Wasted Days and Wasted Nights: Energy Use in Our Nation's Buildings and Industries

by John A. "Skip" Laitner

Growing the Economy Through Global Warming Solutions

Global warming is one of the most urgent problems of our time.

The good news is that many of the solutions to this extraordinary problem are within reach. Many of the solutions to global warming are not only feasible, they are economically and socially beneficial. While some claim that addressing global warming will have a negative impact on the economy, the most recent report by the Intergovernmental Panel on Climate Change ("IPCC") asserts that there is substantial economic potential for the mitigation of greenhouse gas emissions over the coming decade. In fact, there is a growing global market to address global warming, and the United States must act now or risk being left behind.

Growing the Economy through Global Warming Solutions sets forth the steps we can take to curtail global warming, the governance models needed to encourage such a transition, and the economic benefits of doing so. By taking these steps as soon as possible, we not only will minimize the grave risks of global warming, we will position the United States as the leader in the clean industries and technologies that are emerging as the key growth engine of the Twenty-First Century.

It is now a given that global warming is happening. It is caused by the emissions of greenhouse gases – primarily carbon dioxide released during the combustion of fossil fuels -- and already has begun to inflict harms on climate, ecology and people. The most recent IPCC report confirms that global warming is here and will accelerate in the future with serious harms and risks if greenhouse gas emissions are not promptly limited. Dr. James Hansen, of NASA's Goddard Institute for Space Studies, warns that a global average warming of 3.5 degrees Farhenheit will produce a "different planet" by taking us over dangerous climate thresholds that greatly magnify the risks of disintegrating the great ice sheets on Greenland and West Antarctica, an event that would cause massive and rapid sea level rise. Dr. Hansen emphasizes that we can keep the planet within the known boundary conditions by limiting the future global temperature increase to no more than 3.5 degrees Fahrenheit.

To do so, we must stop the business as usual approach in which carbon dioxide and other greenhouse gas emissions increase every year. One of the primary obstacles to moving from this business as usual approach to a problem solving approach is the argument that mandates to limit emissions will cripple the U.S. economy and that the market will produce all necessary solutions on its own. But this argument focuses too narrowly on the economic impact to "big energy", which for too long has dominated the political discussions in Washington. Growing the Economy through Global Warming Solutions asserts that we cannot afford to wait for voluntary market solutions. We must either invest now to implement solutions, or we will pay much more later as we have to adapt to the growing impacts of global warming. Many mitigation strategies, those that will help reduce emissions now, will not only be cheaper to implement, they will stimulate the economy.

Government has an essential role to play in developing a strong governance model – those procedures, rules and regulations that can work to bring greenhouse gas emissions under control. In fact, with the right set of government incentives to help focus their attention, the business community, which is already beginning to recognize challenges and opportunities - and looking to both adapt and innovate - will see even more possibilities for capitalizing on economic opportunities while achieving environmental gains. The good news is that, if we get started right away, we can rapidly move to this solutions-oriented approach in which emissions are limited and reduced in time to avert the worst risks of global warming.

Growing the Economy through Global Warming Solutions is a series of papers written by experts in the fields of economics, public policy, energy policy, architecture, insurance, investment, transportation, and agriculture. It details the solutions that can be taken off the shelf today. While there is no single silver bullet for addressing global warming, there are a wide variety of solutions that, taken together, will lead to a reduction of carbon dioxide emissions, the key to stopping global warming. These promising solutions must be phased in as we phase out our outmoded reliance on foreign oil and coal. Along with its companion reports, *Wasted Days and Wasted Nights: Energy Use in Our Nation's Buildings and Industries, by John A. "Skip" Laitner*, sets out important next steps that can and should be taken in the near and medium term to ensure that we do everything possible to address the challenges of global warming.

We have the know-how and it is the American Way to innovate and problem solve. We have time.

We have to get started now.

> **"We have at most ten years—not ten years to decide upon action, but ten years to alter fundamentally the trajectory of global greenhouse emissions."** *– Jim Hansen, Director of the NASA Goddard Institute for Space Studies, and Adjunct Professor of Earth and Environmental Sciences, Columbia University's Earth Institute.*

Executive Summary

In the effort to reverse global warming by reducing carbon emissions, one crucial strategy is to greatly increase the productivity of all of our energy resources, using more energy-efficient technology to strengthen the economy while at the same time decreasing overall demand for energy supply. Unless the U.S. and other nations greatly *reduce* our demand for energy by *increasing* energy productivity, deploying renewable energy technologies and other clean energy supplies will not happen fast enough to meet the climate challenge.

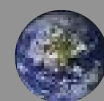
As with renewable energy sources, interest in efficiency is on the rise because it will be such a critical element of any successful effort to combat global warming. In addition, improving energy efficiency is generally acknowledged to be the lowest-cost and quickest-to-deploy resource to slow the growth of carbon dioxide emissions, all the while producing positive economic impacts.

Energy efficiency is already an enormous market, cutting across all sectors of the economy, including building and design, transportation, utilities and industry. Experts at American Council for an Energy-Efficient Economy (ACEEE) estimate that consumers currently invest $200 billion annually in energy-efficient technologies, making the efficiency market actually larger than traditional fossil fuels.

ACEEE estimates that this level of investment could double to $400 billion and carbon dioxide emissions could be cut by one-third to one-half—if we can develop and expand the financial mechanisms for this growing market. In order to support the potential growth of the efficiency market, we will need public policy that supports and fosters innovation and investment.

Perhaps the most urgent imperative of the 21st century is to shift our energy economy from fossil fuels to clean and renewable energy sources. But in this new race for clean energy supplies, the first and continuing challenge is to greatly increase the productivity of all of our energy resources, using more energy-efficient technology to strengthen the economy while we de-couple energy consumption from economic growth. Unless the U.S. and other nations greatly reduce our demand for energy by increasing energy productivity, deploying renewable energy technologies and other clean energy supplies won't happen fast enough to meet the climate challenge.

Fortunately, energy-efficient technologies offer an abundance of investment opportunities that have frequently been overlooked. In fact, investments in more energy-efficient industrial processes and purchases of Energy Star™ computers, household appliances and office equipment provide the means for sustainable economic growth. They allow us to shrink our environmental footprint while improving our quality of life. With accelerated investment, supported by the right policies, energy efficiency can meet and exceed the increasing demand for energy services, allowing the economy to grow while flattening or even reducing energy consumption and carbon dioxide emissions.



The challenge is to define new investment opportunities and policy pathways that can unleash the trillions of dollars of energy-efficient technology investments that will be needed to meet our 21st century energy and climate challenges.

A preliminary assessment by the American Council for an Energy-Efficient Economy (ACEEE) shows that Americans currently invest about $200 billion annually in energy-efficient technologies. ACEEE estimates that this level of investment could double to $400 billion, and carbon dioxide emissions could be cut by one-third to one-half, if we can develop and expand the financial mechanisms for this growing market (Hanson et al 2004; and Laitner et al 2007). The research also suggests that public policies are needed to reduce large and persistent market and regulatory barriers that prevent a more productive investment in energy efficient technologies. The challenge for both public policy and the private market is to define new investment opportunities and policy pathways that, over the next 20 years, can unleash the trillions of dollars of energy-efficient technology investments that will be needed to meet our 21st century energy and climate challenges. This chapter highlights some of those opportunities, with a particular emphasis on buildings, industry, and electric power.[1]

Energy Efficiency: The Little (Big) Engine that Could (and Did)

Although most people think of conventional power commodities like electricity, coal, oil, and natural gas when the subject of energy is mentioned, improvements in energy efficiency have actually contributed more value to our nation's economy in recent decades than all conventional energy resources combined. To understand efficiency's value, we must start by distinguishing between energy commodities like natural gas and electricity, and energy services such as lighting, heating, hot water, and industrial steam and motor drives. In the last 30 years, through the development of efficient technologies, we have learned to provide energy services with reduced amounts of energy commodities. Since 1996, for example, efficiency has satisfied 84 percent of all new demand for energy services. But because it lacks the visible infrastructure of electricity utilities or oil companies such as power plants and refineries, energy efficiency has remained a largely hidden resource.

* *The author would like to thank Karen Ehrhardt-Martinez and William R. Prindle for their assistance in the preparation of this article.*

Although efficiency may be difficult to see, it has long been driving productivity gains across our economy. The pace of those efficiency gains has accelerated noticeably since 1996. As shown in Figure 1, since 1970 *energy efficiency has met three-fourths of all new demand for energy services*.[2] In other words, while conventional energy technologies are the more visible channels for investment, efficiency has outperformed all energy supply resources by a three-to-one margin. These remarkable achievements couldn't have been made without strategic investments in energy efficiency in all sectors of the nation's economy. In fact, ACEEE research indicates that annual investments in the "energy services infrastructure"—energy-efficient buildings, consumer products, transportation equipment, and industrial processes—outweighs the annual investment in the more visible conventional energy infrastructure by about two to one (Laitner 2007).[3] Yet the potential for energy efficiency as a resource is still largely untapped; with the right mix of policies, market incentives and financial mechanisms, energy-efficient technology investments have the potential to satisfy all the growth in U.S. energy demand—and perhaps much more.

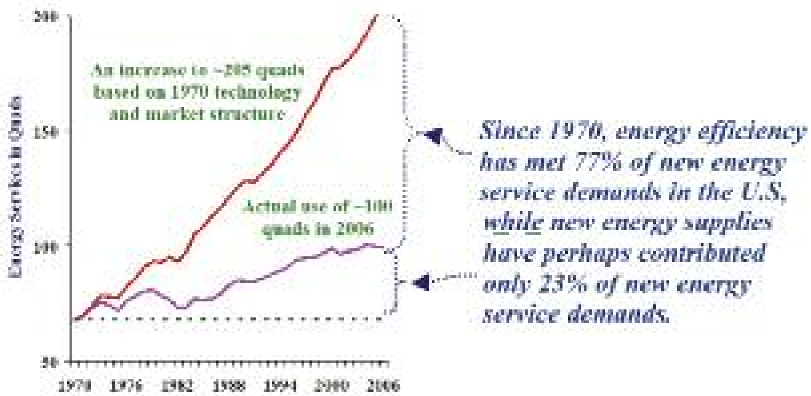


Figure 1. Comparing Growth in Energy Service Demands, Energy Use, and Efficiency
Source: Laitner (2007)

Energy Efficiency: Mapping the Hidden Reservoir of Opportunity

Energy efficiency enables economic growth by increasing the volume of products and energy services generated for each unit of energy consumed. In short, efficiency is not about doing without; in this case it simply means investing in new ways to work and to get to work, new ways to produce our food, clothing, and shelter, and new ways to keep our schools and communities running. Efficiency requires investment in more-productive technologies to replace or avoid less-efficient materials, products and systems. By cutting energy waste, energy-efficiency technologies free up resources for the production of other high-value goods and services. This in turn creates an economic stimulus that ripples throughout the economy. As economist William Baumol and his colleagues properly noted, real economic miracles come from long-run productivity gains (Baumol et al. 1992). And ACEEE (2007), the McKinsey Global Institute (2006), the UN Foundation (2007), and others have noted, energy-efficient technologies drive many of these productivity gains.

Despite energy efficiency's steady contributions to the economy, it has been operating as more of a stealth technology than a visible part of our economy. Its financial impact has been difficult to discern because the required data have not been compiled and analyzed in the right framework. While some analysts do measure the aggregate energy savings impacts of efficient technologies, data on the associated investments have remained scattered and thus hidden. The resulting invisibility of the efficiency market has obscured its massive size and its even greater investment potential. But as we discuss below, there are a number of emerging market forces that are increasing the emphasis on energy productivity.

"Six Degrees of Preparation" for the Emerging Efficiency Market:

Six major forces are driving the renewed focus on energy efficiency:

> Forecasters generally agree that the era of cheap energy is over.

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

Climate urgency. The recent Fourth Assessment reports by the Intergovernmental Panel on Climate Change (IPCC 2007) have effectively ended the scientific debate on global warming. Pressure is mounting for the U.S. to take serious policy action to reduce greenhouse gas emissions. Efficiency is generally acknowledged to be the lowest-cost and fastest-to-deploy resource to slow the growth of carbon dioxide emissions—and it does this while producing positive economic impacts. It is thus known as a "no-regrets" climate policy, because it makes economic sense in addition to its effectiveness in mitigating climate change.

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

The supply straitjacket. Underlying 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 (Elliott 2006).

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. 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. 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.

Global competition. With the increased globalization of business, multinational companies are encountering increasingly stringent climate policies and regulations. These are driving increased efficiency investments (among other environmental improvements) to achieve compliance. At the same time, many companies are pursuing the business potential in the "clean tech" sector. In this context, efficiency is 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 (Rosenfield 2007).

Better mousetraps. A wealth of energy efficiency technology advancements are nearing market readiness. Ford Motor Company has announced a "paint shop of the future" that avoids the conventional three-step, energy-intensive paint application process. The new process applies all three coats at once and captures the fumes to generate electricity, saving $7 to $11 per vehicle. In the high tech world, microprocessor makers are driving performance per watt to new frontiers. For example, 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.[4] Even online banking and recycling of clothes provide "new technologies" that can save energy.

These six factors together have created a new and fertile environment for energy efficiency investment. If investment is the key to unlocking the vast potential benefits of energy efficiency, the next important task is to reveal the hidden scope of America's energy efficiency market.

How Big Is the Energy Efficiency Market Today?

Because it is so fragmented and dispersed, it has been difficult to define and quantify the "energy efficiency resource." This phenomenon is an example of what economist call "search costs", "transaction costs", or "information costs", which comprise one of the classic market barriers that chronically inhibit efficiency investment. The time and (imputed) cost of identifying and evaluating efficiency investments stops millions of worthwhile transactions from happening. For example, research has shown that industrial energy efficiency investments often have a four-year-or-less payback (roughly comparable to a 25 percent return) based on energy savings alone. Including other productivity gains in water, feedstock, or labor costs can reduce the payback period to two years or less (Worrell et al 2003). Yet these investments are routinely overlooked, partly because the full range of benefits is not routinely or easily identified. In smaller business and homes, which account for a much larger fraction of total U.S. energy use, efficiency opportunities may be even less obvious, and the engineering skills to bring about those savings less readily available. For these reasons, a concerted and policy-driven effort is needed to find the "gold nuggets" of efficiency in the vast "ore" of the American building stock and industrial infrastructure.

To answer the question of "how big is the energy efficiency market?", ACEEE recently launched a project to quantify this complex issue systematically. The study combined a "top-down" statistical assessment with a "bottom-up" technology review to make preliminary estimates of the size of current annual investments in energy efficient technologies (Laitner et al. 2007). While the study continues to work on refining its estimates, *the initial estimation suggests that energy efficiency investments are now on the order of $200 billion annually.* In other words, adding up all of the investments in "energy efficiency infrastructure" in 2004, about $200 billion was spent on building structures, consumer products, and commercial equipment that are considered energy-efficient (such as Energy Star™ computers and refrigerators) together with more energy-efficient cars, trucks and industrial equipment. *By comparison, summing up the investments in conventional energy infrastructure by U.S. energy companies—including new power plants, oil and gas wells, and new transmission lines, etc.—indicates that about $100 billion was spent on energy supply infrastructure investments in the same year.*

This initial assessment produces the startling finding that *the "energy services" infrastructure market is substantially larger than the "energy supply" infrastructure market.* Based on their working estimates, ACEEE concludes that the U.S. currently spends roughly twice as much each year on efficient technologies as on all of the energy supply projects built nationwide. Moreover, it is important to note that the energy-efficient technology investments that were identified for this preliminarily study account for only a fraction of the total "energy services" infrastructure investment. In this sense, estimates of size of the energy services side of the economy are likely to be understated and may be several times larger than the energy supply side. Given the conservative nature of the estimates, the actual investment opportunity may be much larger than current estimates suggest.

While these preliminary estimates provide an emerging picture of the current size of the efficiency market, the critical question behind improving the nation's energy independence and reducing our carbon footprint is: How much additional gain in energy efficiency is possible in the future?

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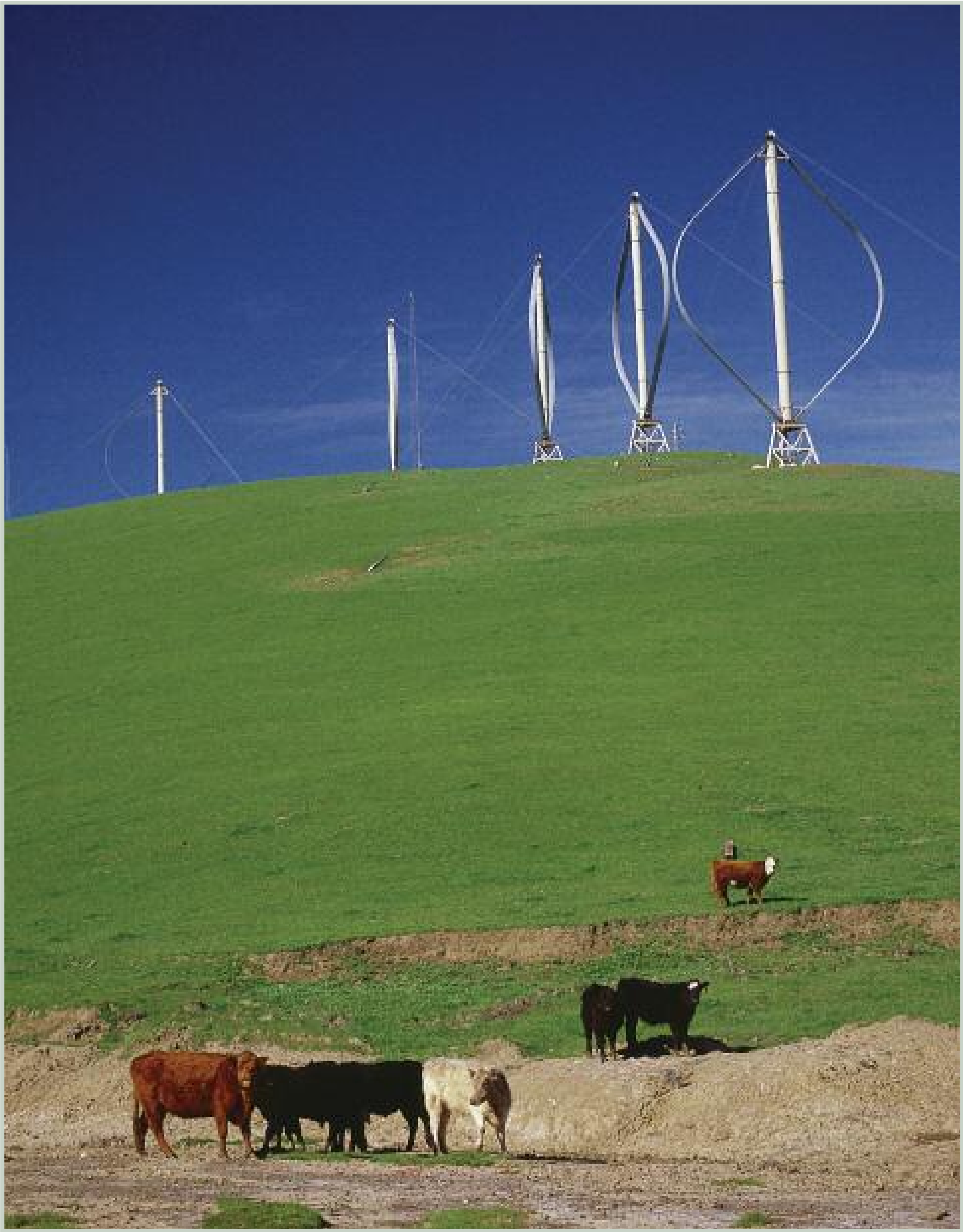
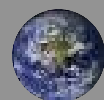


The Future Potential of Energy Efficiency

"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" (*Red Herring,* 8/19/2006). As we shall see, this is, indeed, the case.



While the size and growth of U.S. energy demand is significant, it would be much greater without the contributions from energy efficient technologies.

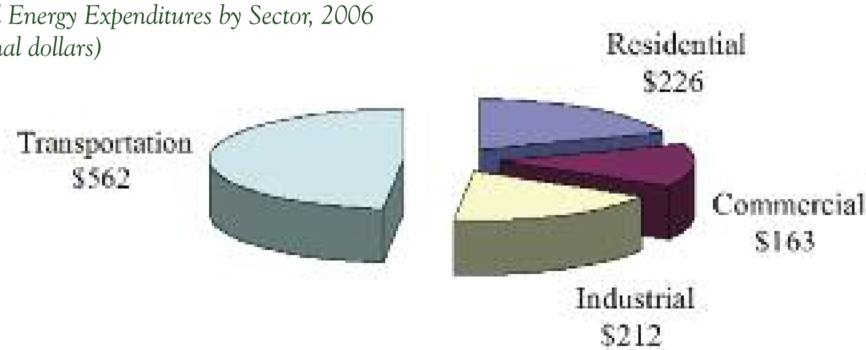
While ACEEE's preliminary assessment indicates an efficiency market that is already quite large, the more important question is how much larger can it ultimately be? And how rapidly it can be developed? The previously-noted United Nations Foundation study (2007) calls energy efficiency both the largest, and least expensive, energy resource. Based on their peer-reviewed assessment, the study suggests that the G-8 and other nations could double historical rates of efficiency improvement by 2030. If the United States were to follow that course—and other ACEEE studies show this is a cost-effective policy path—U.S. energy consumption in 2030 would not exceed the current forecast for 2013. McKinsey Global Insight's recent study of global energy efficiency potential indicates that in North America, all future energy service demand growth can be met through cost-effective efficiency investments (McKinsey 2006). This means that the economy would grow at current forecast rates, but that the growth of energy demand would flatten out. Another analysis completed by the Argonne National Laboratory suggested that a technology-based, investment-driven energy policy could hold energy use at roughly 2000 levels through the year 2050(citation). At the same time, the combination of energy efficiency and clean energy technologies such as renewable energy and combined heat and power systems could actually *reduce energy-related carbon dioxide emissions down to 1963 levels*—despite an economy that is projected to be about three times bigger than today (Hanson et al. 2004).

While definitive estimates are premature, ACEEE analysts scaled up their current research findings to project the impacts of accelerated market transformation through rapidly increased energy-efficient investments. Current findings are based on rather modest rates of return on average efficiency investments—equivalent to about a two-year payback in simple terms. Assuming that policies, market forces, and new financing mechanisms facilitate substantial movement "up the cost curve" to longer-payback investments, they posited a future in which businesses and consumers might invest in new technologies based on an average five-year payback. In that scenario, *annual investment in energy efficient technology would become a $400 billion market. Cumulatively, the total "efficiency infrastructure" investment would reach nearly $5 trillion over the 2008-2030 period.*

Where the Savings Are: Energy Efficiency across Economic Sectors

Notwithstanding the efficiency gains of the last three decades, the United States remains the world's largest energy consumer. We are currently about 5% of the world population, but we consume about 23% of the world's total energy needs (EIA 2006). Our demand for energy continues to grow as population, economic growth, and energy service demands continue to expand. Between 1970 and 2006, total annual energy consumption in the U.S. grew by 47%, from 68 to 100 quadrillion Btus per year.[5] While the size and growth of U.S. energy demand is significant, it would be much greater without the contributions from energy efficient technologies. Without advancements in efficiency, U.S. energy consumption in 2006 would have doubled, surpassing 200 quadrillion Btus (see Figure 2). Looked at another way, efficiency has doubled U.S. energy productivity, enabling the economy to expand and the quality of life to improve at much lower levels of energy consumption per unit of economic output. The sections that follow describe energy use and efficiency opportunities as they occur in key sectors of the economy.

Figure 2. U.S. Annual Energy Expenditures by Sector, 2006
(billion nominal dollars)



Source: U.S Department of Energy, Annual Energy Outlook 2007

Industry: Industrial production—including agriculture, construction, mining, and manufacturing—accounts for a third of total U.S. energy consumption, and despite already substantial efficiency gains represents a large source of energy efficiency potential. Looking at the chart in Figure 2, *the industrial sector spent 212 billion dollars on energy in 2006*, consuming 33 quadrillion Btu (or about one-third of our nation's energy needs). Industrial efficiency opportunities can be grouped in two broad categories: those measures that involve capital investments and new technologies (i.e. the use of more energy-efficient motors and industrial processes, and the installation of combined heat and power technologies); and low-cost/no-cost measures that involve changes in operating or maintenance practices.

Total capital investments in the manufacturing sector alone were $128 billion in 2005. While firms are actively pursuing improvements in efficiency,it is not completely clear at this point what proportion of those investments are being made for this purpose. Data from the Department of Energy's Manufacturing Energy Consumption Survey indicate that 40% of manufacturing industries participated in some type of energy efficiency activity during the previous year. These activities ranged from energy audits to power factor corrections. A smaller, but significant, percent of firms reported installing or retrofitting equipment for the primary purpose of improving energy efficiency. From a cost perspective, data from the Department of Energy's Industrial Assessment Center Database on small and medium sized manufacturers indicates that every dollar invested in efficiency yielded an annual return of $5-$9.

While these limited data points are encouraging, they represent only a small fraction of the potential energy savings that could be accomplished through efficiency investments. A 2006 ACEEE study on the topic revealed that low-cost efficiency opportunities exist in all parts of the industrial sector, and that at least 18% of electricity usage could be saved cost-effectively.

In addition, the switch to more productive combined heat and power technologies—in effect, the use of a single, on-site source of thermal energy to provide both heat and electricity to manufacturing plants rather than buying natural gas for heating separately from electricity purchase—could double the efficiencies of power generation in the industrial sector. Other potential savings include the recycling of chemical feedstocks, the use of energy management systems to optimize overall production, and new product designs that, in turn, lower energy used for technologies sold to other sectors of the economy.

Buildings: The "built environment" holds by far the largest portion of the energy services infrastructure. Energy use in residential and commercial buildings accounts for the largest fraction—about 40%—of total U.S. energy consumption. Residential consumption represents a little more than half of building-related energy consumption; energy consumption in both residential and commercial buildings has continued to increase over the past 25 years.

Since 1970 the number of residential households increased by 80% to 114 million residential units in 2006. While the energy use per square foot is generally lower for newly constructed houses, the trend toward larger houses has offset much of these efficiency gains. *In 2006 household energy expenditures were estimated at nearly $226 billion dollars.*

Energy use per square foot in commercial buildings is approximately double that of residential buildings. According to the Commercial Buildings Energy Consumption Survey, *there are currently more than 5 million commercial buildings in the United States with more than 75 billion square feet of floor space. In 2006, total energy expenditures were estimated at $163 billion dollars.*

Heating, cooling, lighting, and water heating represent the primary energy end-uses in commercial and residential buildings. But there is a rapid growth in "plug loads" like consumer appliances and office equipment and electronics. Building-related efficiency investments have focused both on whole-building designs, using building orientation, high-performance materials, and high-efficiency energy systems in new construction, and on products that reduce energy consumption compared to the units they replace, in equipment replacement markets. Energy efficient technologies include thermal insulation, high efficiency windows and doors, high-efficiency lighting, high efficiency furnaces and air conditioners, and efficient appliances and electronics.

The opportunities to promote energy efficiency in buildings range from the simple to the more complex; but all can save a significant amount of energy and money. For example, if consumers do all of their banking and pay their bills online rather than by writing and sending checks, we would save more than 29 trillion BTUs, more than enough energy to provide the energy needs of 150,000 households for one year (Van Dyke 2007). Improved management of consumer electronics and office equipment (e.g., turning off computers when not being used and buying the more energy-efficient models of these products) could save more than 40% of the electricity needed for these products. That savings is sufficiently large to provide the electricity needs for about 30 million households. Similarly, if we switch to the more efficient compact fluorescent lamps or light emitting diodes, in all of our buildings, we might save enough electricity to power another 30 millions households annually. And the list does not stop there. By using better building materials, recycling carpets and clothes, reducing the amount of packaging in the things we buy, using more efficient windows, washing machines, and air-conditioning systems, consumers and businesses can save even more energy and money.

Transportation: Although we discuss potential efficiency gains in transportation more completely in the next chapter we provide a short background here. Commercial and noncommercial transportation consume some 28% of total energy used in the United States, or approximately 28 quadrillion Btus per year. The vast majority (80%) of transportation-related energy is consumed by an estimated *235 million motor vehicles. This large vehicle fleet consumed 179 billion gallons of fuel and drove nearly 3 trillion miles in 2006.* Since 1970, motor vehicle fuel consumption has increased almost 90%. Most of the increase stems from 120% growth in the number of vehicles and 160% growth in the total number of miles driven. While efficiency improvements have occurred in vehicle technologies, most of these improvements have been applied to increased horsepower, increased acceleration performance, and to propelling heavier vehicle weights. Fleet average fuel economy has thus stagnated and even slightly declined since the late 1980s.

Investments in improving fuel efficiency hold the most promise in reducing transportation-related energy consumption. By simply increasing average fuel efficiency by 5 miles per gallon, we could reduce our annual fuel consumption by nearly 41 billion gallons which would represent an energy cost savings of nearly $110 billion at current fuel prices. The efficiency potential of gas/electric hybrids and plug-in technologies hold much promise. Other investments have focused on efficiency gains associated with public transportation and reducing freight truck idling.

Utilities: Electric utilities consume some 40% of the total primary energy used in the United States. Powerplant generation fossil fuels are second only to oil used in transportation as a source of greenhouse gas emissions. However, due to thermal losses in generation and transmission, some two-thirds of the primary energy input to U.S. power plants is lost as waste heat. This level of inefficiency is virtually unchanged since the 1960s. What we waste in the generation of electricity in the U.S. is more than Japan uses to fuel its entire economy. Efficiency opportunities in the electric utility sector are of two kinds: generation improvements that reduce waste heat losses, and end-use efficiency improvements that reduce electricity consumption.

Power system efficiencies can be greatly improved through Combined Heat and Power (CHP) technologies. CHP produces both thermal and electric energy from one system, achieving net thermal efficiencies in the 70-90% range, more than twice the 33-35% average thermal efficiency of today's thermal powerplant fleet. CHP can be applied at the powerplant level, in industrial plants, and in commercial and institutional facilities like hospitals, college campuses, and large retail stores.

Since the great majority of electric utility output is used in buildings, the buildings sector is the most profitable focus for electricity end-use efficiency investments. CHP systems can be pursued in larger buildings, but the majority of electricity efficiency improvements are available in the lighting, cooling, appliance, and electronics technologies described above. *ACEEE research shows that some 25% of total electricity usage can be saved cost-effectively, at an average cost of 3 cents or less per saved kilowatt-hour (kWh). New generation sources cost 5 cents or more per kWh, making efficiency the lowest-cost electricity resource.*

Utilities also present a policy paradox. On one hand, they are in one of the best positions to serve as natural aggregators for efficiency investment in cooperation with their customers; on the other, they are confronted with major regulatory barriers to efficiency investments. Some 75% of U.S. customers are served by investor-owned utilities under state regulation; the ratemaking policies in most states continue to base utility pricing and thus revenues on the quantity of energy sold, even though utilities are increasingly fixed-cost "pipes and wires" businesses. This means that most utilities suffer revenue and profit erosion when they help their customers save energy. Regulatory reform is needed to make efficiency investments profitable for utilities as well as customers.

Missing Links: Financing Innovations to Accelerate Efficiency

The overwhelming conclusion is that the energy efficiency resource is grossly underutilized. The public policy challenge, and the challenge for the nation at large, is to embrace energy policies and fashion new financing mechanisms to begin harvesting the massive efficiency opportunities outlined in this paper.

Investments in energy efficiency can be generally characterized as high return and low risk. Adapting an assessment of efficiency investments by the Vanguard Group, returns on efficiency investments are shown to be comparable to small company stocks (between 20 and 30%), while the risks are estimated to be roughly equivalent to U.S. Treasury bills (in the 5-8% range).

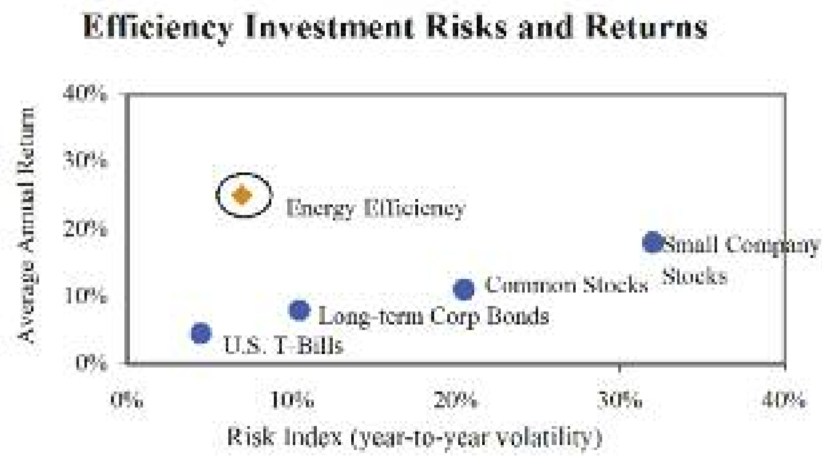


Figure 3. Comparing Efficiency Risks and Returns with Other Typical Investments
Source: Adapted by ACEEE from the U.S. EPA and the Vanguard Group

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 efficiency is so cost-effective, the market will do it anyway."

Market, Regulatory, and Financial Barriers. Efficiency investment has been hobbled by both market barriers and policy barriers, and also suffers 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 (citation), 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 is 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 above 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. 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.

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. The New England Independent System Operator's Locational Installed Capacity market has just created a new channel for efficiency and other demand-side investments, which may spread to other regions. Some 10 states have developed Energy Efficiency Resource Standards that may drive efficiency initiatives to new heights. Through the National Action Plan for Energy Efficiency and other initiatives, this total is expected to grow.

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 mortgages to include financing of energy efficiency measures. 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 stimulators of energy efficiency measures through their commercial real estate portfolios. Current federal tax incentives and other mechanisms could help drive increased efficiency investment in this key sector.

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. With greater policy support, these mechanisms could be used much more widely.
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 energy efficient technologies. ACEEE's emerging technologies reports show dozens of attractive possibilities: solid-state and other advanced lighting technologies have attracted substantial venture capital; 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.

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. 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 efficient technologies. This phenomenon complicates efforts to create a dedicated "energy efficiency" stock fund.

Despite the difficulties, there are encouraging signs that efficiency is gaining ground in the investment community. For example, 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. These new index futures and options will be available via an electronic trading platform to investors, risk managers and traders around the world. 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 Road Not Yet (But Soon to Be) Taken

Energy efficiency is a surprisingly big business. But the untapped opportunities of efficiency are even bigger. The potential efficiency gains that we describe in this chapter are only a first attempt at providing a preliminary picture of the opportunities and challenges associated with energy efficiency. The good news is that the market is beginning to respond to that opportunity. Wal-Mart, for example, plans to reduce packaging needs by 5% starting in 2008. This single action by the world's largest retailer can save enough energy to meet the full energy needs of some 60,000 households in the United States. Likewise, Intel has plans to introduce even greater efficiencies into their computer chips in ways that will provide further gains to the U.S. economy. And major chemical companies like Dow and DuPont are both improving their overall energy efficiencies as well as designing new consumer products that can save even more energy in households and businesses.

But if the urgent imperative of climate change is to be taken seriously, the actions of a few business leaders and select group of corporate innovators may be insufficient. From a technology perspective we have the resources and the know-how to significantly reduce our future energy demands, and to do so in ways that sustain a robust economy while also reducing greenhouse gas emissions. The question remains—to what extent will we choose to shape and build on those opportunities? The challenge for both public policy and the private market is to define new investment opportunities and policy pathways that can unleash the trillions of dollars of energy-efficient technology investments that will be required to meet both our 21st century energy needs and climate challenges.

ENDNOTES

[1] Because of its significant impact on oil consumption as well as emissions of greenhouse gas emissions, transportation efficiency improvements will be discussed more fully in the next chapter.
[2] In this example, "energy efficiency" is broadly defined as the difference between the 1970 and 2006 energy intensities and market structure. Some analysts might suggest that changing market structure – for example, moving away from a manufacturing to a service-based economy – doesn't constitute real efficiency gains. However, we adopt the view that moving toward a higher valued added economy that is also less energy-intensive is an appropriate "efficiency" gain for the United States.
[3] An immediate observation that one might consider is that if energy efficiency has delivered by a margin of three to one, but costs only twice as much then energy efficient technologies are more often than not the more cost-effective technologies compared to new energy supply resources. Indeed, this is exactly what a number of widely-accepted studies suggest. See, for example, McKinsey (2006) and the UN Foundation (2007), among many others.
[4] A "teraflop" is a processing speed of one trillion floating-point operations per second. It is a speed associated with supercomputers.
[5] A Btu refers to a "British thermal unit" which is about the amount of heat given off by one wooden kitchen match. There are about 125,000 Btus (or wooden kitchen matches) in a gallon of gasoline, for example. If we convert all forms of our current energy use to an equivalent gallon of gasoline, and if we in turn express this on a per capita basis, it turns out that the U.S. economy now requires about 2,700 gallons of gasoline equivalent per year for every man, woman, and child now living in the United States.

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Author Biography

John A. "Skip" Laitner is the Senior Economist for Technology Policy for the American Council for an Energy-Efficient Economy (ACEEE). He previously served almost 10 years in a similar capacity for the US Environmental Protection Agency (EPA), but chose to leave the federal service in June 2006 to focus his research on developing a more robust analytical characterization of energy efficiency resources within energy and climate policy analyses and within economic policy models.

In 1998 Skip was awarded EPA's Gold Medal for his work with a team of other EPA economists to evaluate the impact of different strategies that might assist in the implementation of greenhouse gas emissions reduction policies. In 2003 the US Combined Heat and Power Association gave him an award to acknowledge his contributions to the policy development of that industry. In 2004 his paper, “How Far Energy Efficiency?” catalyzed new research into the proper characterization of efficiency as a long-term resource.

Author of more than 150 reports, journal articles and book chapters, Skip has more than 35 years of involvement in the environmental and energy policy arenas. He’s been invited to provide technical seminars in such diverse places as Australia, Canada, China, France, Germany, Korea, South Africa and Spain. He recently served as an adjunct faculty member at the Virginia Polytechnic Institute and State University, teaching a graduate course on the Economics of Technology in the Science and Technology Studies program. He has a master’s degree in Resource Economics from Antioch University in Yellow Springs, OH.

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