MANAGING RISKS AND EVALUATING OPTIONS

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PURPOSE

This paper represents an introduction to the topic of using options and futures to manage risks in energy utility operations. These topics often involve complicated analyses and nuances, which one paper can only touch. The primary purpose is to provide an overview or an introduction to these new aspects of utility resource management, and utility risk management. The reference list included within this paper is a valuable resource for individuals who wish to move beyond this introductory paper.

HOW DID ENERGY UTILITIES BECOME INTERESTED IN "OPTIONS" AND FINANCIAL HEDGING INSTRUMENTS?

Energy utilities' interests in options and financial hedging instruments are a response to the increasing uncertainty seen in their markets. Over the last two decades uncertainty, and perceived uncertainty, have been on the rise, resulting in changes regarding utility planning. As deregulation (or re-regulation with market-based pricing) has increased, uncertainty has increased in both the price of raw inputs as well as final product (energy) prices. This has produced more rapid consideration and adoption of planning methods that incorporate this increased uncertainty.

Prior the first oil embargo, most utility demand forecasting was performed by straight-line trend analysis. This forecasting assumed stable prices, and was used to develop long-term supply contracts in the natural gas utilities and planning for the construction of large electricity plants in the electric utility field. The price spike of the 1973 oil embargo began changing these practices. A greater uncertainty in energy prices, and therefore a greater uncertainty in energy demand, was recognized. This led to using econometric methods for utility demand forecasting, whereby economic factors and energy prices (and their elasticities) were explicitly included.

Over the last decade natural gas deregulation has been undertaken through several steps. The Natural Gas Policy Act of 1978 set in motion the decontrol of the wellhead price of natural gas. Increasing market-based pricing spread to the pipelines through first Federal Power Commission (FPC) rulings on take-or-pay contract provisions in 1967; then Federal Energy Regulatory Commission (FERC) policy statements and rulings. FERC's Order 436 in late 1985 laid out an optional open access system for natural gas transmission. This rule was replaced in 1987 with Order 500, an interim rule establishing a deadline for take-or-pay settlement proposals. This process led to FERC Order 636 in April 1992, requiring pipelines to unbundle transportation services from gas sales, open access for transmission, and timely access to capacity and pricing information via electronic bulletin boards. (30)

Natural gas was sold according to a specific term, "term transactions", or on the spot market. Term transactions have increasingly been priced based upon a formula or indexed price rather than a fixed price. The monthly term transactions are tied to pipeline nominations.

Natural gas deregulation has given all parties more choices; thus, increasing the complexity of the decisions, and increased the uncertainty of future prices and capacity availability.

The New York Mercantile Exchange (NYMEX) established a futures market for natural gas. Futures are financial (paper) instruments that give its holder the right and the obligation to take delivery of a specified quantity of natural gas at a specified price and location. This financial market is based upon standardized contracts with set delivery points and expiration dates (dates of obligated taking) tied to monthly term transactions.

The paper futures market provides a financial market that allows traders to purchase a hedge against price uncertainty. A consumer of natural gas may wish to purchase insurance against increases in the price of natural gas. This insurance could be in the form of purchasing a futures contract so that future delivery of gas, at the time when they require it, is for a contracted price. The consumer will obtain their natural gas for a guaranteed price (a call for the strike price), insuring their production costs. Conversely, a supplier can purchase a futures contract to sell gas at a specified date in the future, for a specified price at a specified location (a put for the strike price).

Deregulation in electricity is behind that of natural gas, but moving in a similar direction in many ways. A major step was taken with the passage of the Public Utility Regulatory Policies Act (PURPA) in 1978. PURPA provided encouragement for cogeneration and small independent power producers, requiring payments of utility avoided costs to Qualifying Facilities. This significantly opened up the generation market and assisted in advancing the technologies and financing capabilities for independent power producers. FERC began implementing case decisions in the late 1980’s and early 1990’s directed towards a path of wholesale power deregulation and transmission service pricing. FERC allowed market-based pricing to utilities that “voluntarily” offered open access transmission tariffs. Similarly, FERC required open access transmission tariffs in its approval of utility mergers. The Energy Policy Act of 1992 (EPAct92) amended the Public Utility Holding Company Act (PUHCA) and the Federal Power Act, allowing utilities to have ownership in independent power producers (Exempt Wholesale Generators, EWG), and expanded FERC’s authority in ordering utilities to provide transmission wheeling of wholesale power. FERC issued a Notice of Proposed Rulemaking for Open Access of transmission in April 1995. Comments and technical conferences are in process as this paper is being written.

All of these steps in the deregulation in the electric industry, and the movement to market-based pricing greatly increase the uncertainty in the electric industry. As with the natural gas industry, these increases in uncertainty are leading to changes in electric risk management. NYMEX is preparing for an electricity futures market. Yet, given the much larger size of the capital investments in the electric industry; an emphasis on responding to the greater risks seen in making generation investments has taken first priority. That is, the first hedging being done in the electric industry has been in supply option contracts.

Supply option contracts provide the purchaser with the right to buy, for a small initial fee, a specified amount of electricity at a specified location and time in the future, but with no obligation at the time of the contract to make this purchase. It allows the utility to postpone its decision to purchase and, therefore, lower its risk.

DEFINITIONS FOR FINANCIAL HEDGING INSTRUMENTS AND CONTRACTS

Derivatives: All financial instruments that derive their value from an underlying asset are derivatives. These include futures and options (including options on futures). A second more restrictive definition is also used where derivatives are those instruments that contain characteristics of future and/or options with other more complicated contract elements for financial hedging. These other elements may include a price cap, price floor, and other more complicated financial positions (e.g., collars, butterfly spread, calendar spread, straddle, short straddle, etc.). The more complicated derivatives are more difficult to value and often offer less liquidity.

Forwards: Contracts for future delivery and purchase of an asset, primarily a goods contract. Used for financial hedging and operational purposes. Often delivery of the good is taken. These contracts are not sold in federally regulated markets. They are primarily a contract between buyer and seller, though some contracts can be sold to others. Payment occurs with the transfer of the goods.

"Swaps: One party agrees to pay a fixed price, while the other agrees to pay a floating price. Swaps seek to pair companies with opposite risk-preference profiles. Swaps substitute counterparty credit risk for price risk, but usually last longer than futures (e.g., 15 years versus three years for oil futures)." (1) (Swaps in financial markets are not always longer than futures, only in energy markets.) A swap is primarily a goods contract rather than a financial instrument.

Futures: A contract for the purchase of an asset for a specified price (called the strike or exercise price) at a specified date (called the exercise, settlement, or expiration date), primarily a financial instrument. These contracts are standardized and sold in futures markets that are federally regulated. This makes them highly liquid, attracting speculators and again adding to their liquidity. Futures contracts carry an obligation to buy or sell. Unlike forward contracts, futures are subject to daily settlement procedures.

Bilateral Options
Contracts: A future goods contract that allows the buyer the right to purchase the good at a specified price at a specified date, but does not obligate the buyer to make the purchase. These are normally bilateral contracts designed for the buyer and seller, not for resale. They may, however, be resold. An option on a goods contract, not a financial instrument. May include timing such that a level of initial or preliminary work is completed as part of insuring option validity prior to exercise date. The cost of this preliminary work is often covered in the initially paid option fee.

Financial
Options: A call option gives the buyer the right to buy the asset at a specified (strike or exercise) price on a specified (exercise, settlement, or expiration) date, but does not obligate the buyer to buy the asset. A put option gives the seller the right to sell the asset at a specified (strike or exercise) price on a specified (exercise, settlement, or expiration) date, but does not obligate the seller to sell the asset. Options (financial, rather than bilateral contract options) are traded on federally regulated exchanges. A call option allows hedgers to cap the price they are willing to pay. Options are financial instruments that provide price insurance, financial hedging. They are less expensive insurance than futures/forwards because they are only buying the option not the asset itself. If an option is exercised (the good is taken for a call option or sold for a put option), then the purchase

is made for the exercise price. Options prices change with respect to volatility and price changes, making option valuation much more difficult.

AN EXAMPLE OF ENERGY FORWARDS

Jorgensen and Felder (19) describe the operation of the tight power pool in the New England Power Pool (NEPOOL). This economic dispatching of electric generation is based upon an accounting settlement of power transactions and a bilateral forwards market. The forwards market allows members to optimize their power-supply with sales, purchases and exchanges in a way that captures cost responsibilities and minimizes overall member costs. The accounting settlement by NEPOOL provides “last resort” power and incentives for each member to optimize their supply provision. Forwards contracts in NEPOOL range from a few hours to years. As of January 1995, there were more than 1,000 active forwards contracts.

FUTURES

Futures markets are based upon a standardized contract for a future delivery of an asset. This allows the trades to only be negotiated on price. This feature of the futures markets allows financial speculators to be attracted into the market. These additional investments increase the market's liquidity. The high liquidity, in turn, offers flexibility for these commodities.

The clearinghouse plays an essential role in the futures market. Contrary to investments in stocks, the sales of futures are not performed directly between buyer and seller’s agents but through the clearinghouse.

Contrary to forwards contracts, futures are settled daily not just upon delivery of the asset. Buyers and sellers could see losses in their futures (caused by the movement in the spot price as the futures price must equate to the spot price on expiration). Due to this risk, the clearinghouse requires that both buyers and sellers establish a margin account. This security account must consist of near-cash assets, such as Treasury bills. The size of the required margin is dependent on the volatility of the price of the asset. Settlement is made daily. This is called marking to market.

Trading in options and futures offer several advantages and several disadvantages compared to the trading (contracting) for the underlying asset.

The advantages are:

- “Easy adjustment of market exposure;
- Reduction of transaction costs;
- Same-day settlement or simultaneous trades;
- No disruption of underlying-asset management; and
  Creation of specialized risk/return patterns.” (7)

The disadvantages are:

- “Need to understand complex relationships;
- Risk of unfavorable mispricing;
- Possibility of tracking error between futures and underlying portfolio;
- Liquidity reserve required for margin requirements;
- Daily settlement required in marking to market; and
- Potential short-term tax consequences.” (7)

EXAMPLES OF ENERGY FUTURES

Natural gas futures began trading on the New York Mercantile Exchange (NYMEX) in the spring of 1990. The standardized futures contract created by NYMEX for natural gas contains delivery at the Sabine Pipe Line Company's Henry Hub in Erath, Louisiana. Other delivery sales are then often indexed to this.

The availability and use of a futures market can have significant impacts on the underlying asset markets. The oil industry changed significantly after crude oil futures were developed. Baum and Treat claim that "natural gas futures accelerated the development of a fiercely competitive natural gas industry, made spot contracts more efficient, encouraged the development of storage, and enabled new product development (such as capped gas prices to industrial customers) (1)". Hedging has created a large natural gas futures market where gas contracts are seven to ten times the amount of available gas (36). Similar changes are being speculated for the electric industry.

The NYMEX is currently completing its electricity futures contract specifications, and obtaining approval from the Commodities Futures Trading Commission. The futures contract being proposed would allow purchase of "1,500 megawatt-hours at a constant 5 megawatts (plus or minus 2 percent) an hour for 20 business days, during peak hours (7 a.m. to 10 p.m.). The power would be deliverable at 500 kilovolts at the Palo Verde, Arizona bus or the California/Oregon border under Western Systems Coordinating Council rules." (1)

The ability for a futures market to provide adequate (efficient) hedging is dependent upon how well the futures contract measures the underlying asset. The current regional nature of natural gas and electricity may require several futures contracts to be traded. A second natural gas futures contract was approved by federal regulators in May 1995 to be traded on the Kansas City Board of Trade. These futures contracts have natural gas delivery at Valero Energy Corporation's Waha gas interchange in West Texas. (6) Brinkmann and Rabinovitch's (6) analysis provides evidence that the first natural gas futures contract could not fully provide the desired hedge given the regional nature of the U.S. natural gas pipeline system. Their work also suggests that a third natural gas futures contract might be needed.

Additional electricity futures contracts are expected. Different contracts for each inter-connected system could be expected to be created. (A futures market for the eastern and north-eastern parts of the U.S. is expected. However, it is unclear whether the Electricity Reliability Council of Texas, ERCOT, has enough players to make an efficient futures market possible.)

OPTION VALUATION MODELS

It is relatively straightforward to understand that there is value in postponing a decision until there is more information, and the probability of making a costly decision is lowered. However, an essential question is: "How much should be paid for the option to postpone your decision?"

Many utilities are familiar with decision analysis, and its greater capabilities over the prior use of net present value analysis (NPV) for making resource planning decisions. Decision analysis, developed in operations research, derives optimal initial decisions recognizing that initial decisions relate to the consequences to be seen from subsequent temporal decisions. Decision analysis was adopted to include uncertainty in the resource planning analysis. Decision analysis can also be used to evaluate options, the value of reducing uncertainty or the value of having the flexibility to wait for better information. Using DA to value options, however, requires the forecasting of prices and price volatility. Yet, this is where our greatest uncertainty lies.

Modern Finance Theory (MFT) provides us with formulas to value options while only forecasting price volatility, not prices themselves. Black and Scholes (2) developed an oft-quoted derivation that provides an option valuation method that depends only on observable variables. The valuation is based upon comparing financial packages that are in essence equivalent. The value of the package without the option is compared to the known values in the package with the option. The difference is the value of the option. The derivation of the valuation formula, however, is somewhat complicated. First, it assumes that the stock price being examined followed “a random walk process” (a log normal diffusion process)(12). Then the analysis followed the correlation between the price of the stock and the option on it through an argument of its risk-free nature and appreciation at the risk-free rate. From here, a second-order linear partial differential equation provided the formula for the value of the option. This formula was a major step in this field of finance. However, this formula does not always offer closed form solutions.

A simplified formula was derived for easier application by Cox, Ross, and Rubenstein (8). They showed that the Black-Scholes formula could be seen as the limit of binomial choices. This method is called the Binomial model of option valuation. It pre-supposes that the differential formula can be achieved by an infinite number of increasingly small binomial choices. The Binomial model is much easier to work with and can provide solutions when the Black-Scholes formula does not. Nevertheless, the Binomial model also becomes complicated once many time periods are analyzed.

A one period Binomial is often the example used to acquaint individuals with the work. We will begin with assumed market volatility factors of ten percent upward and twenty percent downward. The complete set of assumptions for this first example is as follows:

- Upward Market Volatility Factor (u): 10%
- Downward Market Volatility Factor (d): 20%
- Exercise Price (X): $45
- Risk-free rate (r): 5%
- Price per Unit (P): $50

There are two steps in this simplest form of valuing the option. The first is to construct equivalent financial packages and find the rest of our input information. The second step uses this information to calculate the value of the option.

First, we construct two equivalent financial packages, one with the option and one without. This means the two packages have equal returns. One package is the option, the other is the purchase of goods and borrowings to finance this purchase. These two packages and the above assumptions are used to establish equations that make the packages equivalent in returns in both an up or a down market. At this point, we still do not know the quantity of goods purchased or the amount borrowed. These are obtained by what will give us equivalent returns in both of the possible market occurrences, up and down.

For example:
In an up market, the value of the goods package is: [Q*P*(1+u)] - [B*(1+r)]
In an up market, the value of the option is: [P*(1+u)] - X if > 0, else 0
Substituting in our assumptions --

the value of the up market goods package: (Q*55)-(B*1.05)
the value of the up market option: 55 - 45 = $10
The up market equivalency is: (Q*55)-(B*1.05) = 10

In a down market, the value of the goods package is: [Q*P*(1+d)] - [B*(1+r)]
In a down market, the value of the option is: [P*(1+d)] - X if >0, else 0
Substituting in our assumptions --
the value of the down market goods package: (Q*40)-(B*1.05)
the value of the down market option: 40 - 45 = -5
The option value is less than zero, and
the option is not taken. = 0
The down market equivalency is: (Q*40)-(B*1.05) = 0

We have two equations and two unknowns to solve.
These are: (Q*55)-(B*1.05) = 10 and (Q*40)-(B*1.05) = 0.
Solving for these two unknowns is as follows:
Q*40 = 1.05B, Q = 0.02625B, substituting ⇒ (0.02625B*55)-(1.05B) = 10,
(1.44375B)-(1.05B) = 10, 0.39375B = 10, B = 25.40 substituting ⇒ Q = 0.02625*25.40,
Q = 0.6675

Our second step is to calculate the value of the option from this. This is: O = QP - B. Or, O = (0.6675*50) - 25.40 = 33.3375 - 25.40 = $7.94. The value of the option is $7.94.

Multiple years can be applied as a binomial tree. This looks a lot like a decision tree, where each node to the left is calculated from those at the right. In other words, the binomial tree is worked from right to left. The option value is calculated by taking the difference in the tree without the option, from the value of the one with the option. The option is allowing no negative consequences to occur, since the option would not be taken in these cases. That is, at every leftward node the value can be zero or the expected value. Our second example is from the Lowell article (21), and provided graphically in Figure 1.

Assumptions were made as to the market volatility factors, in this example. These factors are very important and most actual uses of the Binomial model spend a significant amount of the research effort in determining these market volatility factors. The application of this method, therefore, is often a two-step analytical process. The first step being the analysis to estimate the market volatility factors, and the second step being the option valuation.

The market volatility factors are the risk-neutral probabilities, or “martingale” probabilities. These can be determined from the current price, the possible high and low prices, and the risk-free rate.

The possible high and low prices can be obtained from the historical standard deviation in price per time period. These are obtained from the following formulas (26, original cite 8):
$u = e^{\sigma\sqrt{(1/n)}}$ and
$d = e^{-\sigma\sqrt{(1/n)}}$, where:
u = upward movement of price;
d = downward movement of price;
σ = standard deviation of price; and
n = number of time periods.

Traditional Approach

123.4 - 100 = 23.4

50% * 23.4 +
50% * 6.6 = 15

50% * 15 +
50% *-0.7 = 7.2

106.6 - 100 = 6.6

50% * 6.6 +
50% * -7.9 = -0.7

92.1 - 100 = -7.9

Option Theory Approach

123.4 - 100 = 23.4

50% * max[0,23.4] +
50% * max[0,6.6] = 15

50% * max[0,15] +
50% * max[0,3.3] = 9.2

106.6 - 100 = 6.6

50% * max[0,6.6] +
50% * max[0,-7.9] = 3.3

92.1 - 100 = -7.9

Option Value = 9.2 - 7.2 = 2.0

Figure 1. Second Binomial Example (21)

The martingale probabilities are obtained with the following formula (26, original cite 8):

$p = [(1+r)P_{current} - P_{low}]/[P_{high} - P_{low}]$, and 1-p;

where: p = probability and P = price.

These are the very basics of option valuation. It would be far beyond the length of this paper for us to cover the derivation or usage of a full Black-Scholes model. The references given below will allow the reader to move forward, if they so desire.

EXAMPLES OF THE USE OF OPTIONS WITHIN ELECTRIC RESOURCE PLANNING

Several utilities are already using the valuation of bilateral options contracts as part of their electric resource planning. These include:

- Bonneville Power Administration
  RFP in 1992 with goal to option 800 megawatts (mW) to be ready by 1995. They received 60 proposals for over 7,500 mW, and selected three projects from these. They have five combined cycle combustion turbines and 1,090 mW in these three contracts. Five-year lead time has been cut to three years. At this time, no expectation to exercise options. The contractor has an exclusive right to build new generation. BPA pays for pre-construction work, a hold price for exclusive right. Hold periods vary up to ten years. BPA will pay a call price to place a plant in service. BPA can terminate at any time with a termination fee. Given current market, BPA would now use financial market hedges if available instead of the resource options contracts.
- Boston Edison Company
  Received approval in 1995 from the Massachusetts Department of Public Utilities to include an options supply bid in their Integrated Resource Management plan. The DPU approval allows BECo to exercise, or not, their option contracts as they deem fit, with option costs recoverable in rate base. Basically, a policy of prudent management review only and allowing the utility to work out the details. The options allow pre-siting work to be completed, shortening plant lead-times, while delaying the actual commitment of the larger construction monies.
- New England Electric System
  - Evaluated an option for a hydroelectric plant
  - Evaluating buyouts, buying delays, and contract extensions with non-utility generators
- Northern States Power
  Evaluating long-term contracts for selling excess capacity at wholesale with a discount
- Tennessee Valley Authority
  Negotiating with bidders who responded to a Request for Proposal (RFP) for Option Purchase Agreements (OPAs) for Supply

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