
Application of Statistical (Monte Carlo) Simulation to Energy Cost Projection, Budgeting, and Value at Risk Analysis

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Introduction

Motivation

Energy (electricity and natural gas) cost projection, budgeting, and value at risk analysis for companies with multiple facilities in multiple states and service territories are extremely difficult. Not only must the energy cost manager judge future rate increases for multiple component tariffs in many utility territories, but he or she must then combine them appropriately with consumption projections and contract prices to project overall budget expenditures.

Most such companies attempt to gauge annual overall portfolio historical trends, query utility account representatives about anticipated rate increases, and then adjust overall budget increases more or less subjectively to project a budget for the upcoming fiscal year. Some of the many difficulties are that a significant fraction (often more than half) of rates, in both regulated and deregulated territories, is driven more or less directly by commodity or fuel costs as a pass-through, responses from account representatives are spotty, utility management—let alone account representatives—can seldom predict accurately rate increases other than the most imminent, and combining a large number of individual potential rate increases appropriately is not a very tractable analytical task.

Overview

Theoretical Bases

The model that was developed and is described herein employs the following approaches in order to address more effectively the challenge of energy cost projection, budgeting, and value at risk analysis for companies with multiple facilities.

Detailed research and analysis were conducted of 300-400 distribution company rates including the salient larger utilities in all states and representative analysis for smaller, lower-impact markets (for example, using 2-3 of the 20 plus public utility districts in Washington to characterize overall group behavior), and generalized behavior as appropriate (for example default gas supply prices in groups of distribution company territories). The research and analysis were based on characterization of the state regulatory regime, utility rate structure and approach, Energy Information Administration (EIA) generation mix data, EIA historical rate data, Edison Electric Institute (EEI) typical data, and, where necessary, representative tariff rate and fuel adjustment calculations.

Individual potential projected rate increases were developed first in terms of the fraction of projected rates (RF) that are dependent more or less directly on commodity or fuel costs and those that are not. Then projected non-fuel or non-commodity rate increases were characterized in terms of most probable (RNF_{mp}), maximum (RNF_{max}), and minimum values (RNF_{min}) for each projection year. Fuel-/commodity-related rate components were based on commodity (natural gas, coal, etc.) historical and projected costs.

Energy contracts were modeled based on their individual characteristics, e.g., fixed price or indexed.

The resulting rate increase projections were folded together with projected facility by facility consumption information (including planned facility opening and closing).

Base year rates were calculated for each facility using base year costs and consumption. Future year rates were then projected forward starting with the base year rates at time zero.

Trending and statistical analysis of historical consumption data, along with adjustments to account for planned changes in usage due to conservation measures can be used, but were not an integral part of model developed and described here, to project consumption, depending upon the availability of data and analysis to the user.

Individual market behaviors were then projected forward and combined using statistical (Monte Carlo) simulation (random variable sampling driving probability distribution functions) to produce probability distributions for overall cost projections.

It is important to recognize that, as with other methods, the projections were based on judgment regarding future rate changes and commodity prices. However the combination of large numbers of smaller scale detailed judgments and the application of statistical simulation in the model would be expected to provide greater detail, greater full cost portfolio accuracy, better defined analytical results in terms of risk, and greater confidence in projections than other approaches.

The model was Excel-based and allowed inputting of a range of data, independently running the models, specifying confidence levels, validating or modifying key assumptions based on the user's own judgment, updating the models, and modifying the models as desired.

The model integrated use of the @Risk® Excel® add-on application developed by Palisade.

The projected values were used, on a facility by facility basis, to compare to actual usage and costs, determine variances, and adjust budgets and projection as appropriate.

Functional Product Elements

Rate Research Database

The bases for the rate research and analysis—overall state and utility regulatory regime and approach, EIA generation mix, EIA historical rate data, EEI typical bills, rate case history, and estimate fuel fractions (RF), most probable (RNF_{mp}), maximum (RNF_{max}), and minimum values (RNF_{min}) non-fuel/commodity-rate increases, as well as discussion supporting the estimates were documented in two forms: portable document format (pdf) and an online Access® database.

Online Access database

The online Access data base included the database form of the rate estimates provided as utility rate profiles that facilitate association of utility profiles to individual facilities. The database also included individual facility account and consumption data. The database also included contract profiles that can be associated with individual

facilities. The database facilitated management of the energy cost data for multiple facilities in multiple utility markets.

Excel spreadsheet

All of the facility, utility, and contract data were structured in a form that enabled easy downloading to an Excel workbook template preformatted with formulas for individual and overall rate and cost projections. Sheets included detailed simulation sheets for electricity and natural gas and summary sheets for each commodity that could be customized to user needs and desires

@Risk Add-on

@Risk is an Excel add-on product developed and licensed by Palisade Corporation. @Risk enables incorporation of probability distribution functions in individual Excel cells, random variable sampling for independent variables of those probability distribution functions, iterative simulation of scenarios for each set of random variable samples, multiple scenario iterations, enveloping of large numbers of individual samples to develop output probability distributions, and testing of convergence for key output measures. @Risk also allows easy replacement of probability distribution functions with expected (or other single) values.

Rate Research and Analysis Details

The rate research and analysis included the following:

- Overall state and utility regulatory regime and approach,
- EIA generation mix,
- EIA historical rate data,
- EEI typical bills,
- rate case history,
- estimated fuel fractions (RF),
- which commodity predominantly drives fuel-/commodity-related rates,
- estimates for most probable (RNF_{mp}), maximum expected (RNF_{max}), and minimum expected (RNF_{min}) non-fuel/commodity-rate increases values, and
- discussion supporting the estimates provided in two forms.

Each source, element, and output is described in greater detail in the following subsections. Figures 1 and 2 provide examples of the pdf form of the research and analysis documentation.

Figure 1 Rate Research Input

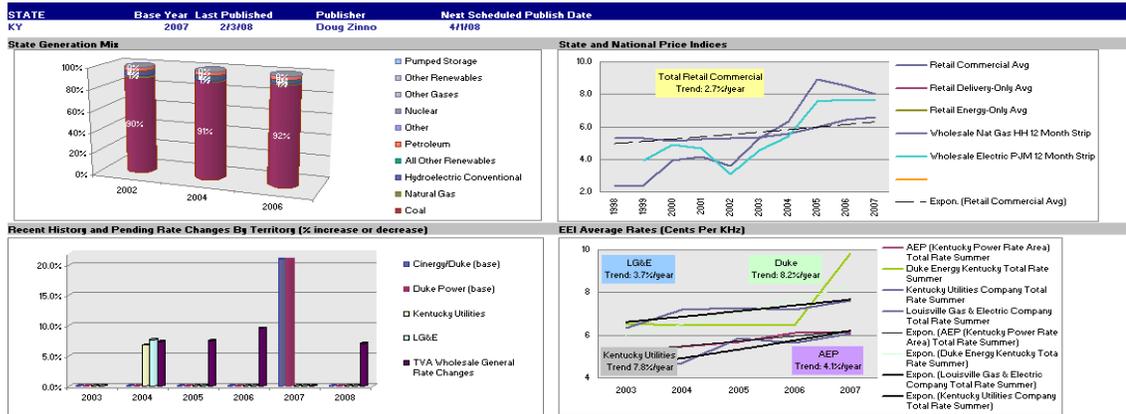
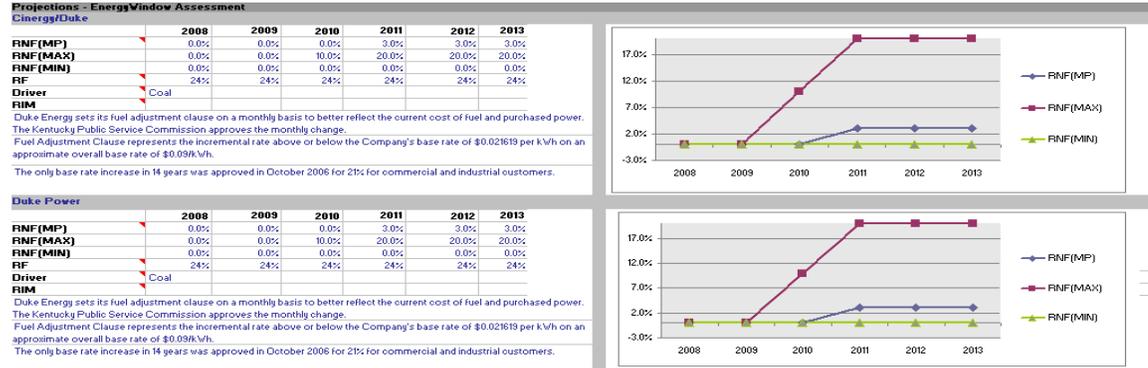


Figure 2 Rate Research Results



State Overview

The state overview discussed the state regulatory regime and status, whether the state is regulated, deregulated or in transitions status, the regulatory body(ies), the general regulatory processes, the method and frequency of setting default supply rates in deregulated states, and whether rates include a fuel adjustment. References and links to relevant web sites were also provided.

Generation mix

EIA generation mix data by state were directly imported into the model. The generation mix influences the selection of fuel-/commodity-cost drivers. The EIA data are available on line. The upper left panel in Figure 1 provides an example of the presentation of the data. While the generation mix varies considerably from state to state, natural gas costs tend to drive commodity and fuel costs in the entire continental US. Even in states with predominantly nuclear, coal, or hydro generation, retail supply rates and fuel adjusted components show strong correlation to and heavy dependence on wholesale natural gas prices. Only in states with a substantial majority of coal generation, for example, are these rates driven by coal prices. This analysis was used

to support the judgment as to which commodity should drive fuel-/commodity-related rate components.

EIA Rate Trends

EIA publishes historical annual rate trend data for residential, commercial, and industrial rate classes for energy, delivery, and bundled rates for each state. The data are available online. The data were plotted and then exponential rate trends were regression fit to the data in order to gain a sense of underlying rate trends in the state. Wholesale energy prices were also plotted for comparison. The upper left panel in Figure 1 illustrates the research documentation.

EI Typical bill data

The Edison Electric Institute publishes semi-annually typical bill data for investor-owned utilities by customer class, state, company, and region with breakdowns by generation, transmission, and delivery including fuel adjustment clause data.¹ The data were plotted and then trended using regression fitting. The lower right panel in Figure 1 provides an example of the figures provided in the research documentation.

Rate Structure and Case Review

An overall review of rate history and changes was conducted. As much as possible, consideration was given to frequency, time delay between request and approval, rate approved versus rate requested, the pattern of periodic versus interim changes, and whether rates include fuel adjustments. In many cases, particularly for smaller utilities, detailed rate information was not readily available. In these cases, press releases, annual reports, and telephone conversations and other indirect information sources were used to estimate rate trends and provide a basis for judgments about future rate changes. For the smaller municipal utilities, cooperatives, rural electric associations, etc., representative utilities were used to characterize all similar utilities in the state.

Fuel and Commodity Costs

One of the most important analyses for the model was analysis of fuel- or commodity-driven rate components. In regulated utilities, these are described variously as fuel or energy costs adjustments, whereby regulatory bodies allow utilities to pass through to customers the cost of fuel or commodities at frequencies ranging from monthly to annually. In deregulated utilities, these are the majority of default supply service costs (some smaller supply costs components are not driven directly by commodity costs). These costs are generally driven through auctions or other market driven mechanisms. Analysis included variously example tariff analysis, review of

¹ See http://www2.eei.org/products_and_services/descriptions_and_access/typ_bill_winter_5.htm.

energy adjustment frequency and timing, estimation of the fraction of supply costs that are or are not driven by fuel-/commodity-costs

Additional information

Market, legislative, and regulatory information for each utility was also documented.

Rate characterization

The results of the rate research and analysis for each utility for all future projected years were the following. It is important to note that these output parameters were judgments based on the input data, research, and analysis.

- Fuel fraction (RF), defined as the percent of the total rate driven by fuel or commodity prices. Note that this is a fraction, not a rate increase.
- The dominant commodity driver (in most cases natural gas or coal)
- Non-fuel rate increases (RNF_i), defined as the estimated rate increase in percent for each projection year.
 - Most probable (RNF_{mp})
 - Maximum (RNF_{max})
 - Minimum (RNF_{min})

A discussion in support of the judgments for each parameter was also provided. The values were provided in both tabular and, for RNF, graphic form.

Format

The research and analysis results above were maintained in spreadsheet format and then converted to pdf format for each state. The parameters and notes were also maintained in the online database described in the next section.

Database

Overview

All utility, facility, and contract data for electricity and natural gas were input into an online Access database that facilitated maintenance, association, and manipulation. All data could then be modified by the user. A baseline database and change history were maintained to facilitate configuration control. While modifications to the database structure and controls required Access, the user could manage and manipulate the data with a run-time reader. All data in the Access database was then easily and quickly downloadable to the statistical simulation workbook. Figures 3, 4, 5, and 6 provide examples of the database presentations for main navigation, utility, facility, and contract data (only electricity is illustrated; the format is similar for natural gas).

Figure 3 Access Database Main Navigation Page

Main Switchboard

- Electric Usage
- Electric Utility Projection Profiles
- Electric Contracts
- Natural Gas Usage
- Natural Gas Utility Projection Profiles
- Natural Gas Contracts

Figure 4 Utility Profile Database

ProfileID: 202 VA_Dominion Virginia Power RFIIndex: Electric (Natural Gas (HH12))

Yr 1 Yr 2 Yr 3 Yr 4 Yr 5 Yr 6

RNFmax: 0.0% 10.0% 6.0% 1.0% 1.0% 1.0%
 RNFmin: 0.0% 15.0% 7.0% 2.0% 2.0% 2.0%
 RFI: 0.0% 5.0% 3.0% 0.0% 0.0% 0.0%

Supply Status: Bundled Adjustment Month:

Projection Notes: Dominion's fuel rate comprises about 20% of a typical electric bill and is adjusted each year, beginning July 2007, an each subsequent July 1 (for 2008 RFI - 4% increase x 20% of bill = 1%). Estimated 2009 base rate increase is calculated by comparing the current cost per kWh of neighboring state utilities (8 cents) versus current rates of Dominion (6.9 cents), assuming a base rate case is presented. Rate increases expected to be modest for base rates from 2008-2009.

State	ProfileID	Yr1_RFI	Yr2_RFI	Yr3_RFI	Yr4_RFI	Yr5_RFI	Yr6_RFI	Supply Stat	Comments				
VA	VA_Allegheny (Potomac Edison)	4.0%	0.0%	6.0%	10.0%	4.0%	0.0%	6.0%	10.0%	4.0%	0.0%	Bundled	On 12/20/07, the SCC allowed
VA	VA_Appalachian Power Co	4.0%	0.0%	4.5%	10.0%	4.0%	0.0%	4.5%	10.0%	4.0%	0.0%	Bundled	Approved Base Rate Increase
VA	VA_Co-ops	0.0%	50.0%	2.0%	4.0%	0.0%	50.0%	2.0%	4.0%	0.0%	50.0%	Bundled	Co-ops are non-profit organiz
VA	VA_Delmarva	2.0%	0.0%	4.0%	10.0%	2.0%	0.0%	4.0%	10.0%	2.0%	0.0%	Unbundled	Delmarva has sold its VA asse
VA	VA_Dominion Virginia Power	0.0%	20.0%	1.0%	2.0%	0.0%	20.0%	1.0%	2.0%	0.0%	20.0%	Bundled	Dominion's fuel rate comprise
VA	VA_Old Dominion Power	4.0%	6.0%	6.0%	8.0%	4.0%	6.0%	6.0%	8.0%	4.0%	6.0%	Unbundled	Not regulated, no need to file r
VT	VT_Central Vermont Pub Serv Corp	1.0%	5.0%	20.0%	30.0%	5.0%	3.0%	7.0%	1.0%	5.0%	5.0%	Bundled	CVPS gets more than 50% of gr
VT	VT_Green Mountain Power Corp	1.0%	5.0%	20.0%	30.0%	5.0%	5.0%	3.0%	7.0%	1.0%	5.0%	Bundled	More than 75% of generation i
VT	VT_Other Co-ops & Municipalities	1.0%	5.0%	20.0%	30.0%	5.0%	5.0%	3.0%	7.0%	1.0%	5.0%	Bundled	Vermont has very low 'Fuel Co
WA	WA_Arista	1.0%	10.0%	2.0%	5.0%	1.0%	10.0%	2.0%	5.0%	1.0%	10.0%	Unbundled	Arista has requested a base r
WA	WA_PacifiCorp	1.0%	10.0%	3.0%	5.0%	1.0%	10.0%	3.0%	5.0%	1.0%	10.0%	Bundled	PacifiCorp is one of the lowest
WA	WA_Public Utility Districts	0.0%	0.0%	2.0%	5.0%	0.0%	0.0%	2.0%	5.0%	0.0%	0.0%	Unbundled	PUDs generally have no fuel a
WA	WA_Puget Sound Energy Inc	1.0%	5.0%	8.0%	9.0%	1.0%	5.0%	8.0%	9.0%	1.0%	5.0%	Unbundled	Puget Sound rates are about 3
WI	WI_Alliant Wisconsin Power & Light	2.0%	0.0%	4.1%	8.0%	2.0%	0.0%	4.1%	8.0%	2.0%	0.0%	Bundled	2009 projected increase in bi
WI	WI_Excel NSP	3.0%	0.0%	6.8%	10.0%	3.0%	0.0%	6.8%	10.0%	3.0%	0.0%	Bundled	No published rate information

Figure 5 Facility Database

Site: 10034-Yuma Status: Active State: AZ Vendor: APS/Arizona Public Service Base Year Ending: 12/31/2008 Site Usage Notes:

Base Year Monthly Usage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
102,887	95,265	110,008	110,272	131,920	146,250	165,787	155,783	142,149	142,200	144,106	125,123	

Base Year Totals: Cost With Tax: \$151,958.96 Unit Cost \$: \$0.097 Total Usage: 1,567,750 Annualized Adjustment: Unit Cost \$: Adj Annual Usage:

Forward Projections: Projection_Profile_Name: # of Sites: Yr1_Usage: Yr2_Usage: Yr3_Usage: Yr4_Usage: Yr5_Usage: Yr6_Usage:
 AZ_Arizona Public Service Co 1,567,750 1,567,750 1,567,750 1,567,750 1,567,750 1,567,750

Supply Contract:

ID	Site Name	State	Vendor	Projection_Profile_Name	SiteStatus	Supply	Base Year 1	Total Usage	Cost With Tax	Unit Cost \$	Cost Per
1451	10456-Fort Smith	AR	OG&E-Oklahoma Gas & Elec	AR_Oklahoma Gas & Electric C	Active		12/31/2008	1,101,460	\$79,110.87	\$0.072	
99	10455-Fayetteville	AR	AEP/24422-Southwestern Ele	AR_Southwestern Electric Pow	Active		12/31/2007	1,267,285	\$72,413.49	\$0.057	
101	10457-Rogers	AR	AEP/24422-Southwestern Ele	AR_Southwestern Electric Pow	Active		12/31/2007	1,210,200	\$67,460.79	\$0.056	
1450	10455-Fayetteville	AR	AEP/24422-Southwestern Ele	AR_Southwestern Electric Pow	Active		12/31/2008	1,181,744	\$80,068.43	\$0.068	
1452	10457-Rogers	AR	AEP/24422-Southwestern Ele	AR_Southwestern Electric Pow	Active		12/31/2008	1,170,012	\$78,180.62	\$0.067	
1077	10034-Yuma	AZ	APS/Arizona Public Service	AZ_Arizona Public Service Co	Active		12/31/2008	1,567,750	\$151,958.96	\$0.097	
115	10638-North Phoenix	AZ	APS/Arizona Public Service	AZ_Arizona Public Service Co	Active		12/31/2007	1,499,100	\$138,852.77	\$0.093	
1617	10638-North Phoenix	AZ	APS/Arizona Public Service	AZ_Arizona Public Service Co	Active		12/31/2008	1,492,286	\$145,576.12	\$0.097	
Total								2,470,829,952	\$221,280,996.07		

Figure 6 Contract Database

Contract Name: Con Edison Solutions / NY_LPA
 ContractStart: 11/1/2006
 ContractEnd: 11/1/2009
 PriceType: Indexed Supply Price
 IndexRatio: 100.00%

Supply Price: BaseYr: 0.115
 Yr1:
 Yr2:
 Yr3:
 Yr4:
 Yr5:
 Yr6:

ContractBaseYr_RF: 57.80%
 ContractUtilityBaseYr_CPUBvTax: 0.118

ContractProfileNotes: Revised base year upward 9-27-08 based on analysis from AIQ

Contract Name	ContractStart	ContractEnd	PriceType	IndexRatio	BaseYr	Yr1	Yr2	Yr3	Yr4	Yr5
Con Edison Solutions / NY_LPA	11/1/2006	11/1/2009	Indexed Supply Price	100.00%	0.115					
Constellation NewEnergy / CT_Northeast Utilities (CLAP)	10/1/2007	10/1/2013	Fixed Supply Price	100.00%	0.1055	0.1161	0.1224	0.1224	0.1224	0.1224
Constellation NewEnergy / CT_United Illuminating	10/1/2007	10/1/2013	Fixed Supply Price	100.00%	0.1055	0.1161	0.1224	0.1224	0.1224	0.1224
Constellation NewEnergy / OR_Portland General Electric Co	1/1/2008	1/1/2010	Indexed Supply Price	100.00%	0.0655					
Constellation NewEnergy / IL_Con Ed	3/1/2006	1/1/2010	Fixed Supply Price	100.00%	0.0666	0.0694	0.0629			
Direct Energy Services / MD_Allegheny (Potomac Edison)	5/6/2006	5/1/2011	Fixed Supply Price	100.00%	0.0855	0.08789	0.08708	0.0846	0.0831	
Direct Energy Services / MD_Baltimore Gas & Electric Co	5/6/2006	5/1/2011	Fixed Supply Price	100.00%	0.0855	0.08789	0.08708	0.0846	0.0831	
Direct Energy Services / MD_Potomac Electric Power Co	5/6/2006	5/1/2011	Fixed Supply Price	100.00%	0.0855	0.08789	0.08708	0.0846	0.0831	
Energy Cooperative Of New York, INC / NY_Rochester Gas & Electric	6/1/2006	1/1/2009	Indexed Supply Price	100.00%	0.09					

Facility and account information

The facility (Usage Data) database included the following information for each facility:

Facility name and number
Utility account number
State
Consumption data for the base and each projection year
Monthly consumption data for the base year
Projected annual consumption
Cost and unit cost data for the base year
Association with utility profile
Association with contract profile, when applicable
Notes

Utility Profile

The utility profiles contained the following data for each utility:

Factors for each year:
RF
RNF _{mp}
RNF _{max}
RNF _{min}
RF Index (commodity driver)
Bundled, unbundled
Adjustment month
Notes
Link to research pdf file

Contract Profile

The Contract database contained the following data for each contract and/or transaction confirmation

Contract name
Start and end
Type: Fixed, indexed, block/index, etc.
Rate by year including the base year
Base year rate for indexed contract
Base year RF
Utility base year default rate
Index ratio (to adjust index contract proportion to commodity driver
Notes

Statistical Simulation (Monte Carlo)

Overview

The data from the online Access database were downloadable to an Excel workbook. The workbook contained four spreadsheets: detailed simulation spreadsheets and summary spreadsheets for electricity and natural gas. The simulation spreadsheets contained the downloaded input data, the formulas for simulating the rate projections, intermediate results for each projection year, and final results for each projection year column-wise. Data and results were organized one account or one utility per row. The summary spreadsheets were customizable presentations of selected specific or aggregate results. The summary spreadsheets also contained key input parameters such as mean return (annual increase) and volatility values for commodities for each projection year.

Simulation Sheet Input Sections

The data that could be downloaded from the online Access database were segregated and clearly identified by blue color shading. The data could be easily updated to reflect changes in the Access database by selecting the upper-left-most cell and clicking Data, Refresh All. Current data would then be downloaded.

Model Formulas and Details

Formulas were developed for each facility or utility for calculating various components of rates and costs starting with base year values: fuel-related rates for the fraction (RF) of rates driven by commodity costs, non-fuel-/commodity-related rates, contract supply rates (for indexed or fixed rates), default supply rates (which must be calculated for modeling supply costs during periods following contract expirations), total rate, and, by multiplying by projected consumption, total cost.

The difference of approach for statistical (Monte Carlo) simulation was that fuel/commodity rates and non-fuel/commodity rates were modeled with probability distributions rather than discrete single values. This was accomplished using the functions available by means of @Risk (discussed further in the next section).

For fuel/commodity price behavior the Geometric Brownian Motion (GBM) model was used. This statistical model used the combination of a mean return (% increase per year) plus a normally distributed random variable characterized by volatility (annualized standard deviation). The mean return (% increase per year) was based on a mean calculated by regression analysis of commodity data or specified by the user; the mean may or may not be a constant over multiple years. The formulas describing this model are provided here.

$$dP/P = \mu dt + \sigma dZ$$

where, P is the commodity price,

μ is the commodity mean return (% change per year),

σ is the commodity volatility (annualized standard deviation),

$dZ = e \sqrt{dt}$, and

e is a normally distributed random variable.

After some mathematical manipulation the formula for P(T), the commodity price at time T, is equal to

$$P(T) = P(0) \exp\{\mu - \sigma^2/2\}T + \sigma e[\sqrt{T}]\}$$

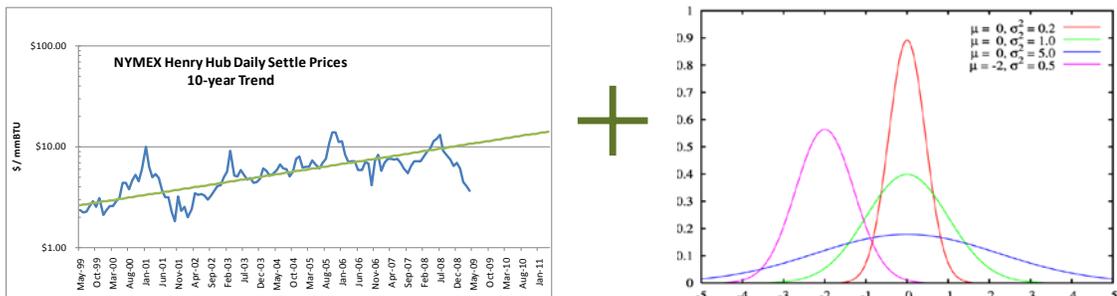
where P(0) is the price at time 0 (or the end of the previous period).

The @Risk function RiskNormal is used for the random variable, e.

Sqrt and exp are the square root and exponential functions.

The graph in Figure 7 is a depiction of the model.

Figure 7 Depiction of the Geometric Brownian Motion Model



The use of the GBM is a common approach used frequently for characterizing commodities, securities, and other market values. It is one of the underlying assumptions for option pricing theory such as the Black-Sholes theory.

For Non-fuel/-commodity rates a simple triangle probability distribution function was used. The function was specified using RNF_{mp} , RNF_{max} , and RNF_{min}

The formula for the triangle probability distribution function, f(r), for rate change r, is

$F(r) = 2(r - RNF_{min})/[(RNF_{mp} - RNF_{min})(RNF_{max} - RNF_{min})]$ for $RNF_{min} < r < RNF_{mp}$
and

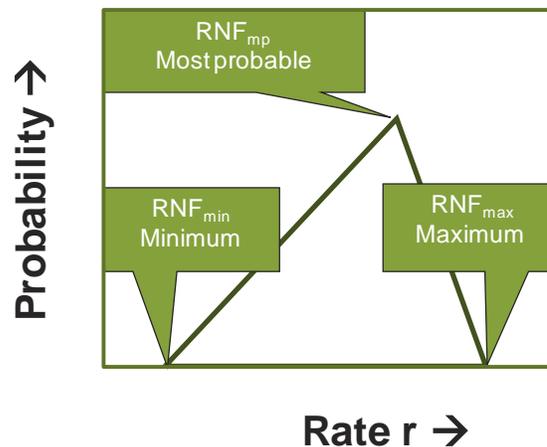
$F(r) = 2(RNF_{max} - r)/[(RNF_{max} - RNF_{mp})(RNF_{max} - RNF_{min})]$ for $RNF_{mp} < r < RNF_{max}$.

Note that the mean and most probable values are the same only for the case when

$$RNF_{mp} = (RNF_{max} + RNF_{min})/2, \text{ a symmetric triangle}$$

Figure 8 provides a depiction of the triangle probability distribution function.

Figure 8 Depiction of Risk Triangle Probability Distribution Function



For the simulation, the @Risk function RiskTriang was used.

Other options for probability functions are available in @Risk.

Statistical Simulation

Statistical (Monte Carlo) simulation was accomplished by random variable sampling, applying the random variable as the independent variable in the appropriate probability distribution function, then calculating the value of the probability distribution, and substituting in the appropriate formula. This was performed for each of hundreds of cells to calculate fuel-related and non-fuel-related rates for each facility or utility for each projection time period. The result produced a single scenario or iteration and a set of values and outputs. The process was then repeated for all facilities or utilities for a second iteration. The process was then repeated for large numbers of iterations. The resulting iterative values were used to construct a probability distribution function for specified outputs. After each iteration, the resulting output distribution functions were tested to determine if the results had converged.

Assumptions

Some of the key assumptions in the model were as follows.

The most important assumption was that the judgments made in the research, analysis, and estimation of future rate changes were adequate to project future prices. While judgments at this microscopic level and combination using statistical simulation were likely to produce better results than more macroscopic approaches, it is important to understand that the models were based on these judgments and the assumption that no radical discontinuous changes in market behavior and regulatory approaches would occur.

Future rates could be projected using base year rates and estimated rate changes by utility; differences among utility and facility rate as a result of load profiles, service classes, rate changes, etc., were adequately captured in base year rate differences.

Rate behavior could be approximately modeled by the fuel-/non-fuel components of rate structure.

Electric and natural gas wholesale and retail rates were highly correlated and retail fuels-/commodity-driven rates could be modeled using a small set of commodity prices or indexes.

Fuel-/commodity driven rates could be modeled using the Geometric Brownian Motion model.

Characterizations of non-fuel rate change components could be reasonably well-described by most probable, maximum, and minimum values

Non-fuel rate components were statistically independent (lack cross-correlation). As a result, aggregate probability distribution functions may exhibit somewhat narrower standard deviations than might actually be the case. This assumption could be relaxed with more detailed correlation analysis and modeling.

Fuel-/commodity-driven rate components in different utility territories and regions were fully correlated (100%). In North America, wholesale and retail price correlations are high, often greater than 90%, but not 100%. As a result, aggregate output probability distribution functions will have wider standard deviations than might actually be the case. More detailed price correlation analysis and use of cross-correlation matrixes in @Risk could remove or reduce the impact of this assumption.

Consumption projections reflected actual usage.

Approximations of supply and fuel/commodity driven components behaved similarly for some calculations even though some supply components were not driven very directly by commodity prices (e.g., congestion charges, ancillary charges)

Behavior of default rates were adequately described by a base year rate projected forward using commodity price models.

Contract models, for fixed values and indexed values, described by base or initial contract rates plus commodity price projections, adequately described contract prices.

Outputs

Selected outputs for which probability distribution functions were desired could be specified. @Risk provides the specified outputs in a summary report or as individual distribution functions. These were specified and provided in the simulation spreadsheets for electricity and natural gas.

Summary pages provided aggregate and important results. The summary page could be customized to suit individual user desires.

@Risk Add-on Module

The @Risk Excel add-on developed and licensed by Palisade was used for statistical simulation. See <http://www.palisade.com/risk/default.asp>. Tutorials and references are provided online as a part of the license. The tutorial includes the content outlined below, taken from the online tutorial outline provided by Palisade at <http://www.palisade.com/risk/5/tips/EN/gs/>. More detailed tutorials and references are also available.

Online Tutorial

The following @Risk tutorial is available online.

QUICK START

- 2 Minute Overview

MODEL — Set Up Your Model

- Define Distributions
- Swap Out Functions
- Define Outputs
- Model Window

SIMULATE — Run the Simulation

- Simulation Settings
- Run Simulation

UNDERSTAND — Analyze Simulation Results

- Histograms and Cumulative Curves
- Tornado Graphs
- Scatter Plots
- Scatter from Tornado
- Overlay Results Graphs
- Graph Markers
- Graph Titles
- Customizing Results Graphs

Summary Box Plots and Trend Graphs
Results Summary Window
Data and Statistics Windows
Sensitivity and Scenario Analysis
Reports in Excel

Advanced Features

Distribution Fitting
@RISK Library
Correlate Inputs
Six Sigma Functions

@Risk Features of Particular or Unique Importance to the Model

The following explanations assume a basic understanding of @Risk derived from the tutorials.

The cells and formulas in the spreadsheets could be modified or added to just as with other Excel spreadsheets. Modifying @Risk functions and output specifications would affect results.

The number of statistical simulations could be set to a specific number of iterations or be set to “Auto,” in which case @Risk tests selected statistical parameters to determine if values are converging. The convergence parameters could be set in “Application Settings” in the “Utilities” menu.

Alternative probability functions could be substituted in formulas using the “Define Distribution” menu/icon.

For static calculations without statistical simulation, the “Swap Functions” menu/icon could be used. In this case a single static value is substituted for statistical functions. The selection of the swapped value is made in “Application Settings” in the “Utilities” menu: expected value, true expected value, mode, or percentile.

Additional output could be specified using the “Add Output” menu/icon.