

VALUE AT RISK FOR ENERGY: IS VaR USEFUL TO MANAGE ENERGY PRICE RISK?

Carlos Blanco, Ph.D.

December 1998

Financial Engineering Associates

All rights Reserved

(View the article in HTML in [http://www.commodities-
now.com/resource/index.html](http://www.commodities-now.com/resource/index.html))

Introduction

Value at Risk is becoming a standard risk management tool which provides a quantification of the primary risk exposures that a firm faces, and offers crucial information of the overall risk profile of the firm to senior management, traders, shareholders, auditors, rating agencies, and regulators.

It is important to point out that Value at Risk is just a tool to measure and manage risk, and not a goal in itself. It is the process that leads to the calculation of the VaR figures which really adds value to the risk management function, not just the VaR numbers by themselves.

Once the exposures to several risk factors have been identified and quantified, it is possible to analyze how those risk exposures interact with each other, which ones are acting as a natural hedge to the portfolio, and which ones represent the largest sources of risk for the firm. With VaR it is possible to minimize the variability of the firm's earnings, decide which risks are worth taking, and hedge those which may cause "too much" variability to those earnings.

One of the main advantages of VaR is that it constitutes an user-friendly way to present concise reports to the board of directors and comply with regulatory requirements. However, most of the surveys conducted among energy corporations regarding the degree of derivatives trading disclosure conclude that energy companies are in general poor at derivatives disclosure. For example, a recent study by Suningdale Publications that analyzes the most recent annual reports of 31 oil companies, found that only three that use derivatives significantly properly disclose full detail of the risks related to derivatives trading activities.

Usually, energy firms use these derivative financial instruments solely for risk hedging purposes, and it is common to find in annual reports the assertion that "no derivative transactions are held or used for trading purposes". One of the surprising trends in recent months is the statements found in annual reports regarding the deliberate lack of use of derivatives to manage risk, such as "the corporation's exposure to market and credit risks from financial derivatives is considered to be negligible."¹

One of the most common critics to VaR energy firms is that their business activities are very different from the sort of trading that most banks practice. The objective of corporate hedging is to offset exposures and reduce earnings volatility. Energy firm's assets and liabilities are continuously exposed to fluctuations in commodity prices. A firm can hedge its market risk by using derivatives like commodity forward and future contracts, options, commodity swaps, swing contracts, average price options, and other types of exotic derivatives.

A firm will always have natural hedges, but in most cases, it is necessary to manage risk proactively by taking a position in a derivatives contract, insurance, etc, due to the fact that not entering into such contracts will increase the overall risk of the firm. However, a company may be increasing its overall risk by getting into a derivative contract, even though that contract is offsetting a particular risk exposure of the firm. Therefore, it is important to have systems and procedures in place to carry out a comprehensive analysis of risk in the context of the portfolio of the firm instead of a trade-by-trade basis

How is exposure defined? Potential impact on Earnings?

The definition of exposure will encompass the firm as a whole, or at least its significant operating units. We can look at the exposure of each unit independently, and/or the firm as a whole. One of the most important contributions of the VaR analysis is that it allows to compare the risks that different units are taking, and aggregate those risks in a consistent fashion, looking at the diversification benefits from having different business units. Management will want to look at the interactions between the different business units of the firm, and be able to quantify those interactions.

¹ Exxon, 1997 Annual Report.

What is Value at Risk (VaR)

VaR tries to answer the simple question: How much money can the firm lose due to normal market movements?

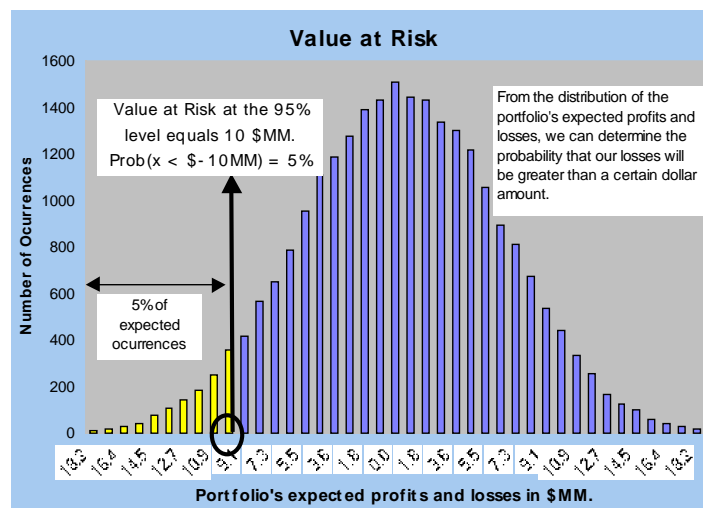
However, the above question is far too imprecise. (Usually, any amount of loss is possible.) We can make this question more precise rephrasing it in the following way:

How much money (or more) might the firm lose over time period T with probability X?

Value at Risk is a number that represents an estimate of how much our portfolio may lose due to market movements for a particular horizon (time period) and for a given confidence level (probability).

The definition of that potential loss depends on two main parameters:

- The **horizon** over which the potential loss is measured. It is not the same to measure the expected loss over a one day period as over a one week period.
- The **degree of confidence** (probability of occurrence). The degree of confidence is a measure of the degree of certainty of the VaR estimate. The most common degree of confidence is 95%, which means that 95% of the time our losses will be lower than the VaR number, while 5% of the time, our portfolio will experience greater losses.



In the graph above, we can see the value at risk concept graphically. Extreme outcomes (large losses, or large gains) are less likely to occur, and therefore, the number of expected extreme portfolio's outcomes, is clearly lower.

For example, if your VaR is US\$10MM and you have set the time period to one day and the probability to 95% then over the next 24-hour period there is a 5% chance your loss will exceed US\$10MM.

Notice that VaR concentrates on financial price risk. If the firm were a utility, the VaR analysis concentrates on the impact of electricity price changes in the value of the portfolio, but would ignore random fluctuation costs arising from credit, operational, legal, and other risks that the firm faces

Choice of horizon

The horizon can be a function either of the position or the investor. In the former case, the longer horizon for estimating risk can be the result of the time it takes for the position to be liquidated or neutralized. In

less liquid markets, it can take up to a week or longer to significantly modify the market risk profile of a portfolio. In the latter case, it is the investor who defines the horizon. Risk is measured over the period until investment objectives are reviewed and reassessed.

When choosing a horizon, consider:

- Unwind period—how long, on average, does it take to reverse a market position or individual trade?
- Attention period—how often, on average, do you re-examine your portfolio and its mark-to-market or hedging trades?
- Accounting period—how long until the next financial reporting must be done?

However, we must remember that a long period is merely the sequence of several short periods of risk. You cannot expect to manage risk over long periods unless you are able to manage it over short periods; there is no “catching up later” in risk management.

Choice of Confidence Interval

The probability of incurring losses larger than our VaR will be $(1-X)$ %, being X the confidence level. For example, for a 95% confidence level (5% one-tail level), the probability that the portfolio’s losses will exceed the VaR number will be 5%. The common choices for a confidence level are 95%, and 99%.

- With a 95% level and a one-day horizon, losses in excess of the VaR will occur about once in every twenty days.
- With a 99% level and a one-day horizon, losses in excess of the VaR will occur about once in every one hundred days.

If the probability of loss is normally distributed, the 5% one-tail level is 1.645 standard deviations from the mean; the 1% one-tail level is about 2.33 standard deviations. Confidence levels should be established for solid statistical reasons, not wishful thinking. No choice is more “conservative” than the other: it is nonsense to say, “*We want to experience a serious loss infrequently, so we use a confidence level which involves a small probability of loss in computing our VaR.*”

There are three types of inputs to calculate VaR: Market data, Portfolio Data, and User’s choices

How do we measure the market risk of a corporation?

A corporation may have different exposures (expected sales in foreign countries, expected purchases of raw materials, changes in the value of their debt portfolio, etc.) in different markets (fixed income, commodities, equities, and foreign exchange). To analyze the overall risk of the firm, it is necessary to determine the risk of the primary exposures, and the interactions (correlations) between them. To compute the volatility for every single exposure of the firm, and then estimate the risk of each single exposure and correlation between them, could be an impossible task.

VaR is highly integrative in nature and provides a global picture of the risk of a portfolio. It attempts to bring together into a single framework:

- Multiple types of market risk
- Multiple types of instruments

In a nutshell, VaR is an attempt to quantify risk, given the portfolio’s current exposure to a certain set of market factors, by asking how much these factors can move (accounting for volatilities and correlations) over a period of time.

As a first step, we must identify a set of common risk factors, for which we have historical data to obtain volatilities and correlations, or to perform the historical simulation, which will represent the “Market Factors”. To continue the analysis, we have to find a way to express all the assets in our portfolio in terms of those risk factors. This process is known as “cash flow mapping” in the variance-covariance method, but it is necessary in the simulation based methods.

MAIN METHODOLOGIES TO CALCULATE VaR

There are three main methodologies to calculate VaR: Variance-covariance, Monte Carlo simulation, and Historical Simulation. The three methodologies are complementary, and despite the debate about the right methodology to use, they all offer a different view of the portfolio risk that can be used simultaneously to obtain an overall view of the risks faced by the firm’s portfolio.

Variance-covariance or Analytic VaR

The most commonly used of the three VaR methods is based on the analysis of the volatilities and correlation between the different risk exposures of the firm’s portfolio.

The main issues that have to be solved in order to calculate analytic VaR are the following:

- The systematic measurement of actual markets for the production of data applicable to the vertex set chosen (for example, using Riskmetrics™ datasets, or creating your own from historical price data; and
- The reduction of a firm exposures to a form which can be analyzed using vertex datasets (“Cash-flow mapping” problem)

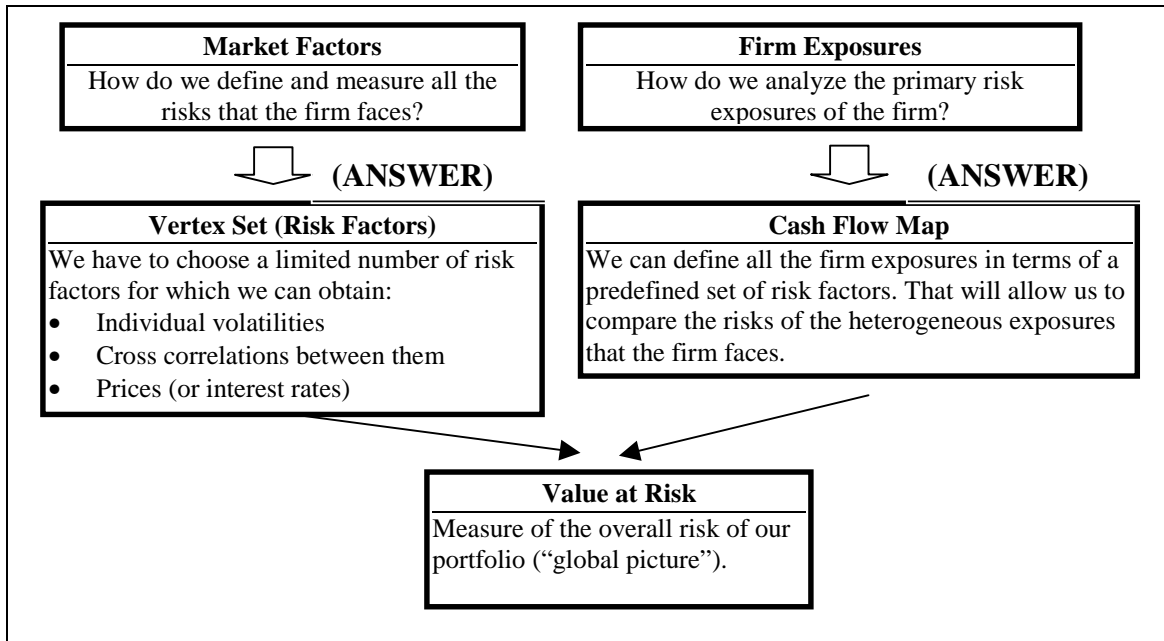
In order to be compatible with the available data (i.e. vertices), every instrument in a portfolio needs to be reduced to a collection of cash-flows in order to derive a “synthetic” portfolio from the assets we hold. The synthetic portfolio is made up of positions (cash-flows) in the risk factors or “vertices” for which we have volatilities and correlations.

The purpose of cash flow mapping is to find the “*best*” replication of a financial exposure for the purpose of measuring its risk in conjunction with the other exposures of the firm. If we map all the firm's exposures in terms of cash flows, we will have a “cash flow map” or replication portfolio which will allow us to study the risk of the firm's exposures.

The main problem is to have a set of risk factors (vertices) small enough to be manageable, but comprehensive enough to capture the risk exposures of the firm. Once we construct the cash flow map, we only need to perform basic matrix manipulation to calculate the VaR of our portfolio.

The choice of vertices or risk factors will depend on the availability of historical data, and the user's needs regarding the level of detail and precision in the analysis. For example, an airline may have to use WTI or Heating Oil as the risk factor for Jet Fuel risk, due to the lack of exchange traded contracts in Jet Fuel. In the choice of Jet Fuel, the airline may be interested in breaking the risk depending on the different delivery points, maturities of the contracts, etc. In most circumstances, the more risk factors or vertices used, the more data required, but the more information given about the risk of the positions.

Analytic VaR simplifies the analysis of market risk in the context of the firm exposures.

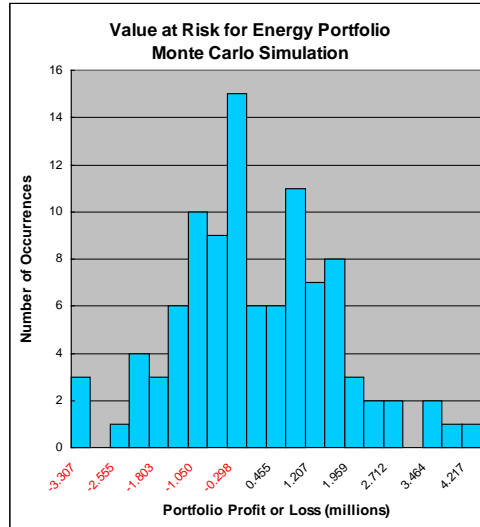


Monte Carlo Simulation

Monte Carlo simulation is based on the generation of random scenarios of prices for which the portfolio is reevaluated. Looking at the hypothetical profits and losses under each scenario, it is possible to construct a histogram of expected profit and losses from which VaR is calculated.

Monte Carlo simulation has the advantage that we do not need to assume that portfolio returns are distributed normally, but we need a correlation and volatility matrix to generate the random scenarios. To perform Monte Carlo simulation it is necessary to have pricing models for all the instruments in our portfolio, and it is a procedure that is computationally intensive.

The main advantage is that is a “forward looking” assessment of risk, and it deals with options and non-linear positions as we conduct a full valuation of the portfolio for each price scenario.



Historical Simulation

Historical simulation consists in revaluing the portfolio for several hundred historical scenarios and build a “hypothetical” distribution of profit and losses based on how the portfolio would have behave in the past. HS has the advantage that does not use estimated variances and covariances, and we do not make any assumptions about the distribution of the portfolio returns. However, we are assuming that the past risk reflects the future risk, which in energy markets is a very extreme assumption. If we think that “every day is a new day in the energy markets”, historical simulation is definitely not the method to use to capture risk.

To calculate VaR though historical simulation we need a database with historical prices for all the risk factors that we want to include in the simulation, and pricing models to reevaluate the portfolio for each price scenario. We can think of historical simulation as a special case of the Monte Carlo simulation in which all the scenarios are defined ex-ante according to the past behavior of market prices. In the case of electricity markets, and OTC energy markets, it is specially difficult to calculate the historical simulation VaR due to the lack of easily available and transparent historical data.

PROBLEMS WITH RISKMETRICS DATASETS FOR ENERGY FIRMS

Riskmetrics™ provides a set of volatilities and correlations matrices calculated on a daily basis for a set of core risk factors. It is important to point out that Riskmetrics™ matrices have a limited number of risk factors, mostly for foreign exchange, interest rate, and equities. One of the main problems of calculating VaR for energy is that the Riskmetrics datasets do not cover a large number of energy assets, and commodities in general.

Therefore, energy firms must use volatility and correlation datasets customized to their own portfolios. In order to do that, it is necessary to find historical price series for the commodity risks they are facing, and create correlation and volatility datasets from that historical data following commonly accepted methodologies. An ideal VaR system must accept arbitrary asset codes, and therefore deal with any kind of exposure, current or potential, with market risk associated (metals, grains, electricity...)

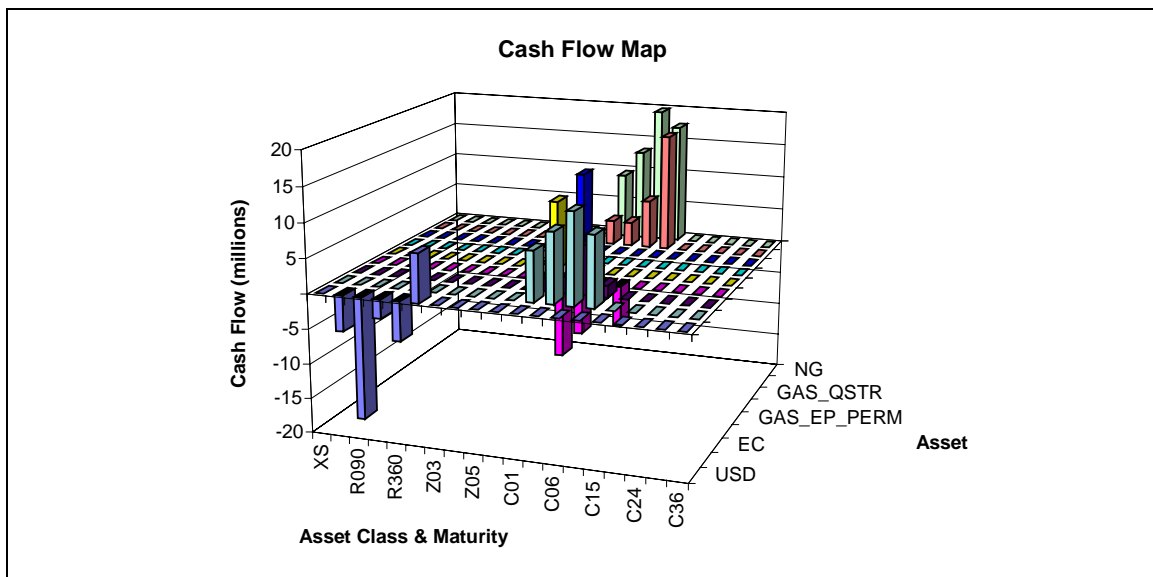
NEW ADVANCES IN VALUE AT RISK: COMPONENT VAR AND VARDELTA

- Risk management reports - understanding pre-covariance vs. post-covariance exposures
- Finding and correcting risk management “hot spots”
- Assessing the incremental risk of a trade
- Defining and using Component VaR and VaR-Beta.

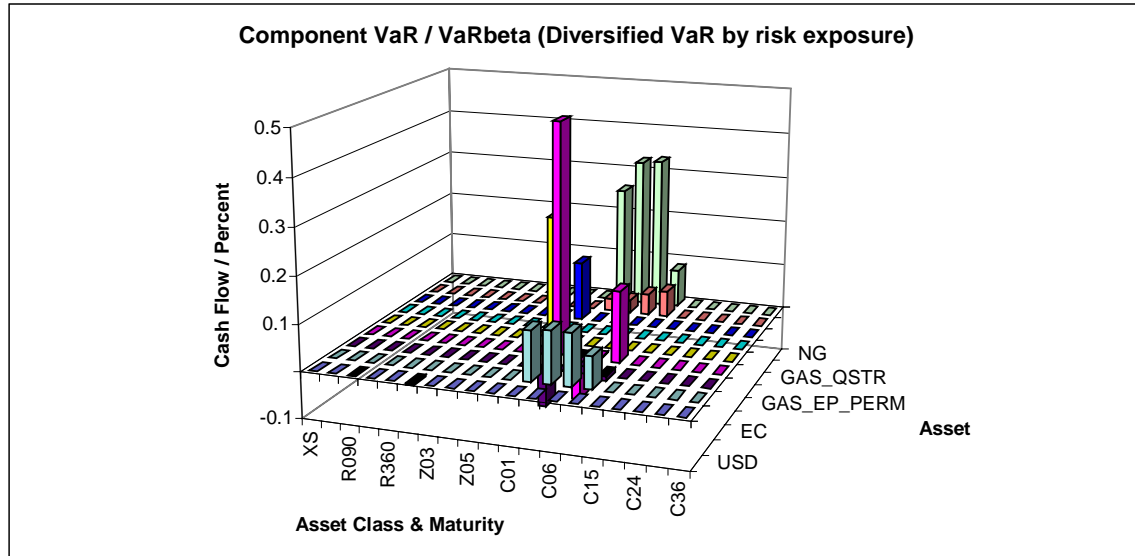
VaRdelta shows the net, effective marginal exposure created by adding a new cashflow. VaRdelta can be thought of as the marginal exposure after volatilities and correlations are accounted for.

Raw cashflow graph can be thought of as a pre-covariance analysis, which employs neither volatilities nor correlations. VaRdelta tells us the marginal exposure of our current portfolio, posterior to correlation and volatility information. In other words, it answers the question of how VaR will change if we inject another (numeraire) unit of a vertex cashflow, given the covariance matrix (market) information. It is always measured in percentage terms (usually in basis points for short horizons). The incremental VaR calculation via VaRdelta is extremely fast, and may be conducted in real time. (It involves only a few microseconds of computer time.)

Current VaR theory seems to permit only (1) diversified portfolio VaR or (2) undiversified VaR of a portfolio or component (e.g. a trade). These are non-additive. With the VaRdelta technology we can take an entire portfolio's diversified VaR and additively allocate it to the individual components comprising the portfolio.



An extension of VaRdelta is "Component VaR", which allows us to break down the diversified VaR into its main sources or components.



With Component VaR and VaR-Beta (Component VaR/Diversified VaR), we can create risk management reports slicing and dicing VaR in terms of traders, trades, business units, locations, delivery months, off-peak vs. on-peak, counterparty, etc.

Trade #	Trade Type	CP	MTM	IncVaR	VaR-Beta
417	NG Swap	CB	14,354	17,783	1.34bp
549	WTI Asian Option	BT	345,873	-121,832	-9.18bp

$$\text{VaR-Beta} = \text{Incremental VaR} / (\text{Total VaR})$$

$$\text{Incremental VaR component} = \text{VaRdelta} \cdot \text{map}(\text{trade})$$

Branch	MTM	IncVaR	VaR-Beta(%)
London	340,394,843	24,038,991	47.6%
Houston	120,494,002	-11,456,821	- 22.7%
Singapore	540,877,836	37,878,955	75.1%
		50,461,125	100.0%

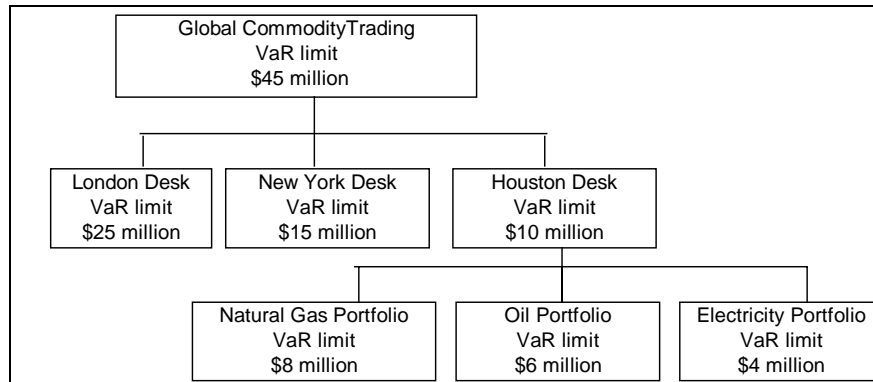
MAIN USES OF VAR

As we said before, VaR is not just a number that measures the risk of the firm. VaR can be used to manage risk pro-actively, and firms are finding ways to incorporate VaR to make decisions ranging from capital allocation to setting VaR based trading limits. Some of the uses of VaR for Energy firms are the following:

- Quantify maximum expected losses for the firms as a whole, or any sub-component of the firm's portfolio
- Assess the trade-offs between risk and returns
- Maximize benefits of diversification
- Minimize the volatility of earnings

- Measuring the effectiveness of a hedging program
- Measuring the risk of fixed-assets, and investment projects
- Create Risk Management reports for senior management to provide a better understanding of the firm overall risk profile.
- VAR measurement can be utilized to develop and evaluate the risk reduction characteristics of several hedging strategies
- Set up VaR-based trading limits, including real-time limits.
- Identify main risk exposures of the firm, and sensitivities to the different risk factors.

Example of VaR based trading limits



CREATING RISK MANAGEMENT REPORTS FOR MANAGING VAR FOR ENERGY

As the complexity in the energy markets increases, energy firms are being forced to implement risk management systems and procedures to compete effectively in the market place. VaR is still in its infancy, but it seems clear that VaR is here to stay, as it gains acceptance and popularity as a legitimate and effective tool for energy price risk management.

There is little doubt among risk managers and regulators that VaR is here to stay, and it is very likely that VaR will become universal practice within a few years, not only for financial institutions, but for all corporations facing market price risks. Energy firms are still in the process of learning about the applications of VaR to manage energy price risks, and it is expected that it is going to change the way corporation deal with risks. Recent S.E.C and FASB rulings, which allow corporations to report VaR numbers as a way to disclosure derivatives risk, will reinforce the trend towards making VaR the standard risk management system, but the risk management revolution will come from the applications of VaR to measure, control, and deal actively with risk.

	Variance-Covariance VaR	Monte Carlo Simulation	Historical Simulation
Easiness of Interpretation / communication to senior management	Intuitive, although intermediate steps difficult to explain (cash flow mapping, volatility and correlation estimation, distributional assumptions..)	Intuitive, but computational aspects more difficult to explain in a non-technical fashion.	Very Intuitive and easy to explain and interpret
Accuracy of VaR estimates	Depends on validity of assumptions (low optionality, stable variances-covariances, normality of returns)	Depends on assumptions about variance and covariances, number of simulations, and distribution of prices	Is the historical time period chose representative of all possible future market scenarios?
Distributional assumptions about portfolio returns	Portfolio returns are independents and distributed normally	None. Only distributional assumptions about risk factor returns to simulate random paths.	None. But implicit assumption that past return behavior is representative of future returns
Volatilities and Correlation matrices	Required. Correlation matrix must be positive-defiite.	Required. Correlation matrix must be positive-definite	Not required.
Amonut of historical data needed for estimation of volatilities/correlation or for performing historical simulation.	Exponentially weighted moving average methods require only a few months of historical data.	Exponentially weighted moving average methods require only a few months of historical data.	Depends on market, structural changes, seasonality effects...
How does it deal with optionality	Delta method. It can be a poor approximation for portfolios with strong optionality, specially with exotic options. Delta-gamma approach improves treatment but still not perfect	Full valuation approach. We can look at changes in volatilities as well as prices of the underlying from day to day.	Full valuation approach
Data Requirements	Can use Riskmetrics datasets or create own from historical price series.	Can use Riskmetrics datasets or create own from historical price series.	Absolute dependence on historical data. Risk factors not represented in the dataset are ignored.
Analysis of VaR for Risk management	Incremental and Component VaR analysis possible. Possible to go from risk measurement to risk managment	Study of worst case hypothetical scenarios. Does not allow incremental VaR analysis	Absolute dependence on past events. Does not allow incremental VaR analysis
Computational Intensity/ Hardware Requirements	Simple matrix multiplication once cash flow map is obtained. Relatively fast for most portfolios	Computationally intensive. All the portfolio instruments must be revalued for each price scenario	Fairly easy to implement, but all instrument pricing functions are required.
Length of horizon	Static approach. Assumes portfolio is valued on the effective date of calculation. Most effective for very short time horizons.	Introduces the effects of time on portfolio returns (time decay of options...) Mark-to-horizon.	Can be adjusted, but there is a problem a data availability