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To: Docket Office, California Energy Commission (CEC)

From: C.K. Woo, E3

Re: Comments on: Discount Rate – Staff Paper

1. Introduction

The Staff Paper discusses the 2007 IEPR's recommendation of using a social discount rate (SDR) of 3% to compute the present value of a combined cycle gas turbine's (CCGT) fuel cost because of the CCGT's fuel cost risk. Using the SDR, instead of a utility's cost of capital, improves renewable energy's cost-effectiveness when compared to the CCGT.

In addition to my 2007 comments referenced in the Staff Paper,[1] this memo demonstrates that the IEPR's recommendation is erroneous for the following reasons:

- When put in the context of a benefit-cost analysis, a renewable contract's net benefit is likely to be more risky than a tolling agreement's net benefit. Based on the IEPR's logic, one should discount the renewable energy contract's net benefit stream at a higher rate than the one used for the tolling agreement's net benefit stream. The resulting present values would make the renewable energy contract less economically attractive than when a single discount rate is used.

[1] Woo, C.K. (2007) Comments submitted for June 4, 2007 Staff Workshop on the Use of Portfolio Analysis in Electric Utility Resource Planning.

- The IEPR's recommendation reflects a misuse of the capital asset pricing model (CAPM), which implies that an asset with more risky returns should have a higher expected rate of return. As the renewable contract can have more risky returns than the tolling agreement, a correct inference of the CAPM is that the renewable energy contact would demand a higher expected return than the tolling agreement.
- A tolling agreement's fuel cost can be effectively cross-hedged using the NYMEX natural gas futures. This questions the validity of the IEPR's recommendation which is based on the tolling agreement's fuel cost risk.
- While a SDR should be used for discounting the net social benefit stream of a contract, the same rate should be used all contract types. Selectively using different discount rates for different contract types is inconsistent with the standard practice of a benefit-cost analysis.

2. Benefit-cost analysis

The recommendation is not based on a benefit-cost analysis, a necessary step to justify project adoption from a private or social perspective. This leads to a misguided view of risk. The analysis below shows that a renewable energy contract's net benefit can be more risky than a tolling agreement's net benefit.[2]

To see this point, consider a 1-MW geothermal energy contract with a take-or-pay provision. We assume that this contract does not have a volumetric variable charge, reflecting that a renewable energy contract can have zero fuel cost. For simplicity, we

[2] Replacing power contract with generation ownership does not alter the analysis below.

further assume that the contract has a constant output level of 1 MWH per hour. Thus, the contract has a fixed take-or-pay $*F*/MWH capacity price (= per MW-year payment ÷ 8670 hours per year).

The question is how should this contract be assessed in a benefit-cost framework? There are two answers, which differ in their empirical computation but not theoretical underpinning:

- Private perspective. The contract's physical benefit is its output, which can be monetized at the spot market price $*P*/MWH. Note that P is also the marginal private benefit of consumption. Thus, the net benefit is profit $\pi = P - F$. Under risk-neutral decision making, the contract should be implemented if $E(\pi) > 0$. As P is random, π is random with variance $v(\pi) = \sigma_P^2$.
- Social perspective. The contract's output is valued at B, the marginal social benefit of consumption. As B contains the uncertain private benefit P, B is random.[3] Hence, the net social benefit $\beta = (B - F)$ is random with variance $v(\beta) = \sigma_B^2$. Under risk neutral decision making, the contract should be implemented if $E(\beta) > 0$.

Now, consider a tolling agreement with heat rate H MMBTU/MWH at a fixed upfront capacity payment of $*T*/MWH. The net benefit of the tolling agreement is as follows:

- Private perspective. The CCGT's per MWH profit is $\theta = (P - X) - T$, where $X = \min(P, HG)$ = per MWH cost when the CCGT is economically dispatched at the spot

[3] B may exceed P. A case in point is that access to affordable electricity improves public health and safety.

natural gas price G against the spot electricity price P. Under risk neutral decision making, the contract should be implemented if $E(\theta) > 0$. The per MWH profit variance is $v(\theta) = (\sigma_P^2 - 2\,\rho_{PX}\,\sigma_P\,\sigma_X + \sigma_X^2) = v(\pi) - (2\,\rho_{PX}\,\sigma_P - \sigma_X)\,\sigma_X$, where ρ_{PX} = correlation between P and X. Empirical evidence indicates $\rho_{PX} > 0.5$ and $\sigma_P > \sigma_X$,[4] implying $(2\,\rho_{PX}\,\sigma_P - \sigma_X) > 0$ and $v(\theta) < v(\pi)$. As $v(\theta) < v(\pi)$, the tolling agreement is less risky than the geothermal contract.[5]

- Social perspective. The net social benefit is $\phi = (B - Z) - T$ where Z = per MWH cost when the CCGT is economically dispatched at the social natural gas price against the marginal social cost of electricity, which may contain various externality costs (e.g., pollution and global warming). Its variance is $v(\phi) = v(\pi) - (2\rho_{BZ}\,\sigma_P - \sigma_Z)\,\sigma_Z$. Hence, if $2\rho_{BZ}\,\sigma_P > \sigma_Z$, the tolling agreement's net social benefit is less risky than the geothermal contract's.

[4] Woo, C.K., I. Horowitz, A. Olson, B. Horii and C. Baskette (2006) "Efficient Frontiers for Electricity Procurement by an LDC with Multiple Purchase Options," *OMEGA*, 34:1, 70-80; Woo, C.K., A. Olson and R. Orans (2004) "Benchmarking the Price Reasonableness of an Electricity Tolling Agreement," *Electricity Journal*, 17:5, 65-75.

[5] A similar point is made by Green, R. (2008) "Carbon Tax or Carbon Permits: The Impact on Generation Risks," *Energy Journal*, 29(3), 67-89:

> "[I]f the cost of gas and carbon are correlated with the price of electricity, the profit margin of a gas-fired generator can be less risky than either its costs or its revenues, considered in isolation. The profit margin of a nuclear generator may be much more risky than that of the gas-fired station, since its costs will not be as correlated with the price of electricity." (pp.67-68)

3. Misuse of CAPM

The idea of using a risk-adjusted discount rate for discounting a cost stream is based on the capital asset pricing model (CAPM).[6] The CAPM relates an asset's return to the market return, with the implication that an asset with more risky returns should have a higher expected return.[7]

From Section 2, the renewable energy contract's return is $r = \pi / F$ whose variance is $v(r) = v(\pi) / F^2$. The tolling agreement's return is $s = \theta / T$, whose variance is $v(s) = v(\theta) / T^2$. While $v(\pi) > v(\theta)$, we expect $F > T$ because the geothermal contract is assumed to have zero per MWH variable cost. Hence, we cannot determine *a priori* if $v(r)$ is larger or smaller than $v(s)$. That said, even if one would accept the CAPM based discounting approach, it is unclear if the discount rate for the renewable contract should be higher or lower the one for the tolling agreement.

4. Cross-hedging

Suppose one would accept the view that risky fuel cost should be discounted at the SDR, which is lower than the utility's cost of capital. However, the same view also implies that reducing the tolling agreement's fuel cost risk would lead to the use of a discount rate higher than the SDR. In the extreme, if the tolling agreement's fuel cost

[6] Awerbuch S. (2003) The True Cost of Fossil-Fired Electricity in the EU: A CAPM-based Approach, Draft Report.
[7] Elton, E.J. and M.J. Gruber (1991) *Modern Portfolio Theory and Investment Analysis*, John Wiley & Sons, NY: New York, Chapter 11.

risk can be removed completely, one might choose the utility's cost of capital for discounting the tolling agreement's cost stream.

The NYMEX natural gas futures contract is an effective instrument for cross-hedging against California spot natural gas price.[8] Moreover, they are for future delivery in the next 12 years, sufficiently long enough for hedging a 10-year tolling agreement's fuel cost risk. Thus, the availability of an effective hedge instrument questions the view's validity.

5. Social discount rate

It is valid to use the SDR to perform a social benefit-cost analysis.[9] Moreover, the SDR may be lower than the private cost of capital (e.g., risk free government bond rates of 3-5%/year vs. average equity returns of 8-12%/year). However, a single identical SDR should be used for analyzing the renewable energy contract's and the tolling agreement's net benefit stream. Selectively using a different discount rate for a particular component of a tolling agreement's cost stream is arbitrary, inconsistent with the standard practice of a benefit-cost analysis.

[8] Woo, C.K., A. Olson and I. Horowitz (2006) "Market Efficiency, Cross Hedging and Price Forecasts: California's Natural-Gas Markets," *Energy*, 31, 1290-1304.
[9] Mishan E.J. (1976) *Cost-Benefit Analysis*, Praeger, NY: New York.