Evaluating a Public Utility’s Investments: Cash Flow vs. Revenue Requirement

By Timothy J. Tardiff and Miles O. Bidwell, Jr.

In spite of current belief, two analytic methods — net present value and revenue requirement analysis — produce the same results for investment analysis.

During a recent regulatory proceeding, we examined two major methods of investment planning that could or should be used by a regulated utility. These plan investments so as to (1) minimize the present value of future revenue requirements and (2) maximize the present value of future cash flows. The hearings were primarily focused on a consulting firm’s report allegations that the two methods give conflicting results — revenue requirements are in the interest of the customers; cash flows are in the interest of stockholders. Based on this supposed difference, and the further allegation that the regulated company had used the method that disadvantaged its ratepayers, the consultants recommended that the revenue requirement approach be used in addition to the net present value method to evaluate central office switch replacements. Since the Northwestern Bell Telephone Company, relying on a cash flow analysis, had already replaced many switches, this recommendation was tied to Northwestern Bell’s request to recover $189 million of its depreciation reserve deficiency.

The consultants argued further:

Pending implementation of this analytical procedure, we recommend disallowance of any reserve ‘deficiency’ allowances (either through remaining life depreciation techniques or an amortization method) which might be proposed by the Company.

Clearly, in this case, a lot of money was riding on the outcome of the debate over appropriate methods. The consultants’ report, which the Commission staff initially found so convincing, pointed out, quite correctly, that revenue requirements include cost categories that are not included in cash flows. However, when an investment is made there is no difference in any cost component that is not represented in both the cash flow and in the revenue requirement analysis.

No matter how we approached the investigation, our conclusion was always the same. When done correctly, investment decisions that minimize the present value of revenue requirements must also maximize the present value of cash flows; alternatively, investment decisions that maximize cash flows must also minimize revenue requirements. After all, the revenue requirement associated with an investment is designed to pay taxes, operating costs, and generate a cash flow for investors that has a present value equal to the cost of the investment.

When we modeled the cash flows and the revenue requirements associated with hypothetical investments, we found no difference in the implied best investment decision. When done correctly, investment decisions that minimize the present value of revenue requirements must also maximize the present value of cash flows; alternatively, investment decisions that maximize cash flows must also minimize revenue requirements. After all, the revenue requirement associated with an investment is designed to pay taxes, operating costs, and generate a cash flow for investors that has a present value equal to the cost of the investment.

When we modeled the cash flows and the revenue requirements associated with hypothetical investments, we found no difference in the implied best investment decision. In fact, we found — when we carefully included all the regulatory conventions for treating deferred taxes and other minutiae — that the dollar differences in the costs or benefits predicted by the two methods were identical if both were expressed in pre- or post-tax terms.

To make sure the equivalence of the results was not due in some way to the examples that we chose, we developed the mathematical proof, which is available from the authors upon request. It demonstrates the general equivalence of the investment planning methods of net present value of cash flow and present value of revenue requirement. In this article, we discuss this equivalence and offer some illustrative examples.

A further source of confusion derives from the fact...
that the method of cash flow analysis comes in two varieties – a pre-tax version and an after-tax version. Thus, there are at least three different methods presently being used to evaluate utilities' investments:

1. net present value of cash flow using the pre-tax discount rate;
2. net present value of cash flow using the after-tax discount rate; and
3. the present value of revenue requirements.

When properly applied, each of these approaches to investment planning gives the same answer. Even though all three approaches give the same results, we prefer using the after-tax cash flow approach. Our preference is based on the greater familiarity and simplicity of this approach.

Use of a pre-tax discount rate requires complex adjustments to the cash flows being discounted, which are not obvious and are not yet found in standard finance textbooks. Use of the revenue requirements approach also involves the modeling of complex regulatory accounting rules. As with the use of the pre-tax discount rate, the unfamiliarity of the revenue requirements approach makes it more susceptible to error, probably requiring that a traditional cash flow analysis be performed as a check on accuracy. Given that the three approaches produce the same results, we see no reason not to use the familiar after-tax present value of cash flow approach, one that is thoroughly discussed in virtually every finance textbook.

We note that our recommended approach -- cash flow analysis with the after-tax discount rate -- agrees with Kenneth Meyer's recent article in this journal on a similar subject. Nonetheless, our conclusions differ from Meyer's in two important respects. First, the equivalence of net present value and revenue requirement is a general result that holds for investments with both zero and nonzero net present values. Second, with appropriate adjustments a pre-tax discount rate can be used in investment planning models that use adjusted pre-tax cash flows. As we discuss later, the decision model used by Pacific Bell that was at issue in the audit mentioned by Meyer can produce correct results when the pre-tax discount rate is used with the appropriate pre-tax cash flow; however, we fully agree with Meyer that the after-tax cost of capital is the only correct measure of a firm's opportunity cost of capital.

The remainder of this paper is organized as follows: in the next section we discuss several fallacies that have both been inspired by and have supported erroneous conclusions about the relationship between the net present value of cash flow and revenue requirement. We then demonstrate the equivalence of the revenue requirement and net present value approaches when the after-tax discount rate is used. Next, we turn to the before-tax discount rate and discuss the circumstances under which using a before-tax discount rate can also produce correct investment decisions.

Four Fallacies

After reviewing a number of articles on utility investments, especially those on plant replacement and modernization, we have identified several widespread misapprehensions which depend on the belief that revenue requirement and cash flow analysis produce different results. Specifically, we have identified a theorem, a lemma, and two corollaries, all of which are fallacious. Recognizing the regulatory mistakes based on them, we call these fallacies, the terrible theorem, the crummy corollary #1, the lousy lemma, and the crummy corollary #2.

The Terrible Theorem

This theorem is stated as follows: The net present value of the cash flows associated with an investment must be different from the present value of the revenue requirements associated with the same investment, because cash flows and revenue requirements have different components. For example, cash flow includes only actual cash outlays, and does not include embedded plant or noncash items such as depreciation expenses, that are included in revenue requirement. Furthermore, in any one year the taxes included in revenue requirement may differ from the actual tax payments shown in a cash flow analysis.

As we have stated it above, the terrible theorem has two parts: an investment part and a tax part. The fallacy in the investment part can be seen by returning to basic definitions. The definition of cash flow used in an investment analysis includes the cost of the investment as a cash flow. (By convention this is entered as a negative flow.) Revenue requirement, on the other hand, does not include the first cost of the investment, but rather includes depreciation expenses, that are included in revenue requirement. Furthermore, the undepreciated portion of an investment is commonly called the embedded rate base. No matter what pattern of depreciation is used, a basic

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That the same investments that maximize cash flow also minimize revenue requirement should not come as a surprise. In an unregulated business, an investment that maximizes the net present value of cash flows also maximizes return on equity. Therefore, making investment decisions on the basis of net present value analysis maximizes shareholder wealth. Because a regulated business cannot earn more than its maximum allowed return on equity, the same investment decision that would maximize shareholder value for an unregulated business minimizes revenue requirements for a regulated business. The benefits from an efficient investment ultimately accrue to the ratepayers because the regulated return on equity limits shareholder earnings. The investment that would be most profitable for the shareholders of an unregulated firm must be the same investment that would lead to the lowest possible rates for customers of a regulated firm.

On the topic of taxes, the reader will recall that the terrible theorem includes the assertion that there is a difference between taxes actually paid by a utility and taxes charged to customers and that this difference causes the net present value of cash flows to be different from the present value of revenue requirements. This assertion is wrong and provides an example of the danger inherent in a little knowledge. Those who base their argument on the tax differences know enough to understand that the tax calculation for IRS purposes is different from the calculation for revenue requirement purposes. What they do not know is that in every regulatory district (at least all those that we or our colleagues have ever come in contact with) some adjustment is made, so that the benefits from depreciating plant more rapidly for tax purposes than for regulatory book purposes are ultimately subtracted from revenue requirements. In many states such adjustment is effected by taking the difference between the taxes charged to ratepayers and the taxes actually paid and reducing the utility's rate base by this amount. Such an adjustment has two effects: (1) it reduces revenue requirements by an amount equal to the tax benefits from accelerated depreciation, and, therefore (2) it makes the present value of cash taxes equal to the present value of revenue requirement taxes.

**Crummy Corollary #1**

This fallacy holds that:

When plant is replaced before being fully depreciated, the present value of revenue requirements may increase even though a net present value of cash flow analysis shows that replacing the old plant reduces the present value of future costs. The revenue requirements may fail to decrease because the undepreciated portion of the retired plant will still be in rate base and customers will still be paying for it in addition to paying for the replacement plant.

This fallacy is based solidly on an error in elementary economics. Many freshman students have trouble understanding the economic concept of sunk costs and their part in efficient investment decisions and persist in trying to include sunk costs among the relevant variables when doing assignments concerning plant shutdowns or replacement decisions. For the very reason that they are sunk, sunk costs cannot be changed and are, therefore, not relevant to decision making: and, depreciated or not depreciated, any existing plant is a sunk cost. The point, which every introductory economics textbook emphasizes, is that the decision maker must concentrate on things that his actions can affect. Revenue requirements can be reduced and the undepreciated part of any plant can be paid for most easily if costs are minimized. If total costs can be reduced by replacing the old plant, it should be replaced.

The economically efficient decision to replace an existing asset of any kind can be stated as, "replace the old machine when the average total costs of the new machine are less than the average variable cost of the old machine." In other words, in present value terms, when the operating costs of the new machine are less than those of the old machine by an amount greater than the capital cost of the new machine, the old machine should be replaced. This rule is independent of who has paid or is paying for the old machine. The cost has been incurred and cannot now be made to vanish. Because total costs are less with the new machine, it will be easier to pay for the old machine if it is replaced than if it is not. The present value of revenue requirement will always be reduced when an economically obsolete machine is replaced. By definition, the old investment has been shown to be economically obsolete. The prospective costs to the company and to the ratepayers will be lowered by the investment, regardless of past decisions.

It is, of course, true that embedded plant costs are
include in revenue requirement and not in cash flow analysis. The important point, which makes the presence or absence of embedded plant irrelevant, is that in neither analysis does the measure of embedded plant change if a new investment is made. In the revenue requirement approach, the same embedded plant is present with or without the replacement investment. Thus its presence does not enter into the calculation of the change in revenue requirement that a replacement investment will cause. In a cash flow approach, the embedded plant is not included in the cash flow with or without the replacement plant. Thus, as in the revenue requirement approach, sunk costs do not enter into the analysis.

The Lousy Lemma and The Crummy Corollary #2

The lemma runs as follows:

When a competitive business replaces plant that is not fully depreciated, it usually writes off the undepreciated balance. Therefore, in competition, the stockholders and not the customers pay for any undepreciated balances for retired plant.

The corollary argument is:

Competitive businesses use net present value of cash flow to evaluate investment decisions and cash flow does not include depreciation; competitive businesses write off undepreciated plant when it is replaced. Therefore, regulated businesses can be made more competitive, and ratepayers benefited, by forcing a regulated firm to write off any undepreciated balances that result from plant replacement decisions. In this way, customers will receive the benefits shown in the cash flow analysis because the undepreciated part of the retired plant will not be included in the rate base in addition to its replacement.

The lousy lemma and derived corollary represent widespread misconceptions. Not only do they play a significant role in the Minnesota case that we mentioned above, but more recently the lousy lemma was stated as fact in a publication of the National Regulatory Research Institute (NRRl). The lousy lemma is simply not true and reflects an appalling ignorance of the workings of a market economy. Even worse, it depends on attributing to a competitive market characteristics that exist only in regulated regimes.

To see why the above lemma is lousy, it is only necessary to look at the following basic characteristics of a competitive market:

(1) In a nonregulated market, price is determined by the market. Price is not determined by the book value of the firm except in the world of rate base regulation. Therefore, in a competitive market writ-
return on equity of 11.5 percent, and an interest rate of 8.5 percent. Table 1 shows that the net present value of this investment is $8.39 and the present worth of the revenue requirement is -$13.98, which equals the net present value divided by the negative of one minus the tax rate, i.e. 8.39/(-1.00) = -13.98.

Use of the Before-Tax Discount Rate

The previous example shows that the net present value and revenue requirement approaches produce identical results when the after-tax discount rate is used. Since the before-tax discount rate corresponds to a utility's authorized rate of return, analyses based on the before-tax rate of return seem reasonable. Unfortunately, use of the before-tax rate of return involves a number of complex and unfamiliar adjustments to the accounting data. Thus, the present worth of return on debt, which is calculated from the after-tax return on equity and the before-tax return on debt, uses a discount rate that is calculated from the after-tax return on equity and the before-tax return on debt. In contrast, the standard textbook net present value calculation uses a discount rate in which both the equity and debt components are after-tax rates. The report commissioned by the CPUC staff cited this difference among a number of alleged errors and, accordingly, recommended penalties totaling $700 million. In the case that followed the report, Pacific Bell's witnesses were able to show that the "before-tax" and "after-tax" net present value calculations, with appropriate adjustment to the annual cash flows, produce the same results, thus removing the basis for this criticism of Pacific Bell's investment program.

The use of the before-tax discount rate poses two questions: (1) under what conditions do net present values based on the before- and after-tax discount rates produce the same result? and (2) under what conditions is a revenue requirement analysis based on the before-tax discount rate equivalent to a net present value analysis?

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Any incorrect results that may occur with before-tax computation are more the result of earnest errors than of the conspicuous confusion that characterizes the "terrible theorem."

The distinction between before-tax and after-tax investment evaluation methods was an issue in the recent review of Pacific Bell's modernization program by the staff of the California Public Utilities Commission (CPUC). Pacific Bell's method for calculating net present values, which is widely used throughout the Bell system, uses a discount rate that is calculated from the after-tax return on equity and the before-tax return on debt. In contrast, the standard textbook net present value calculation uses a discount rate in which both the equity and debt components are after-tax rates. The report commissioned by the CPUC staff cited this difference among a number of alleged errors and, accordingly, recommended penalties totaling $700 million. In the case that followed the report, Pacific Bell's witnesses were able to show that the "before-tax" and "after-tax" net present value calculations, with appropriate adjustment to the annual cash flows, produce the same results, thus removing the basis for this criticism of Pacific Bell's investment program.

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results identical to the standard textbook approach when the following adjustment is made to the standard cash flow: “Before-Tax” cash flow = “After-tax” cash flow + interest tax benefit, where the interest tax benefit is calculated from the remaining value of the investment, not the actual remaining debt.12

Table 2 extends the example in Table 1 to illustrate the Boudreaux-Long solution. Note that with the addition of the interest tax benefit term to the cash flow, the net present value at the pre-tax rate is the same $8.39 as in Table 1.

The Boudreaux-Long definition of the interest tax benefit defines the appropriate debt structure in terms of the economic depreciation of the investment. That is, just as the economic depreciation of an asset is the difference in the present value of future cash flows between two years, so also is the change in the interest tax benefit defined by the change in the asset’s value. Therefore, in addition to providing the correct information for economically efficient rates,13 economic depreciation has the added benefit of guaranteeing that before- and after-tax net present value analyses produce identical results.

A similar answer holds for the question of when a before-tax revenue requirement analysis produces the same result as the standard net present value analysis. If book depreciation and tax depreciation follow true economic depreciation, then we have shown by example14 that an investment based on the present worth of the revenue requirement, calculated with the before-tax discount rate, will be the same as one based on a net present value. In particular, when the net present value is positive, the investment will lower the revenue requirement.

Conclusions

When performed correctly, both of the two approaches described in previous Forman articles, net present value analysis and revenue requirement analysis, provide the correct information for public utility investments. When the after-tax discount rate is used, net present value analysis and revenue requirements analysis are mathematically identical.

Our proof that the methods considered here give the correct information for investment decisions should remove the methods themselves from deliberations of whether or not a utility’s investment program has been prudent. Contrary to the criticisms in the recent Minnesota and California regulatory dockets, the net present value techniques used by the telephone companies provide the correct information for investment decisions, if the techniques are used correctly with accurate information.

Although the actual computations can be complex and extensive even when reduced to illustrative examples, provided that after-tax discount rates or pre-tax rates with modified cash flows are used, the results from NPV of cash flow and PV of revenue requirement analyses must be equivalent. All examples to the contrary contain flaws. Whether the result of conspicuous confusion or earnest error, such studies are wrong.

That so much regulatory time and money have been spent on a nonissue strikes us as both intriguing and distressing. We hope that, by widely disseminating the proof that these investment planning alternatives are equivalent...
Endnotes


Two previous articles in this journal have described different approaches to evaluating public utilities’ investments. The first article (Wallace N. Davidson III, "Net Present Value Analysis: Appropriate for Public Utilities?", Public Utilities Fortnightly, August 28, 1980, pp. 17-21) described the net present value of cashflow analysis, an approach which has been covered extensively in finance textbooks. The second article (Benjamin J. Ewers and Kelly E. Wheaton, "The Revenue Requirement Approach to Financing Alternatives," Public Utilities Fortnightly, July 19, 1984, pp. 23-25) described an approach which uses the present value of revenue requirements to evaluate investment alternatives, claiming that only the use of the revenue requirement approach will "minimize price levels for the company's products."

"Maginnis and Weiss, p. 106.


Meyer’s statement that all regulated utility investments have a zero net present value is correct only from the viewpoint of the securities holder. The statement is not correct from the viewpoint of the investment or the regulated utility. Although shareholders earn no more than the authorized equity return from an investment with a positive net present value (and hence the net present value from their perspective is zero), the gain over and above the cost of capital accrues to the ratepayers through a reduced revenue requirement. The amount of revenue requirement reduction can be directly calculated from the positive net present value as we demonstrate below.

This relationship depends upon the use of the after-tax discount rate in both the net present value and the revenue requirement calculations. When a before-tax discount rate is used in combination with appropriately defined cash flows, the two approaches generally yield different results, although the differences should be quite small. Such an adjustment is needed in the revenue requirement calculation shown in Table 1.

Standard computer programs and operating procedures mitigate the potential for error in the pre-tax approach.

This is the same way that the utility’s rate of return is calculated, although the debt and equity components for project evaluation may differ from the values that are used in the rate of return.

In February 1989, Pacific Bell and the CPUC staff announced a proposed settlement.


The note for Line 13 of Table 2 presents the mathematical formula for the economic value of the remaining life of the investment.

Rebuttal Testimony of Miles O. Bidwell, Jr., on behalf of Northwestern Bell Telephone Company, Minnesota Public Utilities Commission, Docket No. P-412/C-F-86-354, pp. 79-49.

Bidwell, p. 8.

Sources & Notes: Table 1

Line 1, 3, 4, 7, 12: This is an Illustrative assumption.

Line 2: Composite tax rate includes state and federal taxes. The 40 percent figure was selected as an example.

Line 5: Equals (1-debt ratio) x return on equity + debt ratio x return on debt.

Line 6: Equals (1-debt ratio) x return on equity + debt ratio x return on debt x (1-tax rate).

Line 7: Equals (1-tax rate) x return on equity + debt ratio x return on debt.

Line 8: Equals initial asset value minus accumulated book depreciation.

Line 8.1: Tax reserve increment in year i = tax rate x (tax depreciation - book depreciation); tax depreciation appears in line 19, and book depreciation in line 9.

Line 8.2: Net rate base In year 1 equals previous year’s net rate base minus book depreciation in year 1.

Line 9: Book depreciation equals initial asset value divided by project life.

Line 10: Equals previous year’s net rate base x pre-tax rate of return.

Line 11: Taxes are those collected from ratepayers as part of the revenue requirement. Calculation assumes book depreciation. Taxes equal last year’s net rate base x (1-debt ratio) x return on equity x tax rate x(1-tax rate).

Line 12: Revenue requirement attributable to the rate base. Equals book depreciation plus return plus taxes.

Line 13: Net revenue requirement equals fixed charge revenue requirement minus savings.

Line 15, 23: Equals (1 + after-tax discount rate), where i denotes year.

Line 16: Equals net revenue requirement divided by discount factor.

Line 17: Equals line 7 in year 0. Example assumes that no investment occurs in subsequent years.

Line 19: Double declining balance (DBD) depreciation schedule is used to depreciate initial investment.

Line 20: Equals line 19 times tax rate.

Line 21: Equals line 13 times (1-tax rate).

Line 22: Cash flow equals tax depreciation benefit plus after-tax savings minus investment.

Line 24: Discounted cash flow equals cash flow divided by discounted factor.

Line 25: Sum of discounted cash flows.

Line 26: Equals line 17 divided by line 25. The result equals (1+tax rate).

Sources & Notes: Table 2

Line 1-7: Same definitions and values as shown in Table 1.

Line 8-10: See Table 1, lines 19-20.

Line 11: See Table 1, line 13.

Line 12: See Table 1, line 21.

Line 13: Asset value in year 1 =

\[ T \]

\[ \frac{2 \cdot (\text{after-tax savings} + \text{tax depreciation benefit})(1 + r)^{-i}}{r} \]

where 1 and 2 denotes years, 1 is the project life, and r is the after-tax discount rate.

Line 14: Equals line 13 x debt ratio x tax rate x return on debt.

Line 15: Equals tax depreciation benefit plus after-tax savings plus interest tax benefit minus investment.

Line 16: (1 + pre-tax rate of return), where i denotes year.

Line 17: Equals cash flow divided by discount factor.

Line 18: Equals sum of discounted cash flows. Result equals net present value in Table 1.

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