Appendix: Effective Tax Rates for Energy Capital

Following the terminology in Congressional Budget Office (2005), let ρ be the real before-tax return on the marginal investment for a particular capital asset category and r the real return paid to investors. The effective tax rate is defined as

$$\frac{\rho - r}{\rho}. \qquad (1)$$

The required before-tax return is equal to

$$\rho = \frac{(\tilde{r} + \delta)(1 - \tau z)}{1 - \tau} - \delta. \qquad (2)$$

The parameter $\tilde{r}$ in equation (2) is the real corporate discount rate and equals $d(i(1-\tau) - \pi) + (1-d)E$. The discount rate is a weighted average of the real after-tax cost of borrowing, where i is the corporate borrowing rate, π is the inflation rate, τ is the corporate tax rate, d is the share of investment financed by debt, and E is the real return on equity. Assets are assumed to depreciate at an exponential rate, with the rate of decay equal to δ. The present value of tax depreciation is given by z and depends on tax rules specific to each asset.

In some cases, I compute effective tax rates for investments that are composed of different types of capital, each of which faces its own effective tax rate. In those cases, I construct before-tax returns for each capital component and compute the before-tax return for the investment weighting by the share of this component in the total investment cost.

A key element in the taxation of capital assets is the tax treatment of depreciation. Let z equal the present discounted value of the stream of depreciation deductions, assuming particular tax rules for an asset. If D_t is the amount of depreciation allowed in year t for an asset, with initial basis of 1 and a recovery period of T years, then z equals

$$z = \sum_{t=1}^{T} \frac{D_t}{(1+\tilde{r})^{t-1}}. \qquad (3)$$

The present discounted value of depreciation deductions is equal to the tax rate times z (assuming that the tax rate does not change over the life of the asset). Thus, the effective after-tax purchase price of an asset is equal to $1 - \tau \cdot z$ times the cost of the asset. Below, I will show how the effective price is affected by energy-specific tax rules.

Table A1 reports tax depreciation rules and estimates of economic depreciation for various energy-related assets. Capital shares are reported in parentheses after each asset type. Capital shares for nuclear-power plants are taken from table 4.2.2 of Tennessee Valley Authority (2005). This report provides cost estimates for an advanced boiling-water reactor that would be designed and constructed under the new combined construction-permit and operating-license (COL) rules implemented in the Energy Policy Act of 1992. Oil drilling costs vary, depending on the particular characteristics of different sites. I have chosen a representative set of cost shares to construct a composite effective tax rate for drilling. The breakdown of intangible drilling costs for integrated firms reflects tax rules allowing expensing for 70 percent of IDC costs, with the remainder to be deducted over five years.

Table AI. Energy Capital Depreciation

	Recovery Period	Method	Economic Depreciation Rate
Electric Utilities			
Generation			
Nuclear			
Steam Turbines (25%)	15	150%	5.16%
Other Equipment (54%)	15	150%	5.00%
Structures (21%)	15	150%	2.11%
Coal (PC)	20	150%	5.16%
Coal (IGCC)	20	150%	5.16%
Gas	15	150%	5.16%
Wind	5	200%	3.03%
Solar Thermal	5	200%	3.03%
Transmission and Distribution			
Transmission Lines	15	150%	5.00%
Distribution Lines	20	150%	5.00%
Petroleum			
Oil Drilling (nonintegrated firms)			
Oil Drilling (tangible) (10%)	7	200%	7.51%
IDC (70%)	Expensed		10.00%
Depletable Assets (20%)	percentage depletion		7.51%
Oil Drilling (integrated firms)			
Oil Drilling (tangible) (10%)	7	200%	7.51%
IDC (70%)			
Expensible IDC (49%)	Expensed		7.51%
Deductible IDC (21%)	5	200%	7.51%
Depletable Assets (20%)	cost depletion		7.51%
Refining	10	200%	8.91%
Natural Gas			
Gathering Pipelines	7	200%	2.37%
Other Pipelines	15	150%	2.37%

Economic depreciation rates taken from Bureau of Economic Analysis (2008), available at http://www.bea.gov/national/FA2004/Tablecandtext.pdf. The economic depreciation rate in the case of percentage depletion is set equal to the depletion rate for a representative well. See text for more information.

The formula for the before-tax return in equation 2 needs to be modified to account for production and investment tax credits as well as for percentage depletion for oil and gas drilling. Investment tax credits at rate κ are a straightforward modification. Production tax credits and percentage depletion are slightly more complicated. Let θ be the capacity factor for a renewable electricity investment. This is the fraction of time that the unit is producing electricity. The capacity factor for wind, for example, equals roughly 30 percent. A 1 kW facility produces 8760 θ kWhs of electricity over the year. If ρ is the overnight cost of 1 kW of capacity, a ten-year production tax credit is worth (per dollar of investment)

$$(4) \qquad v = \sum_{t=1}^{10} \frac{8760\theta s}{(1+\tilde{r})^t p} = \frac{8760\theta s}{p}\left(\frac{1}{\tilde{r}} - \frac{1}{\tilde{r}(1+\tilde{r})^{10}}\right)$$

where s is the subsidy rate (dollars per kWh). Since the effective-tax-rate methodology generally uses continuous time analogues, an alternative formula is

$$\nu = \frac{87600\theta s}{p}\left(\frac{1-e^{-10\tilde{r}}}{\tilde{r}}\right) .$$

Accounting for production and investment tax credits, the required before-tax rate of return becomes[26]

(5) $$\rho = \frac{(\tilde{r}+\delta)(1-\kappa-\nu-\tau z)}{1-\tau} - \delta .$$

My treatment of percentage depletion follows that of the Congressional Budget Office (1985) study on oil and gas. The denominator in (5) is adjusted to account for the deduction:

(6) $$\rho = \frac{(\tilde{r}+\delta)(1-\kappa-\nu-\tau z)}{1-\tau+\mu\psi\tau} - \delta$$

where ψ is the percentage-depletion rate and μ the ratio of price to the before-tax return.[27] The percentage-depletion rate for oil is 15 percent. Where percentage depletion is taken, the firm would have no depletion as part of z.

The ratio of price to before-tax return (or operating profit) will vary, depending on the particular source of oil. While measuring the price of a barrel of oil is straightforward, determining what is the appropriate measure of operating profit per barrel of oil is not. One approach to measuring operating profit might be to take the oil price and subtract production costs (finding and extraction costs). The domestic first purchase price for oil was roughly $60 in 2006. According to U.S. Energy Information Administration (2007a), production costs were roughly $25 per barrel. This suggests a markup of 1.71.

Adelman (1995) cautions that standard measures of finding costs (the sum of exploration and development expenditures divided by oil and gas reserves added [in oil equivalents]) is a flawed measure. As Adelman notes, exploration adds knowledge, while development adds reserves. The knowledge from exploration may not add to reserves for many years. In addition, the conversion rate of gas into oil equivalents is not stable over time, as it depends on how oil and gas are used, as well as their relative prices. The EIA study acknowledges the first problem and addresses it by averaging finding costs over three years.

Alternatively, one could simply measure operating profit from firm balance sheets. U.S. Energy Information Administration (2007a), table 9, reports income and expenses of major energy producers. The ratio of revenue to operating income in 2006 was 1.86. On the basis of these two estimates of the markup ratio (μ), I use a ratio of 1.75 in my calculations below. Table A2 reports the non-technology-specific parameters I use in my effective-tax-rate calculations.

Table A2. Effective-Tax-Rate Parameters

Parameter	Value
Real Required Return to Equity (E)	7%
Inflation Rate (π)	3%
Nominal Bond Rate (i)	8.6%
Federal Tax Rate (τ_F)	35%
Average State Tax Rate (τ_S)	6.6%
Combined Tax Rate (τ)	39.3%

Source: Real required equity return from table 17 in Congressional Budget Office (2006). Nominal bond rate is the fifty-year average of BAA bonds taken from table B-73 in Council of Economic Advisers (2008).