CHAPTER 1

Energy Markets and Budgets at Risk

High, erratic energy prices have created financial crises for many businesses, institutions, and government agencies over the last several years.

This chapter provides background information on energy markets and price trends, and introduces basic Energy Budgets at Risk (EBaR) concepts. The potential role of EBaR in meeting green objectives and supporting energy policy options is also discussed.

RECENT PRICE INCREASES

As of mid-2007, average U.S. natural gas and oil prices for commercial sector (nonresidential and nonindustrial) establishments were 100 and 250 percent higher than 1999 levels (Figure 1.1). Electricity price increases in this period vary considerably by state; Figure 1.1 shows commercial sector electric prices relative to 1999 for the four most populous U.S. states of California, New York, Texas and Florida. Electric price increases over the 1999 to 2007 period range from 36 percent in California to 54 percent in Florida.

Prices in Figure 1.1 are actual prices that do not take inflation into account. Figure 1.2 shows prices adjusted for inflation. 2007 average real (inflation-adjusted) U.S. commercial sector natural gas and oil prices are 61 and 184 percent higher than 1999 levels. Real electricity price increases range from 11 (California) to 26 (Florida) percent of 1999 values. These inflation-adjusted series provide a general indication of energy price increases relative to all prices.[1]

Energy price increases and the volatility of recent years have transformed a small component of operating costs into a threat to operating reserves and profits for many organizations. Energy-intensive organizations

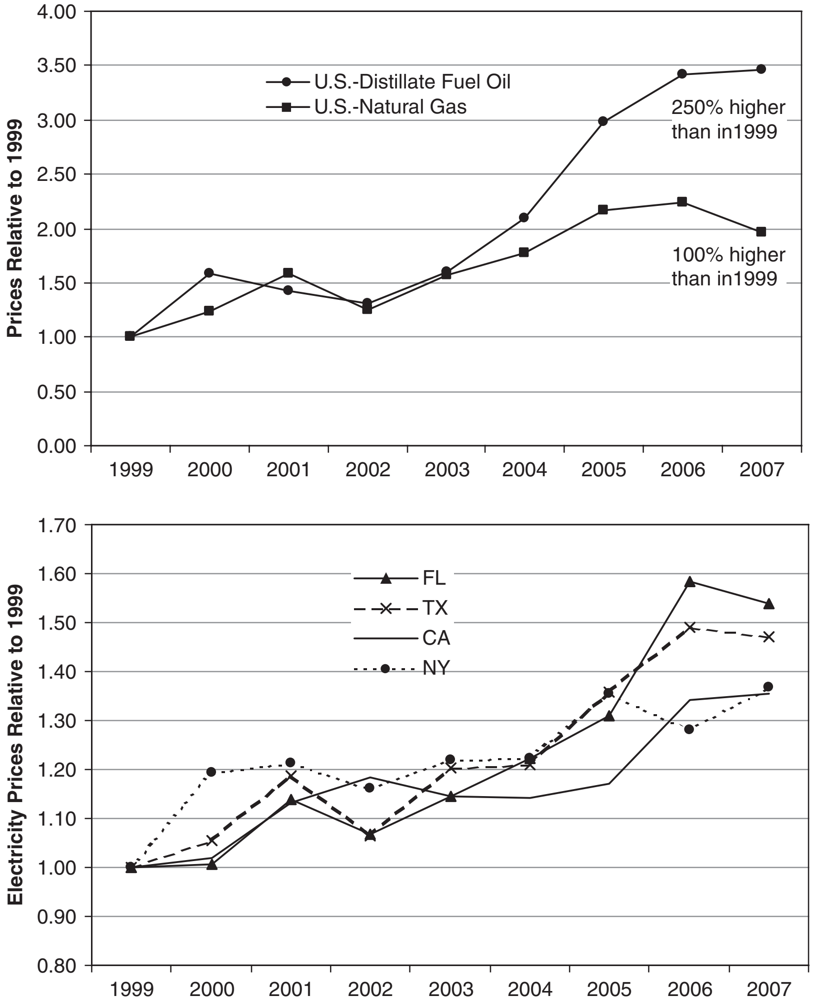

FIGURE 1.1 Commercial sector energy prices relative to 1999
Source: Energy Information Administration, http://www.eia.doe.gov/, June 2007. Estimates for 2007 are based on the first three months of the year.

have been critically affected, and recent financial reports frequently identify energy costs as a primary cause of disappointing earnings. The U.S. Business Roundtable's fourth-quarter, 2006, CEO Economic Outlook Survey identified energy costs as one of the top two cost pressures faced by their businesses.[2]

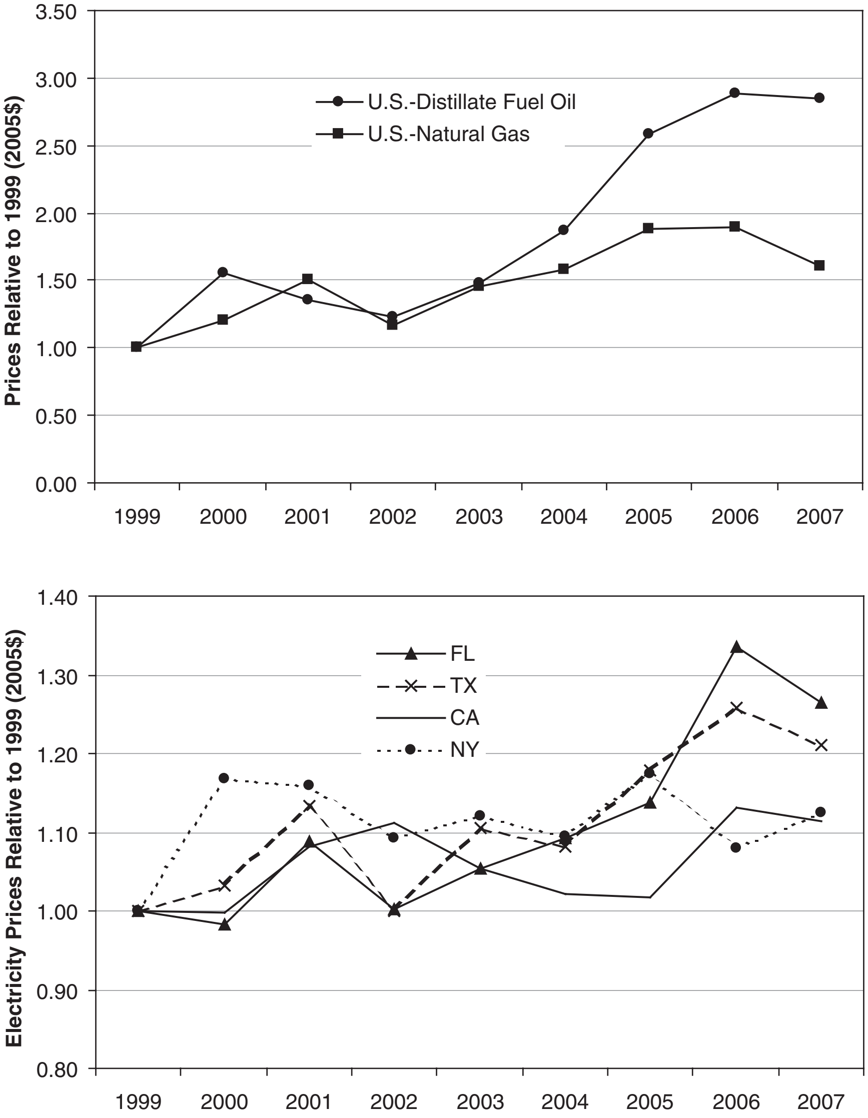

FIGURE 1.2 Commercial sector energy prices relative to 1999 (2005$)
Source: Energy Information Administration, http://www.eia.doe.gov/, June 2007. Estimates for 2007 are based on the first three months of the year. Price index data from US Department of Commerce, available at http://www.gpoaccess.gov/eop/2007/B3.xls.

APPLYING RISK MANAGEMENT TO ENERGY BUDGETS

Evaluating risk associated with energy costs and taking steps to reduce cost and risk exposure in today's energy markets require a process different from traditional energy management approaches. Current high energy prices and volatility mean that using last year's energy costs as an estimate of next year's budget and evaluating energy-reducing investments with simple payback or internal rate of return hurdle rates (minimum acceptable rates) will expose organizations to an unnecessary level of risk and bypass profitable efficiency investments.

ENERGY EFFICIENCY INVESTMENTS INCLUDE

- The **purchase of new, more efficient energy-using equipment** to replace existing equipment—for example, the purchase of new high-efficiency fluorescent lamps and ballasts.
- The **modification of existing equipment or structural characteristics** to operate more efficiently. Adjusting airflow in a ventilation system and installing solar-radiation deflecting roofing are examples of this activity.
- **Redesign of existing energy-using systems** such as delamping (disconnecting existing lighting fixtures) and replacement of standard fluorescent light fixtures with light and motion detectors. Modifying constant air volume ventilation systems to variable air volume designs is another redesign example.
- **Installation of systems to change the operation of energy-using equipment**. For example, energy management and control systems use computerized controls for everything from lighting to heating, ventilation, and air conditioning systems.

This book introduces a new framework to evaluate and quantify energy cost risks, energy efficiency investments, and energy purchase decisions based on risk management tools refined over the last decade in the financial industry. Energy Budgets at Risk (EBaR) analysis explicitly recognizes risk tolerance of individual organizations and risks associated with specific investment decisions.

EBaR is more than a tool to address recent energy price increases; it provides an entirely new framework to bring energy efficiency investment and purchase decisions up to date using best practice risk management tools. Even in relatively low-cost energy areas, organizations can expect to achieve annual net energy costs savings ranging from 20 to 30 percent of current energy bills (net savings are annual savings minus the annual cost of the investment amortized over its lifetime). EBaR can be viewed as an addition to the increasingly quantitative portfolio of management tools required in today's fast-paced competitive markets.

Energy Budgets at Risk shows organizations how to evaluate and manage energy risk in a way that best meets the organization's budget flexibility and risk tolerance.

ENERGY BUDGETS AT RISK WORKSHOPS

This book and the EBaR process have grown out of my consulting practice and a series of energy risk management workshops I developed at Texas A&M University. Comments and questions from my consulting clients and from the broad spectrum of workshop attendees from commercial, institutional, and government agencies make it clear that the tenor of energy concerns has changed dramatically over the last several years. Organizations are eager to reduce energy costs, but lack the ability to make sound financial decisions with respect to energy-efficiency investments. Energy managers are generally aware of many of the options available to improve energy efficiency; however, they readily admit they do not know how to evaluate and prioritize the alternatives or, most importantly, how to make the financial case to their management. CFOs and public administrators almost universally view energy efficiency as a different kind of capital budgeting problem—one that is most conveniently handled with very short payback thresholds, which, unfortunately, exclude many attractive options.

Organizations operating in competitive electricity and natural gas markets face even greater challenges. Energy pricing options can vary in a dozen dimensions, such as contract time period and use of hourly spot market pricing. Because pricing contract terms impact efficiency investment returns and efficiency investments impact competitive price quotes, efficiency investment and purchasing decisions should be made simultaneously. However, efficiency and purchasing decisions are almost always considered separately, usually by different departments within a single organization.

The end result is that individual organizations are losing tens of thousands, hundreds of thousands and in some cases millions of dollars per year in unnecessary energy costs. Remarkably, these neglected opportunities more than pay for themselves, increasing cash flows to provide the equivalent of new revenue opportunities.

Problems presented by two of my workshop attendees are representative of the difficulties many organizations are experiencing. The first attendee is the hands-on owner of a Texas restaurant chain. His electricity bills had more than doubled over the last several years and were cutting deeply into his profits. He was concerned that prices would continue to rise and had recently invested in a dozen different energy-efficiency technologies to cover all the bases. Unfortunately, the return on his investment was small because several of his investments had little impact on his energy bills relative to their cost.

The second attendee is an energy manager at a retail grocery chain who manages more than $5 million per year in energy costs. He knew that he could save substantially with energy efficiency investments—his local equipment suppliers were marketing their efficiency products to him. He did not know how to compare the various investments, however, nor did he know how to evaluate which investments he should undertake with his limited capital budget. To make matters more difficult, his current competitive electricity market contract was about to expire, and competing suppliers were offering many different pricing options. Faced with a seemingly overwhelming number of choices, he had procrastinated for six months at the time of the workshop—the cost of indecision to his company, by my calculations, was running at about $100,000 per month. Of course these opportunity costs are not typically evaluated, so neither he nor his management were aware of the lost revenue opportunity.

Energy Budgets at Risk shows readers how to avoid these and other energy-related investment and purchase problems. The book is written for a nontechnical audience. Concepts and applications such as probability distributions and Monte Carlo analysis are introduced and described in sufficient detail to enable readers to understand and apply EBaR analysis at their organizations.

AN ENERGY BUDGETS AT RISK (EBaR) OVERVIEW

In spite of financial challenges created by recent energy price increases, few organizations apply more than a rudimentary approach to evaluate energy price risk and energy efficiency investment options (Chapter 4 discusses this issue in more detail). Payback analysis is the predominant financial analysis tool used to qualify energy efficiency investments, though conservative internal rate of return hurdle rates or equivalent evaluations are sometimes applied. In competitive energy markets, energy purchase decisions and efficiency investments are almost universally considered separately rather than as part of a coordinated energy risk management process. Energy-related decision making is virtually the same for most organizations as it was in 1972 before energy prices began their modern volatile trajectory. Using short payback periods is a reasonably effective strategy to limit risk since it limits analysis to the near term, where there is the least uncertainty; however, it also ignores some of the most profitable energy efficiency investments.

CFOs and financial administrators in most of these organizations deal with other kinds of financial risk in a much different manner. Most organizations apply sophisticated financial risk management techniques, or hire firms to apply this analysis, in order to maximize returns on financial portfolios and pension funds. Advances in quantitative financial analysis, especially over the last decade, provide an impressive ability to quantify risks and rewards associated with various investment strategies and portfolios. Value at risk, earnings at risk and other at risk measures are now a standard part of the financial risk management vocabulary.

The following sections illustrate how modern risk management techniques are used in EBaR analysis to address energy budget and efficiency investment risks.

Energy Budgeting Under Uncertainty

Although managing facility energy costs and managing financial investments appear to have little in common, they reflect remarkably similar challenges: how best to evaluate and make investment decisions in the face of uncertainty. Analyzing energy budget risk can even be cast as a portfolio problem. Each energy-using system in a facility can be considered an investment characterized in part by its operating costs. Past years' experiences can be used to characterize variability in energy prices and energy use resulting from weather variations, facility utilization and so on—thereby providing a distribution of likely facility energy budgets for the coming year. Figure 1.3 shows an expected budget of $100,000 along with a distribution of other budget outcomes that might occur based on past experience. The area under portions of the distribution, relative to the total area under the curve, shows the probability that an outcome will occur between the two points on the energy budget axis as shown for energy budgets of less than $60,000 and more than $120,000 in Figure 1.3.

Applying at Risk Analysis to the Energy Budget Process

Readers familiar with the widely used Value at Risk (VaR) financial analysis will recognize the similarity between this energy budget analysis and VaR

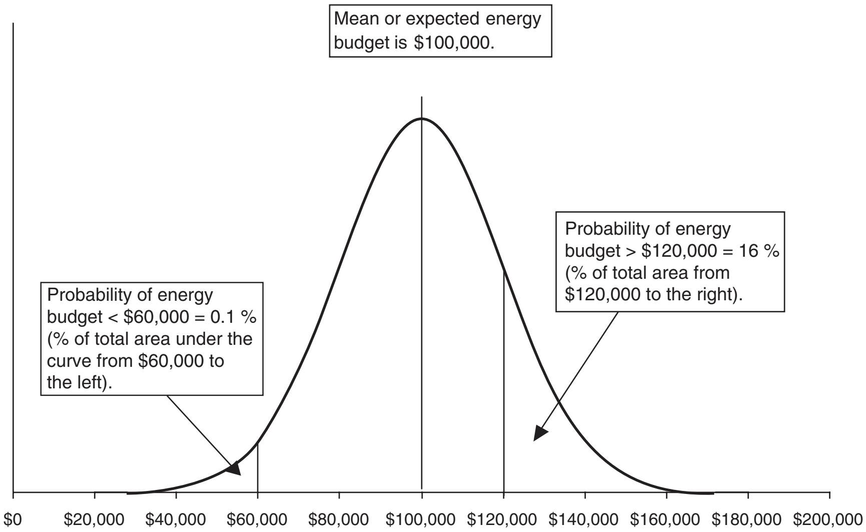

FIGURE 1.3 Distribution of Likely Energy Budget Outcomes

analysis. VaR analysis, with a history that traces back to 1922,[3] was popularized by JP Morgan in the early 1990s and is now widely used in financial analysis to assess risks associated with investments and financial portfolios. As indicated in Figure 1.4, VaR statistics show the maximum daily, weekly or monthly portfolio loss that can be expected to occur based on a specified confidence level. A variety of other "at risk" measures such as Earnings at Risk, Profits at Risk and Cash Flow at Risk have been developed. Technical analysis related to estimation of these VaR-related risk measures is now an active area of academic and applied research. U.S. and international financial regulatory agencies have adopted VaR analysis to evaluate financial institutions' risk exposure. As indicated in the lower panel of Figure 1.4, EBaR reflects an energy budget-counterpart to VaR analysis.

Including New Energy-Efficiency Investments

EBaR analysis can be applied to evaluate new energy-efficient investments—such as replacing existing fluorescent ballasts and lamps with new high efficiency products. Future variations in electric price and uncertainty over the number of hours each fixture will operate result in a distribution of likely returns on this investment. Returns can be measured as annual energy cost savings and an internal rate of return, IRR. The internal rate of return

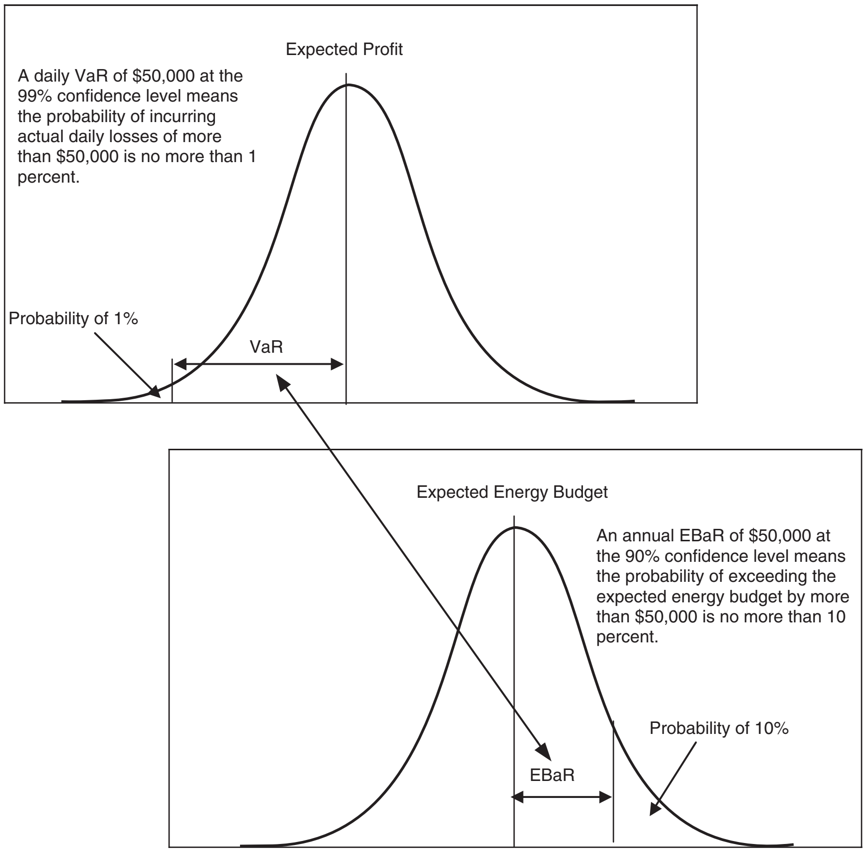

FIGURE 1.4 Correspondence of VaR and EBaR Analysis Concepts

reflects the effective yield on the efficiency investment (investment basics are covered in Chapter 4).

Figure 1.5 shows a hypothetical distribution of annual savings reflecting potential variations in electricity price and operating hours. In this example, the investment cost is $80,000; annual savings are $40,000; and the annual financing cost to pay for the investment over ten years at a 12 percent interest rate is approximately $14,000. Deducting annual financing costs from annual energy cost savings provides an annual cash flow increase of $26,000 per year. However, the payback for this investment is two years, which is more than many organizations accept in traditional efficiency screening analysis.

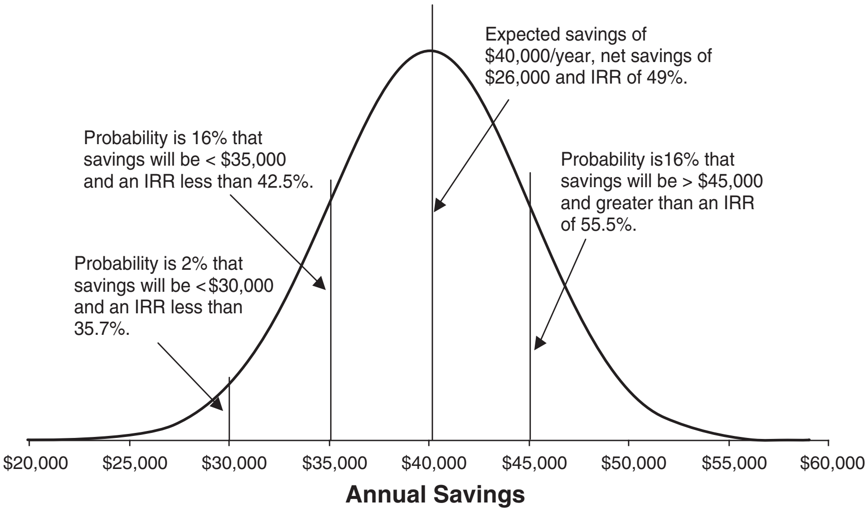

FIGURE 1.5 Hypothetical Lighting Investment Analysis

At the expected value, the internal rate of return is 49 percent. Traditional budgeting practices would recommend this investment if the $40,000 were a guaranteed return—that is, if there was no uncertainty. Of course, there is uncertainty regarding electricity price and operating hours so this investment is rejected based on its failure to meet the organization's payback threshold. The EBaR investment distribution shows, however, only a 2 percent probability that the savings will be less than $30,000 per year. Savings of $30,000 per year provide an internal rate of return of 35.7 percent and an increased cash flow of $16,000 per year. Information on the distribution of investment returns provides insights on investments like this that fail traditional payback or internal rate of return hurdle rates but provide attractive returns and can generate significant cash flows with little risk.

What happens to total energy budget risk with this investment? Subtracting the annual amortized cost of the investment from the annual energy savings and applying the same calculations as above provide a new distribution of expected energy budgets (Figure 1.6). Expected savings were $40,000; however, the amortized cost of financing the investment offsets some of the savings in the new budget to give a new net savings of $26,000 per year. The new distribution reflects a smaller expected energy budget and less variation in potential outcomes, that is, less energy budget risk. The figure shows that while the expected or average energy budget will drop by $26,000, the "worst case" outcome defined by the EBaR probability of

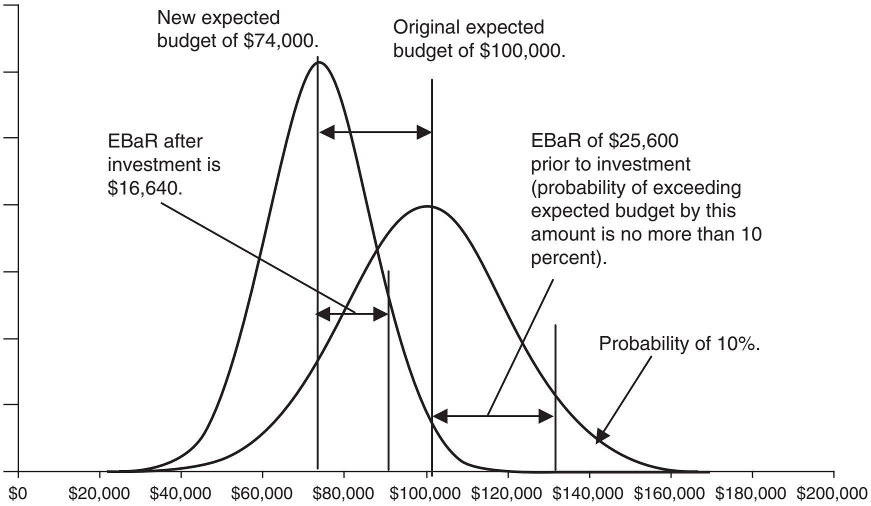

FIGURE 1.6 Total Energy Budgets at Risk after the Investment

10 percent declines by $34,960. Thus, the investment reduced the expected budget but it reduced even more the exposure to extreme budgets that can occur with high energy prices, weather, and other events.

Management and Decision-Making Advantages

The EBaR representations above are only part of the process; however, the intuitive appeal of this approach is obvious—rather than trying to make investment decisions based on a traditional single estimate of expected energy savings, the entire range of investment outcomes and their probability of occurrence should be considered. This inclusive representation allows individual organizations to better understand the risks and rewards of alternative energy strategies, and this understanding accommodates their ability and desire to bear risks. As shown in Chapter 9, assessing uncertainty using this distribution-based analysis is accomplished with Monte Carlo analysis, an accepted and easy-to-apply-approach to treating uncertainty that has been applied in financial and many other application areas for decades.

One reason that VaR analysis is so widely used is its distillation of the many dimensions of information on return and risk into a single decision variable. EBaR decision variables provide the same advantage. For instance, if $\text{EBaR}_{irr,90}$, the smallest internal rate of return likely at the 90 percent confidence level, is greater than a given threshold, say, a return of 25 percent, the investment will be recommended for further consideration. An $\text{EBaR}_{irr,90}$ of 45 percent means that there is no more than a 10 percent probability that the internal rate of return will be less than 45. A more conservative EBaR statistic for the investment, say $\text{EBaR}_{irr,95} = 0.35$, permits only a 5 percent chance of achieving a return of less than 35 percent.

From a management perspective, knowing that an investment has an $\text{EBaR}_{irr,90} = 0.45$ and $\text{EBaR}_{irr,95} = 0.35$ provides much more information

ENERGY BUDGETS AT RISK (EBaR) DECISION VARIABLES

EBaR provides three primary decision variables that measure budget and investment risk.

Energy Budgets

$\text{EBaR}_{budget,x}$ is the budget form of the EBaR statistic showing the largest expected energy budget variance (difference between the expected budget and actual energy costs) at a given confidence level, x, typically, 90 or 95 percent. An $\text{EBaR}_{budget,,95} =$ \$50,000 indicates that the likelihood of experiencing a budget variance of \$50,000 or less is 95 percent.

Efficiency Investment

$\text{EBaR}_{irr,x}$ is an investment form of the EBaR statistic showing the smallest expected investment internal rate of return (IRR) at a given confidence level, x, typically, 90 or 95 percent. An $\text{EBaR}_{irr,95} = 35$ percent indicates that the likelihood of achieving an internal rate of return of 35 percent or more is 95 percent. Chapter 4 discusses internal rate of return and other investment basics.

$\text{EBaR}_{netsav,x}$ is the smallest net savings (energy cost savings minus amortized cost of the equipment, including financing costs) at a given confidence level, x. An $\text{EBaR}_{netsav,x} =$ \$30,000 indicates a 95 percent likelihood of achieving a net savings of \$30,000 or more.

than traditional payback and IRR because it reflects the investment return conditioned on an organization's risk tolerance. Even in cases where decision makers are unwilling to accept almost any risk (perhaps using a confidence level of 97.5 percent), EBaR still provides advantages over traditional measures because it recognizes variations in uncertainty that occur across different efficiency technologies.

Thus, EBaR replaces the single-dimension decision variable, payback (or an IRR hurdle rate), with a single-dimension decision variable, $\mathrm{EBaR}_{irr,x}$, where x is the confidence level. The difference is that payback and traditional IRR analysis is based on initial cost and a single estimate of expected savings, whereas EBaR analysis is based on initial cost and likely distributions of expected savings with an explicit consideration of risk. Short payback periods accommodate risk by only accepting almost sure bets, while EBaR analysis identifies desirable investments based on both investment returns and the associated risk. In other words, EBaR-based analysis manages risk, while payback analysis attempts to avoid risk by setting conservative investment criteria.

It is worth repeating that the EBaR decision variable, $\mathrm{EBaR}_{irr,x}$, is a simple, intuitive and meaningful decision variable: a necessary requirement as capital budgeting requests are bumped up the chain of command for consideration. While intuitive graphs and tables like those in Chapters 9 and 10 can be used to visually convey an additional layer of information on the trade-off between risks and returns, the value of $\mathrm{EBaR}_{irr,x}$ alone is sufficient to qualify investments for consideration by upper management. Making investment decisions based on values of EBaR decisions variables does not require understanding the application details of EBaR analysis.

There are, of course, differences in financial portfolio and energy-related investment analysis. Portfolio managers can sell a financial instrument if its performance is lagging and replace it with another. Energy efficiency investments reflect a physical investment, so a bad investment cannot generally be sold. However, these differences are subtle compared to the overall approach provided by modern financial risk management and can be incorporated in efficiency investments analysis.

Bottom-Line Advantages

What impact can EBaR have on an organization's energy expenditures? Analysis of current energy investment behavior and existing energy efficiency technologies indicates that most organizations can achieve annual savings of 20 to 30 percent of energy costs beyond the annual costs associated with financing the investments. That is, cash flow can be expected to increase by as much as 30 percent of current energy budgets beginning the first day after the investment occurs.

A $100,000 efficiency investment in an office building that, based on the engineering calculations, pays for itself and provides additional savings of, say, $50,000 each year sounds too good to be true. After all, if this potential existed wouldn't the energy manager make the same savings calculations and make the investment without having to resort to more complicated analysis to be convinced that a "free" $50,000 per year is a good option? The answer typically is no. For instance, a recent comprehensive study of 9,000 small and medium manufacturers found an average payback of 15 months was required to prompt an energy-saving investment after a free detailed energy audit had been conducted and conveyed to facility managers and owners.[4] This criterion is equivalent to a return of about 70 percent. If a company borrows money at 10 percent it would realize a net return, after making annual interest and principal payments, of about 60 percent. Ignoring an investment of $100,000 to reap a profit of $50,000 per year does indeed seem paradoxical.

THE ENERGY PARADOX AND EFFICIENCY GAP

By the late 1970s it became apparent that corporate, government, and institutional decision-makers were more reluctant to invest in energy efficiency technologies than in other investments. This enigma was identified as the "energy paradox" or "efficiency gap." It was assumed at that time that information programs and the maturing of new energy-efficient technologies would remove most of this investment barrier. However, the efficiency gap has persisted at approximately the same level for a quarter century. This result has continued to puzzle most energy economists. Explanations have been debated in dozens of articles in the interim without any compelling empirical evidence of the cause.

The example of manufacturers currently requiring a 15-month payback in the "Bottom Line Advantages" section is just one of many examples that illustrate the fact that this investment behavior is still the rule. Studies by the Department of Energy and many other organizations confirm this shortsighted investment strategy.

As indicated in Chapter 4, the energy paradox or efficiency gap is primarily a result of decision-maker use of payback requirements to screen energy efficiency investment risk. EBaR analysis overcomes the limitations of this traditional approach.

The primary explanation for this seeming anomaly has already been mentioned above. Decision makers apply short payback periods to protect against the risk of bad investment outcomes. A mean or expected payback of 15 months may be considered necessary to limit the probability of a bad investment outcome to an acceptable level of, say, 5 percent. To be effective, rules of thumb must reflect worst-case scenarios—in this case, perhaps a technology that costs more to install, incurs greater operating and maintenance expense, and performs less effectively than planned. However, likely distributions of individual efficiency technologies vary considerably so worst-case rules of thumb reject many good investments. Evidence from studies of investment behavior indicates that most current investment decisions are guided by this attempt to limit risk, resulting in a large potential for energy efficiency savings when EBaR analysis is applied.

In summary, EBaR provides organizations with a new framework to evaluate energy budget risks and rewards of energy-related decisions. This process transforms traditional energy efficiency and energy purchase decisions into a financial analysis framework compatible with best financial practices in today's business world. Applying this investment analysis framework can be expected to increase cash flows by 20 to 30 percent or more of current energy costs for most organizations.

A LOOK BACK AT ENERGY PRICES

Most businesses, institutions, and government agencies are acutely aware of recent energy cost increases. Appropriate organizational responses to increased energy costs depend in part on expectations about future energy prices. While forecasting the exact level of energy prices at specific times is a dicey proposition, sufficient information exists on energy markets and market trends to develop reasonable expectations on future energy price trends based on past trends and factors that are expected to influence those trends in the future. This section summarizes historical price trends and relationships beginning in 1972, the year before the first oil embargo.

Energy sources are substitutable to varying extents in providing energy-related services. Oil, natural gas, and electricity can all be used to provide space heating, water heating, and manufacturing process uses; coal, natural gas and oil are substitutes in the generation of electricity. Since fuel choices generally require the purchase of long-lasting equipment designed for the energy source, substitution impacts take some time to play out. Markets for energy sources differ; for instance, oil prices are determined in a world market while natural gas prices reflect geographic supply constraints.

The end result is that the price of individual fuels is jointly determined by a complicated mix of demand and supply relationships that exist across economic sectors and geographic areas. Historical price series for oil, natural gas and electricity are presented in the sections that follow.

Oil Price Trends

The best place to start understanding energy price trends is with oil because of the influence oil prices have on other fuels and energy sources. Two major oil price spikes have occurred in the last 35 years. Figure 1.7 shows the crude oil composite acquisition cost by refiners. The first oil embargo by Arab states in 1973, which more than doubled prices, was followed by another curtailment in 1979. By 1981, oil prices were five times their 1972 level. However, by 1986, prices had fallen to $23 per barrel (in 2005 dollars), just double that of 1972. Oil prices fluctuated within a range of +/– $9 per barrel for 18 years through 2003. Since 1999, real oil prices have tripled from $20 to $60 per barrel. (All of the charts in this section show "real" prices rather than "nominal" prices; that is, the historical prices have been adjusted for inflation.)

Natural Gas Price Trends

The average U.S. price commercial customers paid for natural gas over the 1972 to 2007 period is shown in Figure 1.8.

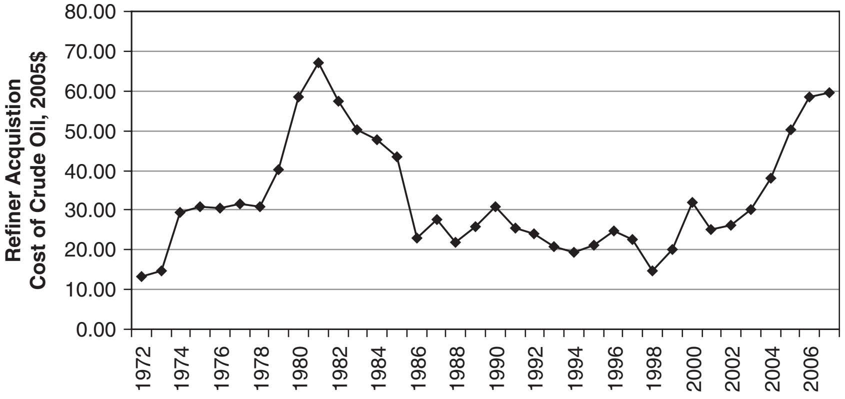

FIGURE 1.7 U.S. 1972–2007 Crude Oil Composite Acquisition Cost by Refiners (2005 dollars per barrel)
Source: Energy Information Administration, 5/29/2007. Data through 2006 are actual; 2007 is estimated based on monthly series through September.

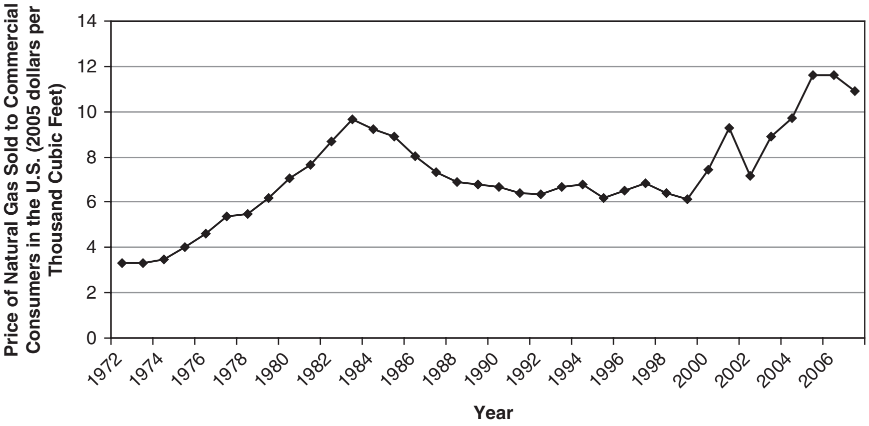

FIGURE 1.8 U.S. Price of Natural Gas Sold to Commercial Consumers (2005 dollars per thousand cubic foot)
Source: Energy Information Administration, 11/11/2007. Data through 2006 are actual; 2007 is estimated based on monthly series through August.

The correlation between oil and gas prices is illustrated in Figure 1.9 where oil and gas series of Figures 1.7 and 1.8 are plotted as annual values divided by the series average. The relationship between oil and gas prices is a stable relationship with oil prices influencing natural gas prices, but natural gas prices having little influence on oil prices.[5] In other words, increases or decreases in world oil prices are reflected in increases or decreases in domestic natural gas prices. However, when gas prices increase because of excess demand, there is an imperceptible impact on world oil markets because of the small size of North American gas markets compared to the world oil market. The recent tendency of natural gas prices to exceed oil prices on a dollars per Btu basis (Btu or British thermal units are a measure of energy content) is reflected in the figure suggesting that demand for natural gas in the North American gas market is greater relative to its supply than the relationship of world oil demand to oil supply.

Electricity Price Trends

Approximately 30 percent of electric utility operating costs (including depreciation) are determined by fuel costs; consequently, changes in generator fuels have a muted impact on electricity prices. From 1972 to 1974, the price of coal, which accounts for about 50 percent of generation capacity, rose dramatically and then steadily declined until 2003 (see Figure 1.10).

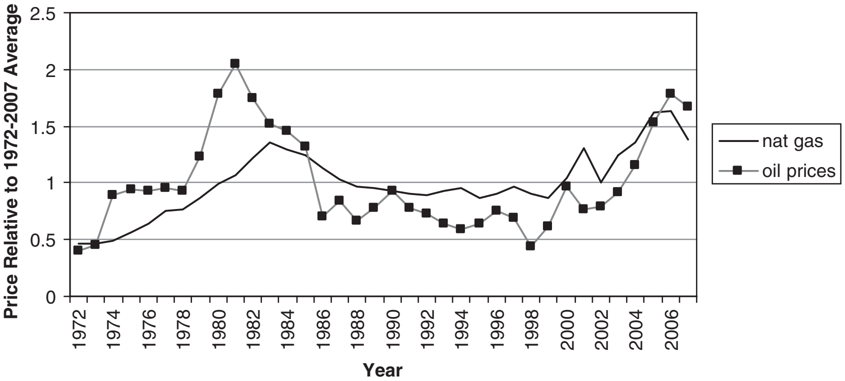

FIGURE 1.9 Comparison of Oil and Commercial Natural Gas Price Series
Source: Energy Information Administration, 5/31/2007. Data through 2006 are actual; 2007 is estimated based on monthly series through March.

With price increases in the last several years, the 2007 price of coal stands at about its 1972 level in real terms. Nuclear power is currently used for about 21 percent of utility customer generation; however, uranium costs are a much smaller part of operating cost than with fossil fuel plants. 1972 uranium prices are unavailable; however, 2005 uranium prices are about 40 percent of their 1981 value.

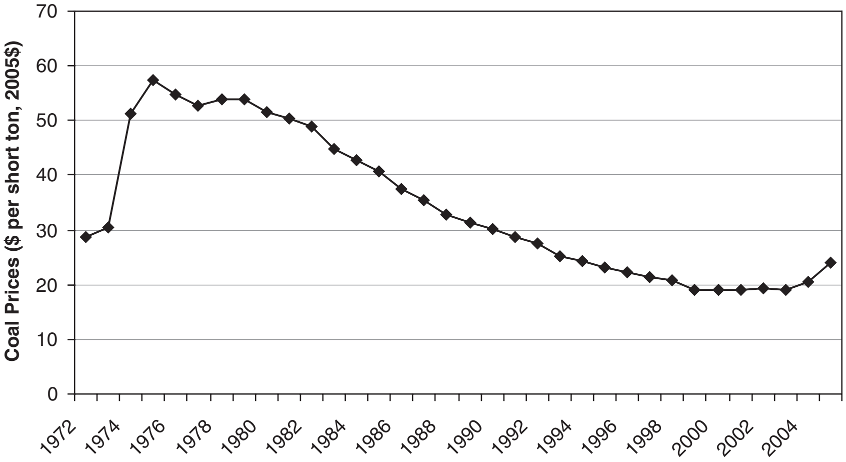

FIGURE 1.10 1972–2005 Coal Prices, 2005 Dollars per Short Ton
Source: Energy Information Administration, Annual Energy Review, 2006.

Other generating energy sources for utility customers include natural gas (17 percent), oil (2 percent), hydro (8 percent) and renewables (2 percent).

ELECTRICITY GENERATION ENERGY SOURCES

The following table shows U.S. utility and independent power producer generation by energy source.

Fuel type	**% Generation**
Coal	50.4
Nuclear	20.1
Natural Gas	18.8
Hydroelectric	7.3
Other Renewables	1.7
Oil	1.5

Source: Net Generation by Energy Source by Type of Producer, data for electric utilities, electric power chp and independent power producers, 2006, http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html

U.S. historical electric prices in Figure 1.11 reflect generating fuel price trends as well as technological advances in turbine design. Although natural gas fuels only about 20 percent of total electric generation, increases in natural gas prices since 2000 have put significant upward pressure on electricity rates in many parts of the United States. Natural gas generators account for about 75 percent of generators added in the last decade and most peaking units that provide electricity in peak summer or winter periods. As a fuel for electricity supplied at the margin, natural gas prices have considerable impact on the price of electricity. As indicated in Figure 1.1 shown at the beginning of this chapter, electric prices have increased substantially in many states reflecting increased natural gas prices. The moderating impact of states with a greater portion of generation provided by coal or nuclear generators has held national average price increases since 1999 to about 9 percent in real terms (Figure 1.11).

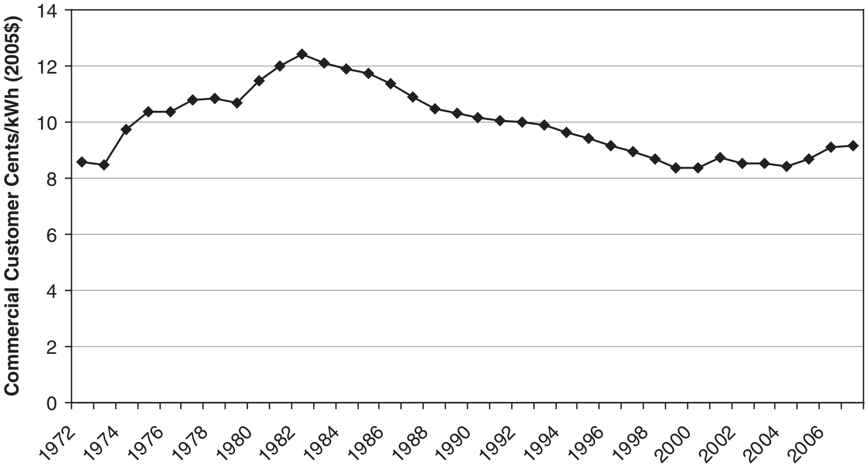

FIGURE 1.11 1972–2007 U.S. Commercial Electricity Prices (2005 cents per kWh)
Source: Energy Information Administration, Electric Power Monthly with data through July 2007, 11/11/2007.

A LOOK FORWARD: ENERGY DEMAND AND SUPPLY FACTORS

Energy prices are determined by demand and supply. Excess supply results in lower prices, and excess demand results in higher prices. Regulated electric and natural gas utilities pass along market-determined prices to their customers with a different process from competitive energy providers; however, in the end, all energy customers pay prices determined primarily by market forces. A number of demand and supply factors are especially interesting in the context of forecasting future price trends because they reflect new trends or, as sometimes happens, because they are often mentioned in the popular press as important but in reality are likely to have little impact on energy prices in the foreseeable future. Some of these factors are discussed in the section below.

Robust Economic Growth in Developing Countries

Globalization of the world economy, liberalized trade policies, and the introduction of competitive market reforms have contributed to unprecedented growth in less developed countries. Economic growth in Asian countries has been remarkable. Annual economic growth averaging more than 9 percent has been sustained since 1978 in China, a country of 1.3 billion people. By comparison, the United States has a population of 300 million and real economic growth averaging 3 percent over the same period. The Department of Energy's "Energy Information Agency" (EIA) forecasts China's 2006 oil consumption to increase by about half a million barrels per day, soaking up nearly 40 percent of the annual increase in world supplies. China, the third-largest net importer of oil, following the United States and Japan, will soon achieve second-place status.[6]

The EIA estimates an increase in energy use in non-OECD countries (mostly developing nations) *four times* that of OECD countries between 2004 and 2030.[7]

Economic Growth in the United States and Other Developed Countries

Globalization has contributed to an unprecedented period of sustained economic growth for developed countries as well as less developed countries. Increased incomes result in larger houses, more appliances, greater demand for services and consumer goods—all of which increase the demand for energy. The steady growth of developed nations provides a background against which growth in developing countries has strained energy supply capabilities since 1999. Most forecasts reflect a healthy U.S. economic growth of about 3 percent through 2010 with only slightly lower growth through 2015.

Innovation and New Technology Development

The discussion of efficient end-use (space heating, lighting, and so on) technologies in Chapter 2 illustrates the potential demand-reducing impact of efficiency improvements achieved through innovation and technology developments that improve on existing energy-using equipment. A number of technologies reduce energy use in more unconventional ways. One such technology is a combined heat and power system (CHP), which uses natural gas to generate electricity at the facility site and captures waste heat from the generation process for space heating, water heating, air conditioning, or process uses. This technology reduces the overall demand for energy because it captures and uses heat from the generation process. CHP units can achieve 90 percent efficiency. That is, only 10 percent of the energy input used in the system is lost to the environment compared to central power plants where about 68 percent of the energy input is lost (average U.S. electric system efficiency is about 32 percent). Cool storage systems are another attractive technology that use electricity in off-peak hours to generate chilled water or ice that can be used to cool buildings during peak summer hours. While total energy use is no less, the ability to use lower-cost off-peak electricity to generate cold water or ice reduces both customer and utility system costs.

Innovation in the form of increased equipment efficiency and new technology developments reflects the single greatest potential impact on future demand for energy. However, new technologies take time to develop and reach the commercialization stage; consequently, for the near future (the next decade), the benefit of technology innovation and development will primarily take the form of the application of more efficient technologies currently on the market.

Oil and Natural Gas Exploration and Production

The market supply reaction to high oil and natural gas prices is as expected. Oil and natural gas rotary rigs are used to drill for, explore, and develop oil and gas wells. The number of North American rotary rigs in operation has increased from 625 in 1999 to 1,649 in 2006 and 1801 in November 2007.[8] Increased exploration and production in non-OPEC countries including former Soviet Union republics, Africa, and even Brazil will also help meet growing demand. Considerable time is required to find and bring new oil sources to the market so any significant relief from current market responses is likely to be at least five or more years in the future.

Declines in production in mature oil fields offset some of the new production. For instance, Mexico's huge Cantarell oil field, one of the largest in the world, reported a year-over-year decline of 13 percent in June 2006. A July, 2007 International Energy Agency report estimates a decline of about 4 percent per year in all existing fields.

Will increased production reduce prices to 1990 levels? If new oil production required only drilling more wells in existing oil fields, the marginal cost of adding new production would be about the same as wells producing in the 1990s, and the price of oil could be expected to fall back close to the 1990s levels. However, new production is successively harder to find and to reach, and consequently costs more. The production costs of new sources determine the market price of oil. While technology advances in exploration and production help limit cost increases, increased cost of producing oil from deep-water wells and other more difficult-to-reach oil deposits can be expected to set a floor for oil prices that is significantly higher than oil prices in the 1990s.

OPEC Reaction

The Organization of the Petroleum Exporting Countries (OPEC), which includes Algeria, Angola, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela, supplies about 40 percent of the world's oil. In market conditions with tight supplies, OPEC member increases or reductions in production can significantly impact oil prices. As recently as March, 2006, OPEC members publicly identified a world oil price target in the $50 to $60/barrel range as "appropriate."

Weakness of the dollar and observations that the sustained higher price levels seem to have relatively little impact on economic activity appear to have prompted OPEC to replace the earlier range with an OPEC target of $60 to $65/barrel beginning in mid-2007.[9] Continued weakening of the dollar through the end of 2007 will likely keep the target in a higher range of $70 to $75/barrel.

Higher oil prices could potentially slow world economies enough to offset higher prices with a greater reduction in oil consumption and encourage development of conventional and unconventional supply development in non-OPEC countries. While there is some consolation in expecting that OPEC will move to limit prices that stay much above $75/barrel for extended periods of time, the downside is that a price below $75/barrel is likely to cause a restriction in OPEC oil production, boosting the price back above the $75 mark.

It is important to note that OPEC targets exclude speculation and risk premiums. As discussed in the $100/barrel oil section below, the current view that these factors add about $25 to the current price means that OPEC has little incentive to increase output in today's $90–100/barrel market.

New Oil Extraction Technologies

A variety of technologies is expected to play a role in the future supply of liquid fuels including oil sands, ultraheavy oils, gas-to-liquids, and coal-to-liquids technologies. While these technologies will contribute significantly to liquid fuels supply at some point, they are economical only when competing with high oil prices, with most technologies requiring oil to be in the $50-plus/barrel range. Consequently, these technologies cannot be expected to reduce oil prices below that breakeven point—a far cry from $20/barrel in 1999 (inflation-adjusted to 2005 dollars, referred to in following text as 2005$).

Renewable Technologies

With the exception of biomass, wind, and passive solar technologies, renewable energy is still an expensive proposition. Although ethanol is expected to contribute increasingly to liquid fuels with the help of government subsidies, renewable sources of electric generation in the baseline or reference

EIA forecast accounts for no more than about 6 percent of new electric generation energy sources from 2006 to 2030. Coal is forecast to provide 54 percent, natural gas 36 percent, and nuclear 4 percent of new generation fuel sources. Cost-effective fuel cells, photovoltaic, and other renewable technologies are still too far in the horizon to influence energy prices in the foreseeable future.

The ability to buy green electricity from most utilities and power providers and publicity over renewable energy portfolio standards, suggest that renewables are making great headway in replacing conventional energy sources. For instance, there is substantial news coverage of state-mandated renewable portfolio standards requiring power producers to include certain percentages of renewable energy sources in their portfolio of electric production technologies. The reality is that relatively little generation capacity is provided with sources other than existing hydro and biomass. New renewable energy sources consist mostly of wind generation (Table 1.1). Biomass includes generators that use methane from organic waste sites to fuel electric generation turbines; however, the number of waste sites limits new biomass contributions. The number of new hydro sites is also limited. Wind generation is economically competitive in many areas; however, electricity is intermittently available, especially on the hottest summer days when it is

TABLE 1.1 U.S. Energy Consumption by Energy Source, 2001–2004 (Quadrillion Btu)

Energy Source	2001	2002	2003	2004	2005
Total	96.563	98.101	98.450	100.586	100.942
Fossil Fuels	83.138	83.994	84.386	86.191	86.451
Coal	21.914	21.904	22.321	22.466	22.785
Coal Coke Net Imports	0.029	0.061	0.051	0.138	0.044
Natural Gas	22.861	23.628	22.967	22.993	22.886
Petroleum	38.333	38.401	39.047	40.594	40.735
Electricity Net Imports	0.075	0.072	0.022	0.039	0.084
Nuclear Electric Power	8.033	8.143	7.959	8.222	8.160
Renewable Energy	5.465	6.067	6.321	6.433	6.588
Conventional Hydroelectric	2.242	2.689	2.825	2.690	2.703
Geothermal Energy	0.311	0.328	0.331	0.341	0.343
Biomass	2.777	2.880	2.988	3.196	3.298
Solar Energy	0.065	0.064	0.064	0.064	0.066
Wind Energy	0.070	0.105	0.115	0.142	0.178

Source: Energy Information Administration, August 2005, http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html.

most needed. For instance, the Electric Reliability Council of Texas counts only 2.6 percent of rated generation towards meeting capacity requirements. While wind is an important resource in reducing emissions by replacing coal and natural gas driven power plants, increased wind-generated electricity will have little impact on electricity prices.

Research and development of renewable technologies is intense and can be expected to provide promising results in the future; however, renewable energy supply contributions are unlikely to be great enough to reduce energy prices in the current planning horizon.

Other Factors

Many other demand and supply factors enter into the market determination of energy prices, including consumer price response, building and appliance efficiency standards, automobile efficiency standards, and so on. The most comprehensive and accessible description of these factors is provided in the Energy Information Administration's Monthly and Annual Energy Outlooks (http://www.eia.doe.gov/oiaf/forecasting.html).

Interpreting $100/Barrel Oil

As of November 2007, oil prices are approaching $100/barrel, nearly equal to the $101.70 (in today's dollars) reached in 1980. The current price reflects a near doubling of the lowest oil price in 2007. How does one interpret this latest spike in oil prices and what does it mean for the longer-term energy price outlook?

Slower than expected production responses to higher oil prices, increasing restrictions placed on foreign participation in oil production by some oil-producing nations, smaller than expected impacts of higher oil prices on world economies, and continuing global economic growth are frequently mentioned as factors suggesting that growing world oil demand will continue to apply pressure on supply. Oil prices also reflect a decline in the dollar and a risk premium associated with current geopolitical uncertainties. It is generally believed that the risk premium reflected in the current price is approximately $25/barrel.

It is important to remember that NYMEX (New York Mercantile Exchange) oil prices quoted in the news are based on commodity futures contracts for the coming month. Commodity prices are volatile and can include, as the current situation demonstrates, a substantial risk and speculative component. Dissecting current futures market prices to determine how much of the $100/barrel price is likely to remain as markets gain additional supply and demand information over time and how much reflects unfounded speculation is difficult. Continued uncertainty concerning supply and demand balances along with geopolitical risks could keep oil prices in the \$90–\$100/barrel or higher for some time. On the other hand, early signs that the market is not as tight as anticipated and that higher oil prices are significantly reducing world economic growth could quickly deflate oil prices.

A consensus view at this time is that oil prices may go higher but will fall back to the \$70 to \$75 per barrel range in the reasonably near future with continuing modest declines over time as oil production increases. This consensus forecast is presented in the next section.

ENERGY PRICE FORECASTS

Viewing historical price series and considering important demand and supply factors provide an interesting context for evaluating whether future price forecasts seem reasonable. However it is difficult to determine whether prices are likely to:

- Decline as they did following the price spike in the early 1980s.
- Continue increasing because of continuing shifts in demand and supply balances associated with new factors such as economic growth in less developed countries.
- Follow some other path.

A modeling process is required to identify the most likely path for future energy prices. The following sections describe a comprehensive modeling approach developed and applied by the U.S. Department of Energy.

Putting Demand and Supply Together

Determining how the interplay of demand and supply factors will impact energy prices beyond the near future requires the use of forecasting models. The most widely referenced energy forecasting model is the Energy Information Administration's (EIA) National Energy Modeling System (NEMS).[10] NEMS is used to develop projections for EIA forecasts. In addition to providing energy demand, supply, and price forecasts, NEMS is used to evaluate policy issues requested by Congress and executive branch agencies.

Other organizations, including economic and energy consulting firms, and other government bodies have also developed and used forecasting models to estimate future energy demand, supply, and prices. Modeling methodologies differ among these organizations, which reflect their focus and resources. A consensus forecast based on EIA and published information from other forecast sources in mid-2007 reflects a scenario with a moderation of current high prices. However, demand is expected to grow at a rate that will continue to apply pressure on fossil fuel supply, keeping prices significantly higher than the 1990s.

Since the NEMS model forecast is consistent with the consensus forecast, its results are presented in Figure 1.12. A comparison with other forecast results is also included in Table 1.2 on page 30. Before presenting the EIA NEMS forecast, it is useful to consider the modeling process to develop an appreciation for the way in which forecasting models can reflect detailed demand and supply factors.

The Modeling Process

NEMS uses a market-based approach that forecasts energy demand for individual sectors for each of the nine U.S. census divisions. NEMS forecasts

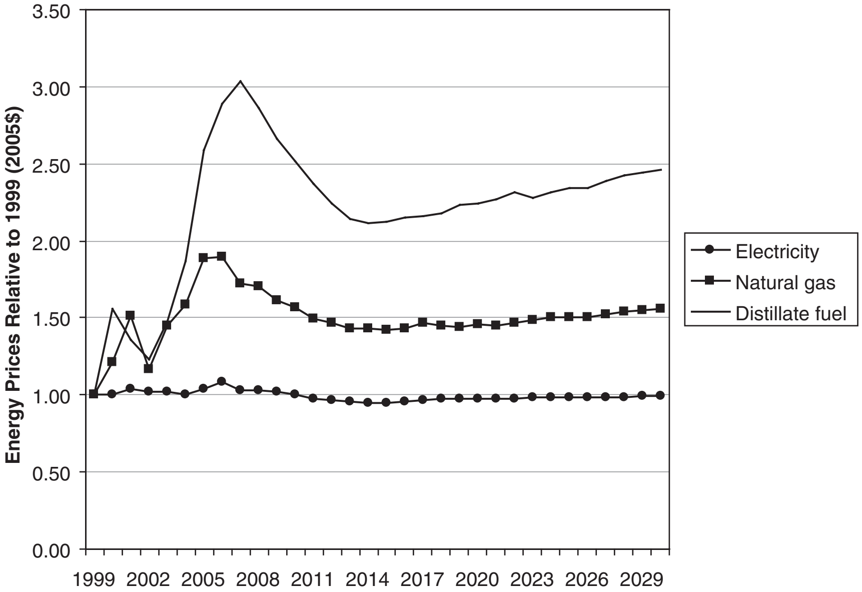

FIGURE 1.12 Annual Energy Outlook 2007
Source: Annual Energy Outlook 2007, with Projections to 2030, February 2007, Energy Information Administration, U.S. Department of Energy, Washington, DC 20585, www.eia.doe.gov/oiaf/aeo/ Historical prices are from Energy Information Administration, June 2007.

energy demand, supply, and prices through 2030. Energy supply modules represent regional markets including the North American Electric Reliability Council regions and subregions for electricity; and the Petroleum Administration for Defense Districts (PADDs) for refineries. NEMS includes macroeconomic and international modules to reflect economic growth and impacts of world energy markets. NEMS balances energy supply and demand for each energy source and energy demand sector. The simulation system determines prices paid by energy consumers and received by suppliers with feedbacks to economic activity and fuel supply modules. NEMS also reflects the impacts and costs of legislation and environmental regulations.

A detailed description of NEMS is beyond the scope of this discussion; however, a summary of one of the demand elements will provide readers with a better understanding of the modeling process. The NEMS residential and commercial demand modules apply a modeling technique called end-use modeling to forecasting energy use. This modeling approach was developed, in part by the author, at Oak Ridge National Laboratory in 1976 and forms the basis for nearly all energy policy models in use today including models used by state agencies in California and Indiana.[11]

End-use models explicitly represent energy use consumed by individual energy-using equipment, sum the energy use to the building type level and then to the sector (residential, commercial). This approach is sometimes called a bottom-up approach for obvious reasons. The modeling approach is intuitive; for instance, in the residential sector, each household occupies a dwelling unit, requiring space heating, air conditioning and equipment including water heaters, refrigerators, dish and clothes washers, and so on. Energy use of each end-use equipment is determined from engineering and/or statistical analysis. From one year to the next, the number of households increases, new dwelling unit construction takes place, and some dwelling units are demolished. New dwelling units require new end-use equipment. End-use equipment that wears out is replaced with new equipment. Some households purchase new end-use equipment. Households make equipment efficiency choices based on energy prices and the cost of equipment. Appliance and building efficiency standards restrict the efficiency choices that households can make. Household behavioral responses to energy price increases, like turning thermostats down, are represented as well as fuel switching in response to changes in relative fuel prices.

Industrial and transportation demand modules reflect somewhat different methodologies; however, each module reflects, to the extent possible, specific energy technology classes, fuel choices, energy price responses, economic, technology, and other factors. Additional modules include macroeconomic, international, electricity market, renewable fuels, oil and gas supply, natural gas transmission and distribution, petroleum market, and coal market.

Relationships in each of the modules are represented with mathematical equations whose parameters are typically estimated econometrically or represent engineering-based analysis. These relationships and parameter estimation are described in more detail in the previously referenced NEMS documentation.

Models applied by other organizations are less detailed than the NEMS model because they are not used to evaluate costs and benefits of alternative federal and state policy prescriptions. However, all models represent the same basic supply and demand relationships. Results from NEMS and several alternative models are presented in the next section.

The Consensus: High Prices for the Foreseeable Future

The baseline or reference EIA NEMS energy price forecasts are shown in Figure 1.12 for commercial sector distillate oil, natural gas, and electricity, measured as a ratio of 1999 prices in 2005 dollars.[12] The commercial sector excludes industrial (manufacturing), residential, transportation, and utility activities. Industrial sector prices are typically less than commercial for the largest industrial customers; however, most industrial customers face energy prices close to those represented by the commercial prices presented in this chapter. Inflation effects have been removed from historical and future prices. For reference, 2015 prices are $49.87 per barrel for oil, $8.73 per thousand cubic feet for natural gas and 8.0 cents per kWh for electricity (all in 2005 dollars).

As indicated in Figure 1.12, future commercial sector fuel oil prices are expected to moderate by about 2015 and remain two to two-and-a-half times their 1999 value through the forecast period. Natural gas is expected to moderate to about one-and-one half times its 1999 value. While the U.S. average commercial sector electricity price more or less maintains its 1999 value, regional variations reflected in Figure 1.1 shown at the beginning of this chapter will continue as a result of elevated natural gas prices.

The baseline forecast shown in Figure 1.12 represents a significant departure from history with the prediction that fossil fuel energy prices will maintain a higher price plateau than experienced in the past. Though many factors are involved, one can summarize this outcome as reflecting a demand/supply relationship that requires the continued use of higher-cost supply options to meet demands of a growing world economy.

Comparison Forecasts

The Energy Information Administration provides a comparison of its forecasts with those of other organizations in its 2007 Annual Energy Outlook documentation (AEO2007). Table 1.2 summarizes this comparison with forecast information for 2015.

While AEO2007 forecasts of world oil prices are on the high side by an average of 9 percent of alternative forecasts, commercial natural gas and electricity prices are on the low side by an average of 12 percent for each. EIA provides a variety of easily accessible data and analyses on its forecast Web page at http://www.eia.doe.gov/oiaf/forecasting.html, where interested readers can learn more on a variety of topics related to energy demand, supply, and price forecasting.

It is important to remember that these price forecasts do not attempt to account for unexpected events such as hurricane damage to offshore wells, wars, or unforeseen economic downturns. Any of these or similar factors could cause prices to spike or to drop; however, the resulting excess demand or excess supply would likely be worked off within a relatively short time period.

In summary, all publicly available forecasts indicate that increases in supply can be expected to reduce current high energy prices through the middle of the next decade; however, demand pressures and higher fossil fuel

TABLE 1.2 Comparison of 2007 Annual Energy Outlook and Alternative Forecasts, 2015 Prices (2005$)

	AEO2007	GII	IEA	EVA	EEA	DB	SEER
World oil prices	49.87	46.54	47.8	42.35	49.8	40.11	45.27
Commercial customer natural gas prices	8.73	10.5	n/a	n/a	9.98	n/a	8.83
Commercial customer electric prices	8.0	9.2	n/a	8.7	n/a	n/a	n/a

Source: Annual Energy Outlook 2007, with Projections to 2030, February 2007, Energy Information Administration, U.S. Department of Energy, Washington, DC 20585.

Table abbreviations:

GII	Global Insights, Inc.
EVA	Energy Ventures Analysis, Inc.
IEA	International Energy Agency
DB	Deutsche Bank, AG
EEA	Energy and Environmental Analysis, Inc.
SEER	Strategic Energy and Economic Research, Inc.

production costs will usher in a new era of higher natural gas and oil prices. U.S. electricity prices are not expected to increase on average; however, areas that rely heavily on natural gas generation will experience price increases as new gas-fired capacity additions are added to the generating mix.

An Increasingly Likely Contrary Forecast

Forecasters tend to follow the pack, thereby avoiding being singled out if future events do not confirm the forecaster's predictions. Increased cost of oil production will almost certainly provide a new higher floor to oil prices compared to the past. While an economic slowdown or some other event may temporarily create an excess supply of oil with falling oil prices, forecasting a higher oil price plateau is a safe bet.

However, the prospects of healthy world economic growth, declines in existing production, and increasing difficulty associated with new production could conceivably lead to even tighter oil markets in the future. This outcome is predicted by the July 2007 International Energy Agency—Medium-Term Oil Market Report. Supply difficulties are forecasted to begin in 2009 with a "crunch" by 2012.[13]

Those who share the IEA's more pessimistic view of world oil markets see the current $100/barrel oil prices as further proof that supply and demand conditions are tighter than generally recognized and that the impacts of greater non-OECD country growth have been underestimated while the ability of oil producers to respond to increased oil prices has been overestimated.

Prices much lower than those predicted in the consensus forecast described in the previous section seem unlikely; however, the IAE's analysis suggests a reasonable likelihood that energy prices will be greater than those represented by the consensus forecast. While $100/barrel oil prices initially appear to be unsustainable because of their expected drag on economic growth, a more limited impact on global economic growth than expected could keep oil prices considerably higher than the consensus forecast.

The important information in the contrary forecast is not the $/barrel estimate; rather it is that there is a reasonable probability that oil prices, and by extension other energy prices, will be higher than presented in the consensus forecast.

Recession Impacts

Economic recessions reduce demand pressure and can create significant declines in energy commodity prices (natural gas, oil, and other fossil fuels). Consequently, an unexpected decline in economic activity will most likely create a temporary deviation from predicted energy price paths. However, on recovery, the same factors will come back into play, and energy prices can be expected to return to their forecast values.

While a temporary recession-caused reduction in energy prices may reduce facility energy costs, economic factors increase the importance of cash flow advantages of efficiency investments identified through EBaR analysis. Efficiency investments that qualify in recessionary periods will provide greater returns when energy prices recover, providing an effective hedge against the coming price increase.

GOING GREEN—THE CRITICAL ROLE OF EFFICIENCY INVESTMENTS

An increasing number of corporations and government organizations are undertaking sustainability initiatives including green building design and operations intended to reduce greenhouse gas emissions. Virtually all of these initiatives involve reductions in energy use. For instance, reduced building energy use is a major component in achieving the U.S. Green Building Councils LEED (Leadership in Energy and Environment Design, http://www.usgbc.org/) certification. Organizations are also investing in energy efficiency to qualify their buildings with an Energy Star rating from the U.S. Environmental Protection Agency (http://energystar.gov/).

An interesting innovation that facilitates this desire to achieve green goals is the Chicago Climate Exchange (CCX, http://www.chicagoclimatex.com). CCX is the first legally binding greenhouse gas emissions allowance trading system. CCX members make a commitment to meet reductions in annual greenhouse gas emissions with reductions beyond the target level claimed as surplus allowances that can be sold or saved for future use. Members whose emissions exceed their targets must purchase contracts to offset excess emissions. Indirectly generated greenhouse gas emissions from purchased energy are also included in the greenhouse gas emissions accounting.

Current CCX members read like a sample of who’s who in business, education, and government, including Rolls-Royce, Ford Motor Company, Dow Corning, DuPont, Steelcase Inc., Eastman Kodak Company, American Electric Power, DTE Energy, Motorola, Sony Electronics, the cities of Chicago, Oakland, Melbourne, Australia and Portland, the State of New Mexico, IBM, Intel Corporation, Michigan State University, and many more.

The CCX framework is important because it offers a market-based system in which organizations that can most efficiently reduce energy use are encouraged to achieve energy reductions. On the other hand, those who are less able to contribute physical reductions in emissions pay others to achieve their reduction goals.

Other new carbon-trading mechanisms are being established both by government and private interests and the growing use of "efficiency certificates" in individual states pass incentives to reduce energy use through to individual facility owners. For instance, efficiency certificates permit individual facility owners to sell efficiency improvement credits to utilities who are required to meet requirements of "efficiency portfolio standards." These market mechanisms provide a prominent role for efficiency investments in meeting organization and social goals to reduce carbon and other greenhouse gas emissions.

Carbon taxes are increasingly discussed as a policy tool to encourage emissions reductions. Tax impacts are likely to affect individual commercial, institutional, and manufacturing facilities based on their energy use, providing additional incentives to invest in energy-efficient equipment.

Energy efficiency is sure to be at the center of future green initiatives. Organizations who develop the EBaR framework now to address efficiency investments will be well positioned to mitigate cost impacts that develop in the future.

EBaR AS A POLICY OPTION

It became apparent in the late 1970s that building owners and managers were not responding to higher energy prices and energy saving investments as policy makers expected. Returns on efficiency investments were five or six times the cost of borrowing. Why wouldn't rational business investors take advantage of that gap and make money on those investments? The so-called energy paradox or efficiency gap has been studied extensively, and many incentive and information programs have been advocated and initiated by federal and state governments specifically to address this problem with little verification that these programs have the desired impact. In fact, a recent study by Resources for The Future, concluded that one of these programs, a university-managed free energy audit program targeted to small and medium-sized manufacturers, appeared to have little or no impact on energy efficiency investments.[14]

The evidence is overwhelming that individual organizations continue to make energy efficiency investments that reflect paybacks of, on average, about one-and-one-half years with comparable internal rates of return of about 50 percent. The Department of Energy and other organizations have evaluated equipment technologies currently in use and, compared to technologies considered cost effective, have identified unachieved potential efficiency savings of 20 to 50 percent. An International Energy Agency study estimates a comparable efficiency gap of 30 percent in OECD (developed) countries.

The many recent strategies promoted by municipal, state, and federal agencies, advocacy groups, and private organizations to address environmental and energy problems include efficiency improvements high on the list, but these strategies are short on details as to how such efficiency improvements are to be achieved. Most plans recommend expansion of utility efficiency incentive programs; however, current utility and other incentive programs are relatively inefficient because they do not address the crux of the efficiency gap—that is, the use of short paybacks and high internal rate of return traditionally used to limit risk.

Providing EBaR educational programs to help decision makers better understand and address energy price risk can significantly extend the impact of efficiency incentives and other efficiency-oriented programs.

SUMMARY

Current high and erratic energy prices have created financial difficulties for many businesses, institutions, and government agencies. In the best-forecast scenario, natural gas and oil prices are likely to be 50 to 100 percent higher than their 1999 levels, after adjusting for inflation. Electricity prices vary significantly by utility; however, high natural gas prices are likely to keep electric prices 20 percent or more above their 1999 levels in many areas.

In spite of these challenges organizations do not yet consider energy efficiency investments with financial risk management tools. Most organizations apply payback or internal rate of return (IRR) analysis using conservative thresholds to qualify efficiency investments for further evaluation. These rules of thumb are designed to limit risk associated with efficiency investments; however, like all rules of thumb, they are designed to prevent worst-case scenarios. Consequently, many profitable efficiency investments are excluded from consideration.

By applying financial risk management analysis to the energy efficiency investment decisions in a process called Energy Budgets at Risk (EBaR), payback and IRR rules are replaced by decision variables that reflect both the return on the efficiency investment and its risk. For instance, an $\text{EBaR}_{\text{irr,mean}}$ of 65 percent and an $\text{EBaR}_{\text{irr,95}}$, of 45 percent means that the expected internal rate of return on the investment is 65 percent and there is no more than a 5 percent probability that the internal rate of return will be less than 45 percent.

From a management perspective, knowing the expected return and probabilities associated with other outcomes provides much more information than traditional payback and IRR hurdle rate because it permits investment decisions conditioned on an organization's risk tolerance.

Organizations in competitive electricity and natural gas markets can include energy purchase decisions as part of the EBaR process to simultaneously consider the feedback between efficiency and purchase decisions, reducing both energy costs and the price paid for energy.

EBaR allows organizations to manage energy cost risks rather than attempting to avoid risks. Most organizations can reduce annual energy costs from 20 to 30 percent even after paying the annual amortized cost of the investment. That is, organizations who implement EBaR practices can increase cash flows by an amount equal to 20 to 30 percent of their current energy costs.