The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture

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About ACEEE

The American Council for an Energy-Efficient Economy is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting economic prosperity, energy security, and environmental protection. ACEEE fulfills its mission by

- Conducting in-depth technical and policy assessments
- Advising policymakers and program managers
- Working collaboratively with businesses, public interest groups, and other organizations
- Organizing conferences and workshops
- Publishing books, conference proceedings, and reports
- Educating consumers and businesses

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Energy Efficiency Information Links

Alliance to Save Energy: www.ase.org
American Council for an Energy-Efficient Economy: www.aceee.org

California Institute for Energy and Environment: www.ciee.ucop.edu
Center for Energy and Climate Solutions: www.energyandclimate.org
CleanEdge: www.cleanedge.com
Consortium for Energy Efficiency: www.cee1.org

Energy Efficiency and Renewable Energy, U.S. DOE: www.eere.energy.gov
Energy Information Administration, U.S. DOE: www.eia.doe.gov
ENERGY STAR, U.S. EPA: www.energystar.gov

Industrial Assessment Center, U.S. DOE: www.iac.rutgers.edu
Industrial Technologies Program, U.S. DOE: www1.eere.energy.gov/industry
International Association of Energy-Efficient Lighting: www.iaeel.org

North American Insulation Manufacturers Association: www.naima.org
Northeast Energy Efficiency Partnerships: www.neep.org

U.S. Green Building Council: www.usgbc.org

World Energy Efficiency Association: www.weea.org

Foreword

Since its inception in 1981, ACEEE has produced a wide variety of reports and assessments focused on energy efficiency as a low-cost, reliable alternative to our nation's growing energy demands. This report departs from ACEEE's traditional focus on energy efficiency as a resource and instead frames efficiency as an invisible powerhouse and an underappreciated investment opportunity. As such, this new ACEEE publication seeks to quantify the size and scope of current investments in energy efficiency technologies both in terms of dollars invested and labor employed. The core question driving the current assessment is, "How Big Is Energy Efficiency in the U.S.?" Despite numerous obstacles and challenges, the authors successfully develop credible estimates of current spending on efficiency and discuss how those investments compare to annual investments in conventional energy supply. The results suggest that our nation is not aware of the role that energy efficiency has played in satisfying our growing energy service demands.

While this research effort is undoubtedly ambitious, the lack of appropriate data makes it even more challenging. Despite the plethora of the data collected and maintained by both government and private sources, measures of the cost of energy efficiency technologies are not collected. Similarly, while data on the annual contribution of energy supply resources are available, data on the annual contribution of efficiency resources are not. For that reason, the authors of this analysis, sociologist Karen Ehrhardt-Martinez and economist John A. "Skip" Laitner, have had to pull together a multidisciplinary analysis that draws on an interesting blend of economics, technology characterization, and working assumptions in providing a first estimate of the scale of the efficiency resource. As a starting point they've chosen the historical test-year 2004 to frame their inquiry and their methodology.

The results of this analysis may surprise some but will hopefully capture the attention of policymakers, business leaders, and the investment community more generally. Notably, since 1970 it appears that energy efficiency has met about three-fourths of the demand for new energy-related services while conventional energy supply has provided only one-fourth of this demand. Nevertheless, the contributions of efficiency frequently go unrecognized. As the authors note, efficiency is the energy we don't use in providing our nation with the goods and services needed to maintain our economy. The report also notes that although efficiency is a proven resource, it remains underdeveloped. In short, the evidence suggests that efficiency can make an even larger contribution towards stabilizing energy prices and reducing greenhouse gas emissions — should we choose to fully develop it. But this is hardly the last word in this investigation. This study provides a starting point for discussion. We anticipate and welcome further contributions to our effort.

Steven Nadel
Executive Director, ACEEE
May 2008

Acknowledgments

The year of research and planning that ultimately came to fruition in the publishing of this report occurred in parallel to another journey upon which the authors recently embarked: a backpacking adventure to the bottom of the Grand Canyon. Both adventures were sufficiently challenging so as to test the endurance, dedication and fortitude of the participants. Both adventures involved taking a calculated and well-planned leap into a large abyss with multiple unknown variables and few, scattered, and sometimes less-than-reliable resources. Despite the difficulties endured, we are pleased to report that we successfully survived both adventures, emerging with greater knowledge of and appreciation for the task that was accomplished and grateful for the help that we received from others along the way.

Of the highest priority, the authors gratefully acknowledge the support of the Civil Society Institute, the North American Insulation Manufacturers Association (NAIMA), and the Kendall Foundation, which helped underwrite this report. Each of these foundations gave us the impetus to move ahead with this initial research effort. We would also like to acknowledge the support of the Energy Foundation, which provided the means to establish the necessary framework within which this research was undertaken.

We are also grateful to the members of the project advisory committee who provided timely comments, insights, and expert opinions — often under significant time constraints — and who helped guide our decisions regarding research methodology, data sources, and underlying assumptions. Their support and encouragement were invaluable in structuring, formulating, and reformulating our research strategy and tactics and the development of our thinking around many of the issues discussed herein.

Finally, the authors would like to recognize the wide-ranging support provided by numerous ACEEE staff members. Glee Murray, Renee Nida, Sarah Black, and Katie Ackerly provided invaluable assistance in the editing, design, and layout of this publication. Vanessa McKinney provided assisted in data collection and assessment. Steve Nadel, Bill Prindle, Neal Elliott, and Harvey Sachs rightfully gave us pause to consider and reconsider the focus, flavor, and emphasis of our work.

Executive Summary

Energy efficiency is a means of using less energy to provide the same (or greater) level of energy services. With efficiency we can drive the same distance with less gasoline or watch the same program with fewer kilowatt-hours of electricity.[1] Achieving greater efficiency requires us to change our technologies, our behaviors, or both. Making these changes necessitates the spending of time, or money, or both. Importantly, however, these costs are not simply expenditures but investments that yield returns in the form of energy savings and often reduce resource consumption in other ways. When considered together, investments in energy efficiency technologies constitute a unique means of providing energy services, while lowering energy consumption and reducing our environmental impact. Taken together, these investments comprise what might be called an energy efficiency market.

Just how big is the market for energy efficiency technologies? How much do we invest annually in that market? What level of energy savings have we achieved? How much more could we invest? Why aren't we investing more to reduce the energy we waste? What could we gain from greater energy productivity? Would it be worth the cost? What should we do to further develop the full array of energy efficiency resources? These are the questions that are the subject of this report.

Whether the goal is reducing the impact of climate change, increasing energy security, or improving economic productivity, energy efficiency is among the most cost-effective solutions available to consumers, businesses, policymakers, and investors. Nevertheless, researchers have yet to establish a clear picture of the size and scale of current efficiency investments. Because the energy efficiency technology market is fragmented and difficult to measure, policymakers, would-be investors, and the public are left without sufficient or accurate information as to its size, or its potential for growth. Unfortunately, the absence of a vivid efficiency picture serves to constrain alternative visions of viable and sustainable energy futures.

This report provides a unique assessment of the size and scale of current investments in the U.S. energy efficiency market and reveals the scope of potential benefits that future investments might yield. Ultimately our goal is threefold: (1) to increase the visibility of the contributions that efficiency currently makes to our economy; (2) to illustrate the potential contributions that efficiency can make in terms of energy security, economic productivity, and climate change mitigation; and (3) to recommend specific means of accelerating our transition to a more energy-productive, low-carbon economy.

Why is there a renewed focus on energy and efficiency? The evidence suggests that the transformation to a much more energy-productive economy is entirely possible. Indeed, there is a palpable shift in the opinions and preferences of policymakers and businesses leaders that may already be changing the market dynamics compared to standard economic forecasts. Consumers are also responding more positively in response to an array of market drivers and influences shaping the nation's energy productivity. Among the major influences are:

[1] See Section II and Appendix A for a more detailed discussion of how we define efficiency.

- Rising and more volatile energy prices
- Tight delivery capacity for conventional energy supplies
- Increased urgency in responding to the climate challenge
- Growing consumer and investor concerns about energy industry responsibility
- Accelerated pressure from global competition
- The rapid pace of technological advancements

Taken together, these six drivers have created a new and fertile environment for energy efficiency investments.

How much are we currently investing? In 2004, an estimated $300 billion was invested in energy efficiency technologies and infrastructure in the United States. This amount is three times the size of investments made in the conventional energy supply infrastructure but represents less than a third of the nation's total annual energy expenditures. Three hundred billion dollars represents the full cost associated with the efficiency technology investments, including the base cost of the technology needed to simply maintain previous levels of energy intensity, as well as the incremental cost needed to provide the increased level of productivity. If we narrow our focus to include solely the premium associated with improvements in energy efficiency technologies, the market (across all sectors of the economy) is estimated at roughly $43 billion.

How much energy did we save? These investments in energy efficiency technologies are estimated to have generated approximately 1.7 quads of energy savings in 2004 alone. In other words, had the nation maintained the same level of energy productivity as it had achieved in the year 2003, total primary energy use in 2004 would have reached 101.8 to 102.0 quads compared to the actual level of 100.3 quads documented in the databases maintained by the Energy Information Administration. These savings are roughly the equivalent of the total energy required by the operation of 40 mid-sized coal-fired power plants. By the end of 2008, these investments will have saved roughly 6.6 quads of energy on a cumulative basis or the equivalent of at least $77.4 billion (2004 $).

Which sectors received the most investment? Not surprisingly, the size of efficiency investments varied considerably across energy end use sectors. Approximately $178 billion or nearly 60% of total energy efficiency investments were made in the buildings sector. Of these investments, nearly half (49%) were made in energy-efficient appliances and electronics, while 29% were made in energy-efficient commercial building structures and 22% were made in energy-efficient residential building structures. Investments in energy efficiency in the industrial sector were roughly $75 billion, representing one-quarter of total efficiency investments. The transportation sector received approximately 11% of investments in efficiency or $33 billion.

Interestingly, this pattern of investments does not mirror the patterns of energy use across sectors. While energy consumption is highest in the building sector, buildings account for only 39% of total energy consumption compared to 62% of total efficiency investments. Within the buildings sector, investments in appliances and electronics (48%) far exceeded the proportion of energy consumed by these devices (7.7%). In the industrial sector, the proportion of investments was lower than the proportion of energy use (25% and 34%, respectively). Notably, however, the transportation sector also proved to be significantly unbalanced, representing only 11% of efficiency investments but 28% of overall energy use.

Table ES-1. Energy Efficiency Investments Summary

	Buildings	Industrial	Transportation	Utilities	Total
Total Energy Use (quads)	38.9 (39%)	33.6 (33%)	27.9 (28%)		100.4 (100%)
Total Efficiency-Related Investments ($billion)	178	75	33	15.7	300
Premium Investments ($billion)	24	11	5	2	43
Investment- Related Employment (000)	990	351	151	139	1,630
Energy Savings (quads)	.72	.66	.08	.19	1.7
Energy Savings ($billion)	12.2	5.6	1.1	0.5	19.5

* Note: Totals may not match due to rounding.

How many jobs rely on efficiency investments? Annual investments in energy efficiency technologies also support a high level of employment across sectors. In total, 1.63 million jobs are supported by efficiency-related investments. If we consider all efficiency-related employment, the largest number of related jobs is found in the buildings sector, which generated approximately two-thirds of all efficiency-related jobs or nearly one million jobs. Within the buildings category, investments in the appliance and electronics sector generated the most jobs (more than 370,000), followed by efficiency-related jobs in residential construction and renovation (316,000) and commercial construction and renovation (301,000).[2] Other significant levels of employment are associated with investments in the industrial sector, which generated an estimated 351,000 jobs. Investments in energy efficiency in transport were lower, generating an estimated 151,000 jobs, while efficiency investments in the utility-sector employed roughly 139,000 workers in 2004.

How much more could we invest? While these figures indicate that, as a nation, we are clearly making positive strides toward increasing our energy productivity and reducing our carbon footprint, analysis performed for this report also suggests that we have only begun to scratch the surface of the potential savings that additional investments in energy efficiency technologies could provide. Although existing data make a precise assessment difficult, our research findings indicate that in an environment of accelerated market transformation and rapid growth in efficiency investments, total investments in more energy efficiency technologies could increase the annual energy efficiency market by nearly $400 billion by 2030, resulting in an annual efficiency market of more than $700 billion in 2030.

This estimate is based on two assumptions. The first is that the right set of policies, market forces, and new financing mechanisms could facilitate a cost-effective, 20% reduction in total energy use by 2030, compared to the forecast from *Annual Energy Outlook 2008* (EIA 2008b). The second is that movement "up the cost curve" implies a longer payback period for energy efficiency investments, beginning with a typical three-year payback today but rising to an average five-year payback by 2030. In that scenario, total cumulative investments in the

[2] These estimates include jobs in manufacturing, sales, installation, and other services.

efficiency technology infrastructure over the period 2008-2030 would increase by nearly $7 trillion.

What can we gain from efficiency? Given the right choices and investments in the many cost-effective but underutilized energy efficiency technologies, a variety of studies (by ACEEE and others) suggest that the United States can cost-effectively reduce energy consumption by 25-30% or more over the course of the next 20-25 years.

Conclusions. The energy-related challenges of the 21st century require a dramatic shift in direction, from an emphasis on energy supply to an emphasis on energy efficiency. While current investments in energy efficiency are having an important impact on our economy, efficiency remains under-funded, and the potential benefits of efficiency remain unrealized. Based on our assessment of existing impediments, we make the following three recommendations:

1. Improve the visibility of the energy efficiency resource through data collection and dissemination. We think this can best be done by creating a national energy efficiency data center.

2. Facilitate investments in energy efficiency technologies and services by expanding the range of investment options.

3. Promote and reward the adoption of energy efficiency technologies and services by identifying and providing social, political, and economic incentives and mechanisms that steer behavior toward sustainable energy practices.

I. Introduction

Currently, our nation consumes more energy than any other country in the world. In the United States our livelihoods and our lifestyles are rooted in, and shaped by, our access to energy and the many services that energy resources provide. Historically, our growing demand for energy services has been satiated primarily through the burning of fossil fuels. However, the energy-related challenges of the 21st century require a dramatic shift in direction. These challenges — ranging from the possibility of disruptive climate change and other environmental concerns to the adequacy of reliable energy supplies at stable and reasonable prices — require a new vision for the future. While the vision must undoubtedly be multi-faceted, affordable solutions to our energy challenges will require strategic investments in maximizing energy efficiency: efficiency investments that will save consumers and businesses money even as they productively reduce energy waste and greenhouse gas emissions. Hence, investments in energy efficiency not only offer the opportunity to build on the historical success and momentum of technological innovations and innovative behavioral change, they also make economic and environmental sense. As such, energy efficiency must become the first fuel of choice to meet our growing demand for energy services.

Although current levels of investment in energy efficiency are arguably inadequate and sub-optimal, energy efficiency is already hard at work in our economy. The irony is that energy efficiency may be best characterized as an *invisible* powerhouse, working behind the scenes to meet our nation's growing demand for goods and services. In many ways, efficiency resources and investments are hard to observe, to count, and to define because they represent the energy that we *don't use* to meet our energy service demands. And the energy that we don't use, almost by default, becomes the energy we don't see. Compared to the construction of a new power plant or the drilling of a new oil well, energy efficiency gains are often distributed across the many productive technologies and market behaviors that are part of the normal course of doing business. However, our very inability to observe, measure, and quantify efficiency acts as an impediment to smart policy, planning, and investment.

Irish satirist, poet, and essayist Jonathan Swift once commented, "Vision is the art of seeing the invisible." In terms of energy production and consumption, a smart energy future must make the invisible contribution of cost-effective energy efficiency investments much more evident so that we can recognize both their past contributions and future potential in helping us meet the energy-related challenges that lie ahead. As such, this report attempts to assist policymakers and business leaders in three ways. First, it provides an assessment of the historical contributions of efficiency and our (in)ability to foresee those contributions. Second, it identifies the forces that are currently shaping the renewed focus on energy and efficiency. And third, it offers "a more visibly concrete" and quantitative picture of the size and impact of current energy efficiency investments in terms of their energy bill savings, their significant environmental benefits, and their positive impact on job creation. The report concludes with a discussion of the future potential of efficiency investments and the mechanisms needed to achieve that potential.

Ultimately, the goal of this report is to enable economic policy leaders and investors to see energy efficiency investments as an accessible and perhaps even a critical resource for the future development of our economy. As such, we see this report as providing the vital information needed to assemble not only a coherent picture of the current contributions of energy efficiency but also for envisioning a more productive and less energy-intensive future — because our vision of the future also influences our actions today. As long as the significant contributions of the many energy efficiency resources remain invisible, they are less able to play a role in shaping our vision of the future, thereby creating a poverty of choice. Unfortunately, the inadequate assessments of the energy efficiency resource, whether in policy forums or economic models, have forestalled productive investments in new programs, technologies, and markets. That, in turn, has retarded potentially significant gains in our nation's energy productivity.

II. The Facets of Efficiency and the Problem of Invisibility

Energy efficiency is a means of using less energy to provide the same (or greater) level of energy services. With efficiency we can drive the same distance with less gasoline or watch the same television program with fewer kilowatt-hours of electricity.[3] Achieving higher levels of efficiency requires that we change our technologies, our behaviors, or both. Making these changes necessitates the spending of time, or money, or both. Importantly, however, these costs are not merely expenditures but investments that yield returns in the form of energy savings and often reduce resource consumption in other ways. When considered together, investments in energy efficiency technologies constitute a unique means of providing energy services, while lowering energy consumption and reducing our environmental impact. Taken together, these investments comprise what might be called an energy efficiency market.

As we indicated in the opening section of this study, the purpose of this report is to enable economic policy leaders to see energy efficiency investments as an accessible and critical resource for the future development of our economy. Importantly, however, while energy efficiency is a distinct element of the larger energy and economic puzzle, it is also closely linked to several other economic concepts. Therefore, in order to generate a clearer picture of the role of energy efficiency, we must begin by defining and distinguishing several core concepts. Subsequently, we discuss the invisibility of efficiency and its implications for policy, planning, and future energy consumption.

A. Efficiency and Other Energy-Related Concepts

The concept of energy efficiency is commonly understood as the use of less energy to provide the same (or greater) level of energy service. However, to really place the idea of energy efficiency within a meaningful policy context, we should think of the energy picture in perhaps six different dimensions. In addition to energy efficiency, we reference the concepts of energy services, energy conservation, energy intensity, energy-related structural change, and overall energy productivity, as we define and describe them below.

(1) Energy services: As each individual, household, or company seeks to maintain a desired level of comfort or a specific level of economic activity, the achievement of these efforts requires a certain level of energy services. For example, when we want to read a book, we are looking for some given amount of light that makes it easier to enjoy the reading of that book. Or if we are making an effort to pay our monthly bills or perhaps complete the assembly of an automobile, there is an implied demand for energy that allows us to undertake and complete the requisite

[3] See Appendix A for a more detailed discussion of how we define efficiency.

tasks. In these and many other cases, energy provides a service that allows us to do the things we actually want done. According to this perspective, we are not interested in accessing the quantity of electricity needed to power the lamp: rather, we simply want sufficient lighting to enjoy our reading experience. As one might already suspect, the idea of sufficient lighting may be viewed differently, even by people within the same family. For now, however, we will assume that a sufficient amount of light might be available from a lamp that provides 900 lumens. In this example, the 900 lumens becomes the energy service that is demanded. Those lumens might be provided by a standard incandescent light bulb requiring 60 watts of electricity, a compact fluorescent lamp (CFL) that might require only 14 watts of electricity, or by normal daylight.

(2) Energy conservation: Conservation activities are more directly focused on reducing the unnecessary use of energy services. As such, energy conservation can be thought of as adjusting our expectations and behavior regarding what we now think an appropriate energy service might be. For instance, one person in a particular household — growing up with a prior set of expectations and preferences — might believe that 1,100 lumens of lighting is the sufficient level for reading. This specific demand for energy services might be provided by either a 75-watt incandescent bulb or a 23-watt CFL. Or it might even be provided by natural daylight. In this case, however, the shift from the use of 1,100 to 900 lumens might be termed energy conservation. Conservation also includes the elimination of waste through behavior changes. In this particular example, it would include someone turning off the lights when he or she is not reading and doesn't really need the energy services at that moment.[4]

(3) Energy intensity: Energy intensity is a specific physical indicator of the energy required to satisfy a given demand for energy services, whether in terms of a nation's economy, an industrial operation, or a business or personal activity. In the case of the U.S. economy, the energy intensity is calculated as the units of energy consumed per dollar of Gross Domestic Product (GDP). We use this specific metric later in this report by noting the decline in U.S. energy intensity from 18,000 Btus per dollar of GDP in 1970 to an expected 8,900 Btus by the end of 2008. In the home reading example, we would say that an incandescent bulb would require 0.067 watts per lumen delivered compared to 0.016 watts per lumen for a CFL. Hence, energy intensity is the *energy input divided by the economic or other desired output*. High levels of energy efficiency are associated with low levels of energy intensity.

(4) Energy efficiency: Energy efficiency can refer to either the performance of a technology in its physical use of energy, or it can refer to a cost-effective improvement in specific appliances and equipment. As a physical attribute we generally think of efficiency as a ratio of energy output per unit of energy provided as an input. For example, the energy value of each kilowatt-hour of electricity delivered to homes and businesses in the U.S. is on the order of 3,412 Btus. Unfortunately, however, the generation and delivery of that same kilowatt-hour requires about 10,800 Btus. Hence, the performance of our nation's electricity system turns out to be only 31.6% efficient (EIA 2008b). A typical furnace provides us with another example. In this case,

[4] Perhaps to offer a further clarification, if we rely on behavioral changes as the primary means of reducing unnecessary use of energy, we would term that energy conservation. If we instead rely on an investment in a technology to assist in waste reduction, we would term that energy efficiency. The installation and use of motion sensors to automatically turn off a light when no one is in the room would be an example of the latter.

a furnace that delivers heat at the rate of 80,000 Btus an hour, but requires a total of 87,000 Btus of natural gas an hour, has an average efficiency of about 92%.

The second definition of efficiency is the one we will employ in this report to estimate the size of the annual energy efficiency market. In this case, efficiency is measured as the cost-effective change in energy use, where "cost-effective" implies an investment in a technology that pays for itself in a short period of time. Let us assume, for instance, that we are switching from a 60-watt incandescent bulb (that costs $0.50) to a 14-watt CFL (that costs $3). In this example, we would find that the higher cost of the 14-watt bulb pays for itself within 2 years when compared to the cheaper incandescent, since the incandescent needs to be replaced annually while the average life of the CFL is closer to 6 years. In this example, we have an improvement in technological performance of nearly 75% that pays for itself in two years. That gives the homeowner or commercial property manager an extra four years to enjoy a net savings on the energy bill.[5]

(5) Energy-related structural change: Some economy-wide changes in energy demand may result from changes in the configuration of the economy. If the current economic structure shifts from an emphasis on agriculture and manufacturing to an emphasis on value-added services, the configuration of energy service demands is also likely to shift. As such, energy-saving structural change is a function of the economic performance and the physical performance of the economy. In the United States, for example, some of the recent economy-wide changes in energy demand have resulted from a shift away from heavy manufacturing toward high-value-added, low-energy-intensity industries. As less energy-intensive industries and services comprise a larger portion of economic activity, energy intensity falls while energy productivity increases. However, it is important to recognize that this type of shift is not necessarily the result of some more energy-efficient means of producing the same economic goods but from a restructuring of the mixture of goods and services that are provided to the economy.

(6) Energy productivity: As with the concept of energy efficiency, energy productivity also has both economic and physical dimensions. In the case of the economy we might think of energy productivity as the inverse of energy intensity. Whereas the nation's energy intensity in 1970 was about 18,000 Btus per dollar of GDP (measured in constant 2000 dollars), the energy productivity equivalent might be evaluated as $55.6 of GDP per one million Btus of energy (EIA 2006). By 2008 we expect energy intensity to decline to about 8,900 Btus, which means energy productivity will increase to approximately $112.4 of economic output for each million Btus of energy consumed (EIA 2008a). These improvements are generally assumed to be cost-effective since the necessary investments are otherwise unlikely to have been made. In short, energy productivity is typically calculated as the units of economic output per unit of energy consumed. Greater energy productivity can be achieved by two different mechanisms: (1) reducing the amount of energy required to produce a given product; and/or (2) increasing the quantity or quality of goods and services produced by a given amount of energy.

[5] This example is drawn from the authors' calculations using published cost and performance data provided by a large retail store. As an emerging market, there is a great variability in costs, which means that shoppers can find much cheaper and more costly examples for both types of lamps. We use these figures only to illustrate the idea of energy efficiency as a cost-effective investment, not as a specific recommendation to purchase at these prices. The calculations further assume an electricity price of 10 cents per kilowatt-hour.

As we previously commented, the critical insight associated with many of these concepts is that efficiency improvements are cost effective. In other words, investments in the relevant technologies are returned in a relatively short period of time through subsequent energy savings. Moreover, the energy bill savings continue to accumulate during the entire lifetime of the new technology, generating returns above and beyond the initial level of investment.

B. Bringing It All Together

Year-to-year changes in energy service demands are best understood in terms of the net change in total demand as well as the changing composition of the demand. In other words, while total energy service demands generally change from one year to the next, so too do the ways in which those demands are met. As shown in Table 1, new energy service demands can be met through various combinations of new energy supply, new efficiency gains, and changes in the underlying economic structure. In effect, Table 1 summarizes the way in which energy service demands were met for the years 2003 through 2005.

Table 1. Adding Up Contributions to Energy Service Demands (Quads)*

	2003	**2004**	**2005**
New Energy Service Demands	2.46	3.84	3.24
New Energy Supply	0.35	2.14	0.34
New Efficiency Gains	2.01	1.61	2.80
New Structural Change	0.09	0.08	0.10
Contribution to Annual Share			
New Energy Supply	14.3%	55.8%	10.5%
New Efficiency Gains	81.9%	42.0%	86.4%
New Structural Change	3.8%	2.2%	3.1%

* Note: Totals may not match due to rounding.
Source: Laitner (2008)

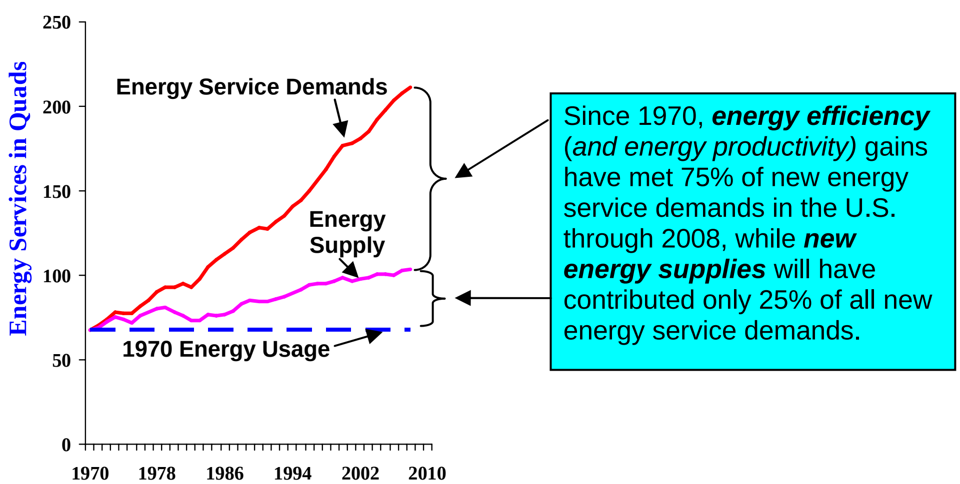
Our estimates for 2004 suggest that new demand for energy services increased by an equivalent of 3.84 quads. In this instance, the incremental change in energy services is estimated by applying the ratio of energy intensity in 2003 to the measure of economic output for the subsequent year of 2004 and then subtracting total energy consumption reported in 2003. The results, as shown in Table 1, indicate that actual rates of economic growth in 2004 required 3.84 more quads of energy services in 2004 given 2003 levels of energy intensity. As we describe more fully in the appendices to this report, we have estimated from various data published by the Energy Information Administration (EIA) that new energy supply provided 2.14 quads of the new demand, while efficiency and structural change satisfied about 1.61 and 0.08 quads, respectively. In other words, new energy supply met about 56% of the higher demand for energy services in 2004, while energy efficiency and structural change provided an estimated 44% in this analysis.

It is important to note that the ways in which new energy service demands are satisfied will vary from year to year. For example, while efficiency and structural change accounted for nearly 86% of new energy service demands in 2003, they accounted for approximately 89% in 2005. When applied to the longer time horizon between 1970 and 2008 (estimated), energy efficiency and structural change are estimated to have accounted for about 75% of all new energy service demands (see Figure 1 below). While these longer-term accomplishments are important (and are discussed in more detail below), the focus of this analysis is on efficiency gains and efficiency investments for just one year: 2004. The goal, then, is to compare annual investments in total efficiency improvements to investments in new energy supply with the purpose of developing a sense of the size and scale of the energy efficiency market. While a variety of factors led us to choose 2004 as the base year for our analysis (see discussion in Section IV.A, the assessment in Table 1 indicates that total efficiency gains during 2004 appear to be somewhat anomalous, and that the impact in 2004 does not easily translate across the larger time horizon. Despite these limitations, our measures do generate some useful insights and comparisons that enable us to estimate "how big energy efficiency" might have been within the year 2004.

C. Past and Future Contributions of Efficiency and the Problem of Invisibility

The historical record clearly indicates that during the past 38 years, we have made significant improvements in energy efficiency. In other words, each unit of energy consumed today provides significantly more energy services than the same unit of energy provided in 1970. In fact, energy efficiency has contributed more value to the economy in recent decades than any conventional energy resource, meeting three-fourths of all new demand for energy services since 1970 (Laitner 2008). As highlighted in Figure 1, estimates for 2008 indicate that by the end of this year U.S. energy consumption per dollar of economic output will have declined by more than 50% since 1970, from 18,000 Btus to about 8,900 in 2008. As such, current levels of energy consumption in the U.S. are only half of what they would have been if levels of energy services, the structure of the economy, and overall energy productivity had remained unchanged.

Figure 1. Efficiency Gains Compared to New Supply, 1970-2008



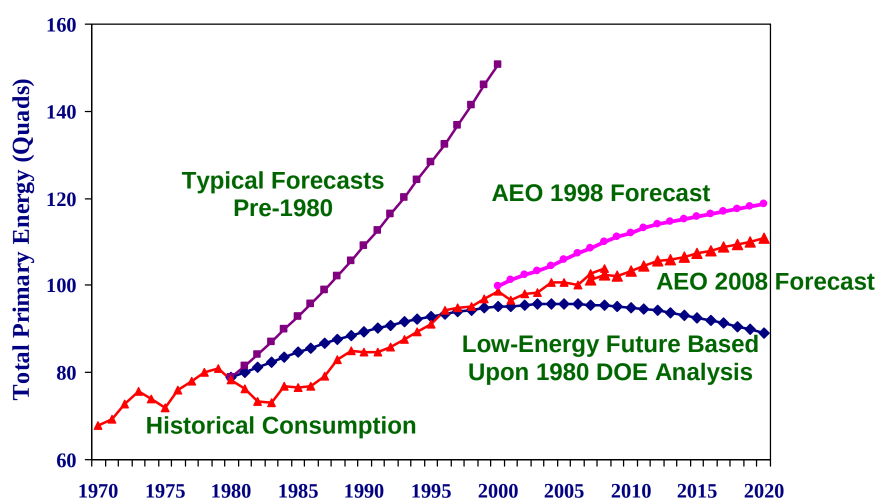
Source: Laitner (2008)

Despite these marked contributions of efficiency, efforts to measure the precise magnitude of new efficiency resources and investments have proven particularly difficult. Unlike conventional energy resources, efficiency isn't concentrated in easy-to-measure reserves. Instead, efficiency resources (and related opportunities for investment) are disbursed throughout a wide variety of products, technologies, and systems that require replacement or retrofit to achieve higher levels of efficiency. Unlike oil and coal resources, efficiency "powers" economic growth by reducing the energy demand associated with each unit of output. As such, efficiency gains are often hidden within new technologies and systems, including more efficient lighting and heating equipment, high quality cooking appliances and electronics, fuel-efficient cars and trucks and manufacturing equipment, and well-designed building structures and manufacturing systems.

The disaggregated nature of the energy efficiency market, combined with the lack of concerted data collection efforts, has made it exceedingly difficult to assemble a holistic picture of the contributions of efficiency — rendering it largely invisible to economists, policymakers, and business leaders alike. Moreover, our incomplete and elusive understanding of the current and potential contributions of efficiency has resulted in inaccurate energy forecasts, uninformed policy choices, and poor business decisions.

For example, a comparison in Figure 2 of energy forecasts from the 1970s and actual outcomes for the past 38 years illustrates the extreme discrepancies between forecasts and actual consumption trends. As opposed to forecasted trajectories of high rates of growth, actual patterns of energy consumption have been much more consistent with what was viewed in the 1980s as low-end energy forecasts. The divergence between forecasts and actual patterns resulted from several unforeseen influences including the adoption of programs, policies, and technological innovations that successfully increased energy efficiency and reduced our actual demand for energy well below projected levels.

Figure 2. Comparison of U.S. Energy Projections Over Time



Source: Authors' calculations using EIA (1998, 2007, 2008a, 2008b); DOE (1980)

In short, the invisibility of efficiency often results in an overly narrow set of estimates regarding future energy consumption trends. This, in turn, leaves policymakers and investors with unrealistic expectations about the nation's energy trajectory and investment opportunities.

While historical gains in efficiency are more readily apparent, this report is dedicated to providing a clearer picture of the size and scope of present day investments in efficiency, the size and scope of hidden investment opportunities that offer the possibility of enhancing current energy savings, and the tremendous employment implications of energy efficiency investments.

III. Current Forces Driving a Renewed Focus and Why Efficiency Is the First Fuel

The opportunity to invest in energy efficiency has never been more salient. There are currently at least six major forces driving the renewed focus on energy efficiency:

- Rising and more volatile energy prices
- Tight delivery capacity for conventional energy supplies
- Increased urgency in responding to the climate challenge
- Growing consumer and investor concerns about energy industry responsibility
- Accelerated pressure from global competition
- The rapid pace of technological advancements

A. Energy Prices

Since the turn of this century, energy prices have been both high and volatile, upending household and corporate budgets, and reducing disposable income and profits. Economists and analysts generally agree that this pattern is not a temporary aberration, and that the era of cheap energy is over (Energy Washington Week 2007). In this environment, energy efficiency investments have become a cost-management strategy for families and businesses (Herrera 2008).

B. The Supply Straitjacket

Underlying these rising energy prices is a set of deeply interrelated energy market problems. The production, processing, and transportation of energy are all experiencing unprecedented constraints that cut across all major energy markets. This "energy straightjacket" is based on market fundamentals that will not be easily resolved; with supply constrained in so many ways, efficiency has become a near-term strategy for balancing energy markets, moderating prices, and providing the badly needed "headroom" to keep energy supply systems reliable. (An expanded discussion is available in Elliott 2006.)

C. Climate Urgency

The Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC 2007) has effectively ended the scientific debate on global climate change. Pressure is mounting for the U.S. to take serious policy action to reduce greenhouse gas emissions. Within the IPCC report and elsewhere (e.g., Expert Group on Energy Efficiency 2007; McKinsey Global Institute 2007, 2008; Laitner et al. 2006; Nadel and Geller 2001), efficiency is generally acknowledged to be the lowest-cost and fastest-to-deploy resource to slow the growth of carbon dioxide emissions, with positive economic impacts. Thus, cost-effective energy efficiency is known as a "no-regrets" climate policy, because it makes economic sense regardless of its climate mitigation impacts.

D. Consumer and Shareholder Activism

Consumer, investor, and voter groups are increasingly voicing their concerns regarding the environmental and human impacts of corporate behavior in the energy industry (Wald 2006). Moreover, socially responsible investing, shareholder activism, and public campaigns are being organized to provide real economic incentives and consequences related to corporate action or inaction on efficiency-related environmental issues such as global warming (Wald 2006; Eisenberger 2006; Burnham 2007; Folk 2006; Tugend 2007). While these concerns have not yet produced a national climate policy, U.S. companies are taking their own actions to reduce their climate impact, and efficiency investments are at the top of most lists.[6]

E. Global Competition

With the increased globalization of business, multinational companies are encountering increasingly stringent climate policy regulations. These are driving increased efficiency investments among other environmental improvements to comply with regulations. At the same time, many companies are pursuing the business potential in the "clean tech" sector. In this context, efficiency is both an internal cost management strategy geared toward maintaining competitiveness, as well as an emerging business opportunity. Experts like Donald B. Rosenfield, a senior lecturer at the M.I.T. Sloan School of Management, point out that companies are increasingly proactive in improving environmental performance as a key to long-term business value (Wald 2006).

F. Better Mousetraps

There is a wealth of energy efficiency technology advancements that are nearing market readiness. From high-speed microprocessors and opportunities for "telework" to more energy-efficient buildings, transportation, and manufacturing technologies, the opportunities for increasing energy efficiency have never been better (Laitner and Ehrhardt-Martinez 2008). In the high tech world, microprocessor manufacturers are driving performance per watt to new frontiers. Intel's first (1996) supercomputer capable of a trillion calculations per second consumed 500,000 watts of power. In March 2007, Intel demonstrated a dime-size 80-core chip that used just 62 watts to break the teraflop barrier (Energy Resource 2007). In the buildings sector, smart meters and other new technologies are reducing the energy required to heat and cool buildings (Hatley et al. 2005), while hybrid motor technologies and variable valve timing are increasing vehicle fuel economy (EPA and DOE n.d.). In industry, manufacturing process controls are using advanced sensors, automatic control systems, software assessment tools, and wireless sensor networks to more effectively manage energy, production inputs, chemical processes, and waste reduction (Ondrey 2004). These improved technologies allow manufacturers to improve productivity, maximize quality, reduce waste, increase production flexibility, and increase innovation.

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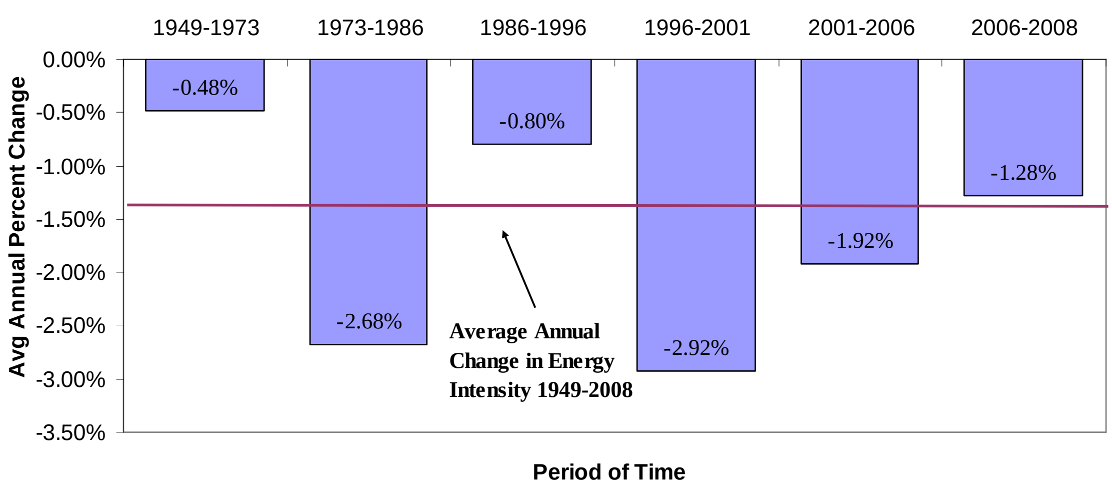
[6] General Electric and Wal-Mart are among the companies that are taking action to increase the energy efficiency of their products and operations. GE is emphasizing the benefits of its electricity generators, washing machines and clothes dryers, while Wal-Mart is trying to find ways to reduce packaging so it can fit more products in each truck load, thereby reducing the number of trucks it uses. Also see the World Wildlife Fund's Climate Savers initiative at: www.worldwildlife.org/climate/item3764.html and the ENERGY STAR Partnership program at: www.energystar.gov.

Taken together, these six drivers have created a new and fertile environment for energy efficiency investments.

IV. Energy Efficiency Investment and Employment Estimates

As with almost any economic endeavor, investments are the linchpin of productivity gains. The same holds true concerning energy productivity.[7] In fact, a brief review of historical investment patterns indicates that periods of elevated investments have been associated with significant growth in energy productivity. For example, during the period 1970-1996 economy-wide investments averaged 13% of GDP. Such investments included ongoing investments in buildings, industries, streets, and bridges as well as energy-related infrastructure improvements or expansions. Declines in energy intensity during the same period averaged 1.8%. During the following 10-year period (1996-2006), total investments climbed to approximately 16.2% — peaking at 17.1% in the year 2000. These higher levels of investments coincided with a significant rate of decline in the nation's energy intensity, which averaged 2.9 and 1.9% for the first five and the last five years of this 10-year period, respectively. Most recently, in 2007 and 2008, it appears that investments will decline sharply to 15.7 and 14.7%, respectively. This sharp decline in investment also appears to coincide with what will be a smaller 1.3% rate of decline in energy intensity for those same two years (Laitner 2008).

Figure 3. Average Annual Reductions in U.S. Energy Intensity, 1949-2008



Source: Laitner (2008)

[7] As we've suggested previously, energy productivity is the economically justifiable decline in the nation's overall energy intensity.

Although historical data indicate that investments in energy efficiency can dramatically change our energy consumption patterns, there is a paucity of data on the amount of money being invested in energy efficiency technologies and how those investments are distributed across different sectors of the economy. In this section, we attempt to estimate the size and scope of the energy efficiency market, including estimates of the current size and scope of investments, their impact on employment, and the energy savings achieved. This section of the report presents and describes our estimates of current investments and investment-related employment, while Sections V and VI estimate the future potential of efficiency, and suggest some initial steps that can be taken to bring us closer to a more energy-efficient future.

A. The Means of Estimation and Methodology

Although the nation's demand for energy services has continued to grow, the ways in which we have been successful in meeting those demand are less well understood. To what degree did we increase our investments in energy supply — coal? oil? natural gas? renewables? To what degree did we invest in more energy-efficient technologies? And, how do the investments in efficiency compare to those in energy supply? This report represents a first attempt at answering these and other questions regarding the size and scope of the energy efficiency market in the United States.

We chose 2004 as the baseline year for our estimates of investments, jobs, and energy savings. The choice to use 2004 as our baseline was determined largely as a function of data availability at the time at which the study was initiated. At the inception of the study, 2004 data were the most recent and complete data available for many of the data points needed for the analysis. Moreover, we want to examine a year that did not overstate or exaggerate the contribution for energy efficiency improvements. As suggested by the data in Table 2 below, the year 2004, in fact, had a smaller rate of improvement than either adjacent year and for the average year over the decade 1996 through 2006.

Table 2. Annual Change in Energy Intensity

Year	Change in Energy Intensity	Difference from Base Year
2005	-2.80%	68%
2004	***-1.66%***	***NA***
2003	-2.10%	26%
Decadal Average	-2.53%	52%

Source: Laitner 2008

In our base year (2004), energy intensity is estimated to have declined by 1.66%. Interestingly, this drop is notably less than the 2.1% decline experienced in 2003, the 2.8% decline in 2005, and the decadal average (through 2006) of 2.53%. Hence, the choice of a different base year could produce significantly different numerical results. However, since the primary focus of this study is on establishing an analytical framework and generating insights rather than projecting precise estimates, the specific changes are less critical than the pattern shown in the different tables of this report. To the degree to which our choice of 2004 as our base year affects our estimates, it is likely that they are more conservative than might otherwise be the case if a different base year had been chosen.

This study uses a variety of research methods (see Appendix A for a complete description) and builds on existing studies of energy efficiency to develop a set of estimates of the size, scope, and composition of the U.S. energy efficiency market (see Appendix B for a complete list and discussion). Data from a wide variety of government and private sources were used to build both a macro-level and meso-level assessment of the energy efficiency market. Finally, efficiency experts and recent studies were also consulted to further test the validity of our estimates. All financial values are reported in constant 2000 dollars unless otherwise indicated. A full discussion of our methodology is provided in Appendix A.

B. Conventional Energy Infrastructure

The continued reliance on conventional energy sources, such as oil, coal, natural gas, and electricity, requires ongoing investments in the conventional energy infrastructure that currently powers U.S. industry, buildings, and transportation systems. In order to keep these systems functioning, investments must continue to be made to build new power plants, drill new oil and gas wells, install new pipelines and transmission lines, and invest in a variety of other equipment. Providing energy resources is one means of meeting the nation's energy service demands. Data from the Bureau of Economic Analysis (2007) suggest that in 2004, U.S. companies spent about $100 billion on conventional energy infrastructure investments (see also Scott et al. 2006).

As emphasized by this report, however, providing increased energy efficiency is another means of meeting those same energy service demands. As such, consumers, policymakers, and business leaders are faced with the choice between expanding investments in the conventional energy supply infrastructure or investing in energy efficiency. Should we continue to focus on the status quo or choose to meet our energy service demand through increased investments in energy-efficient technologies? Making a smart decision requires that we thoughtfully assess which type of investment provides the most benefits, and ascertain the viability of efficiency investments across different sectors of our economy. Finally, we should also assess how each investment strategy is likely to impact employment. The following section provides a more detailed picture of the energy-efficient technology market, assesses the size of sector-specific investments, and estimates the energy savings achieved by current levels of investments.

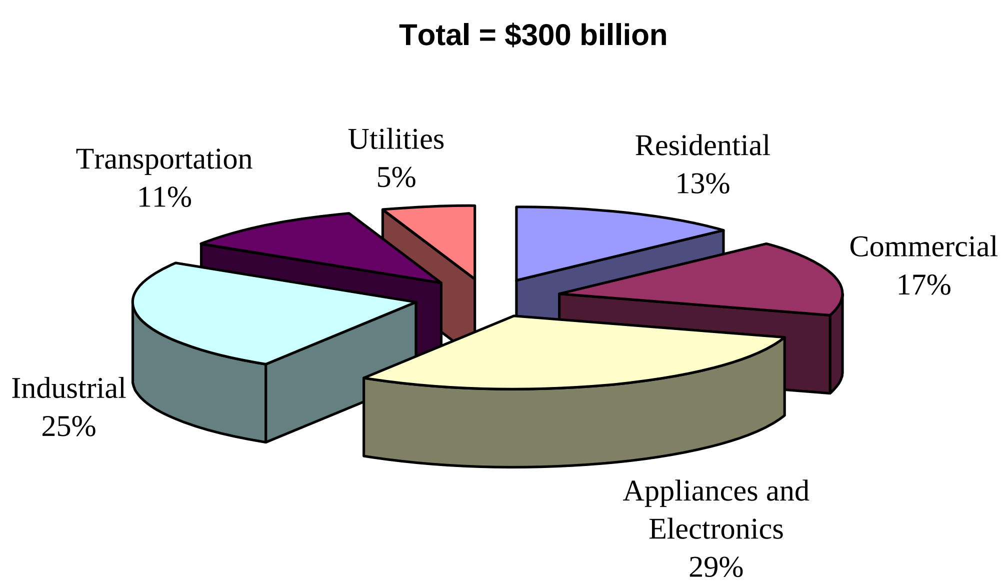
C. Energy-Efficient Technology Infrastructure

Investments in energy efficiency can be conceptualized in two ways: (1) as the total investment in goods and services that are made in order to reduce the amount of energy needed for the delivery of a particular energy service (whether or not the investment was made for the expressed intention of achieving energy efficiency); or (2) the difference in the investment costs associated with efficient versus inefficient goods and services (i.e., the efficiency premium). We refer to the first conceptualization as "total efficiency investments" and the second conceptualization as the "efficiency premium." In other words, a consumer or business that decides to invest in more energy-efficient equipment must pay for the total cost of the equipment, which we can conceptually break out into two parts: the cost of new, inefficient equipment (the base cost) plus the cost of the added efficiency (the efficiency premium). The base plus the premium equals the total investment in efficiency.

Total efficiency investments for 2004, across all sectors of the U.S. economy, are estimated to be on the order of $300 billion, or three times the size of investments in conventional energy infrastructure. Approximately 14.3% of total efficiency investments are associated with the efficiency premium, which was estimated at $43 billion worth of investments across all sectors in 2004. Notably, these investments are estimated to have generated 1.7 quads of energy savings during the same year.[8]

Efficiency investments were made across all sectors of the economy. As shown in Figure 4, approximately 30% of total efficiency investments were made in commercial and residential buildings. Commercial buildings received slightly more than half of the investments in buildings (57%) while residential buildings received the remainder (43%). The appliances and electronics sector received an estimated 29% of total efficiency investments while industrial investments received an estimated 25% of the total. Efficiency investments in transportation and utilities made up a smaller portion of total investments at 10.6 and 5.2%, respectively. Additional statistics are provided in Table 3.

Figure 4. Total Efficiency-Related Investments



[8] Since investments in energy efficiency require the replacement or retrofit of technologies, we include both the base and the premium in our calculation of the total efficiency investment. Given this choice, it appears that conventional energy resources may be cheaper than energy efficiency. However, a closer assessment reveals the 2.1 quads of new energy supply has an incremental cost of approximately $48 per million Btus, while the 1.7 quads of energy efficiency has an incremental cost of approximately $26 per million Btus (2.1 quads divided by the efficiency premium of $43 billion).

Table 3. Overview of Efficiency Investments

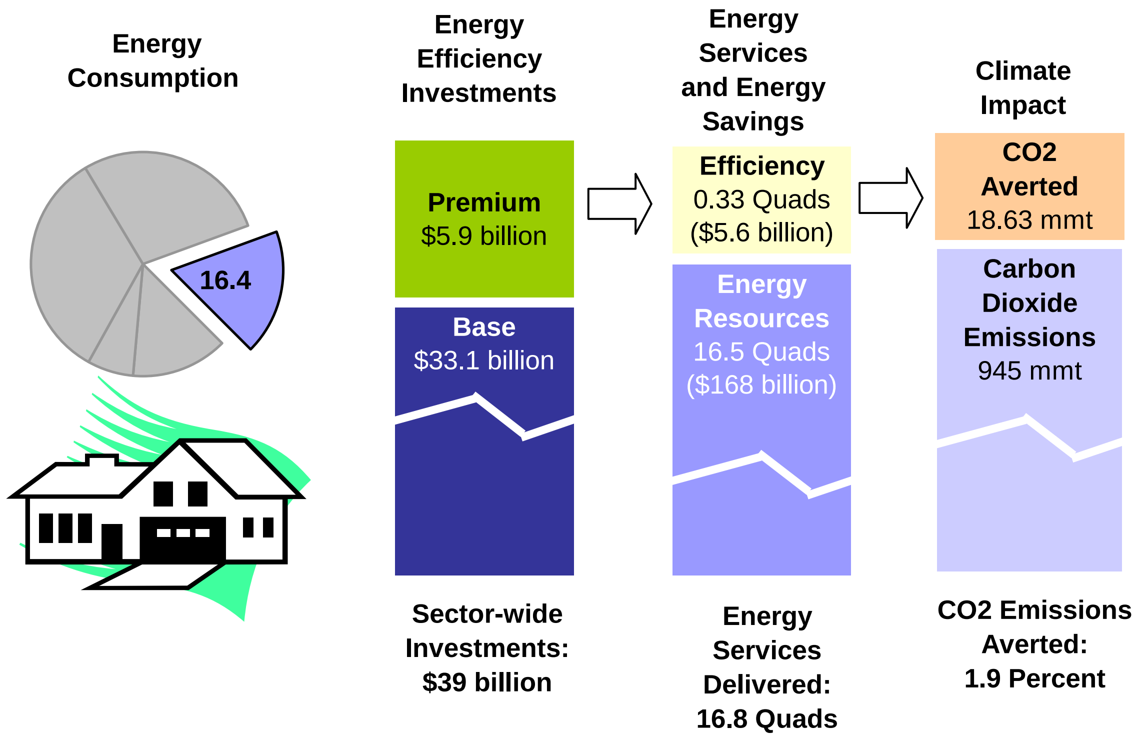
	Total Efficiency-Related Investments		Efficiency Premium Investments Only	
	Billions of 2004 $	Percent	Billions of 2004 $	Percent
Residential Buildings	39.0	12.9%	5.9	13.9%
Commercial Buildings	51.0	16.9%	7.7	18.1%
Appliances & Electronics	88.0	29.2%	10.6	24.9%
Total Buildings	178.0	59.0%	24.2	56.9%
Industry	75.0	24.9%	11.1	26.1%
Transportation	33.0	10.9%	4.8	11.3%
Utilities	15.7	5.2%	2.4	5.6%
TOTAL Investments	301.7	100.0%	42.5	100.0%

Residential and commercial. Total energy efficiency investments in residential and commercial buildings include all investments made in building new, energy-efficient structures and in renovating old structures in ways that make them more energy efficient. Renovations include the installation of insulation materials, energy-efficient windows and doors, and other materials that improve energy efficiency. Total combined investments in building efficiency (excluding appliances and electronics) are estimated at roughly $90 billion dollars for 2004 with roughly $13.6 billion in efficiency premium investments.

Residential. Total energy efficiency investments in the residential sector were much larger than might be suggested by the largely stagnant level of energy consumption in that sector. While residential energy consumption fell by a mere 0.61% (70 trillion Btu), roughly $39 billion in total energy efficiency investments and $5.9 billion in efficiency premium investments are estimated to have been made in that sector in 2004. Many of the efficiency gains associated with these investments are obscured by increases in the housing stock (from 112 to 113.7 million) and the growth in the average size of homes. While the energy use per square foot has generally been lower for newly constructed houses due to more efficient materials and construction practices, consumer preferences for larger houses have offset much of these efficiency gains. Overall household energy expenditures for the year were estimated at $191 billion dollars.

During 2004, 1.53 million new houses were built in the United States with a median value of $221,000 (DOE 2006a). And while the average square footage per house increased from 1,728 to 1,740 (EIA 2007), a growing proportion of new homes were built according to more stringent energy efficiency standards. By improving the energy efficiency per square foot of new homes, from 59.5 Btu in 2003 to 57.8 Btu in 2004 (EIA 2007), an estimated 325 trillion Btus were saved as were $5.6 billion in consumer energy costs and 18.6 million metric tons of carbon dioxide emissions (authors' calculations). Moreover, energy efficiency investments associated with improvements to existing houses were estimated to be on the order of $10 billion (DOE 2006a); also contributing to the trillions of Btus of energy saved in the residential sector. The overall value of total new home construction in 2004 is estimated at $425 billion, with the value of building improvements and repairs estimated at $199 billion (DOE 2006).

Figure 5: 2004 Residential Sector Statistics (Appliances and electronics measured separately)



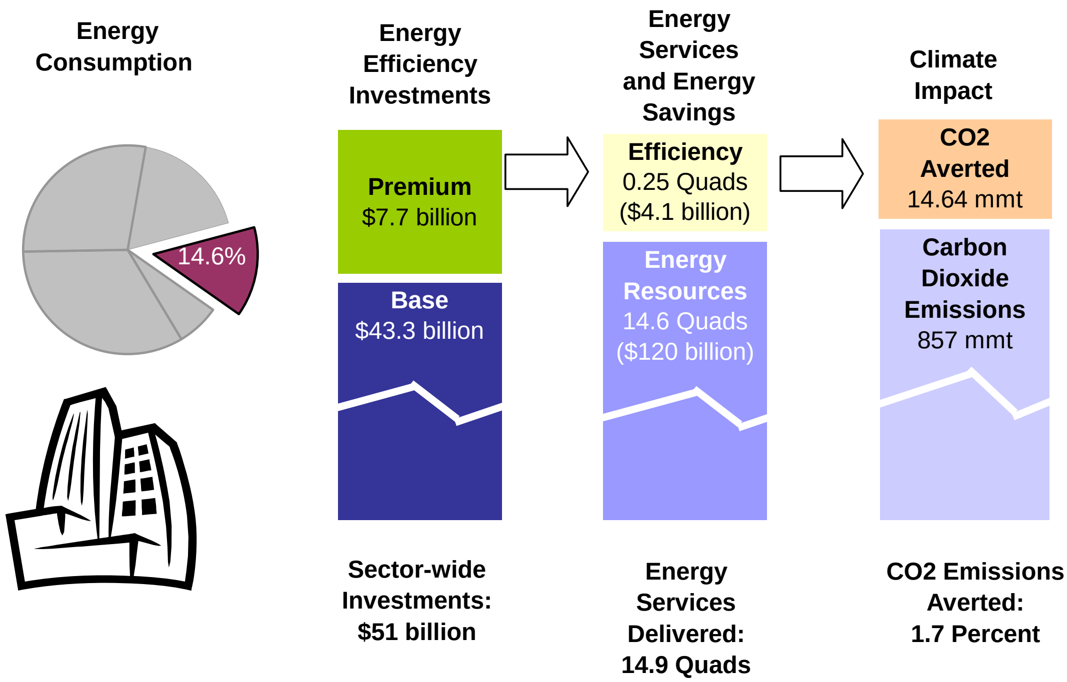
Heating and cooling are responsible for consuming the largest amount of energy in the residential sector. According to the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, today's average home wastes up to 30% of the energy used for heating and cooling as a result of gaps and cracks in the building envelope (DOE 2006b). A variety of existing technologies can reduce energy loss, making residential buildings more energy efficient. For example, energy-efficient roofs and walls can prevent air leakage that could otherwise be responsible for as much as 50% of heating loads. In addition, some new energy-efficient roof technologies use lighter colored roof materials in hot and humid climates to reduce the solar heat gain associated with standard asphalt shingles. These lighter tiles absorb less heat than the traditional darker tiles, reducing the cooling load in the summer and also increasing the durability of the roof (DOE 2006b). Interestingly enough, in this case, the cost differential for the cooler shingles is minimal.

Radiant barriers are also used in roofing to increase the energy efficiency of buildings. When placed between the roof and ceiling, radiant barriers help keep inside temperatures cool in the summer and warm in the winter. Finally, walls can be made more energy efficient by increasing the amount of space for insulation and building walls with tighter joints and seals. Instead of using standard 2-inch by 4-inch studs, efficient buildings are likely to use 2-inch by 6-inch studs and then fill these cavities with high quality insulation (DOE 2006b).

Windows are also a major source of heat gain in the summer and heat loss in the winter. Energy-efficient windows can reduce energy use by 20-30%. According to the DOE, the energy efficiency, or thermal performance, of a window is a function of six factors: the number of panes, the space between the panes, the type of material between the panes, the emissivity of the glass, the frame in which the glass is installed, and the type of spacers that are used to separate the panes of glass (DOE 2006c). The DOE estimates that replacement windows cost from $5 to $50 per square foot of window area. And using spectrally selective glass only adds about an extra dollar per square foot to the cost of a new home.

Commercial. In commercial buildings, $51 billion in total energy efficiency investments and $7.7 billion in energy efficiency premium investments are estimated to have been made in 2004, resulting in energy savings of more than 250 trillion Btu and $4.1 billion. As a result of these investments, energy use per square foot *declined* by approximately 1.4% between 2003 and 2004, averting 14.6 million metric tons of carbon dioxide emissions in 2004 alone.

Figures 6: 2004 Commercial Sector Statistics (Appliances and electronics measured separately

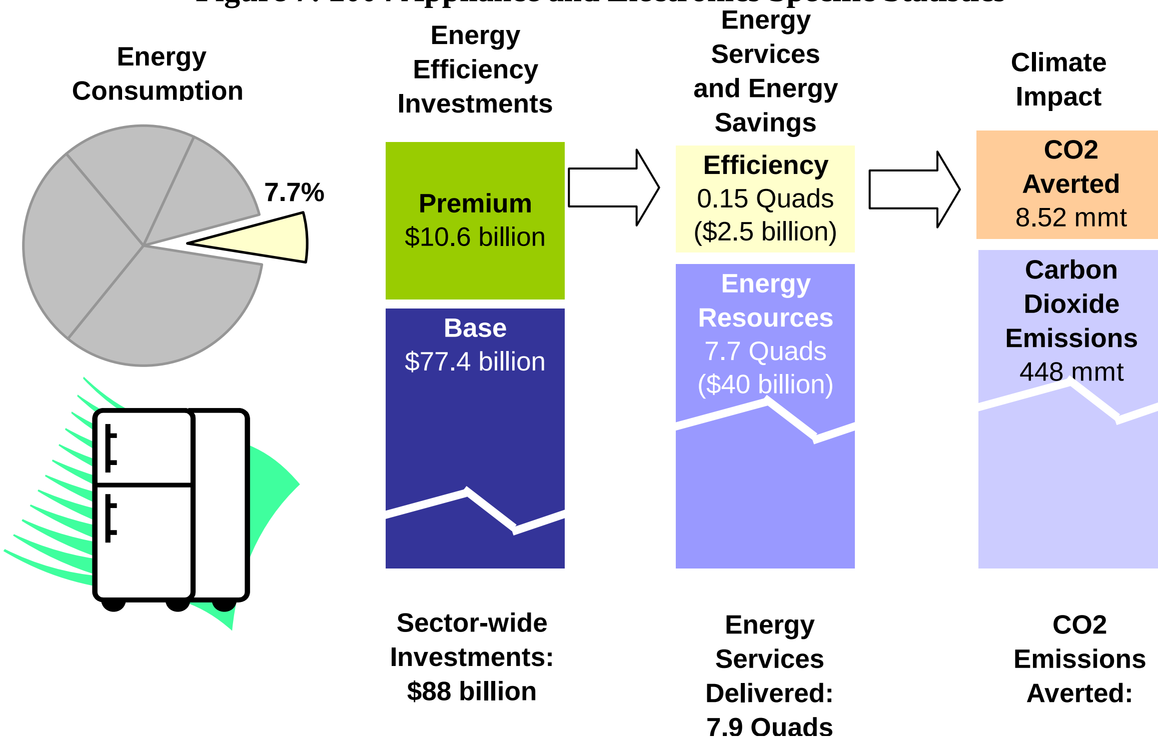


In the context of total U.S. energy demand, the commercial sector is responsible for approximately 17.5% of total U.S. energy consumption (DOE 2006a) or 14.6% excluding appliances and electronics. Despite investments in efficiency, total annual energy consumption in the commercial sector decreased only slightly between 2003 and 2004. As in the residential sector, efforts to reduce energy consumption in the commercial sector have been partially offset by the growth in total building floor space. While significant efficiency gains have been achieved through innovations in building materials and construction practices, commercial square footage increased by 1.3 billion square feet in 2004 alone (EIA 2007). Notably, however, in the absence of efficiency investments, commercial sector energy consumption would have also *increased* by an estimated 1.7% to approximately 17.9 quads in 2004.

The potential for future investments can be framed in terms of the overall value of new residential and commercial building construction and investments in building improvements and renovations. In 2004, investments in new commercial building construction reached $271 billion, while investments in commercial building improvements totaled $168 billion (DOE 2006a). Taken together, commercial building construction and improvements require investments of nearly $440 billion per year.[9]

Energy efficiency in appliances and electronics. In the United States, the federal government's ENERGY STAR program is the primary vehicle promoting energy-efficient residential and commercial appliances, electronics, office equipment, and other products. This successful program is funded and staffed by both the U.S. Environmental Protection Agency and the U.S. Department of Energy, and its rating system of appliances and electronics serves as the bases for assessment of efficiency investments in the appliances and electronics market. The ENERGY STAR program labels are available for clothes washers, dishwashers, refrigerators, freezers, room air conditioners and air cleaners, dehumidifiers, exhaust fans, and ceiling fans. Home electronics and office equipment are also evaluated by the program, including (but not limited to) televisions, DVD players, VCRs, cordless phones, printers, copiers, scanners, personal computers. and monitors. Taken together, more than 40 categories of ENERGY STAR products were evaluated for their energy efficiency in 2004 (LBNL 2006). Investments in these products comprised nearly 30% of total investments in the efficiency infrastructure in 2004, or the equivalent of $88 billion. Efficiency premium investments were estimated at $10.6 billion and resulted in energy savings of 147 trillion Btus with a value of $2.5 billion. These investments also averted approximately 8.5 million metric tons of carbon dioxide emissions.

Figure 7: 2004 Appliance and Electronics Specific Statistics



[9] These figures do not include investments in energy-efficient electronics and appliances, which is discussed below.

The ENERGY STAR designation for efficient appliances and electronics has created an important mechanism for making energy efficiency a distinctly marketable characteristic of an increasing number of appliances and electronics, thereby accelerating the development and dissemination of increasingly efficient equipment. According to the EPA, "[s]ince 2000, awareness of the government's ENERGY STAR label has grown from 40 percent to more than 60 percent nationwide" and in 2004, 30% of U.S. households reported that they knowingly purchased an ENERGY STAR-qualified product (EPA 2005:4). Moreover, the ENERGY STAR label has considerable influence in purchasing decisions. As stated in their annual report, "the ENERGY STAR label ranks among the highest level of influence on product purchases among all consumer emblems, similar in ranking to the Good Housekeeping Seal and Consumer Reports" and "a majority of consumers report that the label influenced their purchasing decisions" (EPA 2005:14).

While the ENERGY STAR program was introduced in 1992, over the course of the past sixteen years the program has continued to expand the number of product categories that are eligible for the ENERGY STAR label as well as strengthen the criterion used to evaluate the energy efficiency of ENERGY STAR products. ENERGY STAR market share can range dramatically depending on the product in question. Market share for office equipment tends to be much higher than market share for most residential appliances. Similarly, price differentials for the more efficient ENERGY STAR products also vary by product category.

In the residential sector, clothes washers and dishwashers are among the appliances that offer the most dramatic efficiency differentials. When compared to standard new products, ENERGY STAR certified clothes washers were estimated to save 38% of energy demand while dishwashers were estimated to save 25% of energy demand (EPA 2003). More recent estimates based on revised ENERGY STAR standards (effective in January 2007) indicate that new resource-efficient models can cut energy and water use by half or more (Thorne Amann, Wilson, and Ackerly 2007). Since most of the energy used in clothes washers and dishwashers (70 to 90% for clothes washers and even higher for dishwashers) is used to heat the wash and/or rinse water, new technologies have focused on reducing the amount of water used. For example, the new front-loading washing machines tumble clothes through a small amount of water rather than using an agitator in a full tub of water. Energy-efficient motors are also used to spin clothes faster, extracting more water, reducing dryer times and using less energy.

Significant variation in energy use can also be found in home electronics and office equipment. Energy use in more efficient electronic devices including televisions, VCRs, audio equipment, and DVD players can be as much as 70% lower than in standard equipment (EPA 2003). Similarly, energy use in computer equipment can vary by as much as 50%.

In 2004 alone, DOE estimates that ENERGY STAR appliances saved enough energy to power 24 million homes and save $10 billion in energy bills (DOE 2005). As shown in Table 4 below, large numbers of ENERGY STAR appliances and electronics were sold during 2004. While more than 50 million ENERGY STAR-qualifying PCs were shipped in 2004, the largest amount of energy savings and dollar savings came from new, more efficient monitors that saved an estimated 220 trillion Btu and $1.64 billion in energy costs in 2004 alone.

Table 4. Select ENERGY STAR Appliance and Electronics Statistics, 2004

	Annual Product Sales (1,000 units)	Percent ENERGY STAR	Energy Saved (trillion Btu)	Dollars Saved (million $)
Appliances				
Clothes Washers	8,830	27%	28.27	249
Dishwashers	6,950	78%	15.81	139
Refrigerators & Freezers	10,910	33%	12.78	104
Electronics				
TVs	19,150	83%	29.82	243
DVD Players	5,440	52%	9.19	75
Home Office				
Printers	19,790	99%	31.06	253
Monitors	14,740	95%	28.67	234
Scanners	4,730	75%	10.97	89
PCs	23,155	74%	10.61	87
Office Equipment				
Printers	16,125	99%	104.15	763
Monitors	20,020	95%	192.04	1,406
Scanners	2,172	75%	4.87	36
PCs	31,515	97%	16.13	118

Source: LBNL (2006)

Energy efficiency investments in industry. The industrial sector represents a little more than a third (33.8%) of total U.S. energy consumption in 2004, using 33.6 quads of energy. Total energy efficiency investments in the industrial sector include all investments made in manufacturing and non-manufacturing establishments.[10] Manufacturing firms of all sizes chose to invest in energy efficiency in 2004 in order to minimize energy costs and material waste while increasing productivity. Total combined investments in industrial efficiency are estimated at roughly $75 billion dollars with roughly $11 billion in efficiency premium investments. These investments saved an estimated 657 trillion Btus of energy and $5.7 billion in energy costs in 2004. Moreover, approximately 33.9 million metric tons of carbon dioxide emissions were averted during 2004 alone.

[10] Non-manufacturing industries include agriculture, construction, and mining.

Figure 8: 2004 Industrial Sector Statistics

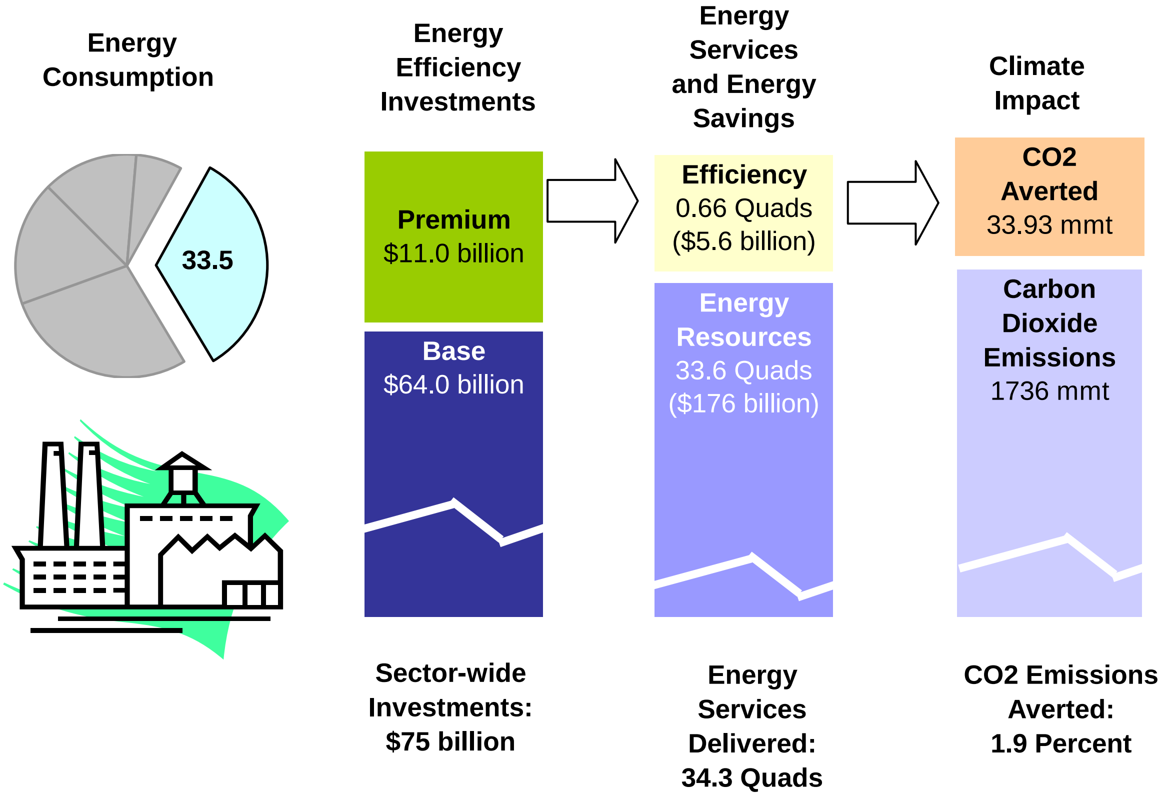


Table 5. Energy Consumption, Efficiency Investments, and Energy Savings in Industry

	Energy Consumption (trillion Btu)	Total Investment ($billion)	Percent of Total Investment	Efficiency Premium Investment ($billion)	Energy Savings ($billion)
Industrial	33,610	75.64	25.0%	11.35	5.70
Non-Manufacturing	10,944	15.35	20.3%	2.30	1.15
Manufacturing	22,666	60.29	79.7%	9.04	4.52
Refining		32.56	54.0%	4.88	2.44
Non-Refining Primary Material Mfg.		15.68	26.0%	2.35	1.18
Non-Refining Non-Primary Materials		12.06	20.0%	1.81	0.90

Source: Authors' analysis as described in Appendix A.

Nearly 80% of the energy efficiency gains and efficiency investments in industry were made in the manufacturing sector. Total 2004 investments in energy efficiency technologies in manufacturing are estimated at $60 billion, while an estimated $9 billion are associated with efficiency premium investments. Manufacturing sector investments in energy efficiency technologies and services resulted in an estimated savings of more than 520 trillion Btus of energy in 2004 alone, representing a savings of $4.5 billion per year.

Data on industrial output per unit of energy in 2004 suggest that energy efficiency in manufacturing increased by 2.6% over the preceding year while efficiency in non-manufacturing increased by 2.3% in 2004. Overall, volatile energy prices and problematic energy supplies have heightened industrial interest in energy efficiency as a resource. Industrial managers are also increasingly concerned about what is coming to be seen as impending U.S. legislation regarding global climate change as well as learning to manage carbon dioxide restrictions in overseas operations (Elliott, McKinney, and Shipley 2008). As a result, an increasing number of firms are actively seeking to reduce the energy intensity of their production practices. In fact, data from the most recently published *Manufacturing Energy Consumption Survey* (EIA 2005) indicate that of the more than 200,000 firms represented by the survey, 40% had reported participating in at least one efficiency activity while 18% had reported having an energy audit performed (EIA 2005.). These numbers represent significant increases over earlier participation rates. In 1998, only 33.3% of manufacturers reported participating in at least one efficiency project, and 10.7% reported having participated in an energy audit. When asked to report on which investments were made with the primary purpose of improving energy efficiency, the largest percentage of firms reported having invested in compressed air systems, direct machine drives, HVAC systems, and facility lighting.

A large percent of total investments in manufacturing occurred in a relatively small subset of those industries with the highest levels of energy intensity, including the chemical industry, the iron and steel industry, and the forest products industry. These industries have been the focus of the DOE's Industries of the Future Program. The goal of the program is to identify and research common problems within these industries with the goal of increasing investments in energy-saving solutions that can be applied across companies. Nearly $100 million was spent on program activities in 2004. According to the Department of Energy, the industrial technologies program

> *… maintains a balanced portfolio of over 500 R&D projects to address the priority needs of energy-intensive industries. Each project meets rigorous criteria for industry participation and cost sharing, relevance to industry defined priorities—set out in the industry roadmaps, energy and environmental benefits, scientific foundation, and technical innovation. Recent tracking results indicate that ITP's projects have cumulatively saved over 1.6 quadrillion (10^{15}) Btu — worth about $6.5 billion.* (DOE 2006d)

Another government-funded program, Industrial Assessment Centers, is oriented to helping small- and medium-sized manufacturing firms achieve greater energy efficiency. According to data from the Industrial Assessment Center, its 26 assessment centers were responsible for nearly 2,600 implemented recommendations in 2004. The average level of investment in efficiency-related projects through the program was approximately $10,500 in 2004. The DOE describes the program as providing: "… energy, waste, and productivity assessments at no charge to small and mid-sized manufacturers. The assessments are performed by teams of engineering faculty and students from more than 26 participating universities across the country. The university IAC team conducts a site visit and performs an assessment to identify energy and cost savings opportunities." (DOE 2006b)

These government-sponsored programs provide important services in expanding interest in, and implementation of, energy efficiency activities throughout the manufacturing sector.

Nevertheless, IAC assessments provide only limited insight as to overall levels of investment in energy efficiency throughout the manufacturing sector, as many of the assessments carried out each year occur by means of private sector firms.

Moreover, total non-manufacturing industrial investments in energy efficiency were estimated to comprise approximately 20% of total industrial investments, or roughly $15 billion. Efficiency premium investments totaled $2.3 billion and generated an estimated 133 trillion Btus of energy savings valued at $1.15 billion in 2004.

Energy efficiency in transportation. A total of more than $33 billion of efficiency-related investments were made in energy-efficient transportation technologies in 2004, resulting in energy savings of approximately 80 trillion Btus and $1 billion. While cars and trucks and other forms of transportation are responsible for a large proportion of our nation's carbon dioxide emissions, investments in transportation-related efficiency technologies were successful in averting the emission of roughly 5.6 million metric tons of carbon dioxide. The transportation sector represents a large and growing proportion of total U.S. energy consumption (roughly 28% in 2004). Despite investments in efficiency, total energy consumption in transportation has continued to increase over the past 10 years at an average annual rate of nearly 2% (EIA 2007).

Figure 9: 2004 Transportation Sector Statistics

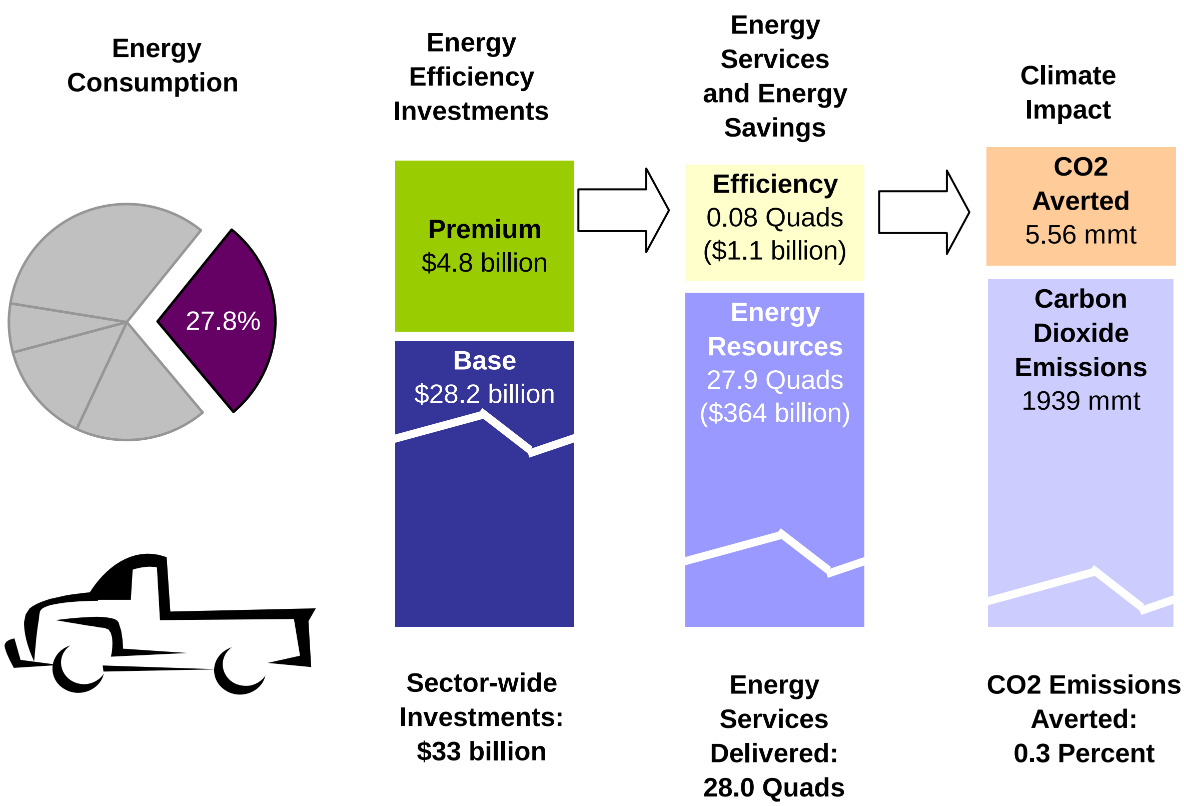


Table 6. Energy Consumption, Efficiency Investments, and Energy Savings in Transportation

	Consumption	Investments		Energy Savings	
	Energy Consumption (Trillion Btu)	Total Investment in Efficiency (Billion$)	Efficiency Premium (Billion$)	Trillion Btu	Million $
Cars & Light Trucks	17,379	23.00	3.50	18.3	320
Med. & Heavy Trucks	5,501	3.97	0.44	13.4	198
Air	2,370	6.44	0.72	51.0	308
Other*	2,962	n.a.	n.a.	n.a.	n.a.
Total	28,212	33.41	4.8	82.7	826

* Estimates of investments and energy savings do not include buses, rail or ship transport.
Source: Authors' estimates as described in Appendix A

Growing energy consumption in transportation is the result of a number of factors that have served to offset the gains in efficiency. Among the offsetting factors are the growing number of miles driven each year (EPA 2006; EIA 2005), the growing use of air travel (EIA 2007), and a shift toward heavier cars in the automotive fleet (EIA 2005), which reduce overall fuel economy. Despite these trends, many significant improvements in energy efficiency have been made in various modes of transportation through investments in the production and use of products that utilize energy efficiency technologies and materials.

Within transportation, light vehicles consume the most energy and have also experienced large investments in energy efficiency technologies. In 2004, light vehicles consumed approximately 62% of all transportation-related energy. During the same period, gross investments in energy efficiency technologies were estimated at $23 billion, saving consumers approximately $314 million in 2004 alone. Efficiency premium investments were estimated to be on the order of $3.5 billion. Energy-efficient engine technologies include direct fuel injection, integrated starter/generator systems, turbochargers and superchargers, cylinder deactivation systems, and variable valve timing. According to the EPA, each of these technologies can increase energy efficiency by 5 to 13% (n.d.). Several transmission technologies can also increase fuel economy. Continuously Variable Transmission technologies and automated manual transmissions can improve energy efficiency by 6 to 7% each.

In the airline industry, a total of $6.5 billion of efficiency-related investments were made in 2004, improving the fleet-wide number of seat miles per gallon by 0.36%. These improvements saved an estimated 60 million gallons of fuel and $308 million in fuel costs in 2004 alone. These savings are significant given that air travel was responsible for only 8.4% of transportation related energy use. Significant enhancements in fuel efficiency are still possible in the airline industry through a combination of technological improvements in engine and airframe technologies, enhancements in air traffic management systems (12%), and operational measures (6%) (EPA and DOE n.d.).

Medium and heavy trucks consumed nearly 20% of transportation-related energy in 2004 or the equivalent of more than 42 billion gallons of fuel equivalent. Total efficiency-related investments in this area were estimated at nearly $4 billion, resulting in efficiency savings of 103 million gallons of fuel and $199 million in fuel costs in 2004 alone.

Buses, rail, watercraft and other forms of transportation accounted for the remaining 9.5% of transportation-related energy consumption. Efficiency investments in these areas were not estimated due to the lack of sufficient data.

Energy efficiency in utilities. The estimation of utility energy savings is a straightforward calculation of a change in heat rates from the period 2003 to 2004 as they might impact total electricity demand in 2004. Based on EIA (2007), the heat rate improved from 9,830 Btus per kWh to 9,780 Btus per kWh. When the resulting savings of 48 Btus per kWh is applied to the net generation of 3,955 billion kWh produced in 2004, that implies a savings of 0.19 quads of primary energy. Assuming the average fossil fuel rate of $2.46 per million Btu, total energy bill savings for electric utilities is an estimated $470 million in 2004. While other savings may have resulted from combined heat and power (CHP) and other "waste to energy" investments, they were not included in this estimate.

D. Estimated Employment Impacts

Current and future investments in energy efficiency technologies hold significant, positive implications for job growth and job security in the United States. As shown in Table 7, total U.S. employment reached 139.3 million in 2004 with approximately one-fifth of the labor force employed in education and health services and 0.8% of the labor force employed in the utility sector. Comparatively, our estimates indicate that efficiency-related employment totaled 1.63 million jobs in 2004 or approximately 1.2% of total employment.

Table 7. 2004 Employment by Industry

	Employment by Industry (in thousands)	Employment as a Percent
Total	**139,252**	**100.0%**
Education and Healthcare	28,719	20.6%
Trade (retail and wholesale)	20,869	15.0%
Manufacturing	16,484	11.8%
Other Services	6,903	5.0%
Government Workers	6,365	4.6%
Transportation	5,844	4.2%
Efficiency	1,630	**1.2%**
Utilities	1,168	0.8%

Source: Non-efficiency employment related statistics from the Bureau of Labor Statistics (2007)

When compared with employment in the energy supply sector, the data (summarized in Table 8 below) indicate that efficiency-related jobs employed more than twice as many people per dollar of output. Overall, efficiency-related investments generated an estimated 5.4 jobs per million dollars of sales compared to roughly 1.9 jobs per million dollars of sales in the energy supply sector. Moreover, efficiency-related jobs tend to be associated with high-tech manufacturing and high-skilled service professions that are expected to endure and expand as we continue to move toward an information-based economy and as we reduce our reliance on the fossil fuel industry. In other words, investments in energy efficiency technologies have and are expected to continue to create job growth precisely in those fields that hold the key for moving our society forward both technologically and economically. As a result the United States will be more globally competitive and less reliant on foreign and unsustainable sources of energy.

While total investments in energy efficiency technologies employed an estimated 1.6 million people, jobs associated with efficiency premium investments were estimated at roughly 234 thousand.

Table 8. Estimated Employment Impacts of Efficiency-Related Investments

	Residential	Commercial	Appliances and Electronics	Industrial	Transportation	Utilities	Total
Total Efficiency Investment Related Employment	316,000	301,500	372,200	351,300	151,000	138,600	1,630,600
Efficiency Premium Related Employment	47,400	45,200	44,700	52,700	22,700	20,800	233,500
Jobs per Million Dollars of Output	8.1	5.9	4.2	4.6	4.7	8.8	5.4

Source: Authors' estimates based on employment data from IMPLAN

Efficiency-related employment: residential, commercial, industrial, appliances and electronics. In 2004, roughly 80% of all efficiency-related jobs were somewhat evenly divided across four investment areas: residential buildings, commercial buildings, industrial production, and appliances and electronics. Roughly one-fifth of all jobs (or approximately 316,000 jobs associated with total efficiency investments) were associated with residential building construction, renovation, and repair. These types of jobs include the manufacture of windows, doors, lighting, and insulation, as well as the work of architects in energy-efficient design and home renovation contractors. Nearly 50,000 of efficiency-related residential sector jobs were generated from efficiency premium investments in the residential sector.

Total efficiency-related jobs in the commercial sector were slightly lower than those found in the residential sector. Approximately 300,000 jobs (18.5% of all efficiency-related jobs) were generated by total efficiency-related investments in the construction, renovation, repair and operation of commercial buildings. Approximately 45,000 of those jobs were generated from efficiency premium investments in the commercial sector.

Total investments in energy efficiency technologies in the industrial sector were responsible for approximately 350,000 jobs. Industrial energy efficiency supports a variety of jobs including those associated with the manufacture, installation and retrofit of steam production systems, compressed air systems, direct and indirect process heating, cooling and refrigeration, direct machine drives, facility HVAC, facility lighting, and industrial process design. Efficiency premium investments in the industrial sector supported roughly 53,000 jobs.

Finally, energy-efficient appliances, electronics and office equipment were responsible for nearly 23% of jobs associated with the efficiency sector in 2004. Overall, more than 370,000 jobs were associated with the design, manufacture, sales and installation of ENERGY STAR appliances and electronics, including refrigerators, cooktops and stoves, clothes washers, dishwashers, televisions, VCRs, audio equipment, computers, monitors, copiers and fax machines. Approximately 44,500 jobs were estimated to be supported by efficiency premium investments in appliances, electronics and office equipment.

Efficiency-related employment: transportation and utilities. The remaining 290,000 efficiency-related jobs are divided between two investment areas: transportation and utilities. In the transportation sector, cars, planes, trains, buses, and ships are becoming increasingly energy efficient as a result of investments in efficient designs and equipment. In the automobile market, for example, a variety of innovative engine and transmission technologies have resulted in significant efficiency gains as described in the section on transportation investments (above). Similarly, the airline industry has set specific efficiency targets, and has succeeded in improving their fuel efficiency by nearly 5% in the past 2 years and by 20% in the past 10 years (EPA n.d.). As a result of these initiatives, total efficiency-related employment in the transportation sector reached an estimated 151,000 jobs in 2004. Jobs associated with the transportation efficiency premium were estimated at roughly 23,000 during the same year.

Apart from the investment areas outlined above, utilities offer unique opportunities for investing in energy efficiency. Investments in energy efficiency in the power industry involve maximizing the amount of energy that can be generated, transmitted and used from the fuels that supply the power plants. According to our estimates for 2004, total efficiency-related investments in the utility industry supported approximately 140,000 jobs while efficiency premium investments supported nearly 21,000 jobs.

E. Dueling Banjos and Comparative Estimates of Efficiency

As discussed earlier, measures of energy efficiency are elusive for a variety of reasons. For example, efficiency involves trying to measure the resources that we avoid using, few readily available data exist, and the sources of efficiency are disbursed and difficult to define. As a result of these difficulties, our estimates of the size and scope of the energy efficiency market rely on the application of multiple research methods in an effort to triangulate our estimates in an approach described in more detail in Appendix A. While we feel confident that our methods provide well-grounded estimates of efficiency-related investments and jobs, we conclude this section with a comparison of our estimates with those provided by other studies as a final effort to situate our research in the larger body of work on this topic.

Table 9 summarizes the findings of related studies for easy comparison with our own findings as presented in this report. For the most part, the studies that we include in this table reported only estimates of what we call the investment premium. Their results were primarily driven by assumptions of future policy impacts. Moreover, they were all done with varying base years for their analytical framework. To normalize their findings with our own, we've taken their results and converted them to the same year constant dollars, and we've assumed the investment premium represents about 15% of the total cost. A more detailed comparison can be found in Appendix B.

Table 9. Comparison of Energy Efficiency Investment Estimates

Study	Scope	Efficiency Measurement	Value (billion 2004)	Jobs (thousands)
Ehrhardt-Martinez and Laitner (2008 — this study)	U.S. Energy Efficiency Market	2004 Total EE Investments	300	1,600 (in 2004)
Bezdek (2007)	U.S. RE & EE Industries	2006 EE Sales and Revenues	879	3,498 (in 2006)
Laitner (1995)	U.S. Energy Efficiency Market	Average Annual Total EE Investments 1970-1990	243	NA
McKinsey (2007)	World Energy Policy Scenario	Estimated Full Technology Investments	3,100	NA
Faruqui (2002)	U.S. Electricity DSM Low Policy Scenario	Estimated 2030 Full Technology Investments	170	NA
Faruqui (2002)	U.S. Electricity DSM High Policy Scenario	Estimated 2030 Full Technology Investments	423	NA
UCS (2001)	U.S. Energy Policy Scenario	Estimated Full Technology Investments	234	NA
Nadel and Geller (2001)	U.S. Energy Policy Scenario	Estimated Full Technology Investments	194	NA
IWG (2000) — Moderate Policy Scenario	U.S. Energy Policy Scenario	Estimated Full Technology Investments in 2020	232	NA
IWG (2000) — Advanced Policy Scenario	U.S. Energy Policy Scenario	Estimated Full Technology Investments in 2020	517	NA
Energy Innovations (1997)	U.S. Energy Policy Scenario	Estimated Average Annual Technology Investments 1998-2010	223	773 (in 2010)

As we might expect, there is a good deal of variability among the studies. This is true with respect to policies and results and in terms of methodologies used to generate the estimates shown in the table. At the same time, they all report a comparable magnitude of energy efficiency investments. This suggests, in turn, that our own analysis provides a useful foundation for understanding and estimating the energy efficiency investment potential.

V. From Possible to Probable: Future Market Potential, Financing Innovations, and Policy Options

American economist Kenneth Boulding who gave rise to the image of "Spaceship Earth" also once commented that "Images of the future are critical to choice oriented behavior." In effect, Boulding was suggesting that unless we are able to visualize future opportunities, we are less likely to realize their full potential. In that same spirit, therefore, we believe it is important to visualize the larger potential of energy efficiency to enable the development of policies and technologies which might enhance our overall energy productivity. While our preliminary assessment indicates that the efficiency market is already large, the more important question is how large can the market ultimately be, and how rapidly it can be developed?

The recent United Nations Foundation study called energy efficiency both the largest and least expensive energy resource, suggesting that the G-8 and other nations could double historical rates of efficiency improvement by 2030 (Expert Panel on Energy Efficiency 2007). If the United States were to follow that course—and other ACEEE studies suggest this is a cost-effective policy path—U.S. energy consumption in 2030 could be reduced to the level consumed in 1996-1997.[11] While any definitive estimate is likely to suffer from a wide range of uncertainties at this time, we scaled a study and modeling analysis by Laitner et al. (2006) to fit within our current research findings and project the impacts of accelerated market transformation through rapidly augmented investments in energy-efficient technologies.

As opposed to current estimates that reflect a rather modest rate of return on average efficiency investments (equivalent to an average three-year payback in simple terms), using the 2006 modeling analysis we can posit a future in which businesses and consumers invest based on an average five-year payback. Assuming that policies, market forces, and new financing mechanisms facilitate substantial movement "up the cost curve" to longer-payback investments, annual investment in energy-efficient technology would increase by $400 billion per year by 2030, reaching a total annual investment of in excess of $700 billion.[12] Cumulatively, the total investment in the "new energy efficiency technology infrastructure" would reach nearly $7 trillion over the period of 2008 through 2030.

> "Energy efficiency is a sleeping giant," said Robert Wilder, CEO of WilderShares, which manages two clean energy indices. "It doesn't have the sexy allure of solar power or huge wind. But we have Saudi Arabia-sized oil reserves under our feet in America through energy efficiency." (Source: DeMonte 2006)

[11] In December 2007 the Energy Information Administration's forecast, the *Annual Energy Review 2008*, indicated that energy consumption would increase to about 124 quads by 2030. With the passage of the Energy Bill by Congress earlier this year, EIA subsequently revised its forecast to 118 quads by 2030. Building on that trend, an additional 20 percent savings by 2030 would imply a total energy use in a high-efficiency scenario would be on the order of 94.4 quads. EIA data suggests that actual energy use was 94.2 quads in 1996.

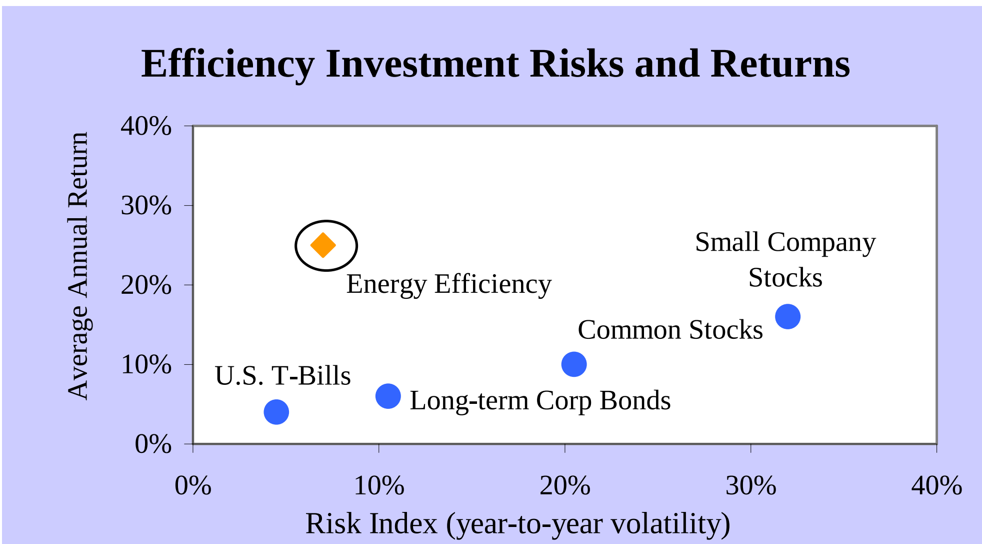
[12] Note this estimate is generally consistent with the range of estimates suggested by the analysis highlighted in Table 9 above.

At this point, we've established that a range of studies by ACEEE and others clearly shows that the energy efficiency resource is a grossly underutilized resource. The challenge for policymakers, business leaders, and the nation at large is to embrace energy policies and fashion new financing mechanisms to begin harvesting the massive efficiency opportunities outlined in this report.

As such, it is important to recognize that investments in energy efficiency can be generally characterized as high return and low risk. By adapting an assessment of efficiency investments by the Vanguard Group, Figure 10 illustrates that returns on efficiency investments are comparable to small company stocks (between 20 and 30%), while the risks are estimated to be roughly equivalent to U.S. T-bills (between 5 and 8%).

Given this favorable risk/return ratio and the growing interest in reducing energy consumption, why is there such a dearth of market-based investments in efficiency? As efficiency skeptics often say, "If this stuff is so cost-effective, the market will do it anyway." Unfortunately, specific market, regulatory, and financial barriers still prevent efforts to maximize the potential benefits that efficiency can offer.

Figure 10. Comparing Efficiency Metrics with Other Investments



Source: Adapted by ACEEE from the EPA and the Vanguard Group (see Laitner 2008)

A. Market, Regulatory, and Financial Barriers

Efficiency investments have been hobbled by both market barriers and policy barriers, and also suffer from a certain asymmetry in U.S. capital markets. ACEEE documented the effects of market barriers in a recent report for the International Energy Agency (Prindle et al. 2007), in which just one type of market barrier affected half or more of the energy use in the most common residential and commercial end-use markets. This barrier is commonly known as the "principal-agent" barrier, typified by the homebuilder-homebuyer situation, where the homebuilder's incentive is to minimize first cost, and the homebuyer's incentive is to minimize total costs of ownership. The builder, as "agent" for the buyer "principal," usually fails to invest in optimal levels of efficiency; this same barrier appears in rental housing and leased commercial buildings markets, where landlords have little incentive to improve efficiency for the benefit of tenants.

Regulatory barriers are also manifold, as discussed earlier in the utilities section. Beyond ratemaking policies, utility practices affecting interconnection and backup tariffs for CHP investments continue to limit the viability of such projects (Brooks, Elswick, and Elliott 2006). But beyond these barriers, U.S. capital markets have been asymmetrically oriented towards large energy supply projects. Because of the basic transaction-cost barrier described above, investment capital tends to flow to larger projects that can support significant transaction costs.

B. Solutions in Utility Markets

Electric and gas utilities, which serve almost the entire building and industrial stock, are the natural aggregators for efficiency. Aggregation approaches, using utility-based investment incentives, have been the most widely used efficiency policy tool in the U.S. over the past three decades. States and utilities are currently spending some $2.6 billion annually on efficiency programs, with the total investment estimated at more than $7 billion (CEE 2007). The New England Independent System Operator's Locational Installed Capacity market has just created a new channel for efficiency and other demand-side investments (Laitner, Ehrhardt-Martinez, and Prindle 2007), which may spread to other regions. In addition, some 16 states have developed Energy Efficiency Resource Standards that may drive efficiency initiatives to new heights. Through the National Action Plan for Energy Efficiency[13] and other initiatives, this total is expected to grow (ACEEE 2008).

> "By creating a policy that places energy efficiency on economic parity with other forms of power supply, utilities will be able to meet customers' needs through saving watts, as well as making watts, without negative financial consequences." *Jim Rogers, Duke Energy* (Source: Electric Utility Week 2007)

C. Solutions in Real Estate Finance

Beginning with a presidential executive order, secondary mortgage market institutions have developed Energy Efficient Mortgage mechanisms that ease underwriting guidelines and encourage efficiency measures to be financed in mortgages (Finkelstein 2008). Policies that make these options attractive at the retail level, such as loan guarantees that would reduce interest rates by 50 basis points or more, could drive much higher participation. Institutional real estate investors, such as pension funds, could become effective investors in their commercial real estate portfolios. Current federal tax incentives and other mechanisms could help drive increased efficiency investment in this key sector.

[13] Available at http://www.epa.gov/cleanenergy/energy-programs/napee/index.html.

D. Solutions in Public Finance

Public agencies at the state level have experimented with bond financing, revolving loans, master municipal leases, and other mechanisms to create new capital sources for public-sector efficiency investments. Many have written enabling legislation and other rules to encourage energy service companies to invest in public and institutional energy efficiency markets. These mechanisms, with greater policy support, could be used much more widely (Prindle et al. 2003).

E. Solutions in Venture Capital

Efficiency, because it applies to so many diverse end-use markets, offers a virtually limitless set of possibilities for startup and expansion of growth companies making the next generation of efficiency technologies. ACEEE's emerging technologies reports show dozens of attractive possibilities: solid-state and other advanced lighting technologies have attracted substantial venture capital, while low-energy materials manufacturing processes, high-performance air conditioning technology, advanced energy storage technologies, advanced controls, communication, and sensing technologies are other examples of emerging technologies waiting to be taken profitably to market.

F. Solutions in Equities Markets

Some socially responsible investment mechanisms and a limited number of "green funds" have grouped energy efficiency together with a broader collection of environmentally preferable investment options (Inside Green Business 2006). However, because efficiency is typically one attribute of a product, or one product within a larger line offered by a company, it is difficult to separate out "energy efficiency companies." Insulation manufacturers, energy service companies, and a few other types of enterprises exist solely to save energy, but efficiency is rarely the main business focus of companies that produce efficiency technologies. This phenomenon complicates efforts to create a dedicated "energy efficiency" stock fund.

Interestingly, the New York Mercantile Exchange and Ardour Global Indexes recently joined forces to introduce alternative energy indexes that incorporate companies involved in five primary alternative energy sectors, including energy efficiency, enabling technologies, environmental controls, distributed generation, and alternative energy resources (Energy Resource 2007). Additional collaboration with equity fund and venture capital markets may be especially helpful in designing new market instruments that might encourage the full utilization of the energy efficiency resource.

The most hopeful observation we make from our research is that because efficiency has been invisible to many investors, it may well be the sleeping giant of the clean technology spectrum. If we can craft the new financing approaches and policies needed to tap efficiency opportunities at a faster pace, we can create vibrant new markets as we make measurable progress on our energy and environmental challenges. We can also make efficiency one of the most effective resources in managing energy-related risks, as its diverse and dispersed nature cut across all areas of the economy. The core question that remains to be answered is: How do we further develop energy efficiency related investment mechanisms to capitalize on the full investment potential of the energy efficiency market?

VI. Conclusions and Recommendations

The energy-related challenges of the 21st century require a dramatic shift in direction — from an emphasis on energy supply to an emphasis on energy efficiency. Although current levels of investment in energy efficiency are arguably inadequate and sub-optimal, energy efficiency is already hard at work in our economy. We argue that energy efficiency is best characterized as an *invisible* and under-appreciated powerhouse, working behind the scenes to meet our nation's growing demand for goods and services. Unfortunately, efficiency resources and investments are currently hard to observe, to count, and to define because they represent the energy that we *don't use* to meet our energy service demands. Moreover, energy efficiency gains are often distributed across the many productive technologies and market behaviors that are part of the normal course of doing business. Our very inability to observe, measure, and quantify efficiency acts as an impediment to smart policy, planning, and investment.

This report attempts to provide a partial remedy to these impediments by (1) assessing the historical contributions of efficiency and our (in)ability to foresee those contributions, (2) identifying the forces that are currently shaping the renewed focus on energy and efficiency, and (3) offering "a more visibly concrete" and quantitative picture of the size and impact of current energy efficiency investments. In addition to the insights offered by this report, a more complete remedy must include three essential ingredients: a concerted data collection effort, smart investments and investment mechanisms, and a smart policy framework.

A. Data Opportunities

Unfortunately, the maxim that "we treasure what we measure" holds just as true for energy efficiency. While we tend to be rigorous in our measurement of energy resources and energy consumption, the collection of data on energy efficiency is under-funded, rudimentary, and incomplete. Even the limited set of data provided in this report required more than a year to collect, estimate, and interpret, and necessitated the collection of indicators from a wide variety of sources using a diverse set of research methods and the development of unique estimation techniques. The required investment in time and resources is prohibitive for most organizations that might otherwise be interested in pursuing and promoting energy efficiency. In other words, the lack of reliable and readily available data serves as a significant barrier to efforts to expand the contribution of efficiency in meeting our nation's energy service demands.

B. Investment Opportunities

During the past 38 years, investments in energy efficiency have proceeded in fits and starts in response to specific policy choices made by the nation's political and industrial leaders as well as the energy demands of the general public. While the oil crises of the 1970s catalyzed political action and investments in efficiency, other periods were characterized by a waning of investments and leadership. The six discrete historical periods (discussed in Section IV of this report) include periods of both accelerated rates of investment as well as periods of slower progress. Notably, however, a variety of factors have recently coalesced in favor of efficiency investments (see Section III). Moreover, our research indicates that investments in the U.S. energy-efficient technology infrastructure were on the order of $300 billion in 2004 — approximately three times the level of investments in the energy supply infrastructure in the same year.

Despite the growing momentum in efficiency investments, we are only beginning to appreciate the vast range of untapped investment opportunities. From real estate finance to venture capital to equities markets, new and innovative investment opportunities are beginning to emerge. In fact, our analysis indicates that efficiency investments could increase by as much as $400 billion per year by 2030, resulting in total annual investments in excess of $700 billion. In order to realize this potential, we need to break down existing market barriers, continue to design innovative investment mechanisms, and promote and support smart energy policies that create favorable investment environments in the efficiency market.

C. Policy Opportunities

The paradox of our age is that while our demand for energy services is unlimited, our access to energy supplies is not. So as our appetite for energy has grown, our resources have shrunk. In addition, efforts to expand our energy supplies are quickly becoming more costly and less viable. Energy efficiency is a practical alternative. Investing in energy efficiency has been shown to be a low-risk, high-return investment option that can provide the means of meeting growing energy service demands while reducing overall levels of energy consumption and carbon dioxide emissions. A smart set of efficiency-friendly policies could serve to catalyze these investments by providing a set of favorable economic policies, public sector leadership, targeted and intensive educational programs, and strict standards

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VIII. Appendices

A. Methodologies for Estimating Investments

1. What Are Considered To Be Investments in Energy Efficiency?

The means of increasing energy efficiency vary widely. Efficiency gains are often embedded within existing technologies and practices and tend to be difficult to measure. In business and industry, efforts to increase energy efficiency or energy productivity can be ingrained in everyday operations and management practices, design decisions, and long-term capital investments. For individuals and households, investments in efficiency include choices in appliances and consumer electronics, home improvements, and new car purchases. Moreover, gains in energy efficiency are often bundled with other benefits of new technologies such that efficiency might be one of several considerations that result in technology adoption or behavioral change. In other words, the weight of efficiency as a decision-making criterion may vary dramatically from the primary motivation, to a minor role, to no role at all. In the case of industry, for example, the larger concern for productivity improvements may lead to cost-effective energy savings as manufacturers reduce material inputs and waste. In household and business settings energy may be saved as concerns for personal comfort and convenience stimulate the purchase of new technologies. How do we identify and measure all of the areas in which efficiency gains are made when they are so fragmented throughout industries, businesses, households and transportation?

Additional factors add to the difficulty in measuring efficiency investments as illustrated by the following set of questions. Should efficiency-related investments only include purchases of long-lived products, or should they also include the purchases of services that also yield a return in energy savings? Should efficiency-related investments only include technologies made with the express purpose of saving energy, or should they also include equipment and appliances made for other purposes that also yield energy savings? Should efficiency-related investments be calculated so as to include the entire cost of the new, more energy-efficient product or simply the incremental costs when compared to a less efficient product on the market? Finally, which products should be considered efficient? Should an absolute or relative standard be used in determining which products should be counted as efficient and which should not? For example, should we think of consumer appliances only if they meet ENERGY STAR specification, or would they be included if they merely improve existing energy use patterns?

All of these questions helped frame our assessment of the size of the energy efficiency market. Ultimately, our approach seeks to identify and capture energy efficiency investments in both products and services across all sectors as outlined below — whether or not these investments were made for the expressed purpose of improved energy efficiency. However, because data related to normal investments in products and technologies are more readily available, it is likely that investments in energy-efficient services are significantly underrepresented in most assessments — and even within this analysis. Noting this limitation, we use available data from a variety of sources to estimate both total efficiency investments as well as the incremental proportion of those investments specifically associated with attaining greater levels of efficiency when compared to a business as usual scenario. For example, if a household is faced with a need to replace a washing machine, they can choose to replace it with an energy-efficient product or a product that is not energy efficient. (In this case we use the ENERGY STAR designation to determine efficiency.) If the efficient product is chosen, we would measure the total cost of the washing machine as well as the incremental cost or the difference in cost between the efficient product and the non-efficient product. Measuring in this way allows us to distinguish between all efficiency-related investments and the efficiency-investment premium.

In order to determine what should be counted as an investment in efficiency, we use ENERGY STAR standards whenever possible. The EPA and DOE ENERGY STAR Program rates the energy efficiency and sales of an expanding list of products, including a wide variety of household appliances, commercial equipment, heating and ventilation equipment and even residential construction. (EPA 2006). For products such as wall and ceiling insulation, whose sole purpose is to reduce energy loss, 100% of the cost is included in the measure of premium investment. Transportation-related efficiency investments are estimated using data from the EPA (2005, 2006), DOE (2006, 2007), Oak Ridge National Laboratory (2007), and the Energy Information Administration (2005, 2007). Investments are estimated separately for cars, trucks and airplanes. Energy efficiency in cars and other light duty vehicles is assessed using EPA data on the adjusted fuel economy and improvements in ton-miles per gallon (EPA 2005) as well as information regarding the application of new, fuel-saving vehicle technologies (DOE and EPA n.d.) Industrial efficiency investment estimates are based on several sources of data. These include information on investments in the more energy-intensive industries available through the DOE's Save Energy Now Program; data on small to medium sized industries available through the Industrial Assessment Center Database, as well as information provided by the Manufacturing Energy Consumption Survey (MECS) and an ACEEE Delphi survey of energy efficiency experts. Efficiency investments in the industrial sector include investments in replacing or retrofitting preexisting technologies as well as adding new technologies that allow for increased efficiency. These might include anything from new lighting to new industrial processes and process controls that reduce the amount of energy needed per unit of output.

2. Estimates of the Efficiency Premium

Our methods of assessing the size of efficiency investments began by distinguishing six sectors of potential energy efficiency investments: residential buildings, commercial buildings, appliances and electronics, industry, transportation, and utilities[14]. Efficiency investments in each sector were assessed independently using a multi-pronged approach that included an economy-wide, macro-level assessment of energy consumption trends, as well as a meso-level assessment that evaluated energy use data for specific sub-sectors and industries as well as census data on population-based and household-based energy consumption trends. In addition, in some cases, we collected our own data to further strengthen the validity of our results. In the appliance and electronics sector, we collected price data from a variety of online stores to assess consumer costs associated with efficient and inefficient products. In the Industrial sector, we performed a Delphi survey of experts to assess the validity of some of the assumptions underlying our estimates. The use of multiple levels of assessment allowed us to adequately triangulate our results and affirm the validity of our estimates. Once we had established our

[14] The macro-level assessment does not create independent estimates for appliances and electronics, but instead assesses these efficiency gains as a subset of residential and commercial buildings.

investment estimates, the last step was to compare them to a set of existing studies as a final means of assessing the validity of our results. (See section B of this appendix for information on our comparative assessment.)

The macro-level assessment uses actual energy consumption data, energy price data and other statistics for 2003 and 2004 (EIA 2005, 2006a) to calculate energy intensities for each sector, the type of energy used by each sector (i.e., electricity, natural gas, etc.), and years (2003 and 2004). To illustrate for the residential sector, the average energy intensity per household (million Btu per household per year) was calculated for both years. Compared to the economy as a whole whose energy intensity declined 1.66% in 2004, the calculations here revealed a decline in energy intensity of 1.34% over that same one-year period in the residential sector. In other words, after taking into account the increase in the number of households and an expanded economy in 2004 compared to 2003, our calculations suggest that increased energy efficiency resulted in a savings of 286 trillion Btu and $4.96 billion dollars of energy expenditures. These savings resulted from the building of more energy-efficient homes as well as home improvements and the replacement of energy-inefficient appliances, increasing the efficiency of existing homes. How much was invested in achieving these efficiency gains? The baseline macro-level assessment uses an assumed payback period of three years to arrive at an estimated premium of $14.9 billion and a total investment of $99 billion. Similar assessments were performed for each of the remaining sectors as summarized below.

Macro-Assessment of Sectoral Efficiency as a Diagnostic Comparison

	Energy Savings* ($billion)	Efficiency Investment Premium** ($billion)	Total Efficiency Investment*** ($billion)	Percent of Total Investment	Implied Energy Savings (Quads)
Residential	2.7	8.1	53.7	32.5	0.23
Commercial	1.9	4.6	32.3	19.6	0.20
Industrial	4.6	9.2	61.4	37.1	0.76
Transportation	0.1	0.3	2.2	1.3	0.06
Utilities	0.5	2.4	15.7	9.5	0.19
ENERGY STAR	n.a.	n.a.	n.a.	n.a.	n.a.
TOTAL	9.8	24.8	165.4	100.0	1.43

From the analytical approach summarized in this table we find that the implied total energy savings across all sectors is an estimated 1.43 quads. This compares to the 1.7 quads we actually report from our more detailed or bottom-up analysis. At the same time, the total investment in more energy efficiency technologies suggested by the macro analysis is a much smaller figure: $165 billion compared to the $300 billion cited in the main report. In both cases we confirm the magnitudes but find the macro perspective appears to underestimate overall efficiency gains. In effect, this might be said to provide a lower bounds of the efficiency gains in 2004.

The meso-level assessment brings together data from a variety of sector-specific sources to develop a more detailed picture of efficiency in each of the sectors for the same years. At the meso-level the buildings sector is broken into residential construction/renovation, commercial construction/renovation, and appliances/electronics. Data on both residential and commercial construction and renovation were collected from the Annual Energy Outlook (EIA 2006, 2004), the 2001 Residential Energy Consumption Survey (2003), the 2003 Commercial Buildings Energy Consumption Survey (2006) and the DOE's Building Energy Databook (2006) among other sources to develop a range of estimates concerning construction-related investments and efficiency gains. Sales data for ENERGY STAR appliances and electronics were used to assess energy efficiency investments for residential and commercial appliances and electronics (LBNL 2006). These data were supplemented with information from an online survey of appliances and electronics conducted by ACEEE as well as information from an EIA report on residential and commercial building technologies (Navigant 2004).

With regard to energy efficiency investments in residential buildings, we began with ENERGY STAR Home construction data for 2004 indicating that approximately 132,000 ENERGY STAR homes were built in the U.S. in 2004. During that year the median price for a new single family home was $221,000, suggesting a gross investment of approximately $29 billion on energy-efficient homes within in the ENERGY STAR program. Additional data on home renovation indicates that approximately $9 billion was spent on efficiency-related home improvements including energy-efficient doors and windows, HVAC systems, and insulation. Energy-related home renovation sales of $9 billion are the equivalent of approximately $80 per household. Finally these data were compared to data on the number and size of households in 2003 and 2004 as well as household energy use data and changes in average household-level energy efficiency.

In the appliance and electronics market, sales data for ENERGY STAR appliances and electronics (LBNL 2006) were used to estimate market share and total sales for each of the many appliances and electronics that are eligible to receive the ENERGY STAR label. A variety of appliances are eligible for ENERGY STAR certification including clothes washers, refrigerators, conventional ovens, microwave ovens, and dishwashers. Eligible electronics include computers, televisions, DVD players and many of the other items that have become integral to our everyday lives. Our assessment relied heavily on data collected by the ENERGY STAR program measuring the number of ENERGY STAR products that are sold each year as well as data on the overall level of sales in each product category. In order to assess the gross investment and efficiency premium of the product sales in each category, we surveyed published documents and online stores to assess the average price of each product category as well as the efficiency premium associated with ENERGY STAR products. We then multiplied the sales and price data to arrive at an estimate of approximately $88 billion in total commercial and residential investment in energy-efficient appliances and electronics. The efficiency premium is estimated to be in the range of $10 billion using data on energy savings and an assumed average payback period of just over a year.

Energy efficiency investments in the commercial building sector assessed energy intensity per square foot of commercial building space in 2003 and 2004 to estimate the amount of energy savings achieved through efficiency investments in new, more efficient buildings as well as the renovation of existing structures. Between 2003 and 2004 total commercial energy consumption remained flat despite an increase in total floor space of 1.3 billion square feet. As such, energy intensity declined from an average of 235,000 Btu per square foot in 2003 to an average of 231,500 Btu per square foot in 2004, saving 306 trillion Btus of energy valued at more than $5 billion. Total investments in commercial (private and public) construction totaled nearly $470 billion in 2004 while the value of commercial building improvements between 2003 and 2004 were estimated at $168 billion. Altogether, nearly $640 billion were invested in commercial building construction and renovation between 2003 and 2004. Our estimates indicate that approximately 1.2% of the value of new commercial buildings and building improvements was invested in efficiency premium investments (approximately $7.7 billion) while total efficiency investments represent just under 8% of new construction and building improvement investments.

Industrial energy efficiency investments were estimated by identifying changes in energy use patterns within specific segments of the industrial sector, including both manufacturing and non-manufacturing[15] sub-sectors. Manufacturing was further broken down into petroleum refining industries, non-refining primary materials manufacturing, and non-primary materials manufacturing. Energy consumption and energy price data were used to calculate energy savings in Btus and dollars for each segment of the industrial sector. Using an assumed payback period of approximately two years, we used the estimated dollar value of energy saved during 2004 to estimate the efficiency premium and total efficiency investments in the industrial sector[16]. These estimates were supplemented with data from the U.S. DOE Industrial Technology Program's *Industries of the Future* (IoF) and *Industrial Assessment Centers* (IAC) programs, and data from the EIA's *Manufacturing Energy Consumption Survey* (MECS). Data from the IoF Program (AMMEX 2006; Anthony 2007; Kavanagh 2005) provided information regarding the size of investments and energy savings associated with the program which works with some of the most energy-intensive industries. In addition, data from the IAC database (DOE 2007) were used to estimate the average cost of efficiency investments across various small to medium-sized industrial enterprises. Other IAC data (DOE 2007) were used to ascertain the proportion of recommendations that are ultimately implemented as well as their characteristics, average payback period, and average level of energy savings. Finally data from the MECS (EIA 2005) were used to suggest the preponderance of energy efficiency investments across the manufacturing sector and an ACEEE delphi survey of industry experts was used to further triangulate our estimates.

Ideally, estimates of energy efficiency and investments in transportation would include a broad set of data including efficiency estimates for each of the various means of transportation (cars, trucks, buses, airplanes, rail and ship). However, the lack of available meso-level data ultimately led us to exclude estimates on investments in rail transport and ships. Instead, our assessment focused on developing estimates of energy savings and energy efficiency investments in light duty vehicles, medium-heavy duty commercial and freight trucks, and airplanes. For motor vehicles, we were able to use the average change in ton-miles per gallon to estimate technology-based energy-savings and investments. Not all of these investments have resulted in a net increase in vehicle fuel economy since manufacturers and consumers have frequently chosen to offset these savings with the application of additional energy service demands and a shift toward the purchase/sales of heavier cars. Despite the lack of net energy savings in many cases,

[15] Non-manufacturing subsector includes agriculture, forestry, fisheries, mining and construction.

[16] It is important to note that the estimated efficiency investments for each of the manufacturing subsectors are likely to vary significantly from one year to the next. Investment estimates for 2004 represent the distribution of energy savings across subsectors for that year only based on changes in energy intensity between 2003 and 2004. While a variety of data sources suggest that the majority of investments are being made in the most energy intensive industries and by some of the largest companies, the lack of reliable data on industrial sector efficiency investments prohibits us from making more reliable estimates.

efficiency gains and investments were assessed based on estimated investments in the many more efficient technologies that allowed consumers to add vehicle features without a reduction in vehicle fuel economy.

For air travel, efficiency is commonly measured as seat-miles per gallon or ton-miles per gallon. Data from the EIA (2007) supplemental tables provided estimates on air travel demand and related energy consumption measures. These data were compared with estimates from the International Air Transport Association indicating that improvements in aircraft engines and airframe technology were responsible for improved fuel efficiency of approximately 2 to 2.5% during the time frame in question (IATA 2004).

Overall, the meso-level assessment provided more detailed measures of energy and efficiency trends within each of the sectors discussed. When assessed in combination with the macro-level estimates, the meso-level measures provide one or more points of comparison that were useful in assessing the validity of our estimates. The meso-level estimates are summarized in the following table.

	Energy Savings ($billion)	Efficiency Investment Premium ($billion)	Total Efficiency Investment ($billion)	Percent of Total Investment	Implied Energy Savings (Quads)
Residential	5.6	5.85	39	15.4	0.51
Commercial	4.1	7.73	51	20.1	0.37
Industrial	5.7	10.13	43	17.0	0.52
Transportation	1.0	4.80	32	12.6	0.92
Utilities	n.a.	n.a.	n.a.	n.a.	n.a.
ENERGY STAR	1.7	13.26	88	34.8	n.a.
TOTAL	18.1	41.77	253	100.0	1.68

3. Estimates of Employment Impacts

Estimating the number of jobs generated through ongoing efficiency investments requires an assessment of the ratio between jobs and industrial output. When compared to other sectors of the economy, particularly energy production, efficiency-related jobs tend to be more labor intensive per dollar of output. However, the specific jobs/output ratio varies from one sector to the next. Therefore, job and output data from the IMPLAN database (2006) were used to develop estimates of jobs/output ratios for each of the six sectors outlined above. Sector-specific estimates were created by identifying both the primary and secondary types of work associated with each efficiency-sector. Once identified, the weighted average of the primary and secondary jobs was calculated by giving more weight to the primary jobs associated with the sector in question (0.7:0.3). For example, in the residential sector the rate of employment per million dollars of output ranged from an average of 9.3 for the primary jobs to 5.3 for the secondary jobs. The final weighted average for the residential building sector was 8.1 jobs per million dollars. Total residential-sector related investments of $39 billion correspond to roughly 316,000 jobs, while the residential efficiency premium investments correspond to 47,400 jobs. Similar calculations were used to estimate the employment impacts of efficiency investments in other sectors as summarized below.

	Total Estimated Investments ($billion)	Efficiency Premium-Related Investments ($billion)	Number of Jobs per $million (weighted average)	Total Efficiency-Related Jobs (000)	Efficiency Premium Related Jobs (000)
Residential	39.0	5.9	8.1	316	47.4
Commercial	51.0	7.7	5.9	302	45.2
Appliances & Electronics	88.0	10.6	4.2	372	44.7
Industrial	75.0	11.0	4.6	351	52.7
Transportation	33.0	4.8	4.7	151	22.7
Utilities	15.7	2.4	8.8	139	20.8
Total	301.7	42.4	5.4	1,630	233.5

B. Comparison with Other Estimates

How do the estimates presented in this report compare with those of other studies? While there has been a significant effort via numerous reports and scenario analyses to determine the scale of energy saving opportunities provided by energy efficiency, little work has been done to assess the current level of investments in efficiency. This section compares our assessment of the energy efficiency industry with other estimates of efficiency-related investments as well as selected estimates of efficiency opportunities as determined through a variety of scenario analyses. Our goal is to provide a context for evaluating the consistency of our estimates relative to those of others. As such, this comparison includes a variety of relevant studies but is not meant to be an exhaustive review of all studies on the potential energy saving opportunities provided by energy efficiency.

1. Comprehensive Estimates of Energy Efficiency Investments

The most comparable study of the energy efficiency industry is a recent study by Bezdek (2007) which provides a coherent effort to define and measure both the renewable energy (RE) and energy efficiency (EE) industries in order to capture their size and scope and to forecast future growth. The highlights of this analysis are provided in Table 9.

The development of Bezdek's estimates of the size of the energy efficiency industry, however, was fraught with many of the same difficulties faced in the development of this report. According to Bezdek "[e]stimating the size of the [energy efficiency] industry is much more difficult than estimating the size of the [renewable energy] industry." We certainly agree. He continues, "[m]ost EE spending is included in partial segments of large industries, such as vehicles, buildings, lighting, appliances, etc." The Bezdek study's estimates begin by establishing estimates for a "core" efficiency industry that includes insulation sales, energy service company (ESCO) industry sales, and the U.S. recycling and reuse industry sales. For other industries, they include data for only the efficient part of the industry such as vehicles that get at least 10% better miles per gallon or mpg than the CAFE mileage as energy-efficient vehicles. For lighting products, household appliances, windows and doors, and components of the industrial sector, they use ENERGY STAR ratings to define efficiency.

Their estimates indicate that combined RE and EE sales for 2006 were nearly a trillion dollars and created 8.5 million new jobs with more than $100 billion in industry profits and more than $150 billion in increased federal, state and local government tax revenues. EE revenues alone were estimated at $932.6 billion in 2006 and EE direct jobs were estimated at just under 3.5 million. (Note that we report the revenues in Table 9 in 2004 dollars to maintain greater comparability to our own results).

Our own review suggests that the Bezdek estimates are higher than those reported here because they use a basic sector approach that adds up the jobs and total spending in the RE and EE sectors rather than just the efficiency investments made which might use the technologies or services provide by those industries. For example, an investment may be made in one year but additional spending may be required to support that investment in subsequent years. While our approach is to highlight only the investment made to improve U.S. energy efficiency in 2004, the Bezdek approach would capture all spending in the related sectors whether it improves efficiency overseas or whether the spending is made necessary as a result of previous year investments. In many ways the Bezdek approach is more compatible with annual energy expenditures while our methodology would compare to annual investments in new energy supply technologies. In effect, the Bezdek estimates provide an upper bound of both investments (or spending) and the employment impacts compared to the analysis we report here.

An older study by Laitner (1995) estimated that cumulative net investments in efficiency during the 20-year period 1971 through 1990 at approximately $460 billion (in 1987 dollars). According to the study, roughly 60% of total investments (or $276 billion) were made during the seven years between 1980 and 1987. When normalized to total investments expressed in 2004 dollars, the average annual investments in energy efficiency in this 20-year period were around $243 billion. Hence, the findings of the Laitner (1995) study are consistent with those presented here.

2. Partial Estimates of Energy Efficiency Investments

Several studies have focused on discrete components of the energy efficiency industry. Due to their focus on market segments, rather than whole market estimates, they were not included as among those reported in Table 9 of the main report. Nevertheless, they provide an instructive review of such estimates and inform our own thinking and, hence, they are referenced here. These studies include a 2007 survey of the U.S. energy service company (ESCO) industry by the Lawrence Berkeley National Laboratory (Hopper et al. 2007), a 2007 report on U.S. energy efficiency programs (CEE 2007), and a 2007 report on U.S.-based venture capital investments in energy technologies (Makower et al. 2007).

According to the LBNL survey, ESCO industry revenues from energy services alone were on the order of $3.6 billion in 2006. Energy efficiency accounted for almost three quarters of industry revenues, or about $2.5 billion of investments in efficiency equipment and services. More than 80% of efficiency investments were made among institutional customer facilities (22% in the federal market, 58% in state/local government, universities, schools, and hospitals, and 2% in public housing authorities) with the remainder going to commercial (9%), industrial (6%), and residential (3%) customer facilities.

The Consortium for Energy Efficiency (CEE 2007) collected data from its own members[17] on ratepayer-funded electric and gas energy efficiency programs. The CEE study found that these energy efficiency programs had reached $2.6 billion in budgeted funds for 2006, representing an increase of 13% since 2005. Approximately 43% was earmarked for commercial and industrial programs (> $1 billion), while 30% (another $798 million) was earmarked for residential programs. California, New York and Florida had the most highly funded programs, representing more than 50% of all ratepayer-funded electric and gas energy efficiency programs.

Finally, the Makower et al. (2007) study of venture capital investments in the cleantech market estimated that U.S. venture investments in clean energy technologies (including both RE and EE) reached $2.4 billion in 2006. These investments have experienced steady and rapid growth over recent years "accelerating the growth of technologies, companies, and markets faster than even many optimists might have imagined." During the past seven years, CleanEdge estimates that venture investments in energy technologies have increased from "less than 1% of total venture investments to nearly 10%." U.S. venture capital investments in energy efficiency alone were estimated at $476 million in 2006 and $274 million in 2005. The largest venture capital investments in efficiency were made in capital-intensive powerline communications deals. Advanced metering initiatives and opportunities for high-speed data communications over the electricity grid have resulted in significant investments in these areas. According to the CleanEdge report, "With energy efficiency and demand response high on the list of many utilities as a "new" source of power, energy-intelligence companies may be the new darlings of energy tech." Globally, CleanEdge expects that venture investments in clean-energy technologies will exceed $226 billion by 2016.

3. Scenario-Based Estimates of Future Market Potential

This section explores several of the numerous scenario-based estimates of the potential energy savings and costs associated with policies aimed at increasing levels of energy efficiency in the U.S. The scenario-based assessments highlighted in Table 9 of the main report generally provide two or more alternative policy futures along with estimates of the environmental and economic impacts of each scenario. A detailed review of three of those scenario-based estimates in this appendix (Faruqui 2002; McKinsey Global Institute 2007; UCS 2001) provides additional information and insights on required levels of investments associated with specific efficiency outcomes. They also provide a broader context from which to evaluate the estimates of current levels of efficiency-related investments as provided in this report. We also reference the three other studies cited in Table 9 for which additional information are available but not reviewed here. Readers are invited to contact the authors for more detail on all of the studies referenced in the Appendix. One caveat is especially appropriate at this point. None of the studies reviewed provide investment-related information in the way we describe in the main report. What we describe here is the way we have tried to "normalize" or "triangulate around" the data as if the studies had been structured to generate comparable estimates. All that we are really able to discern is a rough magnitude of investment estimates that can help us determine the appropriate scale of the analysis discussed in the main part of this report. The readers are cautioned to maintain this perspective as they review the individual results highlighted in Table 9.

[17] According to CEE, CEE members are responsible for 99 percent of gas energy efficiency program budgets and 90 percent of electric energy efficiency program budgets in the U.S.

The first of the six scenario based studies we adapt for this report is a recent report on curbing global energy demand growth by the McKinsey Global Institute (MGI) and McKinsey's Global Energy and Materials Practice (2007) found that large opportunities exist "to contain energy demand growth in economically attractive ways." According to the study, a business-as-usual scenario will result in growing global energy demands that will average 2.2% a year to 2020. This growth in energy demand is projected to occur despite the projected growth in energy productivity of approximately 1% per year.[18] So while McKinsey acknowledges ongoing investments in efficiency in their business-as-usual scenario, they argue for a more proactive approach to increasing energy productivity which could be achieved through the use of existing technologies, potentially saving 135 quadrillion BTUs globally by 2020. Investments in such technologies assume an average 17% rate of return (McKinsey 2008) and would result in an estimated 50% decline in energy demand growth during the next 15 years (from 2.2% per year to less than 1% annually through 2020). At an average cost of $8.73 per million Btus of primary energy (EIA 2006), a 17% return on investment, and a working assumption of a 15% efficiency premium, we estimate an implied total annual investment on the order of $2,719 billion worldwide (in 2004 dollars). Again this is a policy driven total investment needed to reduce total worldwide energy use by 135 quads by the year 2020.

A recent study of demand side management program investments in the U.S. electricity-generation sector (Faruqui 2002) suggests that investments in energy efficiency via demand side management programs can reduce U.S. energy consumption significantly at relatively modest costs. Projected annualized investments in 2010 ranging from $4.6 to $46.9 billion, were estimated to generate energy savings of 230 to nearly 800 billion kilowatt hours (dependent on the per kilowatt hour cost of electricity). By 2030 investments were projected at $18 to $133 billion with energy savings of 890 to 2210 billion kilowatt hours. Assuming an average investment life of 15 years, an assumed 5% discount rate, and again a 15% efficiency premium, we estimate the implied full investment to be $170 to $423 billion dollars by 2030.

An earlier study by the Union of Concerned Scientists also considers the impact of two policy options on U.S. energy consumption. Under a business-as-usual scenario, total U.S. energy use is expected to grow more than 30% between 2000 and 2020 (from 97.4 to 126.8 quadrillion Btu) with an average annual increase of 1.3% per year. Under the Clean Energy Blueprint, energy efficiency, combined heat and power, and renewable energy provide a much greater share of U.S. energy needs. By 2020, total energy use is 19% lower than business as usual and only 5% higher than 2000 levels (from 97.4 to 102.5 quads), generating a savings of 29.4 quads in 2020. Efficiency and CHP contributes 3.47 quads of fossil fuel savings in 2020. Total investments between 2002 and 2020 (in 1999 dollars) were estimated at $596 billion with approximately $13.6 billion of investments necessary in 2004 and as much as $50 billion of investments needed in the final three years of the program. The full average annual investment (in 2004 dollars), as we've normalize it to include the base cost of the technology as well as the investment premium, was estimated at $234 billion. We've similarly transformed the analytical results for the ACEEE analysis (Nadel and Geller 2001), the Interlaboratory Working Group (IWG 2000), and Energy Innovations (1997).

[18] Half of these productivity gains are associated with sectoral shifts to less energy intensive activities while the other half is associated with increased energy efficiency.