CLEAN ENERGY:
Jobs for America's Future

A Study For:
World Wildlife Fund

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About the Tellus Institute

Founded in 1976 as a nonprofit research and policy organization, Tellus addresses a broad range of environment and resource issues. The Institute's staff of 50 scientists and policy analysts is active throughout North America and the world. Internationally, Tellus works closely with the Stockholm Environment Institute, hosting SEI's Boston Center since 1989. The transition to a sustainable world must occur at many levels. Tellus contributes to this goal through its work on global scenarios, regional and national strategies, community sustainability and industrial ecology. Projects focus on such areas as energy, water, waste, transportation, and integrated sustainability planning. This institutes diverse sponsors — foundations, governments, multilateral organizations, nongovernmental organizations and business — reflect this varied program.

EXECUTIVE SUMMARY

Over the past three decades national energy policy has been the subject of intense debate and policy innovation. Americans were buffeted by oil embargoes and price increases in the 1970s, enjoyed low energy prices in the 1980s, and today face the consequences of electricity deregulation, energy supplier market power and regional price spikes. To meet these challenges the public and policy makers have called for the expansion of policies to ensure that energy services remain readily available and affordable, while protecting public health and the environment. These policies, which helped to produce the low energy prices of the 1990s, include appliance efficiency standards, energy-saving building codes, vehicle fuel efficiency and tailpipe emissions standards, clean air legislation, and caps on pollution from power plants. Over the 30-year period during which these policies have been in effect, the U.S. has *reduced* its energy per unit Gross Domestic Product by about one-third, even though the economy *grew* by 160 percent.

In order to create a responsible, forward-looking energy policy, the United States will need to examine a number of important issues. Will the policy help meet America's energy needs? Will it enhance national security? Will it contribute to a strong economy? Will it help meet America's needs for a safe and healthy environment? In order to begin to answer these questions, World Wildlife Fund commissioned the Tellus Institute to consider the potential impacts of implementing a broad suite of clean energy policies over the next 20 years.

Our national choices regarding the production and use of energy have serious implications for our environment. At every step of the process, from extraction, to refining, to transport and combustion, fossil fuels have negative impacts on land and water-based ecosystems. In addition to these well-known effects, it is now clear that overreliance on fossil fuels is a major cause of climate change. Because we consider climate change one of the greatest global threats to biodiversity, we chose to consider a suite of policies that would address our energy needs while reducing our dependence on fossil fuels and decreasing emissions of greenhouse gases. We call this suite of policies the Climate Protection Scenario.

This study analyzes the employment, macroeconomic, energy and environmental impacts of implementing the Climate Protection Scenario. These policies were compared with a base case based on Energy Information Administration's *Annual Energy Outlook* (EIA, 2001).

Climate Protection Scenario

Buildings and Industry Sector

- Building Codes
- Appliance and Equipment Standards
- Tax Credits
- Public Benefits Fund
- Research and Development
- Voluntary Measures
- Cogeneration for Industrial and District Energy

Electric Sector

- Renewable Portfolio Standard

- NO_x/SO_2 Cap and Trade
- Carbon Cap and Trade

Transport Sector

- Automobile Efficiency Standard Improvements
- Promotion of Efficiency Improvements in Freight Trucks
- Aircraft Efficiency Improvements
- Greenhouse Gas Standards for Motor Fuels
- Travel Demand Reductions and High Speed Rail

Implementing these policies would help address many of our most pressing concerns about energy supply, the economy, employment, energy security, and the environment. We found that they would lead to net increases in employment over the next 20 years. They would reduce our dependence on oil and other fossil fuels, thereby greatly increasing our energy security. Household energy bills would decrease despite a small increase in the price of electricity. And, we could mitigate climate change and other air pollution problems. A more detailed description of the benefits can be found in the findings section below.

The benefits of implementing the Climate Protection Scenario would be spread widely across all states and all sectors of the economy — including construction, transportation, motor vehicles, manufacturing, services, retail trade and agriculture. However, some industries within the energy sector would not share in the economic benefits from this transition, as the economy's reliance on carbon-intensive fossil fuels would decline. This suggests that while there would be widespread gains to workers throughout the economy, it would be necessary to provide assistance and support in order to ensure a just transition for workers who would otherwise be displaced during the beginning of this transition.

FINDINGS

If Congress were to implement the policies outlined in WWF's Climate Protection Scenario, the United States could reap the following benefits:

- A net annual employment increase of over 700,000 jobs in 2010, rising to approximately 1.3 million by 2020;

- An 8.5 percent decline in carbon emissions between 2000 and 2010, as opposed to the approximately 20 percent increase projected in the base case, and a 28 percent decline between 2000 and 2020 rather than a 36 percent increase;

- Twenty percent of the electricity generation needed in 2020 would come from wind, solar, biomass and geothermal energy;

- Oil consumption would decline by approximately 8 percent between 2000 and 2020, rather than increase by about 31 percent, thereby saving money and reducing the vulnerability of citizens and our economy to oil price shocks;

- Overall dependence on the consumption of fossil fuels would decline more than 15 percent between 2000 and 2020, rather than increasing by 40 percent as in the base case;

- Households and businesses would accumulate savings of over $600 billion by 2020;
- GDP would be about $43.9 billion above the base case in 2020;
- Energy-related emissions of air pollution would be dramatically reduced — by 2020, emissions of sulfur dioxide would be virtually eliminated, while nitrogen oxide emissions would be almost halved, and emissions of fine particulates, carbon monoxide, volatile organic compounds and mercury would be substantially reduced;
- An additional $51.4 billion in wage and salary compensation by 2020 relative to the base case;
- Each state would experience a positive net job impact, rising to about 140,000 in California by 2020; and
- Electricity sales from central station power stations would be about half of projections for 2020, owing to the policy of promotion of more efficient equipment in homes and offices and the use of waste heat in combined heat and power plants in buildings and factories.

INTRODUCTION

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In order to create a responsible, forward-looking energy policy the U.S. will need to examine a number of important issues. Will the policy help meet America's energy needs? Will it enhance national security? Will it contribute to a strong economy? Will it help meet America's needs for a safe and healthy environment? In order to begin to answer these questions, World Wildlife Fund commissioned the Tellus Institute to consider the potential impacts of implementing a broad suite of clean energy policies over the next 20 years.

Our national choices regarding the production and use of energy have serious implications for our environment. At every step of the process, from extraction, to refining, to transport and combustion, fossil fuels have negative impacts on land and water-based ecosystems. In addition to these well-known effects, it is now clear that overreliance on fossil fuels is a major cause of climate change. Because we consider climate change one of the greatest global threats to biodiversity, we chose to consider a suite of policies that would address our energy needs while reducing our dependence on fossil fuels and decreasing emissions of greenhouse gases. We call this suite of policies the Climate Protection Scenario.

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- Travel Demand Reductions and High Speed Rail

A detailed description of the policies can be found in Annex A.

By implementing this suite of policies we can bring together the various strands connecting our energy, environment, climate, and economic policies into a coherent and harmonious strategy. The expected employment, energy and economic, and environmental impacts are discussed in separate sections below. A detailed description of the methodologies applied can be found in Annex B.

I. EMPLOYMENT AND MACROECONOMIC IMPACTS

The study finds that implementation of the Climate Protection Scenario could lead to a net annual employment increase of over 700,000 jobs by 2010, increasing to about 1.3 million by 2020, while increasing overall national GDP and incomes. These benefits are spread widely across all sectors of the economy — including construction, transportation, motor vehicles, manufacturing, services, retail trade and agriculture. The benefits derive from using our energy resources more efficiently and cost-effectively, commercializing cleaner technologies, and recycling the revenues of an electric sector carbon cap and permit trade system to households and businesses. Each state would enjoy net increases in employment; incomes and economic output as benefits are likely to be spread widely across the country.

As the economy's reliance on carbon-intensive fossil fuels declines, some industries within the energy sector would not share in the economic benefits from this transition. This suggests that while there would be widespread gains to workers throughout the economy, it would be necessary to provide assistance and support that ensured a just transition for workers who would otherwise be displaced during the beginning of this transition. One source of financial resources for this assistance could be a portion of the revenues derived from the government auction of carbon permits. At the same time, energy suppliers could offset some potential employment losses by moving aggressively into the energy efficiency and renewable energy businesses and assisting their workforces in transitioning to these new fields. For example, with electric sector restructuring, some existing utilities and suppliers could shift toward providing energy-efficiency services and alternative energy. Similarly, natural gas and oil suppliers could shift toward providing alternative fuels such as those derived from biomass, wind, and solar resources.

National Impacts

Estimation of the macroeconomic impacts of the climate protection policies was based on the incremental investments and savings required to implement the policies found in the July 2001 study. The analysis tracks expenditures on more efficient lighting, high efficiency motors, more efficient automobiles and many other energy-using technologies that reduce consumption of high carbon fuels. These expenditures create incomes and jobs for the manufacturers and workers who produce the equipment and for the industries and workers who supply and service those producers. They also reduce the energy bills of offices, firms and households who utilize the more efficient technologies. The savings on energy bills will create additional income and jobs in the industries and services in which these new savings are spent.

Figure 1a: Job Impacts

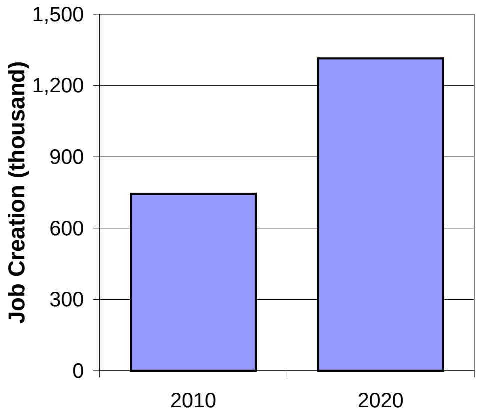


Figure 1b: Income Impacts

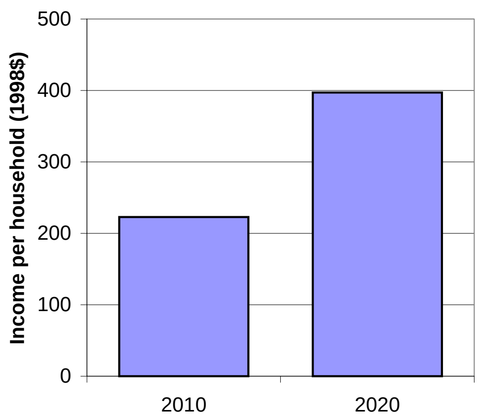
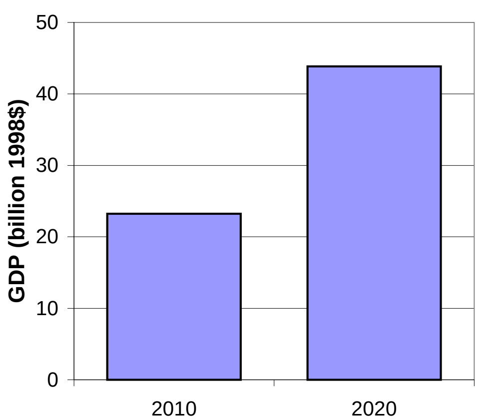


Figure 1c: GDP Impacts



The set of policies analyzed here gives rise to large energy savings, positive job impacts and new opportunities that far exceed the losses that would occur in the traditional energy supply sectors. The analyses also take account of recycling back to households and business the revenues derived from government auction of carbon permits to electricity suppliers.

Figures 1a, 1b and 1c show the positive macro-economic impacts of the Climate Protection Scenario — overall increases above base case in jobs, in incomes per household (a benefit in addition to household energy bill savings) and in GDP. By the year 2020, there would be an additional $400 per household increase in annual wage and salary earnings ($51.4 billion total), while about 1.3 million net new jobs would be created, relative to the base case. At the same time, GDP is projected to be about $43.9 billion above the base case in 2020. Major contributions to increases in annual wage and salary earnings arise from purchases of energy efficient equipment and the spending of net energy bill savings by businesses and households. While these increases are significant, the impacts are relatively small in comparison to overall economic activity. For instance, increasing the nation's GDP by $43.9 billion in 2020 represents only 0.4 percent of the $11.8 trillion (1998$) projected GDP for that year.

Table 1a shows that by 2010 there could be a net job increase of almost 750,000 jobs, with a net increase in annual wage and salary compensation of about $220 per household ($26 billion total) and a $23 billion net increase in GDP. Table 1b reveals that by 2020 these figures could grow to a net job increase of slightly more than 1.3 million jobs, a net increase in annual wage and salary compensation of about $400 per household ($51 billion total) and a net increase in GDP of $44 billion.

Table 1a: Macroeconomic Impacts of Policy Scenario by Sector, 2010

	Net Change in Jobs	Net Change in Wage and Salary Compensation (Million 1998$)	Net Change in GDP (Million 1998$)
Agriculture	18,600	$160	$530
Other Mining	6,900	$420	$880
Coal Mining	(10,100)	($990)	($2,090)
Oil/Gas Mining	(26,900)	($2,280)	($9,040)
Construction	353,200	$10,440	$14,990
Food Processing	2,700	$110	$210
Other Manufacturing	52,500	$3,980	$6,020
Pulp and Paper Mills	2,800	$240	$390
Oil Refining	(2,600)	($260)	($780)
Stone, Glass, and Clay	14,100	$750	$1,260
Primary Metals	11,800	$940	$1,360
Metal Durables	30,400	$2,140	$3,520
Motor Vehicles	36,500	$2,810	$4,610
Transportation, Communication, and Utilities	21,500	$1,100	$2,240
Electric Utilities	(18,400)	($1,900)	($10,070)
Natural Gas Utilities	(16,700)	($1,520)	($5,510)
Wholesale Trade	5,600	$350	$640
Retail Trade	14,400	$290	$510
Finance	31,600	$2,380	$4,890
Insurance/Real Estate	(5,900)	($160)	($1,110)
Services	191,900	$5,730	$8,080
Education	3,800	$140	$140
Government	27,200	$1,180	$1,550
Total	**744,900**	**$26,050**	**$23,220**

Table 1b: Macroeconomic Impacts of Policy Scenario by Sector, 2020

	Net Change in Jobs	Net Change in Wage and Salary Compensation (Million1998$)	Net Change in GDP (Million1998$)
Agriculture	63,100	$620	$2,120
Other Mining	11,200	$870	$1,830
Coal Mining	(23,900)	($2,340)	($4,940)
Oil/Gas Mining	(61,400)	($5,210)	($20,600)
Construction	340,300	$10,460	$15,030
Food Processing	16,100	$750	$1,380
Other Manufacturing	77,900	$9,360	$14,160
Pulp and Paper Mills	5,000	$570	$950
Oil Refining	(6,300)	($650)	($1,910)
Stone, Glass, and Clay	24,800	$1,630	$2,750
Primary Metals	18,600	$2,190	$3,180
Metal Durables	42,000	$4,670	$7,670
Motor Vehicles	54,300	$5,090	$8,350
Transportation, Communication, and Utilities	50,500	$3,320	$6,750
Electric Utilities	(35,100)	($5,180)	($27,540)
Natural Gas Utilities	(26,200)	($3,080)	($11,180)
Wholesale Trade	12,400	$1,030	$1,890
Retail Trade	190,300	$4,410	$7,680
Finance	42,100	$4,570	$9,410
Insurance/Real Estate	11,900	$350	$2,420
Services	394,600	$13,080	$18,460
Education	33,200	$1,330	$1,340
Government	78,900	$3,550	$4,660
Total	**1,314,300**	**$51,390**	**$43,860**

State-By-State Employment Impacts

The preceding analysis suggests that implementing the Climate Protection Scenario policies would result in substantial net employment gains at the national level. Yet, estimates of state-level impacts provide important additional insight into the benefits of such a policy initiative.

The detailed distribution of the national employment impacts across the states is difficult to predict. However, it is likely that the large net benefits found in tables 1a and 1b will be rather widely and evenly distributed across the states, largely owing to the widespread effects of re-spending the energy savings. The results of our indicative analysis of the state-level employment are given in table 2.

Table 2: Job Impacts by State

State	Net Job Gain 2010	Net Job Gain 2020
01 Alabama	13,100	22,600
02 Alaska	2,800	5,000
04 Arizona	11,200	19,900
05 Arkansas	7,500	13,200
06 California	77,400	141,400
08 Colorado	10,000	17,700
09 Connecticut	7,800	14,100
10 Delaware	2,200	3,800
11 District of Columbia	1,600	3,500
12 Florida	37,000	66,800
13 Georgia	21,300	38,300
15 Hawaii	2,700	5,000
16 Idaho	3,500	6,200
17 Illinois	31,900	56,400
18 Indiana	20,900	36,000
19 Iowa	8,300	14,700
20 Kansas	7,100	12,500
21 Kentucky	11,500	19,300
22 Louisiana	19,200	32,900
23 Maine	3,700	6,600
24 Maryland	12,500	22,000
25 Massachusetts	14,500	26,700
26 Michigan	29,800	51,000
27 Minnesota	13,400	24,000
28 Mississippi	7,200	12,600
29 Missouri	15,100	26,600
30 Montana	2,300	4,000
31 Nebraska	4,700	8,500
32 Nevada	5,300	9,100
33 New Hampshire	2,800	5,000
34 New Jersey	20,200	36,200
35 New Mexico	4,200	7,100
36 New York	38,000	68,200
37 North Carolina	22,400	38,900
38 North Dakota	1,900	3,300
39 Ohio	34,600	59,900
40 Oklahoma	8,200	13,700
41 Oregon	8,600	15,600
42 Pennsylvania	31,600	55,500
44 Rhode Island	2,100	3,900
45 South Carolina	11,500	20,000
46 South Dakota	2,000	3,500
47 Tennessee	17,100	29,800
48 Texas	71,500	123,400
49 Utah	5,700	10,300
50 Vermont	1,600	2,800
51 Virginia	18,500	32,100
53 Washington	16,600	29,700
54 West Virginia	3,800	6,000
55 Wisconsin	14,900	26,300
56 Wyoming	1,700	2,600
Total	**744,900**	**1,314,300**

Some of these state-level employment impacts are associated with the direct expenditures made for more efficient equipment and renewable technologies and fuels. Although manufacturers and venders of relevant products and services may not be uniformly spread across the states, they are rather widely dispersed. For example, manufacturers of advanced power plants, including gas turbines, natural gas combined cycle systems, combined heat and power units and fuel cells are located in many regions of the country. Manufacture of more efficient and alternative-fuel automobiles is likely to continue to be located largely with current manufacturers. Petroleum companies with experience in industrial chemistry can play a role in providing cellulosic ethanol or other synthetic fuels. Biomass fuels for transport and power generation will come from states that could provide biomass feedstock. In some states, farms could become sites for wind electric generators and derive income from these facilities.

While these energy-related purchases can stimulate local economic activity and jobs, the major drivers of the overall national employment increases are the net energy-bill savings to households and businesses, which tend to be spent on myriad other purchases across the economy. This spending occurs broadly across all sectors, with much of it local. In those states that supply fossil fuels, losses to these industries and related businesses would be more than offset by gains in other sectors of those state's economies, owing to the expenditures on more efficient equipment and cleaner energy resources and re-spending of energy bill savings. Thus, the national job increases — in construction, services, education, finance, government, miscellaneous manufacturing, agriculture and other sectors — would likely be widespread throughout the country.

While this analysis indicates that there would be overall employment benefits at the state as well as the national level, some industries could face near-term losses before they could adapt to new energy markets or before the benefits of the energy efficiency measures were fully realized. Some of the savings realized from implementing the policies could be used for assistance in a just transition for affected workers and communities.

States such as Texas, which are large energy producers and have relatively low energy prices compared with the national average, still enjoy large benefits. As table 2 indicates, the state of Texas, which currently leads the nation in total energy consumed and is second only to California in total energy expenditures, could expect to have a net gain of about 120,000 jobs in 2020 if these national energy policies were adopted.

II. ENERGY IMPACTS

In this section we analyze expected impacts of the Climate Protection Scenario policy package on energy consumption, energy prices, and household and business energy budgets.

Figure 2a shows how the Climate Protection Scenario policies affect our dependence on the consumption of fossil fuels, which declines by more than 15 percent between 2000 and 2020, rather than increasing by 40 percent as in the base case. Oil consumption itself declines by about 8 percent between 2000 and 2020 instead of increasing by 32 percent, largely from improved efficiency in vehicles and other transportation modes, thereby saving money and reducing vulnerability of citizens and our economy to oil price shocks. While most of this reduced fossil fuel dependence results from policies that induce energy efficiency, figure 2a also shows that the

Figure 2a: Fossil and Renewable Energy Use: Base & Policy Cases

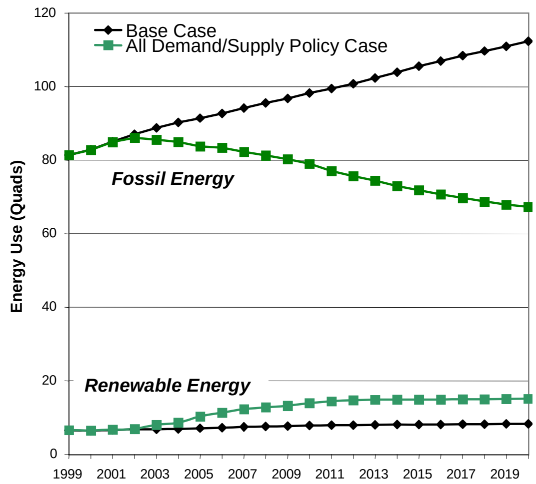
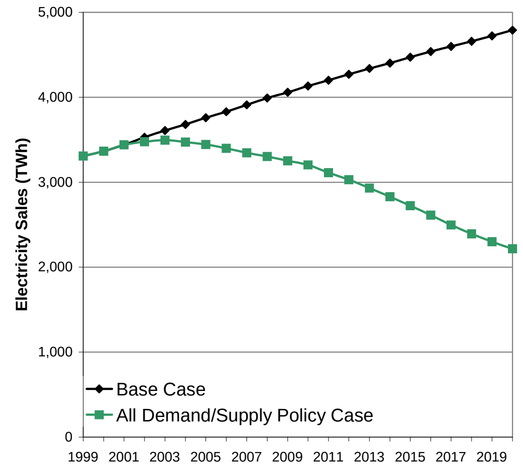


Figure 2b: Electricity Sales: Base & Policy Cases



policy case increases the use of renewable energy, which roughly doubles from current levels instead of remaining essentially constant.

Figure 2b shows how electricity sales from central station power stations would be less than half of projections for 2020, owing to the policy of promoting more efficient equipment in homes and offices and using waste heat in combined heat and power plants in buildings and factories. Electricity sales would decline by 33 percent from 2000 to 2020 rather than increase by 45 percent. By 2020, electricity purchases by residential, commercial and industrial consumers would be 55 percent below business as usual and 20 percent of the remaining generation would come from wind, solar, biomass and geothermal energy.

Figures 3a and 3b show how the policies affect natural gas prices and the costs to households for electricity. Natural gas prices would decline to about 25 percent lower than the base case by 2020. All sectors would enjoy declines in their electricity bills, owing to greater efficiency, even

Figure 3a: Natural Gas Prices, Base and Policy Cases

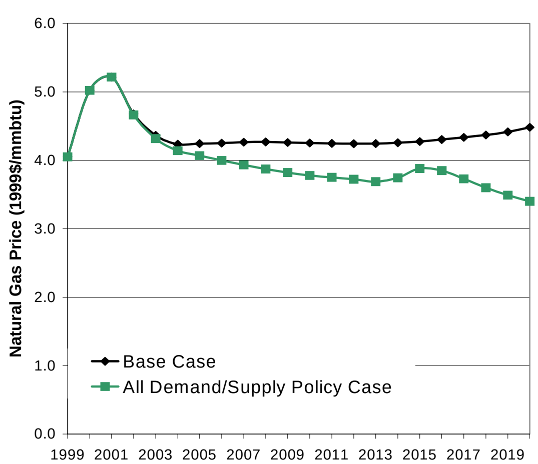
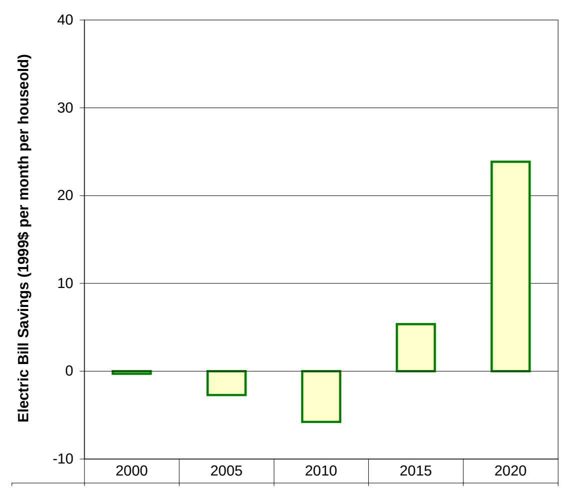


Figure 3b: Monthly Electric Bill Savings to Households



though prices per unit of power would increase in moving to cleaner generation. By 2020 residential consumers would pay about $24 less per month.

Figures 4a and 4b show that net savings to households and business would be substantial, reaching more than $600 billion combined by 2020.

Figure 4a: Cumulative Costs and Benefits – Households (billion $)

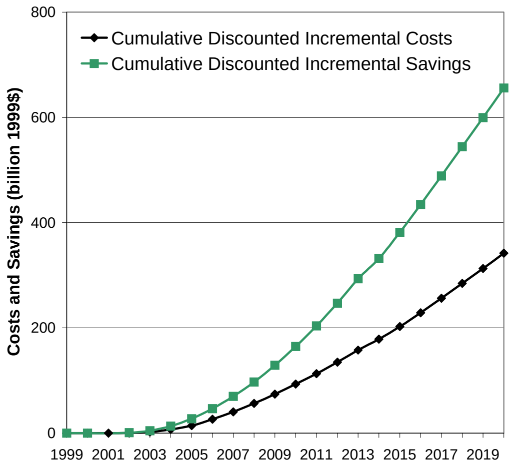
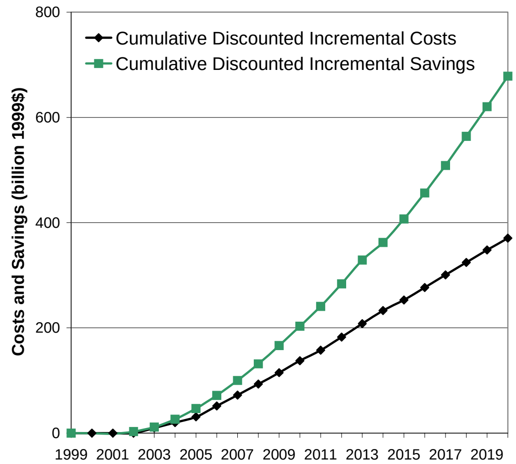


Figure 4b: Cumulative Costs and Benefits–Business, Industry (billion $)



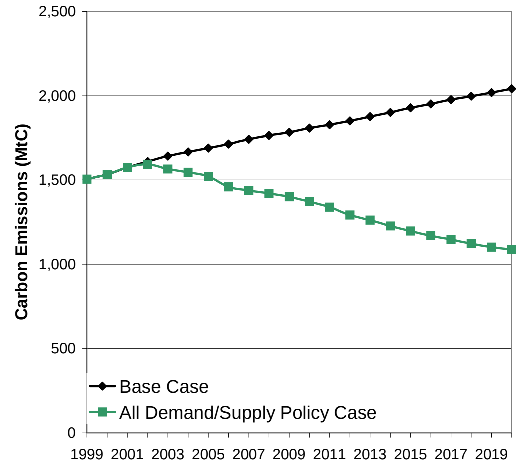
III. ENVIRONMENTAL IMPACTS

Virtually every step in the process of supplying energy from fossil fuels damages the environment. Drilling, mining and pipeline installation can disrupt whole ecosystems. Transportation of fossil fuels results in spills, threatening wildlife and human communities that depend on the natural environment. Fossil fuel combustion emits pollutants that cause global warming, acid rain and smog. Smog and other air pollutants can exacerbate lung disease and cause crop, forest and property damage. Acid rain acidifies the soil and water, killing plants, fish and animals that depend on them. The impacts of global warming pose the greatest global threat to biodiversity.

These environmental threats could be mitigated by a proactive effort to direct our energy supply system away from its current dependence on fossil fuels and toward increased energy efficiency and renewable energy technologies. However, current U.S. policies point in the opposite direction. The fossil fuel and nuclear industries continue to benefit from both direct and indirect subsidies from taxpayers, citizens and the environment, while cleaner energy resources and more efficient technologies are required to prove themselves in a not truly competitive marketplace. Despite the proven economic and environmental track record of energy efficiency, renewables, and pollution limitations, the administration's energy plan and the House of Representative's energy legislation continue to promote fossil fuels at the expense of the environment and the economy.

The policies in the Climate Protection Scenario begin to reduce our dependence on fossil fuels and would thereby dramatically change the trajectory of U.S. carbon emissions from their current rapidly rising path to a downward trajectory needed for long-term climate stabilization. Figure 5 shows that between 2000 and 2010, carbon emissions would decline by 8.5 percent rather than increase by the 20 percent projected in the base case. The July 2001 study shows that the Kyoto Protocol target could be met by implementing these cost-effective policies, reducing non-energy related greenhouse gases and utilizing international trading mechanisms. Under the Climate Protection Scenario, by 2020 carbon emissions would be 47 percent below business as usual and 19 percent below 1990 levels.

Figure 5: Carbon Emissions: Base & Policy Cases



At the same time, the proposed policies would virtually eliminate emissions of SO_2 and reduce NO_x emissions by almost 30 percent, as shown in figures 6a and 6b below. In addition, the proposed policies would substantially reduce emissions of fine particulates, carbon monoxide, volatile organic compounds and mercury.

Figure 6a: SO_2 emissions: Base & Policy Cases

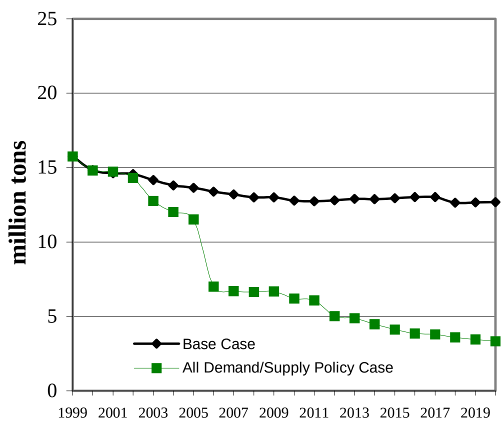
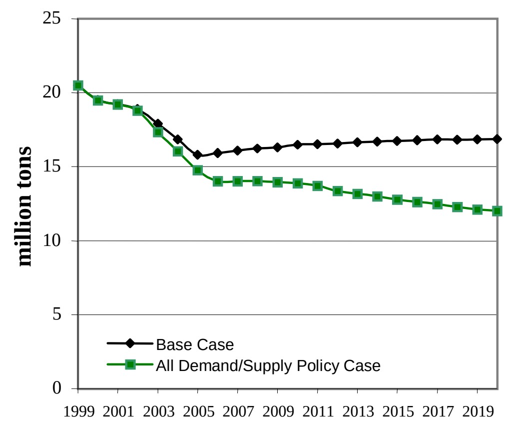


Figure 6b: NO_x Emissions: Base & Policy Cases



ANNEX A

POLICIES

This study examines a broad set of national policies that would increase energy efficiency, accelerate the adoption of renewable energy technologies, and shift to less use of carbon-intensive fossil fuels. The policies address major areas of energy use in the buildings, industrial, transport, and electrical sectors. Analyses of the investment costs and energy savings of policies to promote energy efficiency and cogeneration in the residential, commercial, and industrial sectors were taken primarily from the American Council for an Energy Efficient Economy (1999; 2001).

Below we group these policies into the particular sector where they take effect, and describe the key assumptions made concerning the technological impacts of the individual policies. Unless otherwise indicated, each of the policies is assumed to start in 2003.

As explained further in the methodology discussion in the next section, we adapted the Energy Information Administration's 2001 Reference Case Forecast (EIA 2001) to create a slightly revised "base case." Our policies and assumptions build on those included in this base case forecast (i.e., we avoid taking credit for emissions reductions, costs, or savings already included in the EIA 2001 Reference Case). When taken together, the policies described in this section represent a Climate Protection Scenario that the United States could pursue to achieve significant carbon reductions.

Policies in the Buildings and Industrial Sectors

Carbon emissions from fuel combustion in the buildings (including both residential and commercial) sector account for about 10 percent of U.S. greenhouse gas emissions, while emissions from the industrial sector account for another 20 percent. When emissions associated with the electricity consumed are counted, these levels reach over 35 percent for buildings and 30 percent for industry. We analyzed a set of policies that include new building codes, new appliance standards, tax incentives for the purchase of high efficiency products, a national public benefits fund, expanded research and development, voluntary agreements, and support for combined heat and power.

Building Codes

For this policy, we assume that DOE enforces the commercial building code requirement in the Energy Policy Act of 1992 (EPAct) and that states comply. We also assume that relevant states upgrade their residential energy code to either the 1995 or 1998 Model Energy Code, voluntarily or following adoption of a new federal requirement. Furthermore, we assume that the model energy codes are significantly improved during the next decade, and that all states adopt mandatory codes that go beyond current "good practice" by 2010. To quantify the impact of these changes, we assume a 20 percent energy savings in heating and cooling in buildings in half of new homes and commercial buildings.

New Appliance and Equipment Efficiency Standards

For this policy, we assume that the government upgrades existing standards or introduces new standards for key appliances and equipment types: distribution transformers, commercial air conditioning systems, residential heating systems, commercial refrigerators, exit signs, traffic lights, *torchiere* lighting fixtures, ice makers, and standby power consumption for consumer electronics. We also assume higher energy efficiency standards for residential central air conditioning and heat pumps than was recently allowed by the Bush administration. These are measures that can be taken in the near term, based on cost-effective available technologies.

Tax Incentives

This policy provides initial tax incentives for a number of products. For consumer appliances, we assumed a tax incentive of $50 to $100 per unit. For new homes that are at least 30 percent more efficient than the Model Energy Code, we assumed an incentive of up to $2,000 per home; for commercial buildings with at least 50 percent reduction in heating and cooling costs relative to applicable building codes, we applied an incentive of $2.25 per square foot. For building equipment such as efficient furnaces, fuel cell power systems, gas-fired heat pumps, and electric heat pump water heaters, we assumed a 20 percent investment tax credit. Each of these incentives would be introduced with a sunset clause, terminating them or phasing them out in approximately five years, to avoid their becoming permanent subsidies.

National Public Benefits Fund

Electric utilities have historically funded programs to encourage more efficient energy-using equipment, assist low-income families with home weatherization, commercialize renewables, and undertake research and development (R&D). Such programs have typically achieved electricity bill savings for households and businesses that are roughly twice the program costs (Nadel and Kushler, 2000). Despite these successes, electric industry restructuring, deregulation, and increasing price competition have caused utilities to reduce these "public benefit" expenditures over the past several years. In order to preserve such programs, 15 states have instituted public benefits funds that are financed by a small surcharge on all power delivered to consumers.

This study's policy package includes a national-level public benefits fund (PBF) fashioned after the proposal introduced by Sen. Jeffords (S. 1333). The PBF would levy a surcharge of 0.2 cents per kilowatt-hour on all electricity sold, costing the typical residential consumer about $1 per month. This federal fund would provide matching funds for states for approved public benefits expenditures. In this study, the PBF is allocated to several different programs directed at improvements in lighting, air conditioning, motors, and other cost-effective energy efficiency improvements in electricity-using equipment.

Expand Federal Funding for Research and Development in Energy Efficient Technologies

Federal R&D funding for energy efficiency has been a spectacularly cost-effective investment. The DOE has estimated that the energy savings from 20 of its energy efficiency R&D programs has been roughly $30 billion so far — more than three times the federal appropriation for the entire energy efficiency and renewables R&D budget throughout the 1990s (EERE, 2000).

Tremendous opportunities exist for further progress in material-processing technologies, manufacturing processing, electric motors, windows, building shells, lighting, heating/cooling systems, and super-insulation, for example. EPA's *Energy Star* programs have complemented and amplified the impact of federal R&D, by labeling and certifying to increase consumer awareness of energy efficiency opportunities. R&D efforts should be increased and EPA should be allocated the funds to broaden the scope of its *Energy Star* program, expanding to other products (refrigerators, motors) and building sectors (hotels, retailers), and the vast market of existing buildings that could be retrofitted. In this study, we assume that increased funding to expand research and development efforts in industry (e.g., motors), buildings (e.g., advanced heating/cooling), and transport (e.g., more fuel-efficient cars and trucks) will lead to more energy-savings products becoming commercially available.

Industrial Energy Efficiency through Intensity Targets

There is great potential for cost-effective efficiency improvements in both energy-intensive and non-energy intensive industries (Elliott 1994). For example, an in-depth analysis of 49 specific energy-efficient technologies for the iron and steel industry found a total cost-effective energy savings potential of 18 percent (Worrell, Martin, and Price 1999). In this study, we assume federal initiatives to motivate and assist industry to identify and exploit energy efficiency opportunities. Government agencies would provide technical and financial assistance, and expand R&D and demonstration programs. In addition to these carrots, government may need to brandish a stick in order to induce a large fraction of industries to make serious energy efficiency commitments. If industry does not respond to the federal initiatives at a level sufficient to meet progressive energy efficiency targets, a mandatory, binding energy intensity standard should be triggered to ensure the targets are attained.

Support for Co-generation

Cogeneration (or, combined heat and power – CHP) is a super-efficient means of coproducing two energy-intensive products that are usually produced separately — heat and electricity. The thermal energy produced in cogeneration also can be used for (building and process) cooling or to provide mechanical power. While CHP already provides about 9 percent of all electricity in the United States, there are considerable barriers to its wider cost-effective implementation (Elliott and Spurr, 1999). In this study, we assume the adoption of policies to establish a standard permitting process, uniform tax treatment, accurate environmental standards, and fair access to the grid to sell or purchase electricity. Such measures would help to unleash a significant portion of the enormous potential for CHP. In this study, we assumed 50 GW of new CHP capacity by 2010, and an additional 95 GW between 2011 and 2020. With electricity demand reduced by the various energy efficiency policies adopted in this study, cogenerated electricity reaches 8 percent of total remaining electricity requirements in 2010 and 36 percent in 2020.

Policies in the Electric Sector

A major goal of U.S. energy and climate policy will be to dramatically reduce carbon and other pollutant emissions from the electric sector, which is responsible for more than one-third of all U.S. greenhouse gas emissions. We analyzed a set of policies in the electric sector that include standards and mechanisms to help overcome existing market barriers to investments in technologies that can reduce emissions. Three major policies — a renewable portfolio standard, a cap on pollutant emissions, and a carbon cap and trade system — were analyzed as described below.

Renewable Portfolio Standard

A Renewable Portfolio Standard (RPS) is a flexible, market-oriented policy for progressively increasing the use of renewable energy resources and technologies for electricity production. An RPS sets a minimum requirement for the fraction of total electricity generation to be met by renewable electricity in each year, and requires each supplier of electricity to meet the minimum either by producing that fraction in its mix or by acquiring credits from suppliers that exceed the minimum. The market determines the portfolio of technologies and geographic distribution of facilities that meet the national target at least cost. This is achieved by a trading system that awards credits to generators for producing renewable electricity and allows them to sell or purchase these credits. Thirteen states — Arizona, Connecticut, Hawaii, Iowa, Maine, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, Pennsylvania, Texas, and Wisconsin — already have Renewable Portfolio Standards. Senator Jeffords has introduced a bill (S. 1333) that would establish a national RPS.

The RPS provides strong incentives for suppliers to design and site the lowest cost, highest value and most reliable renewable electricity projects. It also provides assurance and stability to renewable technology vendors, by guaranteeing markets for renewable power and allowing them to capture the financial and administrative advantages that come with planning in a more stable market environment. Yet it still maintains a competitive environment that encourages developers to innovate. Finally, by accelerating the deployment of renewable technologies and resources, the RPS also accelerates the learning and economies of scale that will allow renewable resources and technologies to become increasingly competitive with conventional technologies. This is particularly important, as the demands of climate stabilization in coming decades will require more renewable energy than we can deploy in the next two decades.

In this study, we have applied an RPS that starts at a 2 percent requirement in 2002, grows to 10 percent in 2010, and to 20 percent in 2020, after all efficiency policies are included. Wind, solar, geothermal, biomass, and landfill gas are eligible renewable sources of electricity, but environmental concerns exclude municipal solid waste (owing to concerns about toxic emissions from waste-burning plants) and large-scale hydro (which raises environmental concerns and need not be treated as an emerging renewable resource as it already supplies nearly 10 percent of the nation's electricity supply). We also assume a subsidy to grid-connected solar photovoltaic electricity generation, in order to introduce a small amount of this technology into the generation mix. The purpose of this is to induce technology learning, performance improvement and scale economies to help achieve increased technology diversity and another zero emissions option for the longer term. The level is kept small so that cost and price impacts are minimal.

Tightening of SO_2 and NO_x Emission Regulations

The Clean Air Act Amendments currently require minimal to modest emissions reductions through 2010 and no reductions after that. Yet, despite the improvements brought about by the Clean Air Act and its amendments, recent studies have confirmed that SO_2 and NO_x continue to damage lake and forest ecosystems, decrease agricultural productivity and harm public health through its impact on urban air quality (Clean Air Task Force, 2000.)

In this study, we assume a tightened SO_2 cap-and-trade system that reduces sulfur dioxide emissions to roughly 40 percent of current levels by 2010 and to one-third of current levels by 2020. We also impose a cap-and-trade system on NO_x emissions in the summertime, when NO_x contributes more severely to photochemical smog. This system expands the current cap-and-trade program, which calls on 19 states to meet a target in 2003 that then remains constant and includes all states with a cap that is set first in 2003 but decreases in 2010, relative to 1999 levels. The cap results in a 45 percent reduction from current annual electric sector NOx emissions by 2010 and 83 percent by 2020.

Carbon Cap-And-Trade Permit System

This study assumes that a cap-and-trade system for carbon dioxide emissions is introduced in the electric sector. The cap is set to achieve progressively more stringent targets over time, starting in 2003 at 2 percent below current levels, increasing to 12 percent below current levels by 2010 and 30 percent below by 2020. A progressively more stringent target reduces demand for coal, and hence both combustion-related air pollution and mining-related pollution of streams and degradation of landscapes and terrestrial habitats.

In the SO_2, NO_x, and CO_2 trading systems, permits are distributed through an open auction, and the resulting revenues can be returned to households (e.g., through a tax reduction or as a rebate back to households). Recent analyses suggest that an auction is the most economically efficient way to distribute permits, as it would meet emissions caps at lower cost than allocations based on issuing grandfathered allowances or equal per kWh allowances (Burtraw, *et al.* 2001). Implementing such auctions for the electric sector also could set the stage for an economy-wide approach to carbon reduction in future years based on auctioning. In this study, the price of auctioned carbon permits reaches $100 per metric ton carbon.

With a cap-and-trade system in place for CO_2, SO_x and NO_x, this scenario reduces multiple emissions from power plants in a manner similar to proposals currently under consideration in Congress. The reductions in these three pollutants are as deep as those imposed in four pollutant bills, and are achieved within a comparable time frame. (The Department of Energy's NEMS model unfortunately does not explicitly track mercury, making it impossible to compare the results of this study to the mercury requirement in S. 556 and H.R. 1256.)

Policies in the Transport Sector

Another goal of US energy and climate policy will be to reduce oil use, carbon emissions and pollution from the transport sector, which is responsible for about one-third of all U.S. greenhouse gas emissions. We analyzed a set of policies in the transportation sector that include improved efficiency (light duty vehicles, heavy duty trucks and aircraft), a full fuel-cycle GHG standard for motor fuels, measures to reduce road travel, and high speed rail.

Strengthened Fuel Economy Standards

Today's cars are governed by fuel economy standards that were set in the mid-1970s. The efficiency gains made in meeting those standards have been entirely overwhelmed by increases in population and driving, as well as the trend toward gas-guzzling SUVs. When the fuel economy standards were implemented, light trucks only accounted for about 20 percent of personal vehicle sales. Light trucks now account for nearly 50 percent of new vehicle sales; this has brought down the overall fuel economy of the light duty vehicle fleet, which now stands at its lowest average fuel economy since 1981. If the fuel economy of new vehicles had held at the levels for vehicles sold in 1981, rather than tipping downward, American vehicle owners would be importing half a million fewer barrels of oil each day.

In this study, we introduce a strengthened Corporate Average Fuel Economy (CAFE) standard for cars and light trucks, along with complementary market incentive programs. Specifically, fuel economy standards for new cars and light trucks rise from EIA's projected 25.2 mpg for 2001 to 36.5 mpg in 2010, continuing to 50.5 mpg by 2020. This increase in vehicle fuel economy would save by 2020 approximately twice as much oil as could be pumped from an Arctic National Wildlife Refuge oil field over its entire 50-year lifespan (USGS, 2001). Based on assessments of near-term technologies for conventional vehicles, and advanced vehicle technologies for the longer-term, we estimate that the 2010 CAFE target can be met with an incremental cost of approximately $855 per vehicle, and the 2020 CAFE target with an incremental cost of $1,900. [1] To put these costs in perspective, the fuel savings at the gasoline pump for these more efficient vehicles would be two to three times these incremental costs over the vehicle's lifetime.[2]

Improving Efficiency of Freight Transport

We also assume policies to improve fuel economy for heavy-duty freight trucks, which account for approximately 16 percent of all transport energy consumption. Improvements such as advanced diesel engines, drag reduction, rolling resistance, load reduction strategies, and low friction drivetrains would increase the fuel economy, and thus decrease the oil requirements, of freight trucks. Many of these technologies are available today while others, such as advanced diesel and turbine engines, have been demonstrated technically but are not yet commercially available.

To accelerate the improvement in heavy duty truck efficiency, we have assumed expanded R&D for heavy duty diesel technology, vehicle labeling and promotion, financial incentives to stimulate the introduction of new technologies, efficiency standards for medium- and heavy-duty trucks, and fuel taxes and user-fees calibrated to eliminate the existing subsidies for freight trucking. Together, it is estimated that these policies could bring about a fuel economy improvement of 6 percent by 2010, and 23 percent by 2020, relative to today's trucks.

Improving Efficiency of Air Travel

Air travel is the fastest growing mode of travel, and far more energy intensive than vehicle travel. One passenger mile of air travel today requires about 1.7 times as much fuel as vehicle travel.[3] We assume policies to improve the efficiency of air travel, including R&D for efficient

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[1] Assuming a mean value at a market price of oil of $20/barrel.

[2] Assuming a retail price of gasoline of $1.50/gallon, a 10-year life of the vehicle, and 12,000 miles per year.

[3] Assuming typical vehicle load factors of 0.33 for autos and 0.6 for aircraft.

aircraft technologies, fuel consumption standards, and a revamping of policies that subsidize air travel through public investments.

We assume that air travel efficiency improves by 23 percent by 2010, and 53 percent by 2020, owing to a combination of aircraft efficiency improvements (advanced engine types, lightweight composite materials, and advanced aerodynamics), increased load factor, and acceleration of air traffic management improvements (Lee et al., 2001; OTA, 1994; Interlaboratory Working Group, 2000). This is in contrast to the base case in which efficiency increases by 9 percent by 2010 and 15 percent by 2020. While we assume that air travel can reach 82 seat-miles per gallon by 2020 from its current 51, it is technologically possible that far greater efficiencies approaching 150 seat-miles per gallon could be achieved, if not in that time period then over the longer term (Alliance to Save Energy et al., 1991).

Greenhouse Gas Standards for Motor Fuels

Transportation in the US relies overwhelmingly on petroleum-based fuels, making it a major source of greenhouse gas (GHG) emissions. We introduce here a full fuel-cycle GHG standard for motor fuels, similar in concept to the Renewable Portfolio Standard for the electric sector.

The policy assumed in this study requires a 3 percent reduction in the average national GHG emission factor of fuels used in light duty vehicles in 2010, increasing to a 7 percent reduction by 2020. Expanded R&D, market creation programs, and financial incentives would complement this policy. Such a program would stimulate the production of low-GHG fuels such as cellulosic ethanol and biomass- or solar-based hydrogen.

For this study, we assume that most of the low-GHG fuel is provided as cellulosic ethanol, which can be produced from woody matter from agricultural residues, forest and mill wastes, urban wood wastes, and short rotation woody crops (Walsh et al., 1997; Walsh et al., 1999). As cellulosic ethanol can be coproduced along with electricity, we assume that electricity output reaches 10 percent of ethanol output by 2010 and 40 percent by 2020 (Lynd, 1997). We assume that the price of cellulosic ethanol falls to $1.40 per gallon of gasoline equivalent by 2010 owing to the accelerated development of the production technology, and remains at that price thereafter (Interlaboratory Working Group, 2000).

Improving Alternative Modes to Reduce Vehicle Miles Traveled

The amount of travel in cars and light duty trucks continues to grow due to increasing population and low vehicle occupancy. Between 1999 and 2020, the rate of growth in vehicle miles traveled is projected to increase in the base case by about 2 percent per year. The overall efficiency of the passenger transportation system can be significantly improved through measures that contain the growth in vehicle miles traveled through land-use and infrastructure investments and pricing reforms to remove implicit subsidies for cars, which are very energy intensive. We assume that these measures will primarily affect urban passenger transportation and result in a shift to higher occupancy vehicles, including carpooling, vanpooling, public transportation, and telecommuting. We consider that the level of reductions of vehicle miles traveled that can be achieved by these measures relative to the base case are 8 percent by 2010 and 11 percent by 2020.

High Speed Rail

High speed rail offers an attractive alternative to intercity vehicle travel and short distance air travel. In both energy cost and travel time, high-speed rail could compete with air travel for trips of roughly 600 miles or less, which account for about one-third of domestic air passenger miles traveled. Investments in rail facilities for key intercity routes (such as the Northeast corridor between Washington and Boston, the east coast of Florida between Miami and Tampa, and the route linking Los Angeles and San Francisco) could provide an attractive alternative and reduce air travel in some of the busiest flight corridors (USDOT, 1997). High-speed rail can achieve practical operating speeds of up to 200 mph. Prominent examples include the French *TGV*, the Japanese *Shinkansen* and the German *Intercity Express*. An emerging advanced transport technology is the MAGLEV system in which magnetic forces lift and guide a vehicle over a specially designed guideway. Both Germany and Japan are active developers of this technology.

In this analysis we have taken the USDOT's recent estimates of the potential high speed rail ridership which, based on projected mode shifts from air and automobile travel in several major corridors of the United States, reaches about 2 billion passenger miles by 2020 (USDOT, 1997). While this level of high speed rail ridership provides relatively small energy and carbon benefits by 2020, it can be viewed as the first phase of a longer-term transition to far greater ridership and more advanced, faster and efficient electric and MAGLEV systems in the ensuing decades.

ANNEX B

METHODOLOGY: ECONOMIC IMPACTS ANALYSIS

The overall energy and economic analysis starts with a business-as-usual energy-economic forecast based on the U.S. Department of Energy, Energy Information Administration's Annual Energy Outlook for 2001. This base case reflects a continuation of existing energy consumption and technology trends and policies, and presumes no efforts are taken to reduce greenhouse gas emissions.

Employment impacts from the policy scenarios were computed as net incremental impacts in specified future years. They are derived from the changes in expenditures on energy — operating costs and fuel costs — brought about by investments in energy efficiency and renewable technologies in each sector. The net impacts of these changes on the nation's economy were computed from the following: 1) the net changes in employment; 2) the net changes in wage and salary compensation, measured in millions of 1998 dollars; and 3) the net changes in Gross Domestic Product (GDP), also measured in millions of 1998 dollars.

The analysis used data derived from IMPLAN (IMpact Analysis for PLANning), a widely used input-output (I-O) model that analyzes interactions between different sectors of the economy. IMPLAN was used to track the changes in each sector's demand and spending patterns, as caused by shifts in fuel consumption and energy technology investments owing to the policies, and the shifts induced in other sectors' levels of output (and the inputs required).

The results of these interactions are captured through appropriate sectoral multipliers (jobs, income, and GDP per dollar of output). For each benchmark year (2010 and 2020), each change in a sector's spending pattern is matched to an appropriate sectoral multiplier. The analytical approach used here is similar to that in Geller, DeCicco and Laitner (1992); Laitner, Bernow and DeCicco (1998); Goldberg et al. (1998); and Bernow et al. (1999). These reports offer a more in-depth discussion of methodological issues.

Input-output models were initially developed to trace supply linkages in the economy. Thus, the impacts generated from the policy scenario depend on the structure of the economy. For example, I-O models can show how increasing purchases of more efficient lighting equipment, more efficient cars, high efficiency motors, modular combined heat and power plants, or biomass energy not only directly benefit their respective producers, but also benefit those industries that provide inputs to the manufacturers. I-O models also can be used to show the benefits from indirect economic activity that occur as a result of these transactions (e.g., banking and accounting services) and the re-spending of energy bill savings throughout the economy. Therefore, spending patterns for energy have an effect on total employment, income (i.e., wage and salary compensation), and GDP.

For each sector of the economy, multipliers were used to compute the impacts of the incremental expenditures. These multipliers identified the employment or economic activity generated from a given level of spending in each sector. Changes in expenditures were matched with appropriate multipliers. For instance, employment multipliers show the number of jobs that are directly and indirectly supported for each one million dollars of expenditure in a specific sector.

For this analysis, a job is defined as sufficient wages to employ one person full-time for one year. The employment multipliers for key sectors of the economy are listed in table A.1, below.

The analysis in this study includes several modifications made to the methodology of merely matching expenditures and multipliers. First, an assumption was made that 85 percent of the efficiency investments would be spent within the United States. While local contractors and dealers traditionally carry out upgrades of energy efficiency, this analysis recognizes that foreign suppliers and contractors may also be involved.

Second, we made an adjustment in the employment impacts to account for future changes in labor productivity in specific sectors. Utilizing data from the Bureau of Labor Statistics Economic and Employment Projections 1988, 1998, and 2008, we developed productivity trends for our analysis. These trends suggest that productivity rates are expected to vary widely among sectors. Annual productivity gains are forecast to range from 0.4 percent annually in the construction sector (which will experience a large influx of employment as those sectors become more important to the economy) to 7.4 percent annual productivity gain in oil and gas mining. These factors are given in table A.2, below.

Third, we assumed that 80 percent of the investment upgrades would be financed by bank loans carrying an average 10 percent real interest rate over a five-year period. No parameters were established to account for changes labor participation rates or for changes in interest rates as less capital-intensive technologies (i.e., efficiency investments) are substituted for conventional supply strategies. Although the higher cost premiums associated with the efficiency investments might be expected to increase the level of borrowing in the short term, and therefore, interest rates, this could be offset somewhat by avoided investments in new power plant capacity, exploratory well drilling, and new pipelines. Similarly, while a demand for labor may tend to increase the overall level of wages (and potentially lessen economic activity), the employment benefits from the scenario are relatively small compared with the national level of unemployment.

Fourth, for the residential and commercial sectors, it was assumed that program and marketing expenditures would be required to help promote market penetration of efficiency improvements due to the dispersed nature of the decision makers and the need for greater efforts towards market transformation. This was set at 15 percent of the efficiency investments for those sectors. No program or marketing expense was included for the industrial sector or transportation sector. We assume market penetration is naturally occurring in the industrial sector as decision makers adopt cost-effective and more efficient processes and older, less efficient equipment is replaced with newer, higher efficiency models. In the transportation sector efficiency improvements are assumed to be a part of all new vehicle purchases.

Finally, the analysis took account of the fact that the electric sector carbon cap-and-trade system would involve government auctioning of carbon allowances to electricity suppliers. This was modeled by (1) assuming purchases of the requisite allowances by utilities from the government; (2) payments for the corresponding higher costs of electricity by households and businesses; and (3) a return of the revenues collected by the government to households and businesses.

These results should be taken as indicative, as there are always limits to such a modeling exercise. The analyses do not account for feedback through final demand reductions, input substitution owing to price changes, feedback from inflation, and the constraints on labor and money supplies. They also assume that available labor, plant and materials are not fully utilized. Thus, for example, they assume that there is unemployment in those existing or potential skill areas, for which demand could be induced by policies that shift expenditures to nonenergy commodities. This is contrary to many other economic models, which in effect assume that there is full employment, and that the shift in expenditures from energy to other commodities would not create new jobs. Their view would be that the shift in expenditures would provide largely counter-recessionary jobs, but not many sustained job increases. Yet, it is well known that there is structural as well as business-cycle unemployment. Moreover, economic activity in some sectors such as construction (which enjoys the largest amount of induced jobs in our analysis) where job entry is impeded by cyclical and unstable demand and expectations, could experience sustained increases if a sustained path of increased final demands were established as they are in our policy scenarios.

In addition, while the models used for the energy analyses capture some policy-induced technology innovation, this is limited primarily to the electric sector. The I-O analysis also does not include the potential productivity benefits that could stem from the investments in new and more efficient equipment, and associated changes in organization, know-how and inter-industry interactions. Industrial investments that improve energy efficiency could be accompanied by improved product quality, lower capital and operating costs, increased employee productivity, easier and less costly environmental compliance, and entry into niche markets (see, e. g., Elliott et al. 1997; Laitner 1995; OTA 1994; Porter and Van Linde 1995). Even under full employment, energy policies that improve the efficiency of the economy could increase incomes per worker. Finally, such job-inducing policies could help counteract recessionary business cycles. It would be valuable to develop tools and refine the analyses to account for some of these factors and obtain a more detailed characterization of the results.

For the state-by-state employment impacts, we developed indicative estimates of the distribution of the approximately 1.3 million net national jobs gained by 2020 across the 50 states and the District of Columbia. Absent a more detailed analysis of each individual state or region, we allocated the national job impacts by weighting the key variables to create an overall state-by-state assessment. This estimate reflects the significant energy and economic differences across the states. The key variables used in this assessment were differences in energy prices; the level of energy consumed for each dollar of economic activity in the state; the number of energy-related jobs as a percent of total state employment; and the number of state jobs as a percent of national employment. The results are presented in table 2, which shows a positive net job impact in each state, ranging up to a high of about 140,000 in California by 2020.

Table A.1

Employment Multipliers for Select Economic Sectors

Sector	Multiplier
Agriculture	27.3
Coal Mining	9.9
Oil/Gas Mining	8.2
Other Mining	10.4
Construction	18.1
Food Processing	16.9
Pulp and Paper Mills	11.6
Oil Refining	6.9
Stone, Glass, and Clay	13.2
Primary Metals	12.8
Metal Durables	13.1
Motor Vehicles	10.6
Other Manufacturing	13.3
Transportation, Communication, and Utilities	13.9
Electric Utilities	5.2
Natural Gas Utilities	6.6
Wholesale Trade	13.4
Retail Trade	29.2
Finance	10.7
Insurance/Real Estate	8.1
Services	22.9
Education	28.9
Government	18.0

Table A.2

Labor Productivity Rates for Select Economic Sectors

Sector	Rate
Agriculture	1.6%
Coal Mining	5.2%
Oil/Gas Mining	7.4%
Other Mining	2.4%
Construction	0.4%
Food Processing	1.0%
Pulp and Paper Mills	3.0%
Oil Refining	3.3%
Stone, Glass, and Clay	2.2%
Primary Metals	4.0%
Metal Durables	4.7%
Motor Vehicles	2.0%
Other Manufacturing	4.7%
Transportation, Communication, and Other Utilities	2.5%
Electric Utilities	2.5%
Natural Gas Utilities	1.5%
Wholesale Trade	3.0%
Retail Trade	1.4%
Finance	3.7%
Insurance/Real Estate	0.8%
Services	1.1%
Education	1.0%
Government	0.4%

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