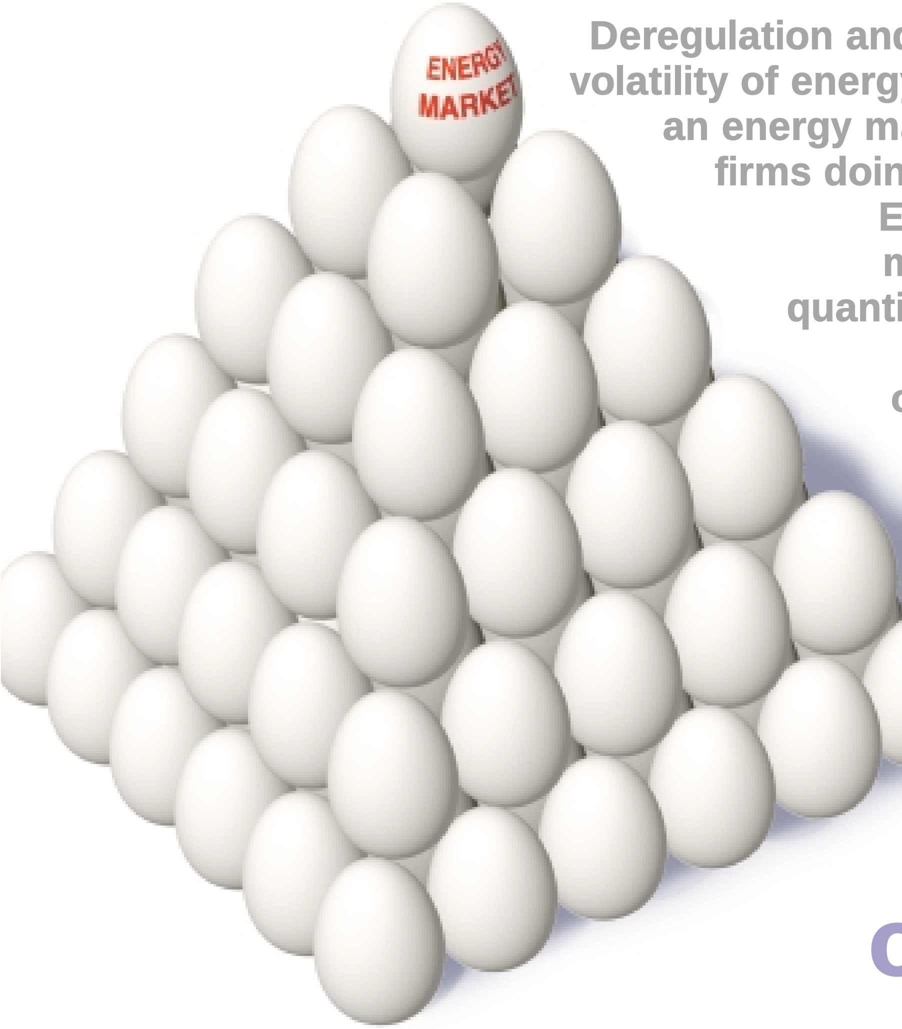


Deregulation and competition increase the volatility of energy prices. The more volatile an energy market is, the riskier it is for firms doing business in that market. Energy traders call this risk market risk, and some now quantify it using measures other than, but based on, the original one—Value at Risk

Value *at* Risk: Variations on a theme

Value at Risk (VaR) is a number that the chief executive of any energy trading company should know before leaving the office each day. It indicates how much money the company could lose if market prices move wildly before the company can close its position. Originally used in finance, VaR was adapted years ago by energy trading companies to meet their needs. Since then, some trading firms have begun using what they consider better measures of market risk, all of which are based on VaR. Three of these new measures are Profit at Risk (PaR), Earnings at Risk (EaR), and Cash Flow at Risk (C-far). The measures are described in the four sections that follow.

Specifically, VaR measures the worst expected loss (for a portfolio) to a specified confidence level (usually 95%) during a given period of time under normal market conditions. The final VaR communicated to top management at the end of each day is aggregated from the individual VaRs of the company's different trading desks and portfolios. In the first section, Dr. Carlos Blanco describes the three main techniques for calculating VaR: analytic VaR, Monte Carlo, and historical simulation.

Just how useful is VaR for

energy companies? In the second section, Chal Barnwell points out its weaknesses. He says that if energy companies use VaR the way that banks use it, they could grossly underestimate their risk exposure. The better measure of market risk that his company has come up with is a variation of VaR called PaR.

Also recognizing the limitations of VaR are Dr. Gary Dorris and Andy Dunn. In the third section, they introduce another measure of market risk—EaR—that they say is more suitable for physical-asset-intensive energy companies. The article includes an example of how managers of a hypothetical gas-fired merchant power plant might use EaR to limit their company's market risk exposure.

Finally, in the fourth section, Louis Guth and Kristina Sepetys explain how their company's patent-pending C-far model can provide an answer to a question that energy trading firms often ask: "What is the probability that this year's cash flow will be inadequate to fund our strategic investments?" The answer takes the form of a risk profile, which the model generates by taking into account the different types of risk to which a company is exposed.

—Anne Ku

Calculating and using Value at Risk

By Dr. Carlos Blanco

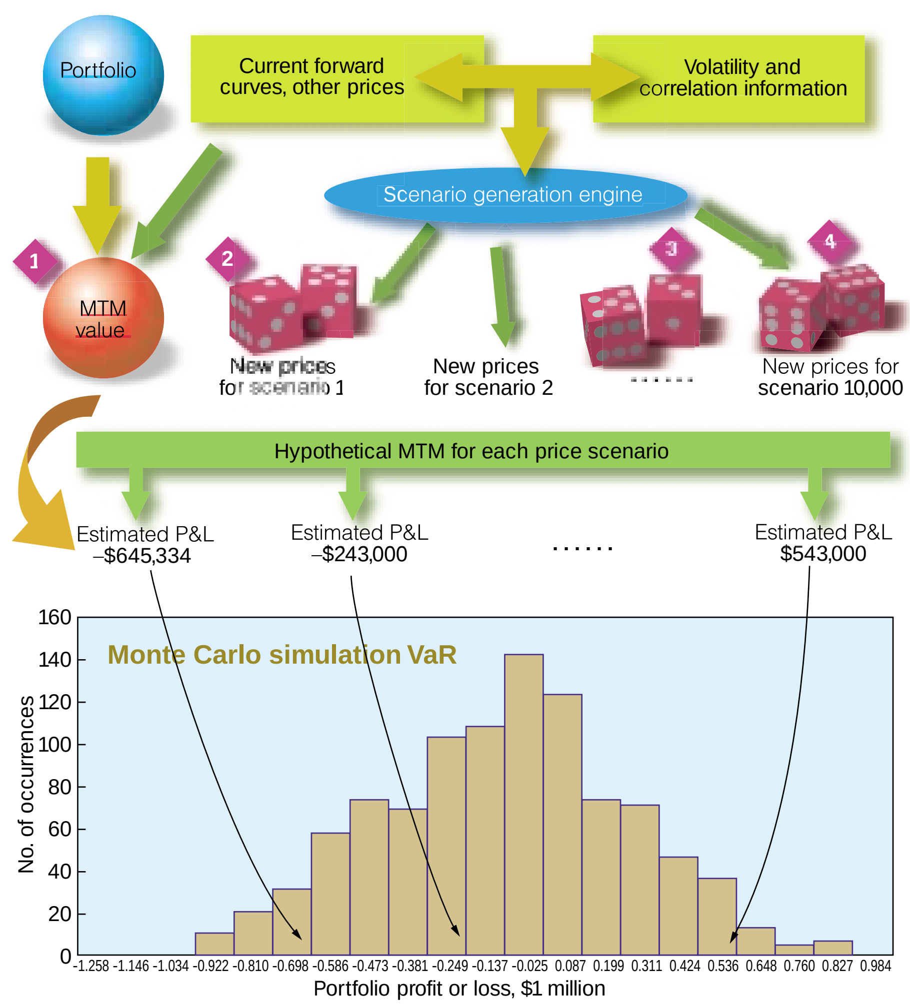
Most risk measurement methodologies are based on the analysis of a set of scenarios that describe possible future "states" of the world. Each of the methodologies makes different assumptions about the possible evolution of markets, but they follow a similar approach towards measuring market risk: First calculate a profit or revenue for each scenario, and then aggregate those results to form a distribution and extract the mean and variability of the profit, portfolio value, or revenue level for the set.

There are three main methodologies for calculating Value at Risk (VaR): variance-covariance (also known as analytic VaR), Monte Carlo simulation, and historical simulation. The three are complementary, but each offers a different view of portfolio risk. Ideally, a firm would use all three methods to obtain the most accurate picture of the market risk it faces.

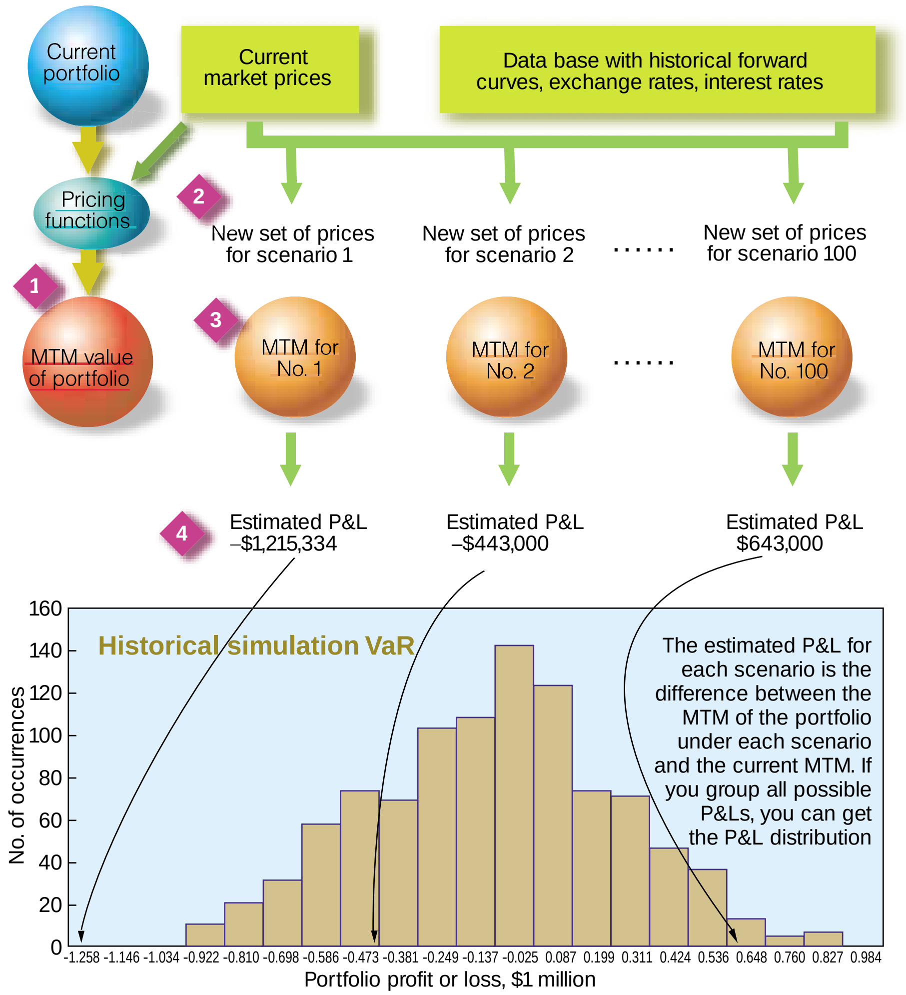
Variance-covariance

The most commonly used of the VaR

1. Monte Carlo simulation



2. Historical simulation



calculation methodologies is based on an analysis of the volatilities of, and correlation among, the different risk exposures of the firm's portfolio.

The calculation of analytic VaR is a two-step process:

- Select a set of market risk factors and systematically measure actual price levels, volatilities, and correlations.
- Put the firm's exposures into a form that can be analyzed using risk factor information. This is called cash flow mapping.

Market risk factors refer to anything that affects the value of the portfolio. Prices are the most common market factors, but you could also include in the analysis non-market-related risks—such as volume and weather. To be compatible with the available risk factor data, every instrument in a portfolio needs to be reduced to a collection of cash flows to derive a "synthetic" portfolio of assets held. The synthetic portfolio is made up of (cash flow) positions in the risk factors, or "vertices," whose volatilities and correlations are known.

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 firm's other exposures. The most difficult part of this step is defining a set of risk factors that is small enough to be manageable, but comprehensive enough to capture all the firm's risk exposures. Once the cash flow map has been created, one need only perform basic matrix manipulation to calculate the VaR of a portfolio.

Monte Carlo simulation

Monte Carlo simulation generates random pricing scenarios. The hypothetical profits and losses, or P&L, of the firm's portfolio under each scenario are converted into a histogram of expected profits and losses, from which VaR can be calculated (Figure 1).

One advantage of Monte Carlo simulation is that it does not assume that portfolio returns are distributed normally. Another is that it is a forward-looking assessment of risk that takes into account options and non-linear positions. However, the methodology requires the use of a correlation and volatility matrix to generate the random scenarios, and that makes it computationally intensive. It also requires the company to have pricing models for all the instruments in its portfolio.

Historical simulation

Historical simulation refers to the process of calculating the hypothetical distribution of profit and losses of a portfolio based on how it would have behaved under several hundred scenarios in the past. Its advantages are that it does not use estimated variances and covariances, and does not assume anything about the distribution of portfolio returns. However, the big disadvantage of historical simulation is its assumption that future risks are much like past risks, and that is less frequently the case in today's fast-changing energy environment.

To calculate VaR through historical simulation, one needs two things: a data base with historical prices for all the risk factors to be included in the simulation, and pricing models to re-evaluate the portfolio for each price scenario (Figure 2). Historical simulation could be considered a special case of Monte Carlo simulation in which all scenarios are defined before the event according to the past behavior of market prices. In the case of electricity and over-the-counter energy markets, it is quite difficult to calculate VaR using historical simulation because price histories are hard to come by.

A new way to calculate VaR

Risk managers are primarily concerned

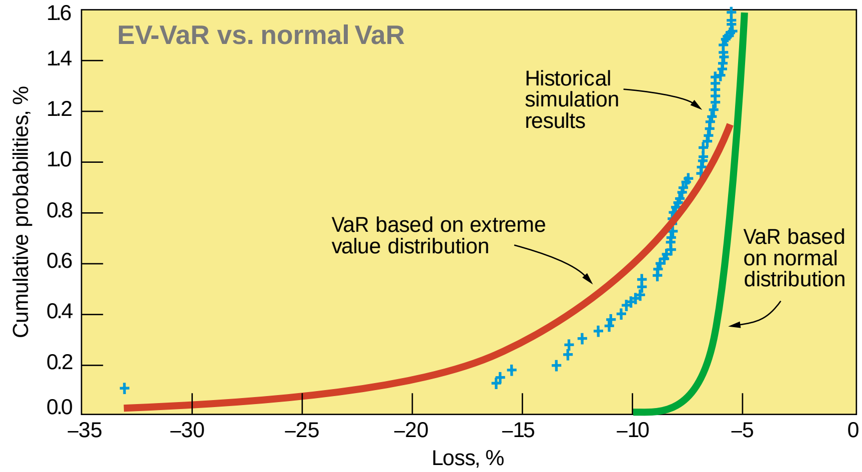
with the risk of events that are very unlikely to occur but could lead to catastrophic losses. Yet traditional VaR calculation methods tend to ignore extreme events and focus on risk measures that accommodate the entire empirical distribution of returns. This is a problem, because it is extreme events—like a large market move—that produce the largest losses.

Using stress tests and scenario analyses to simulate the changes in the value of a portfolio under hypothetically extreme market conditions is no solution, because they cannot explore all possible scenarios. What's more, such analyses do not indicate how likely it is that extreme events will occur.

The problems resulting from extreme events are not unique to risk management; they also arise in disciplines such as hydrology and structural engineering, where extreme events can have devastating consequences. Researchers and practitioners in these fields handle the problem by using extreme value theory (EVT). EVT is a specialist branch of statistics that derives general properties of the tail, or extreme end, of a distribution by making the best possible use of a limited set of its realized extreme values. By focusing on the extreme tail of a distribution, VaR can be estimated with a confidence of greater than 95%.

The difference EVT makes to VaR estimates is illustrated in Figure 3, which shows the tail of the West Texas Intermediate (WTI) daily return distribution from 1983 to 1999. The dots indicate the actual extreme return observations, the continuous line by the right vertical axis represents the tail (assuming that logarithmic returns follow a normal distribution), and the other continuous line represents the tail of an extreme value distribution fitted to these data. The message this figure conveys is that the confidence level of EVT-calculated VaRs is much higher than that of VaRs calculated using traditional methodologies.

3. Extreme value theory applied to value at risk



Toward risk management

Traditionally, the use of VaR within companies has been limited to a passive role—for reporting rather than prescriptive purposes. Now, however, firms in dynamic industries—such as energy—are beginning to use it for more proactive purposes—for risk management rather than just risk measurement. Active VaR can identify business activities that incur too much risk relative to their level of return. It can also point out which assets, business processes, and activities are increasing or decreasing the corporation's overall risk exposure.

Most risk professionals agree that risk management in the energy industry is more complicated—and interesting—than risk management in most other fields because electricity and gas production and trading are physical processes.

As energy markets become more complex, energy firms are embracing risk management systems and procedures, such as Value at Risk, to become more competitive. ■

Dr. Carlos Blanco is manager of global support and educational services at Financial Engineering Associates, (www.fea.com) Berkeley, Calif.

Profit at Risk: More realistic than Value at Risk

By Chal Barnwell

Companies that generate or deliver electricity, or sell load-following ancillary services or retail load services, need a more accurate and robust risk-measurement metric than the "pure" form of Value at Risk (VaR). Profit at Risk (PaR™) is a more useful measure for a variety of reasons.

Volume risk

The financial risks estimated by typical VaR calculations are wholly related to market price movements. However, the real and increasingly complex energy industry engenders additional financial risks that VaR cannot measure. The most important of these is volume risk, which occurs whenever a power plant has an unplanned outage, customers use more power than expected, or a transmission line fails.

Volume risks—and their impact on value and profit—are not caused by market price movements, but rather by physical problems, such as those mentioned above. If anything, the converse is true: Market price movements may result from volume risks. In fact, the biggest and most shocking market price movements in power markets can all be traced back to physical volume risks.

Liquidity risk

Companies that use VaR to measure the impact of market price movements on the value of their asset portfolios typically rely on a "stop loss" strategy. They believe that they can quickly close out their position to limit the damage from negative market price movements. However, the time required to close a position depends on market liquidity—but liquidity changes over time and fluctuates in response to sudden shifts in market prices. In immature power markets, price spikes can be extreme and cause severe market liquidity problems.

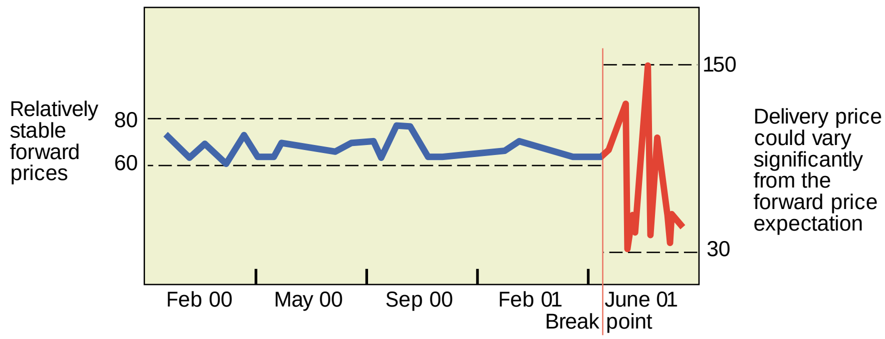
In practice, therefore, closing a position is neither as easy nor straightforward as in theory. Because many real-world contracts do not comply with market standards, they are not easy to sell or trade. The alternatives—selling off generation assets or portfolios of retail customers—are equally unrealistic.

Physical delivery and breakpoints

What makes assessing risk in power markets complex is that market prices change drastically as the date of physical delivery approaches. Prior to several months before that date, price behavior is driven by relatively benign factors—such as economics, forward fuel prices, and the market's anticipated generation level. This is considered the holding period.

However, as the date of delivery approaches, the drivers of market prices

1.Breakpoint



change dramatically. After a certain date, or breakpoint, prices become driven by less benign factors such as weather, the short-term imbalance between supply and demand, plant outages, and transmission system bottlenecks. The environment becomes much more volatile. For energy trading firms, VaR remains a valid way to measure their risk exposure before the breakpoint date. However, for many other energy companies—including generators, retail distributors, and entities involved in complex marketing transactions with load following optionality—PaR offers a way to more accurately measure their risk.

PaR in theory

The biggest difference between PaR and VaR is that the former assumes that positions will be taken through to delivery rather than closed out prior to the breakpoint. Because this measure takes into account the full financial risk of highly volatile spot prices, it is a far more realistic approach.

The foundation of PaR is simulation-based modeling, which basically tests the entire range of risks affecting spot prices at the time of delivery. The model follows a pseudo-Monte Carlo approach that re-bases spot price simulations to match forward curve prices and expected spot volatility. The Monte Carlo simulation method calculates the change in the value of the portfolio using a sample of randomly generated price scenarios that are assumed to be equally probable. The approach requires making assumptions about market structures, the stochastic processes the prices follow, and the correlations between risk factors and the volatility of these factors. The relationships are derived from econometric estimates based on historical data and/or inferred from current market variables—options prices, for example.

The PaR approach considers both the volatility and shape of the forward price curves observed historically during the delivery period, as well as projected price curves and volatility for that time frame. The PaR metric, then, reflects the entire exposed profit of a portfolio position, not just the change expected in it for a brief period of time.

PaR in practice

Short of selling a portion of a generating unit, a company has no way to effectively close out the position represented by a plant without assuming potentially more risk than is hedged. The plant will be subject to forced outages, transmission constraints, generation derates, and many other volumetric variables that are uncontrollable. In many cases for strategically located facilities, forced outages can drive spot prices to abnormally high points at exactly the wrong time for the hedger—when the facility is down. In these circumstances, a VaR measure based on a short holding period of two or three days would give the impression that a plant's risk is minor when it is actually quite substantial.

For example, calculating the VaR of a Cinergy 500-MW gas-fired plant on May 30, 2000, would produce a figure of $5.2 million for the June through September period. But using the PaR metric, the calculation of total profit exposure for this same unit (based upon a 95% confidence level) would produce a very different figure—$69 million. What this means is that leaving the plant completely unhedged for the premium summer months and selling its output on a daily basis would have resulted in an erosion of mark-to-market (MTM) profitability of $69 million by the end of August.

The shortcomings of VaR—in particular its assumption that past events are reliable indicators of the future—are perhaps most glaring if one considers the California crisis. No amount of historical data on wholesale prices could have predicted what happened in the spring of 2000—events that haven't recurred since. Further complicating the situation was the volumetric uncertainty of load, which effectively prevented utilities from closing out their retail positions. And to make matters even worse, regulatory rules made it illegal for them to hedge their positions substantially.

The PaR metric would not have helped California's utilities out of their regulatory dilemma. But it might have flagged the potential for eroding profits in a simulated environment and provided an accurate measure of their risk exposure. ■

Chal Barnwell is vice president of the Houston operations of KWI (www.kwi.com), London.

Earnings at Risk: Better for asset owners

By Dr. Gary Dorris and Andy Dunn

Accounting rules prohibit energy companies with portfolios of physical assets from marking these assets to market. Nor can these companies liquidate or acquire their assets as quickly as companies with purely financial portfolios. For these two reasons, energy companies are embracing Earnings at Risk (EaR) as a more appropriate measure of market risk than Value at Risk.

EaR defined

Calculations of EaR follow calculations of profit, using the following equation:

Profit = Spot price revenues generated by the organization's assets
– cost of production,
+ hedge and other instrument payoffs prior to delivery,
+ hedge and other instrument payoffs during delivery.

A Monte Carlo simulation can provide an estimate of the distribution of the profit function. The distribution of profit captures the upside potential—as well as the downside risk—of variability of market prices, as well as the operational characteristics and reliability of physical assets. A well-constructed EaR model assesses the impact of alternative derivative trading strategies on both tails of the profit distribution curve.

EaR in action

How might EaR be used in the energy industry? Consider the hypothetical case of E-Corp., a U.S. firm that owns a 130-MW gas-fired merchant plant and has a marketing/trading affiliate that does both spot and forward transactions in electricity and natural gas. E-Corp.'s objective is to manage its exposure of earnings to market risk over a 12-month period. First, simulate prices, and then estimate the EaR of E-Corp.'s unhedged portfolio. Next, compare the EaR of this unhedged portfolio both to that of a portfolio of derivative contracts, and to that of a combined portfolio of derivative contracts and the merchant plant.

For the price simulation, assume that derivative prices follow geometric Brownian motion with a monthly term structure of volatility and drift, and spot prices follow a Markov regime-switching model with each regime characterized as having geometric Brownian motion with mean reversion. The regime-switching model for spot prices allows for the large discontinuous jumps observed in electricity prices.

Figure 1 depicts a single simulation of forward and spot prices for power during a typical summer in North America. Spot prices follow the highly volatile purple line at the front of the graph. Forward contracts are less

1. Sample simulation of power prices

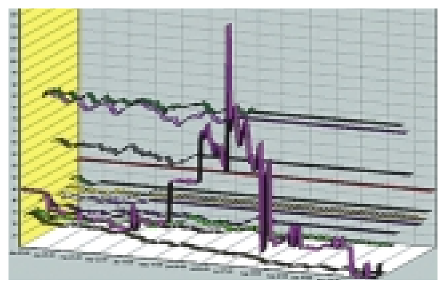


Table 1. Generation dispatch inputs and outputs

Operational inputs	Total
Load	130
Heat rate	13,653
Minimum uptime, hours	2
Minimum downtime, hours	—
Startup costs, $/MW of capacity	1
Startup time, hours	1
Shutdown cost, $/MW of capacity	229
Shutdown time, hours	1
Ramp-up rate, MW/hr	3
Rampdown rate, MW/hr	15
Maximum starts per month	40
Maximum continuous run time/ month, hours	744
Expected forced outage rate	0.10
Expected outage duration	2
Variance in outage duration	1
Outage minimum, days	1
Outage maximum, days	120
Summary output	**Total**
Generation, MWh	773,500
Gross revenue, $1,000	120,157
Net revenue, $1,000	54,043
Net revenue, $/kW	415
Capacity factor, %	68

volatile and turn flat during delivery. Of course, this is only a single simulation of prices; a fair assessment of risk requires several thousand simulations.

Given a series of price simulations and the operating attributes for the plant, the dispatch of electricity as well as the corresponding revenue information can be simulated for the year by mapping each hour of each day's spot price for power and natural gas to the potential generation of electricity. Table 1 tabulates the operational attributes of this plant, its expected generation, capacity factor, and expected revenues.

However, Table 1 provides only a portion of the information needed for effective risk management and budgeting. The rest of the data needed must come from an examination of the distribution of net revenues. Figure 2 depicts the probability density function (PDF) and other key statistics for the unhedged power plant. The statistical summary on the left indicates that the plant's expected net revenues are estimated at $54 million, and that its Earnings at Risk figure is $11.1 million. In other words, you would expect that the plant will generate $54 million in net revenues, and it is 95% certain it will generate at least $42.9 million.

Once the numbers have been determined, you can measure the market risk with respect to the earnings of a portfolio of owned assets, commercial contracts, and/or hedge positions. Suppose that in addition to the merchant plant, E-Corp. has a strip of natural gas forward purchases (1 million mmBtu) and electricity sales (130 MW). A typical risk management activity would be to measure the VaR or EaR of this portfolio alone without considering the generation asset. However, the generation plant has the potential to offset some of the risk of this portfolio of forward purchases and sales.

Table 2 illustrates that both the generation plant in isolation and the portfolio of forward contracts carry significant levels of EaR ($11.1 million and $13.9 million, respectively). In the profit equation for EaR, the derivative contracts offset the volatility of the earnings of the power plants. When these portfolios are aggregated into one exposure, overall risk is reduced to $3.5 million, based on the offsetting profits of the plant and the derivative contracts.

The example clearly shows the hazards of not fully considering all assets that are subject to market risk in risk analysis. If E-Corp. had measured the portfolio of forward contracts in isolation, it would have inaccurately estimated market risk, and that could have led management to pursue an erroneous hedge strategy. The example underscores the need for energy companies to apply sophisticated modeling techniques to all of its market-price-sensitive assets using a method that estimates risk to earnings.

2. Distribution of net revenues

Statistics:	
EaR (C.I. 95%)	11,109,200
Mean	54,034,300
Maximum	74,851,500
Minimum	32,599,900
Std. dev.	7,497,690

Bin data:

Level	Net revenue
0	32,599,900
1	37,721,800
5	42,925,100
10	44,797,200
20	47,002,200
30	49,445,100
40	51,543,600
50	53,826,900
60	56,053,800
70	57,773,800

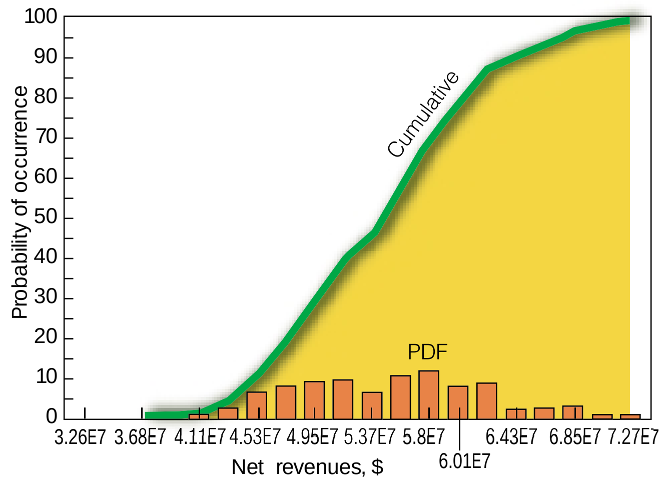


Table 2. Risk-reducing effects of aggregating generation with forwards

	Generation plant alone	Forward contracts alone	Combined portfolio
EaR (C.I. 95%)	11,109,200	13,853,430	3,518,400
Mean	54,034,300	2,091,030	56,209,200
Maximum	74,851,500	24,442,800	63,966,700
Minimum	32,599,900	(18,228,000)	50,635,900
Std. dev.	7,497,690	7,861,020	2,351,140

Bin data

Level	Generation plant alone: Net revenue	Forward contracts alone: Net revenue	Combined portfolio: Net revenue
0	32,599,900	(18,228,000)	50,635,900
1	37,721,800	(16,786,800)	51,047,100
5	42,925,100	(11,762,400)	52,690,800
10	44,797,200	(7,955,730)	53,384,000
20	47,002,200	(4,674,190)	54,248,900
30	49,445,100	49,445,100	54,954,900
40	51,543,600	193,180	55,537,500
50	53,826,900	1,577,460	56,050,700
60	56,053,800	4,574,250	56,561,400
70	57,773,800	6,001,630	57,106,300

From VaR to EaR

Since they came out of the world of finance, methods of measuring market risk have evolved in sophistication and robustness, from basic VaR to measures, such as EaR, that integrate the risks of financial instruments and those of physical assets. The benefits of using such advanced methodologies extend from improving a company's leverage capacity to stabilizing volatility in its earnings to enhancing its stock-price-to-earnings ratio. ■

Dr. Gary Dorris is CEO, and Andy Dunn is vice president of risk management of e-Acumen (www.e-acumen.com), San Francisco.

Cash Flow at Risk for non-financial companies

By Louis Guth and Kristina Sepetys

Cash Flow at Risk (C-far) is a patent-pending diagnostic developed by National Economic Research Associates (NERA) economists. This analytic model is designed to forecast earnings volatility one quarter to one year ahead. It may be used to enhance planning and capital investment, as well as insurance and hedging strategies. It derives from a broad statistical analysis of earnings results and other factors for the entire universe of publicly held non-financial companies. C-far starts with the logical premise that risk reveals itself in non-financial companies as deviations from cash flow.

What and who it's for

The introduction of the C-far model has coincided with what has become a very big season for unanticipated earnings shortfalls at some of the country's largest companies, including many utilities. The model can provide answers to two questions that should be foremost in the mind of any CFO or high-level manager concerned with accurately assessing value:

- "What is the probability that this year's cash flow will be inadequate to fund our strategic investments?"
- "What is the worst thing that can happen to the company financially in the next quarter or year?"

The C-far model considers every conceivable type of risk to which a company can be exposed and produces a risk profile that can help answer these critical questions. Its applicability goes beyond volatile industries—such as energy, manufacturing, and high-tech technology. Lawyers can use it to clarify reported risk in securities litigation and disclosure documents. Investment bankers and venture capitalists will find it a useful method for analyzing investment opportunities.

C-far vs. VaR

Banks, insurers, investment firms, and other financial companies have long used Value at Risk, or VaR, to manage portfolio risk. VaR measures how much the value of financial assets—foreign currency, equities, commodities, bonds—will drop in a day or a week if they are affected by a market reversal. The C-far model can be thought of as a form of VaR for measuring aggregate risk against a company's cash flow. Whereas the VaR method takes a bottom-up approach to quantify the risks caused by individual financial assets, C-far looks directly at cash flow under the assumption that all risks to a corporation are manifest in shocks to expected earnings.

Because the C-far model creates forward-looking probability distributions for a company's cash flow, it provides a measure of the likelihood of rare negative events that could produce a significant drop in earnings. As a tool for corporate treasurers and CFOs, C-far promises to enhance financial strategy and long-term investment planning. But the model can also be used to help companies assess their capital structure and credit-worthiness. C-far can establish whether a company has adequate cash reserves to service its debt in the event of an earnings jolt. What's more, because it can inform decision-making about purchasing insurance and other hedging strategies, C-far could become a benchmark for corporate risk management.

Tailored for the industry

For power companies, the C-far package comprises the model and a data base of 10 years' worth of quarterly cash flow and other financial data for approximately 100 electric utilities. The model includes a statistical methodology for transforming these data into peer-benchmarked risk measurements. It can construct tailored, forward-looking cash flow distributions for a utility's quarter-ahead and year-ahead horizons based upon large samples of cash flow shocks experienced by a set of peer-group firms. These samples are large enough to allow making relatively precise statements about the probability of one in 10-year or one in 20-year bad outcomes. The distributions also allow quantification of the probability of specified adverse cash flow shocks—for example, "What is the likelihood that cash flow falls by 50% in the next year?"

Such information is of great interest to investors, who are naturally concerned about volatility in reported quarterly earnings. By disclosing the results of a C-far analysis to investors or security analysts ahead of time, a company can help put earnings shocks into a credible, objective, peer-benchmarked perspective. ■

> C-far promises to enhance financial strategy and long-term investment planning

Louis Guth is senior vice president, and Kristina Sepetys is senior consultant (San Francisco office) at National Economic Research Associates (www.nera.com), White Plains, N.Y.

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3. Primary Job Function (check only one):
[ ] General or Corporate Management - A
[ ] Library or Company - B
[ ] Other (please specify):

4. My company is a (check only one):
[ ] Primary energy supplier - A
[ ] Utility - B
[ ] Developer/independent power producer - C
[ ] Energy services provider - D
[ ] Consultant, contractor, constructor - E
[ ] Energy marketer, trader, broker - F
[ ] Commission, association, or government - G
[ ] Law, financial services, or insurance firm - H
[ ] Other (please specify):

4a. In question 4 above, if you checked PRIMARY ENERGY, what does your company provide (check ALL that apply)
[ ] Coal - A
[ ] Oil - B
[ ] Gas - C
[ ] Nuclear Fuel - D
[ ] Other (please specify):

4b. In question 4 above, if you checked UTILITY, what services does your company provide (check ALL that apply)
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[ ] Gas - B
[ ] Water - C
[ ] Telephone/communications - D
[ ] Other (please specify):

State or Province of Birth:

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