Chapter 2

An Example Case
Power to the People

This chapter is presented in three parts: the case statement, a description of the solution process, and an example case report. Chapter 4 on sensitivity analysis elaborates on the solution technique used here.

Chapter 2

Part A
The Case Statement

The Power Authority for Northcentral New Hampshire (NcNH) faces increasing demands for electricity, and its aging coal-based facility must soon be replaced. There are three options: a hydroelectric project, a new thermal generation facility (coal, natural gas, or oil-fired), or buying their power from a larger, nearby utility.

The last option has been discarded. NcNH did not join the regional consortium of utility companies when it was formed thirty years ago to support construction of a large nuclear facility. Since then, the nuclear plant has suffered enormous cost overruns. Now that it has finally entered service, the rates of all of the utilities in the consortium are quite high. NcNH has emergency interties with other utilities, but the high wholesale cost of consortium power limits its use to emergencies only.

The shareholders' environmental group has been quite effective, partly because NcNH is a member owned cooperative. This first peak coincided with nationwide gains for the environmental movement, and it kept NcNH from joining the consortium for the nuclear facility. The cost savings of that decision, more recent concerns over global warming, and very effective leadership have increased the influence of the environmental group.

The environmental group is now lobbying hard for replacement of the aging coal facility and for a shift away from coal for the new facility. Ms. Black, the plant manager, and the engineers under her disagree. They support coal as the fuel of choice for the potential new facility. NcNH's general manager, Mr. Herbert, suspects that the environmental group will prevail; thus, he has asked the engineering group to analyze a petroleum based facility as well as a small hydroelectric dam that has been proposed.

There are no local petroleum deposits; thus, the world market price and supply is the critical determining factor. As other utilities in the regional consortium have thermal facilities that burn natural gas and fuel oil, Mr. Herbert anticipates no problem in arranging for either fuel. He also suspects that the difference between the two petroleum fuels will be much smaller than the difference between them and the dam. Thus he has ordered that the preliminary analysis be based on the dam and on natural gas.

From consultation with other utilities and information from an old engineering feasibility study, Mr. Herbert and Ms. Black have pulled together some rough estimates. For example, an old Corps of Engineers report describes a dam that would currently cost about $120 million to build and $6 million a year to operate. The Corps estimates that such dams last about 50 years, and this one should have a capacity of 1500×10^6 kilowatt-hours (kWh) per year.

Generation through natural gas turbines comes in much smaller increments of capacity, allowing estimated costs per kilowatt-hour to be used. At current prices and assuming average loads of 80% on individual generators, the manufacturer's data on production efficiency provide a cost estimate of $0.015/kWh. This includes amortization of the gas turbines, normal maintenance, and an allowance for major overhauls. It does not include an expected average cost increase of 1% per year due to differential inflation in the price of fuel.

NcNH currently generates 600×10^6 kWh/year and expects this to grow 4% per year. (This implies that the dam cannot fully meet the demand for its 50-year life.) The state's Public Utility Commission has historically limited NcNH to a 6% rate of return on its capital investment.

Ms. Black has assigned you the responsibility of analyzing the choice. She suggested that the first decision is to choose which sensitivity analyses should be conducted and how they will be presented to Mr. Herbert and the other managers.

The second stage is of course to analyze these two choices, make a recommendation, and support it. Ms. Black has emphasized that sensitivity analyses are crucial here, as this is really only the first step in a long process. Other alternatives will be developed and the data will be refined, but a complete set of analyses will help NcNH understand the possibilities.

Option. *Not considered for example solution, so can be used as basis for an assignment.*

In addition to the cost of power generation, a second consideration is the cost of peak capacity. Obviously, the generation of electricity varies over the day and over the year. For NcNH the daily peak is 1.9 times the daily average, while the low is only 0.5 of the average. Similarly, January has a peak of 1.8 times the annual average; July has a lower peak of 1.2 times the annual average; while April and September have seasonal lows of 0.6 and 0.7, respectively.

The ability of any dam to respond to this type of variability is limited by the seasonality of water flows and by the dam's designed capacity. These limits imply that the dam's theoretical capacity is two to three times larger than its "average" capacity of 1500×10^6 kWh/year.

Does consideration of peak capacity generation modify your recommendations?

Chapter 2

Part B
The Solution Process

For simplicity, this process is described as a one pass, do-it-all-right-the-first-time process. No case analysis is that simple. Rather all analyses require that some parts be redone as your understanding increases.

Reading the Case

The first reading is to get an overall sense of the problem. This is to analyze several new power sources (natural gas and hydroelectric) with a focus on the cost of power. The second reading would involve highlighting of the various numbers that will be part of the economic model.

Identifying and Modeling the Problem

The problem is to build an economic model that allows sensitivity analyses for two alternatives. The utility's principal objective is to have low cost, reliable power. However, some stakeholders are more concerned with the environmental impacts. This is the first step in what will be a lengthy process where the alternatives will be repeatedly re-defined, so it is more important to develop a solid understanding of what the key variables are than it is to recommend a final choice.

The case limits are defined by Mr. Herbert, the general manager: compare the dam and natural gas alternatives. Ms. Black further emphasizes selecting which sensitivity analyses should be done and how they should be presented. The deliverables must satisfy these requirements.

Identifying the Alternatives

The choice is between two alternatives for replacing the aging coal-fired power plant. If demand grows rapidly, then a large hydroelectric investment may produce power very economically over the problem's 50-year horizon. However, if the growth is slower, then paying the high operating costs of gas-fired turbines is cheaper, because they can be incrementally added to match increases in power demand. Besides the uncertainty in the demand's growth rate, other base case assumptions can be challenged. For example, the horizon and discount rate are somewhat arbitrary selections, and a dam's initial cost is often much higher than expected. The cost of the turbine is stated per kilowatt hour. Thus, we can make the assumption that this cost is the default, do-nothing cost.

In the long run, other alternatives, such as a new coal facility and dams of different sizes will have to be considered. However, the given dam and gas turbine alternatives are a good starting point. Also in the long run, the environmental impacts of the different choices will play a large role.

Compiling the Data

Base Case Assumptions. The following variables are used in the economic model, and their values are found in the case.

Dam	First costs	\$120 million
	Operating & maintenance (O&M) costs	\$6 million/year
	Capacity	1500×10^6 kWh/year
	Life	50 years
Turbine	Turbine cost	\$0.015 / kWh
	Growth rate for turbine	1%/year
General	Initial power demand	600×10^6 kWh/yr
	Demand's growth rat	4%/year
	Discount rate	6%/year

Because the cost of the turbine is stated per kilowatt hour, there is an implicit assumption that this cost is the default, do-nothing cost. Thus, it is natural to assume that incremental power will be generated by natural gas turbines if the dam's capacity is exceeded. Since demand over the dam's capacity will be met by gas turbines in either case, we can ignore demands over the dam's capacity.

A second assumption involves the treatment of salvage or residual values at the horizon. For simplicity, this analysis assumes that the dam and the turbine alternatives have similar residual values. Note that at a discount rate of 6%, taking the present worth of any difference at year 50 reduces the difference by a factor of 20, since (*P/F*, 6%, 50) = .0543.

A third assumption is more arbitrary. When do the geometric gradients for demand and the cost of fuel start? Both geometric and arithmetic gradients are typically assumed to have no change or zero cash flow in period 1. Starting either gradient a year earlier would make the dam more attractive.

Summary of assumptions:

- Demand over dam's capacity met by gas turbines in either case ➔ ignore
- Residual values for dam and gas turbines about the same after 50 years
- Geometric gradients for demand and cost of fuel have no change in period 1

Limits of Reasonable Change. Ms. Black's instructions make it clear that we cannot assume that the data are completely accurate. But there is no information presented on how much the various elements might vary. We could try and research this on the Internet, or we can simply make reasonable assumptions based on some general principles. In general there seem to be more ways for things to go wrong than right, so cost over-runs can be much larger than cost under-runs. Also, the further into the future a cash flow occurs, the more uncertain it is likely to be.

The dam has four variables that define it economically: a first cost, an annual operating cost, a capacity, and a life. Construction costs for dams depend on "ground" conditions, labor relations, etc. But the variability is not balanced. Under runs are possible, but overruns are more likely, and they are apt to be larger. So a range of −40% to +100% is reasonable (or $72 million to $240 million from a base of $120 million). Narrower limits seem appropriate for operating costs (−40%, +60%) and capacity (−10%, +20%). The 50-year life has a "suspicious hint" of arbitrariness, so limits of 30 to 100 years will be used (−40%, +100%) for the sensitivity analysis.

The current operating cost of the turbine should be a fairly exact figure. The turbines are off-the-shelf manufactured items with known performance and cost characteristics. So the cost/kilowatt-hour need only be varied by (−20%, +20%). However, estimating the differential inflation rate for petroleum products over the next 50 years is very uncertain, so a much broader range is assumed for the inflation rate of the turbine's fuel (−80%, +200%).

There are two general economic parameters that are estimated: the annual growth rate in power demand and the discount rate for the analysis. Historically, forecasting the growth rate in demand for power has been very difficult. In fact, numerous nuclear power plants have been canceled due to demand that failed to materialize. Cost overruns and delays simply increase the cost of the power, while a flat demand curve has caused 60% complete plants to be dismantled or mothballed. Thus a range of –80% to +50% is used for the uncertainty in the demand's growth rate.

The discount rate is also somewhat uncertain. The rate for financing may be known, but a 6% discount rate may not adjust for the risk to the members of the cooperative or the opportunity cost of the capital invested. Using a range of 3% to 10% basically corresponds to –50% to +70%.

These limits can be summarized as:

		Lower limit	Upper limit
Dam	First cost	−40%	+100%
	Operating costs	−40%	+60%
	Capacity	−10%	+20%
	Life	−40%	+100%
Turbine	Cost/kWh	−20%	+20%
	Growth rate for turbine cost	−80%	+200%
General	Demand's growth rate	−80%	+50%
	Discount rate	−50%	+70%

Choice of Graphs. Graphs or tables of present worth versus each variable could easily be constructed, but with complex data it is usually easier to interpret a graph. Tables often just overwhelm people with lots of numbers. Rather than drawing separate plots of present worth for each variable, it is more useful to combine them to examine the relative sensitivity of the present worth to each variable.

Figure 2-1 of the case report is a tornado diagram that summarizes the impact of each variable on the present worth. This is the best graph for showing the relative sensitivity of the present worth to many variables. First the variables are ranked based on each variable's range of present worth values. Then the tornado diagram arrays them from the most to the least impact.

The four variables with the most impact are examined in more detail in a spiderplot (Figure 2-2). We could also select variables for a spiderplot by considering the variable's importance, uncertainty, and controllability.

Some pairs of variables may have interesting interactions or they may be linked by importance or logic. Figure 2-3 considers the interaction of life and discount rate, as these are left to the analyst or defined politically in a disconcerting number of cases. Other parameters are more often based on hard data or engineering estimates. Figure 2-4 considers the interaction of the two "engineering" variables that may individually result in the turbine having a lower cost than the dam.

Building the Model. The model is fairly basic cash-flow equivalence, except for the geometric gradients and the dam's capacity. The extensive sensitivity analysis in this case is easier to do with formulas based on equivalent discount rates, but a cash flow table is easier to present and understand. Doing both double-checks the answer of each.

Dam PW = DamFirstCost + [DamO&M * ($P/A,i$, life]

Turbine PW = PW Growth Phase + PW No-Growth Phase

The demand and the cost of fuel for the turbine increase at constant rates rather than by a constant amount each year. Thus, this involves a geometric, not an arithmetic gradient. Either year-by-year entries in a cash flow table are required, or the geometric rates must be combined with the discount rate in equivalent rates that combine all relevant factors.

Given an initial power demand, a growth rate in demand, and the capacity of the dam; the year the dam's capacity is fully utilized ($N_{\text{at capacity}}$) can be calculated.

Capacity = Initial demand * (F/P,growth rate, $N_{\text{at capacity}}$)

This year is equivalent to the end of the growth phase, since we have assumed that excess demand will be supplied by turbines.

Analyzing the Results. The various graphs confirm that the base case results and most variations favor the dam. However, the curves for three variables do cross over the breakeven line: demand rate, the dam's first cost, and the discount rate. Thus, these variables obviously merit further study. Also the variables will change simultaneously. We could create scenarios of sets of changes, but this would greatly expand the case. So only a limited comparison of two pairs is made (see Figures 2-3 and 2-4). Figure 2-4 clearly warrants more concern than does Figure 2-3, where fairly extreme changes are required. Basically, consider the “distance” between the base case and the breakeven line.

Breakeven analysis can facilitate considering non quantifiable factors, which will have to be included before a final decision is made in the future. If a project is close to breakeven, then the economics of the two alternatives do not differ significantly, and other factors dominate. If one alternative is clearly better economically, then the question is whether non-economic factors imply another choice is better.

Chapter 2

Part C
The Written Report

To: Ms. Black & Mr. Herbert
From: SCR (Student Consultants Rule)
About: Identifying key variables to compare a hydroelectric dam and natural gas turbines

Recommendations

1. The dam is the better alternative for this initial analysis.
2. This recommendation is most sensitive to changes in the dam's first cost, the growth rate in demand, and the discount rate.
3. Some mechanism needs to be developed for balancing political risks with each other and with the economics.

Discussion

The given data and reasonable assumptions about its variability are summarized below.

			Lower limit	Upper limit
Dam	First cost	\$120 million	−40%	+100%
	Operating costs	\$6 million/year	−40%	+60%
	Capacity	1500×10^6 kWh/year	−10%	+20%
	Life	50 years	−40%	+100%
Turbine	Cost/kWh	\$0.015 / kWh	−20%	+20%
	Growth rate for turbine cost	1%/year	−80%	+200%
General	Initial power demand	600×10^6 kWh/yr		
	Demand's growth rate	4%/year	−80%	+50%
	Discount rate	6%/year	−50%	+70%

Additional assumptions are:

- Demand over dam's capacity met by gas turbines in either case ➔ ignore
- Residual values for dam and gas turbines about the same after 50 years
- Geometric gradients for demand and cost of fuel have no change in period 1

Only three of the top four variables in Figure 2-1 are "likely to change enough" to allow the turbine to be economically more favorable. Figure 2-2 can be used to estimate the breakeven values for these variables: 160% of the base case value for the dam's first cost, 140% of the base case value for the discount rate, and 40% of the base case value for the growth rate in demand.

Figure 2-3 shows that the preference for the dam is relatively insensitive to the value for its life, so long as that life is at least as long as the shortest life expected of 30 years. Figure 2-4 allows us to examine changes in the dam's first cost and the growth rate in demand at the same time.

However, there are very substantial risks associated with the dam. Basically, this alternative is inflexible, and the future is uncertain. And much of the uncertainty and downside risk is linked to these three variables. The environmentalists can delay the dam with lawsuits, which will increase costs. Also, projects of this size very often exceed their preliminary design estimates. The demand rate is very uncertain because it relies on population and industry estimates extending over a half century. And finally, NcNH's discount rate is fair, but it is open to attack by environmentalists who do not want to see the dam built. There are political risks with economic impacts for all power generation options.

The largest concern is the risk to current rate payers, management, and employees. If the dam is the best choice, it is because of efficiencies when the dam is operating at or near capacity—in twenty or more years. However, if there are overruns or delays that force NcNH to buy high-priced nuclear power, then all suffer in the next five to ten years.

Figure 2-1 Tornado Diagram for $PW_{cam} - PW_{turbines}$

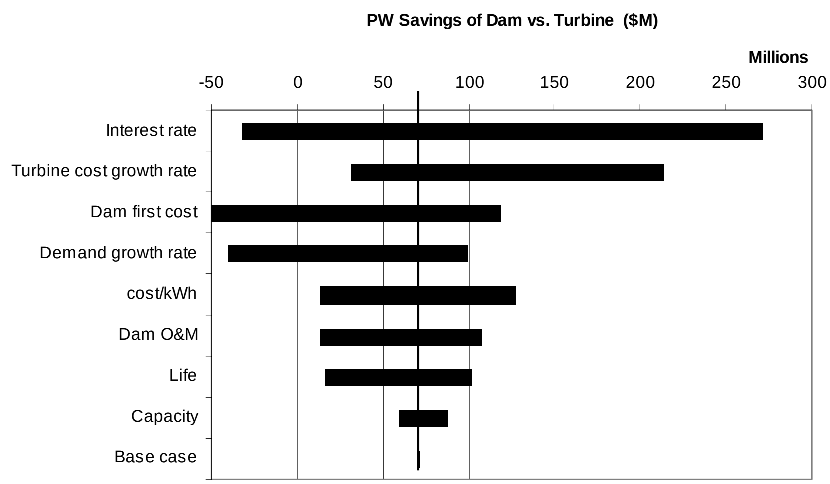


Figure 2-2 Spiderplot of Four Variables with Most Impact

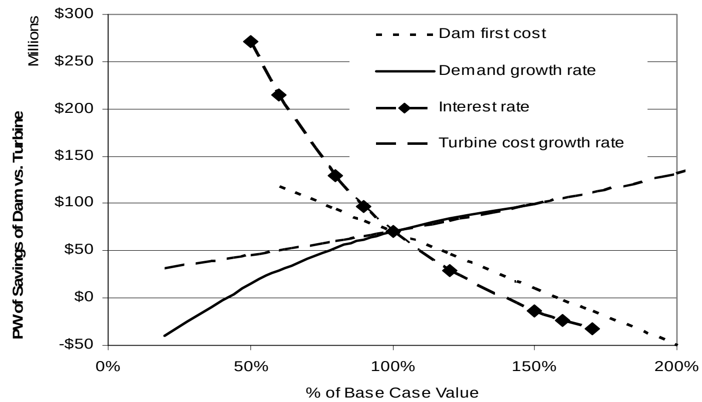


Figure 2-3 Discount Rate vs. Study Period

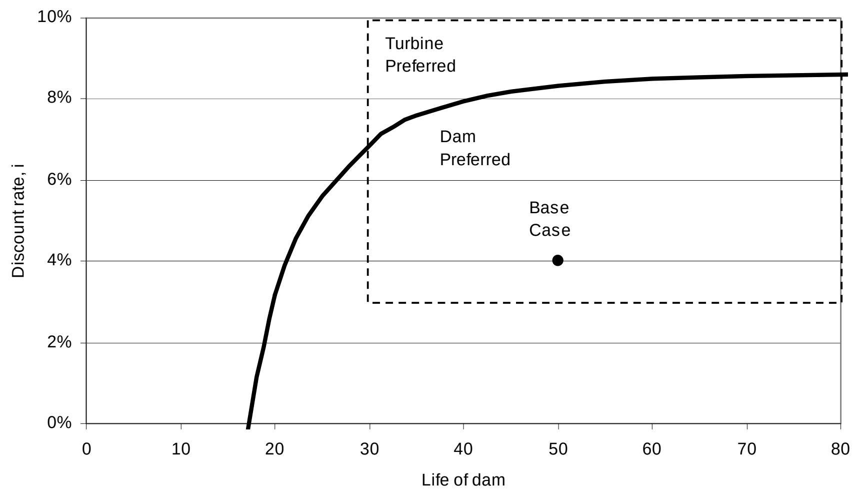
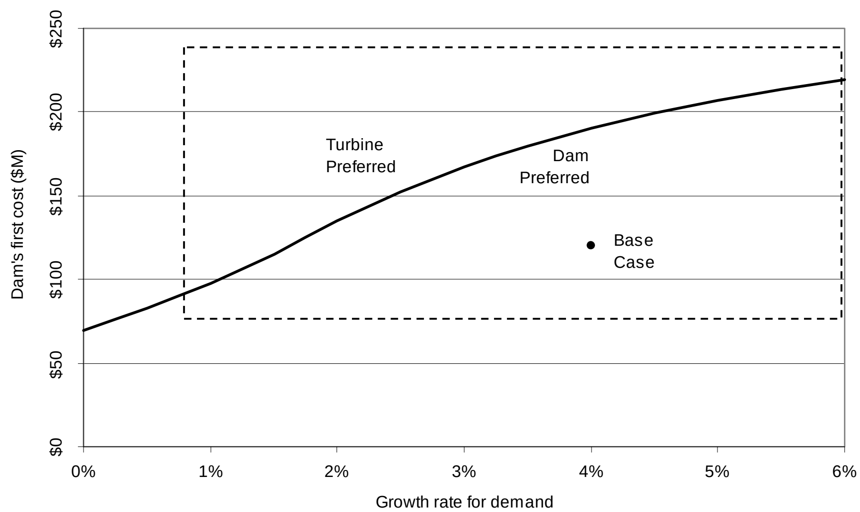


Figure 2-4 Demand's Growth Rate vs. Dam's First Cost



Appendix

The Problem

By direction of management this initial analysis is limited to the economic comparison of two alternatives – a hydroelectric dam and natural gas fired turbines.

The Data

The data summarized in the table is taken directly from the case. If there were different sources, then those sources would be identified here. The following table summarizes the basis for the limits on each variable.

Dam		Lower limit	Upper limit	Basis for limit
First cost	$120 million	−40%	+100%	Large overruns possible due to delays, ground conditions, etc.
Operating costs	$6 million/year	−40%	+60%	Over-runs likely to be larger than under-runs
Capacity	1500×10^6 kWh/year	−10%	+20%	Engineering design except for variability in water flow
Life	50 years	−40%	+100%	20 – 100 years seems more reasonable than exact 50 years
Turbine				
Cost/kWh	$0.015 / kWh	−20%	+20%	Known off-the-shelf technology
Growth rate for turbine cost	1%/year	−80%	+200%	Fuel costs are volatile
General				
Initial power demand	600×10^6 kWh/yr			Known value
Demand's growth rate	4%/year	−80%	+50%	Historically difficult to estimate
Discount rate	6%/year	−50%	+70%	Politically determined variable

The Model

The formula-based model is easier to use for sensitivity analysis, but the cash flow table model is easier to build and understand. Doing both double-checks the result.

In Figure 2-5, the years from 27 to 49 are hidden to help preserve readability. A data block in the top left corner of the spreadsheet defines *ALL* values in the spreadsheet. The PW equals CF_0 + NPV(interest rate, CF_1:CF_{50}) or =F17+NPV(A13,F18:F67).

Figure 2-5 Spreadsheet Model with Year-by-year Cash Flows

	A	B	C	D	E	F	G
1				Plus/minus limits		Limits as factors	
2	Dam			Lower limit	Upper limit	Lower limit	Upper limit
3	$120,000,000	first cost		-40%	100%	60%	200%
4	$6,000,000	O&M		-40%	60%	60%	160%
5	1,500,000,000	Capacity		-10%	20%	90%	120%
6	50	Life		-40%	100%	60%	200%
7	Turbine						
8	$0.015	cost/kWh		-20%	20%	80%	120%
9	1%	growth rate		-80%	300%	20%	400%
10	General						
11	600,000,000	Initial power demand					
12	4.0%	Demand growth rate		-100%	50%	0%	150%
13	6%	Interest rate		-50%	70%	50%	170%
14							
15						=NPV($A$13,F19:F68)+F18	
16					PW=	**70,264,875**	
17	demand	period	Dam	cost/kWh	Turbine	Dam-turbine	
18		0	-120,000,000			-120,000,000	
19	600,000,000	1	-6,000,000	$0.0150	-9,000,000	3,000,000	
20	624,000,000	2	-6,000,000	$0.0152	-9,453,600	3,453,600	
21	648,960,000	3	-6,000,000	$0.0153	-9,930,061	3,930,061	
22	674,918,400	4	-6,000,000	$0.0155	-10,430,537	4,430,537	
23	701,915,136	5	-6,000,000	$0.0156	-10,956,236	4,956,236	
24	729,991,741	6	-6,000,000	$0.0158	-11,508,430	5,508,430	
25	759,191,411	7	-6,000,000	$0.0159	-12,088,455	6,088,455	
26	789,559,068	8	-6,000,000	$0.0161	-12,697,713	6,697,713	
27	821,141,430	9	-6,000,000	$0.0162	-13,337,678	7,337,678	
28	853,987,087	10	-6,000,000	$0.0164	-14,009,897	8,009,897	
29	888,146,571	11	-6,000,000	$0.0166	-14,715,995	8,715,995	
30	923,672,434	12	-6,000,000	$0.0167	-15,457,681	9,457,681	
31	960,619,331	13	-6,000,000	$0.0169	-16,236,749	10,236,749	
32	999,044,104	14	-6,000,000	$0.0171	-17,055,081	11,055,081	
33	1,039,005,869	15	-6,000,000	$0.0172	-17,914,657	11,914,657	
34	1,080,566,103	16	-6,000,000	$0.0174	-18,817,556	12,817,556	
35	1,123,788,747	17	-6,000,000	$0.0176	-19,765,960	13,765,960	
36	1,168,740,297	18	-6,000,000	$0.0178	-20,762,165	14,762,165	
37	1,215,489,909	19	-6,000,000	$0.0179	-21,808,578	15,808,578	
38	1,264,109,506	20	-6,000,000	$0.0181	-22,907,730	16,907,730	
39	1,314,673,886	21	-6,000,000	$0.0183	-24,062,280	18,062,280	
40	1,367,260,841	22	-6,000,000	$0.0185	-25,275,019	19,275,019	
41	1,421,951,275	23	-6,000,000	$0.0187	-26,548,880	20,548,880	
42	1,478,829,326	24	-6,000,000	$0.0189	-27,886,943	21,886,943	
43	1,500,000,000	25	-6,000,000	$0.0190	-28,569,030	22,569,030	
44	1,500,000,000	26	-6,000,000	$0.0192	-28,854,720	22,854,720	
68	1,500,000,000	50	-6,000,000	$0.0244	-36,637,838	30,637,838	
69			=-$A$4		=-A68*D68		
70	=MIN(A67*(1+$A$12),$A$5)			=D67*(1+$A$9)			

Terminology for Formula-Based Model

i = basic discount rate

i_{eq} = equivalent discount rate

$$(1 + i_{eq}) = \frac{(1 + i)}{[(1 + \text{fuel growth rate}) * (1 + \text{demand growth})]}$$

Note 1: When i_{eq} would be negative, the right hand side is inverted.
Note 2: For the at-capacity phase, the (1 + demand growth rate) term is omitted for i_{eq} calculation.

LastGrowthYr = last year before capacity is reached

YrsAtCapacity = number of years with constant power usage

Mathematical Model

Dam PW = DamFirstCost + [DamO&M * (P/A,i, life)]

Turbine PW = PW growth phase + PW at-capacity phase

= (1a) or (1b) + (2a) or (2b)

a: if $i_{eq} \geq 0$

(1a) = TurbCostInitial * Init kWh * (P/A, i_{eq} ,LastGrowthYr)

(2a) = TurbineCostLastGrowthYr * DamCapacity * (P/A, i_{eq},YrsAtCapacity) *
(P/F,i,LastGrowthYr)

b: if inversion is required to prevent $i_{eq} < 0$ (needed for tabulated factors, but not necessary if Excel functions, such as PV, are used)

(1b) = TurbCostInitial * Init kWh * (1 + i_{eq}) * (F/A, i_{eq} ,LastGrowthYr)

(2b) = TurbineCostLastGrowthYr * DamCapacity * (1 + i_{eq}) * (F/A, i_{eq},YrsAtCapacity) *
(P/F,i,LastGrowthYr)

The spreadsheet in Figure 2-6 first builds the result for the $PW_{turbine - dam}$ piece-by-piece before they are combined using cut and paste. Also it is checked against the much easier to follow and verify result in Figure 2-5. This gives a single formula, which can be used to draw the spiderplot. The values at the bottom of the figure are used to draw the tornado diagram and the spiderplot. (A template for constructing tornado diagrams is included with the CD version of this casebook. For more explanation on constructing these figures, see chapter 4.)

Figure 2-6 Spreadsheet Model with Formula Basis

	A	B	C	D	E	F	G	H	I
1			Plus/minus limits		Limits as factors				
2	Dam		Lower limit	Upper limit	Lower limit	Upper limit			
3	$120,000,000	first cost	-40%	100%	60%	200%			
4	$6,000,000	O&M	-40%	60%	60%	160%			
5	1,500,000,000	Capacity	-10%	20%	90%	120%			
6	50	Life	-40%	100%	60%	200%			
7	Turbine								
8	$0.015	cost/kWh	-20%	20%	80%	120%			
9	1%	growth rate	-80%	200%	20%	300%			
10	General								
11	600,000,000	Initial power demand							
12	4.0%	Demand growth rate	-80%	50%	20%	150%			
13	6%	Interest rate	-50%	70%	50%	170%			
14									
15	-$214,571,164	PW dam							
16	24	last year dam not at capacity			=TRUNC(MIN(NPER($A$12,,$A$11,-$A$5)+1,$A$6))				
17	0.914%	Equivalent discount rate -- growth period			=(1+$A$13)/(1+$A$9)/(1+$A$12)-1				
18	4.950%	Equivalent discount rate -- at-capacity period			=(1+$A$13)/(1+$A$9)-1				
19	-$183,895,255	PW turbine growth phase			=PV($A$17,$A$16,$A$8*$A$11)/((1+$A$9)*(1+$A$12))				
20	-$408,702,636	FW(time 0 of at-capacity period)			=PV($A$18,$A$6-$A$16,$A$5*FV($A$9,$A$16,,-$A$8))/(1+$A$9)				
21	0.2470	(*P/F,i*,last yr dam not at capacity)			=PV($A$13,$A$16,,-1)				
22	-$284,836,039	PW turbine			=A19+A20*A21				
23	$70,264,875	PW (dam - turbine)			=A15-A22				
24	$70,264,875	PW (dam - turbine)			Combined function built by cut & paste				
25	=-$A$3+PV($A$13,$A$6,$A$4)-(PV((1+$A$13)/(1+$A$9)/(1+$A$12)-1,TRUNC(MIN(NPER($A$12,,$A$11,-$A$5)+1,$A$6)),$A$8*$A$11)/((1+$A$9)*(1+$A$12))+PV((1+$A$13)/(1+$A$9)-1,$A$6-(TRUNC(MIN(NPER($A$12,,$A$11,-$A$5)+1,$A$6))),$A$5*FV($A$9,(TRUNC(MIN(NPER($A$12,,$A$11,-$A$5)+1,$A$6))),,-$A$8))/(1+$A$9)*PV($A$13,TRUNC(MIN(NPER($A$12,,$A$11,-$A$5)+1,$A$6)),,-1))								
26									
27		Dam first cost	Dam O&M	Capacity	Life	cost/kWh	Turbine cost growth rate	Demand growth rate	Interest rate
28	20%						31333447	-28427635	
29	50%						44986451	14648389	271471939
30	60%	118264875	108093341		16821650		49779520	29147887	214631931
31	80%	94264875	89179108		49598458	13297668	59751489	52565898	129234516
32	90%	82264875	79721992	59130548	61121384	41781272	64938414	62016569	97108735
33	100%	70264875	70264875	70264875	70264875	70264875	70264875	70264875	70264875
34	120%	46264875	51350643	87620991	83263058	127232083	81353991	83976155	28677739
35	150%	10264875	22979294		94273543		99148054	99491461	-13079969
36	160%	-1735125	13522177		96530490		105408609		-23259003
37	170%	-13735125			98315228		111842493		-32069761
38	200%	-49735125			101721463		132240120		
39	300%						214038550		
40		Dam first cost	Dam O&M	Capacity	Life	cost/kWh	Turbine cost gı	Demand grov	Interest rate
41	min	-49735125	13522177	59130548	16821650	13297668	31333447	-28427635	-32069761
42	max	118264875	108093341	87620991	101721463	127232083	214038550	99491461	271471939
43	range	168000000	94571164	28490442	84899813	113934416	182705104	127919096	303541700