Hedging Your Bet on Cheap Gas

Portfolio theory points to energy efficiency as invaluable in resource planning.

By Hossein Haeri, Aaron Jenniges and Paul Youchak

In the world of ratepayer-funded energy efficiency, every once in a while comes a sea change and prompts a few basic questions: What is the value of ratepayer-funded energy efficiency? What is its role in utility resource planning? How much should we invest in it?

The latest waves spread from the recent seismic shifts in natural gas supply, caused by the discovery of new conventional gas reserves and advances in extraction techniques that have opened vast supplies of shale gas and forced a sharp drop in natural gas commodity prices. Natural gas prices dropped to a historically low level of $2.75 per million Btu in 2012 and, according to recent forecasts by the Energy Information Administration (EIA), are projected to grow by no more than two 2% per year, on average, for the foreseeable future *(Figure 1).*

In the context of energy efficiency, low natural gas prices mean lower generation costs – the main component of a utility's avoided power-supply cost, the principal benchmark for economic valuation of ratepayer-funded energy efficiency. A drop in natural gas prices erodes energy efficiency's cost advantage and, in a sense, undermines its basic economic rationale. The recent drops in avoided costs have caused many electric energy-efficiency measures to fail the standard tests of cost-effectiveness. The effects on natural gas efficiency programs have been direct and more pronounced. The drops have prompted several utilities to curtail – or even suspend – their programs and have moved regulators in places such as Washington and British Columbia to consider new economic screening guidelines.

This journal in prior articles has highlighted weaknesses inherent in various standard cost-benefit tests used to calculate a value for energy efficiency, including, among other tests, the Program Administrator Cost (PAC), the Ratepayer Impact Measure (RIM), and the Total Resource Cost (TRC) tests.[1]

But an added problem with these tests, central to our inquiry here, is that they provide only a partial accounting of energy efficiencies benefits – with no allowances for its value in risk management. Here we address that missing metric, and how it can be accounted for by portfolio theory. The central point, typically ignored in the valuation of energy efficiency resources, is that once we consider the benefits of the risk mitigation, it turns out that energy efficiency might prove more advantageous than generation in integrated resource planning, even if the efficiency measures might appear at first blush to cost more than generation alternatives.

Too Much of a Good Thing

Gas-fired power generation provides baseload, intermediate, and peaking electric power. It also offers a relatively short construction lead time, and can provide firm back-up to intermittent renewable resources like wind and solar. These features, coupled with the plummeting fuel prices and, in no small measure, expectations of the power plant emission standards being proposed by the Environmental Protection Agency under sections 111(d) of the Clean Air Act, have caused a surge in activity in power plants fired by natural gas.

Experience suggests that heavy bets on gas market stability are unwise.

According to the 2013 Annual Energy Outlook, a publication of the EIA, electricity generation from natural gas grew from about 750 billion kWh in 2005 to about 1000 billion kWh in 2010, and is expected to increase by another 60% to 1,600 billion kWh by 2040.[2] The latest figures from the EIA show that the share of natural gas in power generation grew from under 18% to over 30% between 2002 and 2012 *(Figure 2).* Nearly all of this gain has come in the form of a loss in the share of coal: coal's share exceeded 50% in 2002 and fell to less than 38% in 2012 – a trend that is likely to persist, especially if more stringent power plant emission standards are imposed.

The result has led to a rethinking in power supply planning. The generation alternatives of choice have turned overwhelmingly to gas-fired plants – usually combined-cycle (CC), or else a standard combustion turbine (CT) design. More than two-thirds of all planned generating capacity between 2013 and 2017 represent one of these two plant types. The only other sources of supply expansion are expected to be investments in efficiency improvements of existing plants or renewable energy.

Nevertheless, in spite of today's calm conditions and soothing

1. See, Hossein Haeri and M. Sami Khawaja, Valuing Energy Efficiency: The search for a better yardstick, *Public Utilities Fortnightly*, July 2013, p. 28.

2. U.S. Energy Information Administration Annual Energy Outlook 2013, DOE/EIA-0383, April 2013.

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FIG. 1 **NATURAL GAS PRICES 2000-2033**

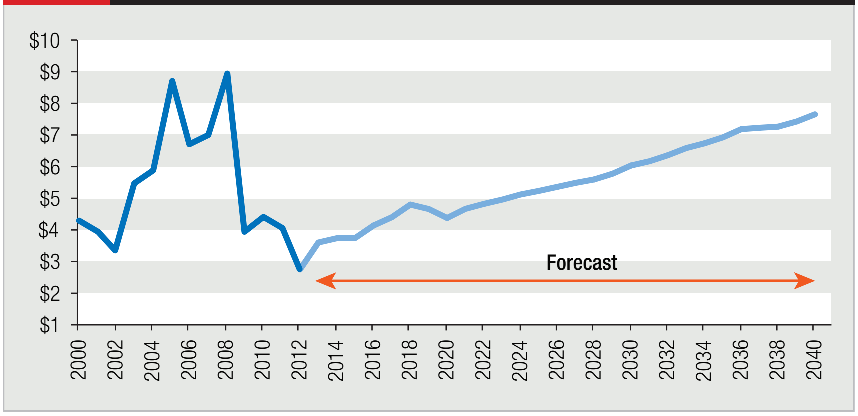
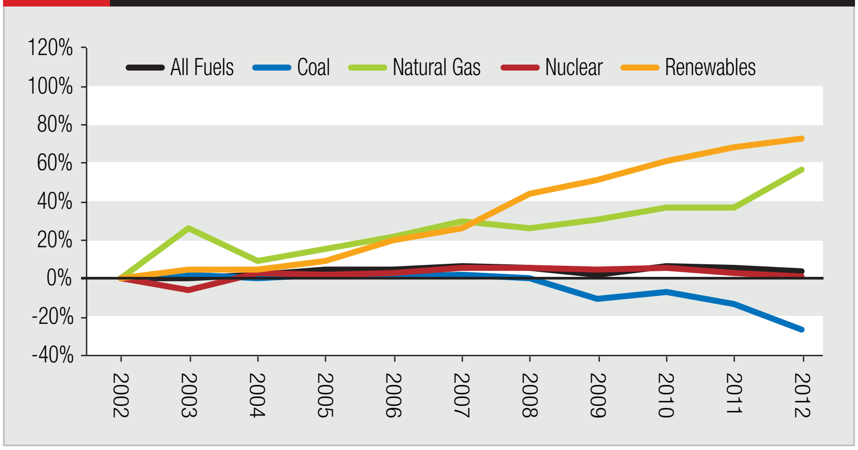


FIG. 2 **ELECTRIC GENERATION FROM ALL SOURCES**



predictions of the future, experience suggests that heavy bets on stability in natural gas markets, or for that matter, energy markets, are unwise. The low gas prices already have begun to stimulate the demand for gas in both direct (primarily for residential heating) and indirect (mainly as feedstock in chemical manufacturing) uses. The recent announcements by industry giants such as Dow Chemical and BASF about their plans for wide-ranging expansion in the United States denote this trend. The easing of restrictions on gas exports to Europe in response to the Crimean crisis will no doubt bring additional pressure on supplies and push the price up. And concerns are growing about the potential environmental impacts of hydraulic fracturing – concerns that may constrain new supplies of shale gas in some areas.

All of this suggests that the current low prices are unlikely to persist. Gas prices are hard to predict but, as the events of the past two decades have shown, the betting has to be that they will go up.[3]

As the role of natural gas in power generation becomes more prominent, power producers will be increasingly exposed to gas price volatility. A heavy reliance on gas also exposes the power system to potentially large reliability risks and possibly security risks.

This article attempts to evaluate the type and scope of such risks in the context of integrated resource planning (IRP) for electric utilities and the potential role of energy efficiency in mitigating such risks. It explores the potential role that energy efficiency might play in mitigating some of the fuel price risks in a typical, fossil-fuel-intensive power generation portfolio.

In other words, can we leverage a negawatt to enhance the value of a megawatt?

A Balanced Diet

There was a time, a few decades ago, when power supply planning was easy. It entailed mainly two challenges: (1) forecasting load, usually through simple extrapolation of recent trends, and (2) expanding capacity by building the lowest-cost mix of power plants that could be built, owned, and operated by the utility. The objective of the planning process was to create a mix of generating resources that minimized the utility's production cost and thus revenue requirements.

This least-cost approach to planning worked well enough in an era marked by steady load growth, relative cost certainty, somewhat stable energy prices, and homogeneous generating alternatives.[4] Things began to change in the early 1990s with passage of the Energy Policy Act of 1992, as utilities began to look at a broader set of resource alternatives, such as power purchases from qualifying facilities and distributed, small-scale generation from unconventional resources such as renewables and demand-side management. What was once *least-cost planning* (LCP) became *integrated resource planning* (IRP).

Today, the resource planning problem has expanded further to encompass a wider range of public policy and environmental concerns, and it folds in procedural considerations such as public participation and stakeholder involvement. More recently, the greater reliance on spot and forward power markets has prompted utilities, particularly those operating in restructured electricity

3. For a historical perspective on natural gas price trends, see Bolinger, Mark, Ryan Wiser, and William Golove, (2004) "Accounting for Fuel Price Risk When Comparing Renewable to Gas-Fired Generation: The Role of Forward Natural Gas Prices" LBNL-53587, August 2003.

4. Awerbuch, Shimon, Valuing Renewable and Conventional Generating Assets in an Environment of Uncertainty and Technological Change, SPRU Energy Group, University of Sussex, Brighton, UK, September 2005.

markets, to systematically account for market risks. The modern IRP process attempts to maximize the return from the electrical system and simultaneously address a host of complications relating to multiple policy objectives and the various uncertainties in energy, capacity, fuel, and environmental markets. The planning process has taken on a new dimension that looks to produce, to use an analogy suggested by an industry expert, a more "balanced diet" of electric service.[5], [6]

The focus has shifted from least-cost planning to portfolio management, turning risk assessment into an essential element of the resource planning process for most utilities.[7] As a recent survey of IRP filings from the major investor-owned utilities in the Western Electricity Coordinating Council (WECC) indicates, all of these utilities emphasize the importance of creating a risk-adjusted, least-cost portfolio by evaluating uncertainties of major inputs such as unit availability, construction costs, and interest rate.[8] The methods by which this is accomplished vary in sophistication from qualitative approaches, to scenario analysis, to more formal methods for portfolio analysis, such as risk-adjusted net present value of revenue requirements (NPVRR).[9]

These plans are striking in that, in spite of its significant share of these resource portfolios, energy efficiency is rarely explicitly included in the modeling process. The practice, common to most IRPs, is to lower the load forecast by the planned (or mandated) amounts of energy efficiency and then evaluate the remaining portfolio. This approach might have been reasonable when energy efficiency was a negligible component of most resource portfolios. But at a time when compliance with energy-efficiency performance targets demands mid- to long-term cumulative savings of as much as 15% and higher, it seems reasonable that their contributions be evaluated with the same analytic rigor as are conventional generation resource options.

5. Connors, Stephen R, Competition, Coordination, and Compliance: The Role of Integrated Resource Planning in a Competitive Industry. Proceedings of the NARUC-DOE Fifth National Conference on Integrated Resource Planning, Kalispell, Montana, May1994.

6. Connors, Stephen R. "Side-Stepping the Adder: Planning for Least-Social-Cost Electric Service." In Fourth National Conference on Integrated Resource Planning in Burlington, Vermont, National Association of Regulatory Utility Commissioners, 355-372, September 1992.

7. For a discussion of the application of portfolio analysis to utility resource planning, see Andrews, C. J., Evaluating Risk Management Strategies in Resource Planning, IEEE Transactions on Power Systems, Vol. 10, No. 1, February 1995.

8. Survey was conducted by Cadmus in 2013 of major Western investor-owned utilities, including Arizona Public Service, Avista, PacifiCorp, Pacific Gas and Electric, Portland General Electric, Puget Sound Energy, Nevada Power, Southern California Edison, and Northwestern Energy.

9. For a comprehensive survey of methods for treatment of renewables in integrated resource plans, see Bolinger, M. and R. Wiser. 2005. "Balancing Cost and Risk: The Treatment of Renewable Energy in Western Utility Resource Plans." LBNL-58450. Berkeley, CA, Lawrence Berkeley National Laboratory.

The Case for Bundling

Formal portfolio analysis is all about the trade-offs between expected cost and risk. It means moving from deterministic cost minimization to the use of an objective function describing a decision-maker's preferences and attitude toward risk. Portfolio theory was initially conceived in the context of financial portfolios, where it relates the expected portfolio performance or return to the total portfolio risk, defined as the standard deviation of periodic returns. Fundamental to portfolio analysis is the application of a mean-variance criterion, in which the decision-maker chooses from a set of alternative portfolios by considering not only the mean of the life-cycle cost, but also its variance, as a criterion for decision making.

Central to portfolio theory is that once we factor in the essential element of risk, the portfolio produces some powerful and often counter-intuitive results that are part of the so-called portfolio effect. It suggests that adding a fixed-cost ingredient to a portfolio can improve the expected return from it, even if its stand-alone cost is higher than alternatives. And, more generally, portfolio risk falls with increasing diversity, as measured by an absence of correlation (covariance) between the costs of assets that make up the portfolio.[10] The corollary to this proposition is that the variance of a portfolio's possible outcomes can also be reduced by using less of an uncertain input.

It is striking how rarely energy efficiency is fully integrated in resource planning models.

The conceptual underpinning of the portfolio approach is the mean-variance portfolio (MVP) theory, a well-established part of modern finance theory based on the pioneering work of Nobel Laureate Harry Markowitz nearly 50 years ago.[11] In addition to its widespread application in optimizing financial portfolios, MVP has been applied to investigate a wide range of research, including (among other things) capital budgeting and project valuation, climate change mitigation, evaluating electricity trading options, and electricity generation resource planning.

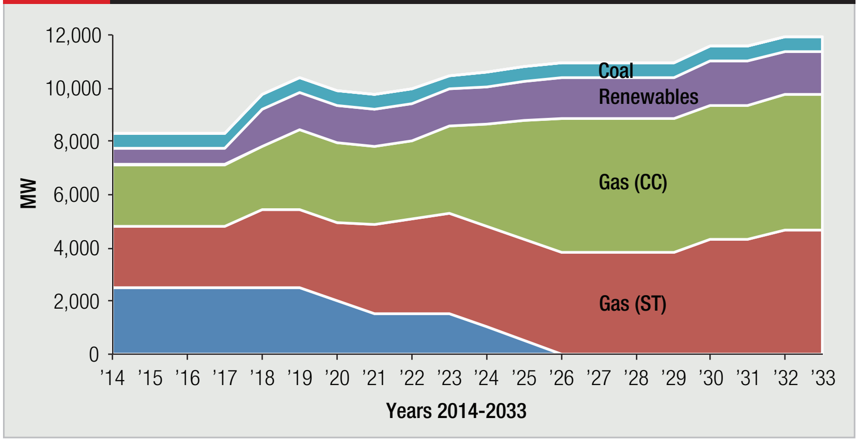
The first application of mean-variance portfolio theory to electric power generation came from a rudimentary analysis by Dan Bar-Lev and Steven Katz in 1976.[12] The practice was later demonstrated empirically in the large body of pioneering work

10. See, among other standard textbooks, Brealey, Richard A., and Myers Stewart C., *Principles of Corporate Finance*, McGraw Hill, 1994.

11. Varian, Hal, "A Portfolio of Nobel Laureates, Markowitz, Miller and Sharpe," *Journal of Economic Perspectives,* Volume 7, Number 1, 1993.

12. Bar-lev, Dan, and Steven Katz. 1976. "A Portfolio Approach to Fossil Fuel Procurement in the Electric Utility Industry." The Journal of Finance 31 (3): 933–947.

FIG. 3 **THE BASE-CASE PORTFOLIO**



of Shimon Awerbuch.[13] The analyses in this article draw heavily from Awerbuch's work.

In the context of integrated resource planning, the notion that energy efficiency lowers a utility's power production does not come as a surprise because cost-effective energy efficiency, by definition, lowers the utility's revenue requirement.[14] Savings will be even larger once the avoided emission costs are properly accounted for.

The effects of energy efficiency on risk are less obvious. What is remarkable about portfolio theory is the idea that throwing in fixed-cost resources, like energy efficiency and renewable energy, would lower overall risk and produce a more robust generation portfolio, even if they cost more than conventional, fossil-fuel-dominated generating alternatives.

Building a Portfolio

To evaluate the effects of energy efficiency on a typical electric resource portfolio, we begin with a hypothetical portfolio of assets with 8,300 MW of generating capacity, which is expected to grow at a rate of 2% annually over a 20-year planning horizon to meet a projected load requirement of 11,950 MW in 2033: a cumulative growth of 44% *(Figure 3).* The portfolio's composition resembles the plan filed with the Public Utilities Commission of Nevada in 2013 by NV Energy, a large investor-owned utility that serves about 1.3 million customers in Nevada as part of the utility's triennial integrated resource plan covering the period 2013-2032.[15]

The base-case portfolio is composed of coal generation (38%); natural gas generation (56%, split evenly between CC and CT units); a mix of renewable resources, including wind, solar, geothermal, hydro, biomass, and waste-heat facilities (7%); and energy efficiency (7%). Potential system capacity shortfalls and open positions are assumed to be met through market purchase.

To meet the newly proposed environmental performance standards for greenhouse gas emissions in Nevada, NV Energy will refrain from adding coal-powered generation and will retire existing coal-powered generation by 2026, replacing it almost entirely with natural-gas-powered units. In this base-case scenario, natural gas generation surges to about 9,750 MW to make up 81% of the portfolio's capacity in 2033. Renewable resources expand from 600 MW in 2014 to 1,400 MW in 2018, and grow gradually to 1,650 MW in 2025, to satisfy Nevada's renewable resource requirement (RPS) of 15%. It stays at that level through the end of the planning period.

Energy efficiency, though undervalued by today's low gas price, can offer a hedge against fuel price volatility.

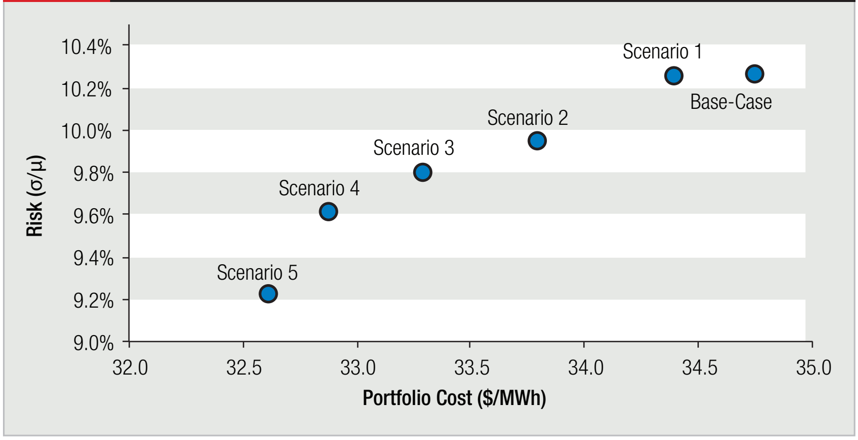
Generating resources are represented in the portfolio in terms of their availability and the present value of their full life-cycle cost (mainly capital and operating and maintenance), discounted by NV Energy's weighted average cost of capital (WACC).[16] Critical inputs, namely load forecast, coal and natural gas prices, CO_2 and SO_2 emission costs, and market electricity prices, are entered as ranges. Distributions for coal and natural gas prices are

13. See:
 - Awerbuch, S. (2000a) "Getting It Right: The Real Cost Impacts of a Renewables Portfolio Standard," *Public Utilities Fortnightly*, February 15, 2000.
 - Awerbuch, S., "The Surprising Role of Risk and Discount Rates in Utility Integrated-Resource Planning," *The Electricity Journal*, Vol. 6, No. 3, (April), 1993, 20-33.
 - Awerbuch, Shimon, and Martin Berger. 2003. "Applying Portfolio Theory to EU Electricity Planning and Policy-making." IEA/EET Working Paper (February).
 - Awerbuch, Shimon, Portfolio-Based Electricity Generation Planning: Policy Implications for Renewables and Energy Security, SPRU–University of Sussex, Brighton, UK, December 2004.
 - Awerbuch, S., Portfolio-Based Electricity Generation Planning: Policy Implications for Renewables and Energy Security, *Tyndall Centre Visiting Fellow,* SPRU–University of Sussex, Brighton, UK, 2005.
14. For a discussion of the various screening criteria used in evaluating energy efficiency see Hossein Haeri and M. Sami Khawaja, Valuing Energy Efficiency," *Public Utilities Fortnightly*, July 2013.
15. Nevada Power Company d/b/a NV Energy 2013-2032 Integrated Resource Plan, Supply Side Plan, Transmission Plan, Economic Analysis, and Financial Plan, Public Utilities Commission of Nevada, Docket No. 12-06.
16. For simplicity, we used the utility's weighted average cost of capital (WACC), but we recognize that because the different resources included in the portfolio have different risk profiles, it is more appropriate to use discount rates that implicitly account for these differences.

set based on their actual 20-year historical variations, ranging between 45% and 350% of the expected price for natural gas, and between 70% and 140% of the expected prices for coal.

We analyzed the expected future distribution and mean values for these inputs using the Monte Carlo simulation method, a technique used to approximate the probability distribution of certain outcomes by running a large number of trial runs (simulations), whereby possible values for inputs are drawn randomly from the predetermined ranges.[17]

FIG. 4 IMPACTS OF ENERGY EFFICIENCY ON PORTFOLIO COST AND RISK



For energy-efficiency resources, we characterize availability as expected *savings realization*, a common metric for evaluating performance in energy efficiency that ranges from 65% to 100% of planned values. Because a utility is expected to ultimately meet its load obligations, we assumed that the utility would procure the necessary amount of energy efficiency needed to meet its resource requirements, but may have to pay more to acquire the savings. To account for this uncertainty, we let the acquisition costs for energy efficiency fluctuate between 50% and as much as 250% of the planned cost in the baseline scenario.

As the energy efficiency bundles grow in size and as low-cost measures are exhausted, the probability increases that the utility will pay higher cost for incremental savings. We factored this into the analysis by allowing the upper end of the range to increase with additional increments of energy efficiency.

We evalutaed the portfolio's outcomes under five scenarios, wherein energy efficiency started at 550 MW in the base-case scenario and progressively replaced larger amounts of natural gas generation until it reached 2000 MW in the final scenario. The assumed levels of energy efficiency capacity are expected to deliver about 3.5% of the portfolio's energy output in the base case to about 12.5% in the final scenario.

We evaluated performance of the five portfolios with respect to their per-unit output cost ($/MWh) and risks. Despite the lable mean-variance, risk is typically measured as the standard deviation. In this analysis, we use the coefficient of variation (CV), a common statistical measure of variability calculated as the ratio of the standard deviation to the mean of a data series. We also use per-unit cost as a measure of portfolio performance, instead of more common metrics of return. (While finance theory usually works with rate of return, an attribute that increases the portfolio's attractiveness, the theory also holds for total cost, which lowers attractiveness.[18])

Figure 4 shows a plotting of the outcomes of the five scenarios, calculated over 200 simulations, with average per-unit output cost ($/MWh) along the horizontal axis and risk (CV) along the vertical axis. The scatter diagram clearly shows the negative correlation between the amount of energy efficiency with both per-unit cost and risks: additions of energy efficiency lower not only the portfolio's cost, but also its risk. For example, increasing energy efficiency's share from 3.5% in the base-case to 4.9% in the first scenario lowers the portfolio's costs by 1%. The effect continues in the same direction as more energy efficiency is added, leading to a 5% decrease in cost as energy efficiency's share approaches 12.6% in the final scenario. Since energy efficiency costs are assumed to increase with volume, cost savings do not correlate perfectly with additional energy efficiency; they taper off as larger amounts of energy efficiency are added.

Portfolio theory can run counter-intuitive – that a fixed-cost resource can improve return, even if it costs more than alternatives.

The impacts of energy efficiency, though somewhat modest in relative terms, are significant in absolute amount. Our analysis shows that the additions of energy efficiency can result in more than $1.5 billion in savings over the course of the plan's implementation.

What is more remarkable is the nearly linear relationship between energy efficiency's share and decrease in risk. The effect also appears to grow at an increasing rate as more energy efficiency is

17. The analysis was performed with Resource Portfolio Strategist, a portfolio model developed by Cadmus to evaluate financial performance of electric generation resource portfolios. Probability distributions were developed with 200 simulations.

18. Levy, H. and R. Sarnat, Portfolio and Investment Selection: Theory and Practice, Prentice Hall International, Englewood Cliffs, NJ, 1984, pp.105-223, 233-305.

added. Over the range of the five scenarios, the results here suggest that portfolio's risk might be expected to decrease by more than 10% as energy efficiency's share grows from 3.5% to about 12.6% of the portfolio. That the impacts of energy efficiency are small on both portfolio cost and risk is a result of the improbably large uncertainties ascribed to availability and cost of energy-efficiency resources. Obviously, the favorable effects of energy efficiency on portfolio performance would be much greater under less extreme (and possibly more realistic) assumptions.

Looking Ahead

When it comes to resource planning, a utility has an obligation to its ratepayers to evaluate and balance the expected cost and risk of candidate portfolios, and to choose the portfolio with the best cost-risk combination. The way in which this cost-risk tradeoff is made may indeed turn things significantly in favor of energy-efficiency resources, even where they may not pass the conventional cost-effectiveness screens.

The conventional portfolio analysis produces a set of alternatives, each representing a cost-risk combination. In the case of energy efficiency, because both cost and risk tend to decline, no such trade-off exists. These benefits of energy efficiency, however, must be balanced against the potential rate impacts and the associated equity considerations.

Utility planners have been understandably reluctant to embrace the portfolio approach entirely. Resource planning tools in use today are complex models, built for analyzing system capacity expansion options and production-costing. These models have been enhanced to allow the evaluation of a wider range of policy options, but they do not readily lend themselves to portfolio modeling. Today's dynamic and uncertain environment presents a need for the practice of resource planning to shift its focus from evaluating alternative resources to evaluating alternative portfolios.

As the era of least-cost planning gave way to integrated resource planning, the practice now must reshape itself to respond to new policy objectives and the demands of modern electricity markets. By selecting programs and technologies to minimize the total cost of electric service, and by including the full environmental and social costs in the cost criteria, the portfolio approach makes it possible for utilities to design and implement a fully integrated resource plan to meet electricity demand without wasting economic or natural resources or exposing the utility and its customers to unnecessary risk.

Studies of the beneficial effects of unconventional resources like renewable and energy efficiency on performance of resource portfolios are few in number and too narrow in scope to be probative. But their findings are wholly encouraging. More studies like this can help portfolio modeling with energy efficiency to evolve from its rudimentary state and turn the practice into a standard modeling approach.

Energy efficiency brings many benefits, but risk management has not been high on the list. More work is needed to firmly demonstrate the validity and the increasing relevance of the portfolio approach and to help turn the debate from speculations about the existence of these benefits to more concrete questions about how to measure them.