STATE OF ILLINOIS
ILLINOIS COMMERCE COMMISSION

COMMONWEALTH EDISON, Proposed General Increase In Electric Rates	ICC DOCKET NO. 82-0026

AG EXHIBIT 28

TESTIMONY OF PAUL L. CHERNICK
ON BEHALF OF THE PEOPLE OF THE STATE OF ILLINOIS

October 23, 1982

I. IDENTIFICATION AND QUALIFICATIONS

Q. Mr. Chernick, would you state your name, occupation and business address?

A. My name is Paul L. Chernick. I am employed as a research associate by Analysis and Inference, Inc., 10 Post Office Square, Suite 970, Boston, Massachusetts.

Q. Mr. Chernick, would you please briefly summarize your professional education and experience?

A. I received a S.B. degree from the Massachusetts Institute of Technology in June, 1974 from the Civil Engineering Department, and a S.M. degree from Massachusetts Institute of Technology in February, 1978 in Technology and Policy. I have been elected to membership in the civil engineering honorary society Chi Epsilon, and the engineering honorary society Tau Beta Pi, and to associate membership in the research honorary society Sigma Xi.

During my graduate education, I was the teaching assistant for courses in systems analysis. These courses covered several topics in modelling, optimization, and evaluation, including present value analysis, cost-benefit analysis, and decision-making under uncertainty, all relevant to the present case. My responsibilities in the course included teaching sections, writing portions of the course text/notes, and presenting some lectures. My Master's thesis was on optimal time-of-use and joint-product pricing.

After receiving my Master's degree, I was a Utility Analyst for the Massachusetts Attorney General for over three years, and was involved in numerous aspects of utility rate design, costing, load forecasting, and evaluation of power supply options. My work included cost projections and cost-benefit analyses for nuclear power plants, estimates of the costs and potential of electricity conservation, the design of conservation programs, and the review of load forecasts. While employed by the Massachusetts Attorney General, I also served as a consultant to the National Consumer Law Center for two projects: teaching part of a short course in rate design and time-of-use rates, and assisting in preparation of an electric time-of-use rates, and assisting in preparation for an electric time-of-use rate design case.

At Analysis and Inference, Inc., I have also been involved in a range of utility-related projects. The subject matter of my work has included nuclear decommissioning frequency and cost, cost allocations, rate design, plant performance standards, utility conservation programs, nuclear power costs, rates and conditions for small power producers, and marginal cost estimation. I have also performed research and analysis on profit provisions for insurance coverages, a topic involving risk and return issues closely related to utility return on equity. My resume is attached to this testimony as Appendix A.

Q. Has any of your work been published?

A. Three of my work-products have been published. My Master's thesis was published by the MIT Technology and Policy Program as Optimal Pricing for Peak Loads and Joint Production: Theory and Applications to Diverse Conditions. With Mr. Meyer, I wrote a paper "An Improved Methodology for Making Capacity/Energy Allocations for Generation and Transmission Plant," which won an Institute Award at the 1981 Institute for Public Utilities, and which is currently in press by Michigan State University. Finally, the Nuclear Regulatory Commission has published a report by Analysis and Inference, which I co-authored with Mr. Meyer and others, entitled Design, Costs and Acceptability of an Electric Utility Self-Insurance Pool for Assuring the Adequacy of Funds for Nuclear Power Plant Decommissioning Expense. My work on the NRC study included estimating decommissioning costs, accident probabilities, and nuclear plant service life.

Q. Have you previously presented expert testimony in utility proceeding?

A. Yes. I have testified approximately twenty times on utility issues before such agencies as the Massachusetts Department of Public Utilities, the Massachusetts Energy Facilities Siting Council, the Texas Public

Utilities Commission, the D.C. Public Service Commission, and the Atomic Safety and Licensing Board of the U.S. Nuclear Regulatory Commission. A detailed list of my previous testimony is contained in my resume. Subjects I have testified on include cost allocation, rate design, long range energy and demand forecasts, costs of nuclear power, conservation costs and potential effectiveness, generation system reliability, fuel efficiency standards, and ratemaking for utility conservation programs. I have filed testimony on nuclear power plant costs and cost-benefit analyses in five previous cases. In NRC 50-470, I predicted that the Pilgrim 2 nuclear units would cost \$3.40 to \$4.93 billion, compared to the official estimate of \$1.895 billion, and the NRC staff estimate of less than \$1.8 billion. When the unit was cancelled two years later, Boston Edison's official estimate for the units had reached \$4 billion. In MDPU 20055 and 20248, I critized as over optimistic several of the projected cost parameters for the Seabrook plant: in-service date, capital cost, capacity factor, O & M expense, and capital additions. Since that time, the projections of the lead participant (Public Service of New Hampshire) have moved toward my estimates for each parameter. In the case of capital additions, the participants apparently did not even recognize the existence of the cost until I pointed it it out to them. I have recently up dated and expanded my Seabrook cost testimony in NHPUC 80-312.

Also, in MDPU 20248, I estimated the probability of major accident-initiated outages (those covered the NEIL replacement power insurance) as being on the order of 1/100 per reactor-year. This estimate was refined Chernick, et al., (1981), and substantially confirmed by an engineering and analysis by ORNL for the NRC (Minarick and Kukielka, 1982), which estimated a frequency of 1/222 to 1/588 per reactor year for the smaller set of accidents which result in severe core damage.

II. INTRODUCTION

Q. What is the basis of your familarity with this proceeding?

A. I have been involved in the current case since April, providing advice and assistance to the Attorney General. In particular, under Professor Bupp's general supervision, I performed much of the research and analysis which supported Section III of his testimony. Thus, I am familiar with large portions of the direct case of Commonwealth Edison (CWE) and of the Attorney General, and with CWE's discovery responses. In addition, I have reviewed CWE's rebuttal testimony, especially that of Mr. Kraatz (Edison Ex. 14R, 14R.2), Mr. Rifakes (Ex. 10R3, 10R4), and Mr. Lee (Ex. 12R).

Q. What is the subject of your testimony?

A. I have been asked by the Attorney General to review the rebuttal testimony of CWE witnesses in this proceeding, especially that of Mr. Kraatz and Mr. Rifakes, to determine:

1. whether the net present value of the "revenue requirements" developed in CWE's rebuttal case is the proper evaluation technique for the ICC to use in determining Braidwood's future;

2. whether CWE's "revenue requirements" analyses presented by Mr. Kraatz and Mr. Rifakes in their rebuttal testimony incorporate assumptions which may be taken "to be unbiased or to favor cancellation," as asserted by Mr. Rifakes (Edison Ex. 10R4, p. 15);

3. whether CWE's rebuttal analyses properly reflect the risks and uncertainties of proceeding with Braidwood construction and operation; and

4. whether various pieces of the CWE rebuttal testimony are mutually consistent.

These four topics are addressed in the following four sections. There is some spill-over between the sections due to the close relationship between the choice of evaluation technique, the choice of unbiased or conservative inputs, the recognition of risk, and analytical consistency.

III. DISCOUNTED "REVENUE REQUIREMENTS" AS A DECISION MAKING TECHNIQUE

Q. Do the analyses presented by the CWE witnesses, such as Edison Exhibits 10R4.3-10R4.12, and 14R.5-14R.15, provide appropriate information for the ICC to determine whether the benefits of continued construction at Braidwood outweigh the costs and risks?

A. No. In addition to the problems with the parameter values used in the analyses, and with the general treatment of risk in those parameters, there are three basic problems with the structure of the rebuttal analyses presented by Mr. Rifakes and Mr. Kraatz. First, it is not clear exactly what "revenue requirements" (or RR) are supposed to be, and hence what costs should be included, and why the ICC should care about "revenue requirements". Second, while the vagueness in the definition of RR makes it impossible to determine exactly what discount rate is appropriate for calculating the net present value (a procedure described by Mr. Kraatz, Edison Ex. 14R, p. 5) it appears that the discount rate used by CWE is too low for any reasonable application, and therefore that the value of remote benefits is overstated. Third, even if RR were defined in a meaningful way, and even if the discount rate were properly selected, the net present value is not the only characteristic the ICC should be concerned with in this case.

Q. Why is the significance of the "revenue requirements" figures used in CWE's analysis unclear?

A. CWE is intentionally vague about the significance of the term "revenue requirements" (RR) as used in the analyses. Mr. Rifakes makes clear that RR is not the same as cash costs to customers, or the rate level (Edison Ex. 10R5, Q. 18).[1/] Nor does RR represent cash costs to CWE, since it includes previously sunk costs (e.g., Braidwood writeoff) and depreciation. This lack of clarity makes it difficult to determine exactly which costs should be included in the analysis; indeed, it is difficult to determine exactly what costs <u>are</u> included. This general problem will reappear below, in connection with some of the specific problems it causes, so only two really fundamental difficulties will be discussed here. First, since present value (or

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[1/] Of course, calling this figure a "revenue requirement" implies that these costs will be reflected in revenues, which come only from ratepayers. But Mr. Rifake's insistence that sunk costs cannot be left out would not make sense if RR is a ratemaking estimate (Ex. 10R4, p. 11).

cost-benefit) analysis is an economic, cash concept, it does not appear that RR can be meaningfully discounted to produce any meaningful figure (Brealey and Myers, 1981, p. 83). Second, CWE never provides any reason to believe that this "revenue requirements" construct is the proper number for the ICC to examine in determining the best course for CWE. If RR corresponds to some point or CWE's income statement, if certainly has not been shown to be the most meaningful point. If, as seems more likely, RR is a partly cash, partly book, partly pre-tax, partly post-tax concept, it is even less clear why the ICC should care about increases or decreases in RR.

Q. Why is CWE's discount rate inappropriate?

A. As I noted before, present value is a cash concept. While the RR values used in CWE's rebuttal are not intended to represent anyone's cash flow exactly, they more closely approximate rates, and hence the customers' cash flow, than CWE's own cash flow. If the evaluation is to be basically from the ratepayer's point of view, the appropriate discount rate is that of ratepayers as a whole. This composite ratepayer discount rate should be the weighted average of the estimated discount rates which the various classes apply to discretionary energy-cost reducing investments (e.g., Braidwood). For example, Hausman (1979) estimated that consumer investments in efficient appliances are made at effective average discount rates of 15%-25% in real terms (that is, above the rate of inflation in electric price). His results indicated that discount rates are higher for low income households, as would be expected. Customers with the lowest income appeared to have electricity-price-reducing real discount rates in the 40%-90% range. Thus, investments which have a positive net present value for high-income customers can be very poor investments for low-income customers. Similarly, while a financially healthy industrial customer may demand an expected payback of 2-4 years on discretionary investments (equivalent to a discount rate around 25%-40%), a cash-strapped company may require much faster paybacks. Thus, cash flow projections from the customer's perspective (i.e., ratemaking projections) should be evaluated at a range of nominal interest rates starting above 20% and probably going up to 40%-50%.

Yet CWE bases its discount rate calculation solely on its own cost of capital, without examining any evidence at all pertinent to its customers' discount rates. (Edison Ex. 14R.3 gives costs of capital used in the base case and the discount rate can be determined from the RR tables; the workpapers provide a more complete derivation of the low-inflation discount rate.) So aside from any questions of whether the rate was calculated correctly, it is clear that CWE has not attempted to derive a discount rate which is even moderately consistent with the shaky "revenue requirement" concept.

Q. You have explained that CWE's analyses do not really represent net present value (NPV) to the company, the stockholders, or customers. If the revenue requirements analyses were restated on a consistent basis, would NPV be an appropriate decision-making tool for the present situation?

A. It would certainly be helpful, but NPV does not capture all aspects of the decision, for two reasons. First, it may be very difficult to quantify the exact effects of Braidwood construction on CWE's cost of capital and on the appropriate discount rate for this investment for CWE or for its customers. In particular, it may be difficult to capture all of the risks of such events as accidents, simultaneous safety-related outages at all four Byron and Braidwood units, or prolonged (multi-year) delays in the final stages of construction.

The second problem includes desirability of the subsidies between generations. This is a frequent argument against placing CWIP in rate base: current customers would pay a disproportionate share of a plant which would primarily benefit customers decades later.[1/] The ICC Staff's proposals in this case regarding the CWIP treatment for LaSalle attempt to correct this problem, essentially by refunding the payments for CWIP to current ratepayers on an expected basis.

Under some sets of assumptions, Braidwood completion would have rate effects much like CWIP. For the first decade of its life, Braidwood would substantially increase the cost of electricity. It may then result in slightly lower rates for another decade, but not enough to balance the huge early losses. Finally, sometime well into the next century (if all goes well), Braidwood may finally allow sufficient delays in new construction so that the NPV to ratepayers goes positive. However, the ratepayers who paid for Braidwood around 1990 when it enters service will really not be the same ratepayers who benefit from it in 2010. Thus, a project with a positive NPV may still pose a difficult decision for the ICC: how much should today's ratepayers spend to produce expected benefits for the ratepayers of the next century?

[1/] Due to depreciation and inflation, plants are usually most advantageous late in their lives.

This quandary would not arise if CWE recovered the costs of building and running Braidwood from its cost savings, as if Braidwood were a small power producer.[1/] Present stockholders benefit from future revenue streams, which raise earnings expectations and hence stock prices. Hence, if Braidwood will eventually be beneficial, and if investors believe that it will be, there would be no transfers of wealth between generations due to the completion of Braidwood. However, normal rate-making procedures would place most of the costs of Braidwood on present customers, who may never benefit from whatever savings it may evenueally produce. Thus, the ICC must explicitly weigh the short-term costs against the long-term benefits; present value is of little aid in this situation.[2/]

[1/]Or as if CWE were in a competitive industry.

[2/]The problem with using NPV in this situation would be less serious if CWE were not using such an unrealistically low discount rate; at a 20% discount rate, benefits 20 years in the future are worth only a third of what they would be worth at 13.4%.

IV. SOURCES OF OPTIMISM IN CWE'S ANALYSES

Q. Do you agree with Mr. Rifakes' characterization (Edison Ex. 10R4, p. 15) that the financial analyses presented in this proceeding by CWE have been unbiased or biased in favor of Braidwood cancellation?

A. No. There are several inputs to those studies which strongly favor nuclear construction and particularly the completion of Braidwood. This pro-Braidwood bias is introduced by the choice of very optimistic parameter values for Braidwood, by the treatment of various aspects of capital costs and of the cost of capital, and by the neglect of substantial sources of risk and of uncertainty.

A. Braidwood Parameters

Q. Which Braidwood parameters are optimistic?

A. Briefly stated, CWE assumes

1. a very long useful life for nuclear units;
2. a very low decommissioning cost;
3. no real inflation in nuclear O & M;
4. very low cost overruns on Braidwood;
5. fairly high nuclear capacity factors; and
6. small additions to nuclear unit costs during commercial operation.

Q. Why is CWE's estimate of nuclear unit life optimistic and how does it favor Braidwood construction?

A. CWE assumes a 35-year life for the Braidwood units.[1/] The oldest nuclear units over 400 MWe are not yet 15 years old, and the large units comparable in size to Braidwood are all much younger. The limited experience available from the smaller units indicates that the average unit life is around 20 years, with considerable dispersion (Chernick, et al., 1981). Overestimating the useful life of a unit will result in overstating its fuel savings, underestimating its depreciation rate, and underestimating the present value of decommissioning and replacing it.

The economic retirements discussed above are precipitated by the cost of repairing, upgrading, and maintaining units in the normal course of operation. In addition to these normal retirements, units may also be retired due to accidents, as at TMI 2. Recent estimates of nuclear power plant major accident rates are in the range of 1/200 to 1/800 per reactor-year (Chernick, et al., 1981; Minarick and Kukielka, 1982). At these rates, the probability of at least one of the Braidwood units suffering a

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[1/] This is most evident in the delay cases, such as Ex. 14R.5.

major accident (if they otherwise survive for 35 years without economic retirement) is between 8% and 30%. A major accident at a plant of any age may be so expensive to clean up that it causes financial distress to the utility: at a young unit, the accident can also result in very premature decommissioning. TMI also raises the possibility that an accident at one unit of a twin plant may result in prolonged outage, or even early retirement, of the undamaged sister unit.

It should also be noted that currently estimated accident probabilities would produce accidents every 2 to 8 years, once 100 reactors are on line. These frequent accidents would tend to perpetuate the regulatory ratcheting, which contributes to declining capacity factors, rising real O & M, large capital additions, and early economic retirement.

Q. Why do you believe that CWE's estimate of decommissioning cost is optimistic?

A. CWE's estimate of $95 million per unit (1982 $'s, from Edison Ex. 14R.3) is consistent with general industry estimates. Other nuclear industry norms, such as forecasts, of capacity factors, and of O & M expense, have been seriously overoptimistic, particularly before considerable actual data is available. Chernick, et al., (1981), extrapolates from errors in past nuclear utility estimates to project a decommissioning cost of about $250 million (1981 dollars) for each large PWR.

Q. Why should CWE include real escalation in nuclear O & M?

A. The cost of running nuclear power plants, excluding fuel, has risen considerably faster than inflation. From the in-service date of the last unit at each plant to 1981, Dresden O & M has risen 8.2% annually above CPI inflation, Quad Cities O & M has risen 14.2% in real terms, and Zion O & M has risen at a 13.0% real rate. CWE's assumption that nuclear O & M rises only with inflation (see the O & M column of almost any run) is at variance with the experience of virtually every nuclear plant.

Q. How has CWE been optimistic in its projection of possible cost overruns at Braidwood?

A. CWE projects that Braidwood will cost $1,224/kw. In its sensitivity runs, CWE uses a "high capital cost" of $1,974/kw, with a one year delay (or $1,811/kw in the 1986 dollars of the base case).[1/] This is sometimes described as a "theoretically" high cost (Edison Ex. 10R4, p. 9). This higher value is the 90th percentile of a normal distribution with the mean and standard deviation derived from the current utility cost estimates for a selected set of nuclear plants currently scheduled to be completed over the next five years.[2/] Unfortunately, experience tells us that utilities generally underestimate the cost of nuclear power plants; and underestimate the costs of plants far from completion more than the cost of plants close to completion. Therefore, neither CWE's estimate nor the higher estimate from the utility sample is likely to be correct.

Chernick, et al., (1981) found that nuclear plant costs, adjusted for inflation, are about 14% higher than the utility estimate for each year into the future that the utility is forecasting. Taking the current estimate for Braidwood as serious January, 1982 estimates for an average in-service date 4.25 years later, would imply that the costs

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[1/] The two cost figures are from Edison Ex. 14R.4, and Ex. 14R, p. 22. Mr. Schultz describes the latter as a two-year delay case, which would imply a real 1986 cost of $1,662/kw. (Ex. 1R, p. 2), but Mr. Rifakes describes it as a one-year delay (Ex. 10R4, p. 9).

[2/] It is not clear how the selection was made, see Edison 14 Ex. R, p. 22.

are likely to be $1,224 x $(1.14)^{4.25}$ = $2,136/kw. Accepting Mr. Komanoff's conclusion that the current Braidwood estimate is really a January, 1981 estimate, the likely cost is $1,224 x $(1.14)^{5.25}$ = $2,435/kw. These figures are both for the currently scheduled in-service dates; a one-year delay would increase the book cost to the $2,500/kw - $2,800/kw range.

Since industry cost-estimation experience suggests that the capital cost of Braidwood will be about twice current estimates, it is hardly conservative to label a 28% real increase as a theoretical limit. Considering the nuclear cost-forecasting record of utilities, basing any cost projection on current industry estimates is probably optimistic.[1/]

Q. Why do you describe CWE's projections on nuclear capacity factors as being somewhat high?

A. The regression results for PWRs of Braidwood size in Easterling (1981) indicate that an average mature capacity factor on the order of 51-55% may be expected for such units. Since this analysis was performed at a national nuclear laboratory (Sandia), with the original purpose of supporting applications for NRC construction permits, these results are not likely to be biased against nuclear units.

[1/] Mr. Rifakes' over-confidence may derive from that of Mr. Lee (Ex. 12R, pp. 1-11), which is based on the fact that the plants have been under construction for many years and have large fractions of <u>expected</u> work completed. It may be useful to note that in 1975, Diablo Canyon 1 had been under construction for 7.5 years, was 93% complete and due for operation in 1976. It is still not commercial.

In general, the equivalent availability factor (EAF) for a nuclear unit is somewhat higher than its capacity factor (CF), due to unavoidable or economic reductions of power, such a ramping down to (or up from) refueling outages. The average difference between EAF and CF for PWR's have been about 1.2 percentage points (Koppe and Olson, 1979, Table 6.1), so the typical PWR of Braidwood size would expect a mature EAF of about 52-57%. Thus, CWE's 61% mature EAF projection for Braidwood is probably 4 to 9 points higher than experience would suggest. CWE's capacity factor projections are considerably lower than its EAF projections, due to the difficulty of fitting the tremendous nuclear capacity of the late 1980's under CWE's load curve. If the CF projections are overstated by even 5 points, Braidwood will annually produce about 980 GWH less than CWE predicts. At a 2¢/kwh savings, this reduces benefits by about $20 million annually in 1981 dollars, or (for example) $65 million in 1995 dollars. The present value of this difference over 35 years would be about $350 million if the discount rate is only four percent greater than inflation, as CWE assumes. This correction, would, by itself, erase a sizable fraction of the projected benefits of completing Braidwood in most of CWE's analyses. If CWE's overoptimism is greater than 5 percentage points, the economic impact would be proportionately greater.

Q. Are CWE's projections of capital additions to Braidwood, after the in-service date, also optimistic?

A. Yes. CWE assumes that annual backfitting additions will cost 1% of the <u>original</u> plant cost (Edison Ex. 14R.3). On this basis, additions to Dresden have been 4% annually (1971-81), to Quad Cities 4% (1972-91), and to Zion 2% (1974-81). An R.W. Beck study of eighteen nuclear plants (23 units) through 1977 found an average annual <u>compound</u> increase in plant cost of 2.92%, starting with the <u>second</u> year of operation (or 1968, if that was later). I have previously determined that additions to 15 plants in the 1968-1980 period (a total of 159 unit-years) averaged $10/kw-yr in 1981 dollars, escalating with inflation (Chernick, 1982). Since CWE assumes a low level of additions in early years and does not allow for either inflation or compounding of the additions, the projections are somewhat favorable to Braidwood.

B. Cost of Capital and CWE's Discount Rate

Q. What aspects of CWE's calculation of the cost of capital are biased twoards completing Braidwood?

A. As I noted previously, CWE uses a discount rate based on its own cost of capital, even though the cash flow it is discounting is more like customer cash flow than like CWE cash flow. In addition, CWE's estimates of its cost of capital for Braidwood, as well as CWE's own discount rate (which is totally irrelevant for the RR analysis, but which would be useful if CWE were doing an internal cost-benefit analysis), suffer from two flaws:

1. The cost of capital and discount rate do not reflect the greater risk of Braidwood construction.

2. CWE's manipulation of the discount rate to reflect tax effects seems to be incorrect, depending on what the cash flow represents, and on how taxes are treated in the cash flow.

Q. How should the discount rate used for Braidwood reflect the risks involved?

A. It is the clear conclusion of financial theory that the appropriate discount rate for an investment is determined by the risk of the investment, not by the cost of capital of the company making the investment (Brealey and Myers, 1980, pp. 166, 185).[1/] If CWE were evaluating the benefits (to CWE, not its customers) of buying a smaller utility with a similar mix of capacity, construction obligations, etc., CWE's incremental cost of capital would be a relevant measure of the appropriate discount rate, because the other utility would be about as risky as CWE. But building a nuclear power plant is probably riskier than running one, and running a nuclear power plant is probably riskier than CWE's other operations as a whole (e.g., owning coal plants, transmission and distribuiton equipment).[2/] Hence, if the Braidwood analyses are to be redone from CWE's viewpoint, they should use an appropriate risk-adjusted discount rate, higher than the general incremental cost of capital.

Q. How did CWE manipulate the discount rate to reflect tax effects, and why is this suspect?

A. CWE calculates the discount rate as the sum of the cost of each source of capital (equity, debt, perferred), weighted by its share of the capital structure, except that the cost of the debt portion

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[1/] Imperfect capital markets and the threat of bankruptcy can produce different discount rates for different companies.

[2/] Braidwood construction financial risks are compounded by the substantial risks of delays and cost overruns in LaSalle and Byron construction.

is roughly halved to reflect the fact that interest payments are tax-deductible. This is a curious way of structuring the analysis. It is certainly not the ratepayers perspective; in ratemaking, taxes on the portion of rates which pay for interest exactly balance the tax benefit of the interest (as for any other expense) and the portion of return related to equity is roughly doubled to reflect the taxes which must be paid on the revenues which provide return on equity.[1/] It is also not the stockholder perspective, for whom only the return on common equity is relevant. In fact, CWE's formulation can only make sense if the "carrying charges" column includes imputed taxes on all revenue to cover return, but the tax deductions on the interest payments are only reflected in the discount rate. The "carrying charge" column does not seem to be large enough to include taxes on interest. Thus, CWE's discount rate appears to be significantly lower than even the average (non-risk-adjusted) incremental cost of capital to CWE.

[1/] CWE estimates this "economic cost of capital" at about 21%-22% (Ex. 1F, Schedule 1.25) even on an embedded basis (it would be over 25% incrementally at CWE's forecast rates), as opposed to the discount rate of about 13.1% used in the rebuttal analyses.

C. Sunk Costs

Q. How is CWE's treatment of Braidwood sunk costs biased towards completion?

A. There are three problematic aspects to CWE's treatment of Braidwood's sunk costs. First, CWE assumes that the value of Braidwood goes to zero (actually negative, due to the cancellation costs)[1/] unless Braidwood is built essentially on its current schedule (with up to three years delay). This is an extreme position, and is inconsistent with CWE's optimism on Braidwood capital cost escalation, completion time, O & M escalation, capital additions, capacity factor, and service life, as I will explain below.

Second, CWE assumes that Braidwood is written off over 10 years, starting immediately, and is therefore an immediate short-term expense for ratepayers. If CWE's cost of capital (especially once ratemaking treatment is set) is much less than the customers' discount rate, the customers will be better off if the write-off is delayed.

Third, it is not clear that a quick write-off would actually increase rates over the next few years. The vagueness in the definition of RR tends to obscure

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[1/] See Edison Ex. 14R p. 19.

the treatment of CWIP and CWE's need for cash flow from CWIP, but these issues are not independent of Braidwood's fate. If Braidwood is cancelled and written off quickly, whatever cancellation costs are passed on to ratepayers would offset the need for cash-flow from CWIP. Thus, from the rate payer's perspective, the large incremental near-term costs shown in the cancellation runs may not occur.

IV. RISK AND UNCERTAINTY

Q. How has CWE neglected sources of risk and uncertainty in its analyses of Braidwood economics?

A. None of the cost parameter values discussed previously is anywhere near a worst case,[1] and all contain large risks and uncertainties. The economic life of any particular unit may be much shorter (or longer) than the average life of its class, and the average life of 1100+MW nuclear units may be less than 20 years or more than 35. It will be decades before we have any direct evidence on the cost of decommissioning large nuclear units with long operating lives. Nuclear O & M varies significantly across plants and growth rates vary both between plants and over time. The same is true for backfitting expenses. Nuclear construction costs vary widely between units, as does the extent of utility overconfidence. Capacity factors vary between units due both to plant specific factors and to annual variability; even after removing the first partial year, the first full year, and some later unit-years with low capacity factors, Easterling (1981) estimates a 95% confidence interval of ±20% over years 2-10.

The greatest source of uncertainty in nuclear power costs, however, is the accident probability. Many of the other cost parameters for Braidwood are uncertain by a factor of two or so: construction cost (perhaps $2000-

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[1] Just as importantly, CWE's sensitivity tests vary only one or a couple of values at a time. A strong sensitivity test would shift several parameters to moderately pessimistic levels (certainly, above industry norms) simultaneously.

$4000/kw in 1986 dollars), levelized capital additions (which increase by 2.3 times if CWE's initial capital additions rise with inflation, hardly an extreme assumption), economic unit life (perhaps 15-40 years), levelized O & M (which doubles if real annual escalation is just 5%, as compared to historical escalation around 10%*), and lifetime capacity factors (30%-70%). Decommissioning costs are much more uncertain, but even a billion dollar decommissioning cost would not have as large an impact as doubling the capital cost of the plant (although it would eliminate a large portion of Braidwood's projected benefits). A major accident, on the other hand, could reduce the life of one unit by an order of magnitude, reduce the lifetime capacity factor of the second unit substantially (perhaps even retire it, as well), and create a billion-dollar cleanup liability, in addition to normal decommissioning expenses (whatever those turn out to be).

Q. Other than the nuclear cost parameters you have described above, are there other substantial uncertainties involved in the calculation of Braidwood's benefits?

A. Yes. Among the other uncertainties addressed to some extent in CWE's studies are sales growth, coal prices, and

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* Continued high real escalation will probably cause early retirement; this sets upper limits on the effect of O & M escalation on nuclear power costs.

and interest rates. One significant uncertainty which CWE does not consider is the cost of replacement capacity for Braidwood, sometime in the twenty-first century, (assuming zero load growth). Rather than conventional low-sulfur coal plants, CWE may be installing new technologies by 2006, such as fluidized-bed cogenerators fired with high-sulfur coal. In both capital and fuel costs, CWE's assumption of no technical progress over the next 20 years may be nearly a worst-case (that is, a best-case assumption for completing Braidwood).

Even for those non-Braidwood parameters on which CWE performs some sensitivity tests, the variations are not really extreme. For example, recent sales patterns indicate that zero load growth is not a lower bound. While recovery from the current recession may increase some customers' consumption of electricity, it may also give other customers the ability to finance deferred conservation investments in response to recent and future increases in electric prices. For industrial customers, the response may include relocation to service areas in which electric rates are not driven by quite such severe problems of excess capacity, excessive fuel contracts, large construction obligations, and large nuclear risks.

Q. Does CWE properly model the risks of, and the linkage between future inflation, incremental interest rates, the cost of capital, and discount rates?

A. CWE assumes that a decrease in the general inflation rate will produce a lower incremental cost of capital, and a lower (CWE) discount rate (See Edison Ex. 10R4, p. 8; it is not clear how the lower costs of money are derived). The major leap of faith CWE makes here is in treating all three changes as instantaneous. CWE actually faces a severe problem if (1) interest rates stay high over the next few years, while CWE is issuing long-term bonds and preferred stock to pay for Braidwood, and (2) inflation and interest rates are relatively low after Braidwood goes on line. In this case, even if the cost of new, post- 1987 (or whatever) capital is lower, the debt and preferred portions of Braidwood financing is locked in at the high current rates. Thus, the carrying charges would be determined by 14-16% debt and preferred, while discount rates are determined in part by (perhaps) 6-8% risk-free interest rates, increasing the net present value (and the inflation-adjusted annual value) of Braidwood's carrying charges. Another way of looking at this problem is to note that the preferred and debt payments which CWE (and thus its customers) must make remain constant, while disinflation reduces the value of the fuels and future capacity displaced by Braidwood. While the danger of making large investments in times of transient high interest rates is a problem for all capital-intensive industries, it is particularly troublesome for projects as large as (and with such uncertain benefits as) Braidwood. Certainly, the possibility of falling interest and inflation rates does not favor prompt completion of Braidwood at much higher rates, as Mr. Rifakes seems to imply (Edison Ex. 10R4, p. 7).

V. INCONSISTENCIES IN CWE'S REBUTTAL CASE

Q. Is Mr. Lee's rebuttal testimony (Edison Ex. 12R) consistent with the rebuttal testimony of Mr. Rifakes and Mr. Kraatz?

A. These pieces of testimony seem to be quite inconsistent. Mr. Lee (Ex. 12R, p. 12-13) indicates that he believes the benefits of Braidwood are not sufficient to induce other utilities to buy into the plant. Many of these utilities are starting to build large amounts of coal capacity to be available in the Braidwood time frame; thus, the benefits of Braidwood to these utilities (immediate fuel and capacity savings) should substantially exceed the benefits to CWE (fuel only for a decade or two). If Braidwood cannot compete with new coal plants, it is hard to see how it can be economical in displacing power from CWE's existing coal plants.

Mr. Lee also indicates that he does not think that any utility would buy into Braidwood unless "it had a need for new capacity at the time the Braidwood units are scheduled to come into operation", which he interprets as a 1986 reserve margin at or below "the 15%-20% reserve required" (Ex. 12R, pp. 11-12). Depending on CWE's growth rate, its 1986 reserve margin is 32%-50%, without Braidwood 2, and 25%-44% without either unit. By Mr. Lee's rule, Braidwood is a shaky investment for CWE, at best.

The discussion of high reserve margins, commitments to units which are less than 20% complete (as compared 60-75% for Braidwood), financial condition,[1/] and so on, may conceal a set of legitimate barriers to the sale of Braidwood capacity. There is no reason for other utilities to accept the burdens and risks of building Braidwood, so long as CWE is sure to continue building it. Under current arrangements, short-term or economy purchases from capacity-glutted CWE will almost certainly be a less expensive (and safer) source of power for the early 1990's than would purchase of Braidwood capacity. Only a serious threat of termination or deferral of the project would give other utilities any real incentive to put their cash on the line; even then, they might demand fire-sale prices on CWE's current investment. But CWE presently faces major rate-making risks if it makes such a threat, and perhaps more so if it sells Braidwood at less than book value. The clarification of ratemaking policy suggested by Mr. Meyer may give CWE the bargaining power it needs to force its neighboring utilities to "put up or shut up" on sharing Braidwood's costs and risks along with its benefits, by making the deferral and cancellation options real.

[1/] If poor financial conditions contraindicates Braidwood investment, CWE is again not the utility of choice to build Braidwood.

Q. Are Mr. Rifakes testimony on the infeasibility of replacing Braidwood with later nuclear capacity (Ex. 10R4, pp. 10-11), and Mr. Kraatz' testimony on the negative value of the Braidwood investment if the current plant is cancelled (Ex. 14R, p. 19), consistent with the confidence of both these witnesses (Ex. 10R4, p. 15, and Ex. 14R, pp. 24-25) and of Mr. Lee (Ex. 12 pp. 1-11), that the current Braidwood cost estimates are fairly reliabile?

A. No. Perhaps Mr. Rifakes is correct that CWE's next plant cannot be nuclear, and Mr. Kraatz is correct in stating that the Braidwood investment is lost if the plant is not completed within a few years of the target date. These conditions would presumably be created by nuclear safety regulations and costs continuing to change as rapidly over the next two decades as they have over the last one. In this case, CWE is probably correct in assuming that Braidwood will be built quickly or not at all, and that Braidwood is CWE's last chance at building a nuclear plant until well into the next century. But CWE cannot rationally believe that the sky-rocketing cost and safety problems which would rule out a revived Braidwood, or a new nuclear plant, would not also produce delays, substantial cost overruns, poor capacity factors, high operating and backfitting costs, and short lives for all of the units CWE is building, and especially Braidwood.

On the other hand, CWE may be correct that the economic capacity choice for the turn of the century will still be nuclear, that capital costs will fall, operating costs will stabilize, and capacity factors rise. In that case, it is hard to see why the replacement for the currently planned Braidwood plant (which I will call "Braidwood-late-80's") would not be a better planned, more up-to-date plant utilizing the same major components (that is, a "Braidwood-2000").[1/] The present investment in Braidwood would then be more like "plant held for future use" than like a dead weight loss. Undoubtedly, Braidwood-2000 will differ from Braidwood late-80's; it may be necessary to write off some of the current investment, such as for instrumentation. But if Braidwood's foundations, pressure vessels, and other major components are safely and adequately designed today, and if costs and requirements stabilize, it is hard to see why they will not be adequate for Braidwood-2000. This outcome would be much more favorable to Braidwood-late-80's cancellation

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[1/] Thus, the present investment in Braidwood would be mothballed, a process which I understand Mr. Bridenbaugh will discuss further.

than CWE's assumptions are, since both the large Braidwood write-offs (as projected by Mr. Kraatz) and the barriers to building the optimal generation program (as assumed by Mr. Rifakes) would be eliminated.

CWE cannot have this crucial point both ways. Its witnesses cannot reasonably maintain that the era of light water power reactor construction is essentially over, for the purposes of requiring large write-offs and expensive replacement capacity, and then assume that all the unfavorable trends in nuclear construction and operation will abruptly stop (or reverse) for the limited purpose of justifying continued construction of Braidwood-late-80's.

VI. SUMMARY AND RECOMMENDATIONS

Q. Please summarize your conclusions regarding the value to the ICC of CWE's rebuttal testimony on Braidwood.

A. CWE'S rebuttal testimony is of very little use to the ICC in determining whether to support continued construction of Braidwood. The "revenue requirements" concept is vague, it does not appear to correspond to any outcome in which the ICC is interested, and its contents[1/] are unreviewable in the context of the present case. The discount rate is not based on the discount rates of CWE's customers and is therefore irrelevant if "revenue requirements" are like rates. The discount rate also appears to be far too low to be the discount rate for CWE or CWE stockholders. The values of several Braidwood cost parameters are optimistic, the treatment of sunk costs is slanted towards completion, and most sources of risk and uncertainty are understated or neglected. Thus, the strong confidence of Mr. Rifakes and Mr. Kraatz in the cost-effectiveness of continued construction of Braidwood is not (and cannot be) supported by CWE's rebuttal

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[1/] For example, it is not clear how CWIP is treated, what tax breaks are taken (especially for cancellation costs), and how the carrying cost column is calculated. As illustrated by the problems with nuclear fuel carrying charges, CWE's analysis may contain errors which are difficult or impossible to identify from the output.

analyses, and the record cannot possibly lead the ICC to conclude that Braidwood's benefits outweigh its costs and risks.

Q. What course of action do you recommend for the ICC, with regard to Braidwood?

A. First, I would recommend that the ICC recognize that CWE's defense of Braidwood is very weak and haphazard. If this is the best CWE can do, it indicates that CWE has not been thinking seriously about Braidwood's cost-effectiveness, and that Braidwood's economics are very shaky. I would suggest that the ICC <u>at least</u> warn CWE that future investments in Braidwood are at CWE's risk, and that recovery of such future investments and operation costs is contingent on the cost-effectiveness of the plant. I also believe that the ICC would be justified in concluding that CWE's weak defense is evidence that there is no adequate defense of continued construction of Braidwood, and therefore urge CWE to mothball or cancel the plant. One mechanism for encouraging these actions would be to delete Braidwood's future financing requirements from the Commission's analyses of embedded cost of capital and of CWE's financial position. If CWE wishes to build Braidwood at its own risk and without affecting current rates, perhaps it should be allowed to do so.

Second, regardless of what actions the ICC takes in this case, it is important that some follow-up proceeding take place. If CWE's weak and inconsistent presentation in this case has not convinced the ICC that the continued construction of Braidwood is uneconomical, any remaining doubts can be resolved by performing appropriate cost-benefit analyses. These analyses would take the present value of a meaningful measure (such as rate level), at a relevant discount rate, with reasonable base-case input parameters, and with significant sensitivity tests, and would also examine the degree to which current ratepayers would be subsidizing the ratepayers of the next century.

Whether the ICC stops construction at Braidwood (or urges CWE to do so) on the basis of the record in the present proceeding, or makes the determination in the follow up case, the second case must resolve several other issues.

The ICC will have to determine whether Braidwood is likely to be useful around the turn of the century (in which case the plant should be mothballed) or whether the era of light-water reactor construction is about over (in which case it should be abandoned). It will also be necessary to determine ratemaking treatment for the actions the ICC orders, or offers as options to CWE, such as mothballing, abandonment, mothballing with write-off of some investment, or continued construction at CWE's risk.

BIBLIOGRAPHY

Brealey, R. and Myers, S.
Principles of Corporate Finance, (New York: McGraw Hill), 1981.

Chernick, P., Fairley, W., Meyer, M., and Scharff, L.
Design, Costs and Acceptability of an Electric Utility Self-Insurance Pool for Assuring the Adequacy of Funds for Nuclear Power Plant Decommissioning Expense (NUREG/CR-2370), U.S. Nuclear Regulatory Commission, December, 1981.

Chernick, P.
Testimony before the New Hampshire Public Utilities Commission, Investigation Into the Supply and Demand for Electricity for Public Service Company of New Hampshire, DE81-312, filed October 8, 1982.

Easterling, Robert G.
Statistical Analysis of Power Plant Capacity Factors Through 1979, prepared by Sandia Laboratories for the U.S. NRC (NUREG/CR-1881), April, 1981.

Hausman, J.A.
"Individual Discount Rates and the Purchase and Utilization of Energy-Savings Durables," Bell Journal of Economics, Spring, 1979, pp. 33-54.

Koppe, R.H. and Olson, E.A.J.
Nuclear and Large Fossil Unit Operating Expense, prepared by S.M. Stoller Corp. for EPRI (EPRI Report NP-1191), September, 1979.

Minarick, J.W. and Kukielka, C.A.
Precursors to Potential Severe Core Damage Accidents: 1969-1979, prepared by Oak Ridge National Laboratory for the U.S. NRC (NUREG/CR-2479), June, 1982.