Portfolio Management for Strategic Growth

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For help in preparation of this article, thanks to Fiona Macmillan, London, England; Graeme Simpson, Gaffney, Cline and Associates, Guildford, Surrey, England; and Jim Thorson, Resource Solutions, Denver, Colorado, USA.

The petroleum industry is shifting emphasis from cost-cutting to more diverse asset-management practices. Portfolio optimization, a fast and effective way of analyzing and improving overall asset value, is one tool that can help.

Ups and downs in the exploration and production (E&P) business are accepted as facts of life in an industry known for its risks. How high the highs, how low the lows and when they occur are difficult to predict, but the cyclic nature itself is taken for granted. During good times, companies grow, invest in riskier ventures and profit if the upturn lasts long enough. During slumps, companies divest and implement cost-cutting measures. Given such unpredictable swings, how can the petroleum industry plan for long-term growth?

Many E&P companies have discovered the value of managing their assets as a blended collection, or portfolio, taking into account interdependence of projects rather than considering investments on a project-by-project basis.[1] Common practice is for a company to first rank individual projects either by net present value (NPV) at a given discount rate or by some other measure of worth, then initiate those projects that fit the current investment budget—starting with the best.[2] This method assumes that projects are independent, or have no common factors.

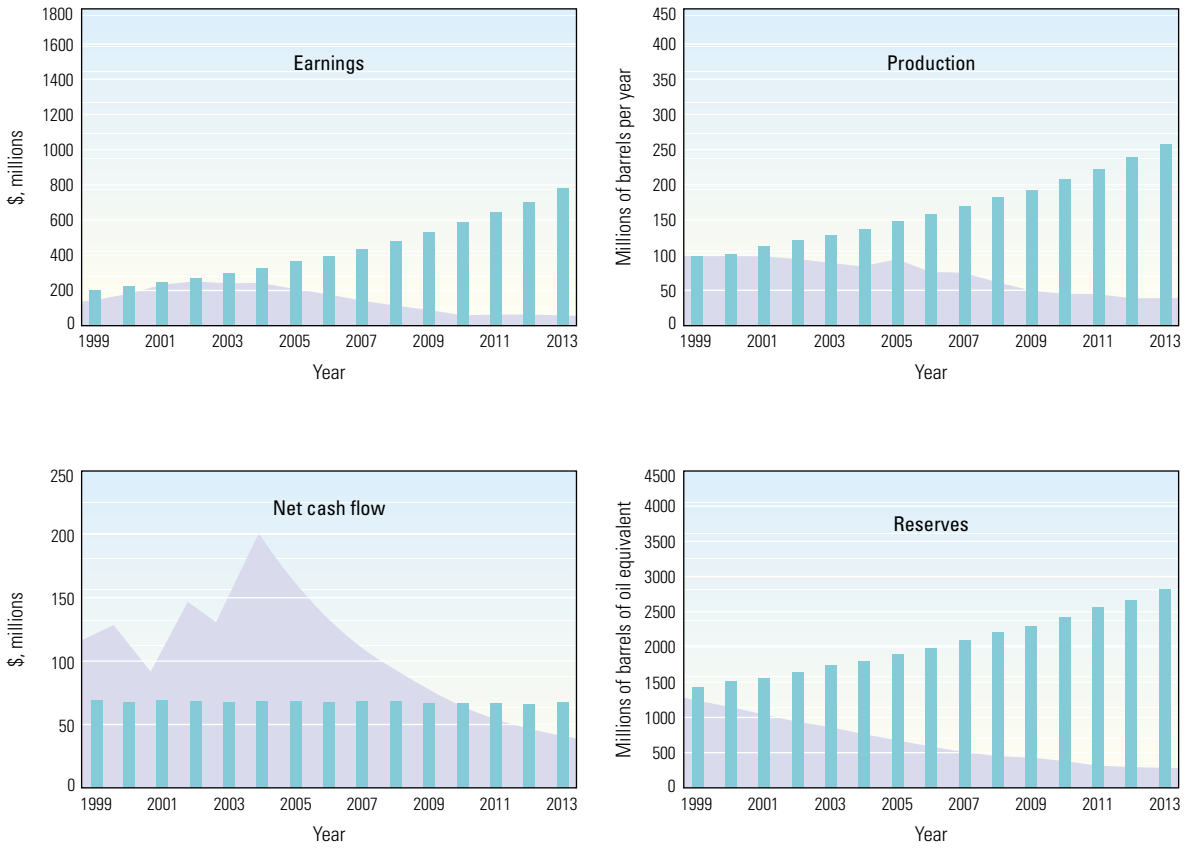
The portfolio-management approach capitalizes on the fact that all projects interact, whether they involve exploration, development, production or acquisition. Factors such as market fluctuations, performance targets and technical risk are among the elements that tie one project to another. Even if there is no apparent technical link between projects, they interact in the sense that pursuing one project may prevent another from being pursued, or one project's success may cause others to be possible. The portfolio perspective helps decision-makers throughout the organization understand how projects interact to satisfy balanced business requirements.

Portfolio management can be thought of as a bridge between a company's vision, or business strategy, and the collection of projects that will bring that strategy to fruition. Corporate strategy and metrics—standards of measurement used to quantify the strategy—along with long-term targets for each metric form the foundation. For example, results of the company's existing base business can be compared to targets for metrics

1. Ball BC and Savage SL: "Holistic vs. Hole-istic E&P Strategies," *Journal of Petroleum Technology* 51, no. 9 (September 1999): 74, 76, 78, 80, 82, 84.

   Howell JI III, Anderson RN, Boulanger A and Bentz B: "Managing E&P Assets from a Portfolio Perspective," *Oil & Gas Journal* 96, no. 48 (November 30, 1998): 54-57.

   Anderson RN, Amaefule J, Forrest M, Howell JI III, Nelson HR Jr and Rumann HA: "Quantitative Tools Link Portfolio Management with Use of Technology," *Oil & Gas Journal* 96, no. 48 (November 30, 1998): 48-50, 53-54.
2. Net present value represents the difference between present values of cash outflows over the life of the project and present values of cash inflows, all discounted at a selected interest rate.



^ Metrics, or standards of measurement, and strategic targets for a generic exploration and production (E&P) portfolio. Metrics for this study are earnings, production, net cash flow and reserves. Targeted levels for these metrics are displayed as vertical bars. The purple shaded area represents business as usual, or the level achieved by the base business, over a 14-year period. Disparity between base-business results and targets shows where company performance falls short. (Adapted from Howell et al, reference 1.)

such as earnings, net cash flow, production and reserves (above).[3] Discrepancies between base-business results and targets highlight potential problems in business performance that must be corrected to meet the targets. However, optimizing a set of assets while simultaneously satisfying multiple competing metrics is not a trivial task.

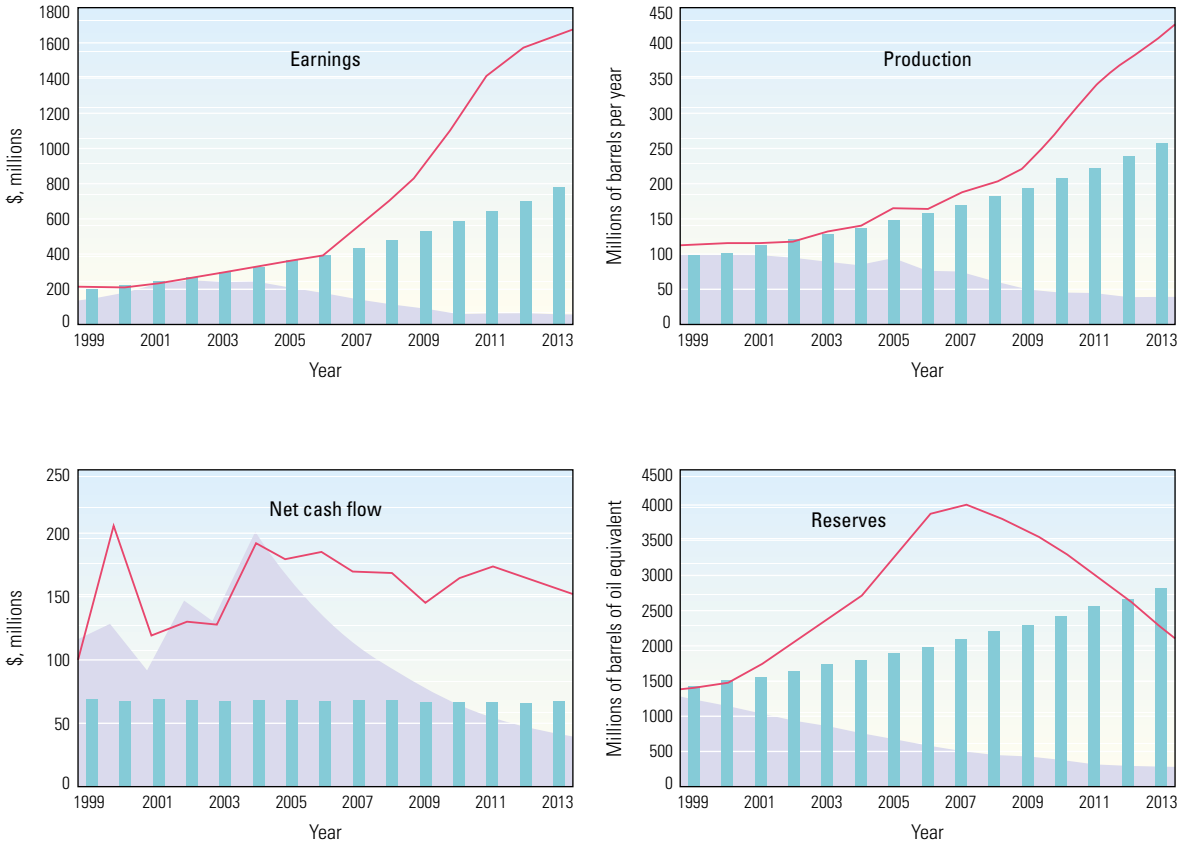
The next structural element of the bridge is selection of assets to pursue, acquire, divest and reconfigure so that overall, the portfolio will meet strategic targets (next page, top). Excesses in net cash flow, for example, might be invested to bring reserves, production and earnings in line with target levels. However, it is not likely that selection of one isolated project will bring base-business results up to target levels. A subset of projects must be selected from what is generally a much larger assortment of possible projects. Potential projects may include exploration opportunities, current development and production assets, and full- or part-ownership of new acquisitions, mergers and trades. As the number of project opportunities grows, corporate or financial planners are faced with the increasingly difficult task of choosing projects that best achieve company objectives.

This article describes some of the techniques available for analyzing and optimizing asset portfolios, including software and consulting services that help rank investments, select projects and predict the probability of portfolio success. These techniques can be used on multiple levels by a variety of decision-makers: at the highest level, for developing a business strategy; at a second level, for evaluating investment opportunities; and at a project level, for supporting ongoing business. First we look at how a method called efficient-frontier analysis, designed for analyzing financial-investment portfolios, is being tailored to suit petroleum-industry problems. Then we present case studies showing how two oil companies are starting to apply these optimization methods to asset-portfolio management.

On the Frontier of Efficient Portfolios

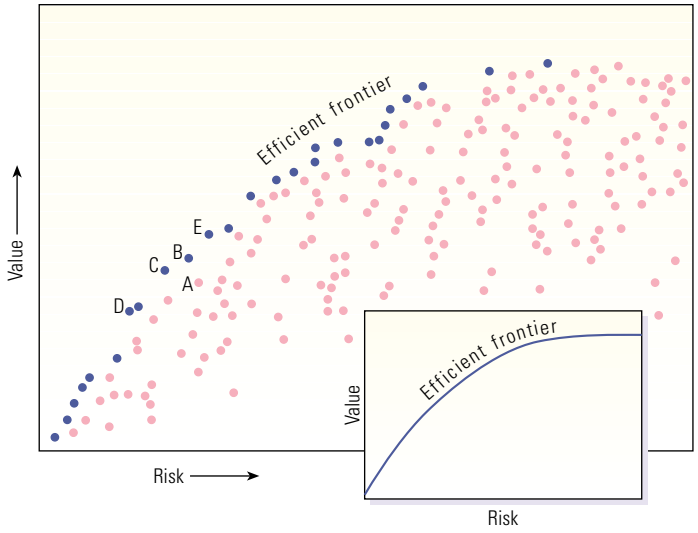
Efficient-frontier analysis considers the balance between value and risk in the selection of optimal portfolios. Efficient-frontier theory was originally developed about 50 years ago to analyze securities portfolios, but it differs in some respects when applied to petroleum portfolios.[4] The original idea states that a portfolio can be worth more or less than the sum of its component projects and that there is not one best portfolio, but a family of optimal portfolios that achieve a balance between value and risk. These statements remain at the heart of efficient-frontier theory as it pertains to the oil field.

A portfolio is said to be efficient if no other portfolio has more value while having the same or less risk, and if no other portfolio has less risk



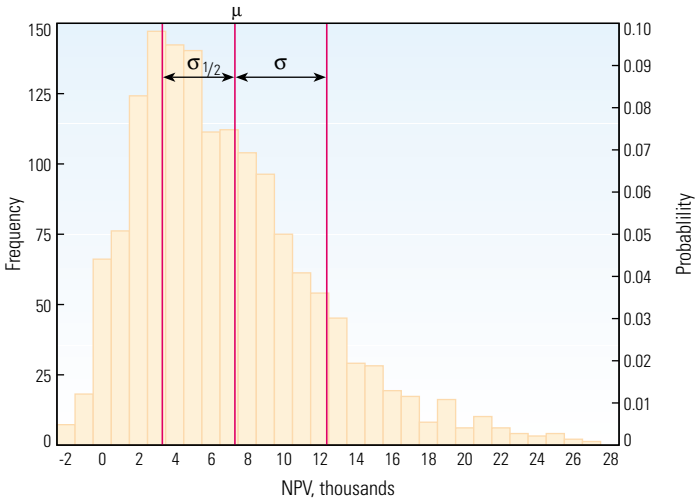
^ A portfolio perspective. The pink line shows an optimized portfolio solution that meets strategic targets, filling in gaps left by the base business. (Adapted from Howell et al, reference 1.)

while having the same or greater value (right).[5] For the purpose of this example, value is defined as the mean net present value of the portfolio, and risk is defined as the semistandard deviation of the portfolio's possible value. Semistandard deviation is a statistical measure of the distribution of possible values a portfolio could have, given that the portfolio value is uncertain. It is calculated in



^ Efficient-frontier theory. Oil-industry portfolios plotted by risk and value delineate the efficient frontier. A portfolio is efficient if no other portfolio has more value for the same or less risk, and if no other portfolio has less risk for the same or more value. Portfolios B, C, D, E and all blue dots are efficient, while A and other pink dots are not. In the securities-investment industry, for which efficient-frontier theory was developed, the efficient frontier is a continuous line *(insert)*. (Adapted from McVean, reference 4.)

3. Base business is the course of business if current projects are continued but no new projects are undertaken.
4. McVean JR: "The Significance of Risk Definition of Portfolio Selection," paper SPE 62966, presented at the 2000 SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA, October 1-4, 2000.
5. Markowitz H: *Portfolio Selection: Efficient Diversification of Investments*, 2nd ed. Oxford, England: Blackwell Publishing Co., 1991.
   Bailey W, Couët B, Lamb F, Simpson G and Rose P: "Taking a Calculated Risk," *Oilfield Review* 12, no. 3 (Autumn 2000): 20-35.



^ Standard (σ) and semistandard ($\sigma_{1/2}$) deviations of a typical portfolio risk profile. For such a probability distribution, which is skewed about the mean (μ), the semistandard deviation is notably smaller than the standard deviation.

the same way as standard deviation, but only values less than the mean are used (above).

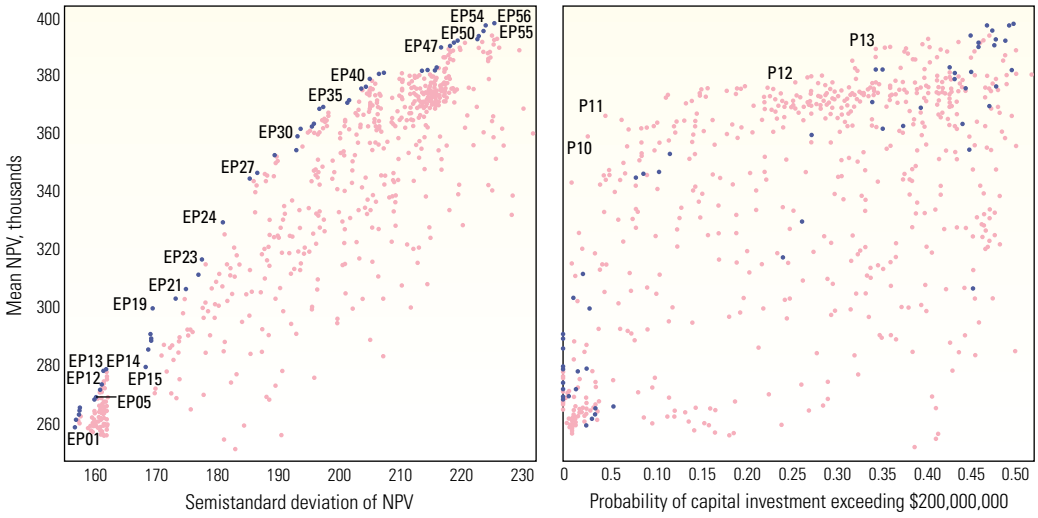
On a plot of value versus risk, the upper boundary of the group of portfolios approaches the efficient frontier. In the financial-investment industry, where each investment can represent infinitesimally small shares in a project, the efficient frontier plots as a continuous line. In the petroleum-asset case, projects are often either done or not done, and so the value-risk space is a collection of points rather than a continuous space. The efficient frontier itself plots as a set of portfolios rather than a line. In this example, portfolios B, C, D and E are all relatively efficient—they lie on or near the frontier—while portfolio A could become more efficient by reducing its risk or increasing its value, or both.

Several companies and consultants have developed software packages to calculate and display efficient-frontier analysis specifically for E&P portfolios. These include the Perspectives package by Portfolio Decisions, Inc. (PDI), Capital Planning software by Merak, a Schlumberger company, and the Portfolio module of the TERAS software by Landmark.[6] Merak and PDI have developed a business partnership combining PDI consulting and functionality from the Perspectives package with Merak Capital Planning software to create an enhanced portfolio-management process.

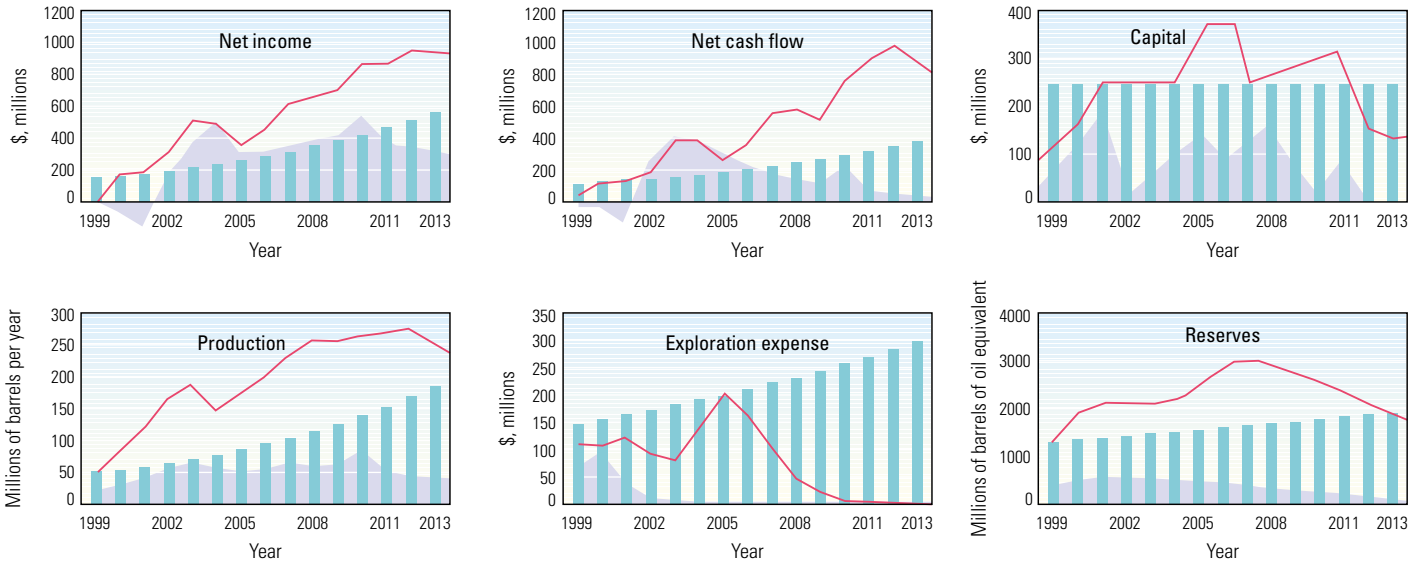
In the Merak suite of software, analyzing portfolios in value-risk space follows three steps. First, the set of projects that could potentially be included in a portfolio must be collected and evaluated. Economic evaluations are carried out by the Merak Peep software, an economic engine capable of performing calculations for fiscal regimes all around the world. Monte Carlo methods are used to model the uncertainty inherent in each of these projects. If required, correlation—such as price—among projects can be set up at this stage.

In the second step, the business strategy is defined in terms of economic, strategic and physical requirements for the portfolio. Constraints may be in terms of maximum capital cost, minimum production, minimum reserves growth, or any other strategic metric, and may be fixed over one or more years of the life of the portfolio. Other factors, such as rig availability, geographic distribution of assets in the corporate strategy and contractual obligations, can be included as constraints.

6. For a list of software and service providers in decision, risk and portfolio management: Thorson J: "Opportunity Management Resources," *Exploration Business Journal* 4, no. 3 (Third Quarter, 2000): 14-15.
7. A genetic algorithm can be thought of as a guided random search engine. For more on its use in portfolio optimization: Fichter DP: "Application of Genetic Algorithms in Portfolio Optimization for the Oil and Gas Industry," paper SPE 62970, presented at the 2000 SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA, October 1-4, 2000.
8. McVean, reference 4.
9. Albers JA and Howell JI III: "Portfolio Balancing to Achieve Long Term Strategic Goals," presented at the Euroforum International Symposium for Strategic Portfolio Management for Upstream Oil and Gas, London, England, March 22-23, 1999.



^ The effect of different definitions of risk on efficient-frontier analysis. The left plot uses the common E&P definition of risk, semistandard deviation of net present value (NPV). Efficient portfolios are blue dots, and are labeled EP01 through EP56, starting at the bottom. On the right, the same portfolios are plotted, but the definition of risk is the probability of exceeding the capital-spending limit in the first year of portfolio life. Some portfolios that were attractive under the original definitions become less so with the new definitions, and vice versa. Portfolios that were efficient before are again shown as blue dots. (Adapted from McVean, reference 4.)



^ Comparison of metrics and targets for a Burlington Resources International (BRI) $5.5 billion portfolio. The base business (purple shading) meets or exceeds only a few of the targets (vertical bars), for example, net income and net cash flow for the years 2002 through 2005. By including other assets and activities, an optimized portfolio (pink line) can be created that meets many more of the target levels.

The third step combines groups of projects to create portfolios, then compares and analyzes the results. Portfolios can be created manually or through a variety of automatic techniques. One of these methods is the random portfolio generator, which creates a selection of portfolios that satisfy the business strategy. Better portfolios can also be sought using more intelligent optimizers. For instance, linear programming—featured in the PDI Perspectives and Landmark TERAS software—can be used when the description of the problem and its constraints are linear. Linear programming delivers optimized solutions for a broad range of business problems. However, some problems require long solution times and may generate suboptimal results when tackled with linear programming.

Another optimizer known as the genetic algorithm has the power to handle highly nonlinear problems.[7] Because of its robustness, it can be directed to maximize value or minimize risk for cases in which value and risk can be defined in virtually unlimited ways. With these methods, thousands of projects can be scrutinized and sorted to compile candidate portfolios.

All of these portfolios, however they are generated, can be compared and examined in a variety of ways. The Capital Planning software provides graphical, tabular and data-management tools for examining and comparing portfolios. Some analysts prefer efficient-frontier plots to evaluate portfolios, while others focus on the probabilities of meeting metric targets. All are useful tools for exploring the strengths and weaknesses of different portfolios.

The efficiency of a selected portfolio, or its position on a risk-value plot, depends on the definitions of risk and value.[8] In the E&P industry, value is often defined as mean NPV at a specific discount rate, and risk is taken to be the semistandard deviation of NPV—representing only the downside in the variance of NPV, or only the results that are less than the mean. A set of portfolios can have a completely different appearance if plotted using different definitions of risk and value (previous page, bottom). In this example, one plot uses the common E&P definition of risk, and the other quantifies risk as the probability of exceeding the capital-spending limit in the first year of portfolio life. Since the cost of each project is uncertain, there is a chance of failing to satisfy this constraint by overspending in the first year. Under this definition of risk, some portfolios that previously were inadequate now appear attractive, and vice versa.

The selection of an optimal portfolio is strongly dependent on which definition of risk is selected. Consequently, it is important to explore multiple risk definitions in order to more fully understand the quality of a portfolio, and ultimately make wise decisions about which projects to pursue.

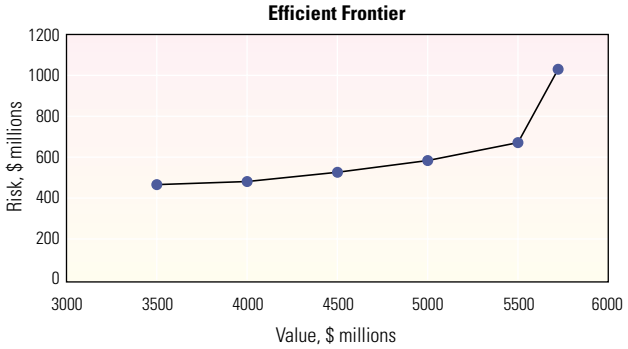
Stepping into Portfolio Management

In 1999, Burlington Resources International (BRI), the international division of Burlington Resources, began using the portfolio-management approach to evaluate both its existing properties and new opportunities. After successful implementation in the international division, modern portfolio-management techniques are now being applied across the corporation. Historically, decision-makers in the industry would have based opportunity-evaluation decisions on intuition and experience. However, these insights are subjective and could result in different decisions from one decision-maker to the next. Under the new approach, projects are judged based on quantitative information about their contribution to the company's long-term strategy and how they interact with other projects in the portfolio.[9]

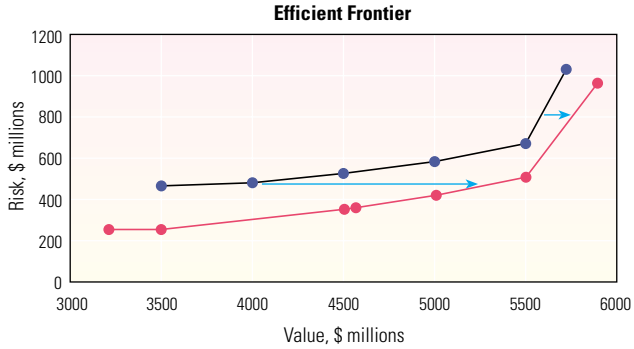
At BRI, the portfolio model is used in several ways to identify why and how a particular opportunity may be beneficial to the portfolio. Efficient frontiers of the portfolio with and without the new opportunity are analyzed to understand its impact on total portfolio value, which may be higher than the NPV of the opportunity alone. The portfolio output is reviewed to determine why the new opportunity may be valuable to the strategy and to identify any downside risks. Confidence levels of meeting strategic goals with and without the opportunity are studied to evaluate how the new project affects the likelihood of meeting those goals. The opportunity is then characterized for the decision-maker in terms of its effect on the total business performance of the portfolio.

One example of how Burlington Resources has used portfolio-management tools comes from evaluation of a specific decision to acquire a production project. As a starting point, an original, optimized $5.5 billion portfolio is analyzed using multiple criteria. Then, economic data for the new project are added, and the analysis is repeated.

The initial analysis compares targets, base-business values and portfolio values for six metrics: net income, net cash flow, capital, production, exploration expense and oil reserves (above). Several of these targets were applied as constraints to the portfolio solution. For example, the



^ Efficient frontier for the pool of Burlington Resources International (BRI) portfolios. The plot has a different shape than previously shown efficient frontiers because the axes are interchanged. The curve represents the family of minimum-risk, maximum-value solutions that all meet the same performance constraints. The $5.5 billion portfolio has the highest value that could be achieved before the risk component increases significantly and becomes too extreme.



^ Comparison of efficient frontiers with and without the new production-acquisition project. The efficient frontier of portfolios that include the new project (pink curve) moves toward higher value for the same risk relative to the efficient frontier of portfolios without the new project (black curve).

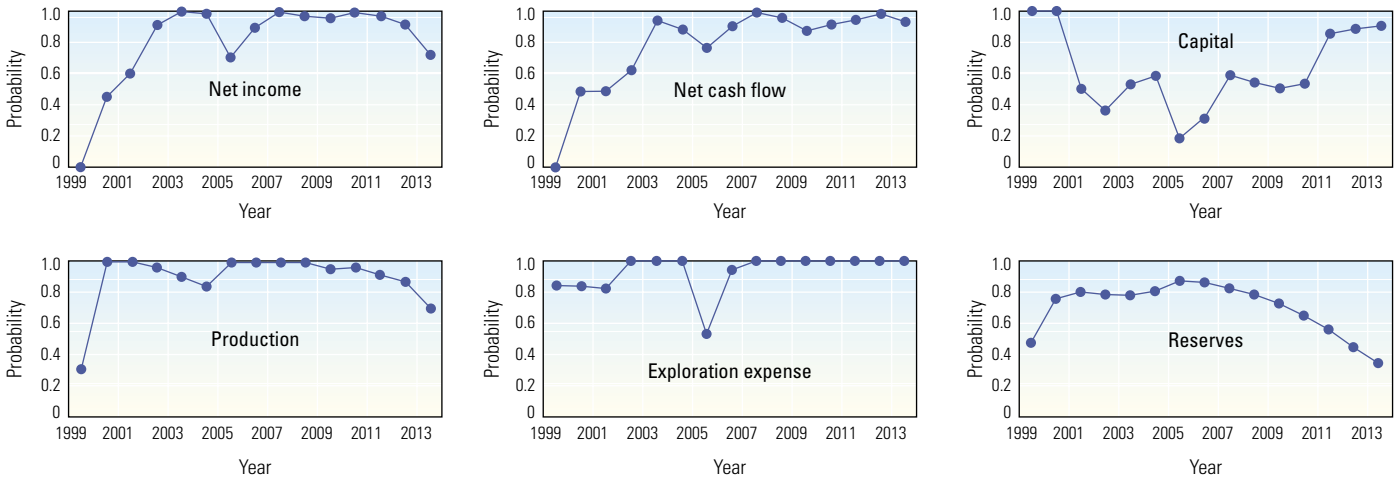
net income and net cash flow targets for 2000 and 2001 were constraints, and so forced the solution to equal these values exactly. Similarly, exploration expense for 2005 and capital targets for the years 2001 through 2004 were matched exactly.

The original optimized portfolio is only one of a set of optimized solutions that can be created using the initial set of projects. An efficient frontier displays the set of portfolio solutions that meet the same performance metrics but have different values and risks (above left). This plot, with risk on the vertical axis and value on the horizontal, contains the same kind of information as in previously shown efficient frontiers, but is simply transposed (software packages differ in their presentation style). The $5.5 billion portfolio was selected as the original test portfolio because it has the maximum value for the level of risk that could be tolerated.

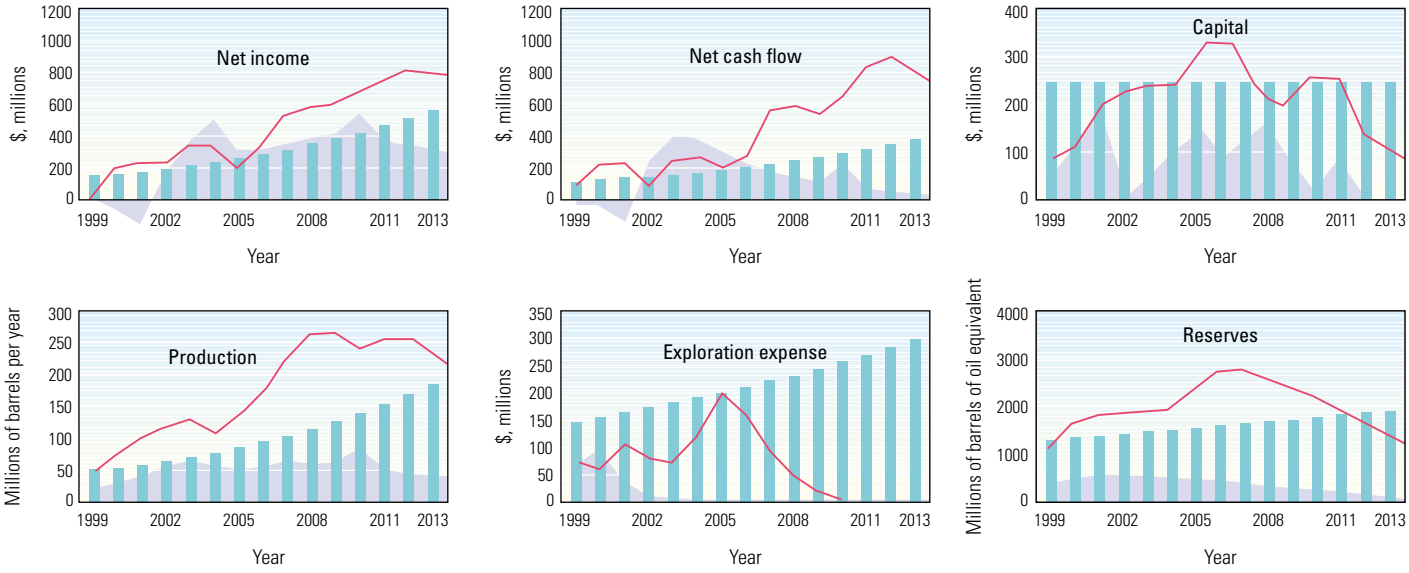
With uncertainty information provided by technical specialists, the original portfolio was analyzed to determine the probability of meeting each performance target through the 14-year period (below). The portfolio has a low chance of meeting near-term targets for net income, net cash flow and production. It also has a poor chance of staying within the target for capital between 2002 and 2010, and likelihood of making the reserves target declines after 2006. These displays help decision-makers understand the impact of project uncertainties at a portfolio level, and can be compared with results that include the new project under consideration.

The production-acquisition project, when added to the pool of available projects, could not be selected for inclusion in the portfolio because initial testing showed that it violates the constraint on capital for the first two years. Following discussion with and approval by the decision-maker, that constraint was relaxed and the project was added to the pool.

All the efficient-frontier portfolios generated from the new pool include the new project, so it unquestionably adds value (above right). The new efficient frontier shifts down and to the right in value-risk space. For the same value, a portfolio from the new pool has less risk, and for the same risk, more value. The increase in value at a constant risk is not the same for all portfolios. For low-risk, low-value portfolios, say at risk level 480, the



^ Probability of meeting or exceeding six metric targets with the optimized portfolio. The portfolio has a low probability of meeting first-year or near-term targets for net income, net cash flow and production. It also has a poor chance of meeting the capital target after the first two years, and a decreasing probability of making the reserves target in the long term.



^ Portfolio performance without the new project. In the absence of the production-acquisition project, the portfolio fails in multiple instances to meet targets. For example, net income in 2005 and net cash flow in 2002 are below target levels. The constraint on capital for the early years of the project had been relaxed.

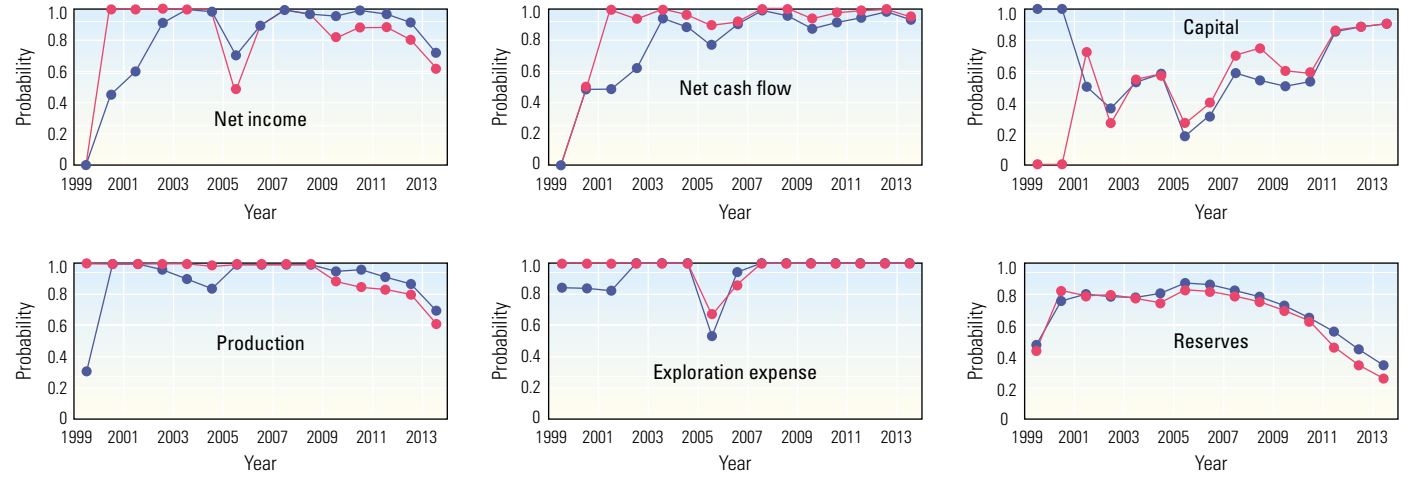
increase in portfolio value if the new project is included is about $1.5 billion. For the higher risk, higher value portfolio at $5.5 billion, the added value is $0.25 billion.

This example demonstrates the difference between portfolio value and NPV of a project. The net present value of a project is constant, and measures properties of the project alone. The portfolio value of a project varies as a function of the portfolio and quantifies the cumulative performance difference the new project brings.

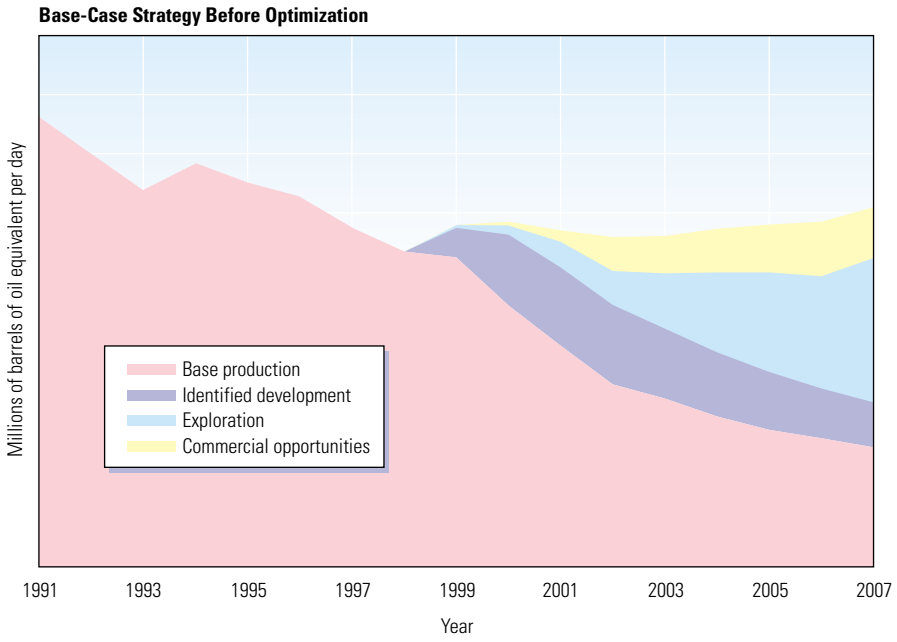
To understand why this project is valuable to the strategy, the newly optimized portfolio can be analyzed without the project (above). Lacking the production-acquisition project, the portfolio fails to meet targets for net income in 2005, net cash flow in 2002 and production and reserves in 1999. These critical contributions are directly attributable to the new project, and show where it adds unique value to the portfolio.

The value is further defined by comparing the probabilities of success for the new and original portfolios (below). Significant improvements are clear in the probabilities of meeting short-term targets for net income, net cash flow and production. However, the improvements are counterbalanced by a marginal reduction in the probability of meeting the long-term reserves target and the short-term capital target—not surprising since this constraint was relaxed earlier.

With these portfolio-optimization techniques, uncertainties in technical information can be translated into chances of success. Decision-makers can quantify the value of each project in terms of its contribution to total business performance and its interaction with other projects.



^ Increased probabilities for the new portfolio to meet targets. In some years, the improvements are small, but overall, the new portfolio (pink line) has higher probabilities of meeting targets than does the original portfolio (blue line). Specifically, short-term targets for net income, net cash flow and production are more likely to be met by the new portfolio. Probabilities for meeting long-term targets for reserves and production are marginally lower.



^ Kerr-McGee E&P production projection before portfolio optimization, showing base production (pink), identified development (dark blue), exploration (light blue) and commercial opportunities (yellow). Production volumes increase slightly from 1999 to 2007.

A Strategy for Growth

The portfolio-management approach is helping managers at Kerr-McGee Oil & Gas Corporation test and refine strategies and communicate those strategies within their organization. The portfolio perspective provides a critical link between strategy and investment options for the teams that take the vision of success defined by top management and produce results that consistently place Kerr-McGee in the top quartile among peer companies.

In 1997, Kerr-McGee began an internal process to examine peer company best practices, and top management adopted a vision to attain a top-quartile ranking among independent oil and gas companies.[10] To reach that status, Kerr-McGee would consider all value-added investment options within their two core businesses—oil and gas E&P and the production and marketing of titanium dioxide chemicals. They would also exploit a deepwater core competence, optimize all existing assets and initiate pay-for-performance incentives based on external performance benchmarking. Kerr-McGee's challenge was the same one facing all oil and gas companies: to generate controlled growth in an industry that is characterized by depleting resources.

A representative E&P portfolio example illustrates the portfolio-modeling methodology adopted by Kerr-McGee. The building blocks of a typical company's economic models for available projects include proven oil and gas properties, exploitation and exploration projects, and commercial opportunities. A sample generic E&P production projection from four types of assets—base production, identified development, exploration and commercial opportunities—indicates a slight increase in production over an eight-year period (above). Comparing production targets for that period with the chance of reaching those targets—90% probability, mean and 10% probability—showed that production targets were unlikely to be met with the existing mix of assets (next page, top left).

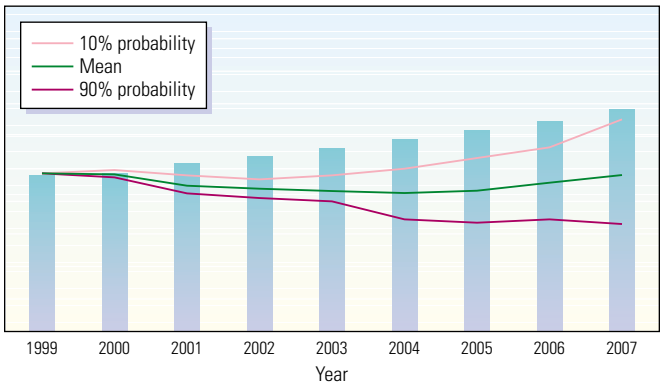
Changing the mix of exploration, commercial opportunities and other projects can help identify an optimized strategy (next page, bottom). In this example, the new asset mix contains a better balance of low-risk, high-certainty opportunities with higher risk, lower certainty projects. This yields a production projection that increases significantly through 2007, meeting short- and long-term objectives while adding significant value to the portfolio. The probability of achieving the production target, as well as other metrics, also increases (next page, top right). The targets correspond to the metrics used to define success—in this case, top-quartile performance.

In addition to providing a useful tool for testing various goals and objectives against the feasibility of generating acceptable results, these plots are an excellent way to communicate the required changes—both upward to the chairman and key corporate executives and downward to regional vice presidents and staff. The portfolio-modeling concept helps to quantify many questions that must be asked when determining the strategic direction and goals of an organization: Is the strategy feasible? How likely is the strategy to succeed? How sensitive is the strategy to price changes or political events? Which goals are problematic? What other strategic alternatives exist?

At Kerr-McGee, the strategy acts as a compass, or general direction, for the company to pursue, and provides a focus to ensure movement toward top-quartile results. The portfolio-management approach continues to be a valued tool after goals and objectives have been set, as internal and external variables change and new opportunities arise. The portfolio-modeling concept also provides an excellent mechanism to investigate investment options, determine trade-offs between opportunities and help managers make better business decisions that add value to the portfolio at an acceptable risk. While the portfolio-modeling concept does not provide "the" answer, it adds discipline to the decision-making process.

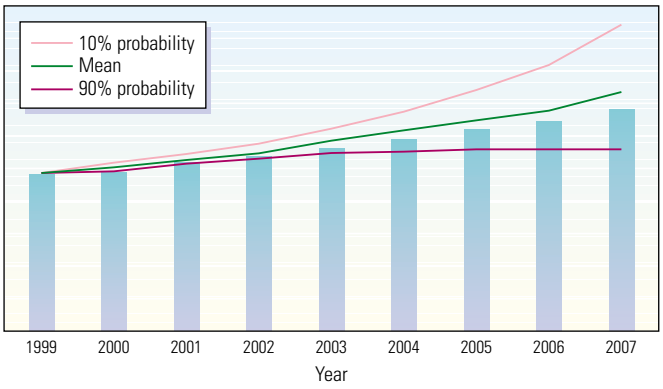
10. Adams T: "Using Portfolio Models to Optimise and Communicate Strategy and Achieve Goals," presented at the Gulf Coast Association of Geological Societies Convention, Houston, Texas, USA, October 26, 2000.
11. Haspeslagh PL: "Portfolio Planning: Uses and Limits," *Harvard Business Review* (January-February 1982): 58-73.

Typical Base Before Optimization



^ Production targets (vertical bars) and three curves showing probabilities of reaching those targets with the original portfolio. The 90% probability curve falls far below the targets, and the mean and 10% curves also fall short of the targets. Probability of meeting the targets is less than 10%.

Optimized Strategy



^ Production targets (vertical bars) and three curves showing probabilities of reaching those targets with the optimized portfolio. Probabilities are high that the new portfolio will meet production targets, and there is some chance that the targets will be exceeded.

The Portfolio Vision

Portfolio management offers a methodology for decision-makers to evaluate asset portfolios, assess the likelihood of meeting objectives and bridge the gap between targets and the results attainable under the current strategy. Many industries already use these methods to reach their goals for long-term growth. Results of a survey conducted almost 20 years ago indicate that several process-driven industries such as chemical, food and paper manufacturing, as well as the downstream petroleum-refining industry, already had years of experience with the portfolio perspective.[11] Now, 20 years later, the upstream petroleum industry finally can take advantage of the approach, thanks to improved computing power and analysis tools.

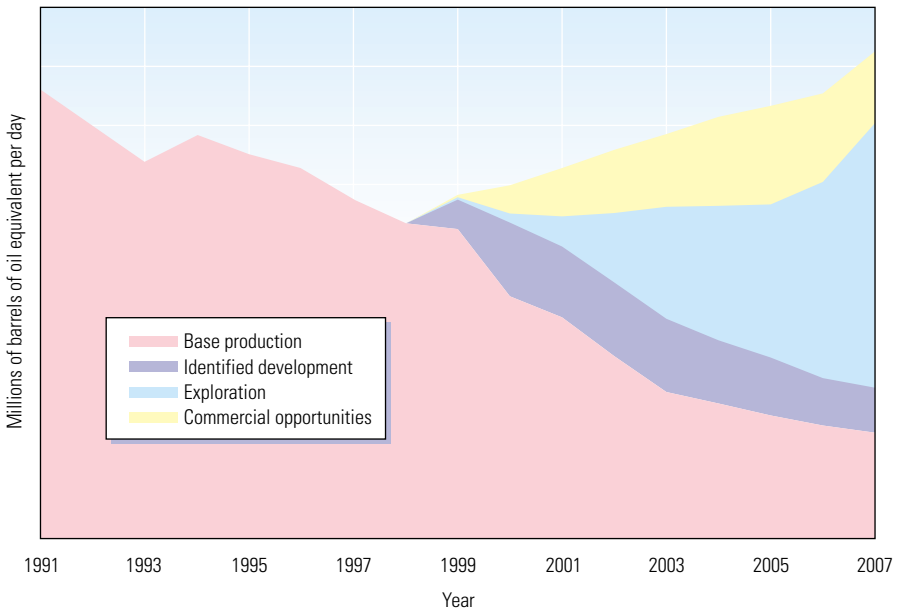
The same survey found that when companies adopted a portfolio approach, their focus shifted from short term to long term. Instead of ranking next year's profit objectives as most important in the planning process, the top ranking went to long-range profit objectives.

Some companies reach the portfolio-management stage quickly, within about three years, while others take longer. In all cases, a strong commitment from top management is the key to fast implementation, and success is based on dealing with administrative and organizational issues related to the portfolio-management approach.

Success also requires that the elegant theory of portfolio management be tailored to fit the complex reality of the E&P business. Several computational-optimization tools, such as the Merak Capital Planning software, allow decision-makers to focus on issues that help balance business performance and manage diverse opportunities.

Using techniques as sophisticated as those found in other E&P domains, such as reservoir modeling and simulation packages, these tools help reduce complex problems to manageable ones that can be analyzed consistently and logically. —LS

Optimized Strategy



^ A new mix of assets for an optimized strategy. Including a better balance of lower risk and higher risk exploration and commercial opportunities yields a production projection that increases significantly over the eight-year period (1999 to 2007).