The Positive Economics of Climate Change Policies: What the Historical Evidence Can Tell Us

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FOREWORD: THE POSITIVE ASPECT OF CLIMATE CHANGE ECONOMICS

Energy efficiency has been the cheapest and largest resource to satisfy growing demands for energy-related services in the U.S. economy. Indeed, productive investments and informed behaviors have enabled energy efficiency to meet three-fourths of the growth in new energy service demands since 1970. As my colleague Skip Laitner and I documented in an earlier ACEEE report (*The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture,* May 2008), we are clearly making positive strides toward increasing our nation's energy productivity and reducing our carbon footprint.

Yet, the analysis we did last year, the new study by McKinsey (2009), and many other recent assessments all suggest that we have only begun to scratch the surface of the potential. In short, the opportunity for greater efficiency gains is huge. If that is the case, the question must be asked why most economic assessments of current climate change policies either ignore or greatly understate the potential advances in energy efficiency — the largest and most cost-effective form of greenhouse gas mitigation?

The present study assesses the historical track record by comparing previous forecasts of energy consumption to what has actually happened within the U.S. economy. The assessment reveals important discrepancies between forecasts and reality. Among the notable trends, the energy efficiency market tends to be more dynamic than economic policy models generally assume. The implications are critical for current climate change policy assessments — all of which are currently based on underspecified models that underestimate the importance of the efficiency resource.

In a recent discussion of this dilemma, climate policy expert and economist James Barrett notes that "in contrast to climate policies based on international offsets and so-called flexibility mechanisms, an efficiency-powered policy can provide a benefit to the climate while actually causing a small but net positive increase in the nation's economy and employment."

Given the growing recognition and interest in securing the unrealized benefits of potential efficiency improvements, it remains unclear why economic assessments of current climate change policies continue to overlook and understate the large and cost-effective benefits that energy efficiency can provide as a means of mitigating greenhouse gas emissions. One explanation is based on the recognition that energy efficiency is in many ways an *invisible* energy resource. It is the energy we don't use in meeting our nation's many demands for goods and services.

The fragmented and invisible nature of efficiency makes it hard to model. In addition, a new McKinsey study also identifies important barriers that stand in the way of efforts to unlock the full potential of existing efficiency resources. Importantly, however, an examination of the historical data provides strong evidence that the development of new technologies and social structures can be (and often has been) an effective means of overcoming constraints to efficiency. Nevertheless, current economic models systematically fail to incorporate these historical realities or question embedded assumptions regarding the continued presence of efficiency barriers. As such, the likely future dissolution of those barriers is rarely considered.

The present study provides an invaluable contribution to the current literature on climate change mitigation and modeling by assessing the shortcomings of current climate change policy models in light of the historical record and provides a critical assessment of the gap between the historical track record and energy consumption forecasts. The implications for climate policy and the economy are serious, suggesting that energy efficiency could play a much larger role as a cost-effective means of reducing greenhouse gas emissions.

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EXECUTIVE SUMMARY

Most economic policy models now suggest a significantly negative impact on the economy if U.S. policymakers choose to reduce greenhouse gas emissions to any significant extent. There are a number of reasons for these inappropriate outcomes. Primarily, they are an artifact of the models and not the data. By turning to the historical record in the United States we can examine recent data to inform policymakers and business leaders what the economic policy models should be saying about energy and climate change policies. We can also use this historical record to perform a diagnostic assessment of recent modeling exercises – all in an effort to improve our understanding of missed opportunities.

Based on the available record and the economic evidence to date, energy efficiency is a substantially larger and more cost-effective resource than most economic policy models now acknowledge. There are a number of exceptions, but these have generally been overlooked within the energy and climate policy discussions now taking place. Those exceptions, together with the available evidence now before us, suggest that affordable policies can enable consumers and businesses to make more productive investments that, in turn, can improve their energy productivity. That improved energy productivity can also enable the U.S. economy to save money while substantially reducing its greenhouse gas emissions by mid-century. Of course, energy savings are just the easiest benefit of energy efficiency to quantify but these investments return a host of other valuable economic and environmental benefits, including but not limited to improved energy security and better air quality that would lead to improvement in public health, and decreased health costs.

The economic data and the historical record suggest that:

- Energy efficiency investments can provide up to one-half of the needed greenhouses gas emissions reductions most scientists say are needed between now and the year 2050.

- Investments in more energy-productive technologies can also lead to a substantial net energy bill savings for the consumer and for the nation’s businesses. In the diagnostic assessment summarized in this report, savings are on the order of two trillion dollars by 2050 (measured in constant 2007 dollars).

- Non-energy expenditures within the U.S. tend to be more labor-intensive and provide a greater rate of contribution to the nation’s Gross Domestic Product compared to expenditures on conventional energy supplies. Instead of taking jobs away from the economy, the diagnostic assessment described in this report suggests a small but net positive gain in the economy.

- Hence, shifting away from the production and consumption of conventional energy resources, in favor of more productive investments in energy-efficient technologies, can lead to a more robust economy and to a greater level of overall employment opportunities with the U.S.

Building on the available economic data and the larger historical data, the American Council for an Energy-Efficient Economy (ACEEE) developed a diagnostic review to evaluate the recent assessments of proposed climate change legislation now before the U.S. Congress. In particular, previous climate policy assessments focused on HR 2454, the Waxman-Markey Bill that is known more formally as the American Clean Energy and Security Act of 2009. The legislation passed the U.S. House of Representatives on June 26, 2009 by a narrow margin of 219 to 212. It is now under consideration by the U.S. Senate.

Table ES-1 below highlights ACEEE’s key findings of its diagnostic review. The data provide a comparison of the anticipated “business-as-usual” reference case in the first data column for the year 2050 with the impacts in the second data column of the HR 2454 climate policy as it was modeled by EPA and others. The last data column of Table ES-1 also provides an alternative assessment based on two things. The first is a greater reliance on productive energy efficiency and clean energy technology investments. The second is a more appropriate accounting for the economic impacts of the policy and program costs as well as the technology investments and resulting energy bill savings. As suggested by several of the data in Table ES-1, the energy bill savings associated with a greater level of efficiency improvement can actually drive a small but net positive gain in the nation's GDP.

Table ES-1. Representative Climate Policy Impacts for the U.S. in 2050

	Reference[1]	Typical[2]	ACEEE[3]
Baseline Total Greenhouse Gas Emissions ($MtCO_2e$)	8,379	8,379	8,379
Actual Domestic Emissions ($MtCO_2e$)	8,379	5,102	1,212
Primary Energy (Quadrillion Btu)	129	115	64
Primary Energy Price (2007$/Million Btu)	$32.39	$41.13	$33.49
Energy Bill (Billion 2007$)	$4,175	$4,718	$2,130
International Permit Cost (Billion 2007$)	$0	$67	$0
Incremental Annualized Investment (Billion 2007$)	$0	$80	$527
Program/Policy Costs (Billion 2007$)	$0	$9	$39
Total Resource Cost (Billion 2007$)	$4,175	$4,874	$2,696
Change in Resource Cost (Billion 2007$)	—	$699	-$1,479
Net Impact on GDP (Billion 2007$)	—	-$229	$456

1. Reference scenario – outcomes expected absent a policy such as HR 2454.
2. Typical – Policy outcomes expected with modeling as undertaken by EPA and others.
3. ACEEE – Outcomes expected following ACEEE assumptions and modeling methods

In presenting these results one significant caveat is in order. These results should not be construed as the likely impacts of HR 2454 or other similar climate policy as such. Rather, the intent of this diagnostic review is to highlight critical missing assumptions that would likely change many of the modeling results done to date. On the other hand, these results can be generally seen as suggesting small but net positive impacts that would likely accrue should climate policy drive more productive technology investments than is generally indicated by past modeling assessments.

ABOUT ACEEE

The American Council for an Energy-Efficient Economy (ACEEE) is a nonprofit research organization dedicated to advancing energy efficiency as a means of promoting economic prosperity, energy security, and environmental protection. For more information, see http://www.aceee.org. ACEEE fulfills its mission by:

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

Projects are carried out by staff and selected energy efficiency experts from universities, national laboratories, and the private sector. Collaboration is the key to ACEEE's ongoing success. We collaborate on projects and initiatives with dozens of organizations including international, federal, and state agencies as well as businesses, utilities, research institutions, and public interest groups.

Support for our work comes from a broad range of foundations, governmental organizations, research institutes, utilities, and corporations.

ACKNOWLEDGMENTS

Both the American Council for an Energy-Efficient Economy (ACEEE) and I would like to express our deep appreciation to the Energy Foundation and the Sea Change Foundation for their active support of this research, and to our many allies and collaborators who have contributed to our deeper understanding about the critical role that more productive investments can have in reducing our nation's dependence on conventional energy resources and also reducing overall levels of greenhouse gas emissions. I gratefully acknowledge the individual contributions of my peer reviewers including James Barrett, Chris Busch, and Don Hanson. Each of them provided useful insights which have been incorporated into this final report. I also want to thank my colleague and fellow researcher Chris Knight who greatly enabled my ability to get this report finished, and also my sometime co-author Karen Ehrhardt-Martinez who said, as I was trying to explain how the change in resource costs could lead to a small but net positive change in GDP, "why don't you just graph it out!" It was a most excellent idea. And also, I extend my thanks for Renee Nida whose patience and careful proofing made it easier to get it done. As always, the responsibility for the analysis, the findings, and the resulting narrative remains with the author.

I. INTRODUCTION

Over the next 40 years, the United States economy is likely to grow at a reasonably robust level of 2.5 percent annually. Based on estimates from Economy.com (2009), the Gross Domestic Product (GDP) will increase from $14 trillion in 2008 to perhaps $39 trillion in 2050 (with all values expressed in constant 2007 dollars to eliminate the effects of inflation). This is more than a doubling of the overall scale of our economy. At the same time, total employment is expected to grow from roughly 145 million jobs in 2008 to as many as 205 million jobs by 2050.[1] While the economy is expected to slow compared to the growth we witnessed in previous decades (the growth in GDP averaged more than a percentage point higher in the preceding 30 years, for example), the per capita income recorded in 2008 is still expected to increase by about 90 percent by 2050. This projected level of economic activity presumes, among other things, a conventional pattern of energy production and consumption. It also presumes a straightforward extension of current production patterns of regional goods and services.

As business leaders and policymakers respond to growing concerns about global climate change, they are looking for insights into how new climate policies might impact the U.S. economy. The question of, course, is whether the economic changes required by climate policy will result in an increase or decrease in consumption, production, and employment levels? In other words, if the United States were to change its mix of energy and technology investments away from the heretofore typical patterns and toward more productive energy efficiency and renewable energy technologies, would this new mix of investments yield a higher rate of return? And would that rate of return be high enough to offset the costs inherent in making a fundamental economic transition such as this? Finally, if businesses and households were to substitute other production processes that eliminate or sequester non-energy-related greenhouse gas emissions, how would that also impact overall economic activity within the nation? Even a cursory review of the technology assessment literature indicates that there are, indeed, many opportunities to reduce total greenhouse gas emissions by a substantial margin over time (see, for example, ACEEE 2009 and McKinsey 2009). But what are the costs and benefits, and how might they impact the larger national economy?

The good news here is that there are two early, promising clues as to how a dynamic climate action strategy might potentially and positively impact the U.S. economy. The first clue is whether the changed patterns of production are deemed cost-effective over time. That is, if we can reasonably conclude that the financial benefits outweigh the costs over the next decades, then we might expect to see a small but still net positive impact on the national economy. The second clue is whether the labor and the value-added intensities associated with any changed spending patterns are greater or smaller than the same intensities as in the reference case. For example, if a dollar's worth of spending contributes to a slightly greater level of employment in the climate policy scenario compared to the reference case, then we might expect to see a small net increase in jobs within national economy. Similarly, if the changed spending and investment patterns produces a slightly larger boost to the nation's value-added as measured by the GDP, then we might expect to see a positive impact there as well.

In the discussion that follows, it turns out that we are likely to find important, positive changes in the magnitude and in the patterns of overall spending for a given climate strategy similar to that outlined in recent legislation passed by the House of Representative.[2] These changes range from a greater level of productive investments to greater spending on complementary programs and policies that ease the transition to a low-carbon future. More critically, the program spending and the changed pattern of investments have significant benefits. In effect, a climate policy scenario represents a different recipe of technology investments compared to the assumed reference case. Yet the

[1] The current forecasts now available from Economy.com extend out to the year 2039. With some judgment applied to that data set, in effect assuming a post-2039 population growth of just over 0.9 percent and a productivity growth slightly larger than 1.5 percent annually, we can provide a reasonably projection out to the year 2050.
[2] H.R. 2454, the American Clean Energy and Security Act of 2009, also known as the Waxman-Markey Bill, was passed by the U.S. House of Representatives by a vote of 219–212 on June 26, 2009.

evidence points to a productive return on those investments – ones that enables the economy to substantially reduce overall greenhouse gas emissions. And as it turns out, the job and value-added returns are slightly greater for the policy initiative characterized in this report.

In short, the available evidence and the historical record indicates that we should expect to see a small but net positive gain for the U.S. economy both in terms of employment and income as a result of a more productive pattern of innovation and technology investments. Changing our investment mix away from traditional, energy-intensive patterns toward one that emphasizes more productive technology and behavior, greater energy efficiency, and more labor-intensive activities can yield higher rates of economic growth and lower economic and environmental costs. In many ways, this is much like the rebalancing of a retirement portfolio to take advantage of changing market conditions and new growth opportunities. While it is important to focus on the potential gains from such a rebalancing, it is equally important to acknowledge the other side of the coin: that remaining on our traditional investment pathway must necessarily lead to lower growth, fewer employment opportunities, and higher environmental costs.

The balance of this report tries to accomplish four things. First, it provides a review of the available historical record and discusses how that set of insights might inform our expectations of economic policy assessments — specifically in the context of how energy efficiency investments might positively impact economic and climate policy outcomes. Second, it describes how the historical context might frame a more appropriate accounting of production patterns that emphasize the potential for greater energy productivity and its resulting impact on the larger economy. Third, it provides a diagnostic review of recent modeling assessments of the climate policy bill that recently passed the U.S. House of Representatives. In carrying out that diagnostic assessment, the analysis specifically shows how a greater level of energy efficiency investments and a more suitable treatment of the resulting costs and benefits might impact the nation's economy differently than is normally suggested by conventional economic policy models. Finally, the report offers several added insights to further underscore the suggestion that the U.S. economy does, indeed, have the opportunity to transition its energy and greenhouse gas emissions markets into a more sustainable system of production and consumption, and to do so in ways that benefit the economy and the climate. The technical details associated with the various economic assumptions are highlighted in a short appendix to this chapter.

II. WHAT THE EVIDENCE SUGGESTS

Energy efficiency has played a surprisingly enduring and critical role in our nation's economy. In the sections that follow, the report documents both the past scale of the energy efficiency resource as it has powered the nation's economy. It also examines what we know about the costs and energy-saving benefits of the array of energy efficiency technologies and behaviors. The benefits include both reduced energy bills and a surprisingly large set of non-energy benefits ranging from reduced operations and maintenance costs to improved product quality and speed of tasks. From there we examine how the resources that are freed up might drive a small but net positive gain benefit for the nation's unemployed or underemployed. The last subsection suggests what we also know about driving changes through programs and policies as a complement to the price signal. In effect, if we have positive non-price signals, then it may require a substantially moderated set of prices to promote the smarter set of investments that can deliver these larger benefits. Put differently, the historical record indicates that a smart set of complementary policies with an emphasis on energy efficiency will produce important economic benefits.

A. Historical Impact of Energy Efficiency

As one of the richest and more technologically advanced regions of the world, the United States has expanded its economic output by more than three-fold since 1970. Per capita incomes are also twice as large today compared to incomes in 1970. Notably, however, the demand for energy and power resources grew by only 50 percent during the same period.[3] This decoupling of economic growth and energy consumption is a function of increased energy productivity: in effect, the ability to generate greater economic output, but to do so with less energy. Having achieved these past gains with a haphazard and often counterproductive approach to energy efficiency and energy policy, there is compelling evidence to suggest that even greater energy productivity benefits can be achieved. Indeed, business leaders and policymakers may be surprised to learn just how big of a role that energy efficiency has already played in supporting the growth of our economy over time. Figure 1 examines the historical context of efficiency gains estimated through 2008 as they compare to the development of new energy supplies since 1970. Figure 1 also illustrates the level of new energy supply that would have been needed in the absence of energy productivity gains due to efficiency measures. In effect, it compares the projected level of energy consumption in 2008 to that which might have been necessary had the economy continued to rely on 1970 technologies and market structure.[4]

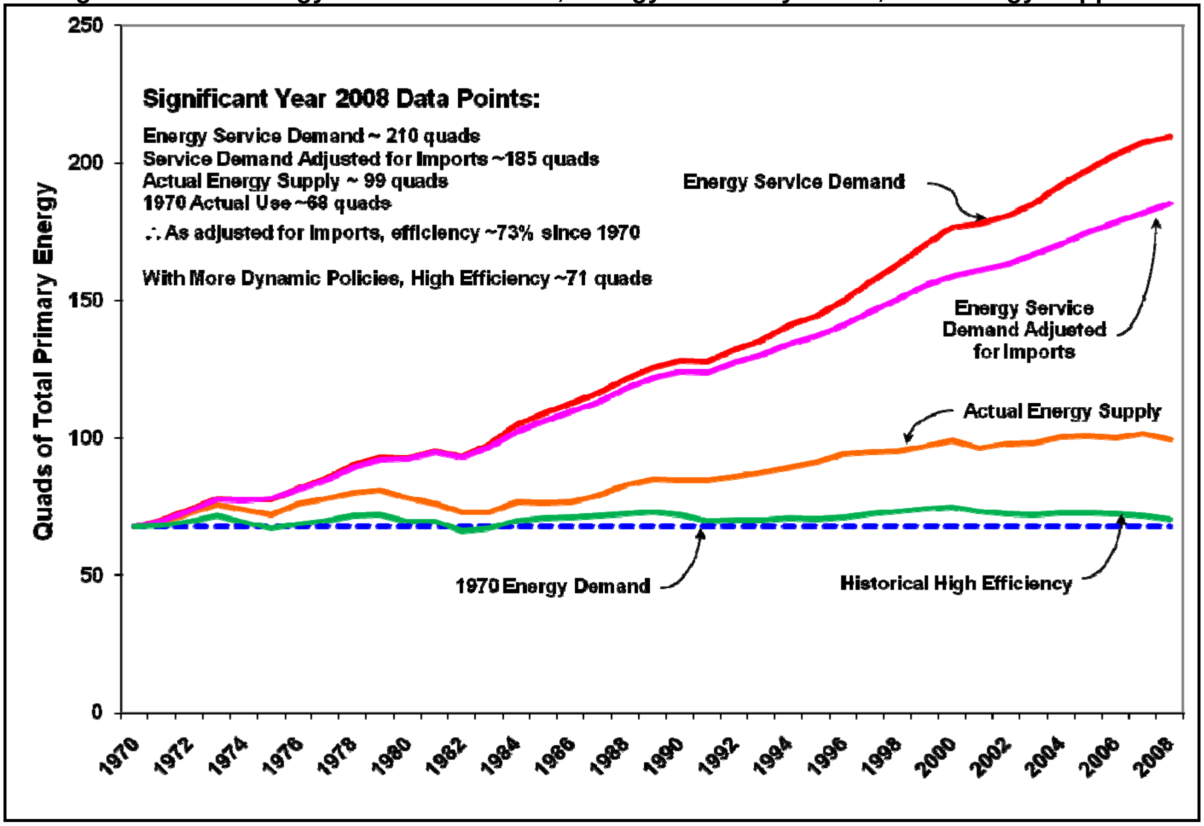
In 1970 Americans consumed an estimated 68 quadrillion Btus (quads) for all uses of energy. These different uses of energy run the gamut from heating and cooling our homes, schools, and businesses to powering our many industrial processes and transporting both people and freight to the various places they needed to go. If we converted all forms of energy consumed in 1970 to an equivalent gallon of gasoline — whether coal, natural gas, or electricity — it turns out that the U.S. economy required about 2,700 gallons of gasoline equivalent for each man, woman, and child living in the U.S. at that time. Had the United States continued to rely on 1970 market structure and technologies to maintain its economic growth, today we would be consuming an estimated 210 quads of energy resources. In per capita terms, that would be equal to roughly 5,500 gallons of gasoline per person. But in fact, the actual level of consumption estimated for 2008 appears to be just over 99 quads of energy (in rounded numbers). Again on a per capita basis, this means that the U.S. economy now requires no more than about 2,600 gallons of gasoline per resident — about 100 gallons less than needed in 1970.

In examining these numbers more closely, however, several important insights deserve to be highlighted. First, although we currently enjoy a much broader set of goods and services in today's economy, we have been able to achieve this expanded level of economic output while maintaining constant levels of energy use per capita. This has been achieved through investments in energy efficiency. Second, although the same level of goods and services hypothetically could have been produced with the consumption of 210 quads of energy per year, we have been able to achieve this level of output with less than half that amount of energy. In effect, investments in energy efficiency have allowed us to reduce total energy use by the equivalent of 111 quadrillion Btus in 2008 (relative to what our energy use would have been without those efficiency gains). Even when we make adjustments to reflect the large number of goods and services that have been imported — things that required energy outside our borders to produce and ship those goods into the United States — the demands for energy services are still 185 quads in 2008. That means energy efficiency has "fueled" about 86 quads, or roughly three-fourths of the *new* growth for energy-related services since 1970. The conventional energy resources, on the other hand, satisfied only one-quarter of the new demands (or about 31 quads, as shown in Figure 1).

[3] These and other economic and energy-related data cited are the author's calculations as they are drawn from various resources available from the Energy Information Administration (2009a and 2009b).

[4] Strictly speaking, the term energy efficiency as used here can be more broadly defined as a reduction in energy intensity; that is, a reduction in the number of Btus needed to support a dollar of economic activity. This change results from two key drivers. The first is a change in market structure as we move away from energy-intensive industries as a source of income to higher value-added services. The second is what we typically think of as energy efficiency — more efficient lighting and consumer products, greater fuel economy in our vehicles, and more efficient power plants and industrial processes. The United States has benefited from both economic drivers; and both were made possible by a combination of behaviors, innovations, and productive technology investments. From a macroeconomic perspective the evidence suggests that anything we can do that positively reduces energy use while maintaining incomes and economic prosperity can be termed "energy efficiency." It is in that larger sense that the term is used in this report.

Figure 1. U.S. Energy Service Demands, Energy Efficiency Gains, and Energy Supplies



Source: Author's calculations based on data from the Energy Information Administration (2009a, 2009b)

One often unappreciated aspect of the growth in energy consumption is what might have been had we previously chosen to develop our energy efficiency resources more completely. For example, a minimum attention to greater energy productivity in the last decades might have kept current energy demands closer to the 1970 level of consumption — even with a growth in both the population and the size of the economy. In that case, as Figure 1 suggests, the historical growth in high efficiency improvements might have kept total energy demand closer to 71 quads by 2008.[5] Perhaps more interesting is the set of previous studies that suggests we might do even better.

B. Where Energy Efficiency Might Have Taken Us and Where We Might Head

The market tends to be more dynamic than policy assessments generally concede, especially when given an appropriate mix of policies and guidance. In the late 1970s, as the United States was assessing its various energy options following the 1973-1974 Oil Embargo, the National Research Council published an authoritative report called *Energy in Transition 1985–2010* (NRC 1979). It was one of the more thorough assessments of its time, but certainly not atypical of the many past studies that explored future technology scenarios. The report suggested that, if one assumed a doubling in the size of the U.S. economy, and if energy prices (adjusted for inflation) stayed roughly the same, U.S. energy consumption would rise from about 72 quads in 1975 to about 135 quads by 2010. The NRC study further indicated that if real energy prices were to double instead, then U.S. energy demand might grow to only 94 quads by 2010. The demand pattern that actually emerged since 1975 provides an especially useful insight as policymakers and business leaders turn their attention to the growing problems of climate change and energy security.

[5] The so-called "Historical High Efficiency" scenario shown in Figure 1 above is generally patterned after a series of low range energy efficiency scenarios that explored such possibilities over the period 1975 through 2010. For more details, see DOE (1980).

As it turned out, the economy has not doubled, but it nearly tripled in volume over the last 35 years. And while energy prices did not remain at the 1975 levels, neither did they double in size. In fact, it appears that real energy prices since 1975 have grown on average by only 70 percent compared to the comparable prices seen in 1975. And what might we say about the nation's actual use of energy? Returning to the data in Figure 1, the latest forecast from the Energy Information Administration (2009a) suggests that total energy use next year will be just under 100 quads. So we've grown the economy much bigger than we anticipated and energy prices have less than doubled, but as Figure 2 below suggests, total energy demand has stayed closer to what analysis in the mid-1970s thought would be an unlikely "low energy future." What is the difference? The evidence suggests two very big factors have made the economy more energy efficient than anticipated in the 1970s. The first is that we have deployed more productive technologies than we thought possible from a 1970s vantage point. But a further investigation also suggests that more informed behaviors and a more dynamic market also played critical roles.

One interesting comparison to emerge from Figure 2 (below) is an early attempt at characterizing just how the energy consumption might look in the event that emerging energy efficiency technologies developed significant market share. Based on a review of 20 earlier studies that explored that same possibility, the U.S. Department of Energy (1980) provided what it termed an "approximate envelope of low energy futures." As illustrated by the solid green line in Figure 2, the envelope of projections extended all the way out to the year 2050. The projection peaked roughly in 2005 at a little more than 90 quads and then sloped gently downward. The overall conclusion of the study was that "if these efficiency improvement measures could be widely and rapidly adopted across all sectors of the economy, the combined and cumulative effects are estimated by most of the studies reviewed to result in negative future growth in U.S. primary energy use — possibly approaching 60 quads."[6]

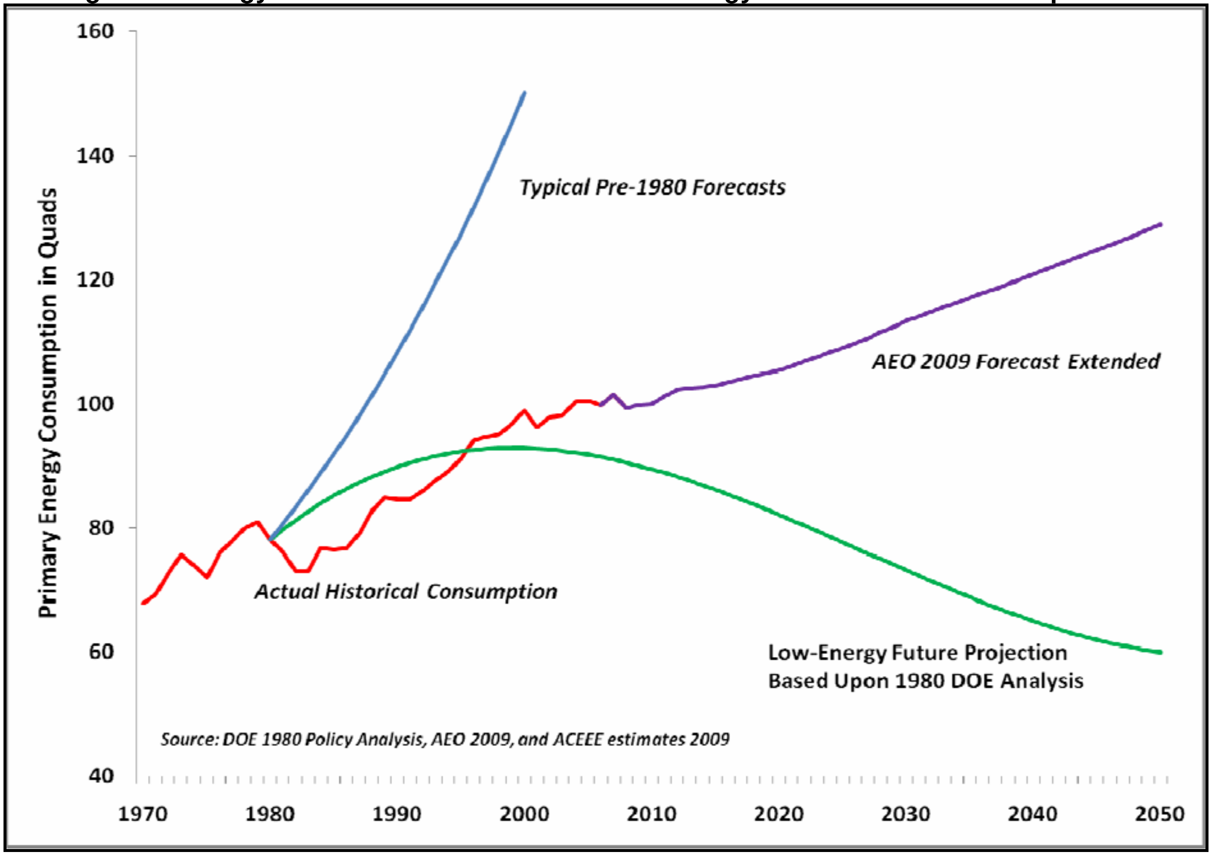
Figure 2 also provides two other important comparisons. The first is a line representing the standard forecast assumption before 1980 with an indication that energy use by the year 2000 might reach as much as 150 quads. The irony here is that, both for expected and for unexpected reasons, the nation's actual energy consumption (highlighted by the jagged red line in Figure 2) more closely reflected what was characterized in 1980 as a "low energy future." In other words, the combination of technology investments, informed behaviors, and supportive energy policies enabled a more dynamic market response than energy modelers anticipated in previous years. Perhaps even more compelling, the economy itself also proved to be more robust than the modelers originally thought likely.

As a final comparison highlighted in Figure 2, the *Annual Energy Outlook 2009* projection for total primary energy (EIA 2009a) — extended to 2050 by incorporating additional data from Economy.com (2009) — nicely splits the difference between the pre-1980 forecasts and what DOE in 1980 referred to as an envelope of low energy futures. The question for policymakers is whether there are opportunities to close the gap between the current projection of business-as-usual and that low energy future first suggested by the 20 studies reviewed in 1980.[7] As we examine the issue next, the evidence continues to underscore that possibility.

[6] An interesting side note is that the 1980 DOE report specifically excluded from its more in-depth analysis a 1979 study with a projection of 33 quads in 2050 "because it assumes major lifestyle changes."

[7] Not to be lost in the comparison, the gap between the pre-1980s projections and what actually occurred by the year 2000 is approximately the same magnitude as the comparison between the extended AEO 2009 forecast for the year 2050 and the 60-quad low energy future.

Figure 2. Energy Scenarios: Differences in Technology and Behavioral Assumptions?

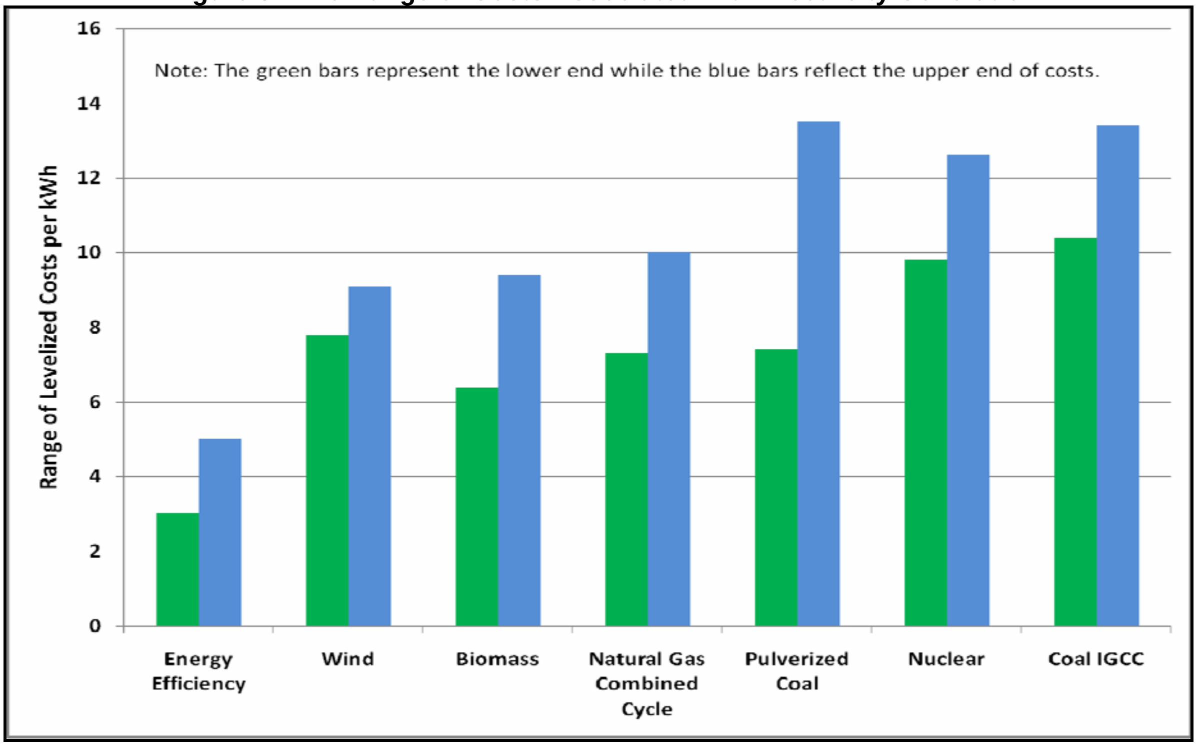


Since the useful compendium and analysis provided by DOE in 1980, there have been a number of other studies that have further explored the feasibility of greater investments in the nation's energy productivity. Two significant studies include *America's Energy Choices* (AEC 1991) and Energy Innovations (1997). These two highly detailed studies, sponsored by a consortium of nonprofit organizations and research groups suggested that — with the right mix of policies and investments — it was technically and economically possible to reduce the nation's total primary energy consumption to between 60 and 70 quads by the year 2050. In effect, their respective scenarios envisioned the substitution of innovation and productive capital as a substation for the inefficient use of energy.

C. Cost-Effectiveness of the Efficiency Resource

The question at this point becomes one of cost-effectiveness. Can the substantial investments that might be required in the more energy-efficient technologies save money for businesses and consumers? Again we turn to the evidence as Figures 3 and 4 offer two initial but different views of this question. Lazard (2008) presented a mix of levelized costs associated with electricity generation expenditures. These are summarized in Figure 3 as they cover new costs associated with the annual costs for a variety of new power plants. The left green bars represent the lower end of the costs while the right blue bars represent the higher end of the estimated costs. Included are estimates for conventional coal-fired power plants, coal units that rely on integrated gasification combined cycle technologies or IGCC, nuclear units, and natural gas combined cycle power plants. Also shown are costs for wind and biomass systems together with both Lazard and ACEEE estimates for the ranges of costs associated with energy efficiency measures. With efficiency cost the equivalent of 3-5 cents per kilowatt-hour of electricity service demand, the resulting electricity savings are clearly the more cost-effective option.[8]

Figure 3. The Range of Costs Associated with Electricity Generation



Sources: Lazard (2008)

Figure 4 provides a different look comparing energy efficiency investments to other opportunities for generating investment returns. This is done in two ways. The first is an annual return on investment. The second is an examination of risk associated with a given investment opportunity. In the past, McKinsey (2007) has assessed the energy efficiency resource as having at least a 10 percent return on energy efficiency investments. When spread out over an annual $170 billion energy efficiency market potential, McKinsey suggests an average 17 percent return might be expected across that spread of annual investments. Although not shown on the chart, Lazard actually suggested that the levelized cost of energy efficiency improvements ranged from zero to five cents per kWh.[9]

At four cents per kWh, we might envision the spending of 36 cents upfront to save one kWh each year for perhaps 15 years. When amortized over the life of that one-time investment, at a 7 percent interest rate, the annual cost is estimated as $0.04/kWh. If we think of the time it takes for that investment to pay for itself, and if we know the monthly electricity cost is 9 cents per kWh, we might then suggest the investment would pay for itself over four years. In that case, the return on that investment is suggested to be 25 percent annually.

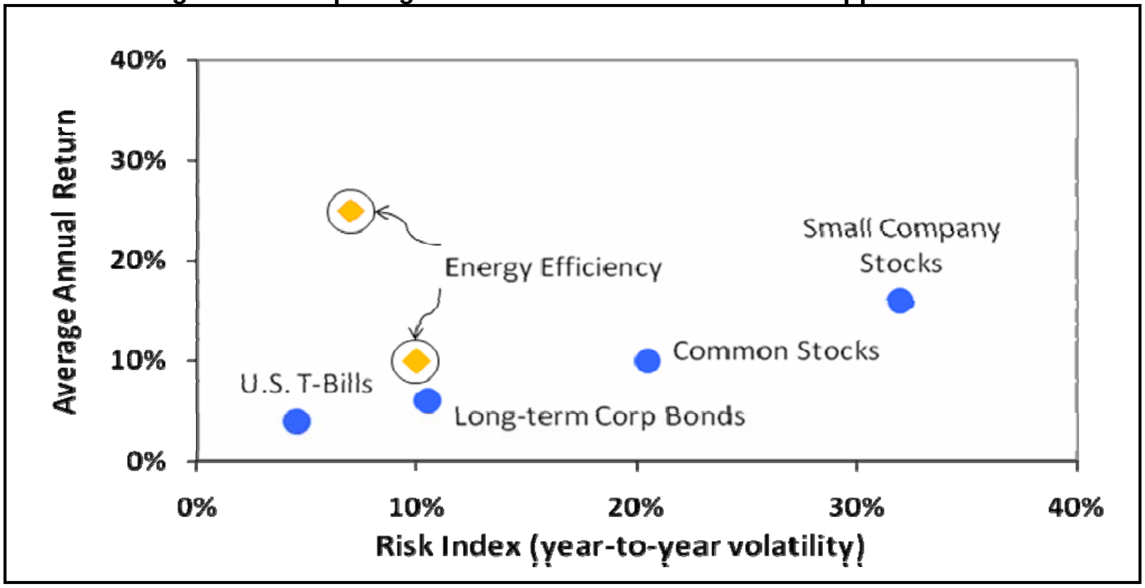
As shown on the vertical axis in Figure 4, a typical range of efficiency investments is suggested as having one of the more durable and better annual returns compared to other investments — whether in treasury bills or common stock. Even more interesting is the stability of the investment as shown

[8] Not included in Figure 3 is a significant supply of negative cost measures. These are essentially measures that rely on changes in procedures that require no capital outlays. In effect, they are so-called "housekeeping" improvements that only require things to be done differently.

[9] The idea of a zero cost is generally associated with productivity improvements made possible by turning attention to ongoing maintenance and accelerated upgrades in building or plant operations. The only cost is directing existing staff to turn their attention to increased energy savings operations without expending any additional capital. Hence, the suggestion that there is a zero capital cost.

on the horizontal axis. Although data is not collected on the risk associated with institutional investments in energy efficiency in any systematic way, it appears to provide a more stable investment opportunity compared to normal market instruments.[10]

Figure 4. Comparing Risk and Return on Investment Opportunities



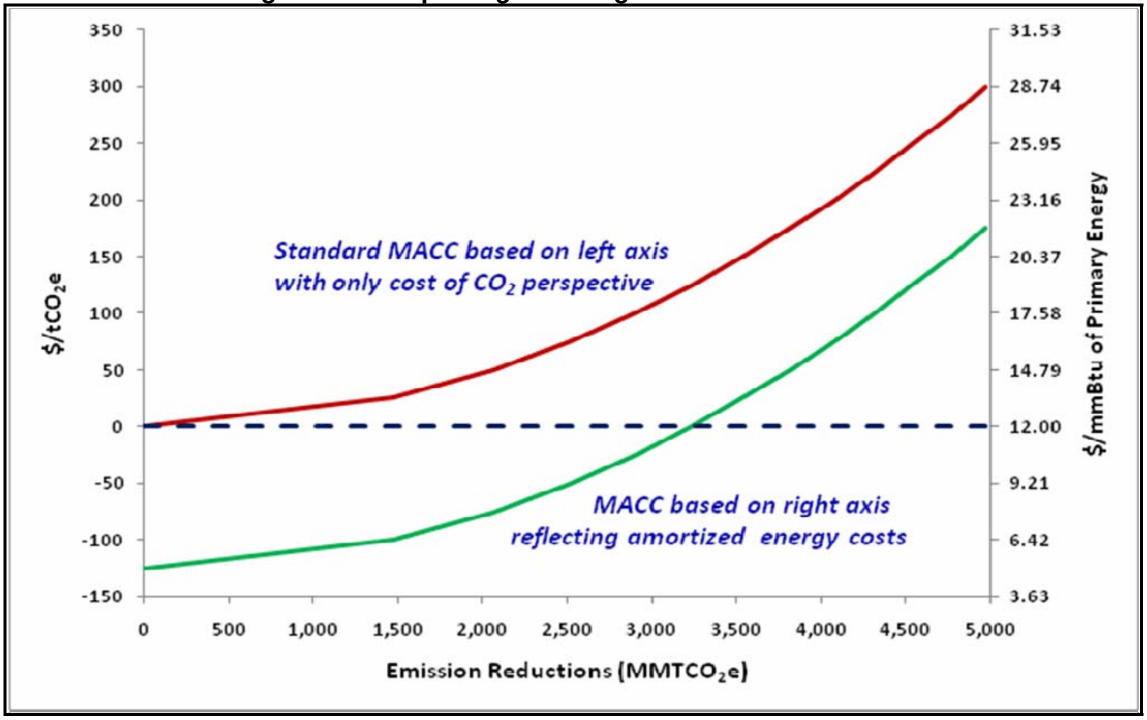
Source: Author's estimates based on a variety of published sources and data

We can extend this issue of cost effectiveness even further to examine policy scenarios rather than discrete technologies. Laitner and McKinney (2008) provided a meta-review of 48 past policy studies that were undertaken primarily at the state or regional level. The set of studies included in this assessment generally examined the costs of economy-wide efficiency investments made over a 15-25-year time horizon. The analysis found that even when both program costs and technology investments were compared, the savings appeared to be twice the cost of the suggested policies.

In a similar way, the AEC (1991) and the Energy Innovations (1997) reports show a benefit-cost ratio that also approached two to one. More recently, the Union of Concerned Scientists (Cleetus, Clemmer & Friedman 2009) published a detailed portfolio of technology and program options that would lower U.S. heat-trapping greenhouse gas emissions 56 percent below 2005 levels in 2030. The result of their analysis indicated an annual $414 billion savings for U.S. households, vehicle owners, businesses, and industries by 2030. After subtracting out the annual $160 billion costs (constant 2006 dollars) of the various policy and technology options, the net savings are on the order of $255 billion per year. Over the entire 2010 through 2030 study period, the net cumulative savings to consumers and businesses were calculated to be on the order of $1.7 trillion under their so-called Blueprint case.

[10] Peretz (2009) has a useful paper that further explores the scale of the investment potential in energy efficiency and the need for financial metrics that might help the market improve its evaluation of such investment opportunities.

Figure 5. Interpreting the Marginal Abatement Cost Curve



Source: Author's illustration of supply curves showing comparability of CO_2 on the Y1, or the left axis, costs with equivalent energy costs on the Y2, or the right axis.

Figure 5, above, highlights yet another aspect of the cost-effectiveness of energy and climate policy scenarios — the so-called marginal abatement cost curves.[11] This implies that marginal abatement cost curves must, therefore, start at zero and can only rise as more of the abatement opportunities are used up. Many economic modelers are uncomfortable with the idea of negative costs and tend to assume that all abatement measures have only positive costs. The figure illustrates, however, the availability of a large supply of emission reductions that could be achieved today at negative cost; that is, with economic savings that result from the value of reduced energy expenditures, based on currently available technology and current costs. Of further interest is that when one compares the cost of carbon dioxide reductions with the cost of energy, in fact, there is no negative cost as such. Any investment in an energy-efficient technology has a positive energy cost, as suggested by the data in Figure 3. The difference is that the levelized cost of the technology is less than the purchased price of energy. Hence, what appears as a negative cost on the left or Y1 axis of Figure 5 is really an amortized cost of energy efficiency on the right, or on the Y2 axis.

There are two final aspects of the evidence to briefly review. The first is associated with the non-energy benefits that typically accrue to energy efficiency investments. The second reflects the changes one might normally expect in the cost and performance of technologies over time. The evidence for these two added benefits is summarized next.

When energy efficiency measures are implemented in industrial, commercial, or residential settings, several "non-energy" benefits such as maintenance cost savings and revenue increases from greater production often result in addition to the anticipated energy savings. Often, the magnitude of non-energy benefits from energy efficiency measures is significant. These added savings or productivity

[11] What this author sometimes refers to as "the Big MACC." While the curves in Figure 5 are not drawn to any specific set of technologies, the red abatement curve reflects the approximate scale of the more conventional policy models that assume no returns from investments in abatement technologies. The green abatement curve generally reflects an assumption that as much as 40 percent of the emissions might be reduced with a net savings — given today's technologies and prices. Presumably, greater investments in research and development, coupled with greater levels of innovation over time, might shift both curves to the right (in other words, getting greater benefits than costs over time).

gains range from reduced maintenance costs and lower waste of both water and chemicals to increased product yield and greater product quality. In one study of 52 industrial efficiency upgrades, all undertaken in separate industrial facilities, Worrell et al. (2003) found that these non-energy benefits were sufficiently large that they lowered the aggregate simple payback for energy efficiency projects from 4.2 years to 1.9 years. Unfortunately, these non-energy benefits from energy efficiency measures are often omitted from conventional performance metrics. This leads, in turn, to overly modest payback calculations and an imperfect understanding of the full impact of additional efficiency investments.

Several other studies have quantified non-energy benefits from energy efficiency measures and numerous others have reported linkages from non-energy benefits and completed energy efficiency projects. In one, the simple payback from energy savings alone for 81 separate industrial energy efficiency projects was less than 2 years, indicating annual returns higher than 50 percent. When non-energy benefits were factored into the analysis, the simple payback fell to just under one year (Lung et al. 2005). In residential buildings, non-energy benefits have been estimated to represent between 10 to 50 percent of household energy savings (Amann 2006). If the additional benefits from energy efficiency measures would be captured in conventional performance models, such figures would make them more compelling.

As a strong complement to the likelihood of large-scale non-energy benefits typically omitted from most climate policy assessments, there is also a significant body of evidence that indicates that technology is hardly static and non-dynamic. Knight and Laitner (2009), for example, cite three dozen examples of recent technologies with noteworthy declines in prices coupled with increased technology performance. Their review covers a multitude of end-uses including transportation, appliances, and consumer electronics. The rapid technological change seen especially in semiconductor-enabled technologies has led to cheaper, higher performing, and more energy-efficient technologies (Laitner et al. 2009). The increasing penetration of information and communication technologies interacting with energy-related behaviors and products suggests that energy efficiency resource may become progressively cheaper and more dynamic as the 21st century moves on (Laitner and Ehrhardt-Martinez 2008). Given this and many other comparable studies, one might conclude with the very strong likelihood that progress in the cost and performance of energy efficient technologies will continue, and that new public policies will greatly increase the continued rate of improvement (McKinsey 2009, and Koomey 2008).

D. Beyond the Price Signal

Computable General Equilibrium, or CGE, models have been a favorite methodological approach to climate policy analysis. These are macroeconomic models that represent linkages among the many sectors of the economy; and between supply and demand with an array of commodity prices that presumably coordinates an efficient outcome in the production and consumption of commodities (and services). While these models can provide some insight, in particular in elucidating the indirect effects of policies, they are in many way inherently biased against the type of bold climate policies that are consistent with sound economic policy and necessary to avoid the most deleterious impacts of global warming. They fail to value the many co-benefits associated with climate solutions, such as those we have discussed as being associated with energy efficiency measures, i.e., non-energy productivity gains, improved energy security, better air quality, and increase public health. But this is a common limitation that the current analysis does not seek to remedy. More to the point, Computable General Equilibrium models operate under an optimality assumption that obscures a range of important sub-optimal behaviors. Essentially, these models assume that people, firms, and markets are perfectly rational, and that markets are perfectly competitive.[12]

[12] In fact, McKinsey (2009) notes that while energy efficiency represents a vast, low-cost energy resource, the study also notes that there are significant and persistent barriers that will need to be addressed to unlock that potential. What is more, these barriers will need to be addressed at a scale sufficient to realize that full opportunity. For the most part, the CGE family of models has yet to adequately handle this critical aspect of the energy efficiency resource. Laitner and Hanson (2006) do provide, however, one approach that opens up this possibility.

In fact, because of a range of market imperfections and market barriers, real world behavior leaves substantial room for public policy to induce behavior changes that produce economic benefits. The entire negative cost range of reductions found in the well-known McKinsey (2007) abatement cost curve exists because price signal alone is not enough. Carbon pricing, the correction of the current under-pricing of fossil fuel-based energy due to the failure of our current economic system to account for the costs of greenhouse gas emissions (i.e., internalization of the current carbon pollution externality) is a necessary but not sufficient condition for the most cost-effective package of policies. Without a robust set of complementary policies, in particular ones targeting energy efficiency gains, a host of negative and low cost emission reductions will be missed. Top-down economic models like Computable General Equilibrium models fail to illuminate this important lesson for policymakers.[13]

One classic example is the misaligned incentive that exists for those living in rental units when the renter pays the energy bills but the landlord purchases the large appliances such as refrigerators and water heaters. In this case, the purchaser of the durable good does not reap the benefits of greater energy efficiency. The Market Advisory Committee of the California Air Resources Board (2007) provides a nice short overview of key market failures.[14] A deeper exploration of the types of market barriers is beyond the scope of this paper, but others have done work to map this terrain (Levine et al. 1995, Brown 2001, Levinson and Niemann 2004, Sathaye and Murtishaw 2004, Murtishaw and Sathaye 2006, Geller et al. 2006, Natural Resources Defense Council 2009, and Brown et al. 2009).

It is worth noting that some economists cling to a belief in the magic of the market (a faith more challenging today after the recent bubble and severe economic downturn that has largely been attributed to the lack of adequate regulation) and tend to dismiss the amount of negative cost emission reductions available. That said, this is hardly a monolithic view. Other economists certainly do recognize the significance of market failures and imperfections beyond the lack of a price on carbon. The importance of reflecting policies that might be directed at market failures was explored, in part, by Hanson and Laitner (2004). In one of the few CGE models that explicitly reflects both policies and behavioral changes as a complement to pricing signals, they found that the combination of both price and non-pricing policies actually resulted in a significantly lower carbon permit price to achieve the same level of emissions reductions.

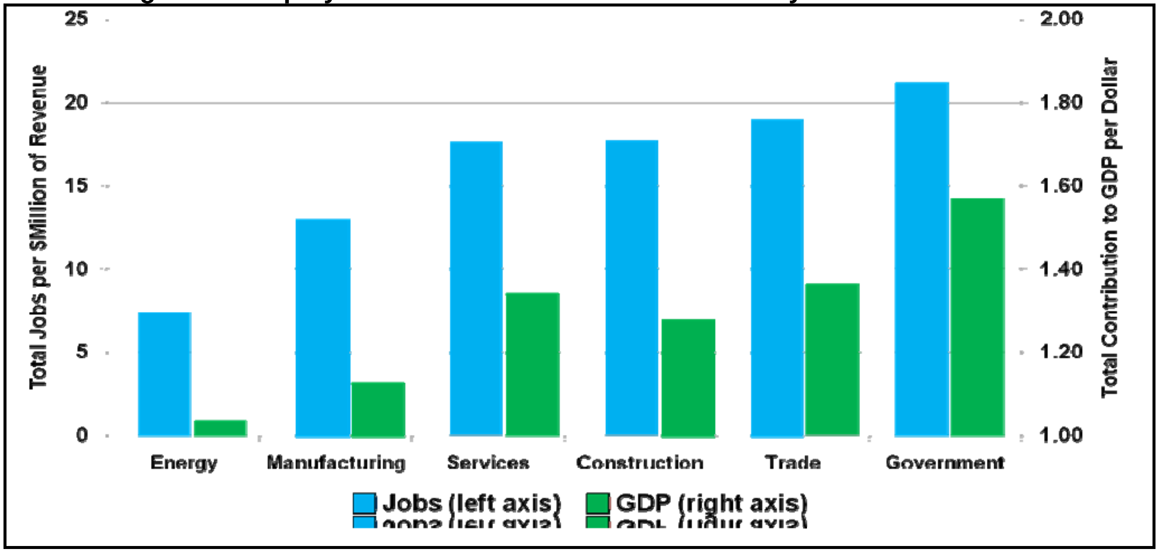
E. Evidence for the Larger Economy-Wide Benefits

There is good news in that if we choose to address the "significant and persistent barriers" and deliver a "comprehensive and innovative approach" to unlock the energy efficiency resource (McKinsey 2009), we are likely to open up an even more robust economic future even as we dramatically reduce greenhouse gas emissions. This result is driven by investments in energy efficiency that are, in effect, an investment in larger economic productivity, and because such investments imply a change in the production recipe of the economy that emphasizes economic sectors which return greater rates of labor and value-added intensities. It is this latter focus to which the discussion now turns.

[13] Again, see Laitner and Hanson (2006) for a suggested framework that opens up the possibility to overcome this set of limitations.

[14] Following are examples of important market failures. (1) Step-Change Technology Development — where temporary incentives will be needed to encourage companies to deploy new technologies at large scale to the public good, because there is otherwise excessive technology, market, and policy risk. Examples of remedies are renewable portfolio obligations, biofuel requirements, and the Low-Carbon Fuel Standard. (2) Fragmented supply chains — where economically rational investments (for example, energy efficiency in buildings) are not executed because of the complex supply chain. Examples of remedies are building codes. (3) Consumer behavior — where individuals have demonstrated high discount rates for investment in energy efficiency that is inconsistent with the public good. Examples of remedies are vehicle and appliance efficiency standards and rebate programs (Market Advisory Committee 2007). McKinsey (2009) further highlights an array of structural and behavioral barriers that tend to lock out the full net benefit of the efficiency resource.

Figure 6. Employment and GDP Contributions for Key Economic Sectors



Source: IMPLAN (2009)

Figure 6, above, shows two sets of economic impact coefficients. The first is the total number of jobs directly and indirectly supported by spending within six major sectors of the U.S. economy.[15] For example, revenues received by the different energy sectors require on average only 7.4 total jobs per million dollars of spending. All other sectors support a larger number of direct and indirect jobs for that same one million dollars of spending. The second is the rate of value-added contribution that is supported by spending for each of the major sectors. Here the data show each dollar spent on energy contributes about $1.04 cents of GDP return while all other sectors show a larger value-added benefit (see the appendix for a more complete review of these sectoral differences and their implication for the national economy given changes in overall spending).

The state of California has had the most comprehensive and aggressive energy efficiency policies for decades. As a result, while per capita energy use has increased since 1970 in the rest of the country, in California it has fallen 18 percent below 1970 levels and the state's per capita electricity consumption is about 40 percent less than the country as a whole (Next 10 2009). Despite relatively high electricity rates, California has the fifth lowest electricity bill in the country as a fraction of Gross State Product. University of California Professor David Roland-Holst has investigated the historical macroeconomic effects of these policies. He concludes that California's efficiency programs from 1972 onward have created about 1.5 million full-time jobs with a payroll of over $45 billion and saved households $56 billion in energy costs over that same period. One causal factor is the same shift from energy-intensive economic activity to labor-intensive economic activity due to efficiency investments that is documented in this work (Roland-Holst 2008). This work is also consistent with assessments as undertaken by Barrett et al. (2005) and the meta-review of four dozen state and regional impact assessments completed last year by ACEEE (Laitner and McKinney 2008).

With the evidence highlighted in this discussion, together with other documented assumptions described in the remaining part of this report and its accompanying appendix, we can evaluate how changed investment and spending patterns might impact the U.S. economy as a whole. These net results are summarized in Table 1 in the discussion that follows.

[15] While Figure 6 highlights only an aggregate of six sectors of the U.S. economy, the IMPLAN data set actually shows the full interaction among 440 sectors of the economy.

III. REVISING POLICY SCENARIOS IN LIGHT OF THE HISTORICAL EVIDENCE

The established record of evidence does, indeed, suggest large opportunities for cost-effective reductions in greenhouse gas emissions. Lawrence Berkeley National Laboratory Staff Scientist Jonathan Koomey suggests: "In the three decades since the energy crises of the 1970s we've learned a great deal about the potential for energy efficiency and the means to deliver it cost effectively and reliably" (Koomey 2008). Still, the logical question is how the array of data might inform our assessments of future energy and climate policies. On the one hand, business leaders and policymakers want to ask very basic questions about the direct costs and benefits that are likely to follow from enactment of possible climate change legislation. On the other hand, we look to the array of data to see how such costs and benefits might impact the larger economy. In the first case, for example, we are asking about net changes in the nation's energy bills and whether the energy bill savings are likely to offset any increased costs. In the second, we are asking what influence that changed pattern of investments and expenditures might have on employment and the nation's gross domestic product.

Despite the seeming complexity of this exercise, we can think of modeling energy and climate policies as requiring three basic steps for each of the four scenarios compared in this study. First we use the available data to set up a benchmark or reference case that becomes our first scenario. In effect, we want to understand how the economy might perform prior to the enactment of any suggested policy. Second, we want to create an accounting framework that allows us to add or subtract likely changes in investment and spending that follows such enactment. Finally, we want to have some means of evaluating the economy-wide effects of all of these changes. In this report, however, we are not actually modeling all of the effects *per se*; rather we are setting up a diagnostic review to understand whether past modeling assessments have properly addressed those questions in a sufficient way that we can be confident they give us useful insights about the larger economic returns from any proposed changes in policies. In this sense we are following very much in the spirit of the Stanford University Energy Modeling Forum in which we are "modeling for insights, not numbers" (Huntington et al. 1982).[16]

Table 1 on the following page provides the basic results that follow from the diagnostic review that is described in the balance of this section. The logical starting point is to benchmark the diagnostic reference case to what we might call an extended *Annual Energy Outlook 2009* published by the Energy Information Administration (EIA 2009a). Since EIA now looks out only to the year 2030, we must push out the reference case to the year 2050 by relying on other forecasts and judgments to give us a sense of the shape and size of the economy in that year. The details of the 2050 benchmark case are highlighted in data column A of Table 1. Note that all financial values are given in constant 2007 dollars. Two things of perhaps most interest are the total greenhouse gas emissions and the level of energy expenditures projected for the U.S. economy in the year 2050.

Total greenhouse gas emissions (including both energy-related carbon dioxide emissions and all other non-energy related emissions) are shown in data row 1a of Table 1. In this benchmark case, they are projected to increase from a 2010 level of 7,119 million metric tons of CO_2 equivalent to 8,739 MMTCO_2e by 2050. In other words, total emissions are expected to grow about 23 percent over the 40-year period 2010 through 2050. At the same time, the nation's energy bill is projected to increase from $1,218 billion dollars in 2010 to a very large $4,175 billion dollars by 2050. As we shall see, making cost-effective reductions in the nation's overall energy expenditures will become the key to containing the costs of climate change policies. The second data column B reports the typical outcomes of the conventional modeling assessments that have been undertaken to this point.

[16] In this same sense we are looking to see what "history can teach us" (Craig et al. 2002), and to seeing how we might find "room for improvement" in our policy assessments (Laitner et al. 2003); again, rather than modeling the precise impacts of any given climate policy.

Table 1. Representative 2050 Impacts of Climate Policy Scenarios

	(A) Reference Case	**(B) Typical Policy Assessment**	**(C) ACEEE Efficiency Scenario**	**(D) ACEEE Sensitivity w/International Tonnes**
(1a) Total Baseline Greenhouse Gas Emissions (MtCO_2e)	8,379	8,379	8,379	8,379
(1b) Baseline Energy-Related CO_2 Emissions (MtCO_2e)	7,192	7,192	7,192	7,192
(1c) Baseline Non-Energy-Related Emissions (MtCO_2e)	1,187	1,187	1,187	1,187
(2a) Effective 2050 Reduction Target (MtCO_2e)	0	2,351	1,212	1,212
(2b) Energy Efficiency Related Reductions (MtCO_2e)	0	894	3,358	2,838
(2c) Clean Energy Supply Reductions (MtCO_2e)	0	1,740	3,100	2,620
(2d) Domestic Offset Reductions (MtCO_2e)	0	643	709	709
(2e) International Offset Reductions (MtCO_2e)	0	1,139	0	1,000
(2f) Banked Allowances (MtCO_2e)	0	1,612	0	0
(3) Total Domestic Reductions in 2050 (MtCO_2e)	0	3,277	7,167	6,167
(4a) Domestic CO_2 Price (2007$/t$CO_2$e)	$0	$73	$465	$331
(4b) International Offset Price (2007$/t$CO_2$e)	$0	$59	$0	$36
(5) Primary Energy (Quadrillion Btus)	129	115	64	75
(6) Carbon to Energy Ratio (MtCO_2e/Quad)	55.80	36.23	11.54	23.04
(7) Primary Energy Price (2007$/MMBtu)	$32.39	$41.13	$33.49	$36.70
(8) Energy Bill (Billion 2007$)	$4,175	$4,718	$2,130	$2,762
(9) International Permit Cost (Billion 2007$)	$0	$67	$0	$36
(10) Incremental Annualized Investment (Billion 2007$)	$0	$80	$527	$317
(11) Program/Policy Costs (Billion 2007$)	$0	$9	$39	$32
(12) Total Resource Cost (Rows 8 + 9 + 10 + 11 in Billion 2007$)	$4,175	$4,874	$2,696	$3,147
(13) Delta Resource Cost (Row 33, Col B, C, or D — Col A in Billion 2007$)	n/a	**$699**	**-$1,479**	**-$1,028**
(14) Net GDP Impact as Function of Price Changes (Billion 2007$)	n/a	**-$509**	**-$71**	**-$267**
(15) Net GDP Impact based on Sector Value-Added Impacts (Billion 2007$)	n/a	**-$229**	**$456**	**$276**

Source: The diagnostic review in the above table is based on an integration of the recent set of H.R. 2454 modeling results. These are used to set up the outcomes in columns A and B, which are then compared to a set of energy efficiency assumptions and economic impacts coefficients developed by ACEEE. See the appendix of this report for a further elaboration of assumptions.

The U.S. Environmental Protection Agency (EPA) has provided one of the more useful and detailed policy assessments. For that reason, the diagnostic review discussed here generally converges to the kind of results EPA released in June of this year (EPA 2009).[17] Things of note are the higher implied cost of energy shown in row 7 of Table 1, the level of overall expenditures for energy consumption in row 8, and the total resource cost to the economy in row 12 (from reducing total domestic greenhouse gas emissions shown in row 3). In other words, the typical analysis suggests that it will cost the economy on the order of $700 billion a year by 2050 (the rounded value shown in row 13) to reduce domestic emissions from 8,379 to 5,102 $MMTCO_2e$ (subtracting row 3 from row 1a). The bottom line here is that the conventional modeling approach suggests a significant cost increase to reduce domestic emissions by only about 39 percent. Understandably, this appears to have a small but negative impact on the U.S. economy as suggested by the negative GDP outcomes, which are shown in two different ways (see rows 14 and 15).[18] The third data column C provides our first comparison of how the evidence might suggest what might be missing in the usual economic assessments. The fourth data column D offers an alternative to the pure efficiency scenario in column C by seeing how the purchase of international offsets might change the economic impacts.

Figure 7 on the following page provides a first look at the critical insights from the scenario summarized by the column C data in Table 1. The starting point for the ACEEE diagnostic review in column C is not H.R. 2454 on which the conventional assessments have tended to focus. Instead, the intent is: first to explore the full energy efficiency potential; and second, to see how that greater energy productivity might positively benefit the larger national economy. That is, following the available evidence, it appears the U.S. economy might be able to substantially but cost-effectively reduce the reference case energy expenditures from $4,175 billion (column A, row 8 in the Table 1) down to $2,130 billion (column C, row 8).[19]

In Figure 7 the first blue column shows the same level of energy expenditures as shown in column A, row 8. The second blue column in Figure 7 shows an increase in energy expenditures resulting from cap and trade provisions that drive the carbon permit price up from $73 per metric ton of CO_2 equivalent to as much as $465/tCO_2e$.[20] That increases costs by an estimated $692 billion. At the same time, the dramatic improvement in energy productivity places a downward pressure on energy prices so that changes in the base price of energy decreases expenditures by an estimated $550 billion as shown in the third blue column of Figure 7. The next column then highlights the savings due to the demand reduction made possible by the greater levels of energy efficiency. In this case, the analysis suggests a drop on the order of $2,187 billion dollars by 2050. The last green column shows the net impact of all these changes. In this case, the net change moves U.S. energy expenditures from $4,175 billion to as little as $2,130 billion.

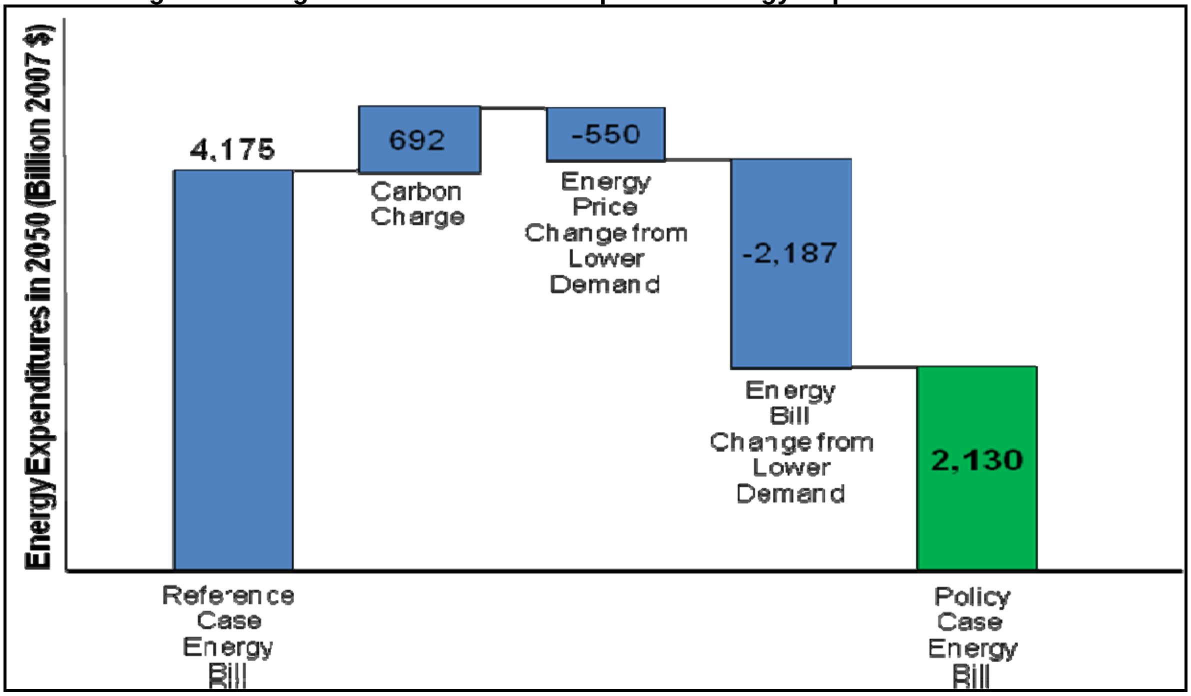
[17] The EPA (2009) analysis of H.R. 2454 is actually the result of several different models whose various results are reported using different sets of physical units (e.g., units of energy and/or greenhouse gas emissions) and different base year dollars. The reader should interpret column A within Table 1 as providing a reasonable approximation of how those different models might integrate into a single modeling result so that they can be compared to the insights that emerge from the diagnostic review. In other words, column A is not the EPA modeling results as such; rather, it summarizes an aggregate set of modeling outcomes in a way that allows a useful comparison. See Hanson and Laitner (2005) for one similar diagnostic review.

[18] We will revisit the estimation of GDP impacts shortly. For now it is worth noting that, strictly speaking, these impacts may be more appropriately described as postponed economic activity rather than outright GDP losses. In other words, taking action on climate change may be better characterized as a postponement of the year 2050 level of GDP until July of 2051.

[19] Note that because this is a diagnostic review to generate larger insights into past assessments, this report does not focus on household or other consumer expenditures. Instead, the analysis presents an aggregate review of how the many previous assessments might be modified to yield more useful insights for policy development.

[20] The conventional models have focused on the carbon dioxide permit price as an indicator of economic well-being. Because they assume a more rigid adjustment in how the economy might respond, their focus has been on things like offsets and other flexibility mechanisms to keep the price down. As this analysis suggests, however, even a high permit price may have a smaller net impact if the assessments assume a more flexible set of energy efficiency investment opportunities. At the same time, if the EPA models that provide the source of cost curve data were to reflect the larger opportunities for cost-effective reductions in emissions, the resulting permit prices would likely to be significantly smaller than reflected in this diagnostic review. See the appendix for further discussion on this critical point.

Figure 7. Diagnostic Assessment: Impact on Energy Expenditures in 2050

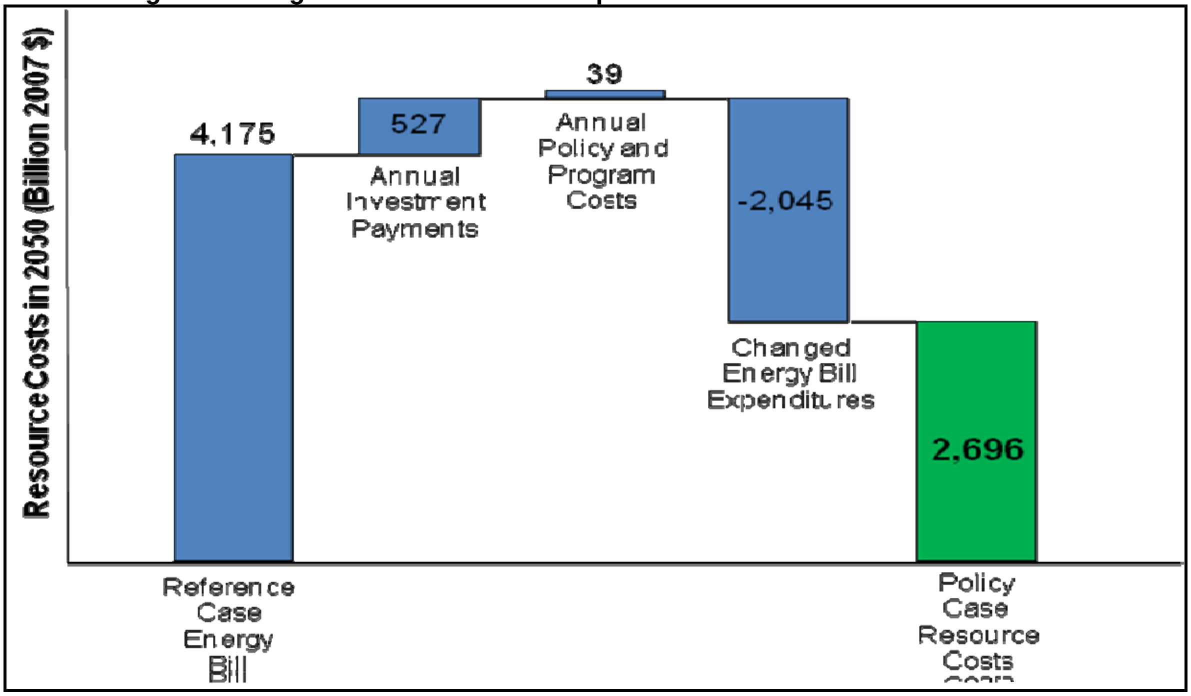


Source: ACEEE Diagnostic Assessment of Climate Economic Policy Models (2009)

The savings described to this point are significant, but Figure 8 on the following page will help place those proceeds in context as it explores the total change in resource costs that helps drive the net benefits. In Figure 8 we again begin with the reference case projection of energy expenditures — now as a starting benchmark of how the total change in resource costs might unfold if we reflect the evidence for additional gains in energy productivity. Given that starting point, the first blue column in Figure 8 shows the same energy bill estimate of $4,175 billion. In this case, however, there are additional investment payments that must be made to drive the productivity improvements. For that reason the second blue column highlights a $527 billion cost to consumers and businesses that is needed to make the needed changes in the way they might otherwise use energy. At the same time, there is a larger set of program and policy expenditures, which adds $39 billion to the resource cost. These are revenues that would pay for research and development programs as well as technical assistance and other information programs.

The full impact of the investments and the program expenditures — which are made in the year 2050 and in earlier years — provides the nation with an opportunity to decrease its energy expenditures by an estimated $2,045 billion. The net result is that instead of spending $4,175 billion in the 2050 reference case, the nation is now spending a net of only $2,696 billion in the policy-driven energy efficiency scenario.

Figure 8. Diagnostic Assessment: Impact on Total Resource Costs in 2050



Source: ACEEE Diagnostic Assessment of Climate Economic Policy Models (2009)

In the Figure 8 comparison, resource cost of $2,696 billion yields a net benefit to the economy with a savings of $1,479 billion (as suggested by Table 1, column C, in row 13).[21] Given this net positive outcome, one can reasonably expect a positive impact on GDP. But that also depends on how the models treat even positive changes in spending. Many models, in effect, rely on the change in energy or permit prices to drive changes in GDP. In that case, if one assumes that higher prices are bad for the economy, then the outcome is likely a small but negative outcome. This is shown in row 14 of Table 1 in which all three scenarios are shown to have negative returns to GDP — even when the change in net resource costs produces an overall savings to the economy. Yet, if we were to examine how the scenarios actually might change the composition and size of the economy, more as a function of investment and change spending patterns rather than simply as a matter of changed prices, the results show a more intuitive outcome as highlighted in row 15 of Table 1.

Before we move on to a further discussion of the Table 1 findings, we might examine the outcomes of the sensitivity case that is highlighted in Column D. This alternative scenario simply acknowledges the possibility of international offsets as part of the policy outcomes. Admittedly, the international (metric) tons of emission reductions shown in Table 1 are less expensive. Yet, this sensitivity reveals a useful insight. Even though the U.S. economy might buy tons that are less expensive compared to domestic abatement opportunities, it is an outflow of dollars from our economy rather than a productive investment in it. The net result is that, even with a total resource cost that is cheaper than the typical policy assessment shown in column B, it is less a optimal result compared to the returns shown in column C.

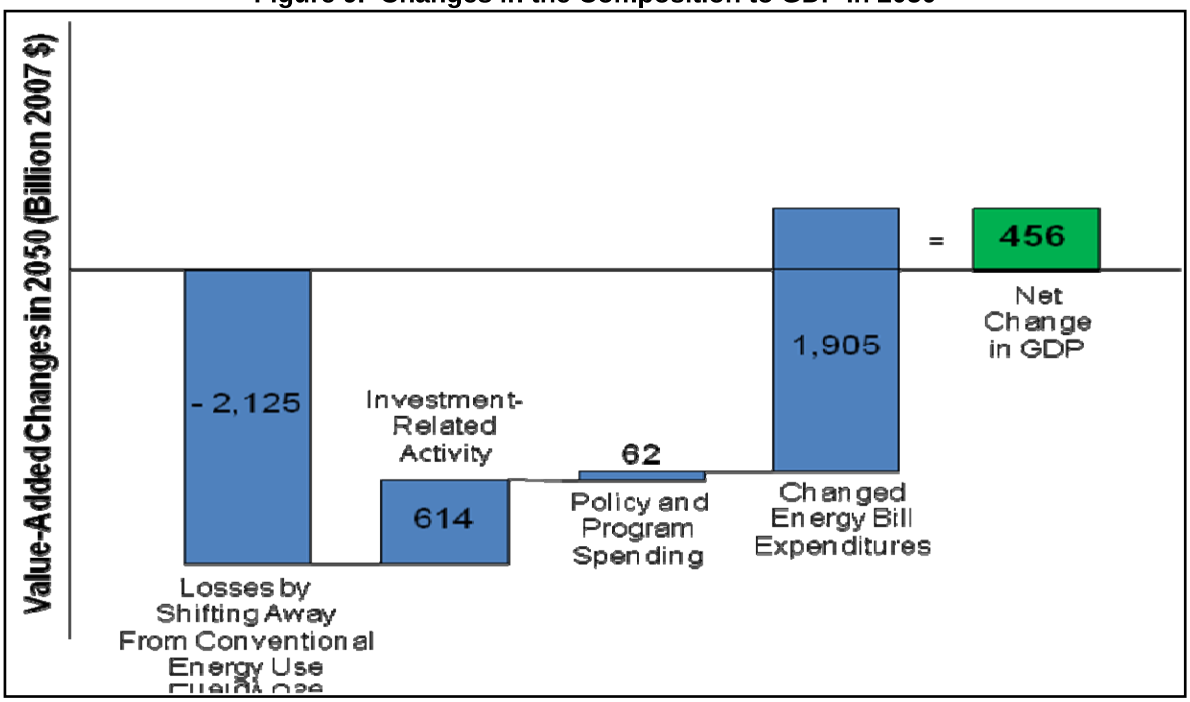
With this overview of the four diagnostic scenarios, we can now illustrate how the changed spending patterns can affect the composition of the nation's Gross Domestic Product. Figure 9 on the following page summarizes the key changes as if the economy consisted of four major sectors — conventional energy production, construction and related activities, business services and public spending, and

[21] Not included in this estimate of net resource costs are the non-energy benefits described earlier in this report, nor have we made allowance for avoided climate or other environmental damages made possible by the policy initiative summarized in column C of Table 1. The good news is that those avoided damages would only improve the net benefits outlined in this particular scenario.

energy consumers. In this case, we continue to use the outcomes of ACEEE's high energy efficiency scenario from column C of Table 1 to illustrate the net benefit to the economy. As the net changes in spending occur within each sector of the economy, it is matched to the appropriate value-added coefficient (shown as the green bars in Figure 6). The resulting pluses and minuses are netted out to a final change in the nation's GDP.[22] In the case of the column C data, the net contribution to GDP is estimated as $456 billion in 2050. That represents a small 1.2 percent net increase to the economy.

Figure 9 provides an effective backdrop for understanding the important role of almost any productivity gains to the economy — and in this case, energy productivity improvements. The standard modeling perspective highlighted in Table 1, column B, shows a small net loss of $226 billion to the nation's GDP. Two reasons generally cause this small but negative impact. The first is that the analysis assumes the majority of expenditures are pure costs to the economy. In other words, compared to the ACEEE energy efficiency scenario, the energy bill savings are insufficient to compensate for the transition costs. Second, a smaller contribution is the role of international offsets. Those are essentially payments made to others outside of the U.S. without a direct benefit to the economy.

Figure 9. Changes in the Composition to GDP in 2050



Source: ACEEE Diagnostic Assessment of Climate Economic Policy Models (2009)

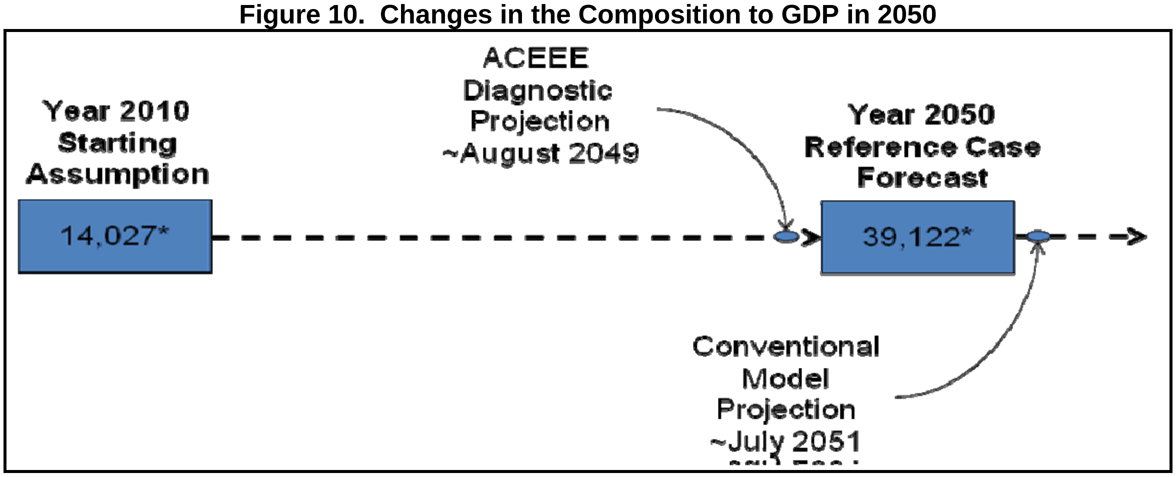
There is one important caveat and two additional insights that help conclude the discussion on the value of productive investments in more energy-efficient technologies. The caveat is a critical one in that the reader is reminded that this assessment is a diagnostic review of previous modeling outcomes rather than a prediction of policy impacts represented by H.R. 2454 or any other climate legislation. While the historical record and the diagnostic review do highlight the essential role and likely positive contribution of productive investments in greater levels of energy efficiency, any net impacts at this point should be considered very preliminary and only an approximation.

[22] It is worth noting that the seemingly negative impact on the nation's energy producers should not be seen as an unavoidable outcome. That would be true if and only if the nation's energy producers refused to change their core business activities. As new investments open up new markets, the nation's energy producers can also make the transition to energy service companies that help their customers maximize their own return. In that regard, the revenues lost from the traditional sale of energy commodities might be more than offset by the delivery of new and more productive energy services.

At the same time, the evidence highly suggests the standard models are not capturing the full efficiency opportunities that are likely to emerge in response to H.R. 2454. For example, the data in column B, Table 1 suggest only an 11 percent energy efficiency gain by 2050 (comparing row 5 in column B with row 5 in column A). Yet, the new study released by McKinsey & Company (2009) suggests a cost-effective savings of more than 20 percent savings in the period 2020 to 2030. The ACEEE (2009) review of the efficiency impacts of H.R. 2454 concluded that with current technologies, energy efficiency "can cost-effectively save 25–30 percent of total energy use, and that new technologies could increase the available cost-effective savings." The historical record further supports that assessment (DOE 1980, AEC 1991, Energy Innovations 1997).[23]

Finally, it may be worth noting that even if one concludes there may be some inevitable transition losses associated with climate change policies, rather than be seen as a net loss that should prevent the enactment of smart climate legislation, it might be better described instead as a postponement of growth in the economy. Figure 10 below underscores this important perspective.

Figure 10. Changes in the Composition to GDP in 2050



Source: Author's calculations (note that this timeline is not drawn to scale)

The starting assumption of the benchmark case for business as usual (as characterized in column A, Table 1) is that GDP will grow from $14 trillion in 2010 to just over $39 trillion in 2050. If we accept as inevitable the scale of losses suggested by the column B scenario, all that is really being suggested is that the economic growth is postponed until sometime early to mid-year of 2051. On the other hand, if we accept the ACEEE energy efficiency scenario, that level of growth might actually occur somewhere around the late summer of the year 2049. Over the 40-year period it might be said, in many ways, for an economy that reaches $39 trillion in either August 2049 or July 2051 might be a distinction without much of a difference. In saying this, the intent is not to minimize the income or transition difficulties of the obvious adjustments and dislocations that will take place. It is only to underscore both the uncertainty of when any specific level of economy activity might occur; and in light of the growing climate change imperative, we might ask the question: does the postponement of 40 years of growth by just a few months actually represent a net loss to the economy?

IV. Conclusion

The diagnostic review described here can be best be characterized only as an indicative level of economic impact. At the same time, the historical record and the economic evidence suggests that if the United States chooses to develop a more productive pattern of investments that substitutes innovation and energy efficiency for the more conventional production and consumption of energy, the impact on the U.S. economy is likely to be small but net positive. The reason is two-fold. First,

[23] See also the discussion around Figure 2 for a further review of the historical record surrounding the full potential of the energy efficiency resource.

the changed patterns of production are generally cost-effective over time. Second, the value-added intensities associated with the changed spending patterns tend to be greater than the value-added intensities associated with conventional energy use. In effect, the ACEEE energy efficiency scenario merely represents a different recipe of technology investments compared to the reference case, but it is one that emphasizes a more productive investment pattern that enables the U.S. economy to substantially reduce overall greenhouse gas emissions — should we choose to invest in and develop that larger opportunity.

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APPENDIX: KEY ECONOMIC AND FINANCIAL ASSUMPTIONS

As implied in the main part of this report, the impact assessment described here is really an examination of how changed behaviors and investment flows might reasonably characterize an alternative and perhaps a more productive future. As business leaders and policymakers first think about the policy implications of suggested climate change legislation, they may conclude that the implied transition to a less carbon-intensive economy will end up costing more. On the other hand, when all system costs are properly included and balanced, it can be shown — on a net basis — that the alternative future or the enacted policy scenarios may actually cost less.

In a format consistent with a number of other past studies that inform this analysis (see, for example, McKinsey 2009, CCS 2008, Laitner and McKinney 2008, Barrett et al. 2005, Laitner et al. 2006, Lovins et al. 2004, and the Interlaboratory Working Group 2000), this appendix highlights the major analytical assumptions that underpin the assessment described in the main part of the report.

The assumptions generally fall into four categories of major assumptions: prices, quantities, investment flows, and input-output modeling. One note of caution is offered. As a diagnostic review, this analysis deals with the aggregate economy rather than highlighting specific consumer or business energy prices and costs. While an actual modeling analysis would likely show prices and consumption differences between households and business sectors, in this review the focus here is on total primary energy consumption and the average energy price of that consumptions. Similarly the review does not include so-called flexibility mechanisms such as the purchase of international offsets or the banking and borrowing of emission credits. Instead, the focus is on the very large aggregate potential to reduce domestic emissions through greater levels of energy efficiency. As the Table 1 data and the discussion elsewhere suggests, the magnitude of the efficiency resource is sufficiently large as to substantially shrink the economic advantage of the flexibility mechanisms.

Energy Prices

Drawing from the *Annual Energy Outlook 2009* (Energy Information Administration 2009a), it appears that the Unites States will have an average energy cost in the reference case that begins in 2010 at about $12 per million Btu (in 2007 constant dollars). This will rise through 2030, reaching an average of $22.50 per million Btu. Continuing that trend through 2050 suggests a total increase of $32.39 per million Btu. This average price is highlighted in Table 1, column A, row 7. Since the economic impacts of each of the three policy scenarios are, in effect, a change from the reference case assumptions, for purposes of a diagnostic review it doesn't quite matter as much what the reference case scenario might actually be as long as we identify reasonable changes in any policy case as they might compare to the reference case.

The EPA assessment of H.R. 2454 suggests an average price increase of about 27 percent in the year 2050 as a result of the higher costs associated with a less carbon-intensive economy. The ACEEE assumptions factor in both the higher costs associated with carbon costs and a downward pressure that is driven by a significant reduction in the use of energy compared to the reference case. In this last regard, we are drawing insights from a number of studies, and also a review of how a changing demand might impact the overall price of energy within the *Annual Energy Outlook 2009* (Energy Information Administration 2009a). For this diagnostic assessment, the working assumption is that a 10 percent drop in demand will have a 2 percent downward impact on energy prices. And a 50 percent improvement in the nation's energy productivity will reduce prices on average to 87 percent of their previous value.

At the same time, the ACEEE scenario anticipates a significantly higher permit price for greenhouse gas emissions. Table 1 suggests a permit equivalent permit price of $465 per metric ton of carbon dioxide equivalent, or $465/t$CO_2$e, for the primary ACEEE efficiency analysis summarized in column C of Table 1. This is significantly higher than the permit price of $73 that the typical policy assessment might suggest. The good news, however, is that the economy is also substantially less carbon intensive by 2050. The CO_2 to energy ratio is only 11.54 million metric tons per quadrillion Btu. Multiplying the equivalent 0.1154 metric ton per million Btu by $465 yields an average price increase of $5.37 per million Btu.[24] But the base price of energy is also lower so that the full price impact would be evaluated as (63.6 quads / 128.9 quads)$^{0.2}$ * 32.39 + 465 = $33.49 per million Btu as shown in column C, row 7 of Table 1.

Technology Investment Streams

As previously noted, the investment costs are estimated for three different categories of emissions reductions: energy efficiency investments, low-carbon energy supply technologies, and non-CO_2 emissions reductions. The key set of assumptions for each of the major source of investment flows is summarized next.

Energy Efficiency

One critical piece of information needed to evaluate the impact of these scenarios is the cost of investment in energy efficiency technologies. To derive this information, we adapt the structure of the Long-Term Industrial Energy Forecast or LIEF model (Cleetus et al. 2003). The key relationship in this model is the current gap between average and best energy efficiency technology or the best efficiency practice.

The assumption in the LIEF model is that as a sector moves closer and closer to best practice or best technology, the cost of efficiency investment per unit of energy saved will increase. The rate of that increase depends on the energy prices, the elasticity of the efficiency supply curve, and the discount rate. As used in this exercise, the investment cost is shown as:

$$\text{Investment per Unit Energy Savings} = \left[\frac{1-G_0}{1-S}\right]^{(1/A)} * \left[\frac{P}{C}\right]$$

where:

P = price of energy in the based year.
C = capital recovery factor (CRF) or discount rate for the given year.
A = an elasticity that reflects the magnitude of the investment response to changes in price levels or the capital recovery factor.
S = percent of savings in current year compared to base year consumption.
G_0 = the energy intensity gap, or the difference between best and average practice

In many ways this can be thought of as the energy savings that would be economically viable in the base year, but have not been realized.

For this exercise, we adopt a current energy intensity gap of 25 percent based on the potential for long-term efficiency gains through the year 2050, a long run efficiency substitution elasticity of 0.6, and an implicit discount rate of 20 percent. [25] With energy prices of about $12.19 per million Btu in 2010, these assumptions suggest an average payback of about 3.7 years for a 10 percent efficiency

[24] As explained in this appendix, it turns out that the impact of a very large $465/t$CO_2$e permit price actually has a much smaller impact because of the substantially lower carbon intensity of the economy in 2050; this seemingly very high cost is primarily the artifact of constraints in the model used to generate these estimates. In short, the models tend to assume less productive or less available technologies that might ease the transition to a less carbon intensive future. The result is a very high price associated with emissions reductions. See also the further discussion on greenhouse gas emissions later in this appendix.
[25] This adaptation of the LIEF equation ignores the autonomous time trend component. In other words, as used here, the assumption of an efficiency gap remains static and there is only movement toward best practice or best technology rather than improvement in the base year representation of best practice or best technology. As the historical record suggests, the gap may actually grow to 50 percent — if the U.S. chooses to invest in greater innovation and energy productivity improvements. Hence, the use of a fixed 25 percent gap for purposes of estimating investment costs will tend to overstate the cost of the new efficiency gains.

gain based on prices in 2010. This rises to a 10-year payback for a 50 percent efficiency gain by 2050. Based on the much higher reference case prices in 2050, these paybacks would decline over time to 1.4 and 3.7 years. These results are broadly consistent with results found in Laitner et al. (2006) and Hanson and Laitner (2004).

Emissions Reductions

Drawing from the IGEM model data using in the EPA (2009) assessment, this analysis builds a set of marginal abatement cost curves for standard abatement costs of carbon dioxide (CO_2) emissions as well as domestic non-CO_2 emissions. These curves are:

Domestic Offsets = 23.03 * YearIndex $^{-0.1378}$ * Price $^{0.918}$

Energy-Related Abatement = 172.23 * YearIndex $^{0.1899}$ * Price $^{0.4898}$

Where:

YearIndex = the year of abatement in which 2011 equals 1 and 2050 equals 40
Price = the price in 2000 dollars / tCO_2e (adjusted to 2007 dollars using a deflator of 1.1894)

In the column C energy efficiency scenario in Table 1, the assumption is that we need to reduce actual U.S. emissions to about 85 percent below the reference case assumption of 8,379 $MMTCO_2e$ in total greenhouse gas emissions by 2050. Alternatively we need to reduce emissions down to 1,212 $MMTCO_2e$. The available non-CO_2 emissions are about 709 $MMTCO_2e$. Given those requirements, and not relying on either banking and borrowing or international tons, we solve for the price that will achieve that level of reduction. This step results in the requisite price of \$465/tCO_2e as previously described.

The earlier discussion in footnote 24 underscored the lack of more productive technology in the typical climate models that is actually now available and that would ease the transition to a lower carbon economy. This constraint is among the reasons for the very high permit prices. Another reason for the significantly higher price is that the ACEEE efficiency scenario is actually achieving twice more the domestic reductions than indicated in the typical modeling assessments (comparing row 3 in columns B and C). This again tends to drive up the permit price.

As Hanson (2007) suggests, however, even if the current generation of models captured the full potential of today’s technology and market flexibilities, the long-term carbon price could be considerably lower than we estimate based on today's knowledge. We know that there will be some breakthroughs on the technological, political, and international scenes, and a shift in consumer preferences and behaviors. All of these imply the strong likelihood that we will find solutions that re not too much more expensive than today. In fact, there is also evidence that some could be even cheaper (see also Knight and Laitner 2009). Notwithstanding the resulting high permit prices, as Figure 7 and the previous discussion on energy prices in this appendix implies, the net impact of higher carbon prices is actually very small compared the potential savings from the larger gains in energy productivity.

Policy and Program Costs

One of the working assumptions in this review is that that policies and programs are needed to drive the requisite investments. In generating an estimate of what these incremental costs might look like, we borrow from a study by Amy Wolfe and Marilyn Brown, “Estimates of Administrative Costs for Energy Efficiency Policies and Programs (Interlaboratory Working Group 2000, Appendix E-1). In that study the average administrative cost is assumed to be \$0.60 per million Btu of efficiency gains. Thus, the very large efficiency gain seen on the ACEEE efficiency scenario in column C of Table 1 suggests an incremental policy expenditure of \$39.2 billion by 2050 (calculated as [128.9 quads – 63.6 quads] * \$0.60/MBtu = \$39.2 billion).

The Input-Output Dataset

The actual data in Figure 6 are drawn from the 2007 IMPLAN Data for the U.S. economy (IMPLAN 2009). "Jobs" refer to the direct, indirect, and induced, or total jobs required in order to provide one million dollars of sales for each of the given economic sector listed in the table below. "Value-added" similarly refers to the total value-added contribution to the nation's Gross Domestic Product (GDP) per dollar of sales or revenue for each sector.

Table of Key Sector Impact Coefficients

Sector	Jobs	Value-Added
Energy	7.4	1.04
Manufacturing	13.1	1.13
Services	17.6	1.34
Construction	17.6	1.28
Trade	19.0	1.36
Government	21.2	1.57

A Final Caveat

Building on the available economic data and the larger historical record, the American Council for an Energy-Efficient Economy developed this diagnostic review to evaluate the recent assessments of climate change legislation now before the U.S. Congress. Based on the available record and the economic evidence to date, the ACEEE findings underscore the critical role of the energy efficiency resource — should we choose to develop it. Indeed, it is a substantially larger and more cost-effective resource than most economic policy models now acknowledge. Despite the compelling evidence in favor of more productive investments in energy efficiency, it should be clear we are not modeling any specific climate legislation such as H.R. 2454. Instead this review only examines the impacts of meeting the H.R. 2454 targets without any banking or international offsets, but investing instead in a much greater level of energy efficiency. This level of efficiency would likely not happen without additional policy interventions beyond those now envisioned in H.R. 2454.