Q. Please state your name, business address and present position with PacifiCorp (the Company).

A. My name is Chris R. Mumm, my business address is 825 N.E. Multnomah, Suite 600, Portland, Oregon 97232. My present position is Director of Structuring & Pricing, Commercial & Trading, which is part of PacifiCorp's regulated merchant function.

Q. Briefly describe your education and business experience.

A. I graduated from Eastern Washington University in 1998 with a Bachelor of Arts in Business Administration, focus in Finance & Economics and from the University of Oregon in 2001 with a Master of Business Administration in Finance. I have been employed in PacifiCorp's Commercial & Trading group since 2002. I have been in my present capacity as the Director of Structuring & Pricing since April 2004. In my current duties, I am responsible for analysis and valuation of the Company's structured wholesale contracts.

Q. What is the purpose of this testimony?

A. The purpose of my testimony is to rebut CCS witness Falkenberg's criticism of Black-Scholes modeling as imprudent for energy resource purchase decisions by a regulated utility.

Black-Scholes Modeling as Applied to Energy Resource Purchase Decisions

Q. What is the issue regarding Black-Scholes modeling in this case?

A. CCS witness Falkenberg claims that the use of Black-Scholes modeling for resource selection decisions is "a novel approach for resource selection for a regulated utility," and that "the Commission could consider disallowing the costs

of resources selected by the model on the basis of imprudence."

Q. What is Black-Scholes modeling?

A. Black-Scholes modeling values option contracts. Some discussion of option contracts is necessary before proceeding to discuss Black-Scholes modeling.

Option contracts give the option owner the right – but not the obligation – to do something, usually to buy or to sell a commodity at a known, fixed price (the "strike" price) at a specific point in time (the "delivery period") and at a certain location (the "delivery location"). If the contract is the right to buy, it is a "call" option; if it is the right to sell, it is a "put" option.

If the option contract is settled physically, the option is a physical option and the option owner takes physical delivery (calls) or delivers (puts) the commodity. If the option is settled financially, the option is a financial option and the owner receives the value, as settled against an agreed upon information source, of the commodity (for a call) or pays the value of the commodity (for a put) as if physical deliveries had taken place.

The option owner will exercise the option only if the option has value or, according to the jargon, if it is "in-the-money." The seller of the call or put has the opposite position. If the owner exercises the option, the seller has an obligation to sell (in the case of the call) or buy (in the case of the put).

Q. How does Black-Scholes modeling come into play?

A. When a prospective option owner is deciding whether or not to buy, or a prospective option seller is deciding whether or not to sell, a model must be used to estimate the option value to determine the option price. The price of an option

is known as the option "premium." The Black-Scholes model helps buyers and sellers determine this premium and, later, to determine the ongoing value or "mark-to-market" value of the option. The Black-Scholes model was developed by scholars in an academic framework; as acknowledged by Mr. Falkenberg, one of the authors, Myron Scholes, won a Nobel Prize in economics in large part due to his development of the Black-Scholes option valuation model. For the purposes of option modeling, Black-Scholes is the most common and most credible model, regardless of industry.

Q. How does PacifiCorp use Black-Scholes modeling?

A. PacifiCorp uses Black-Scholes to determine what to pay for an option and, therefore, whether or not to buy the option. As a load-serving entity, it is very rare that PacifiCorp would consider selling an option during periods of expected resource inadequacy. PacifiCorp also would not buy or sell an option for speculative purposes. In fact, such speculative activity is prohibited by PacifiCorp's energy trading and risk management policies. PacifiCorp also uses Black-Scholes to value the options (mark-to-market) that exist in its portfolio.

Q. Why does PacifiCorp believe Black-Scholes is a valuable tool and appropriate to use in the manner applied by PacifiCorp?

A. PacifiCorp uses Black-Scholes for several reasons. First, in the Company's experience, Black-Scholes has delivered useful and commercially reasonable option values for a wide variety of instruments. Back testing Black-Scholes predictions has shown the model's accuracy. Black-Scholes has validated option quotes from counterparties and has validated published quotes from widely traded

option instruments such as the options traded on the New York Mercantile Exchange (NYMEX). Second, as opposed to other option pricing methodologies which require constant calibration to market quotes, the Black-Scholes equation provides an accurate and easy to use closed form solution for valuing options. Finally, Black-Scholes has tremendous credibility in the financial and commodity community. Many software houses and financial and engineering firms have developed standardized energy derivative valuation software packages, and the most common option valuation model is Black-Scholes.

Q. How do you respond to Mr. Falkenberg's claim that Black-Scholes modeling is "a novel approach for resource selection" when applied for the purposes for which PacifiCorp uses it?

A. The method is entirely appropriate for the purposes for which it is used by PacifiCorp. The energy industry has used Black-Scholes models for many years in valuing options on natural gas, crude oil, diesel fuel, gasoline, and electricity. As mentioned earlier, energy options (calls and puts) traded on the NYMEX for natural gas and crude oil are valued using Black-Scholes models. Black-Scholes models and other stochastic models are valid methodologies for valuing such diverse liquid and illiquid assets as company acquisitions, stock warrants, employee stock option grants, director level option grants, option valuations on gasoline, jet fuel, and diesel fuel. Exhibit UP&L ___ (CRM-1R) is a representative list of companies currently employing Black-Scholes models as disclosed in their recent 10-K filings with the Securities and Exchange Commission. In fact, most commodity markets including banks and financial

institutions use Black-Scholes valuation and analysis techniques.

Q. How do you respond to Mr. Falkenberg's claim that "there is no basis for assuming Black-Scholes – a tool applicable to securities trading – is an appropriate method for evaluating energy resources"?

A. This statement by Mr. Falkenberg is incorrect. Given the assumptions that underlie the use of Black-Scholes, there is a strong basis for using this formula for evaluating energy resources.

Q. What are the economic assumptions underlying the Black-Scholes formula?

A. The economic assumptions behind Black-Scholes include:

1. Energy prices follow the geometric Brownian motion model, or rather; prices follow a random walk and are thus log normally distributed with returns being normally distributed.
2. Short selling of contracts with full use of proceeds is allowed.
3. Interest rates are constant and known.
4. Trading is continuous.
5. The underlying market is liquid.
6. Zero transaction costs.
7. Zero arbitrage opportunities.

Q. Can you please describe how these assumptions are met in the electricity markets?

A. Yes, I will describe how each of these assumptions are addressed in PacifiCorp's application of Black-Scholes.

1. Energy prices do follow the geometric Brownian motion model. Put plainly,

the distribution of energy price returns are normally distributed, or rather, energy prices are log normally distributed. Based on various analyses that the Company has performed, this assumption is met with regards to electricity markets. Exhibit UP&L___ (CRM-2R), for example, tests the June '04, July '04, August '04, and September '04 heavy load hour Mona forward contracts, and demonstrates this assumption to be true.

2. Short selling of contracts with full use of proceeds is allowed, and thus this assumption is also met with regards to electricity markets.

3. Interest rates, while known, are not constant. This can be handled in the Black-Scholes formula by having discrete values for the risk-free rate over the term of the option. Nevertheless, uncertainty surrounding risk free rates clearly impacts the cost of replicating an option (long/short underlying asset, short/long financing instrument). It should be noted that interest rates are volatile, and as a result never constant. Despite this assumption not being met, Black-Scholes modeling continues to be utilized in a variety of markets (foreign exchange, fixed income, equity markets, etc.).

4. Trading in electricity markets is no more continuous than in foreign exchange, fixed income, or equity markets. The lack of 100 percent continuous trading underestimates the cost of replicating an option which, in turn, implies that the Black-Scholes option premium is too low. While this is clearly an issue for the *seller* of an option, given that PacifiCorp is an option *buyer*, the Company is not overly concerned with this assumption not being fully met, as it simply leads the Company to pay a lower price, which is beneficial to customers.

5. The electricity markets are not as liquid as foreign exchange, fixed income, or equity markets, where hourly option replication (hedge rebalancing) is fully achievable for most securities. That being said, the electricity markets are liquid enough for participants to replicate an option position on a daily basis. As a result, this assumption is met reasonably well with regards to electricity markets.
6. PacifiCorp does not hedge each transaction separately but hedges on a net portfolio basis. As a result of transaction costs being minimized, this assumption is met with regards to electricity markets.
7. It is generally true that there are zero arbitrage opportunities in electricity markets. As with foreign exchange, fixed income, and equity markets, arbitrage opportunities are present occasionally. Despite this fact, the foreign exchange, fixed income, and equity markets continue to use Black-Scholes for pricing options. As a result, this assumption is met reasonably well with regards to electricity markets.

Q. Even if all of the underlying assumptions are not entirely met, is it reasonable for Mr. Falkenberg to claim that Black-Scholes modeling is a "novel" method for valuing energy resources, and that PacifiCorp is somehow imprudent by utilizing the formula?

A. Absolutely not. First, one must ask: is there a better alternative available? As Erik Hjalmarsson from Yale University's Department of Economics concludes in his paper "Does the Black-Scholes Formula Work for Electricity Markets? A Nonparametric Approach", after testing five different models, "*from a practical*

viewpoint, the Black-Scholes prices appear to be the best available." This conclusion that Black-Scholes provides the best results for pricing options is further supported by the fact that the participants in the electricity market utilize Black-Scholes modeling when setting the bid-ask for various options. The combination of a top scholar supporting usage of Black-Scholes in electricity markets, and market participants regularly using the formula, should lead one to conclude that Black-Scholes modeling is a widely endorsed method for valuing energy resources, and that PacifiCorp is entirely prudent in utilizing the formula in its analyses of energy resources.

Q. Does this conclude your rebuttal testimony?

A. Yes.