



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# Incentive vs. Conventional Regulation of New Utility Construction

Joan K. Meyer

Major plant construction projects represent a large part of a typical utility's rate base and construction cost overruns are a perennial problem associated with these projects. The conventional approach to prevent overruns is direct regulatory oversight by a regulatory commission. Yet this approach fails to provide on-going incentives for the most cost effective decisions by the utility. This article contrasts an incentive method of regulation, which inversely relates the rate of return granted by the regulatory agency with the level of overruns incurred, with conventional rate regulation. A discounted cash flow simulation model is employed based on data from an electric generation project currently under construction in Central New York.

Recent widespread suspensions and cancellations of nearly completed nuclear power plants by electric utilities highlight a perennial problem faced in public utility regulation—construction cost overruns. The costs of new construction represent a large part of a typical utility's rate base. Because utilities try to recover cost overrun through rate increases, these overruns translate directly into higher utility rates charged to consumers. In the case of the recently cancelled nuclear power plants in Washington and Indiana, the public service commissions ruled that the necessary increases in utility rates exceeded the value of service from these projects.

The conventional approach taken to prevent cost overruns is direct regulatory oversight. Under this approach the rate of return to be earned on investment in a project is established prior to construction. The project is then subject to several levels of review during its planning stages and its progress during construction is audited. Hence, the regulatory commission's role is limited to reviewing decisions made by the utility and disallowing any cost overruns deemed unacceptable as part of the rate base. This after-the-fact approach fails to provide incentives for cost-minimizing de-

cisions by the utility at each juncture during a project's design and construction.

One of the most promising innovations developed as an alternative to direct regulatory oversight was proposed by the Federal Energy Regulatory Commission (FERC) for monitoring the construction of the Alaska Natural Gas Transportation System, the now defunct proposal to build a natural gas pipeline from the Prudhoe Bay region of Alaska to the contiguous lower-48 states. The New York State Public Service Commission recently adopted a modified version of the FERC plan for use in regulating construction of a partially completed nuclear-powered electric generating facility, Nine Mile Point No. 2, as an alternative to abandonment of the project due to excessive overruns (U.S. Department of Energy, 1983).

The FERC alternative establishes a variable rate of return prior to construction which inversely relates the rate of return allowed on investment to the level of construction cost overrun incurred. The utility is rewarded with a greater than normal return on investment if actual construction costs are below the projected estimate, while progressively lower rates are granted as cost overruns increase. The penalty for poor cost containment, then, is a lower than normal return on project investment. In the event that a cost overrun is caused by an event outside of the utility's control, such as inflation or project design changes, the utility can petition the Commission for an adjustment in the original pre-construction estimate around which cost over-

---

Graduate Research Assistant, Department of Agricultural Economics, Cornell University.

The author is indebted to Robert Kalter, Richard Boisvert, and two anonymous reviewers for helpful comments and assistance. Thanks also goes to NYSEG's staff for their efficient provision of data and information. All errors, however, are the responsibility of the author.

runs are defined. In this way, the utility is protected from bearing unfair penalties due to "unavoidable" cost overruns. The underlying rationale of this method is that the incentive of higher returns on investment should keep total project costs low through reduced overruns so that consumers ultimately benefit through reduced rates.

The purpose of this article is to compare the effectiveness of the incentive method of regulation with conventional rate regulation in preventing "avoidable" cost overruns in new utility construction. Because this incentive method has not yet been applied to new construction, data are unavailable documenting a utility's performance under it for comparison with utilities operating under conventional regulation. Instead, a simulation model is used. The Somerset Station project, a coal-fired electric generating facility currently under construction in central New York, provides the basis of data for the model. Before the model is presented, the antecedents to incentive regulation are reviewed.

### Precursors to the Incentive Rate of Return

The incentive method of regulation proposed by FERC bears a strong resemblance to the sliding-scale rate of return employed in the 1800's in England and later applied sporadically to gas and electric utilities in the United States in the early 1900's. Under this method, the rate of return permitted on the utility's entire rate base varied inversely and in fixed proportion with prices charged to consumers for utility services. The motivation for instituting sliding-scale regulation was that the profit motive of the utility's management could be linked with the public interest for lower utility prices. The underlying assumption, however, was that the utility's management was wholly responsible for any price changes (Bussing).

Three major problems, however, surrounded the use of the sliding-scale mechanisms beyond the individual circumstances of their particular application. First, these mechanisms were inflexible in the face of changing economic conditions. Utilities, for example, unfairly absorbed lower rates earned on investment when inflation triggered higher prices. Second, a national standard of utility performance did not exist forcing the individual regulatory agencies to subjectively determine the elements of the sliding-scale formula for their locality. In this context, it was possi-

ble for a poorly managed utility to improve moderately and qualify for a higher rate of return than an efficiently managed utility with no further margin for improvement. Finally, an exclusive relationship between efficiency in a utility's management and prices charged to consumers did not exist. Many other factors contributed to changing prices, the most important of which was technological advancements (Trebling).

The incentive rate of return should mitigate these problems since the preconstruction estimate of a project's costs serves as a clear standard by which to evaluate a utility's performance. The short term nature of a project's construction should limit the need to adjust the mechanism for unforeseen shifts in the economy.

The incentive rate of return schedule developed by FERC consists of three essential parameters; the expected level of cost overruns (EOR), center rate of return ( $r_c$ ) and the marginal rate of return ( $r_m$ ). The EOR constitutes the pivotal point of the schedule. It represents the level of cost overruns that would have likely occurred in the absence of incentive regulation. The utility is penalized for overruns incurred above the EOR and rewarded if overruns are below this level. The  $r_c$  is the return to be earned at the EOR level and, as such, represents the "normal" return the utility would have earned in the absence of incentive regulation. It is intended to compensate investors for risks faced during the construction and operation of the project. Finally, to translate the EOR and  $r_c$  into a schedule covering all possible levels of cost overruns, the  $r_m$  is specified as the rate allowed on incremental investment above or below the EOR. In theory, it is the fundamental component of the schedule because it determines the "incentiveness" of the schedule. A low marginal rate implies a steep schedule, so that the lower the  $r_m$ , the stronger the incentive to avoid construction cost overruns. Figure 1 illustrates this phenomenon, assuming a center rate of fifteen percent and an expected overrun level of twenty percent. The  $r_m$  must be set below the utility's cost of equity capital for the incentive schedule to penalize overruns.

### Model Description

The model used in this study is adapted from a computer simulation model developed by Tyner and Kalter. This discounted cash flow

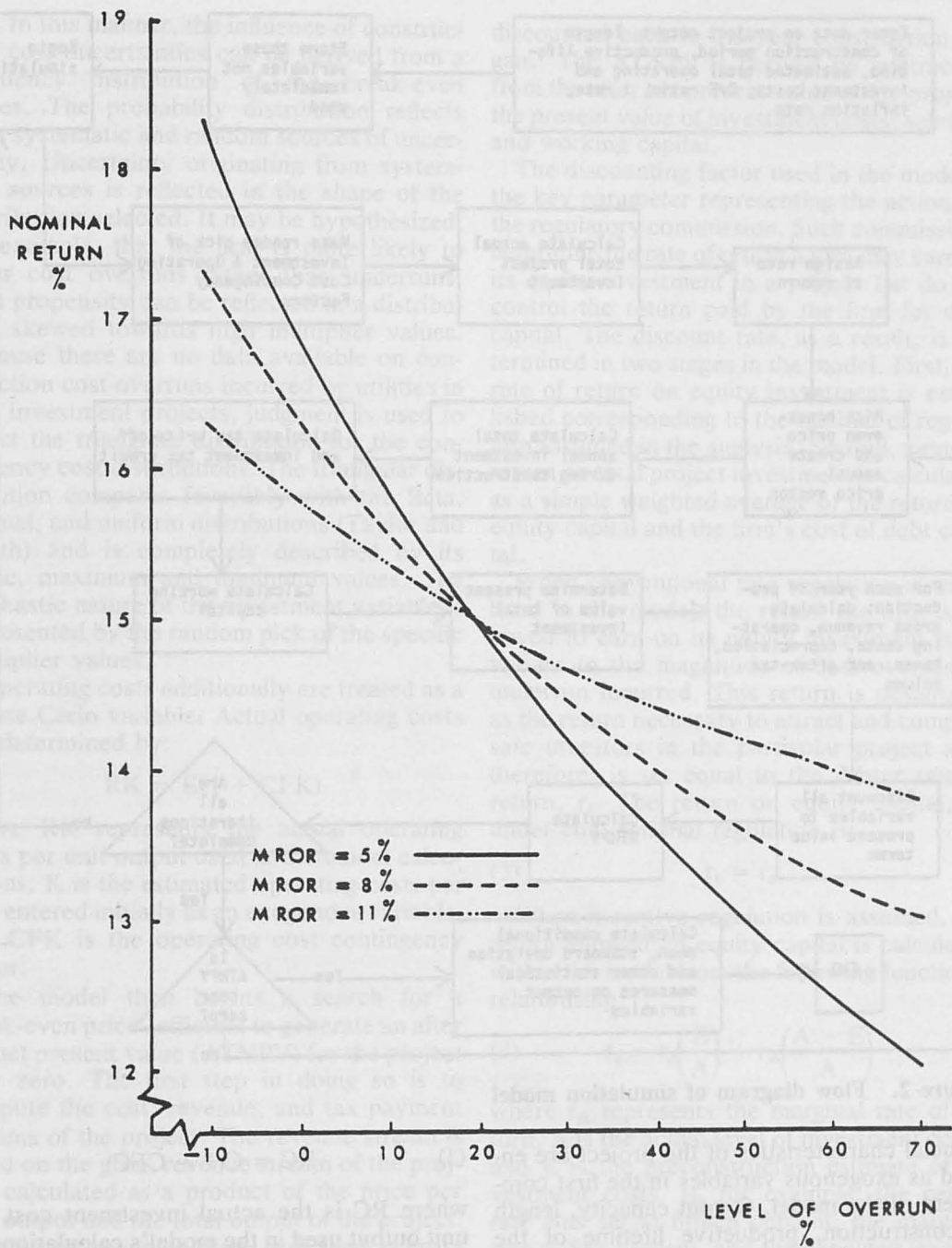


Figure 1. Hypothetical IROR schedules<sup>a</sup>

<sup>a</sup> The schedule is based upon a center rate of return of fifteen percent and an expected level of overrun of twenty percent.

model determines the price per unit output necessary to drive the after tax present value of the project to zero. This price, therefore, is the minimum product price needed by the firm

to earn a given rate of return from the project at a specified level of production.

Figure 2 illustrates the conceptual features of the model. The physical, economic and



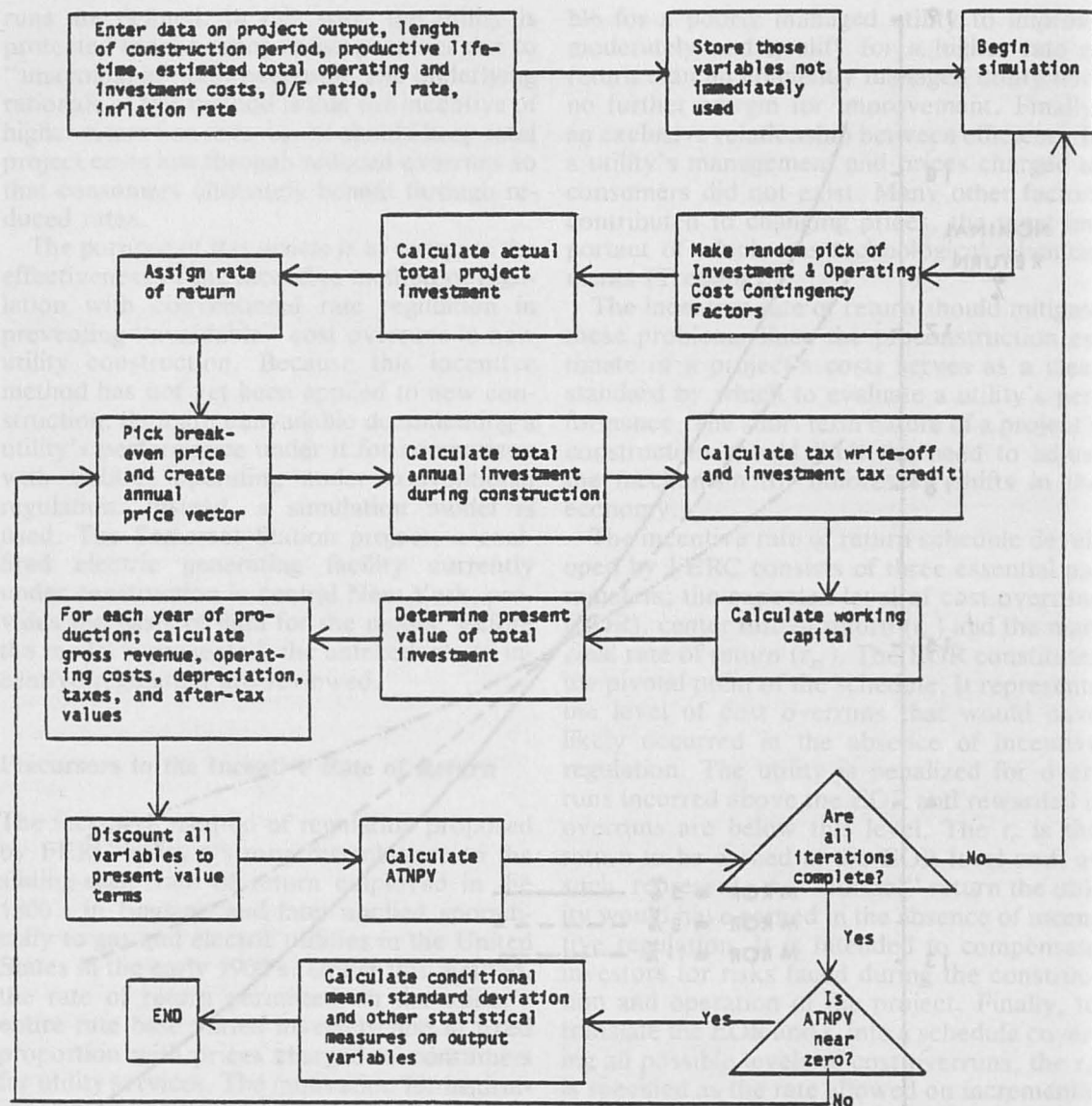


Figure 2. Flow diagram of simulation model

financial characteristics of the project are entered as exogenous variables in the first component of the model. Output capacity, length of construction, productive lifetime of the project, anticipated investment and operating costs, land acquisition costs, debt structure of the utility, inflation rate, and the firm's cost of debt capital are all variables in this category.

The next component of the model simulates the uncertainty surrounding the preconstruction estimate of the project's ultimate investment cost. The preconstruction estimate is treated as a Monte Carlo variable. A multiplier or cost contingency factor is used to modify the estimate as follows:

$$(1) \quad RC = C(1 + CFC)$$

where RC is the actual investment cost per unit output used in the model's calculations, C is the initial construction estimate per unit entered previously as an exogenous variable, and CFC is the investment cost contingency factor.

Selection of the cost contingency factor proceeds as follows: A probability distribution is used to approximate the probable tendencies of the firm to incur cost overruns or underruns. Each model iteration selects a sample from the probability distribution to be employed as a cost contingency factor in that

run. In this manner, the influence of construction cost uncertainties can be derived from a frequency distribution of the break-even prices. The probability distribution reflects both systematic and random sources of uncertainty. Uncertainty originating from systematic sources is reflected in the shape of the distribution selected. It may be hypothesized, for example, that the firm is more likely to incur cost overruns rather than underruns. This propensity can be reflected in a distribution skewed towards high multiplier values. Because there are no data available on construction cost overruns incurred by utilities in new investment projects, judgment is used to select the triangular distribution for the contingency cost distributions. The triangular distribution compares favorably with the Beta, normal, and uniform distributions (Taylor and North) and is completely described by its mode, maximum and minimum values. The stochastic nature of the investment variable is represented by the random pick of the specific multiplier values.

Operating costs additionally are treated as a Monte Carlo variable. Actual operating costs are determined by:

(2) 
$$RK = K(1 + CFK)$$

where RK represents the actual operating costs per unit output used in the model calculations, K is the estimated operating costs per unit entered initially as an exogenous variable, and CFK is the operating cost contingency factor.

The model then begins a search for a break-even price sufficient to generate an after tax net present value (ATNPV) for the project near zero. The first step in doing so is to compute the cost, revenue, and tax payment streams of the project. The revenue stream is based on the gross revenue stream of the project, calculated as a product of the price per unit output and the total output of the project. Taxable net revenue, then, is defined as gross revenue less operating costs and depreciation. The tax stream, in turn, is calculated as a percentage of net revenue. The investment tax credit, calculated as a proportion of total investment, is subtracted from the total federal tax amount at the appropriate time in the production time horizon. After tax value of the project, then, becomes net revenue less the total federal and state tax amounts. To place this value in present value terms, the after tax value for each year of the project's lifetime is

discounted back to the year construction began.<sup>1</sup> The ATNPV is derived by subtracting from the after tax present value of the project, the present value of investment costs, salvage, and working capital.

The discounting factor used in the model is the key parameter representing the actions of the regulatory commission. Such commissions determine the rate of return a firm may earn on its equity investment in a project but do not control the return paid by the firm for debt capital. The discount rate, as a result, is determined in two stages in the model. First, the rate of return on equity investment is established corresponding to the method of regulation assumed in the analysis. Second, a rate of return on total project investment is calculated as a simple weighted average of the return on equity capital and the firm's cost of debt capital.

When conventional rate regulation is simulated in the model, the return the firm is allowed to earn on its equity investment is invariant to the magnitude of cost overrun or underrun incurred. This return is designated as the return necessary to attract and compensate investors in the particular project and, therefore, is set equal to the center rate of return,  $r_c$ . The return on equity capital,  $r_e$ , under conventional regulation is:

(3) 
$$r_e = r_c$$

When incentive regulation is assumed, the return allowed on equity capital is calculated within the model from the following functional relationship:

(4) 
$$r_e = r_c \left( \frac{E}{A} \right) + r_m \left( \frac{A - E}{A} \right)$$

where  $r_m$  represents the marginal rate of return, A is the actual level of investment costs, and E is the preconstruction estimate of investment costs. If, for example, the center rate was set at fifteen percent, the marginal rate at five percent, and the expected level of overruns at twenty percent, an actual overrun of zero would result in a return on equity of seventeen percent while a cost overrun of fifty percent would result in a return on equity of thirteen percent.

Once the return permitted by the regulatory commission on the firm's equity investment is

<sup>1</sup> Cost and revenue streams are continuously discounted while tax payments are discounted in discrete time units.

determined, the deflated rate of return earned on total investment is calculated as follows:

$$(5) \quad R = \frac{1 + (EQK)(r_e) + (DBK)(r_d)}{(1 - FT - ST - (FT)(ST))} - 1$$

1 + INFL

where EQK is the proportion of project investment provided by equity capital, DBK is the proportion of debt capital,  $r_d$  is the nominal interest rate paid on debt capital, FT and ST are the federal and state tax rates, and INFL is the inflation rate. A more detailed description of the model is provided in Meyer.

### Assumptions for Model Application

The Somerset Station electric generation facility is currently under construction in central New York by the New York State Electric and Gas Corporation. The Somerset project will be fueled primarily by coal, providing electricity by steam generation. Its generation capacity of 625 megawatts (mW) or 5,475,000 annual megawatt hours (mWh) is approximately equal to the average unit size of new steam-electric facilities in the United States (U.S. Dept. of Energy, 1980).

The data from the Somerset project are used as guidelines of reasonable cost estimates for new utility construction in order to contrast the effects of conventional versus incentive rate regulation. The data, as a result, are intended to represent the general conditions of utility construction, such as the relative capital to operating costs, and not to exactly duplicate the Somerset facility.

"Reference case" assumptions for the Somerset project are presented in Table 1. All cost estimates are in 1980-base terms. Nominal rates of return are entered into the model since regulatory commissions prescribe rates in such terms.<sup>2</sup>

Several of the reference case parameter values deserve elaboration. First, the values describing the investment cost contingency distribution reflect the considerable variation possible in the level of construction cost overrun. Because historical data on cost overruns incurred in building electric generation facilities are unavailable, these values are determined subjectively. The minimum expected

**Table 1. Reference Assumptions**

Item	Value
<i>Cost Related Inputs</i>	
Investment Cost/MWh	\$156.16
Operating Cost/MWh	\$ 31.20
Operating Cost Real Rate of Change	1%
Working Capital Factor	14%
Investment cost contingency distribution	
Minimum	0%
Maximum	50%
Mode	30%
Operating cost contingency distribution	
Minimum	-10%
Maximum	10%
Mode	0%
<i>Capacity and Planning Horizon</i>	
Installed Capacity	5,475,000 mWh/year
Length of Plant Construction	4 years
Length of Plant Operation	30 years
<i>Economic and Tax Values</i>	
Depreciation Method	Accelerated Cost Recovery System
Lifetime	15 years
Federal Tax Credits	
Investment Tax Credit	10%
Energy Tax Credit	10%
Tax Rates	
Federal	46%
State	4%
Loan Interest Rate (nominal cost of debt capital)	14%
Debt-Equity Ratio	48/52
Rate of Inflation	10%
<i>Rate of Return Variables</i>	
Return on Equity Capital (nominal)	15%
Center Rate of Return (nominal)	15%
Marginal Rate of Return (nominal)	11%
Expected Overruns	30%

Source: Data provided by Mr. H. G. Maste, Generation Planning Section, New York State Electric and Gas Corporation. All cost estimates are in 1980-base dollars.

value for overruns is set at zero since most factors which cause the preconstruction estimate to diverge from the actual investment costs tend to promote cost overruns rather than underruns. The highest level of anticipated cost overruns is estimated to be fifty percent. Although there is evidence indicating that overruns for utility construction can be substantially higher (Mead et al., pp. 88-89), the Somerset project is based on standard technology which should serve to mitigate excessively high overruns. The expected level of

<sup>2</sup> Real after tax rates, however, are used in the simulation model to discount revenue and tax streams. All rates entered into the model, as a result, are deflated internally and adjusted to an after tax value prior to their use as discount factors.



overruns is estimated to be thirty percent. Between the time of the project's approval by the regulatory commission and its completion, it is not uncommon for the utility to petition for adjustments to the project's anticipated costs.

The operating cost contingency distribution for the reference case is defined over a narrower range of plus and minus ten percent. Although market uncertainties such as unexpected inflation also give rise to random variation in operating costs, these uncertainties are short term in nature.

The rate of return variables are defined to simulate the financial environment of the project. To estimate the firm's cost of debt capital, the current average price of new capital for the public utility industry as reported by Moody's Investors Service is used. The fourteen percent figure represents the composite nominal average yield on newly issued bonds by public utilities. The return on equity capital, which serves as the flat rate earned when conventional regulation is simulated and the center rate of the incentive schedule when incentive regulation is simulated, is determined by calculating the historic difference between the return on equity capital for private utilities and the yield on riskless long term government bonds. This difference represents the compensation necessary for the average market risk inherent in the utility industry. It is hypothesized that while the underlying riskless rate may change over time, the risk premium required by investors remains constant. The risk premium over the last twenty-five years as reported by Moody's and Standard and Poor is approximately four and a half percent. When added to a yield on long term government bonds of 11.3 percent, this translates into a nominal rate of fifteen percent. Finally, the marginal rate of return in the reference case is set at an eleven percent nominal rate. In principle, this rate could be set lower but should not exceed the firm's nominal cost of equity capital. Since the reference case assumptions for the rate of return variables, cost contingency distribution values, and the project financing ratio are set with a high degree of subjectivity, they are later relaxed and subject to a sensitivity analysis.

### Model Results and Conclusions

The results of the empirical analysis presented in Table 2 point to three general con-

clusions. First, the method of regulation imposed does not significantly alter the firm's pattern of investment under the reference case assumptions. The break-even prices of \$43.44 and \$43.36 per annual megawatt hour derived for conventional and incentive regulation, respectively, differ by less than one percent. This finding suggests that neither form of regulation is superior on purely economic grounds because both methods result in approximately the same required investment in the project.

The second general conclusion is that when the reference case assumptions are relaxed and the propensity of the firm to incur overruns or underruns is explored, the method of regulation imposed makes a marked difference in the break-even price. When the parameters of the investment cost contingency distribution are changed to -20%, 10%, and -10% to serve as the minimum, maximum, and mode of the distribution, they represent a propensity by the firm to incur cost underruns. Under incentive regulation, the break-even price of \$48.63 is significantly higher than it is under both conventional regulation and the reference case assumptions since the utility is rewarded for superior cost containment with a higher return on its equity capital. When the contingency distribution parameters are changed to 20%, 80%, and 50% for the minimum, maximum, and mode to represent the other extreme of excessive cost overruns, the break-even price of \$41.60 is eight percent lower than its counterpart of \$45.00 derived under conventional regulation. These results indicate that incentive regulation provides direct economic incentives to the firm to limit unnecessary investment expenditures when possible.

When non-policy assumptions are relaxed in the sensitivity analysis, however, the break-even price moves in the same direction and in nearly equivalent magnitudes regardless of which regulation method is simulated. The sensitivity of the model's results with respect to the loan interest rate paid on debt capital, the parameters of the operating cost contingency distribution and the debt/equity ratio are parallel under both types of rate regulation.

The third conclusion drawn from the empirical results is that under incentive regulation, the key parameters in the rate of return schedule that most affect the project's cost are the expected level of cost overruns and the center rate of return. Contrary to expectations, the



**Table 2. Results of Sensitivity Analysis**

Assumptions	Break-even Price (\$/annual mWh)	
	Conventional Regulation	Incentive Regulation
<i>Reference Case</i>	43.44	43.36
<i>Sensitivity Analysis</i>		
Center Rate of Return <sup>a</sup>		
11%	40.31	40.43
13%	41.56	41.89
17%	44.69	45.12
19%	46.56	47.46
Marginal Rate of Return		
7%		43.65
9%		43.65
13%		43.66
15%		44.07
Expected Level of Overrun		
0%		39.40
20%		41.89
40%		45.12
60%		49.22
Investment Cost Contingency Distribution (minimum, maximum, mode)		
-20, 10, -10	41.25	48.63
-5, 10, 0	41.88	47.75
10, 70, 40	44.38	42.19
20, 80, 50	45.00	41.60
Operating Cost Contingency Distribution (minimum, maximum, mode)		
-20, 10, -5	40.63	40.43
0, 20, 10	47.19	47.17
5, 40, 20	49.69	49.80
10, 70, 40	52.81	53.03
Loan Interest Rate on Debt Capital		
10%	41.88	41.89
12%	42.50	42.77
16%	44.06	44.24
18%	45.00	45.12
Debt/Equity Ratio		
80/20	40.08	39.99
60/40	41.88	42.19
40/60	44.38	44.24
20/80	47.50	46.29

<sup>a</sup> The center rate of return represents the cost of equity capital when conventional regulation is simulated.

marginal rate of return has an inconsequential effect on the break-even price. This result may be due to the fact that the marginal rate of return is not the sole return earned on incremental investment beyond the expected level of cost overruns. The investment tax credit and energy tax credit are granted on the total investment cost of the project and not simply on the preconstruction estimate. By far the most crucial parameters in the schedule are the expected level of cost overruns and the center rate of return. The range in the break-even prices caused by varying the expected level of cost overrun is about twenty percent

and is approximately fifteen percent for the range of center rates of return considered.

In summary, it is clear from this analysis that incentive regulation does not result in a lower project cost per unit of output than conventional rate regulation under all circumstances. A distinction must be made regarding the source of uncertainty surrounding the project. If the uncertainty about the project's economic and financial conditions arises from sources outside of the control of the policymaker, then there is no clear advantage of one regulatory method over the other. These sources include the cost of debt capital,

operating costs, and the rate of inflation. Uncertainty with respect to the project's costs arising from cost overruns, however, results in a difference between the method of regulation preferred. If the firm is likely to incur excessive cost overruns, incentive regulation results in a lower cost per unit output than conventional regulation. If cost underruns are likely, the reverse is true. Finally, if incentive regulation is the chosen method of monitoring a project's construction, the critical parameters to be determined in the incentive schedule are the expected level of cost overruns and the center rate of return; not the marginal rate of return. As noted earlier, systematic documentation of the construction cost performance of public utilities with which to guide determination of the expected level of overrun parameter is unavailable. More intensive data collection in this area is recommended.

References

Bussing, Irwin. *Public Utility Regulation and the So-*

*Called Sliding Scale*. New York: Columbia University Press, 1936.

Mead, Walter J.; George W. Rogers, and Rufus Z. Smith. *Transporting Natural Gas from the Arctic*. Washington, D.C.: American Enterprise Institute, 1977.

Meyer, Joan K. "Incentive Regulation of Public Utility Construction: A Policy Simulation." M.S. thesis, Cornell University, 1982.

Taylor, Bernard W. and Ronald M. North. "The Management of Economic Uncertainty in Public Water Resource Development." *American Journal of Agricultural Economics* 58(1976):636-43.

Trebling, Harry M. "Toward an Incentive System of Regulation." *Public Utilities Fortnightly* LXXI (1963):22-28.

Tyner, Wallace E. and Robert J. Kalter. *A Simulation Model for Resource Policy Evaluation*, Ag. Econ. Staff Paper No. 77-28. Ithaca, N.Y.: Cornell University, 1977.

U.S. Department of Energy. Energy Information Administration. *Steam-Electric Plant Construction Cost and Annual Production Expenses—1978*. Washington, D.C.: Government Printing Office, 1980.

U.S. Department of Energy. Federal Energy Regulatory Commission. *Incentive Regulation in the Electric Utility Industry*, by Resource Consulting Group, Inc. RCG No. RA83-0143, July 1983.