Closing the Books:
Forecasting Unbilled Energy and Sarbanes-Oxley Compliance

By J. Stuart McMenamin, Ph.D.

Introduction

Utilities deliver energy continuously throughout the month. At any point in time, they know how much has been delivered (based on metering of generation and transmission facilities), but they do not know who the buyer is until they read the customer's meters. Similarly, they do not know the corresponding revenue until they calculate bills based on meter readings. At the end of the month, the amount of energy that has been delivered but for which the customer meters have not yet been read is called unbilled energy. For a given month, unbilled energy is usually between 40% and 60% of the total energy delivered, depending on the timing of read cycles and the timing of any extreme weather occurring during the month.

To close the books at the end of a calendar month, most industrial firms can compute revenue accruals based on shipments to their customers. They know what has been shipped and they have booked the revenue based on who the outputs have been shipped to and the terms of the deal with that particular customer. This is not possible for utilities, who must estimate the revenue that goes with unbilled energy. Section 404 of the Sarbanes-Oxley act implies that management is responsible for internal controls and procedures related to financial reporting and estimating. Reporting unbilled revenue is one of these procedures. As a result, many utilities are closely examining the methods they use to estimate unbilled energy.

Itron's energy forecasting system, combined with data that are readily available to most utilities, provides a process to accurately and consistently estimate unbilled energy and the corresponding unbilled revenue. Further, the same methods used to look backward at the end of the month to estimate unbilled energy can also be used during the month to look forward and to forecast billed and unbilled energy for the current month. By continuously updating these forecasts as the month progresses, these systems provide management with financial insight into how the month will close, allowing them to sign off on their Sarbanes-Oxley responsibilities with confidence.

Composition of Monthly Energy Deliveries

If all customers had interval data recorders and if utilities collected interval data on a daily basis, we would know exactly what happened during the month. Figure 1 provides a depiction of what such a month would look like at the close of the month. The smallest load, presented at the bottom, represents streetlights, traffic lights and other loads. On top of this are the hourly loads of the industrial class, which are relatively constant and largely unaffected by weather. On top of these are the commercial class loads, which have a strong weekly cycle and low holiday loads, as illustrated on Monday, July 5 in the figure. On top of these are residential loads, which are larger on the weekends than on weekdays and which have the strongest weather effects. The top line is the overall system load, which is larger than the sum of the customer loads because of transmission and distribution system losses and unaccounted for energy (UFE).

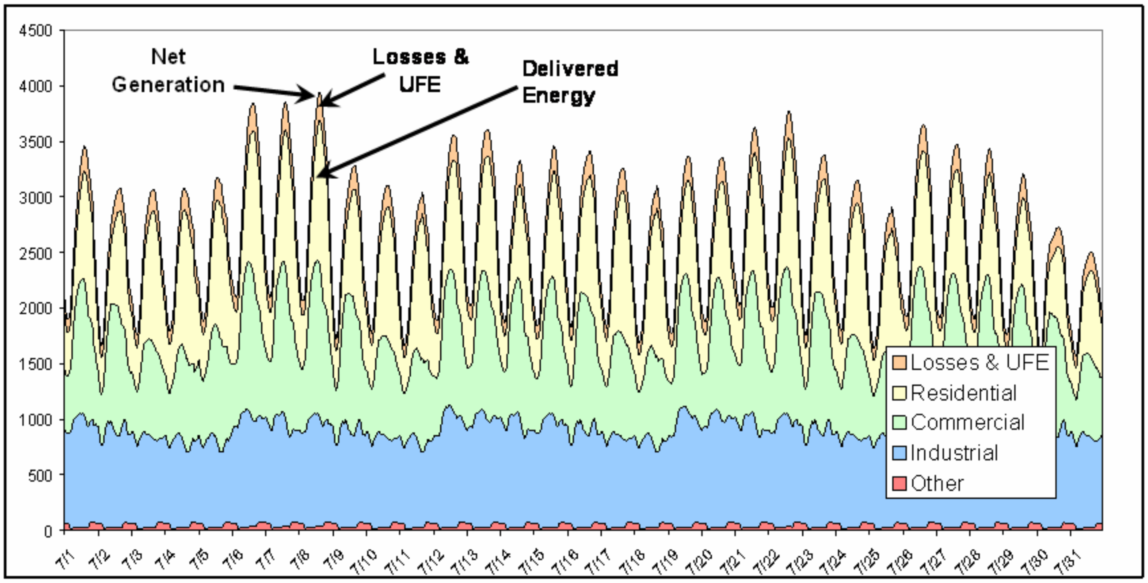

Figure 1. At the end of the month, if all customers had hourly meters we could measure energy delivered to each customer class and compute losses and UFE as the difference between the system load and the class totals.

A few utilities do have automatic meter reading (AMR) systems that allow them to read energy for all customers on a daily basis, but this is the exception. Most utilities have interval data recorders (IDR) that are read daily or monthly for their largest industrial customers, and energy or demand meters that are read once a month for the remaining classes. The challenge for computing calendar month revenue is to develop estimates of the data behind Figure 1 at the end of the month, despite the fact that many customer meters remain unread.

The Source of Unbilled Energy

Most utilities read customer meters on a staggered schedule throughout each calendar month, based on meter reading routes and billing cycles. This approach allows them to level the workload related to meter reading, bill preparation, and customer service related to billing inquiries. This is depicted in Figure 2, which provides an example for a utility with 21 billing cycles. In the example, the meters for customers on Cycle 1 are read on Thursday, July 1. The reading allows calculation of consumption since the last reading on Wednesday, June 2. As a result, most of the energy use for this customer (July 2 to July 31) has not been measured at the end of the calendar month. The energy for these days has been delivered and revenue must be accrued for these deliveries as part of unbilled energy. At the bottom of the figure, meters for customers on Cycle 21 are read on Friday, July 29. For these customers, almost all energy use during the month is covered by this read, with only one day of use remaining in the calendar month.

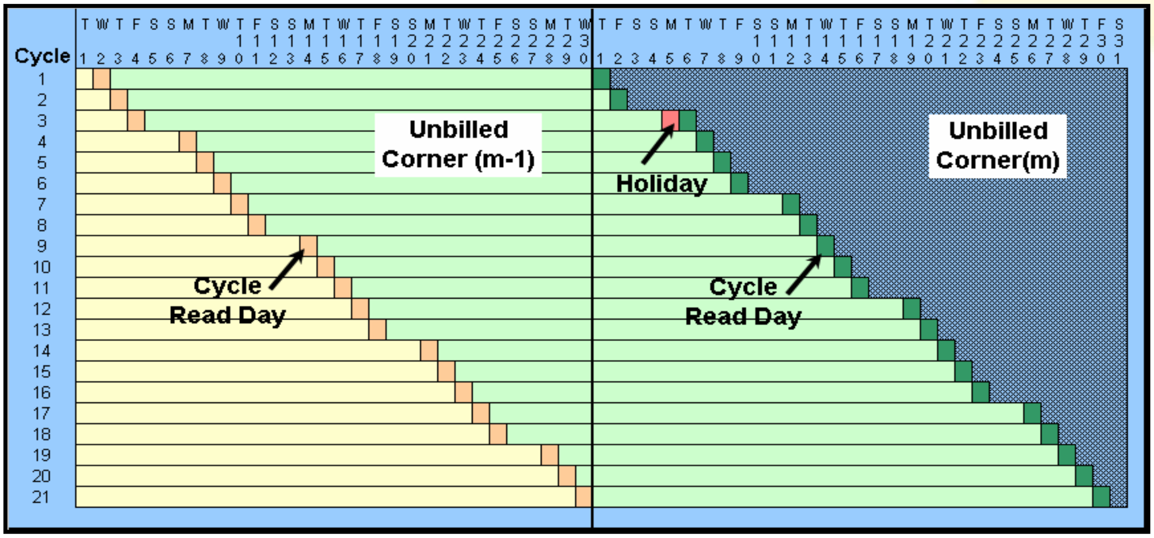

Figure 2. The difference between billing cycles and calendar days creates unbilled energy at the end of each month. The unbilled corner can represent anywhere from 40% to 60% of energy for the month.

The "unbilled corner" represents all days for which energy use remains unmeasured as of the end of the calendar month. Although it is tempting simply to count the number of days, this will not be accurate because of the timing of weekend days and the pattern of weather that occurs during the month. To close the books with an accurate accrual for unbilled energy, it is necessary to complete the picture for the month, as depicted in Figure 1.

Resources for Estimating Unbilled Energy

At the end of a month, unbilled energy can be estimated using actual system load data, AMR data for interval-metered customers, billing cycle data, and load research data or profile models based on load research data. Accurate estimation of unbilled revenue requires understanding and effective use of all available data.

At the end of a month, the following data are available:

- System load data (net generation)
- Interval data for IDR customers
- Billing data for monthly consumption and demand meters
- Billing cycle read dates
- Load research data for a sample of customers
- Hourly weather data by weather station

The following values need to be estimated:

- Daily energy usage by customer class and rate code
- Unbilled energy by customer class and rate code
- Revenue corresponding to unbilled energy

Methods for Forecasting Unbilled Energy

Three approaches can be used to estimate unbilled revenue. The first uses monthly models estimated with billing data. The second uses daily or hourly profile models based on load research data. The third relies on measurement using AMR technologies.

Monthly Method

The monthly method for forecasting unbilled energy is the least detailed of the three methods described in this paper. The process uses the following steps.

1. **Create monthly sales models.** These models are estimated by relating historical monthly billing data to the cycle-weighted average number of billing days, heating degree days (HDD), and cooling degree days (CDD). The models can be **strengthened** based on end-use saturation and efficiency trends as well as day-type factors computed from load research.
2. **Simulate calendar-month sales.** The estimated consumption models for a class are used to simulate calendar month sales by plugging in the **number** of calendar days, as well as calendar month HDD and CDD values.
3. **Calibrate to system-monthly energy.** The scaled results are adjusted to agree with total net generation for the month, adjusted for expected losses. **Calibration** to this measured total provides assurance that the estimates tie out to total deliveries for the month.
4. **Convert monthly sales volumes to revenues.** Estimates of calendar-month consumption are converted to estimates of calendar month revenue. This can be done by allocating sales to rate codes, converting energy to billing determinants, and then computing revenues from billing determinants. It can also be done at a higher level by applying average prices to volumes for the unbilled corner.

Daily Method

The daily method can use dynamic load research samples or models of historical load research data. This dynamic approach relies on load research samples where the data are accumulated and processed on a daily basis. These data provide direct estimates of the typical load profile for a customer class on recent historical days. Load profile models build upon historical load research data and relate the typical loads for a class to the historical weather, calendar events, and other factors. Load profile models can be used to estimate daily and hourly energy use for a customer class based on actual daily weather data. The daily method uses the following steps.

5. **Estimate daily energy models.** This step only applies to the profile model branch of this method. First, historical load research data are processed to estimate the typical consumption pattern in the population. Second, statistical models are estimated that relate this consumption pattern to actual weather data and calendar events for the historical period.
6. **Estimate daily energy consumption.** If dynamic load research samples are used, daily consumption is estimated by reading load research meters for recent days and using statistical expansion weights to estimate the typical consumption pattern in the population for these days. If profile models are used, the actual weather and calendar conditions for recent days are plugged into the models to provide estimates of the typical consumption pattern for these days.
7. **Scale daily energy estimates to represent the population.** Estimates of typical consumption patterns are scaled to represent the total population for each class. Scaling for each billing cycle is based on the most recent measured consumption value for that cycle.

8. **Calibrate to system daily energy.** The scaled results are adjusted to agree with total system load on a daily or hourly basis, adjusted for expected losses. This is similar to the allocation of UFE across energy suppliers in a settlements calculation.
9. **Convert unbilled energy to unbilled revenue.** Estimates of daily consumption for each class are converted to estimates of calendar-month revenue for each class.

AMR Method

The AMR method requires that all customers are equipped with automatic meter reading technologies that can be read on a daily basis or at the end of the calendar month. This method uses the following steps.

1. **Read meters.** Customer meters are read on a daily or monthly basis and the results are stored in a database.
2. **Estimate unread meters**. It is unrealistic to expect 100% success, even with automatic meter reading. In this step, meters that are successfully read are scaled upward to represent the total population of meters in each class. At this point, it may also be advisable to scale the total to agree with total system loads on a daily or monthly basis.
3. **Convert monthly sales volumes to revenues.** The scaled meter data are then converted to estimates of calendar month revenue.

The last step deserves comment. Although most of the energy use for the calendar month is measured in this case, the revenue estimate is still an “estimate.” This is because utility rates are nonlinear calculations based on cycle data, not calendar-month data. For example, if there are increasing or declining energy blocks, it is not possible to calculate calendar-month revenue exactly because there is no way to know how the calendar-month usage will fall in the billing cycle blocks. Similarly, there is no way to use hourly data for a calendar month to compute demand charges for the billing cycles. The calendar-month maximum demand may or may not be used in a billing-demand calculation. The point here is that unbilled revenue estimates on a calendar-month basis are, and always will be, estimates. The only way to make this estimate exact is to bill all customers on a calendar-month basis using AMR data for the month. However, this would create bottlenecks in the creation and delivery of customer bills as well as customer services related to billing inquiries.

Real-Time Forecasting For Financial Visibility

The same process used to look backwards to close the books at the end of the month can be used during the month to forecast sales and revenues for the current month and future months. At any point during the month, the idea is to take maximum advantage of historical measured data and modeling capabilities to estimate how the month will play out. These estimates can be revised every day based on updated measurements and weather forecasts. If the forecasting method is synchronized with the method used to compute unbilled energy and unbilled revenue, the forecasts will converge to the financial closing value as the month proceeds.

On a daily basis throughout the month, the following steps are used to update forecasts of billed and unbilled energy and revenue for the month end close.

- **Update weather forecasts.** Each day, update actual weather data and weather forecasts. Automated processes of this type are in place at most utilities to support operational forecasting. Weather forecasts through the end of the month will be required to support revenue forecasting. In most cases, weather forecasts beyond a 10-day horizon revert to “normal weather” for the time of year.

- **Update system load forecasts.** Each day, update system load data and system load forecasts. Most utilities have automated processes that perform these calculations once a day or more frequently. These are usually short-term forecasts, such as seven days ahead. To support revenue forecasting, these processes will need to be extended to provide forecasts through the end of the month.
- **Update IDR data and forecasts.** Use AMR technologies to read IDR data to-date. Use automated forecasting systems to forecast loads for AMR customers to the end of the month.
- **Update profile forecasts.** Use load research data or profile models to estimate and forecast typical customer consumption patterns through the end of the month.
- **Scale profile forecasts.** Use billing data from the most recent cycle to scale typical consumption profiles upward to represent each customer class.
- **Calibrate forecasts.** Calibrate scaled profile estimates to agree with measured system loads and system load forecasts for the remainder of the month.
- **Update revenue forecasts.** Convert estimates and forecasts by cycle through the end of the month to revenue or price out the unbilled corner for each class.

The results of this process are depicted in Figure 3, which shows revenue forecasts made at the beginning, the middle, and the end of the month.

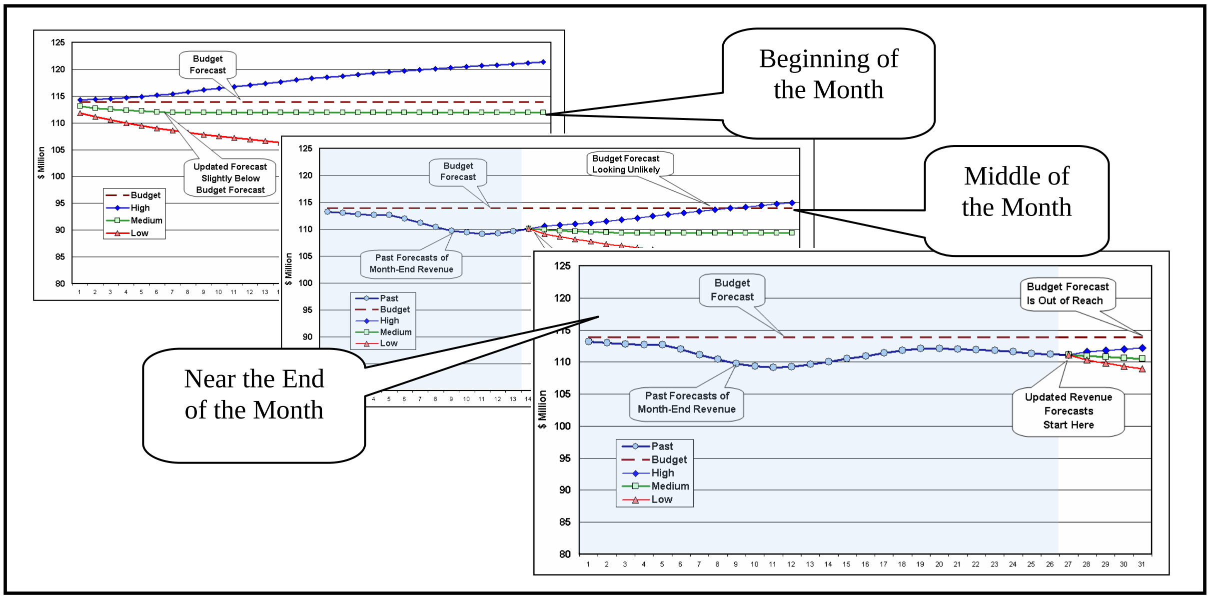

Figure 3. Real-time forecast updates provide visibility into the month-end closing values. If consistent methods are used, the forecast converges to the final revenue estimate for the calendar month.

The biggest sources of uncertainty in real-time revenue forecasting are operational patterns for large industrial customers and weather for the remaining days of the month, which will impact the loads of residential and commercial customers. The uncertainty is greatest at the beginning of the month. As the month progresses, forecasts can be updated based on measured loads and weather data. At any point, the month can be completed based on the most recent weather forecasts, and scenarios can be executed to represent the highest and lowest revenue outcomes that can be expected.

Real-time revenue forecasting systems should be set up as automated processes that run every day based on the most recent available data. Results can be summarized on web-based dashboards that provide executives at-a-glance updates for the month, quarter, and year. If consistent methods are used, forecasts will converge to the final estimate of unbilled revenue that will be used to close the books for the month, providing management with a clear look at financial closing values.

You Can Do This

Many utilities already have access to the information they need to begin accurately forecasting unbilled energy and unbilled revenue. All they need is a tool to put it all together and a little know-how. If your utility could benefit from forecasting unbilled energy, please contact Itron or your Itron representative.

Author Biography

J. Stuart McMenamin, Ph.D. Vice President at Itron, where he specializes in the fields of energy economics, statistical modeling, and software development. Over the last 20 years, he has managed numerous projects in the areas of system load forecasting, price forecasting, retail load forecasting, end-use modeling, regional modeling, load shape development, and utility data analysis. In addition to directing large analysis projects, Dr. McMenamin directs the development of Itron's forecasting software products. He has also directed the development of software packages for external clients, including the EPRI end-use models, regional economic forecasting packages, and home energy rating software. Dr. McMenamin received his B.A. in Mathematics and Economics from Occidental College and his Ph.D. in Economics from UCSD.

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