Appendix B
Details of Present Net Value Calculation

Economics of New Combined-Cycle Generator

This appendix describes in more detail the calculations of net present value (NPV) reported in Chapter 2. The combined-cycle (CC) generator example is particularly relevant because the technology is less capital intensive than other technologies, such as coal, nuclear, and renewable electricity plants. In addition, Energy Information Administration projections show natural-gas-fired generation increasing from 16 percent of total U.S. electricity generation in 2000 to 32 percent of the total in 2020, overtaking nuclear power as the Nation's second-largest source of electricity by 2004.[150] Moreover, a growing number of refineries, petrochemical plants, and other industrial facilities that use natural gas to generate electricity for their own needs are becoming cogenerators, selling excess electricity to local utilities and power marketers. Those firms rely on stable natural gas supplies and prices; volatile gas prices can have considerable impact on their earnings, as noted in Chapter 2.

Capital Budgeting for a Power Generator

In the example shown in Chapter 2, an independent power producer faces a capital budgeting project (e.g., building a gas-fired plant) and uses NPV methodology to evaluate the project. The simple rule often given for choosing investment projects is the NPV rule: choose only projects with positive NPVs. The NPV methodology implicitly assumes that the incremental cash flows from a project will be reinvested to earn the firm's risk-adjusted required rate of return throughout the life of the project. The NPV of a project reveals the amount by which its productive value (present value of net cash flows) exceeds or is less than its cost. Naturally, investors choose only those projects whose productive values exceed or at least equal their costs. If the NPV of a project is positive (NPV > 0), the amount of the NPV is the amount by which the project will increase the value of the firm making the investment.

The assumptions underlying the capital investment example shown in Chapter 2, Table 4, are summarized in Table B1.[151] Table B2 shows the detailed annual cash flow calculations based on the assumptions and the price projections shown in Chapter 2, Table 4. Because the plant has a positive NPV of $2,118,017, it is profitable and should be built.

NPV Distributions with Simulation

In fact, the future output and input prices for the project are uncertain, and it may become unprofitable if the actual input and output prices vary much from their expected means. Therefore, a Monte Carlo simulation was used to estimate the distribution of the project's NPV when both electricity and natural gas prices are varied.[152] For the simulation analysis, lognormal distributions were defined for both electricity and natural gas prices, and the prices were varied by plus and minus 77 percent and 47 percent, respectively, as a standard deviation, from the expected prices.[153] The price variations were based on daily historical data on NYMEX spot prices from March 1999 through March 2002. A historical positive correlation of 0.88 between the average electricity spot price and Henry Hub natural gas spot price

Table B1. Basic Assumptions for the NPV Calculation

Variable	Assumed Value	Variable	Assumed Value
Heat Rate	6,800 Btu per kilowatthour	Corporate Tax Rate	36.00%
Capital Cost	$590 per kilowatt	Debt Capital Fraction	60.00%
Capacity Factor	65%	Equity Capital Fraction	40.00%
O&M Fixed Costs	$14.46 per kilowatt per year	Cost of Debt	10.50%
O&M Variable Costs	$0.00052 per kilowatthour	Cost of Equity	17.50%
Generator Capability	400 megawatts	Weighted Average Cost of Capital	11.03%

Source: Energy Information Administration.

[150] Energy Information Administration, *Annual Energy Outlook 2002*, DOE/EIA-0383(2002) (Washington, DC, December 2001).

[151] Energy Information Administration, *Assumptions to the Annual Energy Outlook 2002 (AEO2002)*, DOE/EIA-0554(2002) (Washington, DC, December 2001).

[152] The use of simulation analysis in capital budgeting was first reported by David B. Hertz. See D.B. Hertz, "Risk Analysis in Capital Investment," *Harvard Business Review* (January-February 1964), pp. 95-106, and "Investment Policies That Pay Off," *Harvard Business Review* (January-February 1968), pp. 96-108.

[153] The lognormal distribution rather than a normal distribution is a legitimate assumption for price data, in that prices cannot be less than zero in reality.

was specified for each year of the project's life.[154] The NPV distribution generated by the simulation is shown Figure 6, and the statistical results and summary are shown Table 5, in Chapter 2.[155] The simulation results indicate that there is about a 17-percent chance that the investment will be unprofitable (i.e., that it will have a negative NPV).

Because the investor faces some probability of loss as a result of price fluctuations, he may have an incentive to mitigate the risk by hedging with such tools as long-term contracts, futures, options, and swaps. It was assumed for the analysis that the power producer's maximum risk tolerance for the price volatilities was plus or minus one standard deviation from their means, or 77 percent and 47 percent of the mean price for electricity and natural gas, respectively. This assumption led to triangular distributions for both prices (Table B3).

When it was assumed that the price volatility would be hedged, the probability of positive NPV increased from 83 percent to 99 percent with a coefficient of variation (CV) of 0.42. Without hedging the price volatility, the CV was 1.09. The distribution is shown in Figure B1. The summary of statistical results and a statistical comparison of the simulations are shown in Table B4. As shown, a hedged project has less probability of negative NPV, smaller standard deviation of NPV, and a smaller risk measurement (CV).

Table B2. Estimation of Annual Net Cash Flows for a New Combined-Cycle Generator

Estimate	2001	2002	2003	2004	2005	2021
Initial Investment	-$236,000,000	—	—	—	—	—
Annual Unit Sales (Megawatthours)	—	2,277,600	2,277,600	2,277,600	2,277,600	2,277,600
Sale Price (Dollars per Megawatthour)	—	$43.29	$42.01	$43.04	$43.40	$66.72
Revenue	—	$98,593,747	$95,687,611	$98,034,736	$98,855,121	$151,965,867
O&M Costs (Dollars per Megawatthour)	—					
Fixed	—	5,940,168	6,100,553	6,265,267	6,434,430	9,854,558
Variable	—	1,216,330	1,249,170	1,282,898	1,317,536	2,017,854
Fuel (Natural Gas) Costs	—	41,204,050	47,722,153	52,391,326	55,030,625	102,132,258
Depreciation	—	11,800,000	22,420,000	20,178,000	18,172,000	0
Earnings Before Taxes (EBT)	—	$38,433,200	$18,195,736	$17,917,245	$17,900,530	$37,961,196
Taxes	—	13,835,952	6,550,465	6,450,208	6,444,191	13,666,031
Net Operating Income	—	$24,597,248	$11,645,271	$11,467,037	$11,456,339	$24,295,166
Noncash Expenses (Depreciation)	—	11,800,000	22,420,000	20,178,000	18,172,000	0
Net Cash Flow from Operations	-$236,000,000	$36,397,248	$34,065,271	$31,645,037	$29,628,339	$24,295,166

Notes: Assumptions based on Energy Information Administration, *Assumptions to the Annual Energy Outlook 2002 (AEO2002)*, DOE/EIA-0554(2002) (Washington, DC, December 2001). Depreciation schedule over the 20-year life of the fixed asset is as follows: 5%, 9.5%, 8.55%, 7.7%, 6.93%, 6.23%, 5.9%, 5.9%, 5.9%, 5.9%, 5.9%, 5.9%, 5.9%, 5.9%, 5.9%, and 2.95% for year 1 through year 16, respectively.

Source: Energy Information Administration.

[154]The positive correlation coefficient, 0.88, was generated by the daily NYMEX spot price relationship between Henry Hub natural gas prices and an average of ECAR, PJM, COB, and Palo Verde electricity prices from March 1999 through March 2002.

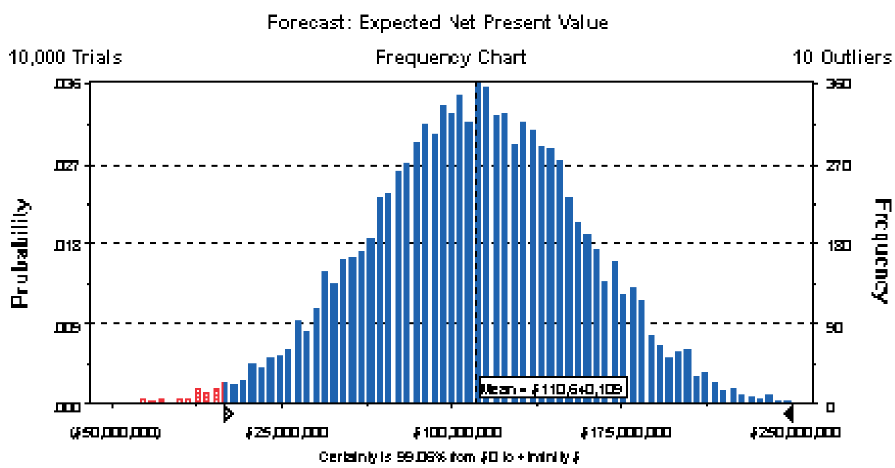
[155]The simulation was run for 10,000 trials using Crystal Ball® computer software. The risk-free rate of 5.62 percent (average monthly 10-year Treasury constant maturity from January 1997 through May 2002) was used for the discount rate rather than the weighted average cost of capital (WACC) to get NPVs and avoid double-counting risk. For details, see R.H. Keeley and R. Westerfield, "A Problem in Probability Distribution Techniques for Capital Budgeting," *Journal of Finance* (June 1972), pp. 703-709.

Table B3. Expected Price Range with Risk Tolerance (Triangular Distribution)

	Electricity Price (Cents per Kilowatthour)			Natural Gas Price (Dollars per Thousand Btu)		
Year	Mean	Lower Limt	Upper Limit	Mean	Lower Limit	Upper Limit
2002	4.215	0.969	7.461	2.590	1.373	3.808
2003	3.983	0.916	7.050	2.921	1.548	4.294
2004	3.974	0.914	7.033	3.123	1.655	4.591
2005	3.902	0.897	6.906	3.194	1.693	4.695
2006	3.816	0.878	6.754	3.225	1.709	4.740
2007	3.769	0.867	6.671	3.258	1.727	4.789
2008	3.737	0.860	6.615	3.313	1.756	4.870
2009	3.719	0.855	6.583	3.343	1.772	4.914
2010	3.741	0.860	6.621	3.381	1.792	4.969
2011	3.758	0.864	6.652	3.460	1.834	5.086
2012	3.732	0.858	6.606	3.524	1.868	5.180
2013	3.746	0.862	6.630	3.572	1.893	5.251
2014	3.735	0.859	6.611	3.610	1.913	5.307
2015	3.740	0.860	6.620	3.654	1.937	5.372
2016	3.760	0.865	6.655	3.685	1.953	5.417
2017	3.797	0.873	6.721	3.729	1.976	5.481
2018	3.847	0.885	6.809	3.777	2.002	5.552
2019	3.877	0.892	6.862	3.818	2.024	5.613
2020	3.916	0.901	6.932	3.871	2.051	5.690
2021	3.916	0.901	6.932	3.871	2.051	5.690

Source: Energy Information Administration.

Figure B1. NPV Simulation with Hedging for Input and Output Price Volatilities



Source: Energy Information Administration.

Table B4. Summary of Statistical Results from the NPV Simulation

	Net Present Value	
Statistics	Without Hedging	With Hedging
Trials	10,000	10,000
Mean	$110,004,525	$110,640,109
Median	$95,173,767	$111,069,433
Standard Deviations. . . .	$120,382,899	$46,299,875
Maximum	$1,187,415,173	$287,794,307
Minimum	-$213,218,338	-$49,672,944
Probability of NPV > 0 . .	82.97%	99.06%
Coefficient of Variation. .	1.09	0.42

Source: Energy Information Administration, output from Cystal Ball® software used with an Excel spreadsheet program.