Chapter 8
RISK AND UNCERTAINTY ANALYSIS

Stochastic Analysis

Stochastic modeling in GenTrader® requires the introduction of variables in the form of implied volatility for electricity and natural gas prices. The basic premise for determining implied (future volatility) is that historical or actual volatility is an indicator of what future price volatility might be. Through the examination of historical market prices, Lands Energy and NorthWestern have developed a 20-year implied volatility schedule for use in GenTrader®.

Results of stochastic models differ from that of the intrinsic models. Instead of a single outcome, a stochastic model produces a range of outcomes that are created from iterative model simulations that employ a sampling of market prices above and below a forecast value. For example, if in a model time period where the price of electricity was forecast to be $50 per MWh, the stochastic model during its iterative process would determine multiple values for electricity using the forecast price and the associated implied volatility to vary the price above and below the $50 value. Because price is allowed to vary, it follows that portfolio total cost will also vary, with the stochastic model capturing the frequency and magnitude of the variation in the model results. With this information NorthWestern has assessed portfolio risk from the market price perspective and the risk mitigation perspective based on portfolio composition and its associated economic performance. The stochastic model outcomes do not define a probability of occurance for individual 20-year simulations. The output of the model simulations define a frequency distribution for the range of portfolio cost.

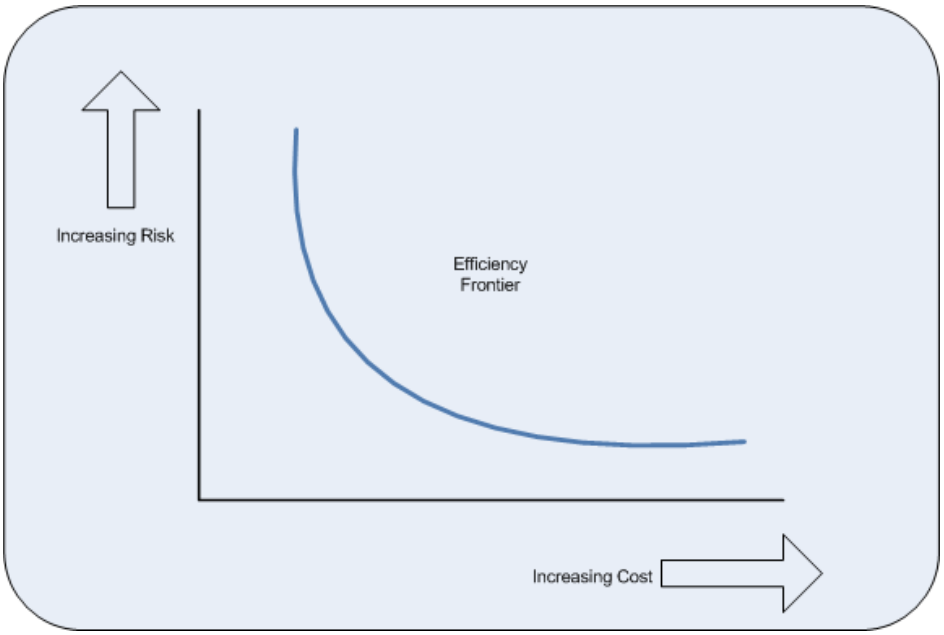
Another important consideration in the stochastic evaluation is the correlation between the price of electricity and natural gas. In determining the forward prices for both of these key inputs, an explanation of the relationship between electricity, natural gas, and the marginal unit was provided in Chapter 6. This is a key relationship for utilities in the Northwest because it figures prominently in the market pricing of electricity. In developing the forward price curves for power and gas, Lands Energy recognized and accounted for the electricity-natural gas price

relationship; a positive relationship. This means that when prices for either of the two commodities rise or fall the other tends to rise or fall as well. Does this mean that they are perfectly correlated all the time? The simple answer is no. However, for long-term planning purposes it is important to maintain this relationship. In GenTrader® the positive correlation of electricity and natural gas price has been established as a fundamental input to the stochastic modeling program.

Efficiency Frontier

NorthWestern employs the Efficiency Frontier as a principle evaluation metric to assess portfolio cost risk relative to expected portfolio cost. The construction of the Efficiency Frontier relies on the stochastic output of the GenTrader® models for the numeric inputs to the plot. As described earlier in Chapter 7 stochastic modeling relies on an iterative process to sample electricity and natural gas prices (positively correlated) using calculated implied price volatilities to determine a range of portfolio cost outcomes. The concept of the Efficiency Frontier is presented in Figure 28:

Figure 28



The Efficiency Frontier is a graphical display of the stochastic model output that quantifies the expected financial outcomes of the portfolios along the x-axis and the risk factor ($/MWh) along the y-axis. The expected financial outcome is computed as the 20-year mean levelized cost of the supply portfolio in $/MWh as determined in the stochastic model. The risk factor is the 20-year levelized value of the 95% confidence interval costs minus the mean levelized cost. Ninety five percent confidence interval of annual costs means that 95% of the annual costs derived from the stochastic model for the portfolio are equal to or less than the reported value. By subtracting the mean or expected cost from the 95% confidence value, a quantitative risk factor can be derived from all stochastic models and produce values that are directly comparable. The Efficiency Frontier is the leading edge of the scatter plot that is closest to the intersection of the x- and y-axes, and therefore represents the portfolios that minimize both cost and risk. The efficiency frontier is constructed using the mean levelized portfolio cost on the x-axis and the risk factor on the y-axis.

Stochastic Results

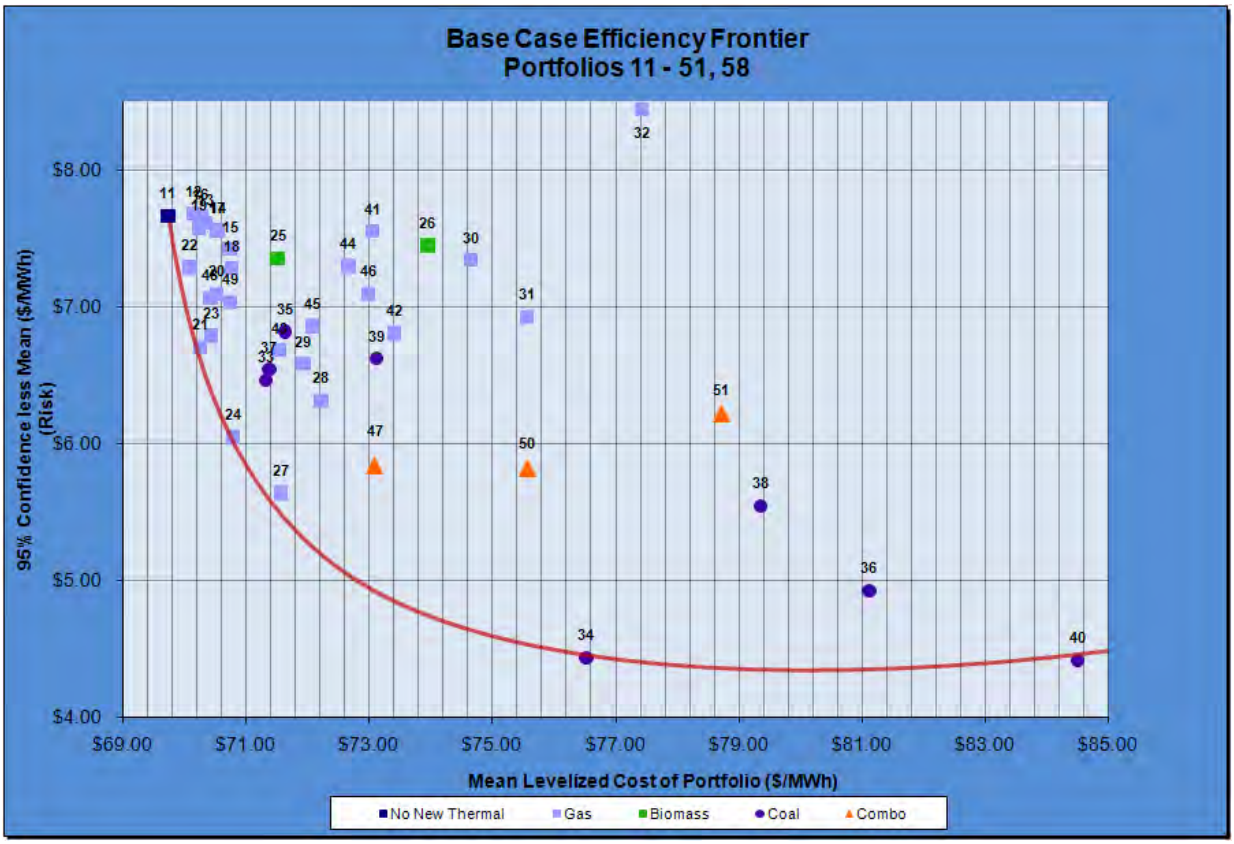
Stochastic models have been executed for portfolios 11 through 51 plus portfolio 58 and efficiency frontier plots created for each of the five cases; basecase, high market, low market, no carbon, and delay carbon. The basecase efficiency frontier is presented as Figure 29. The calculated cost and risk values used to build the plots are tabulated and found in Volume 3 Chapter 5. The efficiency frontier plots employ “markers” of different color and shape to help illustrate how different combustion technologies are grouped and distributed.

The basecase efficiency frontier provides key information about how the different resources performed under the base case market and carbon cost parameters using implied volatility for electricity and natural gas to raise and lower total cost iteratively. The arc of the base case efficiency frontier is defined by portfolios 11, 21, 24, 27, and 34. All other portfolios occur to the right of the efficiency frontier and exhibit, higher cost, higher risk, or both. Seventeen or approximately 40% of the portfolios have a mean levelized cost varying from a low of

$69.74/MWh up to $70.79; roughly a one dollar range. This close grouping of results combined with similar risk factors from $6 to $8 per MWh make it challenging to identify clear winners based on the economic performance defined by the stochastic results.

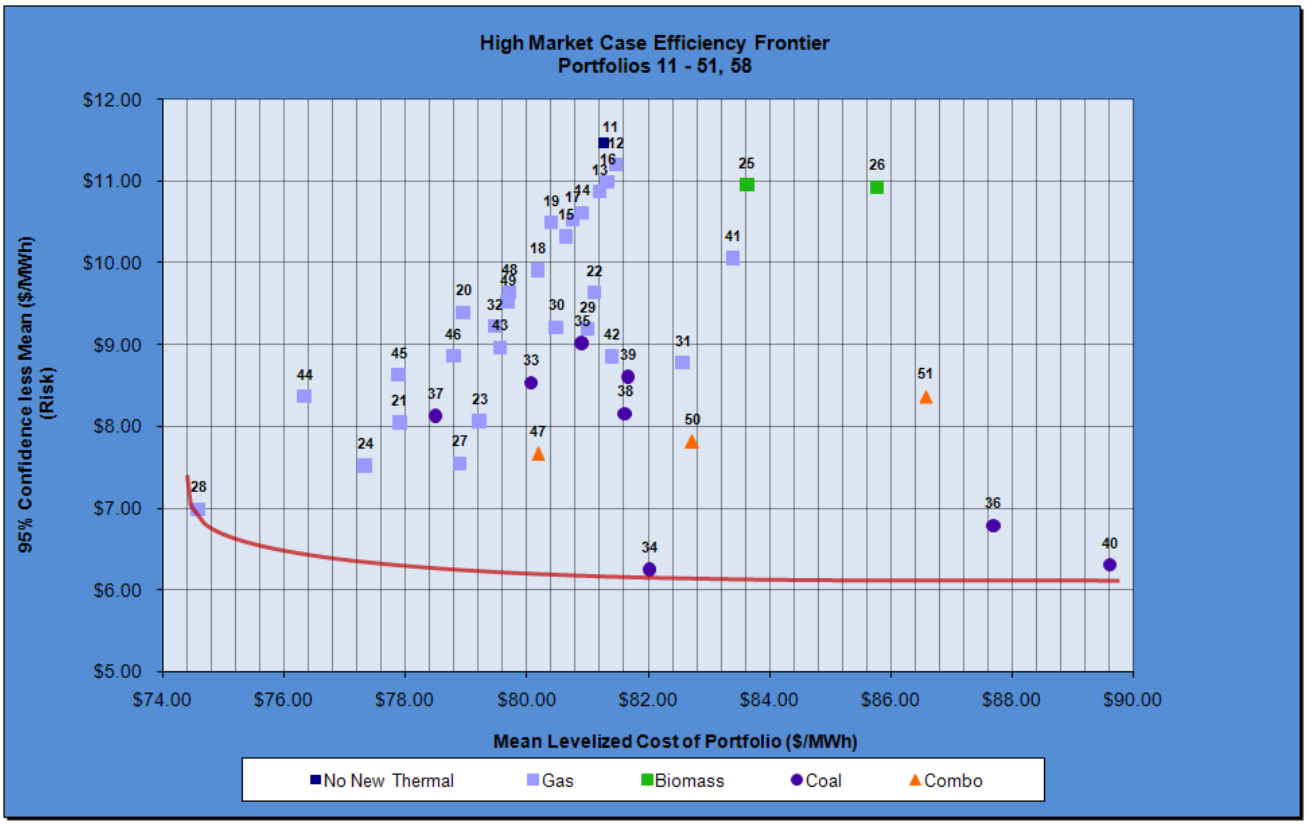
Portfolio 11, the market case with no new thermal resources, has the lowest mean levelized cost coupled with a moderately high risk value of $7.66/MWh. The three portfolios that performed well because of their position on the efficiency frontier are 27, 24, and 21. Each of these resource portfolios are comprised of different gas-fired technologies. Portfolio 27 employs a single 200MW combined cycle turbine. PF 24 includes 3 – 100MW aero- derivative gas turbines and PF21 utilizes 3 – 100MW simple cycle frame gas units. These results provide information on the sizing of the gas-fired units; however the combustion technology selection is not as clear. Based purely on the position along the efficiency frontier, PF27 is closest to the origin and appears to provide the best balance between cost and risk under base case input assumptions.

Figure 29



Results of the high market stochastic studies define an efficiency frontier that identifies clear resource choices for the high market case (Figure 30). PF28 employs 400MW of combined cycle gas technology and clearly provides the least cost, least risk alternative under elevated market assumptions for both electricity and natural gas. The next closest portfolios are PF 24 and PF 44 with 300MW of aero derivative simple cycle capacity and 400MW of combined cycle gas technology installed in 200MW stages in 2015 and 2018. PF34 with 400MW of supercritical coal has a mean levelized cost of $82.03 and only lowers the risk factor relative to PF28 by $0.73/MWh.

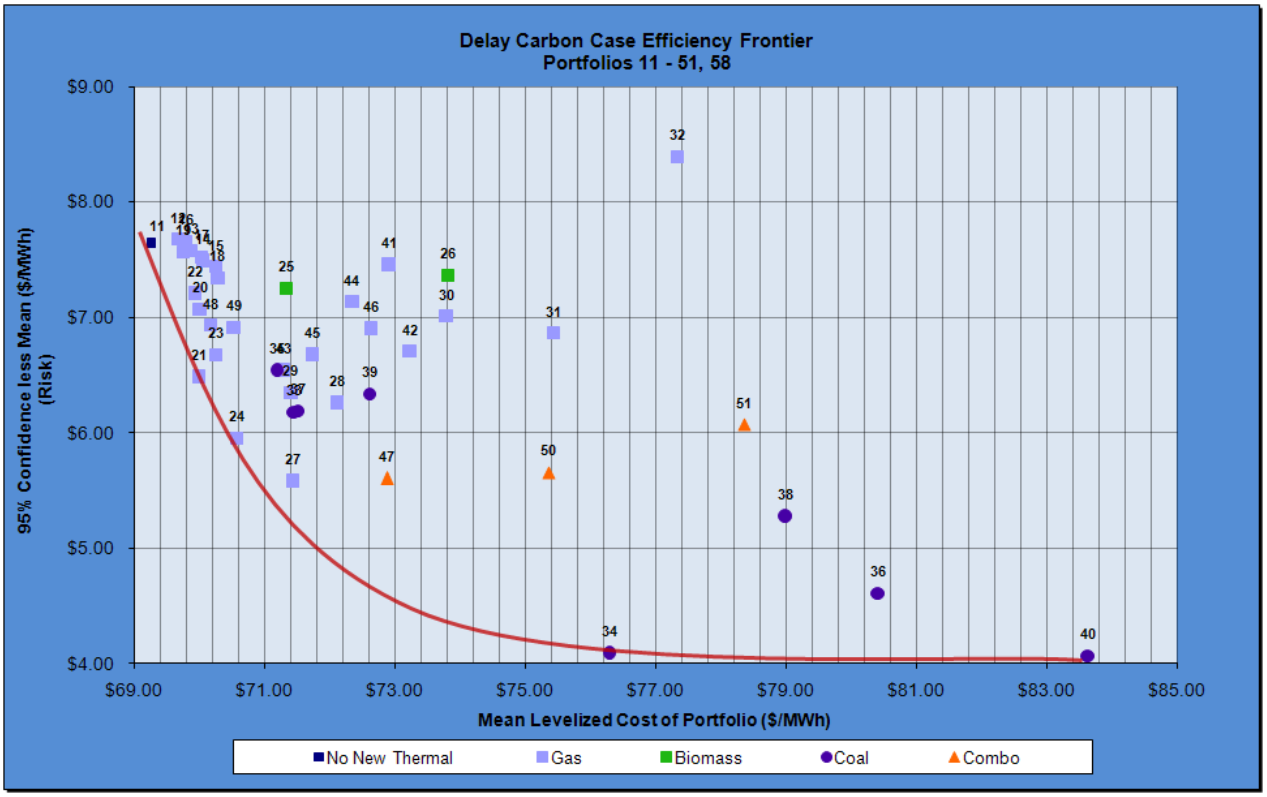
Figure 30



The delay carbon stochastic case (Figure 32) produced results very similar to the base case in terms of the relative performance of portfolios that define the efficiency frontier as well as the remainder of the portfolios to the right of the curve. Because the base case and delay carbon cases have similar inputs for market prices for electricity, natural gas, and carbon, the resulting efficiency frontier is difficult to distinguish from the base case. Based on these results, it appears

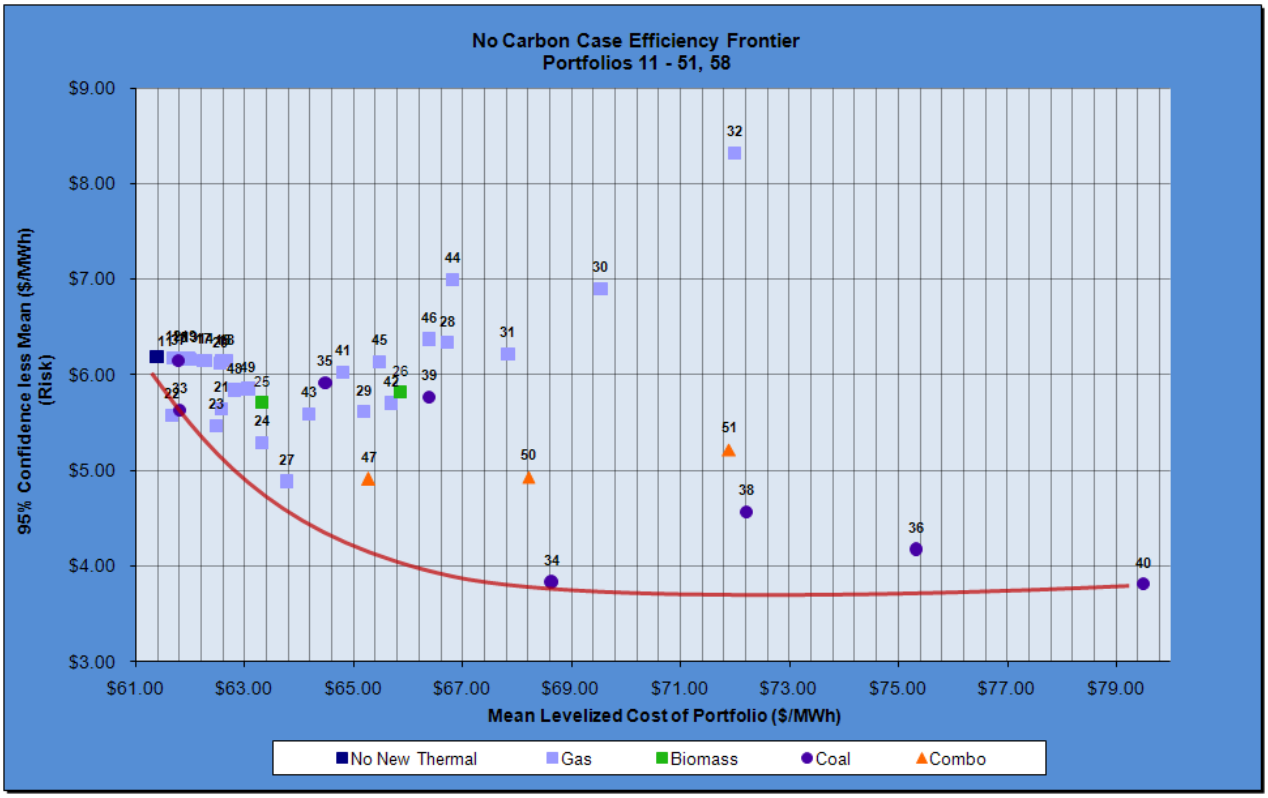
that resource decisions using the base case would be the same as in the case where a delay of implementation of carbon penalties occurs.

Figure 31



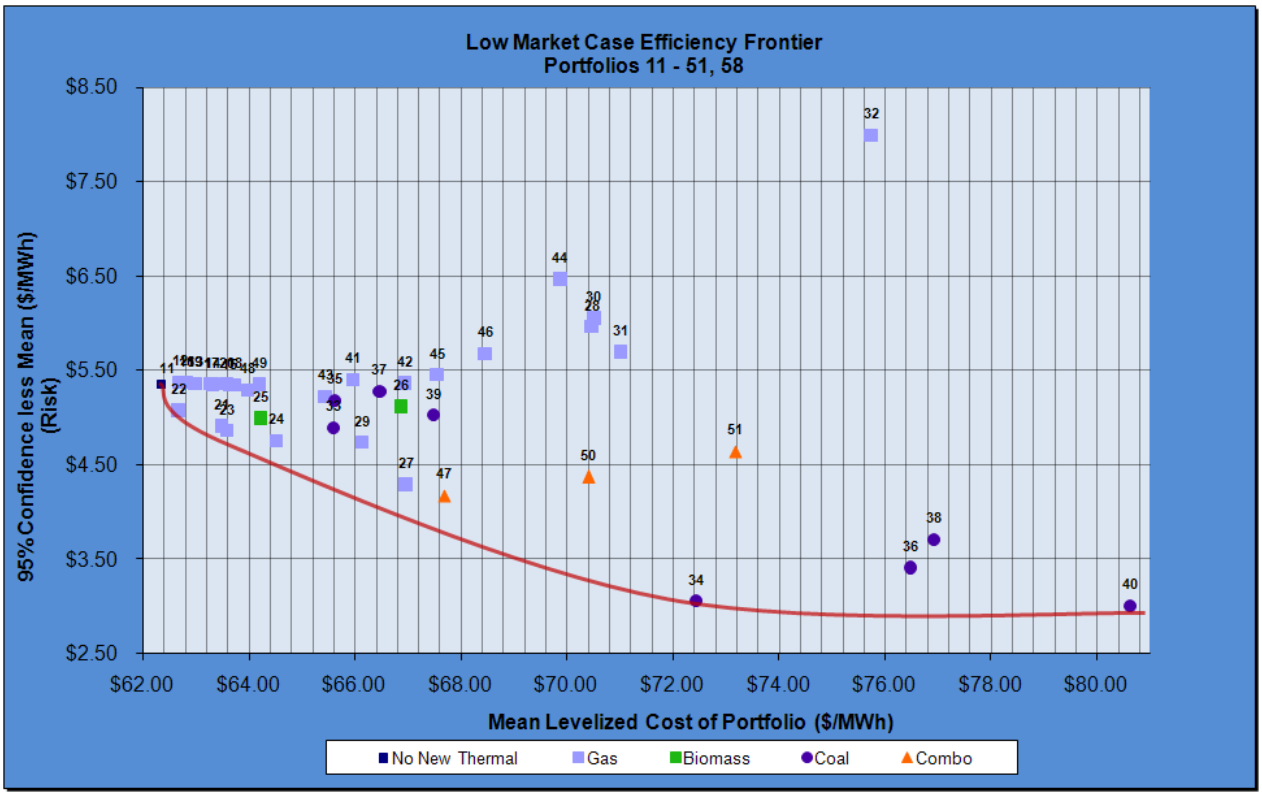
The no carbon stochastic case demonstrates how all portfolios deliver lower cost energy with accompanying levels of reduced risk. The same portfolios that define the efficiency frontier in the base case also define or are nearly on the efficiency frontier in the no carbon case. The no carbon case does not reduce risk completely. Even in the case of portfolios with substantial amounts of coal, resource risk is present because market purchase of energy continues to be employed to meet a component of the load serving obligations.

Figure 32



The final efficiency frontier is constructed for the low market case (Figure 34) to illustrate how a declining market assumption would impact portfolio cost and risk. The shape of the efficiency frontier for the low market case is similar in shape to the high market efficiency frontier with one obvious difference; the higher the percentage of market purchases (ex PF11) the lower the mean levelized cost of the portfolio. This was not the case in the high marker scenario where PF11 was both high cost and high risk. For the low market case the addition of any resources is shown to increase cost with varying changes to risk. Again, even in a scenario where market prices for electricity and fuel are lower than the base case assumptions, risk is present because of implied volatility that drives prices above and below the forecast values.

Figure 33



The final concept in determining how to interpret the stochastic results is the construction of the RiskVar90 value from all five of the stochastic cases, The RiskVar90 is a single value that captures both the mean levelized portfolio cost and the 95% confidence minus mean value (risk value) to create a single metric per portfolio per stochastic case. The RiskVar90 variable is calculated as:

RiskVar90 = (Mean Levelized Cost x 70%) plus (95% Confidence Interval – mean x 30%)

The results of these calculations applied to all stochastic model results are presented in Table 42 with the same weightings applied to establish a single stochastic weighted average value. In this table the top 10 portfolios are high-lighted. The top 4 performing portfolios are identified as those with varying amounts of simple cycle frame or aero derivative gas units. The fifth best performing portfolio is a combination of LM6000 gas turbines with and without combined cycle heat recovery. The existing portfolio (PF11) ranked seventh out of the top ten performers and

seems to indicate that the lack of market price protection for the unsecured portion of the current portfolio can be mitigated through the addition of gas-fired resources.

Table 42

Risk VAR90 for Stochastic Results

PF	Description	Base Case	Low Market	High Market	No Carbon	Delay Carbon	Range	Weighted Average	Weighted Avg Rank
11	Existing Resources	$ 72.03	$ 63.94	$ 84.71	$ 63.25	$ 71.54	$ 21.46	$ 74.10	7
12	1-Internal Combustion	$ 72.46	$ 64.30	$ 84.84	$ 63.55	$ 71.98	$ 21.29	$ 74.42	16
13	2-Internal Combustion	$ 72.63	$ 64.61	$ 84.46	$ 63.85	$ 72.14	$ 20.61	$ 74.45	18
14	3-Internal Combustion	$ 72.81	$ 64.92	$ 84.11	$ 64.14	$ 72.31	$ 19.96	$ 74.49	20
15	4-Internal Combustion	$ 72.96	$ 65.24	$ 83.74	$ 64.44	$ 72.48	$ 19.30	$ 74.52	21
16	1-SCCT LM6000	$ 72.56	$ 64.44	$ 84.62	$ 63.67	$ 72.08	$ 20.95	$ 74.43	17
17	2-SCCT LM6000	$ 72.78	$ 64.89	$ 83.92	$ 64.10	$ 72.29	$ 19.82	$ 74.42	15
18	3-SCCT LM6000	$ 72.95	$ 65.33	$ 83.16	$ 64.52	$ 72.48	$ 18.63	$ 74.36	14
19	1-SCCT Frame	$ 72.51	$ 64.57	$ 83.56	$ 63.83	$ 72.02	$ 19.73	$ 74.11	8
20	2-SCCT Frame	$ 72.65	$ 65.18	$ 81.77	$ 64.39	$ 72.12	$ 17.37	$ 73.76	4
21	3-SCCT Frame	$ 72.26	$ 64.96	$ 80.32	$ 64.28	$ 71.93	$ 16.04	$ 73.12	1
22	1-SCCT Aero	$ 72.27	$ 64.19	$ 84.00	$ 63.34	$ 72.10	$ 20.66	$ 74.07	6
23	2-SCCT Aero	$ 72.47	$ 65.05	$ 81.64	$ 64.13	$ 72.25	$ 17.51	$ 73.62	3
24	3-SCCT Aero	$ 72.60	$ 65.94	$ 79.59	$ 64.91	$ 72.35	$ 14.68	$ 73.24	2
25	1-Biomass	$ 73.72	$ 65.72	$ 86.92	$ 65.05	$ 73.51	$ 21.87	$ 75.99	29
26	2-Biomass	$ 76.19	$ 68.41	$ 89.05	$ 67.62	$ 76.02	$ 21.43	$ 78.40	36
27	1-CCCT	$ 73.25	$ 68.25	$ 81.17	$ 65.25	$ 73.11	$ 15.91	$ 74.31	13
28	2-CCCT	$ 74.12	$ 72.25	$ 76.68	$ 68.63	$ 73.99	$ 8.04	$ 74.14	10
29	1-CCCT w CCS	$ 73.90	$ 67.55	$ 83.76	$ 66.88	$ 73.30	$ 16.88	$ 75.46	26
30	2-CCCT w CCS	$ 76.86	$ 72.33	$ 83.25	$ 71.62	$ 75.89	$ 11.63	$ 77.70	33
31	1-CHP	$ 77.63	$ 72.73	$ 85.20	$ 69.71	$ 77.49	$ 15.50	$ 78.61	37
32	2-CHP	$ 79.97	$ 78.14	$ 82.23	$ 74.50	$ 79.85	$ 7.73	$ 79.91	38
33	1-Super Coal	$ 73.27	$ 67.06	$ 82.64	$ 63.51	$ 73.30	$ 19.13	$ 74.48	19
34	2-Super Coal	$ 77.86	$ 73.36	$ 83.90	$ 69.79	$ 77.52	$ 14.11	$ 78.38	35
35	1-Super w CCS	$ 73.67	$ 67.17	$ 83.61	$ 66.26	$ 73.16	$ 17.35	$ 75.21	25
36	2-Super w CCS	$ 82.60	$ 77.52	$ 89.73	$ 76.59	$ 81.79	$ 13.14	$ 83.55	41
37	1-IGCC	$ 73.34	$ 68.05	$ 80.94	$ 63.64	$ 73.37	$ 17.30	$ 74.12	9
38	2-IGCC	$ 81.02	$ 78.04	$ 84.06	$ 73.59	$ 80.57	$ 10.48	$ 80.85	39
39	1-IGCC w CCS	$ 75.11	$ 68.99	$ 84.26	$ 68.13	$ 74.51	$ 16.13	$ 76.48	30
40	2-IGCC w CCS	$ 85.84	$ 81.53	$ 91.52	$ 80.65	$ 84.85	$ 10.86	$ 86.49	42
41	1-CC LM6000PF	$ 75.31	$ 67.58	$ 86.42	$ 66.62	$ 75.14	$ 19.80	$ 76.99	32
42	1-CC 207EA	$ 75.45	$ 68.56	$ 84.06	$ 67.42	$ 75.23	$ 16.64	$ 76.52	31
43	CC LM6000PF - CC LM6000PF	$ 73.55	$ 67.00	$ 82.26	$ 65.88	$ 73.25	$ 16.38	$ 74.71	22
44	CCCT - CCCT	$ 74.85	$ 71.81	$ 78.84	$ 68.93	$ 74.48	$ 9.91	$ 75.12	24
45	LM6000PF - CCCT	$ 74.13	$ 69.18	$ 80.48	$ 67.33	$ 73.73	$ 13.15	$ 74.82	23
46	LM6000PF - CHP	$ 75.11	$ 70.16	$ 81.45	$ 68.30	$ 74.70	$ 13.15	$ 75.80	28
47	SCCT Frame - Supercritical Coal	$ 74.84	$ 68.93	$ 82.48	$ 66.76	$ 74.55	$ 15.72	$ 75.70	27
48	SCCT LM6000 - CC LM6000PF	$ 72.54	$ 65.56	$ 82.60	$ 64.58	$ 72.25	$ 18.03	$ 74.04	5
49	3-Internal Combustion - SCCT Aero	$ 72.86	$ 65.80	$ 82.54	$ 64.83	$ 72.60	$ 17.71	$ 74.23	11
50	CC LM6000PF - 1/2 IGCC	$ 77.32	$ 71.71	$ 85.07	$ 69.70	$ 77.05	$ 15.37	$ 78.30	34
51	CC LM6000PF - 1/2 IGCC w CCS	$ 80.58	$ 74.57	$ 89.09	$ 73.47	$ 80.18	$ 15.63	$ 81.78	40
58	Colstrip 4 economically dispatched	$ 72.11	$ 64.30	$ 84.84	$ 63.41	$ 71.81	$ 21.43	$ 74.25	12
	Weighting	*40%*	*10%*	*30%*	*10%*	*10%*			