STATE OF NEW HAMPSHIRE

BEFORE THE

PUBLIC UTILITIES COMMISSION

Public Service Company of New Hampshire d/b/a Eversource)
Notice of Intent to File Rate Schedules)

Docket DE 24-070

Direct Testimony

Annual Depreciation Expenses

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Q. **Please state your name, position, and business address.**

A. My name is Marc H. Vatter. I am Director of Economics and Finance at the Office of the Consumer Advocate (OCA).

Q. **How long have you worked for the OCA?**

A. I have been employed at the OCA since August 25, 2023.

Q. **Is a summary of your experience attached to this testimony?**

A. Yes. Attachment MV-1 is my resume.

Q. **Have you previously testified before public utility regulatory commissions?**

A. Yes. I have testified before the New Hampshire Public Utilities Commission, as well as the Energy Facilities Siting Board of the Rhode Island PUC, the Michigan PSC, the Mississippi PSC, and the FERC.

Q. **What is the purpose of your testimony?**

A. I argue for a downward adjustment to depreciation expenses relative to what Public Service Company of New Hampshire (PSNH; the Company) has requested, based on a relationship between the Company's weighted average cost of capital (WACC; its long term "time-value of money"), and cost-minimizing timing of retirement of physical assets. The Company's request is derived from a study submitted with the testimony of John J. Spanos on behalf of the Company; Attachment ES-JJS -2 to his direct testimony. I propose adding an equation to the model Mr. Spanos uses that must hold if the Company is to minimize distribution costs, and I suggest ways to evaluate the variables in the combined model. Evaluating the variables implies a value for depreciation expenses. Mr. Spanos relies substantially on his professional judgment in deriving estimated depreciation, and the additional equation I propose reduces, though it does not eliminate, the need for judgment calls.

Q. Please summarize the OCA's position on the issue discussed in this testimony.

A. Our position is that allowable annual expenses for depreciation should be reduced from the $91,666,445 requested to $73,630,445.

Q. Please discuss the role that professional judgement plays in Mr. Spanos' analysis.

On Bates pages 18891-2 of his direct testimony, Mr. Spanos writes: "The straight line remaining life method of depreciation allocates the original cost of the property, less accumulated depreciation, less future net salvage, in equal amounts to each year of remaining service life." The equation that gives his estimate of depreciation can be expressed as

$$D = \frac{I_N - A_0 - \left(G_T - C_T\right)}{T} \qquad (1)$$

where I_N is "the original cost of the property", A_0 is "accumulated depreciation" in Year 0, which, in this case is 2023, $G_T - C_T$ is "future net salvage", and T is "remaining service life." G_T is gross salvage in Year T, and C_T is cost of removal in Year T. "Gross salvage" refers to revenues from the sale of scrap, and "cost of removal" refers to the cost of having scrap removed. "Accumulated depreciation", a.k.a. "book depreciation reserve", here refers to depreciation expenses incurred before December 31, 2023. The estimated values of all of the variables in Equation (1), except I_N, reflect, at least in part, the exercise of the professional judgement of Mr. Spanos or, in the case of A_0, his predecessor(s). Therefore, his estimate of annual depreciation expenses, D, does, too. Table 1 lists ten separate statements from Mr. Spanos' testimony and study highlighting the role of professional judgment in estimating annual depreciation expenses.

Table 1: Separate statements highlighting the role of professional judgement in John Spanos' analysis

Statement	Bates page	lines
Testimony		
...depreciation is, by nature, a forecast of the future for thousands of individual assets.	18884	3-4
The net salvage percentages in the Depreciation Study are based on a combination of statistical analyses and informed judgment.	18891	6-8
Study		
The service life and net salvage estimates resulting from the study were based on informed judgment which incorporated analyses of historical plant retirement data as recorded through 2023, a review of Company practice and outlook as they relate to plant operation and retirement, and consideration of current practice in the electric industry, including knowledge of service lives and net salvage estimates used for other electric companies.	18927	
Part III, Service Life Considerations, presents the factors and judgment utilized in the average service life analysis. Part IV, Net Salvage Considerations, presents the judgment utilized for the net salvage study.	18927	
The service life estimates were based on informed judgment which considered a number of factors.	18952	
Generally, the information external to the statistics led to little or no significant departure from the indicated survivor curves for the accounts listed below, although for some accounts higher mode curves were recommended than indicated by the historical data.	18953	
Each of the judgments represented a consideration of statistical analyses of aged plant activity, management's outlook for the future, and the typical range of lives used by other electric companies.	18954	
The net salvage estimates for the remaining plant accounts were estimated using the above-described process of historical indications, judgment and reviewing the typical range of estimates used by other electric companies.	18958	
The amortization periods used in this report were based on judgment which incorporated a consideration of the period during which the assets will render most of their service, the amortization period and service lives used by other utilities, and the service life estimates previously used for the asset under depreciation accounting.	18962	
The service life estimates were based on judgment that incorporated statistical analysis of retirement data, discussions with management and consideration of estimates made for other electric utilities.	18965	

Mr. Spanos' professional judgment is the best in the business, but regardless of the quality of his judgment, it is preferable to narrow the range over which judgment calls must be made by using objective criteria in any analysis. I do not challenge the method of straight line remaining life depreciation; rather, I combine it with another analysis based on fundamental concepts of corporate finance and regulatory economics. I use Mr. Spanos' estimate of net salvage in all three scenarios that I present.

Q. What is "depreciation"?

A. Depreciation is a monetary measure of the decline in value of a productive asset between when it is acquired and when it is retired. Though the value of an asset may temporarily rise during that time, appreciate, all produced assets are eventually retired because their value has declined.[1] The "service life" of an asset may be a few years, or centuries. The cost of acquiring the asset, referred to as "original cost", is usually taken to equal its value when acquired.

Typically, owners of assets continue to invest in their productive capability while they are in use. Sometimes, we call this "maintenance," though distinguishing between maintenance and improvement of an asset may be arbitrary. Depreciation is generally separated from both.

Depreciation is treated as a cost for purposes of taxing businesses, measuring national income, and, as it is here, for calculating a regulated public utility's revenue requirement. Depreciation is normally reported on an annual basis, and could represent the decline in an asset's value during each year, but usually is measured only as that year's contribution to the downward trend in value over the service life of the asset, apart from any transient fluctuation in the value of the asset.

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[1] See Shelley, P.B. (1818). "Ozymandias", *The Examiner*, London. Available at **https://www.poetryfoundation.org/poems/46565/ozymandias**, accessed November 1, 2023.

Q. Please describe the "downward trend".

A. Different forms may be imposed on the downward trend when estimating depreciation expenses and are accepted practice, as noted by Mr. Spanos at Bates pages 18883-84 of his testimony. In straight line full life depreciation, the nominal (not adjusted for inflation) depreciation expense is the same during every year between acquisition and retirement. In straight line remaining life depreciation, the nominal expense is the same during every year between when depreciation is estimated and expected retirement. In declining balance depreciation, the nominal expense declines between acquisition or estimation and expected retirement. In all of these forms, real (adjusted for inflation) expenses decline from year-to-year if general inflation is positive, because the real purchasing power of constant nominal expenses declines over time.

Let $I_0 \equiv I_N - A_0$. Nominal straight line remaining life depreciation is equivalent to real declining balance depreciation, but with real depreciation of

$$D_t^r = \frac{I_0 - (G_T - C_T)}{T} \Big/ (1 + \dot{p})^t \tag{2}$$

where $\dot{p}$ is the rate of inflation, and real accumulated depreciation is

$$\sum_{i=1}^{t-1} D_i^r = \frac{I_0 - (G_T - C_T)}{T} \frac{1 - \left(\frac{1}{1+\dot{p}}\right)^{t-1}}{\dot{p}} \tag{3}$$

the sum of a finite geometric series. It is, therefore, not necessarily a problem to use nominal straight line remaining life depreciation for assets with short service lives, for which declining balance depreciation is sometimes recommended.

In straight line remaining life depreciation, the depreciation expense for each current and future year is given by

$$D = \frac{I_0 - (G_T - C_T)}{T} \qquad (4)$$

where $I_0 \equiv I_N - A_0$ is "the original cost of the property, less accumulated depreciation" in Year 0, which, in this case, is 2023. An equivalent expression appears in a document[2] from the California Public Utilities Commission (CPUC) on page 5 in Chapter 2.

Q. What drives the determinants of annual depreciation expenses?

A. Original cost less past depreciation, I_0, is treated as a sunk cost. However, because past depreciation, A_0, was also estimated, even though it is treated as sunk, I_0 is also estimated. Gross salvage, G, changes over time as the market prices of scrap materials change. Cost of removal, C, changes over time as the wages for the labor needed to remove scrap change, so the values G_T and C_T, respectively, depend on the forecast of T, though, if they both increase, the changes are at least partly offsetting. The decision about when to plan to retire a facility, the forecast of T, should depend on expected growth in prices for scrap materials and wage rates. The forecasts of G_T, C_T, and T, which, along with the estimated I_0, jointly determine annual depreciation expenses in an impending electric rate period, and thereafter, D, should be mutually consistent with cost-minimizing planning of PSNH's distribution system.

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[2] California Public Utilities Commission Water Division (1961). *Standard practice manual for determination of straight line remaining life depreciation accruals*. Available at **https://docs.cpuc.ca.gov/published/REPORT/22156.htm**, accessed October 25, 2023.

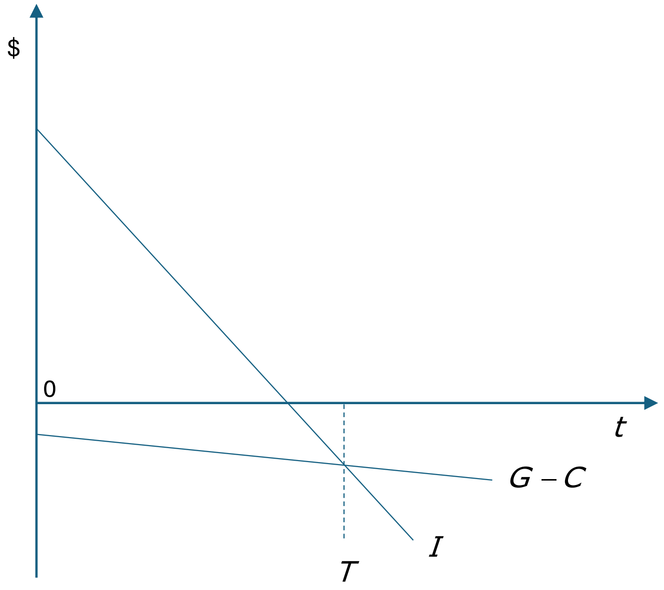
Q. How do these variables determine annual depreciation expenses?

A. By Equation (4), a lower net salvage or a shorter service life implies higher depreciation expenses. For total depreciable plant, Mr. Spanos' estimate of net salvage is -$1,105,053,281, which is original cost less accumulated depreciation less future accruals. His estimate of composite remaining service life, using the formula he gives under the heading "composite remaining life" on page 50 of the study, is 33.9 years, so the (negative) net salvage occurs in 2057.

Q. How should cost-minimization drive annual depreciation expenses?

A. Figure 1 illustrates cost-minimizing timing of retirement, in Year T. I is the value of a distribution facility, which declines over time t, measured in years, as the facility depreciates. When the value of the facility equals net salvage, it should be retired; taken out of service.

Figure 1: Cost-minimizing retirement of a distribution facility



The value of such an asset at any time, here, I, equals the present discounted value of its current and future contribution to a firm's profits, or losses. Since net salvage is cash, it can be thought of as the present value of the stream of earnings that the cash could generate if invested, or, if negative, the present value of financing a liability of that amount. As the present value of operating a facility falls to (the present value of) its net salvage, it is the profit-maximizing, and, therefore, cost-minimizing[3], time to retire the facility.

Suppose the service life of a facility extends through Year $T-1$, and it is retired at the beginning of Year T, at which time the owner collects revenue from or pays the cost of net salvage. Then, the value of the asset at t is

$$I_t = \left(\sum_{s=t}^{T-1} \frac{\pi_s}{\left(1+d\right)^{s-t}} \right) + \frac{G_T - C_T}{\left(1+d\right)^{T-t}} \qquad (5)$$

where π_s is operating profits in Year s, and d is the discount rate. When $t = T$, Equation (5) reduces to $I_T = G_T - C_T$, as in Figure 1. The level at which they are equal may be negative because the facility should continue to operate at some loss in order to defer negative net salvage, so long as the present value of current and future losses, including deferred negative net salvage, is smaller, in absolute terms, than current negative net salvage. The lower operating and maintenance costs are, the lower the losses associated with continued operation. On utility distribution systems, variable operating costs are low, and maintenance, both fixed and variable,

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[3] Cost-minimization is a necessary but not sufficient condition for profit-maximization, but the two reduce to the same problem for a competitive firm, which takes the market price for its output as given, and for a monopoly subject to regulation of price, like PSNH. Under optimal regulation, a firm cannot raise price above the level at which "excess" profits are zero, as is the case for a competitive firm. A regulated monopoly maximizes profits, subject to a rate cap at the intersection of demand and long run average total cost, by minimizing cost for that level of output. Any addition to revenues that would otherwise go into excess profits are, instead, used to minimize average total costs and, therefore, rates.

should be low as retirement nears. (I will not replace the belts and hoses in the engine of a car that I am about to junk.) Note that "fixed" is with respect to load, not necessarily over time.

Q. Please describe the equation you add to Mr. Spanos' model.

A. Equation (6), below, is derived in the appendix from the condition that the value of an asset at the time of retirement equals net salvage, as in Equation (5), and that the market value of plant trends at the same rate for complementary facilities in a network industry. Equation (6) relates annual straight line depreciation expenses, D, to (negative) net salvage, $G_T - C_T$, at the cost-minimizing time of retirement, T, and a company's weighted average cost of capital at T, denoted by $WACC_T$.

$$D = -\left(G_T - C_T\right)WACC_T \tag{6}$$

At the time of retirement, expenses for depreciation come to an end, and expenses for financing negative net salvage begin, and the rate at which those expenses are financed is given by the rate the company must pay for funds, its weighted average cost of capital. The present value of a perpetuity equals the periodic payment divided by the rate of return: Dividing Equation (6) by $WACC_T$ shows that the Company could finance negative net salvage by issuing a perpetuity that paid the holder D annually. In the optimal year for retirement, a company is indifferent between the two sources of annual expense, straight line depreciation and constant debt service on a perpetuity used to finance negative net salvage, because their values are equal.

Setting Mr. Spanos' expression for straight line deprecation, (4), equal to mine, (6), gives

$$\frac{I_0 - \left(G_T - C_T\right)}{T} = -\left(G_T - C_T\right)WACC_T \tag{7}$$

Solving (7) for T,

$$T = \frac{1}{WACC_T}\left(1 - \frac{I_0}{G_T - C_T}\right) \tag{8}$$

$T = 0$ when the asset is retired, and, again, we see that $I_T = G_T - C_T$, as in Figure 1 and Equation (5). If an asset being retired is to be replaced, negative net salvage is a cost of the joint decision to retire *and* replace the asset. With $WACC_T$ being the rate paid to finance the replacement capital, that rate also applies to the financing of negative net salvage. I show in the appendix that the WACC applies without reference to replacement.

Cost-minimizing retirement of distribution facilities, and other assets, implies that straight line depreciation equals the negative of net salvage times the WACC in Year T, which, in Mr. Spanos' study, is 33.9 years hence, looking at depreciable plant as a whole. Taking Mr. Spanos' net salvage of -$1,105,053,281 as given, his annual depreciation expenses of $91,666,445 imply a WACC in 2057 of 8.30 percent. In Equation (8), the optimal end of service life, T, is decreasing in $WACC_T$, so a lower $WACC_T$ implies a later optimal date of retirement. The Company's proposed WACC of 7.44 percent in DE 24-070 (see Bates page 19303 in the testimony of PSNH witness Vincent Rea), if applied in 2061, implies annual depreciation expenses of $82,215,964. A WACC of 6.67 percent in 2065 implies annual depreciation expenses of $73,630,445. These scenarios are shown in Table 2.

Table 2: Evaluating Equation (6); three scenarios

	Depreciation expense	Net salvage	$WACC_T$	Composite date of retirement
John Spanos' depreciation, net salvage, and service life	91,666,445	-1,105,053,281	8.30%	2057
PSNH WACC from filing	82,215,964	-1,105,053,281	7.44%	2061
OCA WACC	73,630,445	-1,105,053,281	6.67%	2065

Calculations are performed in the Scenarios tab of 24-070_2025-03-25_Exh_3.xlsb.

Which estimate is most consistent with planning for cost-minimization turns on the estimated WACC. The OCA WACC in 2065 of 6.67 percent uses OCA Witness Aaron Rothschild's capital structure of 47.24 percent equity and 52.76 percent debt, a trending Capital Asset Pricing Model β for Eversource of 0.64 in 2065, a long run rate of return on the S&P 500 of 9.00 percent, a long run secondary yield on three month Treasury bills of 2.82 percent, and a long run yield on Baa corporate bonds of 7.96 percent, the latter three being the averages since 1980. It also uses a corporate tax rate of 17.50 percent, composed of a ten percent federal effective corporate rate, post-2017 Tax Cuts and Jobs Act, and a 7.50 percent New Hampshire business profits tax. Corporate interest expense is tax-deductible, and the tax deduction should be passed through to customers.

Q. What is the OCA's position on the Company's calculation of annual depreciation expenses?

A. Based on a forecasted after-tax weighted average cost of capital of 6.67 percent in 2065, provided that Mr. Spanos' estimated net salvage of -$1,105,053,281 is correct, I recommend that the Commission allow annual depreciation expenses of $73,630,445.

Q. Does this conclude your testimony on this topic?

A. Yes.

APPENDIX

Aggregation

The table on Bates pp. 18967-8 of Mr. Spanos' Attachment ES-JJS-2 aggregates the determinants of future accruals of depreciation expenses across $N = 45$ categories of depreciable utility capital as follows:

$$\underbrace{\sum_{j=1}^{N}\underbrace{\underbrace{\left[\frac{G_T^j - C_T^j}{I_0^j + BDR_0^j}\right]}_{\substack{\textit{categorical}\\ \textit{net salvage}\\ \textit{percent}}}\underbrace{\left(I_0^j + BDR_0^j\right)}_{\textit{original cost}}}_{\substack{\textit{categorical}\\ \textit{net salvage}}}}_{\textit{aggregate net salvage}} = \sum_{j=1}^{N} I_0^j - \underbrace{\left[\frac{\displaystyle\sum_{j=1}^{N}\frac{I_0^j - \left(G_T^j - C_T^j\right)}{T^j}T^j}{\displaystyle\sum_{j=1}^{N}\frac{I_0^j - \left(G_T^j - C_T^j\right)}{T^j}}\right]}_{\substack{\textit{aggregate composite}\\ \textit{remaining life}\,(T=30.1)}}\underbrace{\sum_{j=1}^{N}\underbrace{\frac{I_0^j - \left(G_T^j - C_T^j\right)}{T^j}}_{\substack{\textit{categorical}\\ \textit{depreciation}}}}_{\textit{aggregate depreciation}} \tag{9}$$

where BDR_0^j is book depreciation reserve in Year 0 (2023).

Equation (9) simplifies to

$$\sum_{j=1}^{N} G_T^j - C_T^j = \sum_{j=1}^{N} I_0^j - T\sum_{j=1}^{N}\frac{I_0^j - \left(G_T^j - C_T^j\right)}{T^j} \tag{10}$$

Executing the summation signs, summing across categories, gives

$$G_T - C_T = I_0 - TD \tag{11}$$

Or,

$$D = \frac{I_0 - \left(G_T - C_T\right)}{T} \tag{4}$$

which is the same as (4), and evaluates to $91,666,445 for depreciable plant as a whole in Mr. Spanos' testimony. Mr. Spanos applies straight line remaining life depreciation to each category of plant and to total depreciable plant for PSNH.

The market value of plant

According to the CPUC, "Depreciation in its value concept represents the loss in market value of property as compared with either its original cost new or the reproduction cost new of equivalent property."[4] Here, we are comparing "with its original cost new". The market value of plant depends on both its physical condition and the other causes of depreciation; that is, anything that changes the value of plant other than maintenance or improvement, with the changes erasing the value of the plant over the course of its service life. Mr. Spanos, on Bates page 18881 of his testimony, and the CPUC[5] provide similar, and fairly exhaustive, lists of admissible causes of depreciation, some of which may well cause temporary appreciation during service life. Examples include "demand" and "obsolescence", which have little or no effect on the physical condition of plant, but do affect its market value.

I assume that the "original cost new" of a distribution network equals its market value (e.g., what it would fetch as part of a corporate merger or acquisition) at the time it becomes used and useful. The time at which a network composed of facilities that have become used and useful at different times can be summarized as Year 0 less composite preceding life, calculated as accumulated depreciation over annual depreciation for all facilities that are used and useful in Year 0. (See Equations (9), (10), (11), and (4).)

In a network industry, the components of the network are complementary. As an example, the capacity of two sections of a power line equals the capacity of the section whose capacity is less than the other. It is this complementarity among inputs that gives rise to the natural monopoly cost structure (declining average total cost) that characterizes networks and motivates economic regulation of network industries. Wohlgenant (2012) shows that, when all inputs are pair-wise complements, a one percent increase in the use of a single input leads to less than a one percent increase in output.[6] Therefore, it is cost-minimizing to increase the use of inputs in tandem when output increases. Both sections of the two-section power line should be expanded in order to meet an increase in peak load.

Let long run marginal cost be given by

$$c' = a + 2bq \tag{12}$$

where c' is long run marginal cost, a linear function of output, q, whose vertical intercept is a, and whose slope is $2b$. Long run total cost, then, is

$$c = f + aq + bq^2 \tag{13}$$

where f is fixed costs, none of which are sunk, since this is the long run. In a network industry, fixed and marginal inputs are complementary, so marginal cost may be reduced by incurring

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[4] Ibid, CPUC, p. 4, Chapter 2.
[5] Ibid, CPUC, p. 5, Chapter 2.
[6] Wohlgenant, M.K. (2012). Input complementarity implies output elasticities larger than one: implications for cost pass-through, *Theoretical Economics Letters* 2, 50-53; **http://dx.doi.org/10.4236/tel.2012.21009**

greater fixed costs, and vice-versa. For example, raising the capacity of a power line can reduce the congestion component of locational marginal price, which is often used as a measure of marginal cost. Correspondingly, allowing greater congestion by deferring fixed costs of transmission capacity raises LMPs. Let the complementarity be represented as

$$b = \frac{1}{f} \tag{14}$$

Substituting (14) into (13) and dividing by q gives long run average total cost

$$\frac{c}{q} = \frac{f}{q} + a + \frac{1}{f}q \tag{15}$$

Minimum average total cost occurs at the level of output where the slope of c/q is zero.

$$\left(\frac{c}{q}\right)' = -\frac{f}{q^2} + \frac{1}{f} = 0 \tag{16}$$

Solving (16) for q gives the level of output at which average total cost is minimized.

$$\begin{aligned} -\frac{f}{q^2} + \frac{1}{f} &= 0 \\ \frac{1}{f} &= \frac{f}{q^2} \\ q^2 &= f^2 \\ q^* &= f \end{aligned} \tag{17}$$

The cost-minimizing level of output equals fixed costs. Natural monopolies have high fixed costs and, therefore, high cost-minimizing levels of output. When $q < q^*$, average total cost is declining; $(c/q)' < 0$. In network industries, complementarity between fixed and marginal inputs, $b = 1/f$, means that greater investment in fixed inputs lowers marginal cost and causes average total cost to decline up to a higher level of output. The fact that a large investment is necessary to minimize the cost of serving additional load renders the network a natural monopoly, suitable for economic regulation.

Define I as the market value of a distribution facility, as in Equation (5). I assume that equity in the company that owns the facility is given by

$$PQ = R - B + S \tag{18}$$

where P is the price of a share of equity in the company, Q is the number of outstanding shares, R is the market value of the company's entire real capital, inclusive of I, B is its corporate debt, and S is corporate saving. If, for example, the company were acquired, the amount paid for its stock in the acquisition would, by definition, be the market value of its real capital less its net corporate debt, like buying a piece of property with a lien on it.

Rearranging (18),

$$R = PQ + B - S \tag{19}$$

Differentiating with respect to time,

$$\dot{R} = \dot{P}Q + \dot{Q}P + \dot{B} - \dot{S} \tag{20}$$

Equation (20) relates a change in the market value of a company's entire real capital to changes in its outstanding financial instruments.

Because this is a network industry, in which inputs are complementary, I assume that the market value of the distribution facility, less maintenance and improvement, changes at the same rate as the rest of the company's real capital, less maintenance and investment, which is synonymous with "improvement", and may be financed by issuing equity, debt, or cash on hand.

$$\frac{\dot{I} - M}{I} = \frac{\dot{R} - (\dot{Q}P + \dot{B} - (\dot{S} - (Sj - Bi - V)))}{R} \tag{21}$$

where $\dot{I}$ is annual change in the market value, I, of the facility, M is additional investment in the facility, referred to as "maintenance," but which may also include improvement, j is the rate of interest on corporate savings, i is the rate of interest on corporate debt, V is dividends, $\dot{Q}P + \dot{B}$ is newly issued equity and debt, and $\dot{S} - (Sj - Bi - V)$ includes the portion thereof that is retained as cash, rather than being used for investment in/improvement of real capital, while the remainder, an "investment" in corporate saving, is also being separated from the change in the market value of extant real capital. This term may be negative if investment/improvement is cash-financed.

Equation (21) becomes a weaker assumption still when I refers to a large amount of depreciable capital, rather than a very specific category thereof, because that large amount accounts for a large share, or all, of a company's real capital.

Substituting (19) and (20) into (21),

$$\begin{aligned}\frac{\dot{I}-M}{I} &= \frac{\dot{P}Q+\dot{Q}P+\dot{B}-\dot{S}}{PQ+B-S}-\frac{\dot{Q}P+\dot{B}-\dot{S}+Sj-Bi-V}{PQ+B-S}\\ &= \frac{\dot{P}Q+V}{PQ+B-S}+\frac{Bi}{PQ+B-S}-\frac{Sj}{PQ+B-S}\\ &= \left(\frac{\dot{P}Q+V}{PQ}PQ+\frac{Bi}{B}B-\frac{Sj}{S}S\right)\Big/ PQ+B-S = WACC\\ \frac{\dot{I}-M}{I} &= WACC\end{aligned} \tag{22}$$

the Coimpany's weighted average cost of capital. In the second to last line of Equations (22), $\left(\dot{P}Q+V\right)/PQ$ is the rate of return on equity, $Bi/B=i$ is the rate of interest paid on debt, and $Sj/S=j$ is the rate of interest earned on corporate saving.

Near the time of retirement, T, funds are no longer spent to maintain or improve the facility; the facility simply depreciates. $M_T=0$, and the rate of change in the value of the facility is $\dot{I}_T=-D$. If net salvage is negative, then, $I_T<0$ from Equation (5). Substituting the terminal values into (22),

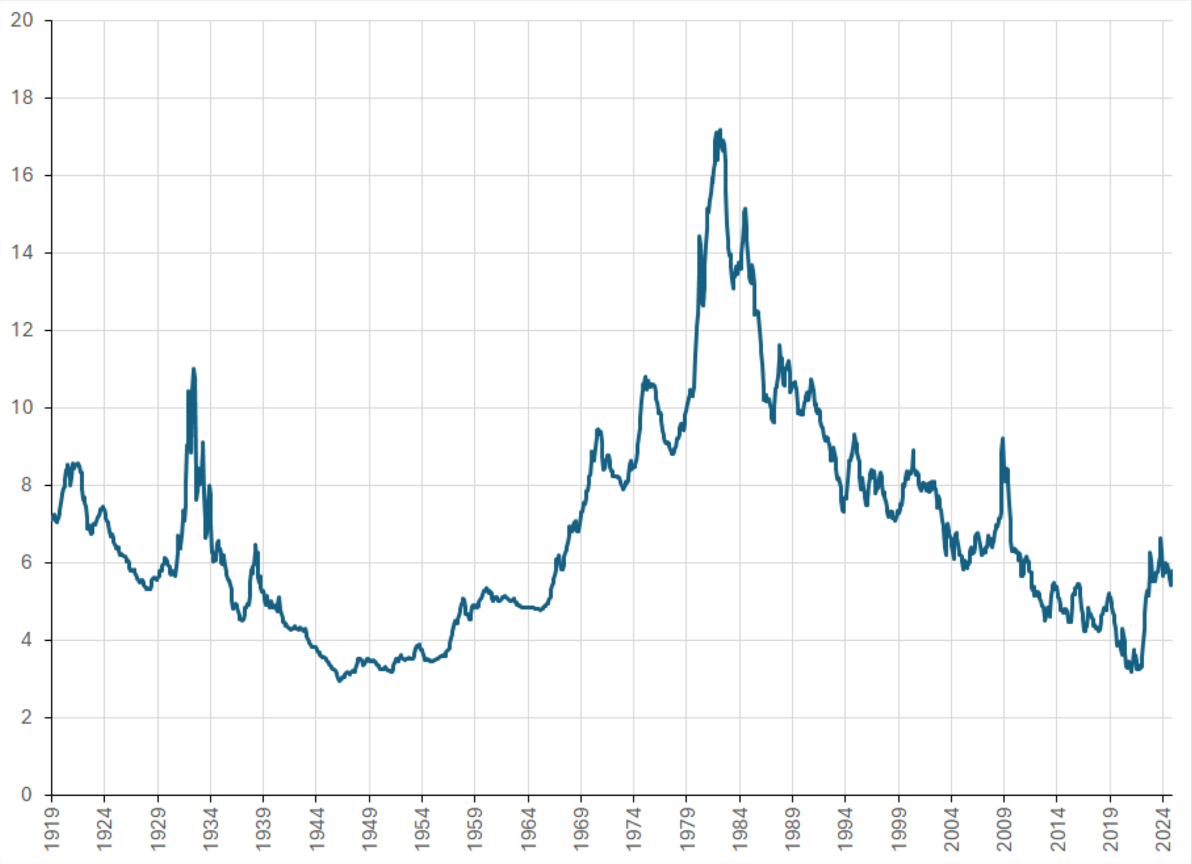
$$\frac{-D}{I_T}=WACC_T \tag{23}$$

At T, the value of the facility equals net salvage; $I_T=G_T-C_T$, as in Figure 1 and Equation (5). Combining (5) and (23) gives

$$D=-\left(G_T-C_T\right)WACC_T \tag{6}$$

Using Mr. Spanos' estimated annual depreciation of \$91,666,445, net salvage of -\$1,105,053,281, and composite remaining life of 33.9 years after December 31, 2023 implies a WACC in 2057 of 8.30 percent. This and two other scenarios that satisfy both his Equation (4) and my Equation (6) are shown in Table 2. For the OCA scenario, I estimate the WACC for 2065. The trend in the CAPM β for Eversource estimated in my testimony on allowed rate of return on equity, extrapolated to 2065, gives β=0.64. The average equity market risk premium from January 1, 1980 to May 16, 2024 was 6.18 percent, the average secondary yield on three-month Treasury bills was 2.82 percent, and the average yield on Baa corporate debt was 7.96 percent, and I use these as values in 2065.[7] Figure 2 shows the bond yields since 1919.

Figure 2: Moody's seasoned Baa corporate bond yield, Percent, monthly, not seasonally adjusted



I apply an effective tax rate of 17.50 percent, which includes a post-2017 Tax Cuts and Jobs Act effective federal rate of ten percent[8] and a New Hampshire business profits tax of 7.50 percent[9], which makes the after-tax cost of debt 6.56 percent in 2065. Using Mr. Rothschild's capital structure of 47.24 percent equity and 52.76 percent debt, then, gives a WACC in 2065 of

(0.64 x 6.18% + 2.82%) x 47.24% + (7.96% x (1-17.50%)) x 52.76% = 6.67 percent. (24)

The calculation is also done in the Scenarios tab of 24-070_2025-03-25_Exh_3.xlsb.

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[7] **https://fred.stlouisfed.org/series/BAA**, accessed December 20, 2024.

[8] **https://www.gao.gov/assets/gao-23-105384-highlights.pdf**, accessed December 20, 2024

[9] **https://www.revenue.nh.gov/taxes-glance/business-taxes#:~:text=The%20tax%20is%20assessed%20on%20the%20taxable%20business%20profits%20of,or%20after%20December%2031%2C%202023**, accessed December 20, 2025

EDUCATION

Ph.D. in Economics, Brown University, Providence, RI, 2007
M.A. in Economics, Brown University, Providence, RI, 1999
B.A. in Economics with departmental honors, University of Oregon, Eugene, OR, 1986

EXPERIENCE

New Hampshire Office of the Consumer Advocate, Concord, NH, August 2023 – present
- Expert testimony and analysis in regulatory proceedings on behalf of residential customers of public utilities in New Hampshire
- Education of customers

Rivier University, Nashua, NH, January 2020 – present
- Teach business economics and macroeconomics

The Economic Utility Group, Nashua, NH, February 2021 – June 2021, July 2022 – July 2023
- Forecasted wages and employment in the skilled trades with Senior Economist at Construction Industry Resources
- Forecasted volatile upstream fuel prices and climate damages
- Forecasted electric vehicle and non-EV electrification load for Hitachi Energy USA

Hitachi Energy USA, Nashua, NH, June 2021 – June 2022
- Analysis, modeling, forecasting, and reporting on wholesale power markets, especially in Mexico, using PROMOD® (a production cost model)

Elevation Direct Corporation, Nashua, NH, July 2015 – January 2021
- Jointly sponsored testimony before the Rhode Island PUC on the employment impacts of Clear River Energy Center (CREC) for the Rhode Island Building and Construction Trades Council; individually sponsored rebuttal testimony on the need for CREC
- Used Aurora® (a capacity expansion and production cost model) to evaluate potential purchase of Termoelectrica de Mexicali, a combined cycle natural gas-fired generator
- Used Aurora to forecast wholesale electric prices in Michigan and sponsored testimony on behalf of Michigan Public Service Commission staff in a case regarding a purchased power agreement for the output of the Palisades nuclear plant
- Work in restructured wholesale power market in Mexico
  - Provided forecasts of gross state product, loads, and fuel, energy, congestion, loss, ancillary service, and capacity prices, as well as prices of clean energy certificates and social costs of emissions in evaluations of pumped storage, combined-cycle gas, internal combustion, and wind and solar facilities; co-authored market studies done using Aurora, Plexos, and Encompass (capacity expansion and production cost models)
  - Assembled Mexican database and used Aurora to model expansion and operation of power grid for several independent generators
  - Co-authored a report on the economics of introducing liquefied natural gas to southern Baja California
  - Estimated a weighted average cost of capital to Comisión Federal de Electricidad (CFE)
  - Trained employees of CFE in load forecasting
  - Estimated Herfindahl-Hirschman indices of market concentration following breakup of CFE under Mexican energy reform

Universidad del Pacifico, Jesús María, Lima, Peru, September 2014
- Taught topical graduate course in energy economics.

Economic Insight, Portland, OR, January 2010 – March 2013
- Used Aurora to model electric resource planning in the Pacific Northwest
- Used Aurora to estimate trade benefits of Entergy and South Mississippi Electric Power Association joining regional transmission organizations, sponsored testimony before the Mississippi Public Service Commission (MPSC)
- Assessed application to install pollution controls on a coal plant; jointly testified with Sam Van Vactor before the MPSC
- Estimated dollars of spending per employee by generating technology
- Analyzed issues regarding pricing and royalties in geothermal and natural gas leases in California and Texas;
- Analyzed pricing and alleged use of market power in California power crisis
- Estimated lost earnings in a wrongful death lawsuit and testified to report
- Editor of scholarly research written by non-native speakers of English (intermittent)

Pacific University, Forest Grove, OR, August 2008 - May 2009
- Taught principles of microeconomics, environmental economics, and international trade

New York Department of Public Service, Albany, NY, August 2006 - December 2007

Eastern Connecticut State University, Willimantic, CT, August 2005 - May 2006
- Taught principles of microeconomics

Allan M. Feldman, Ph.D., Providence, RI, 2002-2003
- Worklife evaluation for litigation related to personal injury or wrongful death

Brown University, Providence, RI, 1999-2002
- Research and teaching assistance in valuation of individual earning capacity, industrial location in Indonesia, and principles of microeconomics and macroeconomics

Synapse Energy Economics, Cambridge, MA, July 1998 - February 1999
- Evaluated forecasts of electricity prices submitted in “stranded-cost” claim by four Maryland utilities

Bonneville Power Administration, Portland, OR, September 1988 - June 1997
- Authored and testified to marginal cost analysis in 1996 rate case before FERC
  - Helped prepare inputs to and interpreted and applied results of Power Marketing Decision Analysis Model (PMDAM) to rate design and to planning and evaluation of resources
  - Prepared and conducted public meetings on analysis and its implications for rate design
  - Fielded and incorporated comments from a variety of participants
  - Authored rate case study, documentation, and testimony
- Research on marginal costs of generating and marketing hydropower on the West Coast
- Prepared workshop briefing material, rate case studies, and documentation supporting marginal cost analysis and other rate-related issues as assigned
- Evaluated contracts for disposition of wholesale power

Economic Insight, Portland, OR, May 1988 - September 1988
- Surveyed forecasts of electricity prices and estimates of demand elasticities related to litigation over Washington Public Power Supply System bond defaults

ECO Northwest, Eugene, OR, July 1986 - August 1987
- Worklife evaluation for litigation related to personal injury and wrongful death; wrote company training manual on the subject

Changsha Normal University of Water Resources and Electric Power, Changsha, Hunan, PRC, August 1987 - January 1988; Brown University, Providence, RI, Summer 2001
- Taught English as a second language

RESEARCH

Vatter, M. (2024). Is LNG a bridge fuel in the mitigation of global warming: a critical review of studies at the EDF, NRDC, and Bloomberg, *IAEE Energy Forum*, 1st quarter 2024, **https://www.iaee.org/newsletter/issue/116**

Vatter, M. (2022). Pricing global warming as a mortal threat. United States Association for Energy Economics (USAEE) Working Paper No. 21-491, **http://ssrn.com/abstract=3821603**, and IAEE Conference Proceedings, online, June 7-9, 2021, **https://www.iaee.org/proceedings/article/17059**

Vatter, M., Van Vactor, S., and Coburn, T. (2022). Price responsiveness of shale oil: a Bakken case study. *Natural Resources Research*, 31:1, **https://doi.org/10.1007/s11053-021-09972-9**, and IAEE Conference Proceedings, Montreal, May 29-Jun 1, 2019, **https://www.iaee.org/proceedings/article/16313**

Vatter, M. (2020). Stratified zoning in central cities. *Journal of Housing Economics*, 50, **https://doi.org/10.1016/j.jhe.2020.101716**

Vatter, M. (2019). OPEC's risk premia and volatility in oil prices. *International Advances in Economic Research*, 25:2, DOI: **10.1007/s11294-019-09734-7**

Vatter, M., Suurkask, D. (2018). The impact of trade with the United States on electric loads in Mexico. *Heliyon*, 4:8, **https://doi.org/10.1016/j.heliyon.2018.e00717**, and *IAEE Energy Forum*, 2nd quarter 2017, **https://www.iaee.org/en/publications/newsletterdl.aspx?id=406**

Vatter, M. (2017). OPEC's kinked demand curve. *Energy Economics*, 63, **https://doi.org/10.1016/j.eneco.2017.02.010**

Vatter, M. (2017). Stockpiling to contain OPEC. USAEE Working Paper No. 17-136, **http://ssrn.com/abstract=912311,** and USAEE Conference Proceedings, New Orleans, December, 2008, **https://www.iaee.org/proceedings/article/17512**

Vatter, M. (2017). Social discounting with diminishing returns on investment, **http://ssrn.com/abstract=1078502**

Vatter, M., Barney, F. (2016). Macroeconomic risk and residential rate design. USAEE Working Paper No. 15-208, **http://ssrn.com/abstract=2596258**

Vatter, M. (2008). OPEC's demand curve, **http://ssrn.com/abstract=1127642**, reviewed at **http://knowledgeproblem.com/2008/05/14/**

Peer Reviewer for *Land Economics*: effects of endowments of petroleum resources on corruption, 2008; hedging in coal contracts under the acid rain program, 2010-11; suburban agriculture as an amenity, 2012; prorationing versus unitization in the U.S. petroleum industry in the 20th century, 2013

STREAMING MEDIA

International Atlantic Economic Society video: Nice world economy you have there; be a shame if something should happen to it, temporarily available at **https://www.iaes.org/**, accessed June 15, 2022

IAEE webinar: Is another oil price shock possible, and would it matter? January 11, 2021, **https://www.iaee.org/en/webinars/webinar_vatter.aspx**

USAEE podcast: OPEC as a destabilizing influence, July 21, 2020, **https://www.usaee.org/podcasts.aspx**

Video: **Discussing transmission costs with New Hampshire Senate Energy and Natural Resources Chair Kevin Avard**, **https://www.youtube.com/watch?v=QRkLdLplz9Y&feature=youtu.be&fbclid=IwAR2Euva286vNRa5Lit0RstjHwtPuV5a_t439Cml4Z8S2WHYptXNdJ40vkZs**

Video: **Discussing manufacturing, net metering rate design, and transmission costs on** *Perspectives* **with David Schoneman**, **https://youtu.be/m9YRY3U-DzM**

AWARDS

Twelve monetary awards for job performance at Bonneville Power Administration
Award for best undergraduate research project in economics at University of Oregon; examined deregulation of U.S. airline industry

OTHER ACTIVITIES

Monitored the House Science, Technology, and Energy Committee in Concord, NH for the Northeast Energy and Commerce Association
Founded and managed "Micro Lunch" seminar, Brown University, 2001-2002
Role of expert witness in Lewis & Clark Law School's mock personal-injury litigation, 1996
Peer Advisor, Department of Economics, University of Oregon, 1984-1986

MEMBERSHIPS

International and United States Associations for Energy Economics; Northeast Energy and Commerce Association; Northeast Energy and Commerce Association; New Hampshire Business and Industry Association, Manufacturing and End Users Policy Committee

TESTIMONIALS

"We asked Marc to provide us with a forecast of future locational marginal prices under two different scenarios, which he managed very well. He provided us with testimony that was on point and met our needs." Lauren Donofrio, Assistant Attorney General, Public Service Division, State of Michigan

"Marc Vatter provided joint testimony with Sam Van Vactor on behalf of Staff in 2010 regarding Mississippi Power's application to install pollution controls on the Victor J. Daniel coal-fired generator. He brought to light critical issues regarding uncertainty over natural gas prices that bore on the decision to install scrubbers. We hired the two again in 2012 in a proceeding on integrating Entergy's transmission assets into a regional transmission organization. Marc added significant detail representing the state of Mississippi to a production cost and capacity expansion model that he used to quantify the effects of integration. A number of consultants engaged in similar efforts, and Marc's analysis was of superior quality." Dr. Christopher Garbacz, Director, Economics and Planning Division, Mississippi Public Utilities Staff