PER UNIT COST ALLOCATION OF INVESTED CAPITAL WITH ANTICIPATED NON-LEVEL PRODUCTION: THE CASE OF EXTRACTIVE INDUSTRIES

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ABSTRACT

The concept of equivalent annual annuity (EAA) has long been used as a method of costing recovery of invested capital and the required return on invested capital over the productive life of a capital project. Academic texts almost universally use EAA methodology with level payment streams (annuities) to allocate capital costs. We develop a methodology for allocating capital costs evenly over each unit of production for projects with anticipated non-level production. This methodology uses a modified EAA approach that allows non-level annuity payment streams. Capital cost allocation is an important component in computing the value of extracted minerals for severance tax purposes; however, many firms and state and federal agencies use *ad hoc* depreciation schedules to allocate these costs. *Ad hoc* depreciation methods such as modified accelerated cost recovery system (MACRS) may be appropriate for income tax purposes but are inconsistent with commonly found requirements that severance taxes "shall be assessed on the wellhead or mine mouth fair market value." The modified EAA approach provides a straightforward alternative that is based on sound financial methodology.

INTRODUCTION

The concept of equivalent annual annuity (EAA) has long been used in engineering, finance and accounting texts as a method of costing required return on invested capital and the return of invested capital over the productive life of a capital project (e.g., see [3, 4, 6, 8]). The EAA approach uses level production and level payment streams (annuities) in deriving capital recovery factors (CRF). The authors are unaware of any popular text in any of these fields that covers capital cost allocation for projects with anticipated non-level production. A representative industry for this type of problem is the natural gas industry, in which declining production curves are generally observed.

The EAA approach often leads to CRF that misrepresent the allocation of capital recovery and return on invested capital for projects with non-level production. This was evident from the author's recent consulting experience in which one of the nation's largest oil and gas firms was required to determine the value of natural gas at the wellhead for State of Wyoming severance tax calculations. Wyoming's statute requires that severance taxes be assessed on the fair market value of gas at the wellhead, and any value added subsequent to the wellhead is not taxed. Thus, any operating costs incurred and all capital costs (e.g., capital investment in a gas processing plant) may be deducted from total sales price to determine the wellhead taxable value.

Capital costs related to investment in a gas processing plant are the major costs to be deducted from total sales revenue in determining the taxable value of gas for severance tax purposes. Interestingly, both the State of Wyoming Department of Revenue and the major oil and gas firm use *ad hoc* depreciation schedules to allocate these costs. However, *ad hoc* depreciation methods such as modified accelerated cost recovery system (MACRS) were never meant for allocating capital costs and are inconsistent with the statutory requirement that severance taxes "shall be assessed on fair market value." These *ad hoc* depreciation methods may be appropriate for income tax calculations, but they are not consistent with standard financial theory that should be applied to severance tax calculations.

To determine CRFs in accordance with Wyoming statute, non-level (or, for natural gas fields, declining) production curves must be considered to allocate capital costs evenly over each unit of production over the field's expected productive life. We develop a methodology for allocating capital costs using a modified EAA approach that accommodates more-general types of annuities that have non-level payment streams. We derive a CRF that correctly allocates capital costs for projects with non-level production. We then apply this methodology to data taken from a currently operating gas field in Wyoming.

Both the State of Wyoming and firms paying severance taxes in Wyoming should require that financially acceptable methodology be used to determine severance taxes. Any perceived lack of fairness in determining severance taxes might hinder the competitiveness of Wyoming's oil, gas, coal and other extractive industries.

MODIFIED EAA METHODOLOGY

We first consider a simple example of a gas field with a 5-year expected life that requires an initial capital investment of $5,000,000, with no additional investment required in subsequent years. The cost of capital is 10% (compounded annually) and the firm pays no taxes. We derive CRFs for both discrete-time and continuous-time frameworks.

DISCRETE-TIME EXAMPLE

To serve as a comparison with the non-level production case, we first consider level production. Then, we generalize the analysis by assuming a declining production function with simple linear decline.

Case 1: Level Production

We initially assume that a gas field is expected to have level production of 1,000,000 thousand cubic feet (MCF) per year. In this case, the conventional EAA methodology correctly allocates capital costs evenly over each unit of production over the project's life. Let A represent the EAA. A is computed as

$$A = \frac{\$5,000,000}{\left(\text{PVAF}_{.10,5}\right)} \tag{1}$$

where $\text{PVAF}_{r,n}$ is the present value annuity factor for an n-year level annuity at rate r:

$$\text{PVAF}_{r,n} = \frac{1-(1+r)^{-n}}{r}. \tag{2}$$

EQUATION (1) yields a solution of A = $1,318,987, with $\text{PVAF}_{.10,5} = 3.7908$. The annual allocation A includes both capital recovery and return on invested capital. An amortization schedule showing the breakdown of A between these two components for each year of production is shown in TABLE 1. Note that capital recovered increases each year but averages $1,000,000.

TABLE 1. Amortization Schedule for Level Production Case.[a]

t	y_t	Total Cost Recovered[b]	Return on Invested Cap[c]	Capital Recovered[d]	EOY Cap Employed[e]
0					$5,000,000
1	1.0	$1,318,987	$500,000	$818,987	4,181,013
2	1.0	1,318,987	418,101	900,886	3,280,126
3	1.0	1,318,987	328,013	990,975	2,289,152
4	1.0	1,318,987	228,915	1,090,072	1,199,079
5	1.0	1,318,987	119,908	1,199,079	0
Tot:	5.0	$6,594,937	$1,594,937	$5,000,000	
Ave:	1.0	$2,198,312	$531,646	$1,666,667	

[a] t denotes years; y_t denotes production level (in mm MCF); this table assumes $A = \$1,318,987$ and $r = 0.10$

[b] (Total Cost Recovered)$_t = A$

[c] (Return on Invested Capital)$_t = (r) \times$ (EOY Capital Employed)$_{t-1}$

[d] (Capital Recovered)$_t$ = (Total Cost Recovered)$_t$ − (Return on Invested Capital)$_t$

[e] (EOY Capital Employed)$_t$ = (EOY Capital Employed)$_{t-1}$ − (Capital Recovered)$_t$

Let c denote combined capital cost of the project per unit of production. For the level production case, we have

$$c = \frac{(\$5\text{mm})\cdot(\text{CRF})}{(1\text{mm MCF})} = \frac{\$1,318,987}{(1\text{mm MCF})} = \$1.32/\text{MCF} \tag{3}$$

where CRF is equal to the reciprocal of the present value annuity factor:

$$\text{CRF} = 1/(\text{PVAF}_{.10,5}) = 0.2638. \tag{4}$$

Case 2: Declining Production

We now assume that all parameters are the same as above except that production is expected to decline linearly from 1,200,000 MCF in the first year to 800,000 MCF in the fifth year. Let y_t denote expected production in year t (in MCF), and let ρ_t denote an index of relative expected production in year t, computed as

$$\rho_t = y_t / y_1 \tag{5}$$

where the index base is $\rho_1 = 1$. Values of y_t and ρ_t for this project appear in the amortization schedule in TABLE 2. Note that average annual production in this case is 1,000,000 MCF, the same as in the previous case.

TABLE 2. Amortization Schedule for Declining Production Case.[a]

t	y_t	r_t	Total Cost Recovered[b]	Return on Invested Cap[c]	Capital Recovered[d]	EOY Cap Employed[e]
0						$5,000,000
1	1.2	1.0000	$1,553,292	$500,000	$1,053,292	3,946,708
2	1.1	0.9167	1,423,851	394,671	1,029,180	2,917,528
3	1.0	0.8333	1,294,410	291,753	1,002,657	1,914,871
4	0.9	0.7500	1,164,969	191,487	973,482	941,389
5	0.8	0.6667	1,035,528	94,139	941,389	0
Tot:	5.0		$6,472,050	$1,472,050	$5,000,000	
Ave:	1.0		$2,157,350	$490,683	$1,666,667	

[a] t denotes years; y_t denotes production level (in mm MCF); r_t denotes relative production index; this table assumes A = $1,553,277 and $r = 0.10$

[b] (Total Cost Recovered)$_t$ = $A \times r_t$

[c] (Return on Invested Capital)$_t$ = (r) × (EOY Capital Employed)$_{t-1}$

[d] (Capital Recovered)$_t$ = (Total Cost Recovered)$_t$ − (Return on Invested Capital)$_t$

[e] (EOY Capital Employed)$_t$ = (EOY Capital Employed)$_{t-1}$ − (Capital Recovered)$_t$

As before, the objective is to determine a cost recovery factor that will allocate capital costs evenly over each unit of production for the life of the field, and to derive an amortization schedule that shows the breakdown of capital costs for each year of the project's life.

We define a modified present value annuity factor, denoted MPVAF, that allows non-level cash flows:

$$\mathrm{MPVAF}_{r,n} = \sum_{t=1}^{n} \frac{\rho_t}{(1+r)^t} \tag{6}$$

This factor computes the present value of a cash flow stream whose proportional payment pattern matches that of the designated production curve. Note that the level production case is simply a special case of EQUATION (6) with $\rho_t = 1$. Although this annuity factor does not, in general, collapse to a simple formula such as EQUATION (2), it does simplify in certain special cases such as exponential decline, as will be demonstrated later in the paper.

We now generalize the level production case as follows:

$$A = \frac{I}{\left(\mathrm{MPVAF}_{r,n}\right)} \tag{7}$$

where I is initial capital used, n is the expected project life in years, and where A is analogous to the equivalent annuity from the level production case. The CRF for the non-level production case is equal to the reciprocal of the modified annuity factor:

$$\mathrm{CRF} = 1/\left(\mathrm{MPVAF}_{r,n}\right). \tag{8}$$

More intuitively, EQUATION (7) may be written as

$$I = A\left[\frac{\rho_1}{(1+r)^1} + \frac{\rho_2}{(1+r)^2} + \cdots + \frac{\rho_n}{(1+r)^n}\right], \tag{9}$$

which shows that the annuity factor in brackets both computes present value and scales each payment relative to year 1. The cost allocation for year t is equal to $A \cdot \rho_t$.

For the present example, we have

$$\$5{,}000{,}000 = A\left[\frac{1.0000}{(1.10)^1} + \frac{0.9167}{(1.10)^2} + \frac{0.8333}{(1.10)^3} + \frac{0.7500}{(1.10)^4} + \frac{0.6667}{(1.10)^5}\right], \tag{10}$$

which yields A = \$1,553,277. The modified annuity factor in brackets equals 3.2190, which results in a CRF of 0.3107. This implies a per unit capital cost of

$$c = \frac{(I \cdot \mathrm{CRF})}{y_1} = \frac{A}{y_1} = \frac{\$1{,}553{,}277}{(1.2\mathrm{mm\ MCF})} = \$1.29/\mathrm{MCF} \tag{11}$$

compared to \$1.32/MCF for the level production case. An amortization schedule for the declining production case is shown in TABLE 2.

Note that the divisor of EQUATION (11) is initial-year production, not average annual production as in EQUATION (3) from the previous case. This is because the modified annuity factor allocates capital costs according to the relative production index, which has as its base year the initial year, whereas the conventional annuity factor allocates capital costs evenly over each year of production. Correspondingly, in EQUATION (11) the quantity A represents initial year capital cost allocation, not average annual cost allocation as in EQUATION (3). Additional insight is obtained by writing EQUATION (9) as

$$I = A\sum_{t=1}^{n} \rho_t (1+r)^{-t} = (c y_1)\sum_{t=1}^{n} \rho_t (1+r)^{-t}. \tag{12}$$

The level production case is a special case of EQUATION (12) with $\rho_t = 1$ and $y_1 = y_t = \bar{y}$ (constant).

Comparing this case to the previous one, we observe that the per unit capital cost is smaller in the declining production case. This is because declining production results in more capital being recovered in early years, which lowers the firm's overall cost burden of obtaining funds. Specifically, it lowers the total dollar amount of return on invested capital charged on the amortization schedule, as can be seen in TABLES 1 and 2. When a project's capital is recovered more quickly, the firm can "pay off" its investors sooner. (Return to investors may be in the form of dividend or interest payments, or retention of earnings by the firm.) When costing capital expenditures, failure to account for the actual timing pattern of cash flows violates basic time value principles, whether the cost accounting is done for severance tax purposes or for financial decision making purposes.

Some taxing authorities have severance tax codes that are vague with respect to how capital costs should be allocated when computing the taxable value of extracted minerals. This may be purposeful, as it would allow the taxing authority to have greater latitude in interpreting what is acceptable methodology, depending on its revenue needs. For example, when commodity prices are low, the taxing authority may compensate for the resulting decrease in tax revenues by explicitly or implicitly enforcing a methodology that specifies less accelerated costing. However, this may seriously distort capital cost allocations and shift price risk to the producer.

CONTINUOUS-TIME EXAMPLE

The non-level production case is easily generalized to a continuous-time framework. Let q_t denote the instantaneous rate of production at time t (in mm MCF), and let Q_t denote cumulative production at time t (in mm MCF). Continuing with the previous example, the continuous-time analogue of the discrete linear decline function is

$$q_t = 1.25 - 0.1t. \tag{13}$$

As in the discrete case, total production over the project's life is 5.0 mm MCF and the annual rate of production declines by 0.1 mm MCF per year. Total production is computed by

$$Q_5 = \int_0^5 q_t\,dt = 5.0, \tag{14}$$

and the annual rate of production decline is indicated by the negative coefficient of t in the linear production function EQUATION (13).

In the continuous case, ρ_t represents instantaneous relative expected production at time t and is defined as

$$\rho_t = q_t / q_0 \tag{15}$$

with an index base of $\rho_0 = 1$. For the present example, with q_t as given in EQUATION (13) and with $q_0 = 1.25$, we have

$$\rho_t = 1 - .08t. \tag{16}$$

The continuous-time modified annuity factor is

$$MPVAF_{i,T} = \int_0^T \rho_t e^{-it} dt \tag{17}$$

where $i = \ln(1+r)$. The continuous-time analogue of EQUATION (9) is

$$I = A\left[\int_0^T \rho_t e^{-it} dt\right] \tag{18}$$

where the instantaneous cost allocation at time t is equal to $A \cdot \rho_t$.

For the present case, we have

$$\$5{,}000{,}000 = A\left[\int_0^5 (1 - .08t) e^{-0.0953t} dt\right], \tag{19}$$

which yields A = \$1,540,930. The modified annuity factor in brackets equals 3.2448, which results in a CRF of 0.3082. This implies a per unit capital cost of

$$c = \frac{(I \cdot \text{CRF})}{q_0} = \frac{A}{q_0} = \frac{\$1{,}540{,}930}{(1.25\text{mm MCF})} = \$1.23/\text{MCF} \tag{20}$$

compared to \$1.29/MCF for the discrete declining production case. The continuous case results in a lower per-unit capital cost than the discrete case because capital recovery is more accelerated. EQUATION (18) can also be written as

$$I = (cq_0) \int_0^T \rho_t e^{-it} dt. \tag{21}$$

An amortization schedule is not shown for the continuous case. In practice, amortization schedules for continuous production curves may be constructed by discretizing the continuous production curve, as will be demonstrated in the next section. A summary of the modified EAA methodology for each of the three cases considered above appears in TABLE 3.

HYPERBOLIC PRODUCTION CURVES

Natural gas fields generally exhibit continuously declining production from the moment production begins. In particular, most wells exhibit hyperbolic decline, which is characterized by the following production function, as formulated by Arps [1, 2]:

$$q_t = q_0\left(1 + nD_0 t\right)^{-1/n}, \qquad t \in \left(0, T\right) \tag{22}$$

where $0 \leq n \leq 1$, and where q_0 is the initial instantaneous rate of production and D_0 is the initial instantaneous rate of decline in production. This rate-time relationship is derived from the differential equation

$$D = K \cdot q^n = \frac{dq/dt}{q} \tag{23}$$

subject to the initial condition

$$K = D_0 / q_0^n \tag{24}$$

where D denotes the decline rate as a fraction of the production rate. Cumulative production is given by

$$Q_t = \frac{q_0^n}{(1-n)D_0}\left(q_0^{1-n} - q_t^{1-n}\right). \tag{25}$$

When $0 < n < 1$, the hyperbolic decline curve is characterized by a continuously decreasing decline rate D_t that is proportional to a fractional power (n) of the production rate. Hyperbolic decline includes the special cases of exponential decline ($n = 0$), for which the decline rate is a constant percentage of the production rate, and harmonic decline ($n = 1$), for which the decline rate is directly proportional to the production rate.

Towler [9; ch.14] and references therein discuss methods of empirically estimating the parameters of EQUATION (22). In practice, the assumption of exponential decline is widely used due to its analytic tractability and its conservative results. Exponential decline has been empirically shown to reasonably approximate the more general hyperbolic form (e.g., [5, 7]).

TABLE 3. Summary of Modified EAA Methodology.

	Capital Recovery Factor and Annuity Factor	Combined Capital Cost Per Unit of Production
Level Production Discrete Case	$CRF = \frac{1}{PVAF}$ $PVAF = \sum (1+r)^{-t}$	$c = \frac{A}{\bar{y}} = \frac{(I \cdot CRF)}{\bar{y}}$ $\bar{y}$ = ave. annual production
Non-level Production Discrete Case	$CRF = \frac{1}{MPVAF}$ $MPVAF = \sum \rho_t (1+r)^{-t}$	$c = \frac{A}{y_1} = \frac{(I \cdot CRF)}{y_1}$ y_1 = year 1 production
Non-level Production Continuous Case	$CRF = \frac{1}{MPVAF}$ $MPVAF = \int_0^T \rho_t e^{-it} dt$ $i = \ln(1+r)$	$c = \frac{A}{q_0} = \frac{(I \cdot CRF)}{q_0}$ q_0 = initial production rate

[a] r_t = Index of Relative Expected Production

[b] I = Initial Dollar Investment in Capital Project

MODIFIED EAA APPROACH WITH HYPERBOLIC DECLINE

For the general hyperbolic decline curve, the modified present value annuity factor is

$$MPVAF_{i,T} = \left[\int_0^T \rho_t e^{-it} dt\right] = \left[\int_0^T \left(1 + nD_0 t\right)^{-1/n} e^{-it} dt\right], \tag{26}$$

which does not have a tractable closed form solution. In practice, one could solve EQUATION (26) numerically, or alternatively one could discretize the production function by specifying year t production as

$$y_t = Q_t - Q_{t-1} \quad (t = 1, 2, \ldots, T) \tag{27}$$

and then proceeding as in the discrete case. After estimating the parameters q_0, D_0 and n, this could be easily implemented on a computer spreadsheet using

$$y_t = Q_t - Q_{t-1} = \frac{q_0^n}{(1-n)D_0}\left(q_{t-1}^{1-n} - q_t^{1-n}\right) \quad (28)$$

where q_t is computed from EQUATION (22). For convenience, we specify the time period as years although in general Δt may represent any desired time interval.

EXPONENTIAL DECLINE

In the special case of exponential decline ($n = 0$), the production function becomes:

$$q_t = \lim_{n \to 0}\left[q_0\left(1 + nD_0 t\right)^{-1/n}\right] = q_0 e^{-D_0 t}, \quad (29)$$

and cumulative production at time t reduces to

$$Q_t = \left[\int_0^t e^{-D_0 s} ds\right] = \frac{\left(q_0 - q_t\right)}{D_0} = \frac{q_0}{D_0}\left(1 - e^{-D_0 t}\right). \quad (30)$$

The index of relative production in this case is

$$\rho_t = \frac{q_0 e^{-D_0 t}}{q_0} = e^{-D_0 t}, \quad (31)$$

and the continuous-time modified annuity factor is

$$\text{MPVAF}_{i,T} = \left[\int_0^T e^{-D_0 t} e^{-it} dt\right] = \frac{1}{\left(D_0 + i\right)}\left(1 - e^{-\left(D_0 + i\right)T}\right). \quad (32)$$

This factor may be used to compute CRFs (by taking the reciprocal of the factor), and to compute per-unit capital costs using EQUATION (20).

To discretize the exponential decline function, we define year t production as

$$y_t = \left(Q_t - Q_{t-1}\right) = \frac{q_{t-1} - q_t}{D_0} = \frac{q_0\left(1 - e^{-D_0}\right)}{D_0} e^{D_0 t}, \quad (33)$$

which results in the following discrete-time relative production index:

$$\rho_t = e^{-D_0 (t-1)}. \quad (34)$$

Hence, the discrete-time modified annuity factor is

$$\text{MPVAF}_{i,t} = \left[\int_{t=1}^{T} p_t e^{-it}\right] = e^{D_0}\left[\sum_{t=1}^{T} e^{-D_0 t}\right] = e^{D_0}\left[\frac{1-e^{-T(D_0+i)}}{e^{(D_0+i)}-1}\right] \quad (35)$$

where the CRF is the reciprocal of this factor, and the per-unit capital cost may be computed using EQUATION (11).

NUMERIC EXAMPLE

We demonstrate the case of exponential decline using an actual decline curve that was estimated using production data taken from a gas field in Wyoming. The field represents a 20-year project requiring an initial capital investment of \$350 million and assuming no subsequent investment. The parameters q_0 and D_0 have been estimated at 50 mm MCF and 0.0805, respectively. The firm is assumed to have a weighted average cost of capital (WACC) of 15%, which implies that $r = 0.15$ and $i = \ln(1.15) = 0.13976$. (Note that EQUATIONS (38) and (44) show i rounded to five significant digits; however, in actual computations, i is unrounded to obtain more-accurate annuity factors.)

Using this information, the expected production curve for this gas field is

$$q_t = 50e^{-.0805t}, \quad (36)$$

and expected total production is

$$Q_T = \frac{50}{0.0805}\left[1-e^{-(.0805)(20)}\right] = 496.964215 \text{ mm MCF}. \quad (37)$$

In continuous time, the modified annuity factor is

$$\text{MPVAF}_{.13976,20} = \left[\frac{1-e^{-(.0805+.13976)(20)}}{(.0805+.13976)}\right] = 4.4846005, \quad (38)$$

and A is equal to

$$\frac{\$350{,}000{,}000}{4.4846005} = \$78{,}044{,}855.95. \quad (39)$$

This implies a CRF of 0.222985 and a per-unit capital cost of

$$c = \frac{A}{q_0} = \frac{\$78{,}044{,}855.95}{(50 \text{ mm MCF})} = \$1.560897/\text{MCF}. \quad (40)$$

Alternatively, using the discrete-time framework, the formula for year t production is

$$y_t = \frac{50\left(e^{.0805} - 1\right)}{0.0805} e^{-.0805t} = 52.067607 e^{-.0805t}, \tag{41}$$

which implies an initial-year production amount of

$$y_1 = 48{,}040{,}433 \text{ MCF} \tag{42}$$

and which results in the following discrete-time relative production index:

$$\rho_t = e^{-.0805(t-1)}. \tag{43}$$

The discrete-time modified annuity factor is

$$\text{MPVAF}_{i,T} = e^{.0805}\left[\frac{1 - e^{-20(.0805+.13976)}}{e^{(.0805+.13976)} - 1}\right] = 4.3448784, \tag{44}$$

and A is equal to

$$\frac{\$350{,}000{,}000}{4.3448784} = \$80{,}554{,}612.45. \tag{45}$$

This implies a CRF of 0.230156 and a per-unit capital cost of

$$c = \frac{A}{y_1} = \frac{\$80{,}554{,}612.45}{(48.040433 \text{ mm MCF})} = \$1.676809/\text{MCF}. \tag{46}$$

An amortization schedule for the discrete case is in TABLE 4. This table represents the correct approach for allocating capital costs for a firm that has non-level production, and especially for governmental bodies that tax only the value of extracted minerals at the mine mouth or the wellhead.

CONCLUSION

The EAA approach, as applied to capital recovery and cost allocation problems in many engineering, finance and accounting texts, assumes that projects have level production over their economic lives. However, there are many examples of non-level production over the life of a project. As happens with natural gas production from a known gas field, essentially all extractive industries anticipate declining production over the field's or mine's life.

TABLE 4. Amortization Schedule for Numeric Example: Exponential Decline.[a]

t	y_t	r_t	Total Cost Recovered[b]	Return on Invested Cap[c]	Capital Recovered[d]	EOY Cap Employed[e]
0						$350,000,000
1	48.04	1.0000	$80,554,612	$52,500,000	$28,054,612	321,945,388
2	44.32	0.9227	74,324,108	48,291,808	26,032,300	295,913,087
3	40.90	0.8513	68,575,503	44,386,963	24,188,540	271,724,548
4	37.73	0.7854	63,271,524	40,758,682	22,512,842	249,211,706
5	34.81	0.7247	58,377,782	37,381,756	20,996,026	228,215,680
6	32.12	0.6686	53,862,547	34,232,352	19,630,195	208,585,485
7	29.64	0.6169	49,696,543	31,287,823	18,408,720	190,176,765
8	27.35	0.5692	45,852,759	28,526,515	17,326,244	172,850,521
9	25.23	0.5252	42,306,273	25,927,578	16,378,695	156,471,826
10	23.28	0.4846	39,034,090	23,470,774	15,563,316	140,908,510
11	21.48	0.4471	36,014,995	21,136,277	14,878,718	126,029,792
12	19.82	0.4125	33,229,411	18,904,469	14,324,943	111,704,849
13	18.28	0.3806	30,659,279	16,755,727	13,903,552	97,801,297
14	16.87	0.3512	28,287,934	14,670,195	13,617,740	84,183,558
15	15.57	0.3240	26,100,001	12,627,534	13,472,468	70,711,090
16	14.36	0.2989	24,081,294	10,606,663	13,474,631	57,236,459
17	13.25	0.2758	22,218,724	8,585,469	13,633,255	43,603,203
18	12.23	0.2545	20,500,215	6,540,481	13,959,734	29,643,469
19	11.28	0.2348	18,914,624	4,446,520	14,468,103	15,175,366
20	10.41	0.2166	17,451,670	2,276,305	15,175,366	0
Tot:	205.81		$345,103,529	$223,319,209	$121,784,320	
Ave:	33.47		$56,115,115	$33,649,195	$22,465,920	

[a] t denotes years; y_t denotes production level (in mm MCF); r_t denotes relative production index; this table assumes A = $80,554,612.45 and $r = 0.15$

[b] (Total Cost Recovered)$_t = A \times r_t$

[c] (Return on Invested Capital)$_t$ = $(r) \times$ (EOY Capital Employed)$_{t-1}$

[d] (Capital Recovered)$_t$ = (Total Cost Recovered)$_t$ − (Return on Invested Capital)$_t$

[e] (EOY Capital Employed)$_t$ = (EOY Capital Employed)$_{t-1}$ − (Capital Recovered)$_t$

We develop and illustrate a modified EAA methodology for determining a CRF that may be used to allocate capital costs evenly over each unit of production for the capital project's entire life. This methodology should be used by government entities to calculate severance taxes on the value of extracted minerals at the mine mouth or the wellhead, and by firms in extractive industries to correctly allocate capital costs.

The use of *ad hoc* depreciation schedules or actual interest paid as a method of allocating capital costs violates many of the financial principles used in capital budgeting, and may result in substantially distorted capital cost allocation. This may lead to incorrect calculations of severance tax liabilities or incorrect capital budgeting decisions by the firm.

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