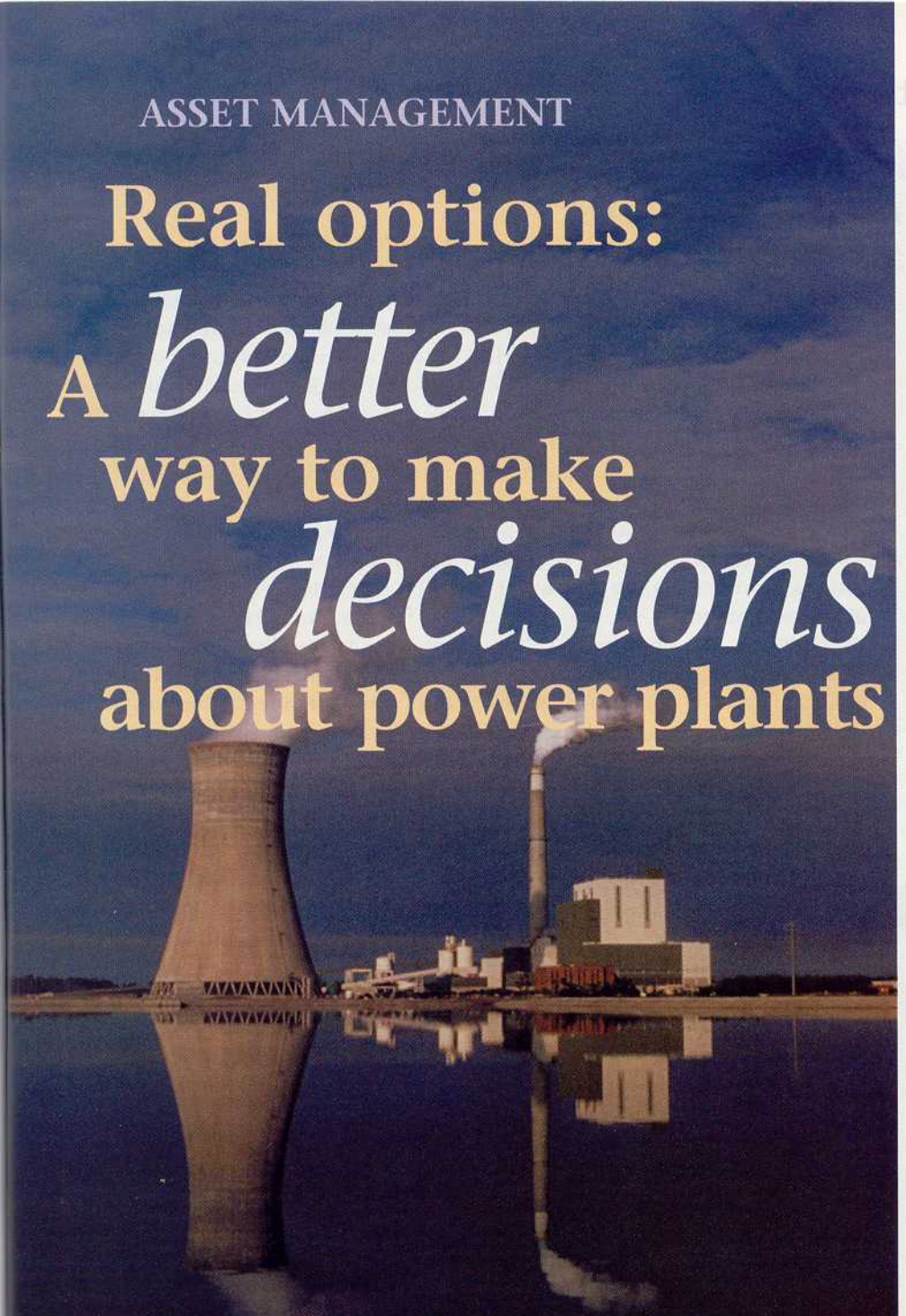
Real options: A better way to make decisions about power plants



Discounted cash flow models traditionally used to value generation assets cannot account for the uncertainties inherent in competitive electricity markets. The real-options methodology can, and that's why other industries have embraced it for decision-making

By Steven Scroggs, Dr. Paul Fischbeck, and David Rode

When making strategic decisions about generation assets, decision-makers at utilities and independent power producers can take either of two general approaches. Strategic planning proponents offer a view that appreciates multiple opportunities, competitive issues, and other concepts that are difficult to quantify. The other perspective approaches valuation from standard, accounting-based approaches, such as the use of discounted cash flow (DCF) models.

The latter perspective, however, is relatively inflexible when attempting to value assets that experience significant changes. The strategic approach appreciates the dynamic complexity of the future, while the DCF approach can better grasp the quantitative detail complexity that affects valuation and strategy. Commonly, the deficiencies of both approaches prompt managers to add their own subjective alterations to shape final valuation estimates.

But at the end of the day, decision-makers must use this information to make decisions about the future. Traditional DCF approaches or qualitative strategic planning methods cannot value management's ability to make decisions in the future. Implicit in the DCF approach is a passive management strategy, whereas asset managers commonly apply—and shareholders expect—active management strategies.

Stakeholders in power production companies must be able to make decisions today about an uncertain tomorrow in a disciplined and objective fashion. These decisions are the very ones that will create value and secure a competitive position by properly allocating resources. Enter the tools of a new generation of asset managers.

Decision science, an umbrella classification that includes a grow-

The introduction of competition into energy sectors has made uncertainty a key, new part of asset valuation

ing set of tools and methods for enabling decision-making under uncertainty, allows practitioners to appreciate and even take advantage of uncertainty when making capital investment decisions. Real options is a term that has been coined to identify the value inherent in a physical asset that is derived from some future contingent decision.

The essence of the theory and practice of real options is that the asset owner (or real option holder) has a right—but not an obligation—to make a decision or set of decisions in the future that can affect the cash flows of the asset. Obviously, the trick is to make managerial decisions that will limit downside and/or capture upside and therefore add value to the asset. The existence of this managerial flexibility is the source of the positive value of real options. Because traditional deterministic valuation modeling cannot capture this value, its own value as a tool for dealing with uncertain environments—such as retail competition—is compromised.

The following broadly introduces the area of decision science and, in particular, real options. It illustrates where the techniques are being applied to capital management of generation assets and compares real options to classic option theory as applied to the more familiar financial options.

Real options vs. stock options

Real options are similar to financial options and share many of the same characteristics. However, they also differ considerably in certain ways, and these differences affect how the value of the real option is determined.

Exclusivity. A stock option is proprietary to its owner, who can decide where and when to exercise it. This is also true of real options, but only if the exercise of a similar option by a competitor in the industry doesn't significantly affect the owner's resulting cash flows.

Tradability. Where stock options are easy to trade, the tradability of real options is much more restricted. To begin with, significant transaction inefficiencies would diminish the value of the real option. Nonetheless, recent generating-asset transactions have included components of value attributed to real options that come with the asset. The values of these real options are left to the individual bidders, increasing the uncertainty of bid ranges—and that generally favors the seller.

Compound nature. Stock options are generally "simple" in that their value upon exercise is restricted to the value of the underlying asset. Real options have the ability to enable future real options, or be options on options. This compound nature of real options offers managers a strategic usefulness that simple options do not. This also complicates the analysis because of the prerequisite nature now imparted on early real options.

Synergy. A share of a stock is the same to all consumers. Real assets, by contrast, can have different value to different consumers. This difference in value is extracted by way of synergies with the potential buyer's current holdings. If the acquisition helps to diversify the buyer's present portfolio, then that specific diversification value is unique to that buyer.

Separability. The value of a stock option can be realized independently from the underlying asset. Real options are generally inseparable from the underlying asset, although some may argue that that is not necessarily the case with tolling and other marketing arrangements.

Current valuation methods are incomplete

In the past, standard valuation approaches have centered on the construction of detailed future cash flow models. Appropriate discount rates were developed to bring these future cash flows back to a present value, representing the investment worth. However, this approach has severe structural limitations that make it less useful for valuing electricity generation assets today.

The discounted cash flow (DCF) approach was developed to price investments in financial instruments that were intended to be passively managed. The framework known today as the capital asset pricing model (CAPM) offered a mechanism to separate systematic (market) and non-systematic (firm-specific) risk, therefore appropriately pricing investments of differing risk levels. The approaches were naturally adapted to the valuation of electric generation assets under the regulated model, and early project financing of independent power producers with stable off-take contracts. The assumption of a stable discount rate over the term of the investment and a passive management of the investment were not inconsistent with the nature of these electric generation assets in the less dynamic, less uncertain world that existed when these projects were financed.

The introduction of competition into energy sectors has made uncertainty a key, new part of asset valuation. As uncertainty is introduced into the cash flow estimating process, participants grapple with how to address it. The natural instinct is to develop scenarios that may help bound the problem. Recognizing the many sources of uncertainty and the need to appreciate the correlation (or lack of it) between uncertain parameters illustrates the considerable challenge facing decision-makers. At the end of the day, decision-makers face a

Calculation methods compared

There are several methods for estimating real option value. Each approach makes various simplifying assumptions. The extent to which the option under consideration conforms to the assumptions will determine the applicability of the approach.

The most straightforward approach uses a binomial lattice to approximate the divergence of option paths at discrete steps in time. Another approach adopts the assumptions of the Black-Scholes equation to price the option. The third and fourth approaches employ a Monte Carlo simulation to model a statistically significant number of logically constructed future states of the world. The twist is that one approach makes decisions about exercising the option using past history only, while the other is forward-looking in its decision-making process.

Black-Scholes

The basic equation developed by Black and Scholes makes some simplifying assumptions. The key assumption that limits the application to real assets presumes that the asset in question has a log-normal return distribution. In reality this assumption is not applicable to all stocks, but is more of a departure when studying real assets. Black-Scholes is most applicable to decisions with a single contingent decision where all uncertainties can be modeled by a single uncertainty. Again, these assumptions are less realistic as applied to real assets, and an uncontrolled error is inherent in any simple application.

Decision tree analysis

Decision tree analysis is a valuable and insightful tool for representing options visually, and providing accurate value approximations of complex decisions. The binomial lattice approach models each step in time as having two optional futures. As time steps are added, multiple nodes are reached. The risk-neutral pricing principle is then used to assign the probability of taking one path over another.

For example, you can model different cash flows being achieved based on making a decision to expand at different times, and from scenario paths that have evolved differently. The lattice is filled with a host of expectations that are contingent upon when the decisions are made, and what has gone before the decision. Comparing the expected value at each point in the binomial space to the cost of the real option, one can see what the value of the option is at each point. Folding these point values back in time, using the risk-neutral probabilities assigned to each path, one can obtain a value that represents what this array of future options are worth to the real option holder today. In fact, the binomial model converges to the Black-Scholes model as the time between steps goes to zero.

Significant steps have been made in adapting this approach to complex decisions. Limitations have been creatively addressed and provide a sound basis for the analysis of simple options. The primary limitation is one of complexity. The analysis can quickly grow well beyond the capabilities of this framework, and much effort is therefore concentrated on simplifying the decision model.

Simulation techniques

Monte Carlo simulation enables the generation of a statistically significant number of logically constructed states of the world, representing the range of feasible futures of a project. Enabled by the increasing power of PCs and the development of off-the-shelf simulation software, simulation techniques are now within reach of most financial analysts.

The flexibility of this approach is unmatched, but also leads to its potential complexity. Multiple option alternatives can be modeled simultaneously. Embedded decision rules can make choices in the simulated future, playing the role of active managers who would be making decisions based on information available at the time. Imperfect or delayed decision-making can also be modeled, limiting potential overestimates of achievable returns. Simulation is a useful technique, but can become complex and time-consuming if it is not executed in a focused and economical manner.

There are several alternatives to estimating real option value. More important is the mindset to seek out this value and the commitment to follow through with the active management style that will realize the value uncovered by these methods.

range of disparate results, with no comprehensive way to measure the likelihood that any scenario will come to pass. The changing nature of risk and the value of managerial flexibility cannot be estimated accurately using the deterministic approach alone. Put another way, the structure of the deterministic approach has proven inadequate for valuing the role of active management.

Another limitation of the DCF approach is that it presents significant opportunities for subjective bias to creep into valuations. Subjectivity creeps in through forecasts of the uncertain parameters used in the analysis and in the construction of the scenarios used as the decision basis. Expert opinion is provided to bolster areas of uncertainty, as is often necessary. However, without a disciplined framework for the objective solicitation of this information, the process loses credibility and utility to the decision-maker. Strategic planning practitioners recognize the need to incorporate concepts such as market timing, competitive advantage, and technological leadership into their decision basis but are unable to do so via the DCF approach.

Real options: A better way

Researchers have demonstrated that real options can be valued in a way similar to financial options, despite characteristic differences (see box, previous page), since the actual question being asked pertains to the market value of the project cash flows. The

application of these tools as a disciplined approach to valuing managerial flexibility has been critical to gains made in many risky ventures.

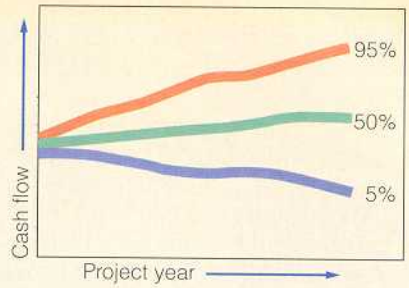
The following are four of many possible examples of real options in action.

- Oil and gas producers have long been applying real-options techniques to provide strategic input to exploration and production investments. In fact, offshore natural gas leases are generally priced using these principles, and the value of expensive exploration programs validating reserve volumes without drilling are often justified through these methods.
- Making pharmaceutical R&D decisions would be a tremendously daunting task without the ability to assign probability to components of an investment analysis and substantiate step-wise investment programs.
- Often, the investment by large international companies in funding institutional research or the acquisition of a promising new company with a unique technology is an initial enabling option in such a step-wise program.
- Lawyers, uncertain about how large an award a jury could grant, have adapted the process to indicate appropriate claim settlements in multiparty lawsuits.

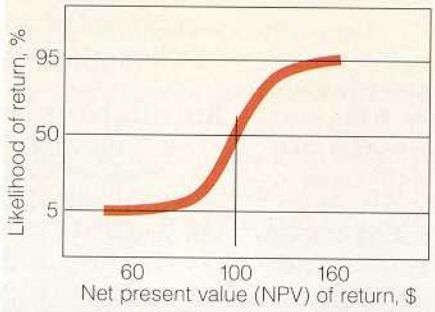
From cash flows to real options

Asset valuation under uncertainty provides estimates that are themselves probabilistic distributions, vs. deterministic values. By adding this dimension of risk, decision-makers are provided with a measure of confidence. Moreover, the groundwork for valuing the impact of some future managerial decisions is laid. Figure 1 shows a cash flow forecast summary graph depicting the cone of uncertainty as time proceeds into the future. Figure 2 illustrates how this information, brought back to net present value (NPV) by DCF methods, provides a representation of asset value—including the dimension of risk. Through active management, managers can influence the shape of future cash flows, accepting and enabling the higher returns and minimizing the impact of the lower returns. This is the essence of an active managerial strategy as quantified by real options.

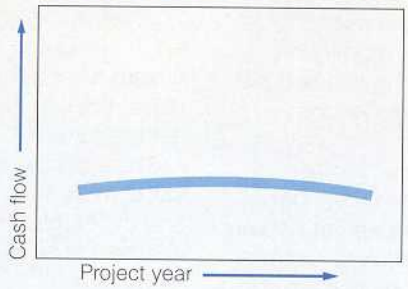
1. Probabilistic summary of cash flow



2. Cumulative distribution of NPV



3. Expected value of status quo cash flow



So, what do we mean by risk? Although risk is an inherently subjective concept, for the purposes of capital budgeting it is often defined as the difference between the expected return and the actual return. The underlying nature of risk is project-specific, and comes from the interaction of many uncertainties that affect the accuracy of the original valuation estimate. Value distributions, such as the one in Figure 2, can be characterized in a simplistic way using an expected value (mean) and a standard deviation (square root of the variance). The mean represents the expected return, while the standard deviation represents how certain we are about the location of the expected value. The quantification of risk then is accomplished by knowing the shape of the distribution of possible outcomes. These characteristics indicate specific implications that must be understood by managers to properly accommodate project-specific risk.

Real options in practice

To illustrate several different types of options, consider a fictitious power plant called Shady Mountain Power (SMP). This facility is a moderate-sized cogeneration plant serving a soon-to-be-closed thermal host. The equipment is a competitive frame-type combustion turbine generator with a (now undersized) steam-turbine generator operating in combined cycle. SMP has decided to enter into a power-purchase agreement buyback arrangement that, coupled with the severing of ties to the thermal host, will leave the facility as a merchant plant.

In considering their future plans, SMP managers have brainstormed several credible alternatives for the facility. Included in the list of five alternatives is a "status quo" configuration that requires no additional capital investment; its cash-flow projection is shown in Figure 3. These alternatives are analyzed individually, resulting in an estimate of the expected value of each new configuration and an estimation of how much risk there is in achieving that return.

The following items sketch out the strategies and tactics of each of the other four alternatives.

- **Option to expand.** One alternative is to add a second combustion turbine and heat-recovery steam gen-

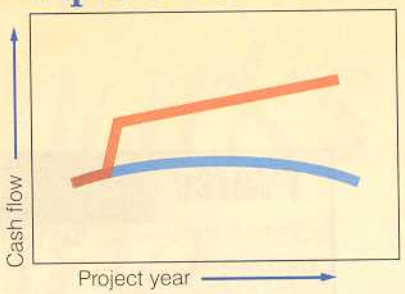
erator with additional steam-turbine generator capacity. The new plant will be more efficient and have a larger capacity for generation, reducing variable costs, but accepting added capital costs. The modeled expected cash flow for the project, assuming a two-year construction period, is depicted in Figure 4.

■ **Option to change operating strategies.** Another alternative would be to operate the plant as a peaking unit in simple-cycle mode for fewer hours each year. This would represent an exchange option. This shift in strategy would not require additional capital investment but would change the efficiency and reduce capacity. The resulting facility would require less maintenance, but increase variable costs. There may also be complications with existing air emissions permits. Figure 5 illustrates the potential impact on expected cash flows.

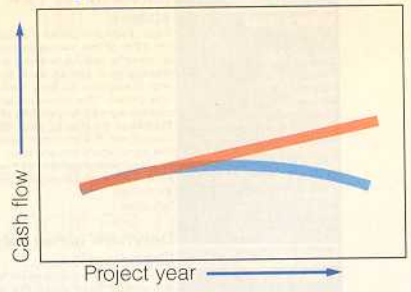
■ **Option to abandon or suspend operations.** Life doesn't always turn out as planned. High impact/low probability outcomes ("surprises," for the non-statistician) can dramatically shape the future. Even less-dramatic events—such as an economic downturn with a postponed rebound—might provoke management action. This simple option is one of the more practical considerations that result in both a reduction of total risk and an immediate rise in expected return (Figure 6).

■ **Option to defer, option to stage.** The ability to defer a decision is valuable in itself. The time that elapses between the present and the future decision point will provide additional information that, whether favorable or unfavorable, will reduce the uncertainty of the investment outcome. This is an example of a type of option that can be combined with other options to represent strategic decision-making. Likewise, the option to stage the investment, learning more at each step, is of significant value. Redevelopment or repowering decisions that can be divided into several smaller projects offer this option to managers.

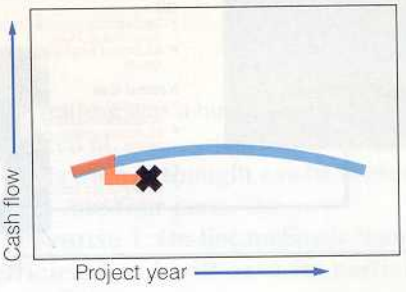
4. Change to expected cash flow created by expansion



5. Exchange of operating strategies may redirect expected cash flow



6. Option to suspend operations is often overlooked in valuation



These options can also be rolled into a consolidated framework that allows for the many alternatives to be analyzed in a complimentary fashion. There are many techniques for approaching this analysis, and each has its pros and cons (see box, p. 33)

Nested options

If you're thinking that real options can (and should) be combined, you're absolutely right. One of the unique characteristics of real options is their compound nature. In venturing down any single path, an asset manager faces decision points that offer a choice that may preclude other contingencies. Similarly, that chosen path may be the only means of achieving other opportunities.

Managers inherently recognize this compound nature and the value in taking measured steps to the achievement of a larger strategy. Implementing change in such a manner allows for a learning process to be initiated. Follow-on decisions are made with the advantage of more information, reducing uncertainty. Therefore we see that the nature of real options, and compound options particularly, provides a change in risk as the project proceeds. Reflecting upon the early lessons learned with DCF, we know that proper accounting for this shift in risk is important to correctly valuing the future path that creates the change in risk.

The incorporation of the value offered by real options into the overall value of a project is an important component of asset management. Furthermore, the strategic implications of value creation and competitive advantage offered by the active management of assets through the perspective of real options are significant. It is imperative for asset managers and decision-makers involved in the electric generation industry to appreciate and incorporate the appropriate analytical tools into the management process. ■

Steven Scroggs is director of the Decision Analysis Group at DAI Management Consultants, Inc., Pittsburgh. Dr. Paul Fischbeck is a professor and David Rode is a doctoral student in Social and Decision Sciences at Carnegie Mellon University in Pittsburgh. For more information on the real options methodology, visit www.daidecision analysis.com or www.realoptions.com—a community site for researchers and students offering news, reference material, teaching cases, and links.