Itron White Paper
Energy Forecasting

Modeling and Accounting Methods for Estimating Unbilled Energy

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Introduction

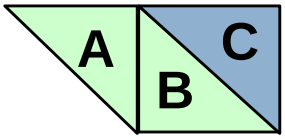
Utilities deliver energy continuously throughout the month. At the end of the month, they know how much has been delivered to the system (net generation), but they do not know who the buyers are until customer meters have been read. Similarly, they do not know the revenue from these deliveries until customer bills are calculated based on the meter readings. For a given month, unbilled energy may be between 35 percent and 70 percent 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, utilities must estimate the revenue that goes with unbilled energy.

This paper focuses on the use of statistical models of billing cycle data to estimate calendar month sales and the unbilled fraction of calendar month sales. It provides an analysis of the implications of two alternative accounting approaches, given the modeling information. The first, called the Direct method, uses models to directly estimate energy use over the unbilled days in the calendar month. The second, called the Prior-Unbilled method, uses accounting information (including the prior months' estimate of unbilled energy) to estimate unbilled energy in the current month. This paper shows that the Direct method is self-correcting, and that the Prior-Unbilled method perpetuates errors from one month to calculations for all the following months.

Geometry of the Problem

Figure 1 depicts the geometric configuration of billing cycles and unbilled corners. Each row shows one billing cycle and the days covered by that cycle. The geometry is as follows:

- Billed Sales = Parallelogram A+B
- Current Month Unbilled Sales = Triangle C
- Prior Month Unbilled Sales = Triangle A
- Calendar Month Sales = Rectangle B+C



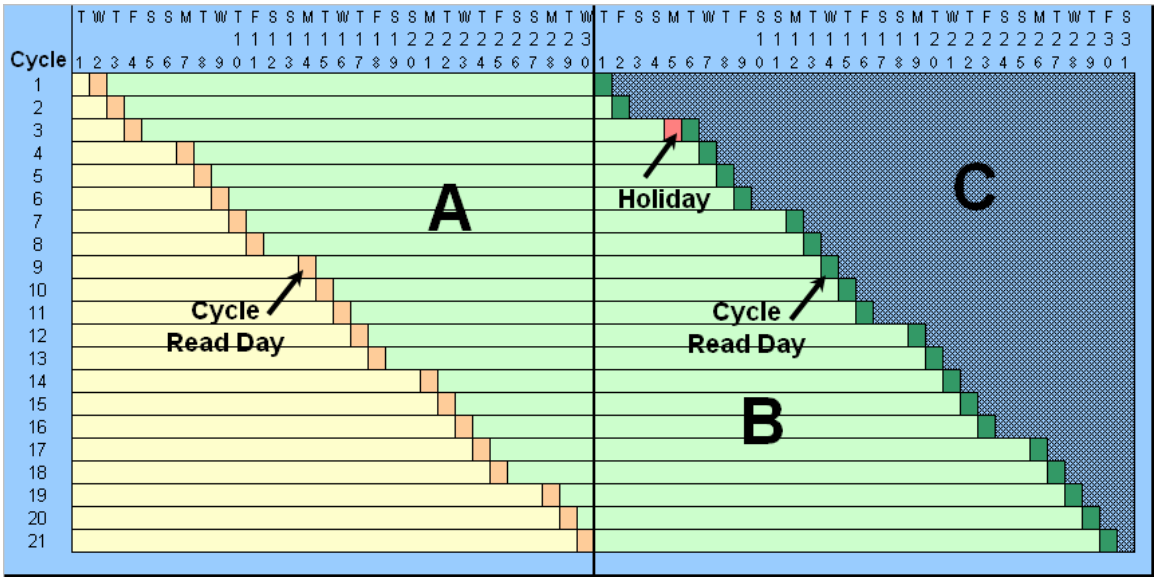


Figure 1 *Depiction of Billing Cycles and the Unbilled Corner*

Methods for Estimating the Unbilled Corner

There are two ways to compute the numerical value for the unbilled corner (C in Figure 1). The first involves direct estimation. We call this the Direct Approach. The second involves a recursive formula in which the current month's unbilled value depends on the prior month's unbilled value. We call this the Prior-Unbilled Approach. As is shown below, with the Prior-Unbilled Approach, errors in the estimation of unbilled energy in one month will propagate to the following month. If there is a consistent bias in the method, this will result in a constantly growing drift in the unbilled estimate, which can result in serious problems, such as negative values for unbilled energy. The purpose of this paper is to demonstrate this fact and also to show the potential impacts of both approaches on income statements and balance sheets.

Both approaches necessarily involve estimation. In the Direct Approach, we estimate calendar month sales and unbilled sales directly. This is typically based on models that account for the number of days in each period (weighted across cycles) and the weather that occurred over the days in each period. In modeling terms, we develop a model that has the number of days, weather, and other seasonal factors as inputs. The model is usually estimated with billing cycle days and billing cycle weather as the inputs. Once estimated, this model can be used to simulate energy use over other calendar periods.

In terms of the geometry, models are estimated using data for the billing cycle parallelograms, A+B. The coefficients of the estimated models can then be used to estimate values using inputs for the calendar month (B+C) or for the unbilled corner (C alone). When the later is done, it is critical that the model works well on a per-day basis, since the number of days in the unbilled corner (C) is likely to be about half of the number of days in the billing cycle.

One way to approach the calculations is through the use of models to create ratios of the geometric areas. We call these ratios the Booked-To-Billed Ratio and the Unbilled Fraction.

Booked-To-Billed Ratio

The first ratio is the Booked-To-Billed (BTB) ratio, and it provides an estimate of calendar month energy (B+C) relative to billing cycle energy (A+B).

$$\begin{aligned} \text{BTB} &= \frac{\text{Model}\left(\text{Calendar Month Days}, \text{Calendar Month Weather}\right)}{\text{Model}\left(\text{Billing Cycle Days}, \text{Billing Cycle Weather}\right)} \\ &= \frac{\text{Model}\left(\text{B} + \text{C}\right)}{\text{Model}\left(\text{A} + \text{B}\right)} \end{aligned} \qquad (1)$$

The BTB ratio will be greater than 1.0 when the number of days in the calendar month is greater than the number of days in the billing cycles and/or the weather in the calendar month is more extreme. Although the adjustment for days can be significant, the adjustment for weather is usually the determining factor for the weather sensitive customer classes. For example, in spring months such as May, the calendar month weather is normally warmer than the billing cycle weather (which spans April and May). As a result, BTB ratios tend to be greater than one and can be as large as 1.5 in extreme cases in the spring and early summer months. On the flip side, fall BTB ratios can be significantly less than one. Especially for gas utilities, a similar dynamic occurs going into winter with BTB ratios greater than one on the way into the winter and BTB ratios less than one coming out of winter.

Unbilled Fraction

The second ratio is the Unbilled Fraction. This provides an estimate of unbilled energy for the current month (C) relative to calendar month energy for the month (B+C).

$$\begin{aligned}\text{Unbilled Fraction} &= \frac{\text{Model(Unbilled Days, Unbilled Weather)}}{\text{Model(Calendar Month Days, Calendar Month Weather)}} \\ &= \frac{\text{Model}(C)}{\text{Model}(B+C)}\end{aligned} \tag{2}$$

The unbilled fraction will be about .5 in neutral conditions when the weather is relatively constant for the month and when the number of unbilled days is about half of the number of calendar days.

Prior-Unbilled Approach

The Prior-Unbilled Approach uses only the BTB ratio. It first estimates calendar month energy using the BTB ratio. It then computes unbilled energy based on the Prior Month unbilled value.

$$\begin{aligned}\text{CalMonth} &= \text{Billed} \times \text{BTB} = (\text{Billed}) \times \frac{\text{Model}(B+C)}{\text{Model}(A+B)} \\ \text{Unbilled} &= \text{CalMonth} - \text{Billed} + \text{Prior Unbilled} \\ &= (B+C) - (A+B) + A\end{aligned} \tag{3}$$

Notice that if the model error is zero for the billing month (Billed = Model(A+B)), the Booked energy expression simplifies to Model(B+C).

Direct Approach

The Direct Approach estimates unbilled energy directly using both ratios, as follows:

$$\begin{aligned}\text{Unbilled} &= \text{Billed} \times \text{BTB} \times \text{Unbilled Fraction} \\ &= (\text{Billed}) \times \frac{\text{Model}(B+C)}{\text{Model}(A+B)} \times \frac{\text{Model}(C)}{\text{Model}(B+C)} \\ &= (\text{Billed}) \times \frac{\text{Model}(C)}{\text{Model}(A+B)}\end{aligned} \tag{4}$$

If the model residual is zero for the billing month (Billed = Model(A+B)), this expression simplifies to Model(C).

From 3 it is clear why errors propagate using the Prior-Unbilled method. Any error in estimating the prior unbilled value adds directly into the estimate of the current unbilled value. This is illustrated in the following example.

Example Data

The example starts with the following table, which presents a set of hypothetically true values. In the example, the current month billed energy is 200 GWh in aggregate across two classes. Half of the billed energy is from the prior month (A) and half of the billed energy is in the current month (B). Energy use for the current month is a smaller value at 185 GWh. Calendar month energy use (B+C) is 90 (which is 10% below billed energy) for the first class and is 95 (which is 5% below billed energy) for the second class.

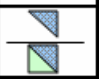
	(A) Prior Unbilled	(A+B) Billed (GWh)	(C) Unbilled GWh	(B) Already Billed	(B+C) Booked	BTB Ratio (B+C)/ (A+B)	Unbilled Fraction C/(B+C)
Class1	50.0	100.0	40.0	50.0	90.0	0.90	0.40
Class2	50.0	100.0	45.0	50.0	95.0	0.95	0.45
Total	100.0	200.0	85.0	100.0	185.0		
							

Figure 2 *Example Data*

For the purposes of the example, assume that these values are correct, although billed energy (A+B) is the only quantity that is actually measured directly.

Examples Using Prior-Unbilled Approach

For the Prior-Unbilled Approach, the monthly process is as follows:

- Prior month unbilled energy (A) is estimated at the beginning of the month.
- Billed energy is measured during the month and is known at month's end.
- Booked energy (B+C) is estimated at the end of the month.
- Unbilled energy for the current month (C) is estimated based on the above.
- Revenue and unbilled accrual are computed for the current month.

The order here is important. Prior month unbilled (A) is estimated before the monthly total (A+B) is known. It is held fixed regardless of the outcome for the sum (A+B). Balance sheet results and income statement results are then based on the dollar values for each of the volume outcomes. Dollar values for billed energy are computed directly from the bills. Dollar values for unbilled energy are estimated, usually based on average prices. The books are closed with the following entries:

$$\begin{aligned} \text{Revenue} &= \text{Billed Sales based on (A+B)} \\ &\quad + \text{Unbilled Sales based on (C)} \\ &\quad - \text{Prior Unbilled Sales based on (A)} \end{aligned} \tag{5}$$

$$\begin{aligned} \text{Assets} &= \text{Cash and Receivables based on Billed Sales (A+B)} \\ &\quad + \text{Unbilled Accrual based on Unbilled Sales (C)} \end{aligned} \tag{6}$$

The revenue calculation is most often stated as Revenue equals Billed Sales plus the change in the Unbilled Accrual. However, the explicit representation of the change in unbilled makes it clear that, from a revenue perspective, revenue from the prior

unbilled accrual is effectively reversed when current month revenue is calculated. From a balance-sheet perspective, the prior unbilled accrual is replaced by the current month unbilled accrual.

Prior-Unbilled Approach: Scenario 1

This process is depicted in Figure 3. The process begins with the Prior Unbilled estimate in Column 1. At the end of the month, Billed energy is entered into column 2. Based on weather over the calendar month relative to the billing cycles, the BTB ratio is computed and entered in column 3. The BTB ratio is multiplied by billed energy to get the calendar month booked estimate, which is entered in column 4.

The key step is in column 5. Here the current month unbilled is calculated as calendar month energy minus billed energy plus prior month unbilled. The idea here is that we have estimated calendar month energy (B+C), but to get the unbilled part (C) we need to subtract out the already billed component (B). We know billed energy (A+B), so we will subtract that out, but that takes away too much and we need to add the prior month unbilled (A) back in. This can be expressed as follows:

C = Calendar month (B+C) – Billed (A+B) + Prior month unbilled (A) (7)

Another way to look at this is that we know billed energy (A+B) and we have the prior month estimate for A. Therefore the already billed part of the current calendar month (B) can be calculated as the difference between measured bills (A+B) and the estimate of the prior month unbilled (A). This interpretation can be expressed as follows:

C = Calendar month (B+C) – Already billed ((A + B) – A) (8)

The numbers are the same under either interpretation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(A) Prior Unbilled	(A+B) Billed GWh	BTB Ratio	(B+C) Calendar Estimate (2)×(3)	(C) Unbilled GWh (4)-(2)+(1)	(B) Already Billed (4)-(5)	Revenue (2)-(1)+(5)
Class1	50.0	100.0	0.90	90.0	40.0	50.0	90.0
Class2	50.0	100.0	0.95	95.0	45.0	50.0	95.0
Total	100.0	200.0		185.0	85.0	100.0	185.0

Figure 3 *Prior-Unbilled Approach: Scenario 1*

The revenue numbers shown in the final column are presented in energy units (priced out at $1 per unit) for purposes of exposition. The revenue calculation is:

Revenue = Billed (A+B) – Prior Unbilled (A) + Unbilled (C) (9)

This can be expressed in two alternative forms:

Revenue = Billed (A+B) + Change in Unbilled (C-A) (10)
= Already billed (B) + Unbilled (C)

Conceptually, the goal is expressed on the second line of expression (10). That is, current month revenue has two components, both of which must be estimated. The two components are the part that has already been billed and the unbilled accrual.

The key point here is that the prior unbilled number drives the interpretation of current month results through the calculations in columns 5, 6 and 7. This is seen in the following example which leaves all current month billed and booked values at their correct levels, but introduces an error into the prior month unbilled values.

Prior-Unbilled Approach: Scenario 2

In this scenario, all numbers are the same as the prior example, except that Class 1 prior unbilled is reduced by 20 GWh and Class 2 prior unbilled is increased by 20 GWh. The idea is that these values are incorrect because of some error in computing the prior unbilled or because of a buildup of accumulated errors or biases from prior calculations.

As seen in Figure 4, the prior month errors propagate directly through to the current month. For example, for Class 1, billed energy is the same (100) and booked energy is the same (90) as in the first example. But because prior unbilled is 20 GWh too low (at 30 instead of 50), the current month unbilled is also 20 GWh too low (at 20 instead of 40). The error in unbilled for the prior month passes directly through to an equal error in unbilled in the current month. Once introduced, this error will never go away unless an offsetting correction is made.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(A) Prior Unbilled	(A+B) Billed GWh	BTB Ratio	(B+C) Calendar Estimate (2)×(3)	(C) Unbilled GWh (4)-(2)+(1)	(B) Already Billed (4)-(5)	Revenue (2)-(1)+(5)
Class1	30.0	100.0	0.90	90.0	20.0	70.0	90.0
Class2	70.0	100.0	0.95	95.0	65.0	30.0	95.0
Total	100.0	200.0		185.0	85.0	100.0	185.0

Figure 4 *Prior Unbilled Approach: Scenario 2*

This error does no damage to the totals because it is assumed that an offsetting error is made to Class 2, which has unbilled overestimated by 20. Also, since the prices for the two classes are equal ($1 per unit), there is no impact on total revenue.

Prior-Unbilled Approach: Scenario 3

In the final example, an error is introduced for Class 1 unbilled only. In this case, the idea is that biases in past calculations caused an accumulated underestimate of unbilled energy in prior periods. This bias has accumulated over time to the point where the prior month unbilled is only 10 out of the billing total of 100. This implies that the difference of 90 is energy usage in the current month, which shows in the Already Billed column. But the current month booked energy estimate is only 90 units, implying a current month unbilled estimate of 0. This occurs despite the fact that all current month totals (billed and booked) are exactly correct.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(A) Prior Unbilled	(A+B) Billed GWh	BTB Ratio	(B+C) Calendar Estimate (2)×(3)	(C) Unbilled GWh (4)-(2)+(1)	(B) Already Billed (4)-(5)	Revenue (2)-(1)+(5)
Class1	10.0	100.0	0.90	90.0	0.0	90.0	90.0
Class2	50.0	100.0	0.95	95.0	45.0	50.0	95.0
Total	60.0	200.0		185.0	45.0	140.0	185.0

Figure 5 *Prior-Unbilled Approach: Scenario 3*

Although the revenue number for the month is not impacted in this scenario, the balance sheet will clearly have an ongoing bias, since the unbilled accrual is understated (45 instead of the true value of 85). This bias will continue until an accounting adjustment is made by increasing the unbilled accrual to a reasonable value in some month.

Examples Using Direct Approach

For the Direct Approach, the monthly process is as follows:

- Billed energy is measured during the month and is known at month's end.
- Booked energy (B+C) is estimated at the end of the month.
- Unbilled energy (C) is estimated at the end of the month.
- Revenue and unbilled accrual are computed for the current month.

The difference here is that these calculations are all made without reference to the prior month unbilled result. As will be shown, this implies an implicit correction to the prior month unbilled based on the billed results (A+B). It is this implicit correction that breaks the momentum and keeps calculation errors in one month from propagating to the following month.

The calculation of Revenue and the Unbilled Accrual are the same as in the Prior-Unbilled method. That is:

$$\begin{aligned} &\text{Revenue} = \text{Billed Sales based on (A+B)} + \text{Change in Unbilled} \\ &\text{Assets} = \text{Cash and Receivables based on Billed Sales (A+B)} \\ &\qquad + \text{Unbilled Accrual based on Unbilled Sales (C)} \end{aligned} \tag{11}$$

Although these calculations take the same form, as shown below, the ingredients are slightly different.

Direct Approach: Scenario 1

The Direct method with correct inputs is depicted in Figure 6. The process begins with the Billed Sales data in column 2. Application of the BTB ratio translated Billed Sales into estimated calendar month sales, presented in column 4. The unbilled fraction is then applied to the calendar month estimate to get Unbilled Sales, presented in column 6. Columns 7 and 8 show additional results that are implied by these calculations.

Column 7 shows the estimate of energy that is Already Billed for the current month. In the example for Class 1, sales for the calendar month are estimated to be 90 and the unbilled fraction (44.4%) implies unbilled sales of 40. This implies that the remaining 50 are in the Already Billed triangle (B).

Column 8 shows the prior month unbilled that is implicit in the current month calculations. This calculation is made with knowledge of current month bills (A+B). Since the current month bills are 100 (column 2) and it is estimated that 50 of these 100 are for the current month (B in column 7), this implies that 50 of the 100 were from the prior month unbilled corner. We label this second estimate of the unbilled corner A2. In this case, the second estimate (A2) is consistent with the unbilled accrual for the prior month (A), so there are no implicit adjustments.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(A) Prior Unbilled	(A+B) Billed GWh	BTB Ratio	(B+C) Calendar Estimate (2)×(3)	Unbilled Fraction	(C) Unbilled GWh (4)×(5)	(B) Already Billed (4)-(6)	(A2) Prior Unbilled (2)-(7)	Revenue (2)+((6)-(1))	Implicit Prior Unbilled Adjustment (6)-(1)
Class1	50.00	100.00	0.90	90.00	0.444	40.00	50.00	50.00	90.00	0.00
Class2	50.00	100.00	0.95	95.00	0.474	45.00	50.00	50.00	95.00	0.00
Total	100.00	200.00		185.00		85.00	100.00	100.00	185.00	0.00

Figure 6 *Direct Approach: Scenario 1*

The important point here is that the prior unbilled number (A) in column 1 does not impact our estimate of the current month unbilled value (C) in column 6. This value is estimated directly from the number of days in the unbilled corner and the weather on these days relative to the number of days in the billing cycle and the weather on those days. In this example the results are the same as in the Prior-Unbilled method, because the starting values are error-free.

Direct Approach: Scenario 2

In this scenario, all numbers are the same as the prior example, except that Class 1 prior unbilled is reduced by 20 GWh and Class 2 prior unbilled is increased by 20 GWh. These values show in column 1 where we record the prior unbilled values. As before, the purpose is not to discuss where the errors in prior unbilled came from, but to understand how the Direct Approach unfolds in the presence of such errors.

As seen in Figure 7, the billed sales data (column 2), the calendar month estimate (column 4), and the unbilled sales estimate (column 6) are not impacted by the error. However, there is an inconsistency between the prior unbilled value (A2) that is implied by these results (column 8) and the recorded prior unbilled values (A) in column 1. For Class 1, examine first the calendar month entries. The model estimates are that 90 GWh (B+C) were used in the month, 50 of which (B) are already billed and 40 of which (C) are unbilled. Now look at the billing month entries. Since billed sales (A+B) are 100, and we have estimated that 50 of these (B) were billed in the current month, the implied prior unbilled value (A2) is also 50.

When revenue is computed, this difference has an impact. For Class 1, revenue is computed as billed sales (100 from column 2) plus the change in unbilled (40 from column 6 minus 30 from column 1). The reverse occurs for Class 2. For this class, total billed sales were also 100 and the change in unbilled is negative 25 (45 from the current unbilled minus 70 from the prior unbilled).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(A) Prior Unbilled	(A+B) Billed GWh	BTB Ratio	(B+C) Calendar Estimate (2)×(3)	Unbilled Fraction	(C) Unbilled GWh (4)×(5)	(B) Already Billed (4)-(6)	(A2) Prior Unbilled (2)-(7)	Revenue (2)+((6)-(1))	Implicit Prior Unbilled Adjustment (6)-(1)
Class1	30.00	100.00	0.90	90.00	0.444	40.00	50.00	50.00	110.00	20.00
Class2	70.00	100.00	0.95	95.00	0.474	45.00	50.00	50.00	75.00	-20.00
Total	100.00	200.00		185.00		85.00	100.00	100.00	185.00	0.00

Figure 7 *Direct Approach: Scenario 2*

Although Class 1 revenues are too high because of the implicit unbilled adjustment of +20 and Class 2 revenues are too low because of the implicit unbilled adjustment of -20, total revenues at 185 are correct, since the errors are offsetting and prices in the classes are assumed to be equal ($1 per unit).

Direct Approach: Scenario 3

In the final example, an error is introduced for Class 1 prior unbilled only, with prior month unbilled set to only 10 out of the billing total of 100. As in Scenario 2, the error does not impact the current month estimates in columns 2 to 8.

However, revenue is impacted. For Class 1, the revenue calculation is billed energy (100) plus the change in unbilled which is 30 (40 from column 6 minus 10 from column 1). This gives revenue of 130. This is the true revenue in the month (90 from column 4) plus the implicit unbilled adjustment of the revenue.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(A) Prior Unbilled	(A+B) Billed GWh	BTB Ratio	(B+C) Calendar Estimate (2)×(3)	Unbilled Fraction	(C) Unbilled GWh (4)×(5)	(B) Already Billed (4)-(6)	(A2) Prior Unbilled (2)-(7)	Revenue (2)+((6)-(1))	Implicit Prior Unbilled Adjustment (6)-(1)
Class1	10.00	100.00	0.90	90.00	0.444	40.00	50.00	50.00	130.00	40.00
Class2	50.00	100.00	0.95	95.00	0.474	45.00	50.00	50.00	95.00	0.00
Total	60.00	200.00		185.00		85.00	100.00	100.00	225.00	40.00

Figure 8 *Direct Approach: Scenario 3*

In terms of the balance sheet, the unbilled accrual comes directly from column 6 and is the same in all three scenarios. That is, the unbilled estimate for the current month is estimated directly based on the days and weather in the unbilled corner, and these estimates are not impacted by the prior month unbilled value.

Comparison of Methods

Prior Unbilled Approach. The key point for the Prior-Unbilled Approach is that the prior month unbilled estimate directly impacts the unbilled estimate for the current month. This point is illustrated in Figure 9, which uses the numbers from Scenario 2. As shown by the timeline arrows, the initial prior unbilled estimate is calculated early in the current month to be 30. This value is computed long before the billing month is complete. In geometric terms, it is the A in A+B and it is estimated before A+B is known. After the end of the current month, we now know total billings (A+B = 100), and we estimate calendar month sales (B+C = 90). So, if A+B is 100 and A is 30, this implies that B is 70. And if B is 70 and B+C is 90, this implies that C is 20.

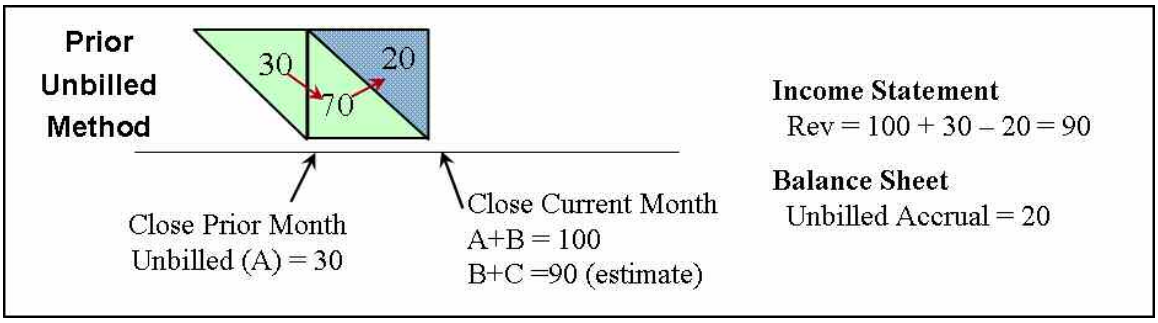


Figure 9 *Causality with the Prior Unbilled Approach (numbers from Scenario 2)*

It should be clear that any error in the prior unbilled estimate passes directly through to a comparable error in the current month unbilled estimate. Although this distorts the estimated split between billed (B) and unbilled (C) in the current month, it does not distort estimated revenue from current month operations. In the example, booked revenue (billed plus the change in unbilled) equals estimated revenue from energy delivered in the current month (90 in the example). With the Prior-Unbilled Approach, booked revenues will be based directly on the current month bills converted to the calendar month, regardless of the prior unbilled calculation and regardless of any errors in this calculation. This can be seen in the following expansion:

$$\begin{aligned} \text{Booked} &= \text{Billed} + \Delta\text{Unbilled} \\ &= \text{Billed} + \text{Unbilled} - \text{Prior Unbilled} \\ &= \text{Billed} + \left(\text{Billed} \times \text{BTB} - \text{Billed} + \text{Prior Unbilled}\right) - \text{Prior Unbilled} \\ &= \text{Billed} \times \text{BTB} \end{aligned} \tag{12}$$

The first line is a statement of the booked revenue calculation (in volume space). The second line expands the change in unbilled into its two parts. The third line substitutes the key relationship in which the current unbilled is computed as a function of the prior unbilled value. The final line cancels out items and shows that the prior unbilled term disappears in this calculation.

Although booked revenue accurately reflects revenue from current month activity, past errors will persist in the unbilled accrual, implying that it persists on the balance sheet and in estimates of year-to-date revenue. Over time, errors in the estimation of unbilled energy will accumulate. In absence of a consistent bias, this will be a random walk, which may build to significant values over time. This can lead to embarrassing outcomes, such as negative unbilled accrual estimates or unbilled energy estimates that are greater than the total billed volumes.

Direct Approach. The Direct Approach uses the prior unbilled value only in the calculation of booked revenue (which is computed as billed plus the change in unbilled for both approaches). If revenue for a class is under-reported in one month, and the unbilled accrual is too low, this will immediately correct itself in the following month, when the independently estimated unbilled accrual returns to the proper number. Revenue will be increased accordingly due to the increase in the unbilled accrual.

This point is illustrated in Figure 10, which also uses the numbers from Scenario 2. As shown, the direction of causality is reversed with this approach. The prior month unbilled estimate is not used to estimate the split between billed and unbilled in the current month. Instead, the current month unbilled is estimated independently. In the example, current month energy (B+C) is estimated to be 90, and unbilled (C) is estimated to be 40 of this total. The remaining 50 is the estimate of the amount of current

month energy that has already been billed. We also know total billings (A+B = 100). So, if A+B is 100 and B is 50, this implies that prior month unbilled (A1) is the remaining 50.

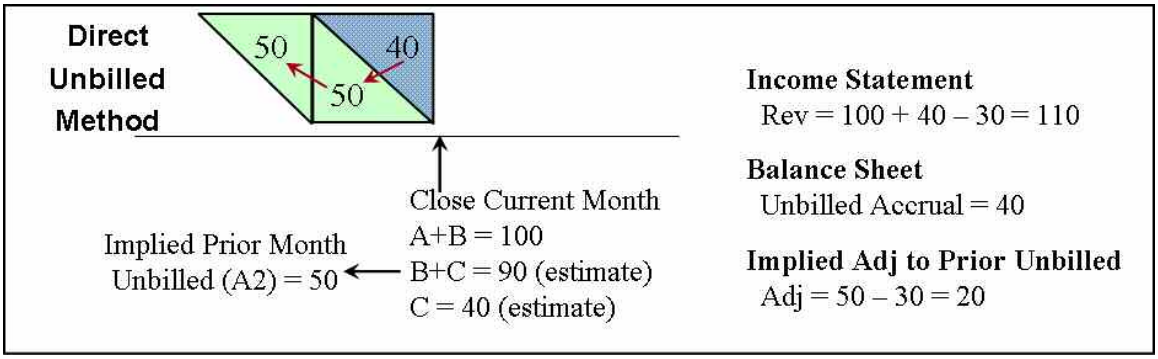


Figure 10 *Causality in the Direct Approach (values from Scenario 2)*

With the Direct Approach, booked revenue for the calendar month will not equal the revenue from current month operations. As seen in the example, booked revenue (110) is computed as billed (100) plus the change in unbilled (10 = 40 – 30). But revenue from calendar month operations is only 90. The remaining 20 comes from an implicit adjustment to the prior month unbilled. This can be seen algebraically as well. Denoting the estimated unbilled fraction for the month as UF and using ABF to represent the fraction already billed (UF + ABF = 1), we have the following:

$$
\begin{aligned}
\text{Booked} &= \text{Billed} + \Delta\text{Unbilled} \\
&= \text{Billed} + \text{Unbilled} - \text{Prior Unbilled} \\
&= \text{Billed} + (\text{Billed} \times \text{BTB} \times \text{UF}) - \text{Prior Unbilled} \\
&= \text{Billed} + \text{Billed} \times \text{BTB} \times \text{UF} - \text{Prior Unbilled} \\
&\quad - \text{Billed} \times (1 - \text{BTB} \times \text{ABF}) + \text{Billed} \times (1 - \text{BTB} \times \text{ABF}) \\
&= \text{Billed} \times \text{BTB} \times (\text{UF} + \text{ABF}) + (\text{Billed} \times (1 - \text{BTB} \times \text{ABF}) - \text{Prior Unbilled}) \\
&= \text{Billed} \times \text{BTB} + \text{Implied Unbilled Adjustment}
\end{aligned}
\qquad (13)
$$

The first two lines are the accounting definition of booked revenue (booked = billed + change in unbilled). The third line substitutes the direct estimate of unbilled into the expression. The following line adds and subtracts the estimate for prior unbilled energy implied by the current month calculations. The next line cancels entries and groups the UF and ABF terms. The final expression relies on the identity, UF+ABF=1, and an interpretation of the final term as an implied unbilled adjustment. This interpretation follows from the following calculation for our revised estimate of the prior month unbilled value:

$$
\begin{aligned}
\text{Revised Prior Unbilled} &= \text{Billed} - \text{Already Billed} = \text{Billed} - \text{Billed} \times \text{BTB} \times \text{ABF} \\
50 &= 100 - 50 = 100 - 100 \times .90 \times 5/9
\end{aligned}
\qquad (14)
$$

The numbers below the expression provide values from the numerical example for each term in the expression. Expression 13 reinforces what we saw in the example. With the Direct approach, booked revenue will not equal revenue from calendar month operations. It will equal calendar month revenue plus the implicit correction to prior month unbilled. It is not necessary to state this as an accounting correction. All that needs to happen is the following:

-- Estimate Calendar Month based on Billed and the BTB ratio
-- Estimate Unbilled based on Calendar Month and the Unbilled Fraction
-- Report Revenue as Billed plus Change in Unbilled.

The point of expression 13 is that the correction to the prior month unbilled is implicit in the revenue calculation. If the implicit correction is positive (prior unbilled was understated) then booked revenue will exceed revenue from calendar month operations. If the implicit correction is negative, then booked revenue will be less than revenue from calendar month operations.

The key advantage of the direct approach is that it limits cumulative errors to the error in the estimation of the unbilled accrual in the most recent month. And if the modeling is done in a reasonable way, this error is strictly bounded by the number of days and weather in the current unbilled corner relative to the number of days and weather over the most recent billing cycle.

Volume Calibration to Zone Sales

Note that the above conclusions are independent of whether calendar month volume estimates are calibrated to zone sales. Calibration can be treated as a minor variation in the calculation of the Booked-To-Billed multipliers. With calibration, the multipliers are adjusted upward or downward to make the calendar month sales estimates tie out to zone sales for that month less losses. Assuming that losses are accurately estimated and relatively stable, this provides calendar month and unbilled estimates that are calibrated to a measured control total for the month.

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