SMART ENERGY POLICIES: SAVING MONEY AND REDUCING POLLUTANT EMISSIONS THROUGH GREATER ENERGY EFFICIENCY

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September 2001

Report Number E012

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EXECUTIVE SUMMARY

Multiple Energy Problems Confront the United States

There are a variety of serious energy challenges confronting the United States. California has experienced power shortages and severe electricity price spikes. Power reliability problems could spread to other regions such as the Pacific Northwest or New York. Even if the lights stay on, electricity prices will continue to climb in many regions of the country—utilities in several states have increased electric rates by 40–50% this year. Natural gas prices have also significantly increased in many parts of the country, causing skyrocketing home energy bills this past winter. Furthermore, our reliance on imported oil has grown—oil imports more than doubled during the past 15 years and oil imports now exceed domestic oil production. Rising demand for oil and tight supplies have also caused gasoline prices to rise; the average price of gas in the United States topped $1.70 per gallon earlier this year and while prices have since abated, price spikes are likely to be a periodic phenomenon in the future.

In addition, emissions of the gases that contribute to global climate change continue to rise. In 2000, U.S. greenhouse gas emissions were up 16% relative to levels in 1990. However, under the Global Framework Convention agreed to in Rio de Janeiro in 1992 by then-President Bush and subsequently ratified by the Senate, the United States voluntarily committed to reducing our emissions to 1990 levels by 2000.

Energy Efficiency—A Critical Foundation for U.S. Energy Policy

Most of these problems—reliability, high prices, and reliance on imports—are all fundamentally due to imbalances between energy demand and energy supply. As demand approaches available supply, prices rise and reliability deteriorates. Rising demand for oil (driven primarily by growing transportation sector energy use) combined with declining domestic production feeds the need for more imported oil. Statements by the current Bush Administration suggest that these problems can largely be solved by increasing energy supplies—more oil wells, coal mines, pipelines, refineries, power plants, and transmission lines. However, a supply-only strategy will be expensive (e.g., energy prices will need to be high to sustain private-sector investments in supply), time-consuming (it takes years to develop new energy sources), and harmful to our environment (e.g, adverse impacts on our land and air). Furthermore, available domestic supplies are not adequate to fully support the domestic economy. The United States accounts for one-quarter of global energy demand but has only 8% of known worldwide oil and natural gas reserves, placing limits on how much expanding energy supply can contribute to our energy needs. Instead of a supply-focused energy strategy, a far more rationale approach would be to first reduce energy demand to the extent that it is cost-effective to do so, and then meet the remaining demand with increased energy supplies (domestic or imported).

Energy efficiency improvement has contributed a great deal to our nation's economic growth and increased standard of living over the past 25 years. Total primary energy use per capita in the United States in 2000 was almost identical to that of 1973. Over the same 27-year period, economic output (GDP) per capita increased 74%. In 2000, consumers and businesses spent over $600 billion for total energy use in the United States. Had the nation not dramatically reduced its energy intensity over the previous 27 years, they would have spent at least $430 billion more on energy purchases in 2000.

Even though the United States is much more energy-efficient today than it was 25 years ago, there is still enormous potential for additional cost-effective energy savings. Some newer energy efficiency measures such as hybrid vehicles and sealing home heating ducts have barely begun to be adopted. With proper support, other efficiency measures could be developed and commercialized in coming years. The U.S. Department of Energy (DOE) estimates that increasing energy efficiency throughout the economy could cut national energy use by 10% or more in 2010 and approximately 20% in 2020, with net economic benefits for consumers and businesses. A 1999 ACEEE study estimates that adopting a comprehensive set of policies for advancing energy efficiency could lower national energy use by as much as 18% in 2010 and 33% in 2020, and do so cost-effectively.

Whether the energy savings potential is 20% or 30%, increasing the efficiency of our homes, appliances, vehicles, businesses, and industries should be the cornerstone of national energy policy since it provides a host of benefits. Furthermore, increasing energy efficiency does not present a trade-off between enhancing national security and energy reliability on the one hand and protecting the environment on the other, as do a number of energy supply options. Increasing energy efficiency is a "win-win" strategy from the perspective of economic growth, national security, reliability, and environmental protection.

Energy Efficiency Policy Recommendations

We have identified nine specific policy recommendations that could have a substantial impact on the demand for energy in the United States while also providing positive economic returns to American consumers and businesses. We list these policies in approximate order of energy savings, starting with the policies that yield the largest savings.

1. Increase Corporate Average Fuel Economy

The average fuel economy of new passenger vehicles (cars and light trucks) has declined from about 26 miles per gallon (mpg) in 1988 to 24 mpg in 2000 due to increasing vehicle size and power, the rising market share of light trucks, and the lack of tougher Corporate Average Fuel Economy (CAFE) standards. The original CAFE standards for cars were adopted in 1975 and reached their maximum level in 1985. We recommend increasing the CAFE standards for cars and light trucks by 5% per year for 10 years so that they reach 44 mpg for cars and 33 mpg for light trucks in 2012, with further improvements beyond 2012. Alternatively, the standards for cars and light trucks could be combined into one value for all new passenger vehicles, specifically 38 mpg by 2012. This level of fuel economy improvement is technically feasible, cost-effective for consumers, and can be achieved without compromising vehicle safety.

Higher fuel economy standards should be complemented by (1) implementing tax credits for purchasers of innovative, highly efficient vehicles, (2) expanding taxes on gas-guzzling vehicles, (3) increasing labeling and consumer education efforts, and (4) continuing vigorous research and development (R&D) on fuel-efficient, low-emissions vehicles. This combination of policies would facilitate compliance with the tougher standards.

2. Adopt a National System Benefit Trust Fund

Electric utilities historically have funded programs to encourage more efficient energy use, assist low-income families with home weatherization and energy bill payment, promote the development of renewable energy sources, and undertake R&D. Experience with utility energy efficiency programs in the Northeast, Northwest and Great Lakes region shows that these programs have been highly effective. The value of energy bill savings for households and businesses is about double the costs to produce these savings. Unfortunately, increasing competition and restructuring have led utilities to cut these discretionary "system benefit" expenditures over the past 5 years. Total utility spending on all demand-side management programs (i.e., energy efficiency and peak load reduction) fell by more than 50% from a high of $3.1 billion in 1993 to $1.4 billion in 1999 (1999$).

In order to ensure that energy efficiency programs and other public benefits activities continue following restructuring, 15 states have established system benefits funds through a small charge on all kilowatt-hours flowing through the transmission and distribution grid. We recommend creation of a national systems benefits trust fund that would provide matching funds to states for eligible public benefits expenditures. Specifically, we recommend a non-bypassable wires charge of two-tenths of a cent per kilowatt-hour. This policy would give states and utilities a strong incentive to expand their energy efficiency programs and other public benefits activities.

3. Enact New Equipment Efficiency Standards and Strengthen Existing Standards

Federal appliance and equipment efficiency standards were signed into law by President Reagan in 1987 and expanded under President Bush in 1992. Minimum-efficiency standards were adopted because many market barriers (such as lack of awareness, rush purchases when an existing appliance breaks down, and purchases by builders and landlords) inhibit the purchase of efficient appliances in the unregulated market. Standards remove inefficient products from the market but still leave consumers with a full range of products and features to choose among. Appliance and equipment standards are clearly one of the federal government's most effective energy-saving programs. In 2000, federal appliance and equipment efficiency standards reduced consumer energy bills by approximately $9 billion, with energy bill savings far exceeding any increase in product cost. By 2020, standards already adopted will reduce peak electrical demand by an amount equal to the output of more than 400 power plants of 300 MW each.

In order to provide additional cost-effective savings under this program, we recommend that Congress adopt new efficiency standards for products now or soon to be covered by state efficiency standards. Among the products that should be included are distribution transformers, exit signs, traffic lights, and torchiere lighting fixtures. California is now adopting standards on these products and Massachusetts and Minnesota already have standards on distribution transformers. None of these standards have been controversial and all yield highly cost-effective energy savings. Congress should also adopt standards on commercial refrigeration equipment, commercial unit heaters, and standby power consumption for household appliances and electronic products (such as televisions, VCRs, cable boxes, and audio equipment). In addition, DOE, with adequate funding and encouragement from Congress, should complete equipment standard rulemakings in a timely manner. Finally, the Bush Administration should drop its efforts to roll-back the recently set SEER 13 efficiency standard for residential central air conditioners and heat pumps.

4. Enact Tax Incentives for Highly Energy-Efficient Vehicles, Homes, Commercial Buildings, and Other Products.

Many new energy-efficient technologies have been commercialized in recent years or are nearing commercialization. But these technologies may never get manufactured on a large scale or widely used due to barriers such as their initial high cost, market uncertainty, and lack of consumer awareness. Tax incentives would help manufacturers justify mass marketing for innovative energy-efficient technologies. Tax credits also could help buyers (or manufacturers) offset the relatively high first cost premium for the new technologies, thereby helping to build sales and market share. Once the new technologies become widely available and produced on a significant scale, costs should decline and the tax credits could be phased out.

We recommend tax incentives for advanced, high-efficiency appliances, new homes, new commercial buildings, hybrid and fuel cell vehicles, combined heat and power (CHP)systems, and other building equipment such as air conditioners and heat pump water heaters. The total cost to the Treasury would be on the order of $10 billion. These credits would save energy directly due to purchases of equipment eligible for the credits, but even more importantly, if the credits helped to establish these innovative products in the marketplace and reduced the first cost premium so that the products would be viable after the credits were phased out, the indirect impacts would be many times greater than the direct impacts.

5. Expand Federal Energy Efficiency R&D and Deployment Programs

DOE has made many valuable contributions towards increasing the energy efficiency of U.S. buildings, appliances, vehicles, and industries. Consequently, the President's Committee of Advisors on Science and Technology (PCAST) stated in 1997 that "R&D investments in energy efficiency are the most cost-effective way to simultaneously reduce the risks of climate change, oil import interruption, and local air pollution, and to improve the productivity of the economy." A July 2001 National Academy of Sciences review of some of DOE's R&D programs found that a sample of energy efficiency R&D programs resulted in net realized economic benefits of approximately $30 billion (1999$), substantially exceeding the roughly $7 billion (1999$) in total energy efficiency RD&D investment over the 22-year life of the programs. Similarly, the ENERGY STAR deployment programs operated by EPA and DOE have also been very successful.

Based on specific budget recommendations in the PCAST report, we recommend that instead of cutting funding for DOE's R&D programs as proposed this spring by the Bush Administration, funding should instead be increased by about 17% per year for the next 3 years. Funding for EPA's programs should also be expanded at a similar level.

6. Promote Clean, High-Efficiency Combined Heat and Power Systems

CHP systems produce multiple usable energy forms (e.g., electricity and steam) from a single fuel input. These combined systems achieve much greater efficiency than the usual separate systems for producing steam and electricity because the CHP systems recover heat that would otherwise be wasted in separate power production, and use this heat to displace the fuel that otherwise would be used to produce heat in a separate boiler.

Several inequities in government and utility regulations hinder development of CHP resources. These include environmental standards that do not recognize the efficiency gains of CHP systems, utility rules that make it difficult for many CHP systems to connect to the utility grid, and tax depreciation rules that vary the depreciation period for CHP systems from 5–39 years depending on plant ownership. Each of these problems need to be addressed, including: (1) reforming regulations to regulate emissions per unit of energy output rather than per unit of energy input; (2) developing uniform standards for CHP facilities to be interconnected with the local distribution facilities; and (3) standardizing depreciation periods for CHP systems based on the technical and market life of current systems.

7. Voluntary Agreements and Incentives to Reduce Industrial Energy Use

There is substantial potential for cost-effective efficiency improvement in industry. For example, in-depth analyses of specific energy efficiency technologies for the iron and steel, paper and pulp, and cement industries found a total cost-effective energy savings potential of 11–22%. In order to stimulate widespread energy efficiency improvements in the industrial sector, we propose that the U.S. government establish voluntary agreements with individual companies or entire sectors. Companies or sector trade associations would pledge to reduce their overall energy and carbon emissions intensities (energy and carbon per unit of output) by a significant amount, for example, at least 1% per year over 10 years. Companies that make a more substantial commitment (for example, at least 2% per year) could be given ENERGY STAR or similar recognition. The government could encourage participation and support implementation by: (1) providing technical assistance to participating companies that request assistance; (2) offering to postpone consideration of mandatory emissions reductions or tax measures if a large percentage of industries participate and achieve their goals; and (3) expanding federal R&D and demonstration programs for sectors with high participation.

A number of major companies have already made voluntary energy efficiency commitments on their own. For example, Johnson and Johnson set a goal in 1995 of reducing energy costs by10% by 2000 through adoption of "best practices" in its 96 U.S. facilities. As of April 1999, they were 95% of the way towards this goal, with the vast majority of projects providing a payback of 3 years or less. Voluntary agreements between government and industry along the lines proposed here have resulted in substantial energy intensity reductions in some European nations such as Germany, the Netherlands, and Denmark. The United States should build on this experience.

8. Improve the Efficiency and Reduce the Emissions of the Existing Power Plant Fleet

Many old, highly polluting power plants are "grandfathered" under the Clean Air Act. This means that they do not need to meet the same emissions standards for nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulates as plants built after the Clean Air Act of 1970 was enacted. Currently, 850 plants built before 1970 are still operating, with a combined power output of 145,400 MW. In 1999, these plants produced about 21% of our nation's electric generation. These older, dirty power plants emit 3–5 times as much pollution per unit of power generated as newer, coal-fired power plants and 15–50 times as much NOx and particulates as a new combined-cycle natural gas power plant. These older plants also are less efficient than most new plants; the pre-1970 plants have an average heat rate of 11,025 Btus of fuel per kWh generated, compared to modern combined-cycle plants with heat rates of 7,000 or less. When the Clean Air Act was adopted, it was expected that these dirty power plants would eventually be retired. However, many utilities are continuing to operate these plants beyond their "design life" due to their low capital and operating cost.

If old, grandfathered plants were required to meet the same emissions standards as new plants, some plants would be modernized and cleaned up, but many would be shut down and replaced with much more efficient and cleaner generating sources such as combined-cycle natural gas power plants. We recommend that a policy to end "grandfathering" be enacted soon but not take effect until 2010 or thereabouts. This phase-in period would allow owners of these old plants to make plant upgrade vs. replacement decisions and then have sufficient time to implement these decisions without unduly disrupting power markets. Alternatively, the same general objectives would be achieved by adopting new emissions standards as part of a Clean

Air Act "four pollutant" strategy that has been proposed in order to address SOx, NOx, mercury, and carbon dioxide (CO_2) emissions in an integrated fashion. Such a strategy would include tradeable emissions permits, with the number of emissions allowances based on the phase-out of old, dirty, inefficient power plants.

9. Greater Adoption of Current Model Building Energy Codes and Development and Implementation of More Advanced Codes

Building energy codes require all new residential, commercial, and industrial buildings to be built to a minimum level of energy efficiency that is cost-effective and technically feasible. "Good practice" residential and commercial energy codes have been adopted by just over half the states. However, some major states (such as Arizona, Illinois, Michigan, New Jersey, and Texas) have not adopted these "good practice" energy codes. Furthermore, building codes can and should be upgraded. In the case of residential codes, codes can be further improved by including several measures to reduce use of air conditioning in hot climates and by reducing energy losses due to air infiltration and duct leakage. In the case of commercial codes, a new national model standard was published in 1999 that reduces energy use approximately 6% compared to the old "good practice" code. Here too, substantial additional improvements are possible as measures with 10–20% additional savings were included in early drafts but dropped as part of a political process to gain "consensus."

In order to capture the available savings, states should be directed to review their codes and encouraged to revise them. DOE should continue to provide technical assistance for these efforts, with preference given to states that adopt statewide mandatory codes at or above the model codes. The model code organizations (International Energy Conservation Code [IECC] and American Society of Heating, Refrigerating and Air-Conditioning Engineers [ASHRAE]) should also be encouraged to regularly update their codes to incorporate the latest in cost-effective energy-saving measures. IECC has been doing well in this regard, but ASHRAE's 1999 standard revision achieves far less savings than ASHRAE had targeted. Given ASHRAE's conservatism, DOE should broaden its funding activities to include organizations and consortiums of states that are interested in achieving higher levels of energy savings than ASHRAE is able to deliver.

Integrated Analysis

In order to estimate the energy and emissions savings of these nine policies as well as their costs and benefits, we conducted an integrated analysis using the DOE/EIA National Energy Modeling System, known as NEMS. Most of our assumptions for the base case were taken from the NEMS model, specifically as it was applied to produce the *Annual Energy Outlook 2001.* We then modeled each of our policies individually and together to estimate the overall impacts of our policy set and the contribution of each policy towards these combined impacts.

Energy Impacts

Key results of the analysis are summarized in Table ES-1. Overall in the base case, total U.S. primary energy consumption grows1.3% per year on average. Relative to the base case, the nine policies reduce primary energy consumption by 11% by 2010 and by 26% by 2020. Primary energy use rises slightly during the next decade but falls significantly during 2010-2020 (see Figure ES-1).

Table ES-1. Summary of Overall Results for the Base and Policy Cases

	1990	1999	2010 Base Case	2010 Policy Case	2020 Base Case	2020 Policy Case
End Use Energy (Quads)	63.9	71.6	86.5	79.4	98.3	78.9
Primary Energy (Quads)	84.6	96.1	114.6	102.2	128.1	94.2
Energy Use by Fuel (Quads)						
Coal	19.1	21.4	25.2	18.1	26.2	9.5
Oil	33.5	38	44.9	41.9	51.7	42.1
Natural gas	19.3	22	28.7	26	35.5	27.5
Nuclear	6.2	7.8	7.7	7.8	6.1	6.3
Hydro	3	3.2	3.1	3.1	3.1	3.1
Other renewables	3.5	3.4	4.8	5.1	5.2	5.5
Carbon Emissions (Million Metric Tons)	1,338	1,505	1,817	1,540	2,063	1,338
Other Emissions (Million Metric Tons)						
Sulfur dioxide	19.3	20.5	16.5	14.9	16.9	13.1
Nitrogen oxides	21.9	15.8	12.8	11.6	12.7	6.6
Particulate matter (PM-10)	1.7	1.5	1.5	1.4	1.6	1.4
Cumulative Net Savings ($ billions)			-	152	-	591

In the base case, oil consumption would increase by about one-third by 2020, and oil imports would increase by more than 60% over that period. Thus, the oil import fraction is projected to rise from a little over 50% today to about 70% of total U.S. oil use by 2020. The policies evaluated here would significantly reduce overall oil imports. Relative to the base case, annual oil use would be reduced by about 19% and imports by about 40% by 2020. With implementation of the nine policies, U.S. total energy use in 2020 would be about 2% lower than energy use in 1999. Within this overall trend, use of some fuels would increase and use of other fuels would decrease. For example, use of coal would decline 56% over this period, primarily due to substantial retirements of old coal-fired power plants and replacement with natural gas. Due to increased use of natural gas for electricity generation, natural gas use would grow 25% under the policy case relative to 1999 consumption, indicating that increased natural gas supplies would be needed. This growth in natural gas use in the policy case would be substantially less than the 62% increase in natural gas use in the base case. As for petroleum, even with substantial efficiency improvements, petroleum use in the policy case would be 11% higher than use in

1999. With domestic production at best stagnant, this would mean that oil imports would grow modestly, even with a full array of efficiency policies. (By way of comparison, petroleum use would grow 36% in the base case.) Finally, electricity use in 2020 would be about the same as 1999 use, although growth in CHP systems would decrease the need for centrally generated power relative to 1999. In total, while our nine policies would dramatically reduce the need for new energy supplies, even with these policies, there would be some need for new supplies, particularly natural gas.

Figure ES-1. U.S. Energy Consumption Over Time in the Base and Policy Cases

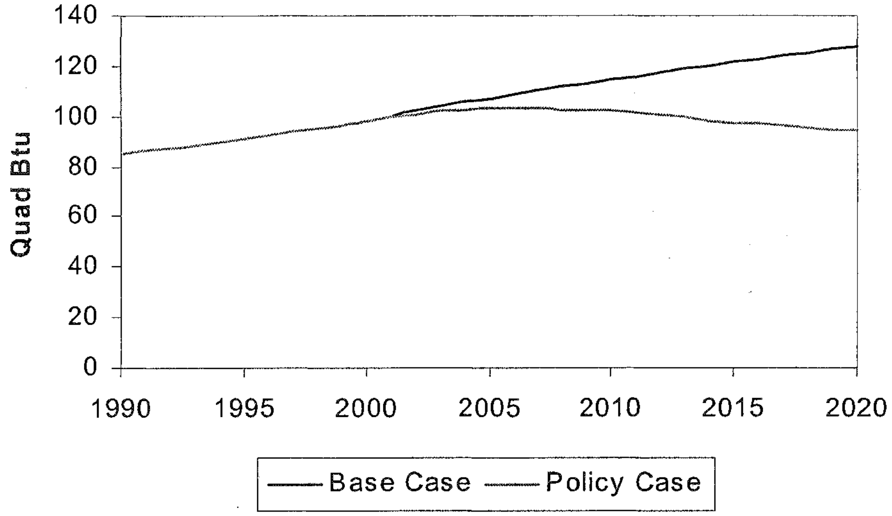


Table ES-2 summarizes savings from the different policies. Each of the policies would have a substantial impact on U.S. energy use, with all saving at least 1.5 quad by 2020 (although tax credits are listed with lower savings since a substantial portion of their savings would be subsumed under the CAFE standards, CHP, appliance standards and building code policies). The largest savings would be achieved by CAFE standards and related policies to improve the fuel economy of light duty vehicles. Public benefit funds and industrial voluntary programs would have the next largest savings. These three policies together would account for about 60% of the savings in our policy case. However, for these policies to achieve such savings, they would need to be stringent along the lines discussed above, with the equivalent of a 38 mpg CAFE standard, a two-tenths of a cent per kilowatt-hour matching public benefit fund, and an industrial targets program backed by significant "carrots and sticks." Scaled-back versions of these policies would result in significantly lower savings.

Intermediate levels of energy savings would be achieved by updated and expanded appliance and equipment efficiency standards, expanded federal R&D and deployment efforts, increased use of CHP systems, and tax credits. Finally, more moderate, albeit still substantial, savings would be achieved by building codes and retirement of old, inefficient power plants. Savings from this latter policy are somewhat limited by our analytical approach, whereby demand-side measures are applied before supply-side measures. With this convention, efficiency programs would lead to substantial power plant retirements, leaving only about half of the old "grandfathered" plants to be affected by the power plant policy. If we had instead considered supply-side policies first, power plant retirements would be included among the policies with intermediate energy savings.

Table ES-2. Energy Use Reductions by Policy

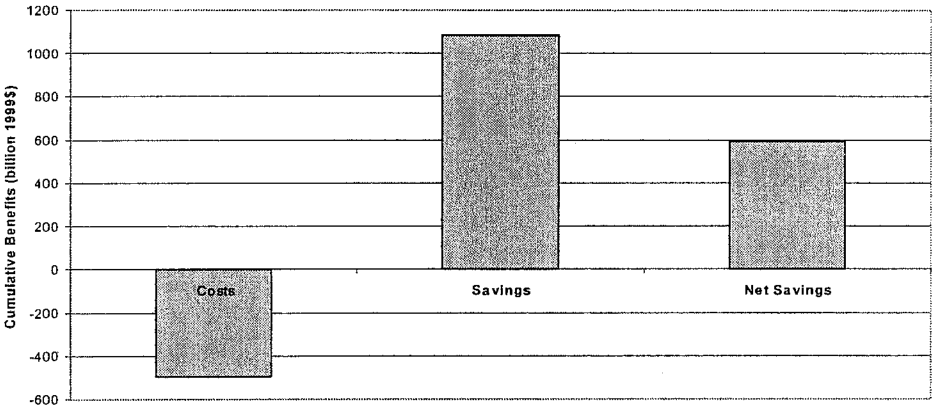
	2010	2020
Total Policy Case Consumption	102.2	94.2
Reduction from industrial policies	4.5	9.5
Reduction from commercial policies	2.7	7.9
Reduction from transport policies	2.1	7.7
Reduction from residential policies	2.5	7.2
Reduction from electric supply policies	0.6	1.5
Total Base Case Consumption	114.6	128.1

Economic Impacts

Figure ES-2 summarizes the direct economic costs and benefits in the policy case. The policies would induce incremental investments in advanced industrial processes; more efficient buildings, lighting, and appliances; more fuel-efficient cars and trucks; cleaner and more efficient power plants; and so on. We estimate a total investment of $127 billion through 2010 and $495 billion through 2020, expressed in 1999 dollars using a 5% real discount rate. To place these figures in context, total U.S. energy expenditures (excluding on-site renewables) equaled a little over $600 billion in 2000. Overall, we estimate that end-users would save over $1,100 billion through 2020 as a result of these policies. The energy bill and operating savings would more than offset the investments costs, with net savings of about $170 billion through 2010 and over $600 billion through 2020. The net savings would grow over time since energy efficiency measures would have more time to pay back their initial cost.

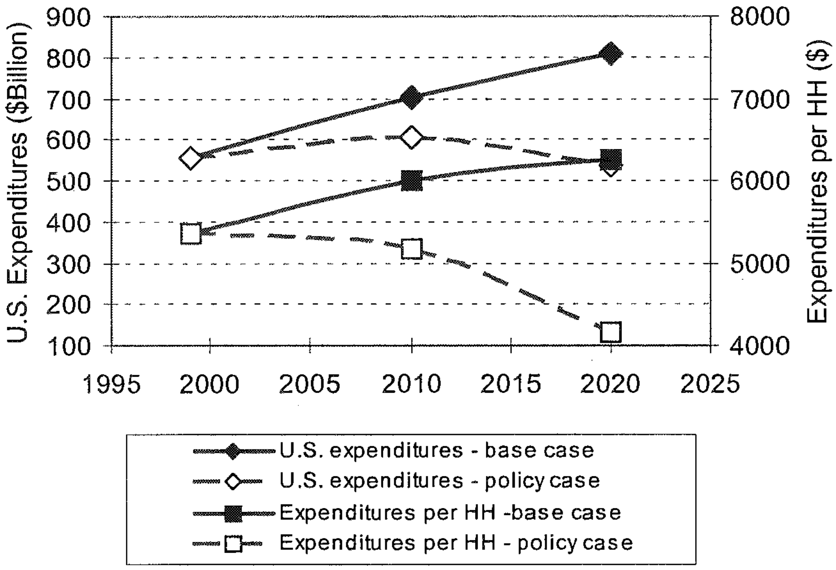
The nine policies would also have a positive impact on the economy by weakening demand for different energy sources, which would result in lower energy prices. In the base case, NEMS projects that domestic electricity and coal prices will decline somewhat in real terms over the 1999–2020 period (e.g., declines of 8% and 25%, respectively), while natural gas prices will increase by 49%. Under the policy case, electricity and coal prices are projected to drop by an additional 7% and 1%, respectively. More dramatically, natural gas prices are projected to decline to below 1999 levels (e.g., to $1.9 per million Btus in 2020), a *37%* decline from the base case.

Figure ES-2. Costs, Savings, and Net Savings for the Policies by 2020



These price declines would have a substantial and positive impact on the U.S. economy and would benefit all consumers and businesses. These indirect benefits are in addition to the direct benefits discussed above. Figure ES-3 summarizes our model results for energy expenditures in the base and policy cases, incorporating both the direct and indirect effects. Viewed on a per household basis, in the base case, energy expenditures per household would gradually climb from $5,355 in 1999 to $6,249 in 2020 (1999$). In the policy case, expenditures per household would be only $4,156, an annual savings of $2,093 per household (a savings of one-third).

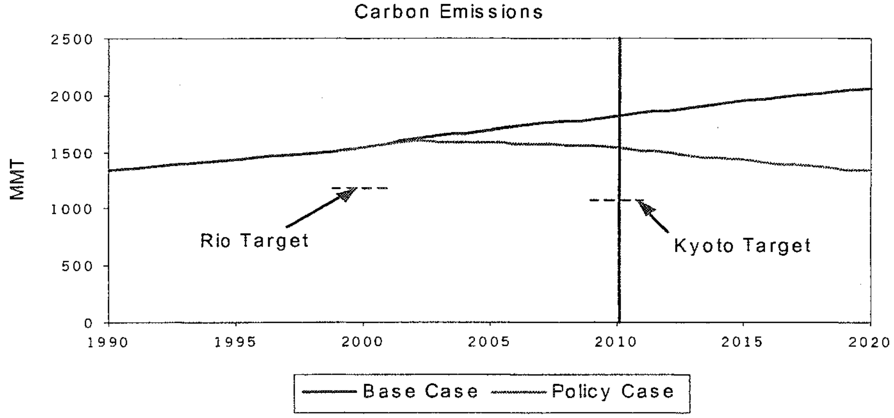
Figure ES-3. Energy Expenditures in the Base and Policy Cases



Emission Impacts

U.S. carbon emission trends in the base and policy cases are illustrated in Figure ES-4. In the base case, carbon emissions would reach 1,817 million metric tons (MMT) carbon equivalent by 2010 and 2,063 MMT by 2020, a 1.5% annual average growth rate during 2000–2020. Base case emissions would be 36% greater than the 1990 level by 2010 and 54% greater by 2020. In the policy case, carbon emissions would decline by 2010 so that they would be the same as 2000 emissions and about 15% above 1990 emissions. While this would not be enough to reach America's Kyoto Protocol target of 7% below 1990 emissions during 2008–2012, it would be strong steps in that direction. It should be possible to achieve the Kyoto target (i.e., a further 290 MMT annual reduction) through some combination of: (1) further domestic reductions from additional policy initiatives, such as policies to promote use of renewable energy sources and policies to reduce energy use for air and truck transportation and vehicle miles traveled for passenger cars; (2) reductions in emissions of other greenhouse gases; (3) purchase of emissions reductions from other Annex 1 countries; and (4) reductions in developing countries from Clean Development Mechanism projects.

Figure ES-4. U.S. Carbon Emissions Over Time in the Base and Policy Cases



In addition to carbon emission reductions, the set of nine policies would also reduce emissions of criteria air pollutants. Implementing the nine policies would reduce SO_2 emissions the most— 48% by 2020. Emissions of NOx would be cut 19% by 2020 and fine particulate emissions would drop 13% by 2020. Clearly, taking action to reduce energy use as proposed in the policy case would provide significant public health and local/regional environmental benefits.

Discussion and Conclusion

Energy efficiency should be a cornerstone for America's energy policy. Taken together, the nine policies recommended here could reduce U.S. energy use by more than 20% in 2020. These efficiency policies alone would not solve all of our energy problems—energy use would continue to grow for a decade or more while these energy-saving policies would gradually take effect. Furthermore, sustaining current rates of energy use into the long-term future would require new sources of energy supply and distribution. However, these efficiency policies would substantially reduce our energy problems, making it easier to find reasonably priced and environmentally acceptable energy supplies to meet U.S. energy demand. In other words, relative to a supply-focused energy strategy, a balanced energy strategy that complements efforts to expand supplies with a major focus on improving efficiency, would have a greater chance of success in terms of ensuring the reliability of the U.S. energy system, reducing economic costs (since all the efficiency strategies incorporated here save consumers and businesses money at projected future energy costs), and protecting the environment.

The general public voices strong support for increasing energy efficiency and a balanced energy strategy. For example, a recent nationwide poll conducted for the *Los Angeles Times* found that when people were read a list of 11 actions to deal with the energy situation, the top four actions (supported by 85–91% of respondents) were "invest in new sources of energy," "mandate more energy-efficient appliances," "mandate more energy-efficient new buildings," and "mandate more energy-efficient cars." Options for increasing the supply and delivery of traditional energy sources received significantly less support.

Ten years ago the previous Bush Administration issued its National Energy Strategy. It gave considerable priority to greater energy efficiency and called for expansion of energy efficiency R&D and technology deployment programs, new policies to stimulate utility energy efficiency programs, establishing new appliance and equipment energy efficiency standards, and new federal incentives to increase energy efficiency. Many of these proposals were incorporated in the Energy Policy Act of 1992, and the budget for and impacts of DOE's energy efficiency programs rose throughout the previous Bush Administration.

In May 2001 the current Bush Administration released its *National Energy Policy*. This policy calls for "advanc[ing] new, environmentally friendly technologies to increase energy supplies and encourage cleaner, more efficient energy use." Unfortunately the policy details do not bear this rhetoric out. Instead, the plan proposes many specific policies for increasing energy supplies, but the major specific efficiency policy is a call for tax incentives for efficient vehicles and CHP systems (a subset of the tax credits we propose). In addition, the plan calls for "reviewing" CAFE and "tak[ing] steps" to set new appliance efficiency standards. These latter suggestions fall well short of our specific policy prescriptions.

Congress is now beginning to consider energy legislation, and these efforts so far go farther than the Bush Administration proposes, but are still well short of what is needed. As of this writing, legislation passed by the House of Representatives includes many of the tax incentives we call for, some of the appliance standards we call for, and an extremely modest increase in CAFE standards. At the same time, both houses of Congress have passed appropriations bills that reverse the budget cuts proposed by the Bush Administration, but do not provide the growth in funding that is needed. All of our other policies are not included in the House legislation. Congress is so far doing much less than what polls show the American people want. Congress needs to redouble its efforts in order to properly value and support energy efficiency in new energy legislation and in appropriations for energy programs.

This report shows that energy efficiency policies would make a very large contribution towards meeting U.S. needs for new energy sources, while reducing emissions and saving consumers and businesses billions of dollars. However, without aggressive policy intervention, many of these benefits will be lost, costing the United States dearly in terms of economics, public health, dependence on imported energy, and adverse impacts on our environment.

ACKNOWLEDGMENTS

Funding for the research and writing of this report was provided by grants from the Joyce Foundation, the Turner Foundation, The Energy Foundation, and the Pew Charitable Trusts. The integrated analysis using the NEMS modeling system was done by the Tellus Institute, particularly Steve Bernow, Bill Dougherty and Allison Bailie. In addition to the lead authors, we are grateful for help from other ACEEE staff, particularly Neal Elliott (industrial programs), Therese Langer (transportation programs), and Renee Nida (editing and production). Helpful comments on a draft of this report were provided by Skip Laitner (U.S. Environmental Protection Agency) and Harvey Sachs (ACEEE).

CURRENT ENERGY PROBLEMS

There are a variety of serious energy challenges confronting the United States. California has experienced power shortages and severe electricity price spikes. Power reliability problems could spread to other regions such as the Pacific Northwest or New York. Even if the lights stay on, electricity prices will continue to skyrocket in many regions of the country. In Washington state, retail electric rates have risen by up to 40%; in Montana, new power supply contracts will lead to retail rate increases of as much as 50%; and in New York City, electricity prices climbed 40% for part of last summer and the Chairman of the local utility says that prices this summer are expected to jump "about the same" (Smith and Emshwiller 2001).

Natural gas prices have also significantly increased in many parts of the country, causing skyrocketing home energy bills this past winter. Earlier this year, residential natural gas prices passed $1 per therm[1] in many states, and while prices are now down somewhat, they still substantially exceed the approximately $0.60–0.70 per therm price that prevailed for most of the past decade (EIA 2001a, 2001b).

Our reliance on imported oil has grown—oil imports more than doubled during the past 15 years and oil imports now exceed domestic oil production.[2] Rising demand for oil and tight supplies have also caused gasoline prices to rise; the average price of gas in the United States topped $1.70 per gallon earlier this year and the average price is still above this level in California (EIA 2001c; Macintyre 2001).

Also, our emissions of the gases that contribute to global climate change continue to rise. In 2000, U.S. greenhouse gas emissions were up 16% relative to levels in 1990 (EIA 2001d). However, under the Global Framework Convention agreed to in Rio de Janeiro in 1992 by then-President Bush and subsequently ratified by the Senate, the United States voluntarily committed to reducing our emissions to 1990 levels by 2000.[3]

Most of these problems—reliability, high prices, and reliance on imports—are all fundamentally due to imbalances between energy demand and energy supply. As demand approaches available supply, prices rise and reliability deteriorates. Rising demand for oil (driven primarily by growing transportation sector energy use) combined with declining domestic production feeds the need for more imported oil. Statements by the current Bush Administration suggest that these problems can largely be solved by increasing energy

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[1] A therm is the unit of natural gas sales. It's 100,00 Btus of energy and approximately equal to 100 ft^3 of gas.

[2] In 2000, oil imports averaged 11,093 barrels per day, up from 5,067 in 1985. In 2000, imports exceeded total domestic petroleum consumption by 36% (EIA 2001b).

[3] This commitment is a voluntary one—there are no penalties for non-compliance. Also, the United States is not the only country to fall short of its Rio targets.

supplies—more oil wells, coal mines, pipelines, refineries, power plants, and transmission lines. However, a supply-only strategy will be expensive (e.g., energy prices will need to be high to sustain private-sector investments in supply), time-consuming (it takes years to develop new energy sources), and harmful to our environment (e.g, adverse impacts on our land and air). Furthermore, available domestic supplies are not adequate to fully support the domestic economy. The United States accounts for one-quarter of global energy demand (EIA 2000a) but has only 8% of known worldwide oil and natural gas reserves (USGS 1996, 1998), placing limits on how much expanding energy supply can contribute to our energy needs. Instead of a supply-focused energy strategy, a far more rationale approach would be to first reduce energy demand to the extent that it is cost-effective to do so, and then meet the remaining demand with increased energy supplies (domestic or imported).

THE HISTORIC AND POTENTIAL FUTURE ROLE OF ENERGY EFFICIENCY

Energy efficiency improvement has contributed a great deal to our nation's economic growth and increased standard of living over the past 25 years. Consider the following facts (EIA 2000c, 2001b; 2001e):

- Total primary energy use per capita in the United States in 2000 was almost identical to that of 1973. Over the same 27-year period, economic output (GDP) per capita increased 74%.
- National energy intensity (energy use per unit of GDP) fell 42% between 1973 and 2000. About 60% of this decline is attributable to real energy efficiency improvements and about 40% is due to structural changes in the economy and fuel switching (Murtishaw and Schipper 2001).
- In 2000, consumers and businesses spent over $600 billion for total energy use in the United States. Had the nation not dramatically reduced its energy intensity over the previous 27 years, they would have spent at least $430 billion more on energy purchases in 2000.
- Between 1996 and 2000, GDP increased 19% while primary energy use increased just 5%. Imagine how much worse our energy problems would be today if energy use had increased 10 or 15% during 1996–2000!

Even though the United States is much more energy-efficient today than it was 25 years ago, there is still enormous potential for additional cost-effective energy savings. Some newer energy efficiency measures, such as hybrid vehicles and sealing residential heating ducts to prevent leakage, have barely begun to be adopted. With proper support, other efficiency measures could be developed and commercialized in coming years. DOE estimates that increasing energy efficiency throughout the economy could cut national energy use by 10% or more in 2010 and approximately 20% in 2020, with net economic benefits for consumers and businesses (EERE

2000a). A 1999 ACEEE study estimates that adopting a comprehensive set of policies for advancing energy efficiency could lower national energy use by as much as 18% in 2010 and 33% in 2020, and do so cost-effectively (Geller, Bernow, and Dougherty 1999).

Whether the energy savings potential is 20% or 30%, increasing the efficiency of our homes, appliances, vehicles, businesses, and industries should be the cornerstone of national energy policy since it provides a host of benefits. Increasing energy efficiency would:

- reduce energy waste and increase productivity without forcing consumers or businesses to cut back on energy services or amenities;
- reduce the risk of energy shortages and improve the reliability of overtaxed electric systems;
- save consumers and businesses money since the energy savings more than pay for any increase in first cost;
- reduce energy imports;
- reduce air pollution of all types since burning fossil fuels is the main source of most types of air pollution; and
- lower U.S. greenhouse gas emissions and thereby help to slow the rate of global warming.

Furthermore, increasing energy efficiency does not present a trade-off between enhancing national security and energy reliability on the

Energy Efficiency vs. Energy Conservation

Energy efficiency means improving equipment and systems to get the same or increased output (e.g., miles traveled or widgets produced) but with less energy input. Essentially everybody is in favor of energy efficiency. For example, in a speech to the Associated Press, Vice President Cheney (while maligning "conservation") did say that the United States needs "to make better use, through the latest technology, of what we take from the earth [including] efficient use..." (Cheney 2001). And in a radio address to the nation, President Bush stated: "Over the long term, the most effective way to conserve energy is by using energy more efficiently." (Bush 2001).

Energy conservation means reducing energy use, and at times may mean reducing the services received. Examples of energy conservation include changing thermostat settings, reducing lighting levels, and driving less. To the extent energy conservation eliminates waste, it is generally desirable. For example, quite a few commercial buildings are overlit (lighting systems provide more lumens of light output than called for in current lighting design guidelines) and energy can be saved by reducing lighting levels to conform to current guidelines. Similarly, energy is wasted when thermostats are set so low that sweaters are needed in the middle of the summer.

But in those instances where conservation results in discomfort (e.g, "freezing in the dark"), conservation is much less desirable. During energy emergencies, such as the oil shortages of the 1970s and the electricity shortages in California today), some discomfort may be necessary. However, by pursuing a balanced and comprehensive energy policy (including energy efficiency and waste-reducing conservation), we can reduce the number of energy emergencies and the need for cutbacks that cause discomfort.

one hand and protecting the environment on the other, as do a number of energy supply options. Increasing energy efficiency is a "win-win" strategy from the perspective of economic growth, national security, reliability, and environmental protection.

ENERGY EFFICIENCY POLICY RECOMMENDATIONS

We have identified nine specific policy recommendations that could have a substantial impact on the demand for energy in the United States while also providing positive economic returns to American consumers and businesses. These policies involve new incentives, funding for R&D and technology deployment, and new or updated regulations. The policies would significantly increase the efficiency of energy use in our homes, commercial buildings, factories, and vehicles. The policies would not entirely solve our nation's energy problems but they would make a major contribution towards addressing the energy and environmental challenges our nation is facing. We list these policies in approximate order of energy savings, starting with the policies that yield the largest savings.

1. Increase Passenger Vehicle Fuel Economy

The average fuel economy of new passenger vehicles (cars and light trucks) has declined from about 26 mpg in 1988 to 24 mpg in 2000 due to increasing vehicle size and power, the rising market share of light trucks, and the lack of tougher Corporate Average Fuel Economy (CAFE) standards. The original CAFE standards for cars were adopted in 1975 and reached their maximum level in 1985.

We recommend increasing the CAFE standards for cars and light trucks by 5% per year for 10 years so that they reach 44 mpg for cars and 33 mpg for light trucks in 2012, with further improvements of 3% per year beyond 2012. Alternatively, the standards for cars and light trucks could be combined into one value for all new passenger vehicles, specifically 38 mpg by 2012. This level of fuel economy improvement is technically feasible, cost-effective for consumers, and can be achieved without compromising vehicle safety (DeCicco, An, and Ross 2001; Friedman et al. 2001; Ross and Wenzel 2001). The 5% annual fuel economy improvement is the rate of improvement that Ford has indicated it will achieve voluntarily with its sport utility vehicles (SUVs) over the next 5 years. If this rate can be achieved with SUVs, it can be achieved in all new vehicles made by Ford and other manufacturers.[4]

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[4] The rate of 5% annual improvement in fuel economy is higher than that included in the "breakeven" scenario in the National Academy of Sciences' report (National Academy of Sciences 2001b). The range of fuel economy improvement technologies considered in ACEEE's analysis (DeCicco, An, and Ross 2001) is similar to what the NAS report considers and, while percentage improvement and cost estimates do not track measure-for-measure, they are generally comparable in the two analyses. ACEEE's estimates of the potential for overall fuel economy improvements are somewhat higher than those in the NAS report, however. This is largely attributable to the NAS panel's exclusion of vehicle mass reduction as a fuel-savings strategy, due to safety concerns. The ACEEE analysis, (continued...)

Car manufacturers will protest and say that this improvement in fuel economy will " lead to unsafe cars" or "cost U.S. jobs." However, these arguments ignore the facts: safe, fuel-efficient cars could be built, and fuel efficiency improvements to large SUVs could actually help improve overall on-road safety, as many vehicle-related deaths would be avoided if the weight of these behemoths were reduced (Friedman et al. 2001; Ross and Wenzel 2001). Even the National Academy of Sciences report finds that significant fuel economy improvements could be made without compromising safety, provided manufacturers have enough time to prepare (National Academy of Sciences 2001b). As for the impact on jobs, analyses indicate that improved fuel economy would actually increase jobs in the United States, including employment in the auto industry. Jobs would tend to increase due to the retooling needed to provide the more efficient vehicles, the increased costs and therefore larger sales revenues associated with light vehicles, and the significant respending effect resulting from the gasoline bill savings, which enables greater purchase of non-energy goods, including cars and light trucks. These effects are likely to be larger than any adverse impacts improved fuel efficiency would have on domestic automobile production directly (Geller, DeCicco, and Laitner 1992).

The initial CAFE standards were enacted by Congress and signed into law by President Ford in 1975 in the face of industry opposition, and the car companies complied with these standards at reasonable cost. Higher performance standards are now long overdue and should be adopted before we face another oil price shock or crisis, considering "technological feasibility, economic practicability, and the need of the nation to conserve energy," as stated in the Energy Production and Conservation Act of 1975.

Higher fuel economy standards should be complemented by (1) implementing tax credits for purchasers of innovative, highly efficient vehicles—see Policy 4 below, (2) expanding taxes on gas-guzzling vehicles, (3) increasing labeling and consumer education efforts, and (4) continuing vigorous R&D on fuel-efficient, low-emissions vehicles (see text box on next page). This combination of policies would facilitate compliance with the tougher standards. An alternative approach would be to establish a cap on the use of petroleum products by passenger vehicles and then come up with the policy mechanisms (including but not limited to stronger CAFE standards) that would enable the cap to be met. This approach was included in recent Senate legislation (S. 597), which sets the cap at 105% of fuel consumption in 2000 starting in 2008.

The CAFE standards proposed here would save about 1.1 million barrels of petroleum per day by 2010 and 4.0 million barrels per day by 2020, equivalent to 3 and 10 quadrillion Btus[5]

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[4] (...continued)
by contrast, exploits the potential of light-weighting not only to increase efficiency, but also to improve safety, by targeting the heavier vehicles for greater weight loss, thereby reducing the average weight differential in two-vehicle crashes.

[5] A *quad*—by way of reference, the United States used 98.5 quads in 2000.

of energy on an annual basis in 2010 and 2020, respectively.[6] Over 40 years, increasing vehicle efficiency as suggested above would save 10–20 times more oil than the projected supply from the Arctic National Wildlife Refuge (ANWR) and more than three times today's total proven oil reserves (Geller 2001). Under business-as-usual policies and trends, net imports of crude oil and finished petroleum products are projected to rise 67% from 1999 to 2020 (EIA 2000c). Energy savings from fuel economy improvements would reduce this increase from 67% to 19%, which would be a major cut in the growth of petroleum imports.

Standards along these lines could save consumers $196 billion net (discounted gasoline savings minus discounted vehicle cost) through 2020.[7] Additional money would be saved because reductions in gasoline demand also tend to reduce gasoline prices. The avoided CO_2 emissions would reach about 40 MMT of carbon equivalent by 2010 and 142 MMT by 2020. The fuel consumption cap proposed in S. 597 would result in a similar level of energy savings, economic savings, and avoided CO_2 emissions in the near term (i.e., by 2010).

Complementary Policies to Improve Passenger Vehicle Fuel Economy

- Inefficient cars are already subject to a "gas guzzler" tax ranging from $1,000 to $7,700. But millions of inefficient light trucks (including SUVs) are used as passenger vehicles, yet are not subject to the tax, creating a loophole that encourages their production and sale. Applying the tax to new gas-guzzling passenger vehicles of all classes would "pull up" the bottom end of the vehicle fleet and generate billions of dollars in new tax revenue, which could be used for incentives for buyers of high-efficiency vehicles (see Policy 4).
- The federal government should also extend ENERGY STAR® labeling to high-efficiency and low-emitting vehicles. This would make it easier for consumers to identify "greener vehicles" and for manufacturers to promote them. Government agencies should also continue their participation in information campaigns to raise public awareness of greener vehicles, and programs to facilitate fleet purchases of these vehicles.
- Given the importance of dramatically improving new vehicle economy in the coming decades, federal participation in R&D on highly efficient vehicles and technologies (such as fuel cells, hybrid-electric drivetrains, and lightweight materials) should be expanded. Such efforts should focus simultaneously on developing cleaner and more efficient vehicles by adopting aggressive emissions goals to complement fuel economy goals.

2. Adopt a National System Benefit Trust Fund

Electric utilities historically have funded programs to encourage more efficient energy use, assist low-income families with home weatherization and energy bill payment, promote the development of renewable energy sources, and undertake R&D. Experience with utility energy

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[6] The figures cited here come from the "Integrated Analysis" section later in this report.

[7] The figures here are also from the "Integrated Analysis" section.

efficiency programs in New England, New York, and California shows that these programs have been highly effective. The value of energy bill savings for households and businesses is about double the costs to produce these savings (Nadel and Kushler 2000). Unfortunately, increasing competition and restructuring have led utilities to cut these discretionary "system benefit" expenditures over the past 5 years. Total utility spending on all demand-side management programs (i.e., energy efficiency and peak load reduction) fell by more than 50% from a high of $3.1 billion in 1993 to $1.4 billion in 1999 (1999$) (EIA 2000b; Nadel and Kushler 2000).

In order to ensure that energy efficiency programs and other public benefits activities continue following restructuring, 15 states have established system benefits funds through a small charge on all kilowatt-hours flowing through the transmission and distribution grid. We recommend creation of a national systems benefits trust fund that would provide matching funds to states for eligible public benefits expenditures. Specifically, we recommend a non-bypassable wires charge of two-tenths of a cent per kilowatt-hour. This concept and specific amount were included in utility restructuring bills sponsored by Senator Jeffords (S. 1369) and Rep. Pallone (H.R. 2569) in the last Congress. These bills provide one federal dollar for each state dollar but other matching ratios could also be considered, such as a 2:1 federal:state match, or a baseline funding amount with no matching requirement plus an additional supplemental amount subject to a match.

This policy would give states and utilities a strong incentive to expand their energy efficiency programs and other public benefits activities. All states and utilities would pay into the fund, but they would only get money back out if they establish or continue energy efficiency programs and other public benefit activities. However, individual states, not the federal government, would decide how the money gets spent.

Our analysis indicates that this policy would lead to widespread energy efficiency improvements in lighting, appliances, air conditioning, motors systems, and other electricity end-uses. We estimate it could save nearly 300 TWh in 2010 (7% of projected use), equal to about 2.5 quads of primary energy savings. By 2020, annual savings would exceed 800 TWh (6.5 quads). The impacts estimated here are for a federal systems benefit program and do not include savings from existing state programs. Savings from the federal program include direct national expenditures as well as incremental state expenditures induced by the federal matching program. Net lifetime economic benefits (i.e., net present value lifetime benefits minus program and measure costs) from measures installed under this program through 2020 would be about $100 billion (i.e., nearly $1,000 per household). With these levels of electricity savings, the risk of power shortages in the future would diminish, there would be fewer price spikes caused by periods of tight supply and demand, and there would be less need to build often contentious new power plants. In addition, pollutant emissions from power plants would fall (including carbon emission reductions of about 46 and 127 MMT in 2010 and 2020, respectively), thereby improving public health and helping cities and states meet the ambient air quality standards.[8]

3. Enact New Equipment Efficiency Standards and Strengthen Existing Standards

Federal appliance and equipment efficiency standards were signed into law by President Reagan in 1987 and expanded under President Bush in 1992. Minimum-efficiency standards were adopted because many market barriers (such as lack of awareness, rush purchases when an existing appliance breaks down, and purchases by builders and landlords) inhibit the purchase of efficient appliances in the unregulated market. Standards remove inefficient products from the market but still leave consumers with a full range of products and features to choose among.

Appliance and equipment standards are clearly one of the federal government's most effective energy-saving programs. Analyses by DOE and others indicate that in 2000, appliance and equipment efficiency standards saved 1.2 quads of energy (1.3% of U.S. electric use) and reduced consumer energy bills by approximately $9 billion, with energy bill savings far exceeding any increase in product cost. By 2020, standards already enacted will save 4.3 quads per year (3.5% of projected U.S. energy use) and reduce peak electric demand by 120,000 MW (more than a 10% reduction) (Geller, Kubo, and Nadel 2001).

In order to provide additional cost-effective savings under this program, we recommend three actions:

- Congress should adopt new efficiency standards for products now or soon to be covered by state efficiency standards. Among the products that should be included are distribution transformers, commercial refrigerators, exit signs, traffic lights, and torchiere lighting fixtures. California is now adopting standards on these products and Massachusetts and Minnesota already have standards on distribution transformers. None of these standards have been controversial and all involve highly cost-effective energy savings. In addition, Congress should adopt standards for commercial unit heaters, ice makers, and standby power consumption for household appliances and electronic products (such as televisions, VCRs, cable boxes, and audio equipment). Commercial furnaces are covered by existing federal standards; the same standard should be extended to unit heaters that are widely used to heat open spaces such as warehouses, garages, and factories. Ice makers are covered by an existing federal purchase specification, which should be enacted as a standard. Regarding standby power, many household electronic products use electricity even when they are switched "off." In a recent speech, President Bush pointed out these "vampires" and directed the federal government to purchase products with a standby power use of 1 Watt or less. This 1 Watt requirement should be adopted as an across-the-board standard (Nadel 2001).

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[8] The figures cited here are from the "Integrated Analysis" section later in this report.

- DOE, with adequate funding and encouragement from Congress, should complete equipment standard rulemakings in a timely manner. Current rulemakings include updated standards for commercial air conditioning systems and residential heating systems. DOE should begin proceedings over the next few years to update standards for residential dishwashers and refrigerators, and then should consider updates to some of the standards that were set in the past few years.

- The Bush Administration should permit implementation of a SEER 13 efficiency standard for residential central air conditioners and heat pumps. The Administration recently proposed rolling back the standard issued in January from SEER 13 to SEER 12. This change would increase peak electricity demand by 18,000 MW once the standard is fully phased in and would increase consumer electricity bills by over $18 billion over the next 30 years. This rollback is now being challenged in court under a provision in the law that prevents DOE from weakening standards once they have been set. In addition, California and other states are developing new state standard and code requirements at SEER 13 and are planning to petition DOE for exemption from a SEER 12 standard. DOE can avoid many of these battles, and capture substantial energy and economic savings, by restoring the standard to SEER 13 (Nadel 2001).

Analysis by ACEEE indicates that these three steps would save approximately 95 billion kWh of electricity in 2010 and 265 billion kWh in 2020. The savings in 2020 amount to about 8% of projected residential and commercial electricity use in that year, and reduce projected peak electrical demand by the equivalent of nearly 300 power plants (300 MW each). In addition, the unit heater standard by itself would reduce commercial building gas consumption by about 3% in 2020, a remarkable achievement for a product with annual sales of only about one-quarter million units. These standards would also result in substantial economic savings for consumers and businesses. Our analysis indicates that for products purchased through 2020, discounted net benefits (benefits minus costs) would total about $80 billion, with a benefit-cost ratio of more than 4:1. Furthermore, we estimate that these standards would reduce carbon emissions by more than 70 MMT in 2020, which could be a useful component of U.S. efforts to reduce greenhouse gas emissions.[9]

4. Enact Tax Incentives for Highly Energy-Efficient Vehicles, Homes, Commercial Buildings, and Other Products

Many new energy-efficient technologies (including fuel cell power systems; hybrid and fuel cell vehicles; gas-fired heat pumps; and super-efficient refrigerators, clothes washers, and new buildings) have been commercialized in recent years or are nearing commercialization. But these technologies may never get manufactured on a large scale or widely used due to barriers such as their initial high cost, market uncertainty, and lack of consumer awareness.

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[9] The figures are from the "Integrated Analysis" section later in this report.

Tax incentives could help manufacturers justify mass marketing for innovative energy-efficient technologies. Tax credits also could help buyers (or manufacturers) offset the relatively high first cost premium for the new technologies, thereby helping to build sales and market share. Once the new technologies become widely available and produced on a significant scale, costs should decline and the tax credits could be phased out.

We recommend providing tax incentives for a variety of very energy-efficient vehicles, buildings, and other products. A key element in designing the credits should be that only highly efficient products would be eligible. If the eligibility level is set too low, then the cost to the Treasury will be high and incremental energy savings will be low because incentives will be paid for sales that would have happened anyway (so-called "free riders"). Also, tax credits should be of limited duration (e.g., approximately 5 years) and possibly reduced in value over time so that the credits would help innovative technologies get established in the marketplace rather than become a permanent subsidy. We recommend tax incentives for the following products:

- **Appliances**. A tax credit of $50–100 for manufacturers of highly efficient clothes washers and refrigerators (with a cap on the total credit per manufacturer) would help save energy and water. This proposal is included in the energy bill that recently passed the House of Representatives and has been introduced in the Senate by Senators Grassley and Allard. It is strongly supported by the appliance industry.

- **New Homes**. A tax credit of up to $2,500 for highly efficient new homes (with 50% reductions in space heating and cooling costs compared to homes meeting the current Model Energy Code) would stimulate efficiency and help lower housing costs for American families. The House energy bill includes tax credits for homes with 30% energy savings. We recommend providing moderate tax credits for 30% savings and substantially higher tax credits for 50%. Bills with provisions along these lines have been introduced by Senators Bob Smith and Bingaman (S. 207 and S. 596, respectively), and Representatives Cunningham and Inslee (H.R. 778 and H.R. 2392, respectively).

- **Other Building Equipment**. We recommend a 20% investment tax credit (with caps) for innovative building technologies (including air conditioners, electric and gas-fired heat pumps, electric heat pump water heaters, stationary fuel cell power systems, and very efficient furnaces). This proposal is included in the Bingaman bill and also in a bill by Rep. Inslee (H.R. 2392). The fuel cell provision was included in the House energy bill.

- **Hybrid Electric and Fuel Cell Vehicles**. Tax credits of up to $5,000 for hybrid electric vehicles and $8,000 for fuel cell vehicles would help jump-start introduction and purchase of these innovative, fuel-efficient technologies. The incentives should be based primarily on energy performance and also require emissions reductions, as is the case in the CLEAR Act introduced by Sen. Hatch and others (S.760). The House energy bill includes tax credits along these lines but does not include any emissions requirements, and includes extra incentives for vehicles with only modest fuel economy improvements. We strongly prefer the original CLEAR Act as it would provide much better energy and environmental returns for taxpayer dollars.

- **Commercial Buildings**. We recommend a tax deduction of $2.25 per square foot for investments in commercial buildings and multifamily residences that achieve 50% or greater reductions in heating and cooling costs compared to buildings meeting the current ASHRAE model energy standards. This proposal is included in the House energy bill and in legislation sponsored by Sen. Bob Smith (S. 207).

- **Combined Heat and Power (CHP).** We recommend either a 10% investment tax credit or a shortened depreciation period (7 years for industrial systems and 10 for building systems) for CHP systems with overall efficiencies of at least 60–70%, depending on system size. This proposal has strong industry support and is included in both the Bingaman and Murkowski (S. 389) bills, as well as bills targeted at promoting CHP that were introduced by Representatives Wilson and Quinn (H.R. 1045 and H.R. 1945, respectively) in the House. The House energy bill includes a 10% investment tax credit but excludes small systems and takes back much of the benefits by *lengthening* depreciation periods for many systems. The depreciation change is a step in the wrong direction and there is no rationale that we are aware of for excluding small systems. We recommend that these deficiencies be corrected.

Regarding potential costs and impacts, it is likely that there would be millions of qualifying products, buildings, and CHP systems sold during the 2002–2006 time period. The total cost to the Treasury would be on the order of $10 billion, with vehicles and commercial buildings likely being the most costly components of the package. Participation on this scale would have a relatively modest direct impact on energy use and CO_2 emissions, saving on the order of 0.5 quads of energy and 5 MMT of carbon emissions per year by the end of the eligibility period. However, if the credits help to establish these innovative products in the marketplace and reduce the first cost premium so that the products would be viable after the credits are phased out, the indirect impacts would be many times greater than the direct impacts. We estimate that the total energy savings would reach 1.1 quads by 2010 and 3.6 quads by 2020 if the credits are successful. Under this scenario, avoided carbon emissions would reach around 20 MMT by 2010 and 75 MMT by 2020 (Geller and Quinlan 2001).

5. Expand Federal Energy Efficiency R&D and Deployment Programs

DOE has made many valuable contributions towards increasing the energy efficiency of U.S. buildings, appliances, vehicles, and industries. Consequently, the President's Committee of Advisors on Science and Technology (PCAST) stated in 1997 that "R&D investments in energy efficiency are the most cost-effective way to simultaneously reduce the risks of climate change, oil import interruption, and local air pollution, and to improve the productivity of the economy." (PCAST 1997).

Similarly, a July 2001 National Academy of Sciences review of DOE's energy efficiency and fossil energy R&D programs found that "the total net realized economic benefits associated with [DOE's] energy efficiency programs that [we] reviewed were approximately $30 billion (valued in 1999$), substantially exceeding the roughly $7 billion (1999$) in total energy efficiency RD&D investment over the 22-year life of the programs." The NAS review went on to recommend an R&D portfolio in energy efficiency that "focus[es on] national public good goals... [and has] (1) a mix of exploratory, applied, development and demonstration research and related activities, (2) different time horizons for the deployment of any resulting technologies, (3) an array of different technologies for any programmatic goals, and (4) a mix of economic, environmental and security objectives." (National Academy of Science 2001a).

In a similar vein, DOE recently documented that 20 of its most successful energy efficiency projects have already saved the nation 5.5 quadrillion Btus of energy, worth about $30 billion in avoided energy costs, mostly over the past decade (EERE 2000b). The cost to taxpayers for these 20 activities was $712 million, less than 3% of the energy bill savings so far. In fact, the energy bill savings from these 20 projects alone is over three times the amount of money appropriated by Congress for all DOE energy efficiency and renewable energy programs during the 1990s, demonstrating that spending taxpayers' money on energy efficiency R&D and deployment is a very sound investment. There are many other indicators of success and effectiveness besides the 20 projects reviewed in this report.

The ENERGY STAR deployment programs operated by EPA and DOE have also been very successful. Since starting the Green Lights program in 1991, EPA has shown great creativity in developing cost-effective, practical programs that have a substantial impact. For example, 16% of the commercial and public sector building space in the country has now signed up for the ENERGY STAR Buildings™ program. Program participants saved more than 27 billion kWh of energy in 2000 alone, according to data compiled by EPA. This is more than twice the level of savings as of 1998. In other words, the impacts are growing rapidly as new participants join and all participants move forward with their energy efficiency upgrades. Similarly, the ENERGY STAR New Homes program is growing rapidly with over 1,600 builders now participating and more than 25,000 ENERGY STAR homes built. These homes use 35% less energy for heating and cooling on average compared to the 1993 Model Energy Code (Brown, Webber, and Koomey 2000; EPA 2001).

The ENERGY STAR labeling program has transformed the market for personal computers, photocopiers, printers, and facsimile machines. Prior to ENERGY STAR, most of this equipment consumed energy whether the machine was in use or not. Through the ENERGY STAR program, EPA stimulated use of power management that allows equipment to go into a low-power "sleep mode" when equipment is not in use. Power management can reduce the energy use of office equipment by up to 50%. Around 80% of new personal computers, 95% of monitors, 99% of printers, and 65% of copiers now have the ENERGY STAR label. In total, consumers bought more than 120 million ENERGY STAR products in 2000. As a result of cumulative purchases, consumers saved more than 49 billion kWh in 2000—worth about $3.9 billion (Brown, Webber, and Koomey 2000; EPA 2001).

The Bush Administration has proposed cutting DOE's energy efficiency R&D and technology deployment programs (apart from grants to low-income households for home weatherization) by $180 million (29%) in FY2002. Some programs would be cut by 50% or more. Proposed funding for EPA's ENERGY STAR program is approximately level with last year. Cutting funding for DOE's energy efficiency programs would increase consumers' energy bills, hurt U.S. economic growth, increase the likelihood of power shortages, put upward pressure on energy prices, increase oil imports, and increase air pollution. Deep cuts in DOE's energy efficiency programs also would harm both the public-private partnerships that have been built up over many years and the energy efficiency R&D and deployment "infrastructure" that exists at national laboratories, state energy offices, and elsewhere. In light of the serious energy problems our nation is facing, we should expand, not cut, energy efficiency R&D and deployment programs.

Based on the PCAST recommendations of long-term funding of $880 million annually, we suggest increasing funding for DOE 's energy efficiency programs by about 17% per year for the next three years.[10] PCAST estimated that if these recommendations were adopted, energy bills would be reduced by $30–45 billion in 2010 and $75–95 billion in 2020, and carbon emissions reduced by 60–150 MMT in 2010 and 90–200 MMT by 2020 (PCAST 1997). These savings would overlap to some extent with savings from many other deployment policies recommended in this report.

Funding for the EPA programs should also be expanded. We recommend that EPA ENERGY STAR funding be increased 20% per year for the next 2 years and then funding should be sustained, in real terms, at those levels. EPA has projected that with continued funding at current levels, energy and emissions savings in 2010 will be more than double savings in 2000, including carbon emissions reductions of about 90 MMT (EPA 2000) (these savings overlap to some extent with other policies.) With increased funding, savings would be even greater. EPA and DOE should expand the scope and level of promotion associated with the ENERGY STAR program. ENERGY STAR labeling should be extended to additional types of electronic products, commercial refrigeration equipment, motors, and other mass-produced products not currently covered. The commercial building benchmarking and rating program should be expanded to include retail buildings, healthcare, lodging, groceries, and warehouses. Also, more funding is needed to expand promotion and training activities in the ENERGY STAR new homes and small

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[10] Funding in FY2001 was $556, so 17% increases for three years would bring the program to the PCAST target.

business programs, and to develop and implement a major program to encourage home energy retrofits, as well as to increase consumer awareness and market penetration of energy-efficient ENERGY STAR products of all types.

Overall, we estimate that expanding DOE and EPA R&D and deployment programs would reduce U.S. energy use by about 1 quad in 2010 and 3 quads in 2020. These estimates are based on EPA calculations of savings from the current ENERGY STAR programs plus extrapolations based on a few successful DOE R&D programs over the past decade (EERE 2000b; EPA 2000). Additional energy would be saved from likely program expansions, and other R&D projects besides a few of the biggest "winners," but in order to prevent double-counting of savings with other policies, we use these very conservative savings estimates. These energy savings in turn would result in carbon emissions reductions of about 20 and 65 MMT in 2010 and 2020, respectively. We estimate that these savings could be achieved with an average simple payback period of 4–5 years.

6. Promote Clean, High-Efficiency Combined Heat and Power Systems

Combined heat and power (CHP) technology is a system that produces multiple usable energy forms (e.g., electricity and steam) from a single fuel input. These combined systems can achieve much greater efficiency than the usual separate systems for producing steam and electricity because the CHP systems recover heat that would otherwise be wasted in separate power production, and use this heat to displace the fuel that otherwise would be used to produce heat in a separate boiler. Because of the greater efficiency achieved, the total emissions from CHP systems are usually lower than the combined emissions required to produce the same output from separate systems.

Several inequities in government and utility regulations hinder development of CHP resources. These include environmental standards that do not recognize the efficiency gains of CHP systems, utility rules that make it difficult for many CHP systems to connect to the utility grid, and tax depreciation rules that vary the depreciation period for CHP systems from 5–39 years depending on plant ownership. Each of these problems need to be addressed.

Most stationary-source air quality regulations are based on either the emissions per unit of fuel burned or the concentration of a pollutant in the smokestack. This smokestack approach makes no adjustment in allowable emissions based on the efficiency of energy production. Thus, a CHP system receives no credit for net total emissions reductions achieved when compared to separate systems for providing heat and power. To address this problem, the permitting of CHP systems should be shifted from an input-based to an output-based approach (i.e., maximum emissions per unit of useful energy output). Output-based levels equivalent to current input-based levels for separate heat and power should be designated by EPA. Output based standards clearly are within the scope of the Clean Air Act. In fact, they are applied to all mobile sources (e.g., grams per mile traveled for passenger cars) and stationary reciprocating engines (grams per horsepower-hour). Since these regulations would be implemented at the state level, EPA should also educate state environmental officials and assist them in implementing this change.

CHP and other distributed generation technologies have encountered hurdles in interconnecting with the electric utility system, which has lead to a hostile environment for CHP in many utility service territories. These hurdles include: (1) a lack of standard technical specifications, which results in each utility developing its own specification with unreasonable requirements in some cases (e.g., expensive equipment or project analyses); and (2) discriminatory pricing and contractual practices by some utilities (e.g., "exit fees" and onerous terms and conditions of service).

While some states have begun to address these issues, many have not. And states are starting to take somewhat different approaches. Federal legislation is needed to address these issues in a consistent manner across states. The legislation should require the development of standards for CHP facilities to be interconnected with the local distribution facilities. CHP facilities should have a right to back-up power sold at rates, terms, and conditions that are reasonable and not discriminatory, as determined by the appropriate state regulatory authority. In addition, states should be mandated to exempt CHP facilities from exit fees that are not directly related to service to the customer.

Under current IRS rules, CHP assets are depreciated over varying time periods depending on system configuration and owner (i.e., the same equipment can be depreciated over as little as 5 years to as much as 39 years). For example, equipment at a data center is depreciated over 5 years while the same system installed in an owner-occupied commercial building is depreciated over 39 years. This treatment is a result of policies that did not envision the changes in technology and markets that have occurred in recent years. A common depreciation period is needed for CHP equipment. Based on the technical and market life of current systems, we recommend a depreciation period of 7 years for CHP systems used in industrial facilities and 10 years for CHP systems used in residential and commercial buildings.[11] More reasonable depreciation periods would increase the amount of capital cost that is treated as a tax deduction, thereby improving CHP economics. Alternatively, depreciation periods could be standardized at somewhat higher levels and an investment tax credit enacted to encourage CHP development.

DOE and EPA have set a goal of adding 50,000 MW of new CHP capacity by 2010. If the barriers described here were removed, we believe that this target would be achievable, and further growth could add an additional 95,000 MW over the 2011–2020 period. Relative to the conventional power plants these systems would displace, this new CHP capacity would result in net energy savings of approximately 1.1 quads in 2010 and 2.9 quads in 2020. Much of this

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[11] CHP systems in industry tend to be operated for more hours than those used in buildings. This shortens the system life and by extension the recommended depreciation period.

capacity would likely be fired with natural gas, although some would use coal, waste heat, waste gas, and industrial process byproducts. Due to the higher efficiency of CHP systems and their common use of natural gas, CO_2 emissions would be cut by approximately 29 MMT of carbon equivalent in 2010 and 78 MMT in 2020.[12] Owners of CHP systems (businesses and industries) would realize net cost savings that pay back the first cost in 4–5 years on average, based on projected energy prices (Geller et al. 1998).

7. Voluntary Agreements and Incentives to Reduce Industrial Energy Use

The industrial sector accounts for about 39% of total U.S. energy consumption. Manufacturing represents about two-thirds of industrial energy use, with six energy-intensive sectors dominating (petroleum refining, chemicals, primary metals, paper and pulp, food and kindred products, and stone, clay, and glass products). There is substantial potential for cost-effective efficiency improvement in both energy-intensive and non-energy-intensive industries. For example, an in-depth analysis of 49 specific energy efficiency technologies for the iron and steel industry found a total cost-effective energy savings potential of 18% (Worrell, Martin, and Price 1999). Similar analyses for the paper/pulp and cement industries found cost-effective available savings of 16–22% and 11%, respectively (Martin, Anglani, et al. 2000; Martin, Worrell, and Price 1999). Furthermore, new energy-saving technologies and practices continue to be developed. For example, a recent study on *Emerging Energy-Efficient Industrial Technologies* identified 32 new technologies with substantial energy savings and a medium or high likelihood of commercial success (Martin, Worrell, et al. 2000).

In order to stimulate widespread energy efficiency improvements in the industrial sector, we propose that the U.S. government (White House or DOE) establish voluntary agreements with individual companies or entire sectors. Companies or entire sectors would pledge to reduce their overall energy and carbon emissions intensities (energy and carbon per unit of output) by a significant amount, for example, at least 1% per year over 10 years. Companies that make a more substantial commitment (for example, at least 2% per year) could be given ENERGY STAR or similar recognition. The government could encourage participation and support implementation by: (1) providing technical assistance to participating companies that request assistance; (2) offering to postpone consideration of mandatory emissions reductions or tax measures if a large percentage of industries participate and achieve their goals; and (3) expanding federal R&D and demonstration programs for sectors with high participation.

In order to get a large fraction of industries to make serious commitments and enter into voluntary agreements with the federal government, it may be necessary for the government to threaten to take more drastic action. For example, the government could indicate that it was going to issue carbon emissions standards or energy efficiency standards on major types of

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[12] The figures are from the "Integrated Analysis" section later in this report.

industrial processes (e.g., steelmaking, aluminum production, paper and pulp making, petroleum refining, etc.) and/or adopt carbon emissions taxes if industries did not enter into meaningful voluntary agreements. And if participation in the voluntary agreements is limited or participants do not meet the agreed-upon targets, then the government should proceed with adopting mandatory energy intensity or carbon emissions reduction requirements for energy-intensive industries.

A number of major companies are demonstrating that it is possible to significantly reduce energy and carbon intensity while enhancing productivity and profitability, and have set voluntary goals for doing so. For example, Johnson and Johnson set a goal in 1995 of reducing energy costs by10% by 2000 through adoption of "best practices" in its 96 U.S. facilities. As of April 1999, they were 95% of the way towards this goal, with the vast majority of projects providing a payback of 3 years or less (Kauffman 1999). In 1998, British Petroleum announced it would voluntarily reduce its carbon emissions to 10% below 1990 levels by 2010, representing an almost 40% reduction from projected emissions levels in 2010 given "business-as-usual" emissions growth (Romm 1999). And DuPont announced it would reduce its greenhouse gas (GHG) emissions worldwide by 65% relative to 1990 levels while holding total energy use flat and increasing renewable energy resources to 10% of total energy inputs by 2010. DuPont is on track for achieving earlier commitments to reduce energy intensity by 15% and total GHG emissions by 50% by 2000, relative to 1990 levels (Romm 1999). If J&J, BP, and DuPont can make and deliver on these voluntary commitments, so can other companies.

Voluntary agreements between government and industry along the lines proposed here have resulted in substantial energy intensity reductions in some European nations such as Germany, the Netherlands, and Denmark. In the Netherlands, for example, the energy intensity of a wide range of industries improved by 20% on average during 1989–99, and thus industries achieved the targeted improvement of 20% by 2000 (CADDET 2000; Nuijen 1998; van Luyt 2001). A key factor in the success of these programs was the threat of new taxes or regulations (e.g.,the threat of additional taxes in the Denmark) if voluntary programs were not successful, and/or substantial financial incentives (e.g., in the Netherlands and Germany). Without these "carrots" and "sticks," according to expert observers of these programs, savings would have been far less (Price and Worrell. 2000; Worrell and Price 2001).

In order to estimate the impacts of this policy, we rely on a detailed analysis of voluntary agreements carried out by a team from the national laboratories (Murtishaw and Schipper 2001). Based on this analysis, we estimate that widespread adoption of voluntary agreements and supporting activities would reduce primary energy use in the industrial sector by about 3.3 quads (8.5%) in 2010 and 6.7 quads (16%) in 2020, relative to energy consumption levels otherwise forecast by the Energy Information Administration. The corresponding reductions in CO_2 emissions are 67 MMT of carbon by 2010 and 132 MMT by 2020. In order to realize these energy savings, a cumulative investment in efficiency measures of about $50 billion through

2020 is needed. But the energy bill savings during this period would equal around $160 billion, leading to net economic benefits of about $110 billion, with further savings due to reduced energy use after 2020 (all values are in discounted 1999$).

8. Improve the Efficiency and Reduce the Emissions of the Existing Power Plant Fleet

Many old, highly polluting power plants are "grandfathered" under the Clean Air Act. This means that they do not need to meet the same emissions standards for NOx, SO_2, and particulates as plants built after the Clean Air Act of 1970 was enacted. There are now 850 plants in operation, with a combined power output of 145,400 MW, that were constructed prior to 1970. In 1999, these plants produced approximately 760 billion kWh, about 21% of our nation's electric generation (Shoengold 2001). These older, dirty power plants emit 3–5 times as much pollution per unit of power generated as newer, coal-fired power plants and 15–50 times as much NOx and particulates as a new combined-cycle natural gas power plant (Cavanagh 1999). These older plants also are less efficient than most new plants; the pre-1970 plants have an average heat rate of 11,025 Btus of fuel per kWh generated, compared to modern combined-cycle plants with heat rates of 7,000 or less (Shoengold 2001). When the Clean Air Act was adopted, it was expected that these dirty power plants would eventually be retired. However, many utilities are continuing to operate these plants beyond their "design life" due to their low capital and operating costs. In fact, electricity generation from older coal-fired power plants increased about 16% during 1992–98 due in part to restructuring of wholesale power markets, which enabled utilities to sell low-cost, "dirty" kilowatt-hours outside their region (Coequyt and Stanfield 1999)

If old, grandfathered plants were required to meet the same emissions standards as new plants, some plants would be modernized and cleaned up, but many would be shut down and replaced with much more efficient and cleaner generating sources such as combined-cycle natural gas power plants. We recommend that a policy to end "grandfathering" be enacted soon but not take effect until 2010 or thereabouts. This phase-in period would allow owners of these old plants to make plant upgrade vs. replacement decisions and then have sufficient time to implement these decisions without unduly disrupting power markets.

Alternatively, the same general objectives would be achieved by adopting CO_2 emissions standards as part of a Clean Air Act "four pollutant" strategy that has been proposed in order to address SOx, NOx, mercury, and CO_2 emissions in an integrated fashion. Such a strategy would include tradeable carbon emissions permits, with the number of emissions allowances based on the phase-out of old, dirty, inefficient power plants. Bills along these lines have been introduced by Senators Jeffords and Lieberman (S.556) and Representatives Boehlert and Waxman (H.R.1256).

Yet another strategy that could achieve similar results would be "CAFE-like" power plant heat rate standards that would require generators to achieve a specified average heat rate (Btus of fuel per kWh generated) from their plants or else buy allowances from other generators with an average heat rate below the specified average. The allowable average heat rate would be based on some percentage reduction from the current national average heat rate. A single target could be set (e.g., a 10–20% reduction) or the allowable average heat rate could gradually ramp down each year (e.g., a 2% reduction each year). This would result in the retirement of some older, less efficient coal-fired plants.

Applying new emissions standards to old, grandfathered power plants has been done or is being considered by several states, including Texas and Massachusetts. In Texas, restructuring legislation passed in 1999 calls for grandfathered plants to reduce NOx emissions by 50% and SO_2 emissions by 75%, beginning in 2003. Emissions allowances will be established for several regions in Texas and these allowances can be traded so that the market can help determine the most cost-effective way to reach the emissions reduction targets (Texas Legislature 1999). In Massachusetts, new, tighter emissions standards have been adopted for large, pre-1977 power plants subject to the Federal Acid Rain Program. The program covers SO_2 and NOx, with the new standards gradually phasing-in over the 2004–2008 period (Clean Air Task Force 2001).

To model the impact of these policies, we estimate that 25% of the generation from old, grandfathered power plants can be displaced by generation from state-of-the-art natural gas-fired power by 2010 and 50% by 2020. These estimates result in the replacement of approximately 36,000 MW of generating capacity by 2010, and 73,000 MW of capacity by 2020 (although it is likely that most of the old plants would still be kept in reserve for short-duration periods when extra capacity is needed). Due to the better heat rate of new power plants, energy used to generate electricity would be reduced by about 37%, saving 1.55 quads in 2010 and 3.10 quads in 2020.[13]

These policies would have an even bigger impact on emissions of the key air pollutants since the old power plants are especially dirty and the new ones are cleaner than average. A 2000 analysis by the Environmental Law Institute and Resources for the Future found that replacing half of the old coal plants with new cleaner plants (primarily natural gas, but with a small contribution by wind and other sources) would reduce power industry SO_2 emissions by 50%, NOx by 40%, mercury by almost 60%, and CO_2 by 25% (a 172 MMT reduction in annual carbon emissions). They examined the economic impacts of completing this transition by 2010 and found that the principal economic impact would be a six-tenths of a cent rise in the price of

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[13] These savings calculations are based on 1999 generation from these old plants; we take no credit for the fact that the new plants would likely have higher capacity factors than the old plants and that some of the old plants are likely to be retired or "mothballed" due to other factors. Also, as discussed in the "Integrated Effects" section later in this report, energy and carbon savings from retiring old power plants overlap with savings from efficiency measures since efficiency measures reduce the need for power, helping to spur the retirement of marginal generation plants. The numbers discussed here are for power plant upgrades only, in the absence of any other efficiency policies. The incremental effects beyond the other efficiency measures are discussed in the "Integrated Effects" section.

electricity above a business-as-usual scenario, which was about 9% of the average price of electricity in 2000—a modest price to pay for cleaner air (ELI 2000).[14]

9. Greater Adoption of Current Model Building Energy Codes and Development and Implementation of More Advanced Codes

Building energy codes require all new residential, commercial, and industrial buildings to be built to a minimum level of energy efficiency that is cost-effective and technically feasible. "Good practice" residential energy codes, defined as the 1995 (or a more recent) version of the Model Energy Code (now known as the International Energy Conservation Code or IECC), have been adopted by 27 states. "Good practice" commercial energy codes, defined as the ASHRAE 90.1-1989 model standard, have been adopted by 29 states (BCAP 2000). Some major states (such as Arizona, Illinois, Michigan, New Jersey, and Texas) have not adopted these "good practice" energy codes. However, the Energy Policy Act of 1992 (EPAct) requires that all states adopt a commercial building code that meets or exceeds ASHRAE 90.1-1989, and consider upgrading their residential code to meet or exceed the 1995 (or later) Model Energy Code.

Furthermore, building codes are being regularly updated. In the case of residential codes, the 2000 IECC includes higher insulation requirements than the 1995 code and also includes additional measures to reduce heat gain in hot climates. The code in California also includes measures to reduce air infiltration and duct leakage—these measures could be models for other states. In the case of commercial codes, ASHRAE has adopted a new 90.1-1999 standard that reduces energy use approximately 6% compared to the 1989 standard (Office of Codes and Standards 2001). Here too, substantial additional improvements are possible as measures with 10–20% additional savings were included in early drafts but dropped as part of a political process to gain "consensus."

Overall, we estimate that about half of the new homes built today do not meet the 2000 IECC, and upgrading them to meet the IECC would reduce energy use by about 15%. We further estimate that adoption of enhanced codes by 2010 could improve new home efficiency by a further 20%. For the commercial sector, we estimate 10% savings on average from adoption of 90.1-1999, and a further 20% savings from advanced codes adopted by 2010. Not all states would adopt these codes and we make allowance for this by assuming that 10% of homes and buildings would not be covered by the current codes and 25% would not be covered by the advanced codes. Based on these estimates, energy savings from improved codes would total 0.3 quads in 2010 and 1.5 quads in 2020. These energy savings would translate into GHG emission reductions of nearly 30 MMT of carbon by 2020. Based on a variety of published and unpublished sources, we estimate that improved codes would provide positive cashflow to

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[14] They also projected that the increase in natural gas use for power generation would increase natural gas prices paid by electric utilities by about 70 cents per million Btus. If the transition occurred more gradually, the impact on electricity and natural gas prices would likely be lower.

homebuyers, meaning that the annual energy savings would be greater than the annual additional mortgage payments needed to amortize the cost of the efficiency improvements. Similarly, the new commercial codes would result in simple payback periods of 3–6 years for commercial building developers.[15]

In order to achieve these savings, states should be directed to review their codes and encouraged to revise them. DOE should continue to provide technical assistance for these efforts, with preference given to states that adopt statewide mandatory codes at or above the model codes. The model code organizations (IECC and ASHRAE) should also be encouraged to regularly update their codes to incorporate the latest in cost-effective energy-saving measures. IECC has been doing well in this regard, but ASHRAE's 1999 standard was very disappointing in that the final standard achieved only about a fourth of ASHRAE's 25% savings target. Given ASHRAE's conservatism, DOE should broaden its funding activities to include organizations and consortiums of states that are interested in achieving higher levels of energy savings than ASHRAE is able to deliver.[16]

Integrated Analysis

In the preceding sections, each of the nine policies were discussed and analyzed individually. However, the policies do interact (and sometimes overlap) with each other. In this section, we discuss an integrated analysis, in which the data were carefully adjusted to eliminate overlap between policies,[17] and then data on all of the policies were entered into an integrated model of U.S. energy use.

Methodology and Key Assumptions

The analysis of the national policies and measures was undertaken using several models. The principal model used was the DOE/EIA National Energy Modeling System, known as NEMS (EIA 2000c). Likewise, many assumptions (including base case energy prices and various

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[15] These economic calculations are based on the energy use of new homes and commercial buildings as collected in DOE's residential and commercial energy consumption surveys, and cost estimates for the efficiency improvements compiled by the Alliance to Save Energy, New Buildings Institute, and ACEEE.

[16] For example, the New Buildings Institute (headquartered in White Salmon, Washington) is now planning to develop a "Commercial Reach Code" that targets 30% savings relative to 90.1-1999. This code is intended for use by voluntary programs as well as by states that want a more advanced code than ASHRAE's. States and utilities on the West Coast and the Northeast are working with the New Buildings Institute on this effort.

[17] We adjusted for overlap by carefully considering the efficiency measures implemented under each policy, and where there was overlap with other policies, excluding the savings from one policy so savings would not be double-counted. These adjustments particularly affected our estimated savings for tax credits since we excluded savings from CHP (covered under the CHP policy), vehicles (covered under the passenger vehicle fuel economy policy), and advanced appliances and buildings (covered in part under appliance standards and building codes). Similar adjustments were made in a number of other cases.

technology cost assumptions) were taken from the NEMS model, specifically as it was applied to produce the *Annual Energy Outlook 2001* (EIA 2000c). Our base case is derived from and very similar to the reference case scenario in the *Annual Energy Outlook 2001*. Several changes have been made to the EIA's base case but these are mainly related to renewable energy technology assumptions. The one significant change we made to EIA's base case was to scale back the passenger vehicle fuel economy improvements included by EIA. As noted previously, passenger vehicle fuel economy has stagnated or declined for more than a decade. The EIA's base case assumes this trend will suddenly reverse and that passenger vehicle fuel economy will increase from 24.2 mpg in 1999 to 28 mpg in 2020 in the absence of any new policies. We find this assumption unrealistic and scaled back this increase to 26.3 mpg by 2020.

NEMS is a computer model that projects future U.S. energy consumption and supply based on energy technology and fuel choice for each sector and end-use, which in turn are derived from fuel prices, technology costs and characteristics, equipment turnover rates, and financial and behavioral parameters. These in turn affect the amounts, types, and cost of energy supplies necessary to meet these demands. In our analysis, NEMS was used for modeling the base case and policy case impacts on electricity supply and emissions and the amounts and cost of fuels supplied for electricity generation. The impacts of the efficiency policies on fossil use and emissions in buildings, industry, and transportation were calculated using spreadsheet models because NEMS is not set up to model end-use efficiency improvements in fossil fuel use.

The electricity supply module of NEMS includes detailed data for all existing power plants in each of the thirteen National Electric Reliability Council (NERC) regions of the United States and in neighboring Canadian regions. It simulates dispatch of these plants and new plants needed to meet electricity demand in each region, based on the costs and technical characteristics of the electricity supply options and their fuels. It takes account of regional power exchanges and the sulfur-dioxide cap and trade system of the 1990 Clean Air Act Amendments. It also accounts for the limited NOx trading regime for nineteen States. The model assumes some cost reductions for new power plants as the number of units placed in operation increases (i.e., from learning and economies of scale).

Policies that reduce projected end-use electricity requirements would affect the amount, type, size, and timing of new electric power supplies, as well as the amount and mix of generation dispatched each year, within each NERC region. Demand reductions thus result in avoided costs from reduced plant construction and operation, and avoided emissions from reduced generation. Electricity demand reductions can also result in lower cost of fuels not only for electricity generation but also for other uses in buildings and industry. Similarly, policies that constrain emissions from power supply, such as the coal power plant retirement policy, would affect electricity costs and emissions.

NEMS is used to obtain the impacts of the policies that induce efficiency improvements in the use of electricity in buildings and industry, and of the policies that induce fuel shifts in the electric generation mix. The cost and emission impacts of the electricity demand policies were obtained by reducing the electricity demand in each sector, per exogenous inputs as described in the previous report sections, for each year as the policies and their impacts phase in. These sectoral demands are then disaggregated by NEMS within each region. The model finds the least cost capacity expansion and dispatch to meet those regional demands. These results are then compared with the NEMS base case runs in order to obtain the net annual changes in costs and emissions.

The avoided costs and emissions from any given demand reduction, by policy, end-use, or sector, would be the marginal changes in capacity expansion and generation owing to that demand reduction. The results for each policy thus depends on the sequence with which these reductions are modeled, as each reduction changes the margin that the next reduction affects. Rather than adopt an arbitrary sequence, we modeled the aggregate impact of all demand-side energy efficiency together to obtain the total avoided costs and emissions. This yields an average emissions and costs savings across all kilowatt-hours saved. We then allocated the avoided energy use, costs, and emissions from the entire set of policies to the individual policies based upon the relative magnitude of their impacts when modeled separately.

The electricity supply policy was also modeled in NEMS. The coal retirement policy was modeled by iterating on a carbon tax to achieve a specified level of economic retirement of coal-fired power stations. The 2010 goal of an incremental 36 GW of retired coal capacity and the 2020 goal of an incremental 73 GW of retired coal capacity due to the retirement of old grandfathered power plants was modeled by imposing a $8 per tonne CO_2 tax on the electric sector together with the demand-side policies.[18]

All fuel prices for the base case are taken from the *Annual Energy Outlook 2001* (EIA 2000c). Electricity costs for the policy case are modeled in NEMS taking account of the impacts of the demand reductions and shifts in generation mix caused by the policies. Fossil fuel prices reflect changes in demand through the fuel supply modules of NEMS. Economic growth is assumed to be the same in the base and policy cases. A 5% real discount rate is assumed in the analysis of costs and benefits. The costs of efficiency investments are amortized over the life of each efficiency measure in order to account for costs and benefits in a consistent manner. As a result, for efficiency measures with a life that extends beyond 2020, not all costs are included in the analysis, as some of these costs relate to benefits that occur after 2020. Likewise, benefits

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[18] These retirements, combined with retirements induced by lower electricity demand due to demand-side efficiency policies, exceeded the amount of retirements we thought was reasonable and so we scaled back total retirements of coal capacity to 16 GW in 2010 and 113 GW in 2020, leaving 20%of the old plants still in the generation mix. Most of these retirements would be achieved if our demand-side policies are enacted, leaving only 6 GW of retirements in 2010 and 14 GW in 2020 that are not driven by demand reductions.

that occur after 2020 are also not included in the analysis. Finally, we assume that for every quad reduction in oil consumption in transportation or other sectors, there is an additional 0.2 quads of energy savings in oil refining (Delucchi 1999; EIA 2000c).

Energy Impacts

Table 1 provides the overall energy use, carbon emissions, air pollutant, and economic impacts for 2010 and 2020. In the base case, total primary energy consumption reaches 114.6 quads by 2010 and 128.1 quads by 2020, a 1.3% per year growth rate on average. Energy growth in our base case is slightly higher than the reference case forecast in the *Annual Energy Outlook 2001* (EIA 2000c) primarily due to the modifications we made (discussed above) to EIA's projections of passenger vehicle fuel economy improvements in the absence of new policy interventions.

Table 1. Summary of Overall Results for the Base and Policy Cases

	1990	1999	2010 Base Case	2010 Policy Case	2020 Base Case	2020 Policy Case
End Use Energy (Quads)	63.9	71.6	86.5	79.4	98.3	78.9
Primary Energy (Quads)	84.6	96.1	114.6	102.2	128.1	94.2
Energy Use by Fuel (Quads)						
Coal	19.1	21.4	25.2	18.1	26.2	9.5
Oil	33.5	38	44.9	41.9	51.7	42.1
Natural gas	19.3	22	28.7	26	35.5	27.5
Nuclear	6.2	7.8	7.7	7.8	6.1	6.3
Hydro	3	3.2	3.1	3.1	3.1	3.1
Other renewables	3.5	3.4	4.8	5.1	5.2	5.5
Carbon Emissions (Million Metric Tons)	1,338	1,505	1,817	1,540	2,063	1,338
Other Emissions (Million Metric Tons)						
Sulfur dioxide	19.3	20.5	16.5	14.9	16.9	13.1
Nitrogen oxides	21.9	15.8	12.8	11.6	12.7	6.6
Particulate matter (PM-10)	1.7	1.5	1.5	1.4	1.6	1.4
Cumulative Net Savings ($ billions)			-	152	-	591

The nine policies reduce primary energy consumption 11% by 2010 and 26% by 2020, relative to energy use in the base case in those years, through increased efficiency and greater adoption of CHP. Primary energy use rises slightly during the next decade but falls significantly during 2010–2020 (see Figure 1).

Figure 1. U.S. Energy Consumption Over Time in the Base and Policy Cases

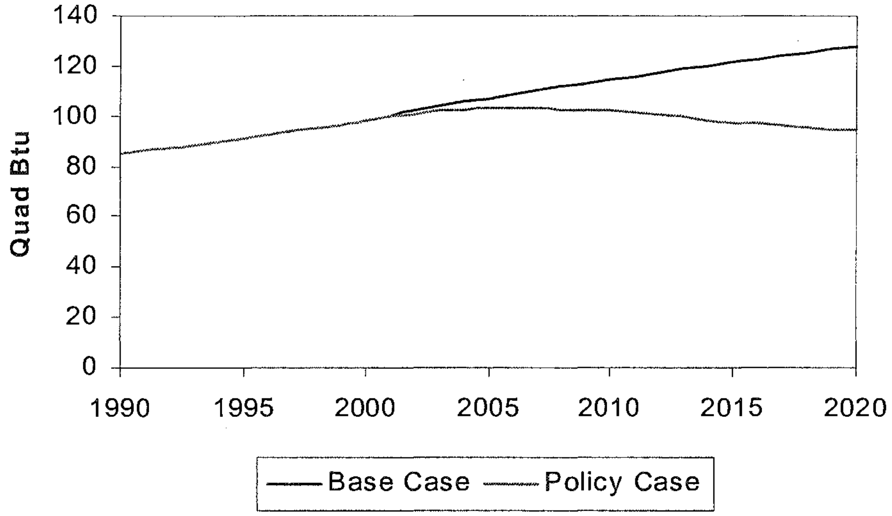


Figure 2 summarizes the breakdown of energy use by fuel type in each scenario over the 1999–2020 period. Oil consumption increases by about one-third by 2020 in the base case, with oil imports increasing more than 60% over that period. Thus, the oil import fraction is projected to rise from a little over 50% today to about 70% of total U.S. oil use by 2020. The policies evaluated here would significantly reduce overall oil imports. Relative to the base case, annual oil use by 2010 would be reduced by about 7% while annual imports would decrease by about 9%, assuming that domestic production remains unchanged. By 2020, annual oil use would be reduced by about 19% and imports by about 25%.

With implementation of the nine policies, U.S. total energy use in 2020 would be about 2% lower than energy use in 1999. Within this overall trend, use of some fuels increases and use of other fuels decreases. For example, use of coal declines 56% over this period, primarily due to substantial retirements of old, coal-fired power plants and replacement with natural gas. Due to increased use of natural gas for electricity generation, natural gas use grows 25% under the policy case relative to 1999 consumption, indicating that increased natural gas supplies would be needed. This growth in natural gas use in the policy case is substantially less than the 62% increase in natural gas use in the base case. As for petroleum, even with substantial efficiency improvements, petroleum use in the policy case is 11% higher than use in 1999. With domestic production at best stagnant, this would mean that oil imports will grow modestly, even with a full array of efficiency policies. By way of comparison, petroleum use grows 36% in the base case. Finally, electricity use in 2020 would be about the same as 1999 use although growth in CHP systems would decrease the need for centrally generated power relative to 1999. In total, while our nine policies would dramatically reduce the need for new energy supplies, even with these policies, there would be some need for new supplies, particularly natural gas.

Figure 2. Allocation of U.S. Energy Consumption by Energy Type in the Base and Policy Cases

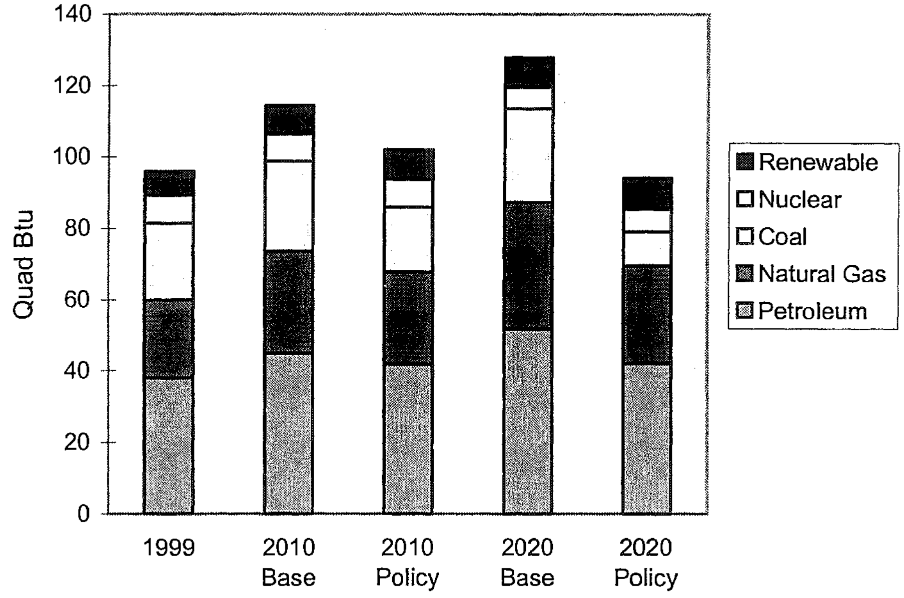


Table 2 summarizes savings from the different policies by sector. In this breakdown, energy savings arising from all policies that reduce electricity use are credited to the buildings or industrial sectors. With this perspective, the buildings-related policies are responsible for about 44% of the overall reductions (including 23% in the commercial sector and 21% in the residential sector), largely through impacts on electricity generation. The industrial policies are responsible for about 29% of the total reductions, the transportation policies about 23%, and the electric supply policy about 4%. Figure 3 displays these results graphically.

Table 2. Energy Use Reductions by Sector in the Policy Case

	1999	2010	2020	
Total Policy Case Consumption	96.1	102.2	94.2	
Reduction from residential policies		2.5	7.2	Residential
Reduction from commercial policies		2.7	7.9	Commercial
Reduction from industrial policies		4.5	9.5	Industrial
Reduction from transport policies		2.1	7.7	Transport
Reduction from electric supply policies		0.6	1.5	Electric Supply
Total Base Case Consumption	96.1	114.6	128.1	

Figure 3. Energy Use Reductions in 2020 by Sector

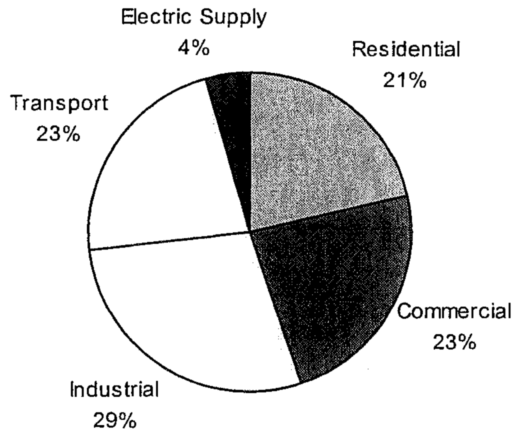


Table 3 and Figure 4 report on integrated savings by policy. These estimates take total integrated savings across all the policies and allocate them to the individual policies based on each policy's share of total unintegrated savings. Each of the policies has a substantial impact on U.S. energy use, with all saving at least 1.5 quad by 2020 (although tax credits are listed with lower savings since a substantial portion of their savings are subsumed under the CAFE standards, CHP, appliance standards, and building code policies). The largest savings estimates are achieved by CAFE standards and related policies to improve the fuel economy of light duty vehicles. Public benefit funds and industrial voluntary programs have the next largest savings. These three policies together account for about 60% of the savings in our policy case. However, for these policies to achieve such savings, they need to be stringent along the lines discussed in preceding sections of this report, including a 38 mpg CAFE standard, a two-tenths of a cent matching system benefit fund, and an industrial targets program backed by significant "carrots and sticks." Scaled-back versions of these policies would result in significantly lower savings.

Intermediate levels of estimated energy savings are achieved by updated and expanded appliance and equipment efficiency standards, expanded federal R&D and deployment efforts; increased use of combined heat and power systems, and tax credits. Finally, more moderate (albeit still substantial) savings are achieved by building codes and retirement of old, inefficient power plants. Savings from this latter policy are somewhat limited by our analytical approach whereby demand-side measures are first applied before supply-side measures. With this convention, efficiency programs lead to substantial power plant retirements, leaving only about half of the old "grandfathered" plants to be affected by the power plant policy. If we had instead considered supply-side policies first, power plant retirements would be included among the policies with intermediate energy savings.

Table 3. Energy Use Reductions by Policy

	1999	2010	2020
Total Policy Case Energy Consumption (quads)	**96.1**	**102.2**	**94.2**
Reduction from passenger vehicle effic. policy	0.0	2.1	7.7
Reduction from public benefits fund	0.0	2.5	6.5
Reduction from industrial voluntary program	0.0	3.3	6.4
Reduction from appliance standards	0.0	1.2	3.6
Reduction from R&D and deployment programs	0.0	0.9	3.3
Reduction from CHP	0.0	1.1	2.9
Reduction from power plant retirement policy	0.0	0.6	1.5
Reduction from building codes	0.0	0.3	1.5
Reduction from tax credits	0.0	0.3	0.6
Total Base Case Energy Consumption	96.1	114.6	128.1

Figure 4. Energy Use Reductions Over Time by Policy

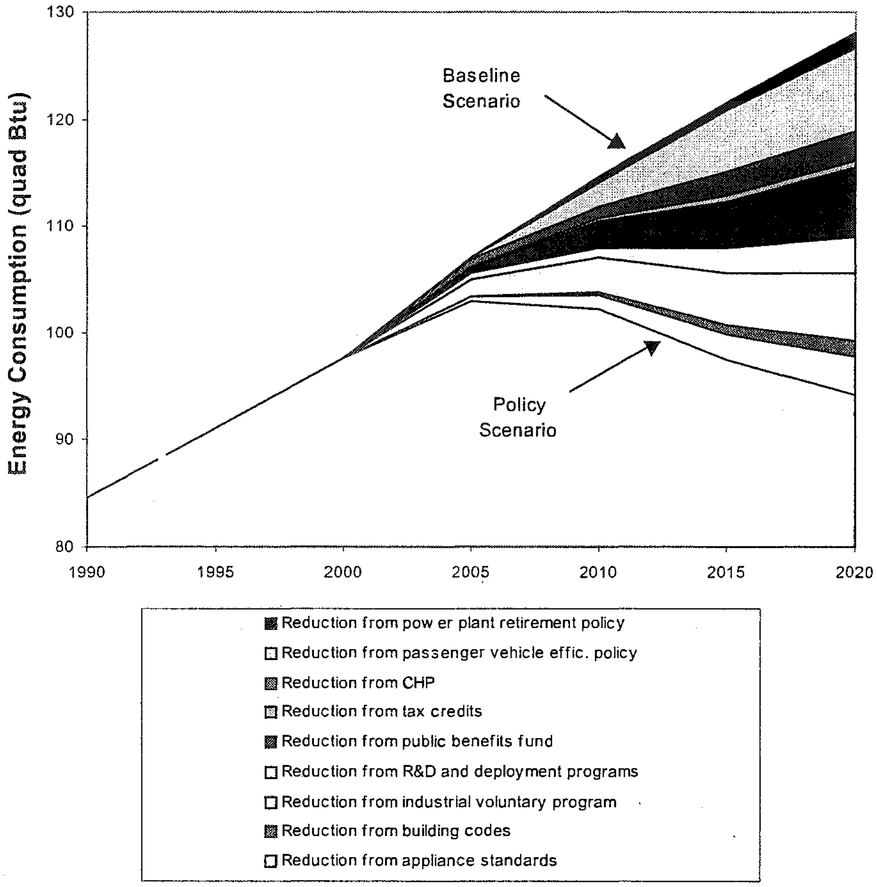
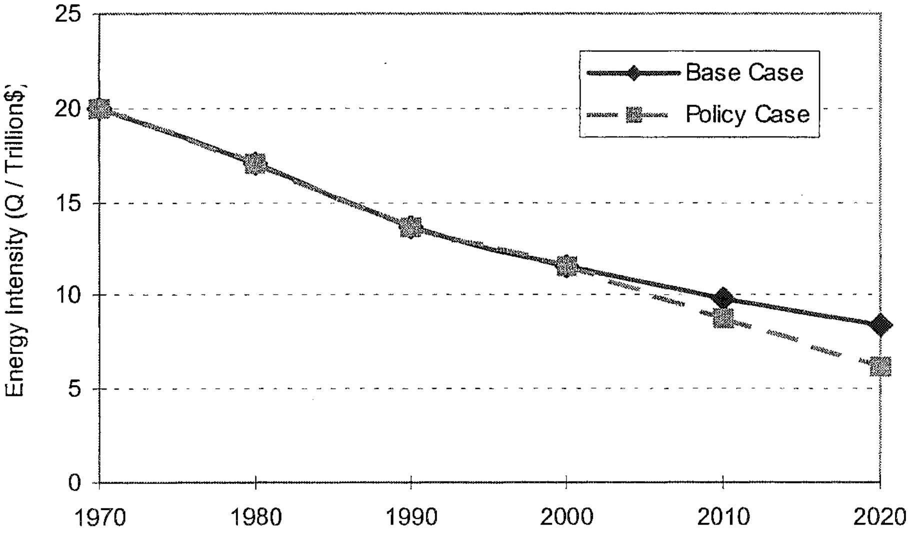


Figure 5 shows the history of the energy intensity of the U.S. economy (primary energy use per GDP) from 1970 to the present, as well as in the base case and policy case projections. The historic decrease in energy intensity is dramatic, at about 1.85% per year during 1970–2000. Energy intensity decreased 2.6% per year on average during 1973–86 but the decline fell to 1.1% per year during 1987–96. From 1996–2000, the energy intensity decline picked up speed, averaging 3.6% over the period.

Figure 5. Energy Intensity (GDP Basis) in the Base and Policy Cases

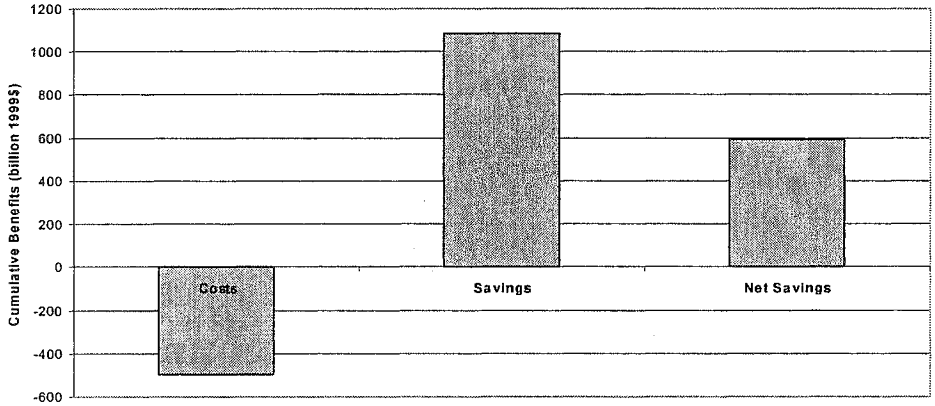


The base case forecast envisions a continued decline in energy intensity at about 1.3% per year so that energy intensity would be about 80% of the current level by 2020. In the policy case, the energy intensity of the economy drops about 2.6% per year on average through 2020, twice the rate in the base case but approximately equal to the rate of energy intensity reduction that occurred during 1973–86 and slightly slower than the improvement in the past few years. In the past few years there has been particularly rapid decline in energy intensity, driven in part by high economic growth, high capital investment in new technologies, and modest growth in residential energy demand (residential sector energy use has significantly lagged economic growth in recent years). These factors, and thus the 3.6% rate of energy intensity improvement, are probably not sustainable in the long term. Additional details on energy use by year in the base and policy cases are provided in Appendices A and B.

Economic Impacts

Figure 6 summarizes the direct economic costs and benefits in the policy case. The policies would induce incremental investments in high-efficiency motors; advanced industrial processes; more efficient buildings, lighting, and appliances; more fuel-efficient cars and trucks; cleaner and more efficient power plants; and so on. We estimate a total investment of $127 billion through 2010 and $495 billion through 2020, expressed in 1999 dollars using a 5% real discount rate. To place these figures in context, total U.S. energy expenditures (excluding on-site renewables) equaled about $558 billion in 1999 (EIA 2000c). The implementation of energy efficiency measures leads to lower utility bills, less fuels purchased, and some operating cost savings in areas such as petroleum refining. Overall, we estimate that end-users will save over one trillion dollars through 2020 as a result of these policies. This energy bill and operating savings more than offset the investment costs, with net savings of about $150 billion through 2010 and nearly $600 billion through 2020. The net savings grow over time since energy efficiency measures have more time to pay back their initial cost.

Figure 6. Costs, Savings, and Net Savings for the Policies by 2020



Note: Figures are cumulative present value by 2020, in billion 1999$.

Table 4 shows further details on the cost-effectiveness of the various policies, considering all costs and savings through 2020. The demand-side policies in aggregate are very cost-effective, with fuel and O&M savings that are nearly three times the investment costs, thereby yielding net benefits of about $655 billion. On the other hand, the supply-side policy—requiring coal-fired power plants to meet tougher emissions standards—is not cost-effective by itself, due in part to the switch from a less expensive to a more expensive fuel (coal vs. natural gas). For the power plant policy, investment costs exceed the fuel and O&M savings by $64 billion. Thus, combining all of the policies results in a net savings of $591 billion during the 20-year period. Appendix C provides further data on costs and savings.

Table 4. Net Benefits by Policy (Cumulative PV by 2020, billion 1999$)

	Costs	Savings	Net Savings
Total Policy	495	1087	591
passenger vehicle effic. policy	102	251	148
public benefits fund	130	231	101
industrial voluntary program	48	159	112
appliance standards	26	110	84
R&D and deployment	33	86	53
CHP	63	189	125
power plant retirement policy	64	0	-64
building codes	11	34	23
tax credits	17	26	8

Note: Figures are cumulative present value by 2020, in billion 1999$.

The nine policies would also have a positive impact on the economy by weakening demand for different energy sources, which would result in lower energy prices. In the base case, NEMS projects that domestic electricity and coal prices decline somewhat in real terms over the 1999–2020 period (e.g., declines of 8% and 25% respectively) while natural gas prices increase by 49%. In 2020, base case prices are projected by NEMS to be $0.061 per kWh for electricity, $12.71 per ton for coal at the mine mouth, and $3.10 per million Btus for natural gas at the wellhead (1999$). Under the policy case, electricity and coal prices are projected to drop by an additional 7% and 1%, respectively. More dramatically, natural gas prices are projected to decline to below 1999 levels (e.g., to $1.90 per million Btus in 2020), a *37%* decline from the base case. These trends are illustrated in Figure 7.[19]

These price declines would have a substantial and positive impact on the U.S. economy and would benefit all consumers and businesses. These indirect benefits are in addition to the direct benefits discussed above. Figure 8 summarizes the NEMS model results for energy expenditures in the base and policy cases incorporating both the direct and indirect effects. In the base case, U.S. energy expenditures are projected to rise from $557 billion in 1999, to $703 billion in 2010, to $809 billion in 2020 (all figures in 1999$). In the policy case, total energy expenditures would be reduced to $605 billion in 2010 (a savings of $98 billion relative to the base case) and $538 billion in 2020 (a savings of $271, a 33% reduction relative to the base case). Looked at on a per household basis, in the base case, energy expenditures per household (including energy used in homes, transportation, and businesses) would gradually climb from $5,355 in 1999 to $6,249 in 2020 (1999$). In the policy case, expenditures per household would be only $4,156, an annual

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[19] The policies may also have a moderate impact on gasoline prices since 2020 gasoline consumption declines 27% in the policy case relative to the base case. However, since we did not use the NEMS transportation module, gasoline prices were not modeled.

savings of $2,093 per household (some of these savings would be in reduce household energy bills and some in lower prices for other goods and services).

Figure 7. Gas, Coal, and Electricity Prices Over Time in the Base and Policy Cases

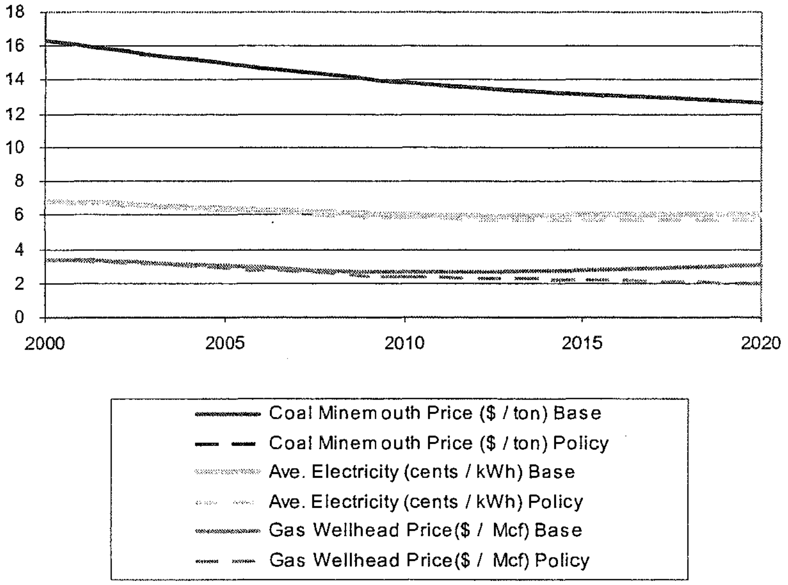
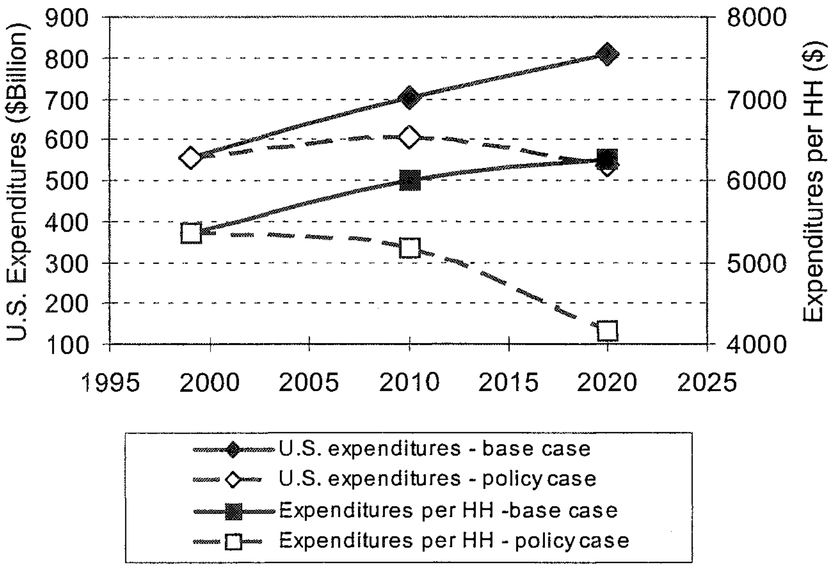


Figure 8. Energy Expenditures in the Base and Policy Cases



The companies that produce, market, and service the energy efficiency and renewable energy measures implemented in the policy case would employ workers and add to personal income while the energy supply industries would lose workers as demand for conventional fuels falls. The efficiency measures would also lower the energy bills of the businesses, industrial firms, and households that utilize the more efficient equipment, as well as the energy bills of all consumers due to the downward pressure on energy prices. Re-spending of these energy bill savings would create additional jobs and income since expenditures would be shifted to areas of the economy (such as food, housing, and entertainment) that are more labor-intensive than the energy supply sectors. The combination of the direct expenditures and re-spending would occur broadly across all sectors, and much of it would be local. Thus, national job increases—in construction, services, education, finance, manufacturing, agriculture, etc.—would be spread throughout the country.

While an analysis of overall macroeconomic impacts was not undertaken in this study, prior studies of this type show a net increase in jobs and personal income when energy efficiency and renewables measures are widely implemented (Bernow et al. 1999; Geller, DeCicco, and Laitner 1992; Goldberg et al. 1998; Laitner, Bernow, and DeCicco 1998; Sanstad, DeCanio, and Boyd 2000). These analyses used an input-output (I-O) model that represents interactions among different sectors of the economy. The most recent national analysis, *America's Global Warming Solutions,* indicated a potential net increase of nearly 900,000 jobs by 2010 (Bernow et al. 1999). While there are uncertainties in such an analysis, and a variety of dynamic economic phenomena that are not captured, this study gives an indication of the overall macroeconomic impacts likely to result from pursuing the nine policies considered here. Furthermore, this analysis includes only the impacts of direct energy savings and does not include the impacts of reduced energy demand on energy prices, which would likely add to the job gains.

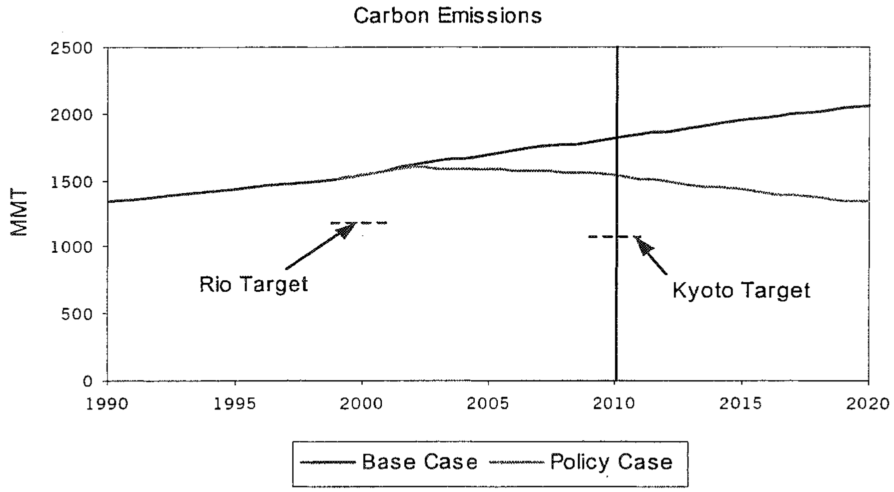
It also should be noted that our analysis does not take full account of the economies of scale, learning, or leadership in technology innovation that could be stimulated by the set of policies (Arthur 1994; Azar 1996). Nor does it account for the ancillary benefits, such as the human, systems, and organizational productivity improvements that could accompany the accelerated diffusion of advanced technologies and new energy resources (Porter and van Linde 1995). Such technological innovation and diffusion could have dramatic impacts on both the economic well-being and carbon intensity of society over the long run (Grubler, Nakicenovic, and Victor 1999).

Emission Impacts

U.S. carbon emission trends in the base and policy cases are summarized in Figure 9. In the base case, carbon emissions from burning fossil fuels reach 1,817 MMT of carbon equivalent by 2010 and 2,063 MMT by 2020, a 1.5% annual average growth rate during 2000–2020. Base case emissions are 36% greater than the 1990 level by 2010 and 54% greater by 2020. In the policy case, carbon emissions decline by 2010 so that they are the same as 2000 emissions and about 15% above 1990 emissions. Carbon emissions in 2010 in the policy case are about 280 MMT (16%) less than in the base case.

While this would not be enough to reach the United States's Kyoto Protocol target of 7% below 1990 emissions during 2008–2012, it would be a strong step in that direction. It should be possible to achieve the Kyoto target (i.e., a further 290 MMT annual reduction) through some combination of: (1) further domestic reductions from additional policy initiatives such as policies to promote use of renewable energy sources and policies to reduce vehicle use as well as energy use for air and truck transportation; (2) reductions in emissions of other GHGs; (3) purchase of emissions reductions from other Annex 1 countries; and (4) reductions in developing countries from Clean Development Mechanism projects. A recent study for the World Wildlife Fund examines the impacts of these other policies, in combination with the nine policies discussed here, and concludes that all of these actions together would bring the United States to within its Kyoto target (Bailie et al. 2001).

Figure 9. U.S. Carbon Emissions Over Time in the Base and Policy Cases



Note: The Kyoto Protocol includes six greenhouse gases. We only show carbon here since it accounts for approximately 84% of total global warming potential from gases covered by the Kyoto Protocol.

The set of nine policies continues to provide carbon emissions reductions after 2010 while the economy is expanding. For some of the polices, such as stimulating vehicle efficiency improvements and removing barriers to CHP, the impact of the policies accelerates after 2010. This is due to the time required to commercialize new technologies, increase their market share, and deploy them in a significant fraction of the eligible market. Compared to the base case, carbon emissions are cut 741 MMT (36%) in 2020 in the policy case. Emissions in 2020 in the policy case also are about 14% less than carbon emissions in 2000 and 1% less than energy sector emissions in 1990. When combined with the other actions discussed in the previous paragraph, this level of carbon emissions reduction is consistent with a climate stabilization scenario whereby industrialized nations cut their absolute carbon emissions by over 50% by 2050 and over 90% by 2100 (Bailie et al. 2001; PCAST 1997).

Figure 10 shows the history of the carbon intensity of the U.S. energy mix (carbon emissions per quad of primary energy) of the economy from 1970 to the present, as well as in the base case and policy case projections. The carbon intensity of primary energy consumption declined modestly (0.3% per year on average) during 1970–2000. The reduction was caused by expansion in nuclear, bioenergy, and hydro power, although growth in coal use offset much of the de-carbonization due to nuclear and renewable energy expansion during this period. The carbon intensity of U.S. energy supply actually has been declining over the past two centuries, falling at an average rate of about 0.9% per year during 1900–90 (Grubler, Nakicenovic, and Victor 1999.). The base case forecast, however, projects a slight increase in carbon intensity (0.1% per year on average) through 2020. The policy case, on the other hand, is more consistent with long-term trends and shows a 0.5% per year average drop in carbon intensity due to shifts from coal to natural gas within the electric sector.

Figure 10. Carbon Intensity (Energy Basis) in the Base and Policy Cases

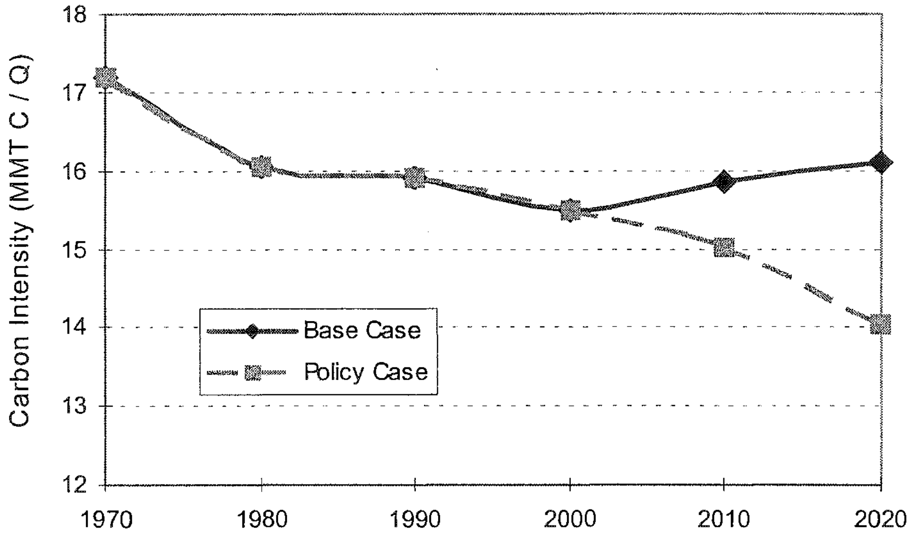


Figure 11 combines the impacts of changing energy intensity (Figure 5) and carbon intensity of energy use (Figure 10) to arrive at the carbon intensity of the overall economy. Carbon intensity has declined by nearly 50% over the past three decades—a compound annual average of 2.2%. In the base case, it is projected to decline at a slower rate—about 24% from 2000 to 2020 (1.4% per year) due to continued modest reductions in energy intensity. In the policy case, the projected decline is much more dramatic, by 51% from 2000 to 2020 (3.5% per year), owing to both energy intensity reduction and decarbonization of energy supplies.

Figure 11. Carbon Intensity (GDP Basis) in the Base and Policy Cases

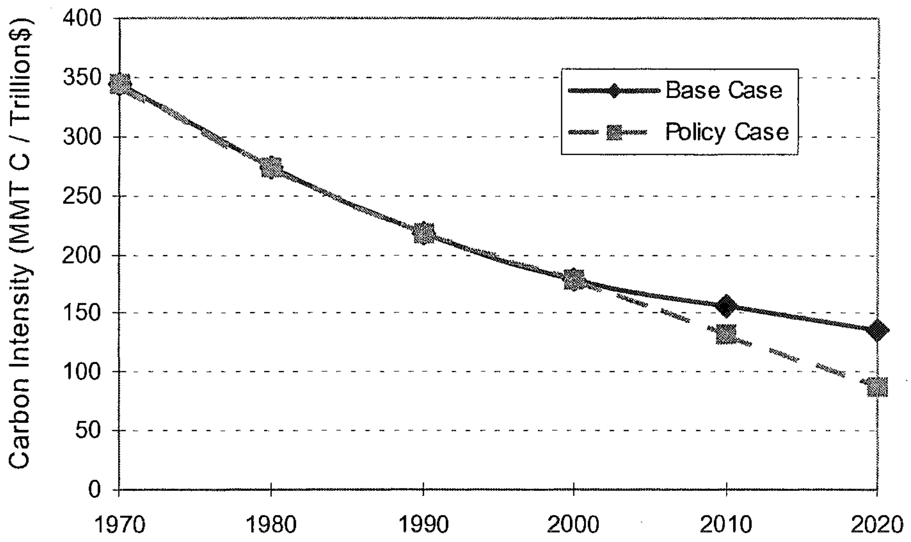


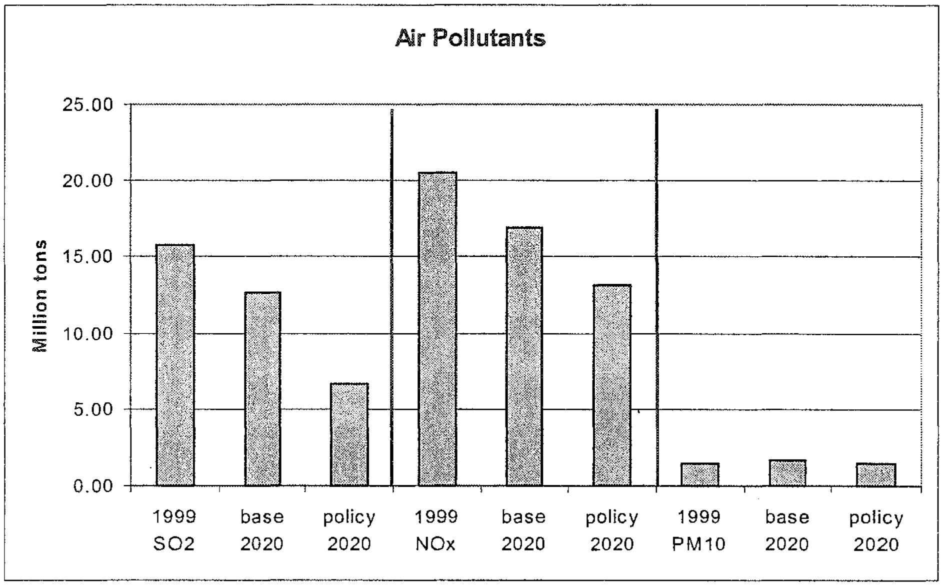
Table 5 presents the carbon emissions reductions from each of the nine policies. Upon inspection, it may appear surprising that tighter emissions standards on coal-fired power plants cause rather modest carbon reductions of 43 MMT in 2010 and 71 MMT in 2020. As noted above, this is in part a result of the convention adopted in this study that carbon reductions from the supply policies are computed after the impacts of the demand policies are taken into account. The set of demand policies results in significant reductions in electricity generation and emissions. Demand reductions reduce both natural gas and coal-fired generation, with coal displacement weighted towards the less efficient plants. The effect of tighter coal plant emissions standards were computed based on a percentage reduction in coal generation; thus, with the demand policies in place it would give lower emissions reductions than without these policies in place. For comparison, we computed the impacts of the supply policy before implementing the demand policies. If the tighter emission standards are considered before any of the demand-side policies, then the carbon reductions are about 83 MMT in 2010 and 104 MMT in 2020. Additional information on carbon emission reductions by year can be found in Appendices D and E.

In addition to carbon emission reductions, the set of nine policies also reduces criteria air pollutants. Air pollutants such as fine particulates (PM-10), carbon monoxide (CO), SO_2, and ozone (formed by a mix of volatile organic compounds [VOC] and NOx in the presence of sunlight) cause or exacerbate health problems that include premature mortality and morbidity. Small children and the elderly are particularly at risk from these emissions (Dockery et al. 1993; Schwartz and Dockery 1992.). These emissions also damage the environment, adversely affecting agriculture, forests, water resources, and buildings. Figure 12 presents the impacts of the nine policies on combustion-related emissions of several criteria air pollutants (data for this table can be found in Appendix F). Implementing the nine policies would reduce SO_2 emissions the most—9% by 2010 and 48% by 2020. Emissions of NOx would be cut 7% by 2010 and 19% by 2020 and PM-10 emissions would drop 6% by 2010 and 13% by 2020. Clearly, taking action to reduce energy use as proposed in the policy case would provide significant public health and local/regional environmental benefits.

Table 5. Carbon Emissions Reductions by Policy

	2010	2020
Total Policy Case Carbon Emissions (MtC)	**1540**	**1338**
Reduction from passenger vehicle effic. policy	23	71
Reduction from public benefits fund	6	28
Reduction from industrial voluntary program	67	132
Reduction from appliance standards	19	65
Reduction from R&D and deployment programs	46	127
Reduction from CHP	4	10
Reduction from power plant retirement policy	29	78
Reduction from building codes	40	142
Reduction from tax credits	43	71
Total Base Case Carbon Emissions	**1817**	**2063**

Figure 12. SO_2, NOx and Particulate Emissions Over Time in the Base and Policy Cases



DISCUSSION AND CONCLUSION

Energy efficiency is an important cornerstone for America's energy policy. Taken together, the nine policies recommended here would reduce U.S. energy use by more than 20% in 2020.

These savings could well exceed projected growth in U.S. energy use over the next two decades. These efficiency policies alone will not solve all of our energy problems—energy use would continue to grow for a decade or so while these energy-saving policies gradually take effect. Furthermore, new sources of energy supply and distribution will be needed as current surpluses are exhausted and portions of current infrastructure need to be replaced. In addition, infrastructure may need to be expanded in rapidly growing regions. However, these efficiency policies would substantially reduce our energy problems, making it easier to find reasonably priced and environmentally acceptable energy supplies to meet future U.S. energy demand. In other words, relative to a supply-focused energy strategy, a balanced energy strategy that complements efforts to expand supplies with a major focus on improving efficiency has a greater chance of success in terms of ensuring the reliability of the U.S. energy system, reducing economic costs (since the efficiency strategies incorporated here save consumers and businesses money at projected energy costs), and protecting the environment. Furthermore, all consumers and businesses would benefit from adoption of these policies due to the reduction in energy prices expected as demand falls relative to business-as-usual trends.

ACEEE is not the only organization suggesting that national policymakers should increase support for and adopt new policies to raise energy efficiency. The Council on Foreign Relations convened an independent task force that recently completed an in-depth report on the United States' energy challenges and what should be done about them (Council on Foreign Relations 2001). The Council concludes: "Energy policy has underplayed energy efficiency and demand-management measures for two decades." The Council urges that the United States "take a proactive government position on demand management" including to "review and establish new and stricter CAFE mileage standards, especially for light trucks."

Many newspapers have recently editorialized for increasing energy efficiency and a balanced energy strategy with a major focus on energy efficiency. These newspapers include *Business Week (*Raeburn 2001), the Los Angeles Times (2001), *Miami Herald* (2001), *New York Times* (2001), *Seattle Post-Intelligencer (2001), USA Today* (2001), and *Washington Post* (2001). For example, *USA Today* concluded: "[F]or an energy-dependent nation, more power plants and new oil and gas supplies aren't enough. Making more efficient use of existing energy must also be part of the solution."

In addition, the general public voices strong support for increasing energy efficiency and a balanced energy strategy. For example, a recent nationwide poll conducted for the *Los Angeles Times* found that when people were asked how to meet our energy needs, "15 percent called for greater conservation efforts, 17 percent supported development of new supplies and 61 percent said they favored both steps in equal measure (Barabak 2001)." Similarly, in a May 2001 Gallop Poll, 47% of respondents said the U.S. should emphasize "more conservation" versus only 35% who said we should emphasize production (an additional 14% volunteered "both"). In this same poll, when read a list of 11 actions to deal with the energy situation, the top four actions (supported by 85–91% of respondents) were "invest in new sources of energy," "mandate more energy-efficient appliances," "mandate more energy-efficient new buildings," and "mandate more energy-efficient cars." Options for increasing energy supply and delivery generally received significantly less support (Moore 2001).

Ten years ago the previous Bush Administration issued its National Energy Strategy. It gave considerable priority to greater energy efficiency and called for expansion of energy efficiency R&D and technology deployment programs, new policies to stimulate utility energy efficiency programs, establishment of new appliance and equipment energy efficiency standards, and new federal incentives to increase energy efficiency (DOE 1991). Many of these proposals were incorporated in the Energy Policy Act of 1992, and the budget for and impacts of DOE's energy efficiency programs rose throughout the previous Bush Administration.

The current Bush Administration and the current Congress should make improving energy efficiency a cornerstone of its energy strategy and adopt policies that would truly make a difference. In May 2001 the Administration released its *National Energy Policy*. This policy calls for "advanc[ing] new, environmentally friendly technologies to increase energy supplies and encourage cleaner, more efficient energy use." Unfortunately the policy details do not bear this rhetoric out. Instead, the plan proposes many specific policies for increasing energy supplies, but the major specific efficiency policy is a call for tax incentives for efficient vehicles and CHP systems (a subset of the tax credits we propose). In addition, the plan calls for "reviewing" CAFE and "tak[ing] steps" to set new appliance efficiency standards. These latter actions fall well short of our specific policy prescriptions (National Energy Policy Development Group 2001).

Congress is now beginning to consider energy legislation, and these efforts so far go farther than the Bush Administration proposes with respect to advancing energy efficiency, but they are still well short of what is needed. As of this writing, legislation passed by the House of Representatives includes some of the tax incentives and appliance standards we call for and an extremely modest increase in CAFE standards. At the same time, both houses of Congress have passed appropriations bills for R&D and deployment programs in 2002 that essentially leave funding for DOE and EPA R&D deployment programs level with 2001, a substantial improvement relative to the original Bush budget proposal, but well short of the increases that are needed. All of our other policies unfortunately are not included in the House legislation.

Overall, Congress so far merits a grade of "D" in terms of meaningful action to raise energy efficiency and is doing much less than the American people want, as indicated in the polls. Congress, starting with the Senate, needs to redouble its efforts in order to properly value and support energy efficiency in new energy legislation and in appropriations for energy programs. In particular, we urge Congress to adopt substantial energy efficiency provisions along the lines of our proposals. Implementation experience with the energy efficiency provisions included in the Energy Policy Act of 1992 indicates that most of the energy savings actually achieved in practice are from a few major provisions (e.g., new equipment efficiency standards), and that smaller provisions tend to have little impact but can divert needed attention from implementation of the major provisions (ACEEE and ASE 1997).

In this report, we show that energy efficiency policies can make a very large contribution towards meeting U.S. needs for new energy sources while reducing emissions and saving consumers and businesses billions of dollars. However, without strong policies, many of these benefits would be lost, costing the U.S. dearly in terms of excessive energy bills, adverse impacts on public health, over-dependence on imported energy, and increased risk of dangerous climate change. Congress now has it in its power to take a different tack—it is time for Congress to rise to the occasion and adopt a comprehensive and strong set of policies that would increase energy efficiency throughout the U.S. economy for decades to come.

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APPENDIX A: SUMMARY OF ENERGY USE IN THE BASE AND POLICY CASES

Total Energy Consumption by Fuel and by Sector in 1990 (Quads)

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.06	0.10	2.75	0.00	16.20	19.11
Oil	1.27	0.91	8.31	21.81	1.23	33.53
Gas	4.52	2.76	8.47	0.68	2.88	19.31
Nuclear	0.00	0.00	0.00	0.00	6.19	6.19
Hydro	0.00	0.00	0.00	0.00	2.99	2.99
Non-Hydro	0.83	0.09	2.07	0.00	0.50	3.49
Primary Total	**6.68**	**3.86**	**21.60**	**22.49**	**29.99**	**84.62**
Electricity	3.15	2.86	3.24	0.01		9.26
End-Use Total	**9.83**	**6.72**	**24.84**	**22.50**		**63.89**

Total Energy Consumption by Fuel and by Sector in 1999 (Quads), Base Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.04	0.07	2.54	0.00	18.78	21.43
Oil	1.42	0.59	9.39	25.54	1.08	38.02
Gas	4.85	3.15	9.43	0.67	3.86	21.96
Nuclear	0.00	0.00	0.00	0.00	7.79	7.79
Hydro	0.00	0.00	0.00	0.00	3.17	3.17
Non-Hydro	0.41	0.08	2.15	0.01	0.78	3.43
Primary Total	**6.71**	**3.90**	**23.52**	**26.23**	**35.45**	**96.33**
Electricity	3.91	3.70	3.63	0.06		11.29
End-Use Total	**10.62**	**7.59**	**27.15**	**26.28**		**71.65**

Total Energy Consumption by Fuel and by Sector in 2005 (Quads), Base Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.07	2.62	0.00	21.43	24.18
Oil	1.42	0.66	9.95	29.16	0.32	41.51
Gas	5.46	3.71	10.43	0.83	5.41	25.84
Nuclear	0.00	0.00	0.00	0.00	7.90	7.90
Hydro	0.00	0.00	0.00	0.00	3.08	3.08
Non-Hydro	0.43	0.08	2.42	0.03	1.10	4.06
Primary Total	**7.36**	**4.52**	**25.42**	**30.01**	**39.25**	**107.09**
Electricity	4.49	4.34	3.90	0.09		12.82
End-Use Total	**11.85**	**8.86**	**29.32**	**30.10**		**80.14**

Total Energy Consumption by Fuel and by Sector in 2005 (Quads), Policy Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.07	2.25	0.00	18.48	20.86
Oil	1.41	0.64	9.54	29.03	0.22	40.84
Gas	5.35	3.74	10.33	0.83	4.96	25.21
Nuclear	0.00	0.00	0.00	0.00	7.90	7.90
Hydro	0.00	0.00	0.00	0.00	3.09	3.09
Non-Hydro	0.43	0.08	2.46	0.03	1.49	4.49
Primary Total	**7.23**	**4.53**	**24.59**	**29.88**	**36.15**	**102.90**
Electricity	4.28	4.02	3.38	0.09		11.77
End-Use Total	**11.51**	**8.55**	**27.97**	**29.97**		**78.00**

Total Energy Consumption by Fuel and by Sector in 2010 (Quads), Base Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.07	2.62	0.00	22.41	25.16
Oil	1.29	0.67	10.55	32.21	0.19	44.91
Gas	5.70	3.89	11.14	0.99	6.97	28.69
Nuclear	0.00	0.00	0.00	0.00	7.69	7.69
Hydro	0.00	0.00	0.00	0.00	3.08	3.08
Non-Hydro	0.43	0.08	2.64	0.04	1.60	4.79
Primary Total	**7.47**	**4.71**	**26.95**	**33.24**	**41.94**	**114.62**
Electricity	4.95	4.86	4.17	0.12		14.10
End-Use Total	**12.42**	**9.57**	**31.12**	**33.36**		**86.47**

Total Energy Consumption by Fuel and by Sector in 2010 (Quads). Policy Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.07	2.09	0.00	15.89	18.10
Oil	1.26	0.62	9.35	30.49	0.13	41.85
Gas	5.39	3.93	10.82	0.99	4.85	25.98
Nuclear	0.00	0.00	0.00	0.00	7.81	7.81
Hydro	0.00	0.00	0.00	0.00	3.09	3.09
Non-Hydro	0.43	0.08	2.76	0.04	1.78	5.09
Primary Total	**7.13**	**4.71**	**25.03**	**31.51**	**33.54**	**102.23**
Electricity	4.15	3.82	2.94	0.12		11.03
End-UseTotal	**11.28**	**8.53**	**27.97**	**31.63**		**79.41**

Percentage Difference in Primary Consumption by 2010 Relative to 1990, Policy Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	-13%	-28%	-24%	NA	-2%	-5%
Oil	-1%	-32%	13%	40%	-90%	25%
Gas	19%	42%	28%	45%	68%	35%
Nuclear	NA	NA	NA	NA	26%	26%
Hydro	NA	NA	NA	NA	3%	3%
Non-Hydro	-48%	-8%	33%	NA	255%	46%
Primary Total	**7%**	**22%**	**16%**	**40%**	**12%**	**21%**
Electricity	32%	34%	-9%	1081%		19%
End-Use Total	**15%**	**27%**	**13%**	**41%**		**24%**

Total Energy Consumption by Fuel and by Sector in 2015 (Quads), Base Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.07	2.62	0.00	22.97	25.72
Oil	1.24	0.67	11.15	35.21	0.18	48.45
Gas	5.99	4.05	11.78	1.12	9.37	32.32
Nuclear	0.00	0.00	0.00	0.00	6.79	6.79
Hydro	0.00	0.00	0.00	0.00	3.07	3.07
Non-Hydro	0.43	0.08	2.86	0.04	1.59	5.01
Primary Total	**7.71**	**4.88**	**28.41**	**36.38**	**43.97**	**121.57**
Electricity	5.36	5.30	4.44	0.15		15.25
End-Use Total	**13.08**	**10.18**	**32.85**	**36.52**		**92.63**

Total Energy Consumption by Fuel and by Sector in 2015 (Quads). Policy Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.07	1.99	0.00	11.80	13.92
Oil	1.18	0.58	8.90	30.51	0.09	41.27
Gas	5.31	4.05	11.56	1.12	4.50	26.55
Nuclear	0.00	0.00	0.00	0.00	7.08	7.08
Hydro	0.00	0.00	0.00	0.00	3.08	3.08
Non-Hydro	0.43	0.08	3.02	0.04	1.75	5.33
Primary Total	**6.98**	**4.79**	**25.47**	**31.68**	**28.30**	**97.45**
Electricity	3.82	3.24	2.25	0.15		9.46
End-Use Total	**10.80**	**8.03**	**27.73**	**31.83**		**78.38**

Percentage Difference in Primary Consumption by 2015 Relative to 1990, Policy Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	-16%	-26%	-28%	NA	-27%	-27%
Oil	-7%	-37%	7%	40%	-93%	23%
Gas	18%	47%	36%	65%	56%	37%
Nuclear	NA	NA	NA	NA	14%	14%
Hydro	NA	NA	NA	NA	3%	3%
Non-Hydro	-48%	-8%	46%	NA	249%	53%
Primary Total	**5%**	**24%**	**18%**	**41%**	**-6%**	**15%**
Electricity	21%	13%	-30%	1355%	NA	2%
End-Use Total	**10%**	**19%**	**12%**	**41%**	**NA**	**23%**

Total Energy Consumption by Fuel and by Sector in 2020 (Quads), Base Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.08	2.62	0.00	23.50	26.24
Oil	1.21	0.66	11.78	37.86	0.20	51.70
Gas	6.31	4.14	12.38	1.24	11.40	35.48
Nuclear	0.00	0.00	0.00	0.00	6.09	6.09
Hydro	0.00	0.00	0.00	0.00	3.06	3.06
Non-Hydro	0.44	0.08	3.08	0.05	1.62	5.27
Primary Total	**8.01**	**4.96**	**29.86**	**39.15**	**45.87**	**128.07**
Electricity	5.80	5.59	4.79	0.17		16.34
End-Use Total	**13.81**	**10.54**	**34.65**	**39.32**		**98.32**

Total Energy Consumption by Fuel and by Sector in 2020 (Quads). Policy Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	0.05	0.08	1.90	0.00	7.43	9.46
Oil	1.13	0.52	8.75	31.64	0.05	42.09
Gas	5.26	4.09	12.54	1.24	4.36	27.50
Nuclear	0.00	0.00	0.00	0.00	6.33	6.33
Hydro	0.00	0.00	0.00	0.00	3.07	3.07
Non-Hydro	0.44	0.08	3.27	0.05	1.70	5.55
Primary Total	**6.88**	**4.77**	**26.46**	**32.94**	**22.95**	**94.22**
Electricity	3.53	2.53	1.60	0.17		7.82
End-Use Total	**10.41**	**7.30**	**28.05**	**33.10**		**78.86**

Percentage Difference in Primary Consumption by 2020 Relative to 1990, Policy Case

	Residential	Commercial	Industrial	Transportation	Electricity	Total
Coal	-19%	-24%	-31%	NA	-54%	-51%
Oil	-11%	-43%	5%	45%	-96%	26%
Gas	16%	48%	48%	83%	52%	42%
Nuclear	NA	NA	NA	NA	2%	2%
Hydro	NA	NA	NA	NA	3%	3%
Non-Hydro	-47%	-8%	58%	NA	241%	59%
Primary Total	**3%**	**24%**	**22%**	**46%**	**-23%**	**11%**
Electricity	12%	-12%	-51%	1559%	NA	-16%
End-Use Total	**6%**	**9%**	**13%**	**47%**	**NA**	**23%**

APPENDIX B: ENERGY SAVINGS BY POLICY AND YEAR

	1990	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Policy Case Energy Consumption (quads)	84.6	96.1	97.6	99.9	100.8	102.6	102.8	102.9	102.9	102.9	102.7	102.4	102.2
Reduction from appliance standards		0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.6	0.7	0.9	0.7	1.2
Reduction from building codes		0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3
Reduction from industrial voluntary program		0.0	0.0	0.0	0.4	0.9	1.2	1.7	2.0	2.3	2.6	2.9	3.3
Reduction from R&D and deployment programs		0.0	0.0	0.0	0.3	0.4	0.4	0.5	0.6	0.5	0.7	0.6	0.9
Reduction from public benefits fund		0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.9	1.5	1.8	2.6	2.5
Reduction from tax credits		0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.2	0.4	0.3
Reduction from CHP		0.0	0.0	0.0	0.6	0.4	0.6	0.6	0.7	0.8	0.9	1.0	1.1
Reduction from passenger vehicle effic. policy		0.0	0.0	0.0	0.0	-0.1	0.0	0.2	0.4	0.8	1.2	1.6	2.1
Reduction from power plant retirement policy		0.0	0.0	0.0	0.0	-0.1	0.0	0.1	0.2	0.3	0.5	0.5	0.6
Total Base Case Energy Consumption	84.6	96.1	97.6	99.9	102.2	104.1	105.7	107.1	108.6	110.3	111.7	113.1	114.6

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Policy Case Energy Consumption (quads)	101.2	100.3	99.4	98.2	97.4	96.7	95.9	95.2	94.7	94.2
Reduction from appliance standards	1.5	1.7	1.9	2.1	2.4	2.5	2.7	3.0	3.3	3.6
Reduction from building codes	0.4	0.5	0.6	0.7	0.9	0.9	1.1	1.2	1.4	1.5
Reduction from industrial voluntary program	3.6	3.9	4.3	4.5	4.9	5.2	5.5	5.7	6.1	6.4
Reduction from R&D and deployment programs	1.2	1.4	1.7	2.0	2.3	2.4	2.6	2.8	3.1	3.3
Reduction from public benefits fund	2.9	3.2	3.6	3.9	4.4	5.0	5.5	5.8	6.1	6.5
Reduction from tax credits	0.3	0.3	0.4	0.5	0.5	0.5	0.6	0.5	0.7	0.6
Reduction from CHP	1.4	1.6	1.8	2.0	2.3	2.4	2.4	2.6	2.8	2.9
Reduction from passenger vehicle effic. policy	2.8	3.6	4.4	5.3	5.8	6.2	6.6	6.9	7.3	7.7
Reduction from power plant retirement policy	0.7	0.7	0.8	0.9	0.7	1.0	1.4	1.6	1.5	1.5
Total Base Case Energy Consumption	115.9	117.3	118.7	120.1	121.6	122.9	124.2	125.4	126.7	128.1

APPENDIX C: COST AND BENEFITS BY POLICY AND YEAR

											Annual											
Costs by Policy (billion 1999$)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Policy Case Incremental Costs	**0**	**0**	**0**	**1**	**9**	**12**	**15**	**20**	**25**	**30**	**36**	**43**	**50**	**58**	**66**	**67**	**79**	**89**	**101**	**110**	**118**	**124**
Cost from appliance standards	0	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5	6	6	7	7	8
Cost from building codes	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2	3	3	3	4
Cost from industrial voluntary program	0	0	0	0	0	1	1	1	2	2	3	4	4	5	6	7	8	9	11	12	13	14
Cost from R&D and deployment programs	0	0	0	0	0	1	1	1	1	2	2	3	3	4	4	5	6	7	7	8	8	9
Cost from public benefits fund	0	0	0	0	0	1	2	3	5	7	9	11	13	15	17	20	23	26	29	31	34	35
Cost from tax credits	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3
Cost from CHP	0	0	0	0	1	2	2	3	3	4	5	5	6	7	8	9	10	11	12	13	14	14
Cost from passenger vehicle efficiency policy	0	0	0	0	0	1	1	2	3	5	6	8	9	12	14	16	19	21	24	26	28	30
Cost from power plant retirement policy	0	0	0	0	6	7	7	8	8	8	8	8	8	8	8	1	3	4	6	7	8	7
(net fuel, O&M, capital, wholesale costs)																						

											Annual											
Savings by Policy (billion 1999$)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Policy Case Incremental Savings	**0**	**0**	**0**	**6**	**11**	**21**	**32**	**43**	**57**	**70**	**84**	**98**	**115**	**132**	**151**	**150**	**166**	**193**	**213**	**231**	**245**	**261**
Savings from appliance standards	0	0	0	0	0	2	3	4	6	8	9	11	13	14	16	15	16	19	21	23	25	27
Savings from building codes	0	0	0	0	0	0	1	1	1	2	2	2	3	4	5	5	5	7	8	9	9	10
Savings from industrial voluntary programs	0	0	0	2	4	6	8	10	12	13	15	16	18	19	20	21	21	23	24	26	28	29
Savings from R&D and deployment programs	0	0	0	1	2	3	3	4	5	6	6	7	9	10	11	11	12	15	16	18	19	20
Savings from public benefits fund	0	0	0	0	1	2	4	7	11	15	19	23	26	30	33	30	34	42	48	52	56	59
Savings from tax credits	0	0	0	0	1	1	1	1	2	2	2	3	3	3	3	3	3	3	4	4	5	5
Savings from CHP	0	0	0	3	4	7	10	11	12	14	16	17	19	22	24	19	22	29	34	37	40	44
Savings from passenger vehicle efficiency polic	0	0	0	0	-1	0	1	4	7	10	14	19	25	31	38	47	51	55	58	61	63	67
Savings from power plant retirement policy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

											Annual											
Net savings by Policy (billion 1999$)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Policy Case Incremental Net savings	**0**	**0**	**0**	**6**	**2**	**9**	**17**	**23**	**32**	**40**	**48**	**56**	**65**	**75**	**85**	**82**	**87**	**104**	**112**	**121**	**128**	**137**
Net savings from appliance standards	0	0	0	0	0	2	3	3	5	7	8	9	10	11	12	10	11	14	15	17	18	19
Net savings from building codes	0	0	0	0	0	0	1	1	1	1	2	2	2	3	3	3	3	4	5	6	6	7
Net savings from industrial voluntary programs	0	0	0	2	4	6	7	9	10	11	12	13	13	13	14	13	13	14	14	15	15	15
Net savings from R&D and deployment program	0	0	0	1	1	2	3	3	4	4	4	5	5	6	7	6	7	8	9	10	11	12
Net savings from public benefits fund	0	0	0	0	0	1	3	4	6	8	10	12	13	14	16	10	11	16	19	21	22	24
Net savings from tax credits	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	2	2
Savings from CHP	0	0	0	2	4	5	7	8	8	10	11	12	13	14	16	10	12	17	21	24	27	29
Savings from passenger vehicle efficiency polic	0	0	0	0	-1	-1	0	2	4	6	9	12	15	20	25	31	32	34	35	35	35	37
Net savings from power plant retirement policy	0	0	0	0	-6	-7	-7	-8	-8	-8	-8	-8	-8	-8	-8	-1	-3	-4	-6	-7	-8	-7

APPENDIX D: SUMMARY OF CARBON EMISSIONS IN THE POLICY AND BASE CASES

Carbon Emissions in 1990 (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	41.2	26.8	408.8	NA	476.8
Residential	65.0	24.0	1.6	162.4	253.0
Commercial	38.7	18.1	2.3	147.5	206.6
Industrial	119.6	91.9	67.8	166.3	445.6
Transportation	9.9	422.3	0.0	0.7	432.9
Totals	274.4	583.1	480.5	0.0	1,338.0
Fossil Fuel Share	20.5%	43.6%	35.9%		
Elect. Share					35.6%

Carbon Emissions in 1999 -- Base Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	55.6	23.1	476.6	0.0	555.3
Residential	69.8	26.8	1.1	192.2	289.9
Commercial	45.4	11.6	1.7	181.7	240.5
Industrial	135.8	93.6	64.5	178.4	472.4
Transportation	9.7	489.5	0.0	2.9	502.1
Totals	316.3	644.7	544.0	0.0	1,504.9
Fossil Fuel Share	21.0%	42.8%	36.1%		
Elect. Share					36.9%

Carbon Emissions in 2005 -- Base Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	77.9	7.0	544.0	NA	628.9
Residential	78.6	26.9	1.3	220.4	327.1
Commercial	53.5	12.9	1.8	212.9	281.0
Industrial	150.2	99.6	66.6	191.3	507.8
Transportation	11.9	559.2	0.0	4.3	575.4
Totals	372.1	705.6	613.6	0.0	1,691.3
Fossil Fuel Share	22.0%	41.7%	36.3%		
Elect. Share					37.2%

Carbon Emissions in 2005 -- Policy Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	71.5	4.7	469.1	NA	545.3
Residential	77.0	26.6	1.3	198.2	303.0
Commercial	53.8	12.5	1.8	186.1	254.2
Industrial	148.8	91.9	57.2	156.7	454.6
Transportation	11.9	556.7	0.0	4.3	573.0
Totals	363.0	692.4	529.4	0.0	1,584.7
Fossil Fuel Share	22.9%	43.7%	33.4%		
Elect. Share					34.4%

Carbon Emissions in 2010 -- Base Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	100.4	4.2	568.8	NA	673.4
Residential	82.0	24.4	1.3	236.5	344.3
Commercial	56.0	13.1	1.9	232.2	303.2
Industrial	160.4	105.9	66.4	199.0	531.8
Transportation	14.2	617.9	0.0	5.6	637.7
Totals	413.1	765.4	638.5	0.0	1,817.0
Fossil Fuel Share	22.7%	42.1%	35.1%		
Elect. Share					37.1%

Carbon Emissions in 2010 -- Policy Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	69.8	2.8	403.2	NA	475.9
Residential	77.6	23.8	1.3	178.8	281.5
Commercial	56.6	12.2	1.9	164.6	235.2
Industrial	155.9	83.2	53.0	126.8	418.9
Transportation	14.2	584.8	0.0	5.6	604.7
Totals	374.0	706.9	459.4	0.0	1,540.3
Fossil Fuel Share	24.3%	45.9%	29.8%		
Elect. Share					30.9%

Percentage Difference in Carbon Emissions in 2010 Relative to 1990 -- Policy Case

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	69%	-89%	-1%	NA	0%
Residential	19%	-1%	-16%	10%	11%
Commercial	46%	-33%	-20%	12%	14%
Industrial	30%	-9%	-22%	-24%	-6%
Transportation	44%	38%	NA	706%	40%
Totals	36%	21%	-4%	NA	15%

Carbon Emissions in 2015 -- Base Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	135.0	4.0	583.1	NA	722.1
Residential	86.2	23.4	1.3	253.9	364.9
Commercial	58.4	13.1	1.9	250.9	324.3
Industrial	169.6	112.2	66.4	210.3	558.6
Transportation	16.2	675.3	0.0	6.9	698.4
Totals	465.4	828.1	652.7	0.0	1,946.2
Fossil Fuel Share	23.9%	42.5%	33.5%		
Elect. Share					37.1%

Carbon Emissions in 2015 -- Policy Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	64.8	1.9	299.4	NA	366.2
Residential	76.5	22.3	1.3	147.3	247.4
Commercial	58.3	11.3	1.9	125.0	196.6
Industrial	166.5	70.2	50.4	87.0	374.1
Transportation	16.2	585.2	0.0	6.9	608.2
Totals	382.3	690.9	353.1	0.0	1,426.2
Fossil Fuel Share	26.8%	48.4%	24.8%		
Elect. Share					25.7%

Percentage Difference in Carbon Emissions in 2015 Relative to 1990 -- Policy Case

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	57%	-93%	-27%	NA	-23%
Residential	18%	-7%	-19%	-9%	-2%
Commercial	51%	-38%	-17%	-15%	-5%
Industrial	39%	-24%	-26%	-48%	-16%
Transportation	63%	39%	NA	884%	40%
Totals	39%	18%	-27%	NA	7%

Carbon Emissions in 2020 -- Base Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	164.1	4.5	596.4	NA	765.0
Residential	90.9	22.9	1.3	271.6	386.6
Commercial	59.6	12.9	2.0	261.6	336.0
Industrial	178.3	119.4	66.5	224.0	588.2
Transportation	17.9	725.9	0.0	7.8	751.6
Totals	510.9	885.5	666.1	0.0	2,062.4
Fossil Fuel Share	24.8%	42.9%	32.3%		
Elect. Share					37.1%

Carbon Emissions in 2020 -- Policy Case (Million metric tons)

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	62.9	1.1	188.7	NA	252.6
Residential	75.8	21.2	1.3	112.9	211.2
Commercial	58.9	10.2	2.0	80.9	151.9
Industrial	180.5	62.3	48.3	51.0	342.1
Transportation	17.9	606.6	0.0	7.8	632.3
Totals	396.0	701.4	240.1	0.0	1,337.6
Fossil Fuel Share	29.6%	52.4%	18.0%		
Elect. Share					18.9%

Percentage Difference in Carbon Emissions in 2020 Relative to 1990

Sector	Gas	Oil	Coal	Indirect Electric	Totals
Electric	52.6%	-96.0%	-53.8%	NA	-47.0%
Residential	16.6%	-11.6%	-21.7%	-30.5%	-16.5%
Commercial	52.2%	-43.6%	-15.0%	-45.2%	-26.5%
Industrial	50.9%	-32.2%	-28.8%	-69.3%	-23.2%
Transportation	81.1%	43.7%	NA	1009.4%	46.1%
Totals	44.3%	20.3%	-50.0%	NA	0.0%

APPENDIX E: CARBON SAVINGS BY POLICY AND YEAR

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Policy Case Carbon Emissions (MMT)	1505.0	1533.1	1575.3	1594.6	1592.2	1588.8	1584.5	1576.6	1568.9	1560.6	1548.2	1540.1
Reduction from appliance standards	0	0	0	-1	0	4	6	10	14	17	11	23
Reduction from building codes	0	0	0	-1	0	0	2	2	3	4	7	6
Reduction from industrial voluntary program	0	0	0	9	17	25	34	40	46	52	59	67
Reduction from R&D and deployment programs	0	0	0	7	6	5	8	10	11	14	12	19
Reduction from public benefits fund	0	0	0	-6	1	4	9	18	27	34	49	46
Reduction from tax credits	0	0	0	-7	1	2	2	2	4	3	7	4
Reduction from CHP	0	0	0	13	8	14	14	18	22	25	27	29
Reduction from passenger vehicle effic. policy	0	0	0	0	-1	0	3	8	14	22	30	40
Reduction from power plant retirement policy	0	0	0	0	19	24	29	33	36	38	40	43
Total Base Case Carbon Emissions	1505	1534	1575	1610	1643	1668	1691	1716	1746	1770	1791	1817

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Policy Case Carbon Emissions (MMT)	1513.9	1492.6	1470.0	1444.1	1426.2	1405.4	1385.5	1367.3	1349.1	1337.6
Reduction from appliance standards	27	31	36	41	47	48	52	57	63	71
Reduction from building codes	8	10	12	14	17	16	20	22	26	28
Reduction from industrial voluntary program	73	80	87	93	101	106	113	118	125	132
Reduction from R&D and deployment programs	23	28	32	39	47	47	50	54	59	65
Reduction from public benefits fund	54	59	68	76	85	94	103	110	117	127
Reduction from tax credits	4	5	6	9	10	10	10	9	12	10
Reduction from CHP	36	42	46	54	61	62	62	69	74	78
Reduction from passenger vehicle effic. policy	52	66	81	98	108	116	123	129	135	142
Reduction from power plant retirement policy	48	50	54	51	43	66	78	81	78	71
Total Base Case Carbon Emissions	1839	1863	1891	1918	1946	1970	1996	2017	2039	2063

APPENDIX F: EMISSIONS OF CRITERIA AIR POLLUTANTS IN THE BASE AND POLICY CASES (MILLION TONS)

EMISSIONS (million tons) by Pollutant

	1999	2010	2020
BASE CASE			
NOx	20.51	16.48	16.88
SO2	15.75	12.79	12.68
PM-10	1.45	1.49	1.63
POLICY CASE			
NOx	20.51	14.95	13.13
SO2	15.75	11.63	6.61
PM-10	1.45	1.38	1.44
REDUCTION			
NOx	0.00	1.53	3.75
SO2	0.00	1.16	6.07
PM-10	0.00	0.11	0.20