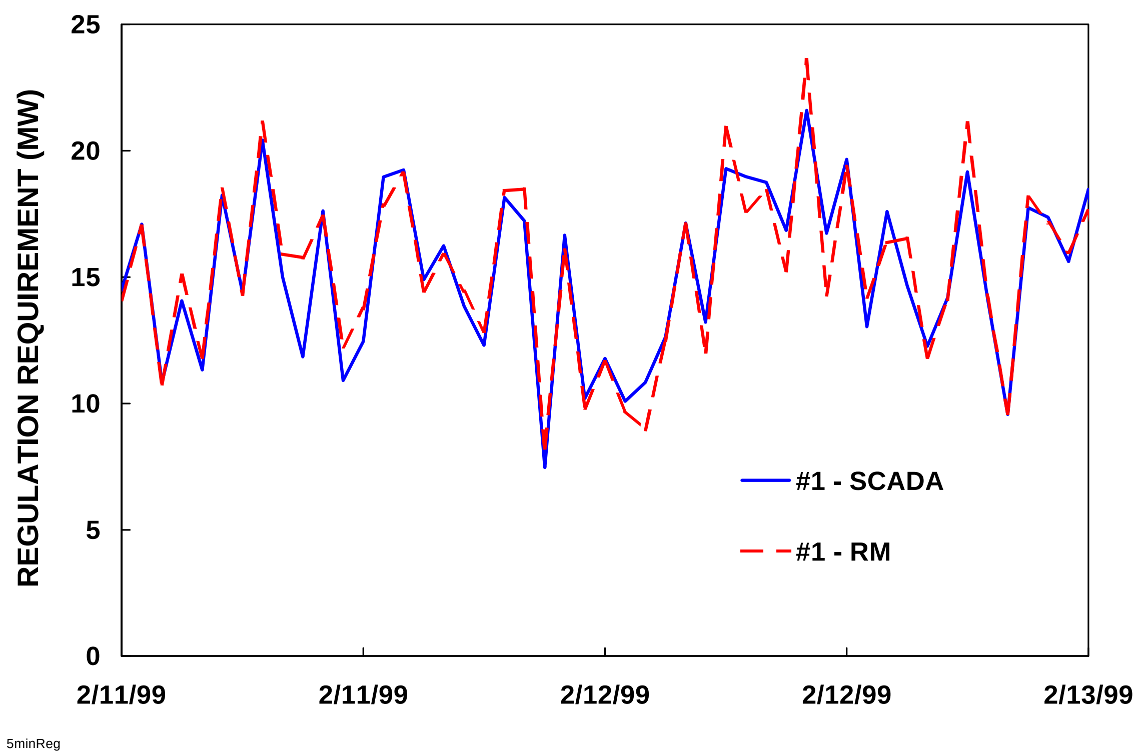

Fig. 3. Comparison of estimates of regulation requirements for customer 1 based on SCADA vs RM data, both using 5-min averages.

SECTION 5

Conclusions

Electricity markets are becoming increasingly competitive at both the wholesale and retail levels. Therefore, it is very important to understand the contributions that individual customers and groups of customers make to system requirements and costs. A project we conducted in 1999 examined electricity-use data from eight of this control area's largest industrial customers. We used these data to develop and test system- and customer-specific metrics for regulation and load following.

This project extended our prior work to additional customers. The question we addressed herein is whether 5-min RM data, available for about 600 retail customers, can be used to accurately allocate system costs for these two ancillary services. The answer to that question is simple: Yes! Although the SCADA and RM data for two of the eight customers differed substantially, the customer-specific assignments of regulation and load-following requirements were quite similar for the two data sets.

On the basis of these positive results, we recommend that utilities, and especially independent system operators and regional transmission organizations, modify their billing systems to incorporate these calculations and charges on a customer-specific basis. Such changes would more accurately assign costs to those customers who caused the costs to be incurred.

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