Appendixes

Description and Evaluation of the Simulation Model

To evaluate quantitatively the alternative incentives, a computerized model was used, developed by Tyner and Kalter[1] that captures the probabilistic attributes of the oil shale development process through Monte Carlo simulation techniques. The core of the model is a discounted cash flow algorithm computing the after tax profit.

In computing aftertax profit, the model uses a conventional discounted cash flow algorithm in which the net cash flow for each year (i. e., revenues less costs and taxes) is discounted to the beginning of the project. These discounted cash flows are then summed to arrive at the aftertax net profit.

With the model, the user can input probability distributions of prices and costs instead of single value estimates. The model then constructs a probability distribution for aftertax profits using the Monte Carlo method. With this method, the model makes repeated runs in which profit is calculated. In each run the model randomly selects values from the input distributions. The resulting profit calculations are then cumulated into probability y distributions characterized by an expected value and standard deviation, The expected value gives the average profit for all the Monte Carlo runs and the standard deviation provides a measure of dispersion or variation about this average value. The model also totals the number of Monte Carlo runs that results in positive profits and plots a histogram of the frequency distribution of the profit outcomes, From this output the user can compute the probability that a loss will be incurred.

Although the model was designed to test the effects of alternative mineral leasing systems on profits and Government revenues, it incorporates several financial incentives, including construction grants, price supports, purchase agreements, investment tax credits, depletion allowances, and variable depreciation schedules. Indeed, its authors used an earlier version to evaluate the effects of some of these incentives on the profitability and risk of oil shale development. '

However, because the model was not designed specifically to test incentives, it has several limitations. First, it does not provide for inflation indexing of the floor price under a price support program. Thus, if the user inputs nominal (i.e., gross of inflation) values into the model, the real (i.e., net of inflation) floor price will decline over time. Alternatively, the user can input all real values (as OTA did) which implicitly indexes the floor price. However, this solution causes some distortion in the tax calculations. With inflation, income increases in nominal value, but the amount of depreciation deducted for tax purposes remains constant. Thus, in real terms, the value of depreciation decreases with inflation. However, since the model does not account for this real decrease when the user inputs all real values, the model underestimates the amount of tax payments. This distortion was not considered serious, given the short depreciation period and the higher fraction of depreciation claimed in early periods.

Second, the model has a limited capability with respect to purchase agreements. To model a purchase agreement for the entire production, the user can input the purchase price in place of the market price for oil. However, the model cannot directly handle purchase agreements for only a portion of the output in a given year. To evaluate a partial purchase agreement, the user must perform offline calculations to obtain an average of the market and purchase agreement prices, weighted by the proportion of output sold for each price, A similar calculation must then be performed for the standard deviation of the price distribution.

Third, the model has no capability to simulate the effects of production tax credits. It does allow for a price subsidy, but this subsidy is not a tax credit. Unlike a tax credit, the subsidy increases taxable income and hence income tax payments. Because of this limitation, the model was not used to perform the necessary calculations for the $3/bbl tax credit. To estimate the increase in expected profit, the per barrel tax credit was multiplied by each year's production. The total annual credits were than discounted to the present and summed. The same procedure was used to calculate the expected cost to the Government, except that the Government discount rate was used in the calculation. To evaluate the effect on risk, it was assumed that the standard deviation would not change as a result of the tax credit. This assumption follows because the tax credit does not alter costs or prices; these alterations determine the standard deviation. Because the standard deviation is the same for the tax credit as it is with no incentive, it was possible to transform the histogram computed for the no-incentive case into a histogram for the production tax credit case. With this new histogram an estimate could be made of the percentage of cases falling below the zero profit level. Finally, the breakeven price was calculated by subtracting the production tax credit from the breakeven price with no incentive.

Fourth, the model is not able to simulate the effect of low-interest loans. Although the user could adjust the discount rate downward to account for the low-interest loan, this method has several limitations because it fails to account for all the terms of the loan. In particular, this method is not sensitive to the time when the loan is received and the time when it must be repaid. Moreover, the approach is based on very restrictive and unrealistic assumptions about the structure of debt financing for the project.[3]

Accordingly, the model was not used to perform the calculations for the low-interest loan. The steps for the low-interest loan computations are referenced in table A-1, The actual cash flows (both loan payments and repayments) to the firm were set up based on the Government's lending rate and the structure of the loan. These cash flows were then discounted using the borrowing rate for the firm on the open market (assumed to be 3-percentage points higher than the Government lending rate), A similar calculation was performed to estimate the expected cost to the Government. As with the production tax credit, it was assumed that the standard deviation of the distribution of profits would not change, since the loan does not alter any of the costs or prices in the model. With the estimated mean for the profit distribution and the standard deviation, the histogram of profit distribution from the no-incentive run was subsequently used to estimate the probability of a loss. The price increment was then computed, which, when multiplied by the production for each year, yielded a discounted value equal to the estimated increase in expected profits. The price increment was then subtracted from the breakeven price with no incentive to yield the breakeven price under the low-interest loan program.

Finally, the model does not directly calculate the net cost to the Government. However, if the Government and the firm use the same discount rate, the cost to the Government exactly equals the gain in expected profit to the firm calculated

Table A-1 .–Calculating Change in Expected Profit and Cost to the Government for a Low-Interest Loan

Assumptions

- The average total construction cost is $1.7 billion
- 70 percent of one-fifth of the total construction cost, $238 million, is loaned at the end of each of the 5 years of construction
- Interest is calculated on the principal from the moment the first loan is made
- The loan principal plus interest is amortized over 20 years
- The interest rate is 3 percent in real terms
- The firm market borrowing rate is 6 percent in real terms
- The Government's discount rate is 10 percent in real terms

Calculations

Step		Result ($ million)
1.	Calculate annual loan amounts (1 ,700x .7x 2), ., '	238/yr '
2	Calculate the future value in year 5 of five payments of $238.00 (3-percent Interest) . .	1,264
3.	Calculate the annual principal and Interest payment to the Government (years 6-25) based on the future value in step 2 (3-percent Interest)	85/yr
4.	Calculate the present value to the firm year 5 of the payment from step 3 (6-percent Interest)	974
5.	Calculate the present value to the firm in year O of the value from step 4 (6-percent Interest),	726
6.	Calculate the present value to the firm in year O of the annual loan amount from step 1 (6-percent Interest).	1,003
7.	Calculate the *change in profit* for the firm (1 ,003-726)	277
8.	Calculate the present value to the Government in year 5 of the payment from step 3 (l O-percent interest) .,	723
9.	Calculate the present value to the Government in year O of the value from step 8 (l O-percent Interest)	448
10,	Calculate the present value to the Government in" year O of the annual loan amounts from step 1 (10-percent interest)	401
11.	Calculate the *net cost the Government (901-448)*	453

SOURCE :Office of Technology Assessment

by the model. This is so because, except for small tax payments to State governments, all the monetary exchanges occur between the Federal Government and the firm. If the discount rates are the same, the present value of the exchanges to both entities is the same, Therefore, since a lo-percent Government discount rate has been assumed, the net cost to the Government of each incentive is equal to the net gain in profitability to the firm calculated at a lo-percent discount rate. The only exception occurs with the Government loan. Because it has been assumed that the real interest rate on debt financing for firms is less than 10 percent, the present value to the firm of the low-interest loan is less than its cost to the Government.

Appendix A References

[1]Wallace E. Tyner and Robert J. Kalter, "A Simulation Model for Resource Policy Evaluation, " Cornell Agricultural *Economic* Stuff Paper, September 1977.

[2]Wallace E. Tyner and Robert J. Kalter, An Analysis of Federal Leasing Policy for Oil Shale Lands, prepared for the Office of Energy R&D Policy, National Science Foundation, April 1975.

[3]tewart C. Meyers, "Interactions of Corporate Financing and Investment Decisions—Implications for Capital Budgeting, " in Modern Developments in Financial Management, Hinsdale, Ill.: Dryden Press, 1976.