



Utility Supply Portfolio Diversity Requirements

Prepared for:

Edison Electric Institute

Prepared by:

Frank Graves, Philip Hanser
The Brattle Group

May 2007

The Brattle Group

The Brattle Group provides consulting services and expert testimony in economics, finance, and regulation to corporations, law firms, and public agencies worldwide. Our principals are internationally recognized experts, and we have strong partnerships with leading academics and highly credentialed industry specialists around the world.

The Brattle Group has offices in Cambridge, Massachusetts; San Francisco; Washington, D.C.; Brussels; and London.

Edison Electric Institute (EEI) is the association of United States shareholder-owned electric companies. Our members serve 95 percent of the ultimate customers in the shareholder-owned segment of the industry, and represent approximately 70 percent of the U.S. electric power industry. We also have more than 65 International electric companies as Affiliate members, and more than 170 industry suppliers and related organizations as Associate members.

Organized in 1933, EEI works closely with its members, representing their interests and advocating equitable policies in legislative and regulatory arenas. In its leadership role, the Institute provides authoritative analysis and critical industry data to its members, Congress, government agencies, the financial community and other influential audiences. EEI provides forums for member company representatives to discuss issues and strategies to advance the industry and to ensure a competitive position in a changing marketplace.

EEI's mission is to ensure members' success in a new competitive environment by:

- Advocating Public Policy
- Expanding Market Opportunities
- Providing Strategic Business Information

For more information on EEI programs and activities, products and services, or membership, visit our Web site at www.eei.org.

© 2007 by the Edison Electric Institute (EEI).

All rights reserved. Published 2007.

Printed in the United States of America.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage or retrieval system or method, now known or hereinafter invented or adopted, without the express prior written permission of the Edison Electric Institute.

Attribution Notice and Disclaimer

This work was prepared by the Edison Electric Institute (EEI). When used as a reference, attribution to EEI is requested. EEI, any member of EEI, and any person acting on its behalf (a) does not make any warranty, express or implied, with respect to the accuracy, completeness or usefulness of the information, advice or recommendations contained in this work, and (b) does not assume and expressly disclaims any liability with respect to the use of, or for damages resulting from the use of any information, advice or recommendations contained in this work.

The views and opinions expressed in this work do not necessarily reflect those of EEI or any member of EEI. This material and its production, reproduction and distribution by EEI does not imply endorsement of the material.

Published by:

Edison Electric Institute

701 Pennsylvania Avenue, N.W.

Washington, D.C. 20004-2696

Phone: 202-508-5000

Web site: www.eei.org

TABLE OF CONTENTS

I. Introduction	1
II. Financial Portfolio Theory’s Diversification Lesson	3
III. Applying Portfolio Theory to Utilities	5
IV. Critical Questions to Be Addressed About Utility Diversity	7
V. A Positive Theory of Utility Diversification	9
The Integrated Utility Perspective	9
The Pure Distribution Company Perspective	11
The Pure Merchant Generating Company Perspective	11
VI. Conclusions.....	13
Sidebars	15
Sidebar 1—The Basic Diversified Financial Portfolio Model	15
Sidebar 2—How Financial Portfolio Diversification Leads to Lower Risk	16
Endnotes	19

I. INTRODUCTION

Diversifying utility supply portfolios and managing them under principles and practices borrowed from financial investment is a topic of much recent discussion in regulatory policy and utility planning. For instance, the recently enacted Energy Policy Act of 2005 includes provisions for utilities to develop plans to minimize their dependence on one fuel source by requiring them to use a diverse range of fuels and technologies in meeting their customers' energy requirements.¹ Advisory reports have also been published, advocating that utilities adopt a portfolio-management approach to their physical and contractual assets, to better manage costs and risks.² Many state regulatory commissions and utility executives have expressed general support for the notion that diversifying across fuels, suppliers, and technologies can be a useful strategy.

While there are good reasons to be concerned about utilities' fuel and generation supply mix choices, we suspect that diversification and portfolio management are often advocated with little or no formal concept of how much or what type of diversity would really be economically beneficial, or of when and why the principles of financial diversification and portfolio management can be applied. Some of the enthusiasm for diversity may stem from the fact that diversification across securities has been shown to be desirable in financial portfolio theory. However, the authors believe that this analogy to financial markets is largely misplaced when applied to utilities. Financial theory has much to offer, such as principles of valuation and risk management, but the portfolio theory that some might like to apply to utilities' resource choices is not analogous to the supply problems arising at the individual utility level.

We provide a brief review of standard financial portfolio theory; then we describe the reasons why it is inappropriate to draw too many lessons from this theory to apply to a utility's fuel and technology portfolio. One clear insight that can be drawn from portfolio theory is that diversification is best pursued with formal economic criteria for how and why to do it. As a partial step in this direction, we conclude with some ideas for when and how diversity might be economically incorporated into power supply planning.

II. FINANCIAL PORTFOLIO THEORY'S DIVERSIFICATION LESSON

Some of the enthusiasm for diversifying utility supply portfolios seems to be coming from analogies to investment practices often recommended for individuals buying common stocks and other securities. (More informally, the common aphorism warning us “not to keep all our eggs in one basket” may be the motivation.) In the financial portfolio model framework, the focus is on an individual who has the opportunity to purchase either an asset with a return that is virtually perfectly assured, i.e., a “riskless” or “risk-free” asset such as a short-term U.S. Treasury bill, or to purchase any number of assets that have higher expected returns but which all come with material levels of correspondingly increased risk. The individual’s goal is to maximize his portfolio’s expected return subject to his tolerance of the portfolio risk.³

Through diversification an individual investor can reduce his or her portfolio exposure to the effects of each company’s unique risk, although not to the broader market risk arising from the correlation of his/her shares’ values to the market’s vicissitudes. Such diversification benefits (risk reductions) can be shown to be maximized when the portfolio includes value-weighted holdings of all the risky securities available in the market. The investor can then adjust the overall amount of risk in his/her portfolio by borrowing or lending (owning) risk(less) bonds. (See Sidebar 1 for more details on financial portfolio theory.) The diversification lesson from finance theory is that under certain circumstances (that seem to describe efficient financial markets fairly well), it is best to diversify broadly.

It is important to note that there are no “operational” problems in financial portfolio management or its diversification recommendation. For instance, securities do not have any scheduling problems analogous to periodic commitment costs that must be borne so they can be “available” to satisfy daily reliability obligations, nor do they interact with each other via anything equivalent or similar to economic dispatch or congestion constraints. Their expected returns can simply be aggregated and monitored over time to see if their likely performance corresponds to original statistical expectations. If not, adjustments are made by selling the losers and buying new candidates that are hoped to become winners.

An implicit assumption in financial portfolio management is that the assets in the portfolio can be acquired and disposed of readily; this is critical to their remaining efficiently priced at all times. Efficient pricing is what allows investors to focus on returns rather than on the time-pattern of cash flows forthcoming over future years of holding the assets. One can capture any changes in the expected return immediately, by selling the security.

Even in securities investments, if risk and return are not the only attributes you care about, then the simple diversification rule does not hold. For instance, you may want to hold certain stocks as a hedge against the cost of one of your consumption preferences (say, chocolate), or you may have non-monetary values you want to honor, such as preferring stocks from “green” companies or avoiding companies that use child labor in developing countries. If you want something different than an efficient risk-return tradeoff, then your portfolio composition strategy changes. You would also be foolish to diversify conventionally if you believed (knew) that some securities were mispriced. If they seem under-valued (and you are willing to speculate that you know more about their true value than the market), you should buy disproportionately more of those stocks.

III. APPLYING PORTFOLIO THEORY TO UTILITIES

The foregoing may make it obvious why the financial theory of portfolio diversification does not transfer well to utilities. The basic reason is that the assets involved in financial portfolio management are much simpler than the types of assets (power plants, fuel contracts, etc.) that a utility holds. To paraphrase Gertrude Stein, a share of stock is a share of stock is a share of stock. Regardless of what the underlying companies in a financial portfolio produce and sell, each share has a monetary return, and since a dollar is a dollar is a dollar, the return from one company's shares is indistinguishable from the return from any other company's shares, save for the level and riskiness of the yield. What about electric generation assets, such as power plants and supply contracts of different types, terms, underlying fuels, durations of commitment, and so on? Can these be adequately described as efficiently priced, freely substitutable assets that differ only in their risk-return characteristics? In a word—no.

Although all generating stations produce electricity, they also produce other products for which they are valued. Utilities require a mix of generation because of the differing technical capabilities of generators and the complexity of the load-following (consumption) requirements of keeping their customers' lights on. This alone imposes some diversity, but not for its own sake: A nuclear unit is very useful for producing base-load power, but the unit's inability to vary its output very quickly makes it impractical for providing operating reserves. On the other hand, the nimbleness of gas-fired combustion turbines makes them good candidates for providing operating reserves. Thus utilities must have a mix of generation, not for fuel diversity, but simply to have the right combination of technologies to meet their customers' loads reliably.

Put another way, the output of a generator, or portfolio of generators, cannot be characterized in terms of just the cost and risk (volatility of costs) of the resulting energy. The electricity portfolio must also supply reliability, load-following, quick response/recovery, voltage support, and so on, at many locations simultaneously. These locations at which power is supplied or needed are often not fully substitutable for each other either, due to transmission constraints and flow interactions. Distinct locations may also not have equal access to a diversity of fuel or technology choices.

Simply as a practical matter, fuels don't arrive at a utility without a means of transport. Coal may be unavailable or uneconomic at some locations because of inadequate rail capability, while natural gas requires proximity to a pipeline. Similar constraints restrict diversification across generation types. High-head hydroelectric dams are not an option for Florida utilities, nor are urban utilities likely to view building a large coal plant as a realistic prospect. Indeed, there are smaller coal plants that were originally built in the then-undeveloped "countryside" that were subsequently surrounded by suburbs and now cannot acquire sufficient land to add air pollution control equipment; many must limit operations as a result.

The simple point is that there are constraints on the candidate fuels and generation technologies that a utility can choose from, and these may severely restrict the options that are available. These constraints must be honored first and foremost, and they may be antagonistic to financial portfolio diversification. In addition, these common constraints mean that diversification for its own sake would entail substantial additional costs that would not be necessary absent the goal of diversifying. In contrast, essentially no such implementation costs or constraints arise when diversifying among financial securities.

The diversification paradigm for financial securities is based on the notion that investors only care about current period cash flows and changes in the market values of the securities in their portfolio. Those values (prices) reflect the present value of all future cash flows, over an essentially unlimited horizon. That is, diversified investors do not care whether a given stock's returns are projected to grow in year 5 or year 8; rather, they care about how either growth expectation affects the stock's resulting price and risk. In contrast, power plants or fuel contracts produce differing patterns of annual cash flows that customers may care about greatly. For instance, a coal plant may offer low power prices today but potentially very high prices in distant years if CO₂ taxes should be imposed. Conversely, a gas-fired plant may look expensive to own and operate today, with high natural gas prices, but it could look quite attractive in a few years if LNG should drive the price of natural gas down to \$4-5/mcf. The time pattern of benefits from utility plants and contracts matters.

Thus there is no single measure of risk for a utility planner to minimize or manage via diversification. Unlike a financial portfolio manager, a utility does not have a specific, single constituent whose risk-return preferences are to be satisfied with its supply portfolio. Not every ratepayer will have the same horizon of participation or concern about future annual benefits, so there is no single measure of expected benefit from the asset whose risks and returns can be monitored in portfolio-style management.⁴ At the very least, a utility manager considering a strategy of diversification should first be very explicit about what time period and type of risk he/she is seeking to control, and how that factor may conflict with other, alternative specifications.

IV. CRITICAL QUESTIONS TO BE ADDRESSED ABOUT UTILITY DIVERSITY

The foregoing should not be taken to suggest that fuel and generation technology diversity for utilities is a bad thing, but rather that it is not a per se good thing. Before diversity can be incorporated as a utility planning criterion, some careful thought must be given to how supply risk should be measured and how/why/when reducing it would be valued. What measure of diversity will be used? Given the constraints on available fuels, and the kinds of generation technology options available to utilities, how could one utility be compared to another, or one expansion plan to another for a given utility, to determine whether one of them has a better level of fuel and generation diversity than the other? Relatedly, at what cost is diversity worthwhile? Is there the possibility that a utility might have too diverse a portfolio? At what penalty (if any) to other service attributes, such as reliability or near-term costs, is diversity still useful? For instance, a very large shift to photovoltaics would diversify most systems, but it might also do so at worse reliability or higher cost. A low-cost utility with primarily nuclear and hydro resources would be hard pressed to justify adding oil-fired generation simply to create additional resource portfolio diversity.

These questions show that diversity as an independent goal for utility supply is virtually meaningless and even potentially harmful. Very heavy dependence on a particular fuel may not superficially seem like an attractive outcome, but even this may be optimal in some circumstances. There may be sufficient constraints on utility choices, fuel and generation technology, and their economics such that reliance on a dominant technology and fuel is the best alternative. Finally, planners (and regulators) should ask why (if at all) diversification would be more useful than simply hedging an undiversified generation portfolio. Questions such as these must be answerable before a supply diversity campaign is embraced.

V. A POSITIVE THEORY OF UTILITY DIVERSIFICATION

To develop a more specific view of when diversity could be helpful for electric power planning, it is useful to consider how it could affect different kinds of industry participants' costs and/or profits. We will compare three kinds of market participants, which can be combined to create most of the other types of entities in the industry—an integrated utility supplying its customers largely out of its own portfolio of owned and operated generating assets, a pure distribution company (distco) buying wholesale power for its customers, and a merchant generating company (genco).

The Integrated Utility Perspective

The integrated utility typically seeks to find a least-cost plan. As explained above, acceding to diversity goals at the expense of the natural engineering advantages and constraints at various possible expansion sites will tend to move the supply plan away from least cost, so there must be a well-reasoned justification. At a minimum, there must be a specification of the time horizon over which the portfolio risk and cost management plan is to be developed and evaluated. Here we will assume the focus is on the long term (many years); shorter-term risk management is discussed below in regard to distcos.

When the utility's planning horizon is long, diversifying generation assets and types (fuels) may help to hedge risks that are too long-lived to be covered by financial forwards. For instance, if a utility has agreed to a 10-year rate freeze, or to very long-term sales at fixed prices to its industrial customers, it may want to have an equivalent amount of low-risk (and ideally low-cost) supply in its mix to be assured of an ability to always honor those commitments. Native load obligations might be a similar obligation, subject to some understanding about how much price adjustment over time is likely to be feasible with the local utility commission. But diversification to smooth costs must be done with a keen appreciation for the fact that it may involve forgoing an engineering benefit that would otherwise obtain from using less diversified technology. For this to be worthwhile, the potential costs of remaining undiversified should be monetized and compared to the incremental cost of the diversifying assets.

An important factor to consider in designing a diversification plan is the potential for divergence between shareholder and customer interests in the pursuit of risk reduction. The shareholder holds a utility's stock in the hope that it will earn an adequate financial return. He can already reduce his risk by diversifying his portfolio of stocks by purchasing other companies' (and other industries') shares. However, customers generally have little such capability to inoculate themselves against the local technology's energy price volatility. They can choose alternative fuels for some of their end-uses, for example, by purchasing a wood stove, but they ultimately cannot avoid exposure to the utility's supply mix. Accordingly, some diversification may be to the customer's advantage, if it is superior to other risk-reducing strategies such as rate-smoothing tariffs or financial hedges bought by the utility.

To make evaluations of customer protections, specifying a time frame is critical. Are ratepayers in need of risk protections against monthly bill variance, or against year-on-year average costs (or even longer horizons)? Even if a plan is least cost in a present value of revenue requirements (PVR) sense, potential rate shocks or variability in some periods could be intolerable for some customers, such as might occur if there is a likelihood of extreme risks arising in the future (such as CO₂ penalties).

So why should an integrated utility diversify? We posit three reasons. First, diversity may be useful when there isn't the capability to use other risk management tools to limit exposure. Thirty-year forwards in coal or gas don't exist to create financial hedges (and even if they were offered, they would probably not be credible). There is no negatively correlated asset to materially hedge potential risks such as CO₂ penalties, and there is not yet a clear time frame for when and to what extent such hedges may be needed. A diversifying investment into a share of a low-carbon technology like a nuclear plant might be the best possibility that is available.

Second, diversity may offer value from flexibility or optionality that is not readily or typically quantified in least-cost assessments. Just as there are financial options so, too, can there be physical options. A simple example is the staged development of a combined-cycle power plant. It could be built initially as a simple-cycle combustion turbine, albeit with an appropriate physical environment to permit expansion. Later, it might be converted into a gas-fired combined-cycle unit with the addition of a heat recovery steam generator. Such a combined-cycle gas turbine might have fuel oil capability with sufficient tank storage so as to be able to operate easily with either fuel. Later in its development, coal gasification might be another possibility. Over the life of the plant, choices could be made with regard to whether to make additional investments or modifications in the light of market conditions and, if so, what kind. Thus, the plant's development cycle creates optionality for the utility. The utility then has the potential to be a carpenter with lots of tools. Diversifying into a mix of fuels and technologies, where that does not entail any other significant loss of engineering benefits or premium costs, may be worthwhile for the flexibility to opportunistically expand or modify assets later. The value of such optionality can be quantified as a test of whether the incremental costs (relative to not pursuing a less diversified expansion plan that looks better under expectations without option values) are worthwhile.

A third rationale is what may be labeled a political theory of diversity, a sort of "safety in numbers" argument. Even if diversity raises costs, it may increase customer satisfaction with the outcomes, especially if the metric of concern is not absolute risk but rather relative risk, i.e., the relative performance of the utility in comparison with others. This rationale might lead to eschewing the least-cost technology if another technology is not too much worse on average and would align the utility's portfolio more with its neighbors or the rest of the market. Here, shareholders may be equally concerned as ratepayers, due to the asymmetric risk of regulatory disallowances. If the utility should do much better than the average of its peers, it may gain little benefit, while doing much worse might entail significant penalties. If so, a portfolio more correlated with the regional market could be safer for shareholders and more satisfying to customers. Of course, in some areas, such a market-compatible portfolio might have relatively little diversity.

Again, the essential first step for an integrated utility considering diversification is to be explicit about a time frame and a performance metric to be stabilized. Supply strategies can then be compared for success in achieving more stability across a range of worrisome scenarios. Where stability is found, its costs should be reconsidered to assure they are not higher than is worthwhile for the amount of risk reduction. That cost-benefit test will depend on some economic understanding of what adverse effects arise (primarily for customers) if risks become too extreme. These are adverse effects above and beyond simply having high-cost or low-reliability power; they are additional costs whose avoidance would justify bearing direct utility costs, reflected in rates. Initially, that will likely be a subjective and somewhat political judgment, but over time it may be amenable to formal analysis.

The Pure Distribution Company Perspective

A pure distco buying its electricity from competitive wholesale providers is not in a position to choose supply assets (contracts) on the basis of “least cost” because it is a price-taker from the wholesale market. Moreover, the prices in the wholesale market generally do not reflect the degree of fuel or generation diversity in the underlying asset mix, because prices are set on the margin, not on average. Thus a distco may face a price driven largely by natural gas even if the regional power pool has only 20-30% of its MWs in gas-fired plants, because gas plants will tend to be dispatched above the nuclear and coal plants that are cheaper to operate. Such a buyer cannot diversify away from whatever fuel/technology is mostly setting prices, unless it decides to get out of market-based procurement altogether (e.g., with very long-term, cost-based contracts to whole plants, or with a new plant it constructs and puts into rate base, i.e., re-integration).

A more modest risk-management strategy available to such a buyer is to use financial instruments (forwards, or puts or calls on future power prices) to reduce exposure to the market’s marginal price volatility. Note that this does not involve physical (fuel or generation type) diversification, but an overlay of hedges on top of contracts for delivered power. It can also be achieved by asking physical suppliers to bear more of the fuel or market price volatility in the price terms they offer. In principle a distco could even consider holding long positions in natural gas contracts as a partial hedge against the cost of power. (If gas prices go up, its power costs would rise, but so would the value of its forward gas sales, partly negating the effect of the power price increase.)

Note that this kind of hedging and horizon-diversification reduces risk at no penalty or benefit to expected costs whatsoever, except perhaps for a small administrative cost of obtaining and managing such contracts. That is because hedges and forwards contracts in the secondary market do not (cannot) offer an advantage for buyers over sellers, or vice versa. They trade at expected value on a risk-adjusted basis.

A variant on this risk-management strategy that does use diversity is for the distco to diversify across its hedge suppliers to manage credit risk. Distcos can also make purchases at various time intervals and/or over various time horizons (sometimes called “laddering”) in order to avoid having too much of their costs determined by market conditions prevailing at a single point in time. Doing so actually increases potential price risk, compared to locking in forward prices sooner in one large purchase. However, this practice likely decreases the political risk that a distco’s procurement will be deemed imprudent after the fact due to inopportune timing. The difficult task here is for the utility, its regulators and key intervenors (perhaps) to agree on how much risk reduction (what profile of possible future costs) is desirable for customers.

Some utilities or their commissions have considered imposing upstream diversity requirements on suppliers eligible to participate in distco procurements. While well intended, it is highly questionable whether such rules will, in the end, produce economic results. This could simply reduce competition and/or impose the use of uneconomic resources on bidders, thereby raising prices. Distcos will generally be better off imposing service requirements on the characteristics of the contracts they seek, such as tolerable price escalations, volatility, etc., and then let the wholesale suppliers decide if they have the operational wherewithal to perform under those terms. To the extent that diversity helps them meet these performance terms, they will pursue it, and those already so endowed will be more secure and more willing to offer a lower price.

The Pure Merchant Generating Company Perspective

Pure merchant gencos do not have retail customers to worry about. They should “diversify” only if that helps reduce otherwise untenable risks of any forward positions to which they have committed. Depending on what

those sale positions look like, this may not involve supply mix diversification, but rather risk-matching. For instance, if all of the forward sales made by the genco have 100% load factors, they can be covered primarily with base-load assets. On the other hand, if they are selling peaking services, they may want to own mostly peakers! Finance theory reminds us that there is no advantage to diversifying the merchant genco's fuel and technology mix, except insofar as this eliminates the indirect costs of financial distress that could arise if its portfolio became too out of synch with the market.⁵ Otherwise, it is best to let investors do the diversification across the stocks they hold in their financial portfolios.

VI. CONCLUSIONS

People like to reason by analogy. If, in finance, prudent investors put together diversified portfolios of financial assets and, likewise, electric utilities assemble portfolios of fuels and generation, then it might seem plausible that applying the lesson of portfolio diversification learned in finance to the utility context would be a good idea. However, analogies also break down, and that happens quickly in this instance. There are many assumptions that go into the financial portfolio model that simply aren't realized in a utility context. The financial advice to diversify strongly holds only because (or when) financial assets are efficiently priced and can be readily substituted for one another in terms of their expected return and risk. Utility assets involve many more spatial and temporal performance attributes, interactions, and constraints that make them not satisfy these preconditions. This is not, however, to say that there are not reasonable concerns about levels and types of risk in utilities' or the market's recent choices about fuel and generation technologies. Rather, in examining those choices one can't simply appeal naively to portfolio theory as a basis for assessing those choices.

In general, diversification for its own sake by utilities is likely to come at significant cost from ignoring or having to overcome engineering reasons for preferring a less diversified portfolio of resources. If utilities are going to diversify, the best lesson they can take from financial portfolio theory is that they will also need a formal theory of how much diversity is a good thing. While we did not offer a full answer to that question, we showed that the diversification which could make sense for utilities and power suppliers depends on the nature of their organization and its obligations.

Integrated utilities that are covering their needs with owned generation may want to diversify to reduce their customers' exposure to very long-term, complex risks (such as CO₂ taxes or continually rising oil and gas prices) that cannot be hedged away with financial contracting. Pure distcos that buy power off the wholesale market can really only diversify across purchasing horizons, types of instruments, and suppliers, which helps to manage credit risk and hindsight risk regarding potential criticism of the timing of purchases. It may also help to achieve rate smoothing that customers appreciate. Merchant gencos have the least need to diversify, as they have only shareholders to satisfy. For them, diversity could be useful to the extent it helps keep them viable in the face of large, secular shifts in the wholesale power markets that could impose disruption costs on them. Otherwise, shareholders can probably do better on their own.

SIDEBARS

Sidebar 1—The Basic Diversified Financial Portfolio Model

We will not attempt to give a complete rendition of an area of finance that is as developed and actively researched as optimal portfolio theory, but we will describe the foundations for financial diversification and how these concepts are or are not relevant to the discussions of utility fuel and generation technology choices.

The original optimal portfolio framework by Markowitz⁶ and extended by Sharpe and others into the Capital Asset Pricing Model (or CAPM) was concerned with an individual who faces a choice among the financial assets she wishes to hold. The individual has the opportunity to purchase either an asset with a return that is perfectly assured, i.e., a “riskless” or “risk-free” asset such as a short-term U.S. Treasury bill, or to purchase any number of assets that have higher expected returns but which all come with material levels of risk. The individual’s goal is to maximize her portfolio’s expected return subject to her preference for risk, as measured by the variance (or the square root of this quantity, the standard deviation) of the portfolio.⁷ By mixing assets that behave differently under the same market conditions, some of the risk of her portfolio can be eliminated. (See Sidebar 2.)

For example, if computer stocks tend to go up, but recreational equipment stocks typically go down, under the same circumstances and vice versa, then holding both in the portfolio will be less risky than holding either of them separately. Diversification of the assets in her portfolio can rid the individual of some amount of the portfolio’s risk, while achieving an expected return that is the value-weighted average of the expected returns available from the component securities. The risk that can be eliminated in a portfolio goes under various names—unique, nonsystematic, idiosyncratic or diversifiable. However, some risk cannot be diversified away. That risk is called market, systematic, or undiversifiable risk.

The reason some systematic risk will remain in any portfolio (cannot be diversified away) is that the available securities have cash flows and returns that are at least partly correlated with each other and with the economy (market) as a whole. That is, they are all partly susceptible to the commonly shared influences of macroeconomic and geopolitical events, demographic trends, and other major factors—in addition to having their own individual influences (such as the effectiveness of their management, the appeal and usefulness of their new products, as well as simply good (or bad) luck).⁸ The effect of these shared, common influences cannot be diminished by diversification, while the idiosyncratic risks can be diversified away.

Finance theory has gone much further than simply observing that holding several imperfectly correlated securities reduces risk. It has demonstrated that there is an optimal strategy for how much to diversify one’s portfolio: Assuming that all stocks are efficiently priced and that investors only care about the return and variance of their stocks/portfolio, then there is an optimal mix of securities for any given level of portfolio risk—that is, a mix giving the highest possible return for that particular variance. Moreover, there is one portfolio—the “market portfolio,” consisting of value-weighted quantities of all securities available in the market—which can be levered up or down (by borrowing at the risk-free, government bond rate) to achieve risk-return combinations that dominate all others. This portfolio also has diversified away as much nonsystematic, firm-specific risk as possible.

Finally, because this portfolio dominates all others, individual securities should be priced (in equilibrium) in relation to how they affect the riskiness of this market portfolio. That riskiness is measured by a security's "beta," reflecting both its correlation with the market and its own overall riskiness. Stocks with a beta greater than 1.0 are riskier than average, while a beta lower than 1.0 indicates less than average risk. For this insight, the Nobel Prize in economics was awarded in 1990 to Harry M. Markowitz, Merton H. Miller and William Sharpe.

Sidebar 2—How Financial Portfolio Diversification Leads to Lower Risk

For concreteness, let's suppose our investor had two assets in her portfolio, say Dell Computers, with an expected yield of 20 percent, and Nike, with an expected yield of 15 percent. She holds 60 percent of her portfolio in Dell and the remainder in Nike. Her expected portfolio return would be the weighted average of the expected returns from each of the individual stocks, namely Dell and Nike, with weights the relative proportion of each stock in her portfolio. Thus:

$$\begin{aligned}\text{Expected portfolio return} &= E(\text{return}_{\text{portfolio}}) = w_{\text{Dell}} \times E(\text{return}_{\text{Dell}}) + w_{\text{Nike}} \times E(\text{return}_{\text{Nike}}) \\ &= (0.60 \times 20) + (0.40 \times 15) \\ &= 18\%.\end{aligned}$$

Where $E(\)$ denotes taking the expected value of the quantity in parentheses.

Calculating the risk of this portfolio is a little trickier. Suppose that the standard deviation of expected returns, σ_{Dell} , for Dell is 75 and that of Nike, σ_{Nike} , is 40. If these stocks were perfectly independent of one another in their expected returns, then we could compute the portfolio's variance as the sum of the squares of the stock's proportion in the portfolio times their respective variances. However, this won't work because stock returns are generally correlated. This correlation must be accounted for in the calculation of the risk.

Say that the correlation between Dell's and Nike's returns, $\sigma_{\text{Dell,Nike}}$, is 0.25. The variance of this portfolio is given by:

$$\begin{aligned}\text{Portfolio variance} &= \sigma_{\text{portfolio}}^2 \\ &= w_{\text{Dell}}^2 \times \sigma_{\text{Dell}}^2 + w_{\text{Nike}}^2 \times \sigma_{\text{Nike}}^2 \\ &\quad + 2 \times (w_{\text{Dell}} \times w_{\text{Nike}} \times \sigma_{\text{Dell,Nike}} \times \sigma_{\text{Dell}} \times \sigma_{\text{Nike}}) \\ &= [(0.6)^2 \times (75)^2] + [(0.4)^2 \times (40)^2] \\ &\quad + 2(0.6 \times 0.4 \times 0.25 \times 75 \times 40) \\ &= 2641.\end{aligned}$$

The standard deviation is the square root of the variance, so her portfolio has a standard deviation, $\sigma_{\text{portfolio}}$, of 51.4. Thus, this portfolio is somewhat riskier than holding Nike alone, with a standard deviation expected return of 40, and substantially less risky than holding Dell alone, with a standard deviation of 75, yet the overall expected return on the portfolio, 18%, is closer to that of Dell than of Nike.

ENDNOTES

- ¹ Energy Policy Act of 2005, Title X-Electricity, Subtitle E-Amendments to PURPA, Sect. 1251-Net metering and additional standards, “(12 Fuel sources.-Each electric utility shall develop a plan to minimize dependence on 1 fuel source and to secure that the electricity it sells to its customers is generated using a diverse range of fuels and technologies, including renewable technologies.”
- ² In principle, risk may need to be described by more than just the variance in a portfolio, but under the assumptions that the returns to securities are normally distributed, or that investors have quadratic utility functions, variance is sufficient.
- ³ See, for instance, Synapse Energy Economics, “Portfolio Management: Tools and Practices for Regulators,” July 17, 2006 (“Synapse Report”), available at <http://www.synapse-energy.com/Downloads/SynapseReport.2006-07.NARUC.Portfolio-Management-Tools-and-Practices-for-Regulators.05-042.pdf>.
- ⁴ Of course some portfolio managers serve more than one customer. For instance, a 401(k) plan may be used by thousands of employees whose individual preferences for risk and return are never canvassed by the portfolio manager. However, those employees typically have the opportunity to opt into one or more of several alternative portfolios that are designed to have stated risk-return characteristics.
- ⁵ The predominance of natural gas as the fuel of choice for merchant generators has given some pause because of the potential strong correlation among outcomes for the market’s participants. This year’s co-winner of the Nobel Prize in economics, Thomas C. Schelling, has an entire book devoted to such situations. See his *Micromotives and Macrobehavior* (New York: W. W. Norton, 1978).
- ⁶ Markowitz, H.M., “Portfolio Selection,” *Journal of Finance* 7 (March 1952), pp. 77-91
- ⁷ In principle, risk may need to be described by more than just the variance in a portfolio, but under the assumptions that the returns to securities are normally distributed, or that investors have quadratic utility functions, variance is sufficient.
- ⁸ See *Fooled by Randomness: The Hidden Role of Chance in Life and in the Markets* by Nassim Nicholas Taleb (New York: Random House, 2005) for some fascinating arguments about the significance of chance in markets.



**EDISON ELECTRIC
INSTITUTE**

701 Pennsylvania Avenue, N.W.
Washington, D.C. 20004-2696
202-508-5000
www.eei.org