RESULTS

As explained in the introduction, Questar Gas has utilized for a number of years, a computer-based linear-programming modeling tool to evaluate both supply-side and demand-side resources. This software product, marketed under the name of "SENDOUT," is maintained by Ventyx headquartered in Atlanta, Georgia.

Questar Gas is utilizing the most recent release of SENDOUT, Version 12.5.5, which was installed during March 2009. As was the case with the release used for last year's IRP, Version 12.5.5 has the capability of performing Monte Carlo simulations thereby facilitating risk analysis. The Monte Carlo method utilizes repeated random sampling to generate probabilistic results. It is best applied where relative frequency distributions of key variables can be developed or where draws can be made from historic data. Because of the need for numerous random draws, this method has been greatly facilitated by the availability of high-speed computer technology.

Questar Gas Company representatives work closely with consultants from Ventyx. On February 20, 2009, Questar Gas received correspondence from a Ventxy consultant documenting his understanding of how Questar Gas has utilized and configured the SENDOUT model. While the Ventyx consultant acknowledged that the linear-programming problem being solved by Questar Gas is among the "more complex" he had seen modeled, it was his opinion that "Questar is using SENDOUT reasonably" (see Exhibit 9.1).

Constraints and Linear Programming

While the concepts of linear programming date back to at least the early 19th century, it was not until the middle of the 20th century that this approach began to be more widely accepted as a method for achieving optimal solutions in practical applications. In a nutshell, linear programming problems involve the optimization of a linear objective function subject to linear constraints. Constraints are necessary in the determination of a maximum or minimum solution. Constraints must be linear functions and can either represent equalities or inequalities. An example of an inequality constraint in the natural gas business would be that the quantity of natural gas that can be transported over a certain segment of an interstate pipeline must be "less than or equal to" a certain level previously contracted for with that pipeline company. Another example of an inequality constraint would be the production available from a group of wells providing cost-of-service natural gas. The levels of this resource that can be taken can never exceed the maximum level available as production naturally declines over time. All resources are defined by constraints including purchased gas. Some peaking contracts have minimum levels that must be taken during an agreed-upon period of time which would be translated into a "greater than or equal to" constraint. Constraints must be carefully defined to accurately reflect the problem being solved. The arbitrary removal of required constraints results in an inaccurate solution. For example, if the constraint on how quickly the Company's capacity at the Clay Basin storage facility can be refilled were to be removed, the model would assume that it could be done instantaneously, resulting in an unrealistic solution. The removal of all constraints in a linear programming problem results in no solution being obtained. Questar Gas periodically reevaluates the constraints in its SENDOUT model to determine if they accurately reflect the realities of the problem being solved. The consultant from Ventyx, who is familiar with Questar Gas' use of the SENDOUT model, has indicated that he sees "no evidence that the Questar model is unduly constrained." (See Exhibit 9.1).

Monte Carlo Method

When performing Monte Carlo analysis, the length of computer run times can become an issue. To have a meaningful simulation, it is important to have a sufficient number of draws (typically hundreds). Each draw consists of one deterministic linear programming computer run. With the complexity of the Company's modeling approach, one simulation usually takes several days to run. The base Monte Carlo simulation developed by the Company this year utilized 1,095 draws.

When the developers of SENDOUT incorporated the Monte Carlo methodology, they limited the number of variables for which stochastic analysis can be applied to avoid excessive computer run times. The two variables which they appropriately determined should be included are price and weather (within SENDOUT demand is modeled as a function of weather). No other variables have a more profound impact on the cost minimization problem being solved by SENDOUT than these two.

The output reports generated from the SENDOUT modeling results consist primarily of data and graphs. Most of the graphs are frequency distribution profiles from a Monte Carlo simulation. Many of the numerical-data reports show probability distributions for key variables in a simulation run. The heading "max" in these reports refers to the value of the draw in a simulation with the highest quantity. The heading "min" refers to the value of the draw in a simulation with the lowest quantity. The heading "med" refers to the median draw (or the draw in the middle of all draws). Questar Gas believes that the median value is a good indicator of the most likely occurrence, given the underlying assumptions in a simulation. Also in these data reports are the headings "p95," "p90," "p10," and "p5." The label "p95" on an output report means, based on input assumptions, that a 95 percent confidence exists that the resulting variable will be less than or equal to that number. Likewise, a "p10" number suggests that there is a 10 percent likelihood that a variable will be less than or equal to that number. These statistics and/or the shape of a frequency curve help define the range and likelihood of potential outcomes.

Natural Gas Price

The price for which natural gas supplies can be purchased in the future is extremely difficult to model with any level of accuracy. It is not atypical for the best industry forecasts to be off for periods of time by orders of magnitude. Most of the natural gas purchased by

Questar Gas is tied contractually to one or more of nine area price indices. Three of those indices are published first-of-month prices for deliveries to the following interstate pipeline systems; Kern River, Questar Pipeline, and Northwest Pipeline. The remaining six are published daily indices for Kern River (3), Questar Pipeline, Northwest Pipeline, and Colorado Interstate Gas. To develop a future probability distribution, Questar Gas assembled three years of historical data and determined the means and standard deviations associated with each price index. Questar Gas then utilized the average of two long-term price forecasts developed by Global Insights[1] and CERA[2] as the basis for projecting the stochastic modeling inputs. Forecasted standard deviations have been scaled up pro rata based on prices to more accurately mirror reality. Exhibits 9.2 through 9.37 show, for the first model year, the resulting monthly price distribution curves for the first-of-month prices and the daily prices for each of the nine price indices used in the base simulation.

Weather and Demand

In addition to the price of natural gas, the other single most unpredictable variable in natural gas resource modeling is weather induced demand. Questar Gas makes available to the SENDOUT model 79 years of weather data. When forecasting future demands, heating degree days are calculated from the weather data base which, along with usage-per-customer-per-degree-day and the number of customers, is used to calculate the customer demand profile used by the model. For each month of simulation, the model randomly selects a monthly-degree-day standard-deviation multiplier to create a draw-specific monthly-degree-day total. It then scans through 79 years of monthly data to find the closest match. Then the model allocates daily degree-day values from the draw-specific monthly value. Exhibits 9.38 through 9.50 show first the annual and then the monthly demand distribution curves for the first year of the base simulation.

In prior years, before Questar Gas utilized Monte Carlo modeling techniques, a high demand and a low demand scenario were modeled as part of a sensitivity analysis. Currently, with the use of a Monte Carlo modeling approach, the wide variability in weather-induced demand resulting from historical weather data is broader than any reasonable range of load growth scenarios. This year there are 1,095 deterministic cases in the Monte Carlo simulation, each with a different demand level, thus obviating the need to model just one high and one low demand case.

Peak Day and Base Load Purchase Contracts

An important consideration in the modeling process is the need to have adequate resources sufficient to meet a design-peak day. The design-peak day for the 2009/2010

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[1] Global Insight, a worldwide forecasting company, has over 3,800 clients in industry, finance, and government. Global Insight has 700 employees and 25 offices in 14 countries.

[2] Cambridge Energy Research Associates, Inc. (CERA) is a leading advisor to international energy companies, governments, financial institution, and technology providers. CERA has a staff of 200 employees in nine offices worldwide.

winter-heating season has been determined to be 1.256 million Dth per day at the city gates. The design-peak day for many years has been defined to be a 1-in-20-year weather occurrence. The most likely day for a design peak to occur is on January 2, although, the probability of a design peak occurring on any day between mid-December and mid-February is relatively flat. Even though it is unlikely that a design-peak day will occur this year, the Company must be prepared to meet such a need should it occur. Selecting a draw from a Monte Carlo simulation that utilizes on the maximum demand day a level of resources approximately equaling the design-peak day has proven to be problematic in that the SENDOUT model selects too much base-load purchased gas for a typical weather year. The draws which have a design-peak-day occurrence also tend to be much colder than normal throughout the entire year. The solution to this dilemma is to perform a statistical clustering analysis of all the Monte Carlo draws for first-year peak demand versus the median level of first-year annual demand. The results of this clustering exercise are then used to determine the optimal mix of purchased-gas resources from the cluster that most closely meets both the design-peak day and median annual demand for the first model year. The optimizing nature of the SENDOUT model ensures that adequate purchased gas resources at the least cost will be available in the remote event that a design-peak day were to occur. Most of the base-load-purchased-gas resources, with their associated time-availabilities, must be committed to during the springtime, prior to the beginning of the gas supply year, to be ready for cold weather in the fall. Patterns of usage for storage resources, spot gas, and cost-of-service gas do not need to be committed to before the gas year begins. This modeling approach also lends itself to performing operational analysis periodically during the year as natural gas prices change.

Exhibit 9.51 shows the resources utilized to meet the design-peak day. Exhibit 9.52 shows the firm-peak-day demand distribution for the base simulation for the first plan year. Understandably, the design-peak day for Questar Gas is in the upper tail of the curve.

Base Case Identification

Whenever one draw of a stochastic analysis is identified as a base case, there is a general tendency to assume that there is a greater likelihood of all the attributes of that draw occurring than actually exists. Nevertheless, it is useful to identify a base case for ease of discussion and to facilitate the measurement of deviations.

In determining a base case, Questar Gas made available to the SENDOUT model, all of the optimal purchase gas resources selected to meet the design-peak day occurrence as described previously. Then, another Monte Carlo simulation was performed. Re-running the simulation allowed the model for each draw, to size the appropriate level of purchased-gas resources from packages which, for the most part, will actually be under contract. Inevitably, when purchased-gas RFP responses are made, a few of the deals will fall through for a variety of reasons. These deals can usually be replaced under fairly similar terms.

There are a number of criteria, however, that could probably be used to determine a base case from the simulation. The draw with the median demand level could be used, for example, but that draw will not be the same as a draw with the median price for any one of the nine price distributions used, and vice versa. Questar Gas developed an algorithm this year to systematically select its base case. Using the distributions for 21-year total cost, first year demand, first-year purchase gas and first-year cost-of-service gas, each distribution was ordered from least to greatest result value. Then, in the stated order above, starting with the median value, a window of draws was selected centered at the median. Those selected draws were then taken as the starting point to look in the second distribution with the same size window for matches. If matches were found, then those were taken to the third distribution as the starting point. The first draw that was found within the window and that existed in all distributions was selected as the base case. When no match was found from one distribution to the next, the process started over and the bounds of the window were increased to include the next highest and next lowest draws.

Purchased-Gas Resources

Exhibits 9.53 through 9.64 show the probability distributions for purchased gas for each month of the first plan year from the base simulation. Exhibit 9.65 shows the annual distribution from the simulation. Exhibit 9.66 shows the numerical monthly data with confidence limits. The sum of the median monthly totals for purchased gas for the first plan year from the base simulation is approximately 73.8 million Dth. Questar Gas is confident that for a colder-than-normal year, sufficient purchased-gas resources will be available in the market. Likewise, Questar Gas is confident that in the event of a warmer-than-normal year, it has not “over-bought” base-load purchase contracts.

Cost-of-Service Gas

Another important output from the SENDOUT modeling exercise each year is a determination of the level of cost-of-service gas to be produced during the upcoming gas-supply year. Exhibits 9.67 through 9.78 show the distributions for cost of service gas for each month of the first plan year from the base simulation. Exhibit 9.79 shows the annual distribution from the simulation. Exhibit 9.80 shows the numerical monthly data with confidence limits. The sum of the median monthly totals for cost-of-service production for the first plan year from the base simulation is approximately 51.0 million Dth.

First-Year and Total System Costs

The linear-programming objective function for the SENDOUT model is the minimization of variable cost. A distribution curve for first-year total cost from the base simulation is shown in Exhibit 9.81. The first year median total from the base simulation is approximately $656.4 million. A similar curve for the total 21-year modeling time horizon is shown in Exhibit 9.82. The median cost for this time period is approximately $11.7 billion.

Gas Supply Plan

Exhibits 9.83 through 9.86, show additional planning detail for the first two years of the base case. Monthly data for each category of cost-of-service gas and each purchase-gas package are listed. Also included are injections into and withdrawals from each of the four storage facilities utilized by the Company. Although no actual gas-supply year will ever perfectly mirror the plan, these exhibits are among the most useful products of the IRP process. They are used extensively in making monthly and day-to-day nomination decisions.