EXHIBIT NO. _____ (EMM-35)
DOCKET NO._____
2003 POWER COST ONLY RATE CASE
WITNESS: ERIC M. MARKELL

BEFORE THE

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. PUGET SOUND ENERGY, INC., Respondent.	Docket No. _____

DIRECT TESTIMONY OF
ERIC M. MARKELL
ON BEHALF OF PUGET SOUND ENERGY, INC.

E. Probabilistic Analysis of Risk Factors

Following PSE's previous Least Cost Plan, the WUTC issued a comment letter, dated August 21, 2001, directing PSE to include probabilistic risk analysis in its next Least Cost Plan filing. PSE developed its Least Cost Plan screening model to assess uncertainties through probabilistic Monte Carlo modeling. The LCP screening model employs Crystal Ball™ as the Monte Carlo analysis tool. The Monte Carlo analysis considers three uncertainty factors:

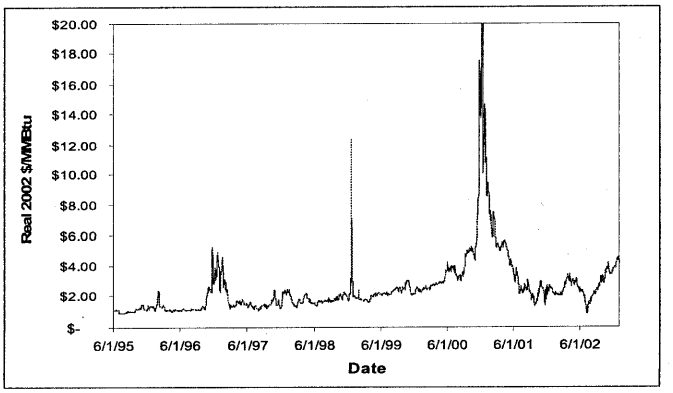
- Market prices for natural gas
- Market prices for power
- Hydroelectric generation availability

For each of the uncertainty factors, the Monte Carlo analysis requires two pieces of information – the distribution of possible outcomes for each uncertainty factor, and the correlation between the uncertainty factors. This section addresses the development of these inputs to the Monte Carlo analysis. The distributions associated with the uncertainty factors were developed using historical data and will be dealt with separately, while PSE based the correlation factors on historical information and will address these factors collectively. The historical data sets span June 1995 to December 2002, based on daily data points. The individual data sets were aligned to assure no gaps or holes existed in the data set.

Market prices for natural gas

Historically, market prices for natural gas exhibit a high degree of volatility. Exhibit XI-10 illustrates the Sumas index data set used for natural gas prices.

Exhibit XI-10
Historical Sumas Daily Gas Prices

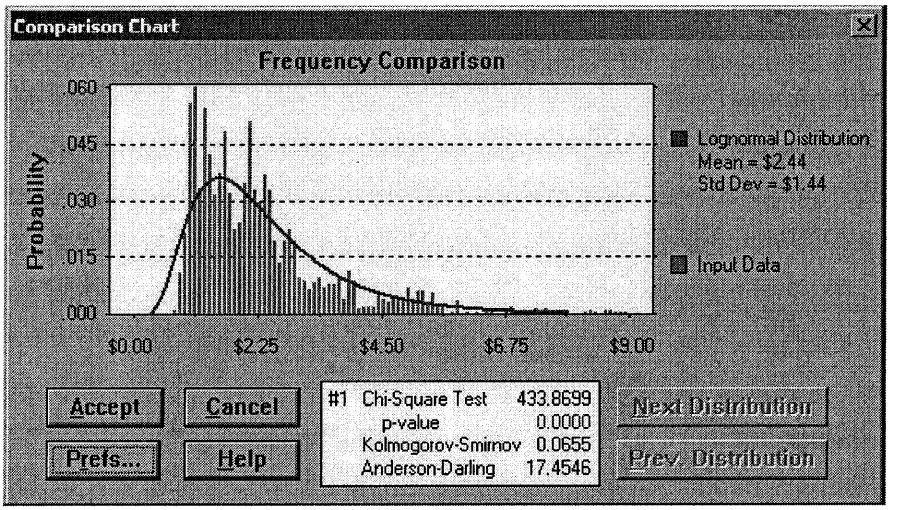


Source: Gas Daily

The Sumas gas index revealed a few days during the 2000 - 2001 period in which the price for natural gas exceeded $20/MMBtu. In the development of the distribution of prices based on this historical data set, PSE set a cap for gas prices at $20/MMBtu. For any days in which the price exceeded this level, PSE set that day's price to $20/MMBtu.

Using Crystal Ball™ the historical data set of real 2002 $/MMBtu data points can be curve-fit to a number of distributions. The lognormal distribution ranks highest and is displayed in Exhibit XI-11.

Exhibit XI-11
Historical Sumas Daily Gas Price Distribution



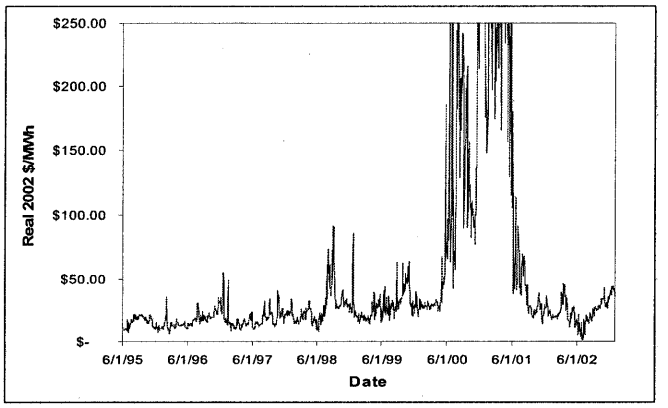
The mean of this data set is $2.44/MMBtu (real 2002$), with a standard deviation of $1.44/MMBtu. These values translate to a coefficient of variability of 59 percent (standard deviation as a percent of the mean). PSE applied this measure of gas price volatility to the gas prices in the screening model on an annual basis, with this annual volatility applied evenly across the monthly gas price profile used in the model.

Market prices for power

Historical power prices show even greater volatility than gas prices. Exhibit XI-12 provides the data set used for power prices, with the Mid-Columbia hub as the index.

Exhibit XI-12

Historical Mid-Columbia Power Prices

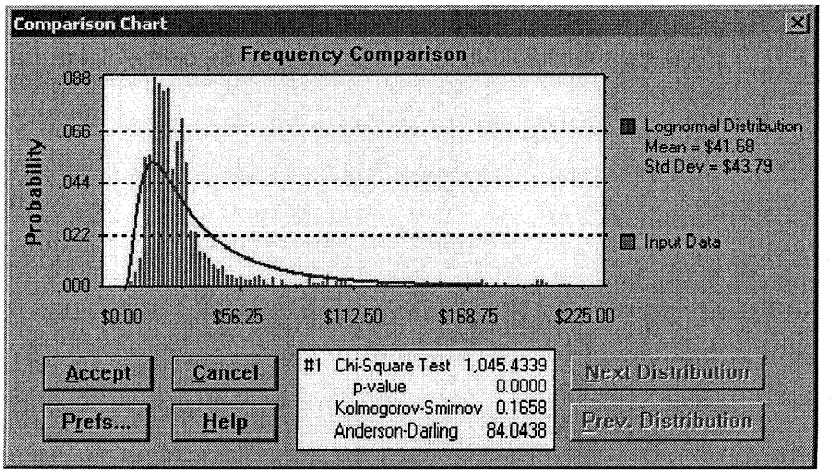


Source: MegaWatt Daily

The Mid-Columbia power index revealed several days during the 2000 - 2001 time period in which the price for power exceeded $250/MWh. In the development of the distribution of prices based on this historical data set, PSE set a cap for power prices at $250/MWh. For any days in which the price exceeded this level, PSE set that day's price to $250/MWh.

Using Crystal Ball™ the historical data set of real 2002 $/MWh data points can be curve-fit to a number of distributions. Exhibit XI-13 displays lognormal distribution which ranked highest.

Exhibit XI-13
Historical Mid-Columbia Daily Gas Price Distribution



The mean of this data set is $41.68/MWh (real 2002$), and the standard deviation is $43.79/MWh. These values translate to a coefficient of variability of 105 percent (standard deviation as a percent of the mean). Similar to gas prices, the screening model applies the power price volatility on an annual basis. The annual volatility factor is applied equally to the AURORA hourly price profile. Since the power prices are represented on an hourly basis, the concern of "double counting" volatility arose. The AURORA hourly price profile already has an equivalent 30 percent coefficient of variability built into it due to hourly price fluctuation. The annual volatility factor used in the screening model therefore has the 30 percent netted from the 105 percent to yield an annual coefficient of variability of 75 percent.

Hydroelectric generation

PSE based the variability of hydroelectric generation on the 40-year (1948-1988) NWPP hydro availability data set. The 10 facilities owned by PSE are divided into two systems – the Western System and the Mid-Columbia System. The NWPP has projected the availability of each of these 10 hydroelectric facilities for each of the 40 years of hydrological data in its data set. Each facility has an associated mean and standard deviation availability. In order to "roll up" the statistics on each facility into the two systems detailed above, PSE calculated the MW weighted average standard deviation. Exhibits XI-14 and XI-15 illustrate these facilities, their associated capacity, and coefficient of variability.

Exhibit XI-14
Western Hydroelectric System

Plant	40-year SD (% of mean)	MW
Upper Baker	12.1%	104.90
Lower Baker	14.4%	79.00
White River	12.1%	62.50
Puget Small Plants	9.4%	69.65
Weighted Avg SD	12.1%	

Exhibit XI-15
Columbia River Hydroelectric System

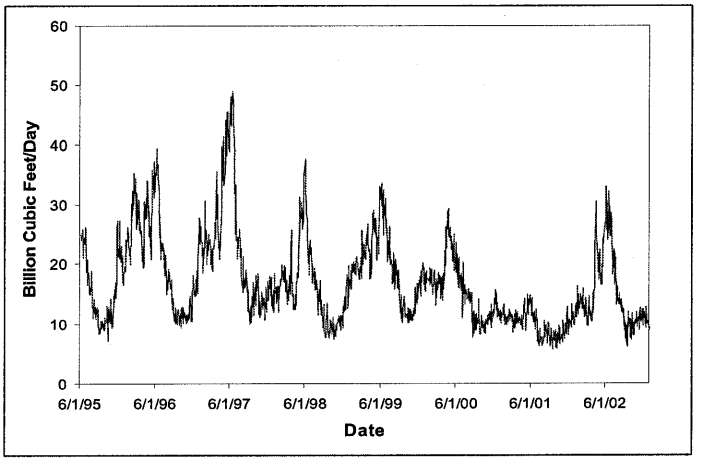
Plant	40-year SD (% of mean)	MW
Wells	9.9%	262.92
Rocky Reach	9.9%	492.67
Rock Island 1	4.5%	163.08
Wanapum	4.5%	106.49
Priest Rapids	7.8%	72.96
Rock Island 2	7.8%	173.95
Weighted Avg SD	8.3%	

As Exhibits XI-14 and XI-15 illustrate, the distribution for each of the hydroelectric systems is assumed to be normal.

Correlation between Power, Gas, and Hydroelectric Availability

In order to correlate both power and gas to hydroelectric availability, PSE needed to chose a proxy for hydroelectric availability. The NWPP data detailed by the availability distribution on ends in 1988, and sufficient data on gas or power prices do not go back this far back in order to allow for a determination of a good statistical relationship. PSE chose the daily river flow at the Dalles, as shown in Exhibit XI-16.

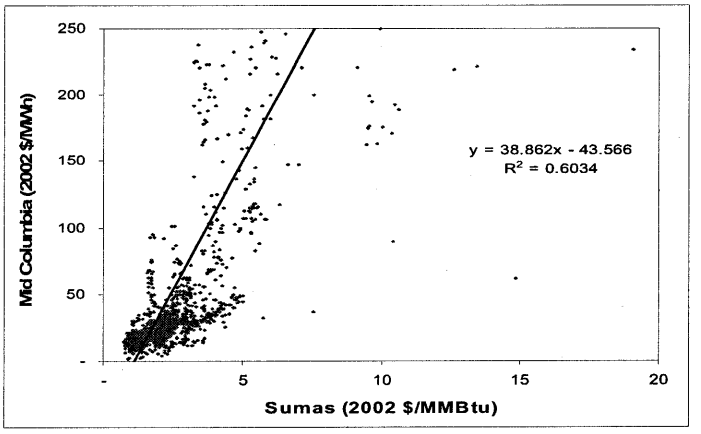
Exhibit XI-16
Volumetric River Flow at The Dalles



Source: US Geological Survey

PSE now has three consistent sets of data for gas, power, and hydroelectric availability. The assessment of correlation between these three factors began with an analysis of the level of determination between the data sets. Variation in gas prices account for a significant portion of the variation in power prices. Exhibit XI-17 illustrates this relationship and demonstrates a coefficient of determination (R-squared) of close to 60 percent.

Exhibit XI-17
Power Price as a Function of Gas Price



Similarly, PSE examined the level of variation in both power and gas prices as a result of variation in hydroelectric availability (Dalles River flow). Exhibits XI-18 and XI-19 portray this relationship.

Exhibit XI-18
Power Price as a Function of Dalles River Flow

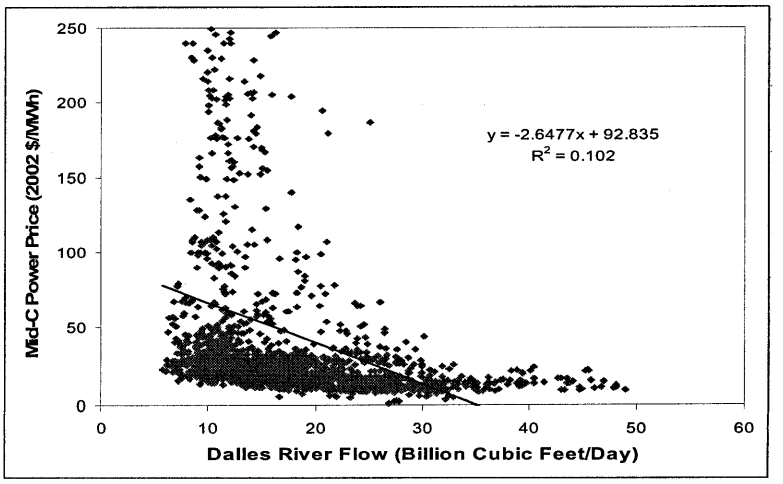
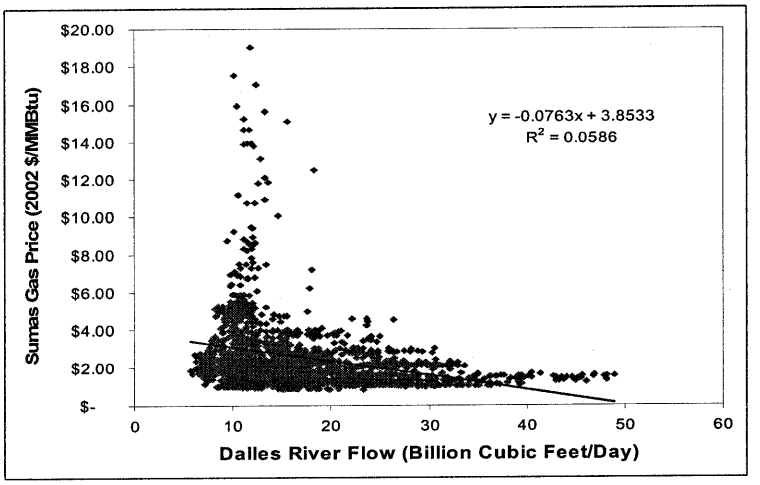


Exhibit XI-19
Gas Price as a Function of Dalles River Flow



These exhibits characterize both of these relationships as negative, thus higher river flow drives lower power and gas prices, but the level of determination is quite small.

It should be noted that Crystal Ball™ treats the uncertainty factors as independent variables, and therefore, requires correlation coefficients as inputs to relate power, gas and hydroelectric availability to each other. Excel™ was used to calculate the correlation coefficients between the three uncertainty variables. Exhibit XI-20 shows the results of these calculations.

Exhibit XI-20
Correlation Coefficients

	Mid C ($/MWh)	*Sumas Gas ($/MMBtu)*	*Dalles (Cf/Day)*
Mid C ($/MWh)	1.00		
Sumas Gas ($/MMBtu)	0.67	1.00	
Dalles (Cf/Day)	(0.32)	(0.24)	1.00

As expected, gas and power have a high and positive correlation. Again, as expected, power/gas and hydroelectric availability have a somewhat lower and negative correlation.

Since two hydroelectric systems were modeled, PSE assumes the correlation coefficient between the two systems to be one. Lastly, there is no inter-year correlation within each uncertainty factor for all three variables.