ESTIMATING THE JOBS IMPACTS OF *TACKLING CLIMATE CHANGE*

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EXECUTIVE SUMMARY

Tackling Climate Change

In January 2007, ASES published the report *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions From Energy Efficiency and Renewable Energy by 2030* (TCC) which illustrated how energy efficiency (EE) and renewable energy technologies (RE) can provide the emissions reductions required to address global warming. It analyzed energy efficiency in buildings, transportation, and industry, and assessed six RE technologies: Concentrating solar power, photovoltaics, wind power, biomass, biofuels, and geothermal power. The findings indicated that these technologies could displace approximately 1.2 billion tons of carbon emissions annually by 2030 -- the magnitude of reduction that scientists believe is necessary to prevent the most dangerous consequences of climate change.

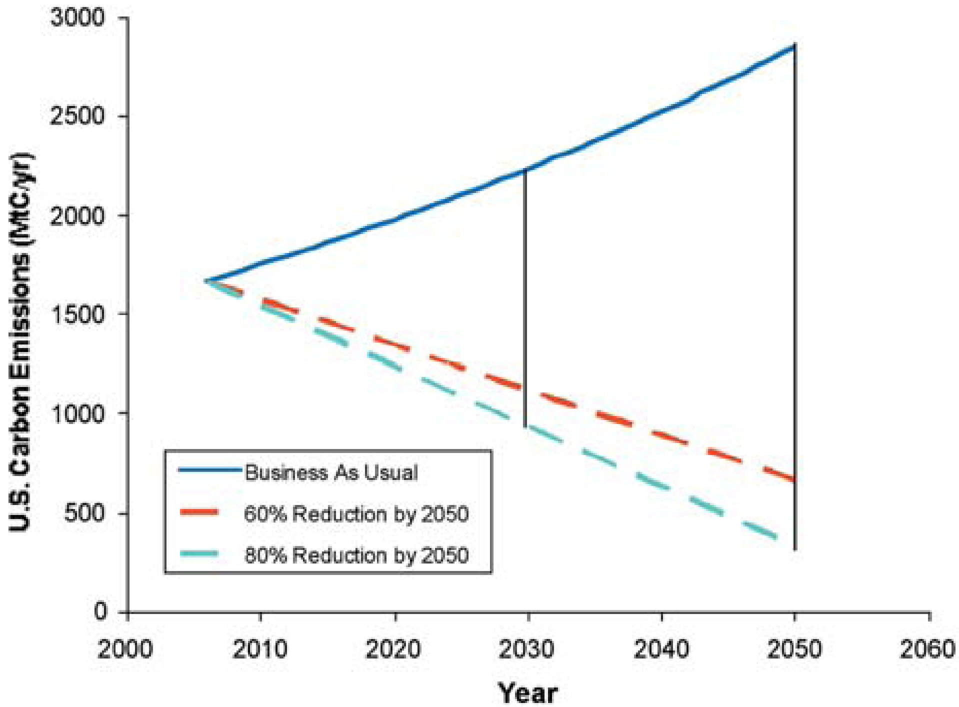
However, the report did not estimate the jobs impacts of the TCC initiatives, and the jobs issue has become increasingly important and contentious as climate change legislation is being considered in the U.S. Congress. Here we estimate the jobs impacts through 2030 of the initiatives detailed in TCC.

Achieving Climate Change Mitigation Goals

Addressing global warming and limiting temperature increases implies limiting carbon dioxide (CO_2) levels in the atmosphere to 450 to 500 parts per million, and estimates are that industrialized nations must reduce CO_2 emissions about 60 percent to 80 percent below current levels by mid-century. Figure EX-1 shows the U.S. emissions reductions that would be required by 2030 to achieve this goal. Accounting for expected population and economic growth and associated increases in carbon emissions in a business-as-usual case indicates that in 2030 the U.S. needs to displace between 1,100 and 1,300 million metric tons of carbon per year.

TCC assessed EE&RE technologies to determine the potential carbon reduction for each, described the resource, discussed current and expected future costs, and developed supply and carbon-reduction curves for 2015 and 2030. Table EX-1 summarizes the potential carbon reduction contributions from the various areas, and Figure EX-2 shows the contributions through 2030. Approximately 57 percent of the total carbon reduction contribution is from EE and about 43 percent is from RE. Energy efficiency measures can allow U.S. carbon emissions to remain about level through 2030, whereas the renewable technologies can provide large reductions in carbon emissions below current levels.

Figure EX-1
U.S. Fossil Fuel Carbon Reductions Required by 2030



Source: American Solar Energy Society, 2007.

Table EX-1
Potential Carbon Reductions

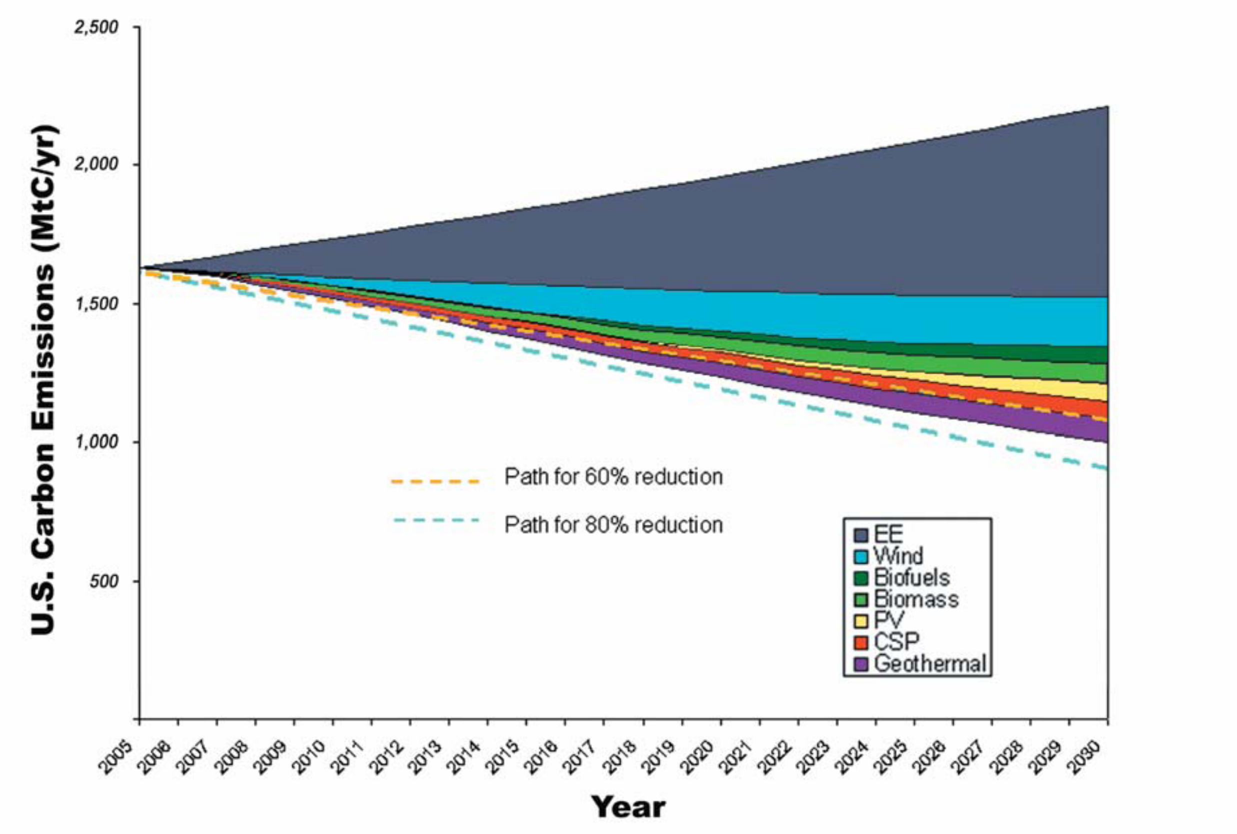
Application	Potential Carbon Reductions (MtC/yr.)
Energy Efficiency	688
Concentrating Solar Power	63
Photovoltaics	63
Wind	181
Biofuels	58
Biomass	75
Geothermal	83

Source: American Solar Energy Society, 2007.

Economic and Job Impacts

To address the potential costs of the TCC initiative, analysts examined the various technology costs in the TCC report. To estimate the equivalent annual cost of deploying each technology, they considered the deployment curve for each -- how many gigawatt-hours of electricity or gallons of cellulosic ethanol or energy saved through efficiency would occur each year between 2005 (the base year of the study) and 2030. They then estimated how much each amount of deployment would cost in the year deployed.

Figure EX-2
Potential Carbon Reductions Required in 2030



Source: American Solar Energy Society, 2007.

For each technology, they took into account supply curves and R&D and learning curves. RE plants and EE deployed in any year will contribute energy for 25 years or more into the future, and standard life-cycle cost-analysis techniques were used to get an equivalent annual cost in 2005 dollars of all that energy per year for each technology. Finally, current and projected costs of the conventional energy displaced were subtracted to derive the net cost. Table EX-2 and Figures EX-3 and EX-4 summarize the net costs and jobs impact of the TCC initiative in 2020 and 2030.

Table EX-2 shows that the net costs of the EE and RE components of the TCC initiative differ dramatically among technologies and over time. For example:

- In 2020, the net costs are -$67 billion
- In 2030, the net costs are +$4 billion
- In 2020, EE has net savings of $85 billion, while all of the RE technologies except biofuels have net costs
- In 2030, EE has net savings of $17 billion, while all of the RE technologies except wind and biofuels have net costs
- The net savings from EE decline significantly over the forecast period, from $85 billion in 2020 to $17 billion in 2030

- Biofuels net savings increase from -1 billion in 2020 to -$8 billion in 2030
- Biomass costs increase from $3 billion in 2020 to $4 billion in 2030
- PV costs increase nearly three-fold, from $5 billion in 2020 to $16 billion in 2030
- Concentrating solar costs decrease 60 percent, from $5 billion in 2020 to $2 billion in 2030
- Geothermal costs increase by over one-half, from $4. billion in 2020 to almost $7 billion in 2030
- Annualized costs over the entire period also differ dramatically, from a -$108 billion for EE to more than $9 billion for biofuels and nearly $7 billion for concentrating solar

Table EX-2
Net Costs and Jobs Resulting From the TCC Initiative

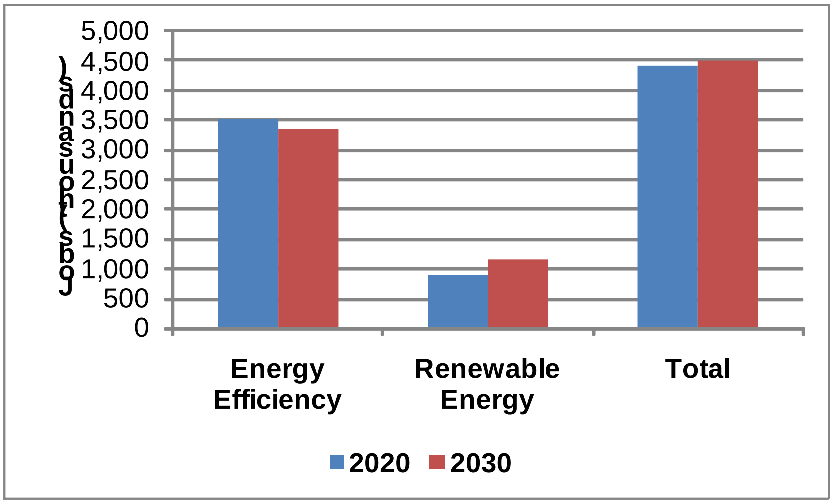
	Net Costs			Net Jobs	
	Annualized	2020	2030	2020	2030
	billion 2005 dollars			thousand FTE	
Energy Efficiency	-$107.9	-$84.8	-$17.4	3,533	3,360
Wind	$0.0	$0.3	-$0.4	149	93
Biofuels	$9.2	-$0.5	-$7.6	261	257
Biomass	$2.6	$3.3	$4.5	122	172
Photovoltaics	$4.7	$5.3	$16.0	105	340
Concentrating Solar	$6.6	$5.2	$2.2	156	147
Geothermal	$2.5	$4.0	$6.7	93	144
Total	-$82.3	-$67.2	$4.0	4,419	4,513

Source: ASES and Management Information Services, Inc., 2009.

Table EX-2 and Figures EX-3 and EX-4 show that the EE component of the TCC initiative generates many more net jobs than does the RE component:

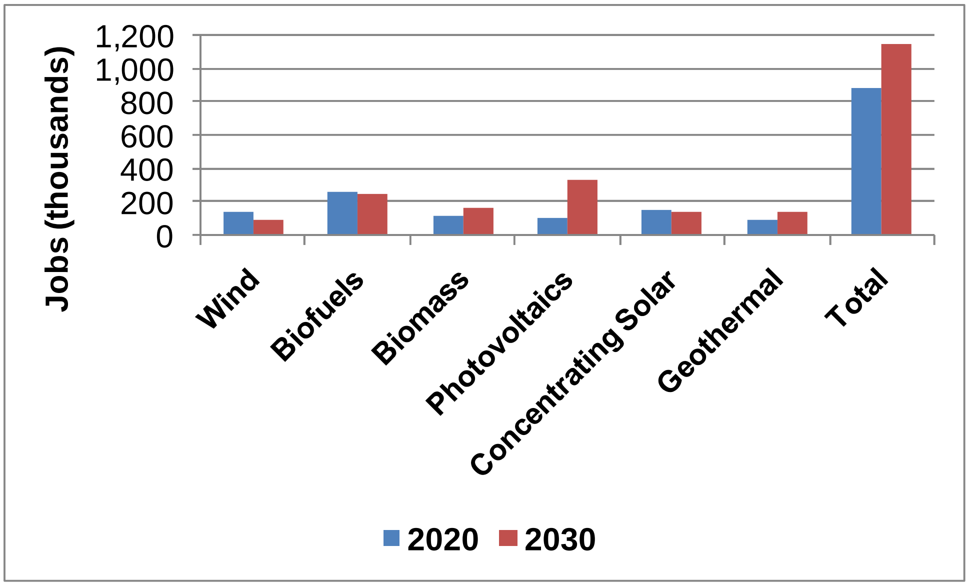
- In 2020, EE generates more than 3.5 million net jobs, compared to less than 900,000 generated by RE
- In 2030, EE generates more than 3.3 million net jobs, compared to 1.15 million generated by RE
- In 2020, 80 percent of the total net jobs created by the TTC initiative are generated by the EE component
- In 2020, 74 percent of the total net jobs created by the TTC initiative are generated by the EE component

Figure EX-3
Energy Efficiency and Renewable Energy Jobs Created by the TCC Initiative



Source: Management Information Services, Inc., 2009.

Figure EX-4
Renewable Energy Jobs Created by the TCC Initiative



Source: Management Information Services, Inc., 2009.

Net job generation differs significantly among the RE components – by technology and time period:

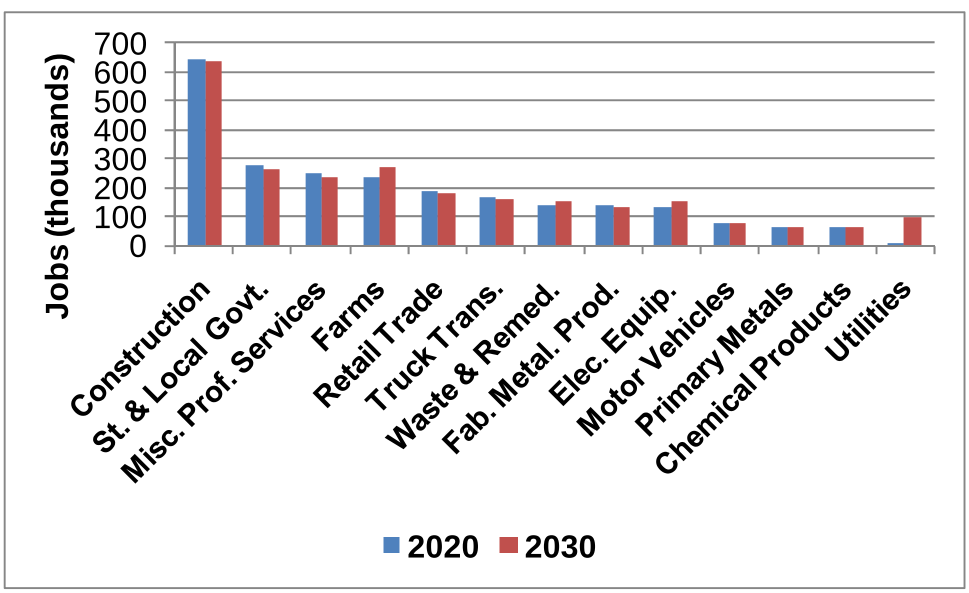
- In 2020, the most jobs are generated by biofuels (261,000), followed by concentrating solar (156,000), wind (149,000), biomass (122,000), PV (105,000), and geothermal (93,000)
- In 2030, the most jobs are generated by PV (105,000), followed by biofuels (257,000), biomass (172,000), concentrating solar (147,000), geothermal (144,000), and wind (93,000)
- In 2030, more jobs are generated than in 2020 for biomass, PV, and geothermal
- In 2020, more jobs are generated than in 2030 for wind, biofuels, and concentrating solar

We thus estimate that the TCC Initiative, while requiring deployment costs in most years for most alternate energy technologies, would have an overwhelmingly positive impact on the U.S. economy.

Employment by Industry

The jobs impacts by industry of the TCC initiative are summarized in Figure EX-5. Examining the net jobs generated by industry from TCC initiative indicates that the impacts are well distributed throughout the U.S. economy. The industries involved are not surprising, and it is easy to understand the parts they will play in the evolving transformation to a new energy consumption structure and the subsequent economic growth. The top industries showing the largest jobs impacts in 2030 include:

Figure EX-5
Net Jobs by Industry Generated by the TCC Initiative in 2020 and 2030
(Selected Industries)



Source: Management Information Services, Inc., 2009.

- Construction -- the industry received an overwhelming direct stimulus from almost all the growing EE and RE sector technologies, in addition to a positive indirect impact from the improvement in overall economic growth due to energy savings
- Farms – the industry was primarily affected by the stimulus of the biomass and biofuels technologies, which require increasing levels of agricultural plant products
- State and local general government – this sector is the county's largest commercial consumer of petroleum and coal products: Vehicle efficiency and the use of cheaper biofuels drastically reduce expenditures and leads to potential expansion of other services and employment
- Miscellaneous professional, scientific, and technical services – the industry and its employees play a large part in driving the new energy and energy efficiency technologies
- Truck transportation – the industry in directly impacted by the increase in the biomass and biofuels technology transportation requirements and energy transportation efficiency improvements
- Waste management and remediation services – the industry will play a large part in energy efficiency and in supplying biogas
- Electrical equipment, appliances, and components – the industry will be relied upon to supply not only new electrical components and testing equipment to all the alternative electric energy technologies, but will also contribute to efficiencies in the smart grid from generation to final consumer use
- Fabricated metal products – the industry will be the primary supplier of parts, products, and systems for the photovoltaic, wind, and concentrating solar technologies
- Forestry, fishing, and related activities – the forestry industry and the agricultural services component of the industry will be playing a major role in supplying the biomass and biofuel feedstocks and will also be conducting agriculture research and development
- Nonmetallic mineral products – the industry supplies at least two major products that will be in high demand in both the solar-related and energy efficiency technologies: Glass and fiberglass
- Utilities – the industry is the center of attention as electric and gas energy supply technologies change, and the industry will also be stimulated by various customer energy efficiency initiatives
- Motor vehicles, bodies and trailers, and parts – the industry will be positively affected by transportation energy improvements that will stimulate research and development and vehicle sales as the country's rolling stock turns over
- Computer systems design and related services – the industry will be stimulated by the smart grid and other energy efficiency applications

- Primary metals – a direct supplier of metal for finished products, this industry will be indirectly impacted by increased demand from other manufacturing industries
- Chemical products – the industry will be stimulated in particular by the increase in the growth of biofuels and biomass

While about 100,000 more net jobs are created in 2030 than in 2020, this varies among industries:

- In some industries, more net jobs are created in 2030 than in 2020 – these include Farms, Waste Management and Remediation Services, Electrical Equipment and Components, and Utilities
- In some industries, more net jobs are created in 2020 than in 2030 – these include Construction, State and Local Government, Miscellaneous Professional, Scientific, and Technical Services, Retail Trade, and Truck Transportation
- In some industries, about the same number of net jobs is created in 2030 as in 2020 – these include Motor Vehicles and Parts, Primary Metals, and Chemical Products

Jobs by Occupation and Skill

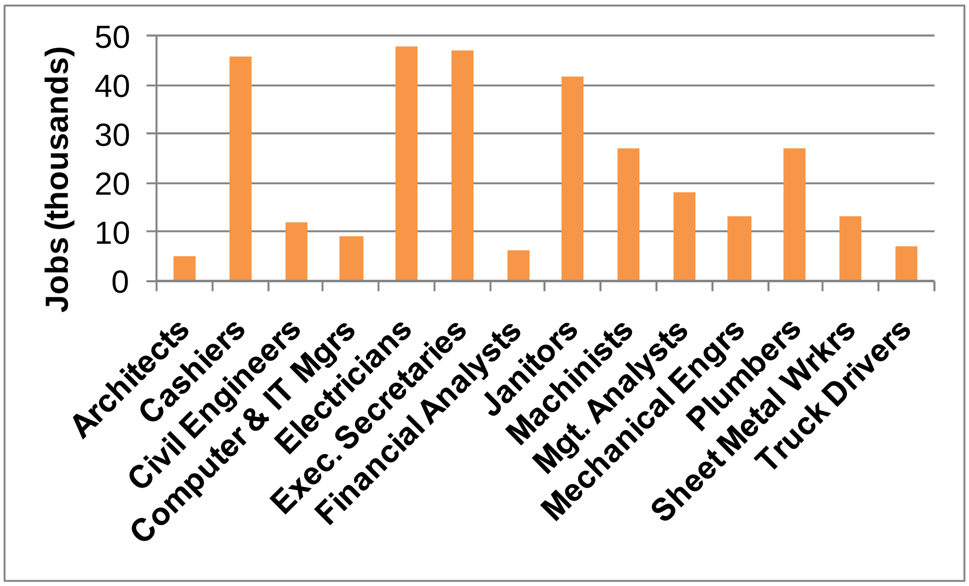
The vast majority of the jobs created by the TCC initiative are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. and most of the persons employed in these jobs may not even realize that they owe their livelihood to climate change mitigation. This is illustrated in Figures EX-6 and EX-7, which show the jobs created by the TCC initiative in 2020 and 2030 within selected occupations. These demonstrate that the TCC initiative will generate:

- More jobs for cashiers than for recyclable materials collectors
- More jobs for order clerks than for architects
- More jobs for executive secretaries than for waste treatment plant operators
- More jobs for janitors than for civil engineers
- More jobs for customer service representatives than HVAC mechanics and installers
- More jobs for accountants and auditors than for roofers
- More jobs for truck drivers than for plumbers
- More jobs for stock clerks than for electrical and electronics engineers
- More jobs for customer service representatives than for welders
- More jobs for inspectors and testers than for sheet metal workers
- More jobs for bookkeeping and accounting clerks than for mechanical engineers

- More jobs for business operations specialists than for electric power line workers

Thus, occupational data demonstrate that the TCC initiative will create a variety of high-paying jobs, many of which take advantage of manufacturing skills currently going unused as manufacturing continues to undergo restructuring in the U.S. Many workers will be dependent on the TCC initiative for their jobs, although they often would have no way of recognizing the connection unless it is brought to their attention.

Figure EX-6
Net Jobs by Occupation Generated by the TCC Initiative in 2020
(Selected Occupations)

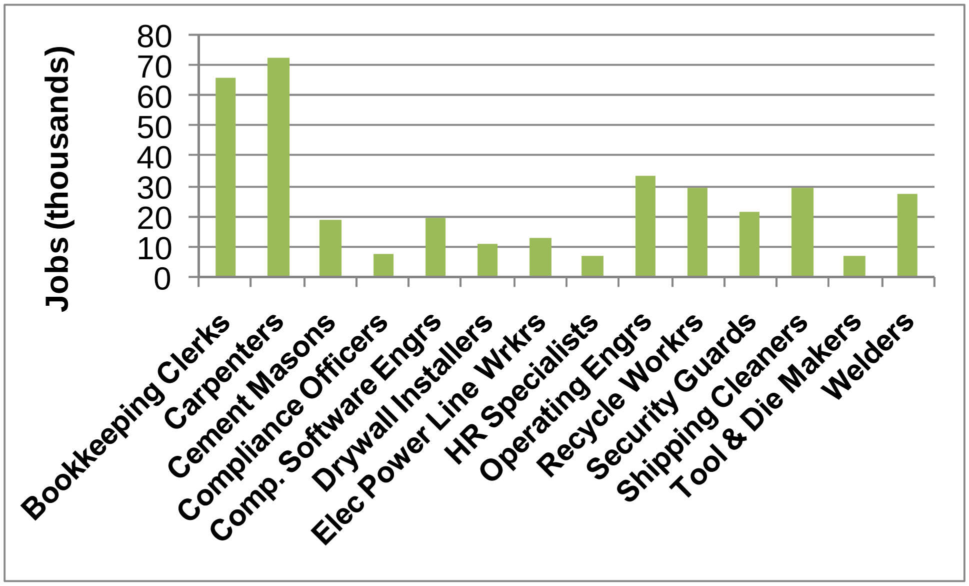


Source: Management Information Services, Inc., 2009.

Implications

The issue of the potential costs and jobs impacts of climate change mitigation policies is current and highly contentious. Numerous studies have been published contending that such policies could cost the U.S. trillions of dollars and many millions of jobs over the next several decades, and many analysts are skeptical of the impacts of these policies. Further, the U.S. is currently experiencing the worst economic and financial recession in seven decades and, as of September 2009 has lost nearly seven million jobs since the beginning of the recession. Thus, the economic and jobs impact of climate change mitigation policies is a legitimate issue.

Figure EX-7
Net Jobs by Occupation Generated by the TCC Initiative in 2030
(Selected Occupations)



Source: Management Information Services, Inc., 2009.

The TCC report described how EE&RE technologies, in an aggressive but achievable scenario, can provide the U.S. carbon reductions needed to mitigate global warming by 2030. The research reported here indicates that effective and economically beneficial climate change mitigation policies can be developed. The TCC initiative involves ambitious, aggressive programs in the areas of EE&RE that can, by 2030:

- Effectively reduce U.S. carbon emissions
- Have total, cumulative net costs of near zero
- Generate more than 4.5 million net jobs.

It is important to note that the jobs estimate here is *net* jobs. Any ambitious climate change mitigation program will both create jobs and will cause job losses in different sectors, industries, and occupations. However, we estimate that, in total, more than 4.5 million more jobs will be created by the TCC initiative than will be lost. These jobs will be widely dispersed throughout the U.S. in virtually all industries and occupations.

Thus, the major conclusion of this study is that the TCC initiative will be a major net job creator for the U.S. economy.

I. INTRODUCTION

In January 2007, ASES published the report *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions From Energy Efficiency and Renewable Energy by 2030* (TCC).[1] The report illustrated how energy efficiency and renewable energy technologies can provide the emissions reductions required to address global warming.

It analyzed energy efficiency in buildings, transportation, and industry, and assessed six renewable energy technologies: Concentrating solar power, photovoltaics, wind power, biomass, biofuels, and geothermal power. The findings indicated that these technologies could displace approximately 1.2 billion tons of carbon emissions annually by 2030 -- the magnitude of reduction that scientists believe is necessary to prevent the most dangerous consequences of climate change.

TCC illustrated how energy efficiency measures could keep U.S. carbon emissions roughly constant through 2030 as the economy grows, and how renewable energy technologies could make deep cuts below current emissions. Wind energy provides about 35 percent of the renewable energy contribution, while the rest is divided about evenly among the other technologies.

However, the report did not estimate the jobs impacts of the initiatives designed to address climate change, and the jobs issue has become increasingly important and contentious as climate change legislation is being considered in the U.S. Congress. The current study estimates the jobs impacts through 2030 of the initiatives detailed in TCC.

The report is organized as follows:

- Chapter II summarizes the *Tackling Climate Change* report and details the energy efficiency and renewable energy options considered.
- Chapter III reviews previous studies of the issue.
- Chapter IV discusses the analysis framework and methodology used here.
- Chapter V derives cost, employment, and jobs estimates for the TCC options for 2020 and 2030.
- Chapter VI discusses the findings and policy implications.

[1] *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions From Energy Efficiency and Renewable Energy by 2030,* Charles F. Kutscher, editor, American Solar Energy Society, January 2007.

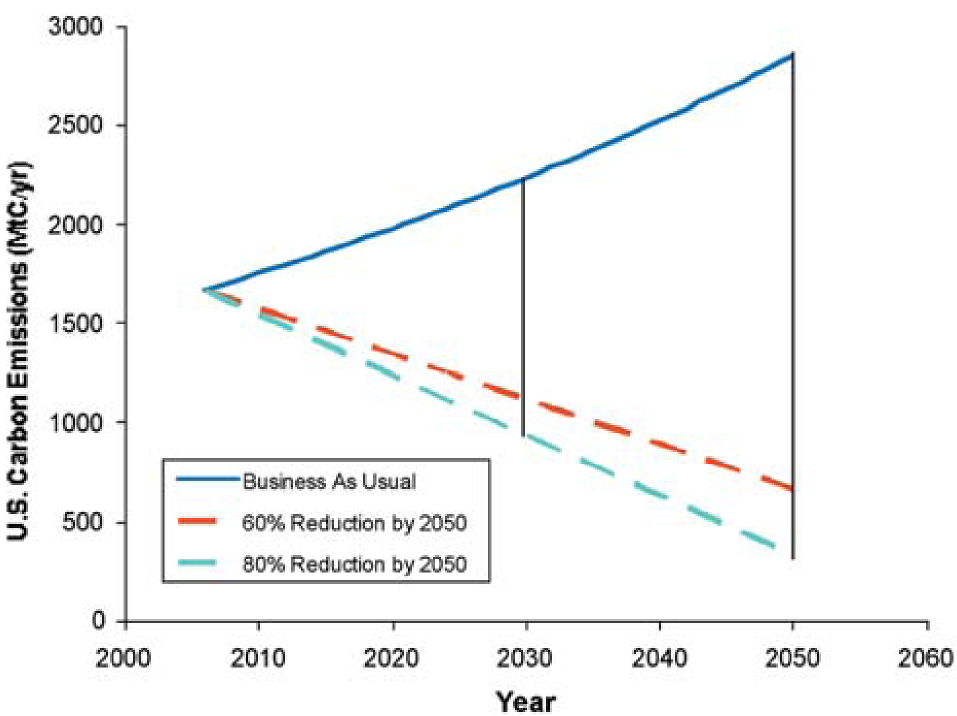
II. SUMMARY OF THE *TACKLING CLIMATE CHANGE* REPORT

II.A. Overview

For SOLAR 2006, its 35th Annual National Solar Energy Conference in July 2006, ASES focused on the global warming issue. A key feature of the conference was a special track of nine invited presentations by experts in energy efficiency and renewable energy (EE&RE) that detailed the potential for these technologies -- in an aggressive but achievable climate-driven scenario -- to address the needed U.S. carbon emissions reductions by 2015 and 2030. These presentations covered energy efficiency in buildings, industry, and transportation, as well as the following RE technologies: Concentrating solar power, photovoltaics, wind, biomass, biofuels, and geothermal. Subsequent to the conference, these studies were subjected to additional review and were revised for publication in TCC.

Addressing global warming and limiting temperature increases implies limiting carbon dioxide (CO_2) levels in the atmosphere to 450 to 500 parts per million (ppm), and estimates are that industrialized nations must reduce CO_2 emissions about 60 percent to 80 percent below current levels by mid-century. Figure II-1 shows the U.S. emissions reductions that would be required by 2030 to achieve this goal. Accounting for expected population and economic growth and associated increases in carbon emissions in a business-as-usual case indicates that in 2030 the U.S. needs to displace between 1,100 and 1,300 million metric tons of carbon per year (MtC/yr).

Figure II-1
U.S. Fossil Fuel Carbon Reductions Required by 2030



Source: American Solar Energy Society, 2007.

The SOLAR 2006 exercise assessed EE&RE technologies to determine the potential carbon reduction for each, and the authors of the renewable technology papers described the resource, discussed current and expected future costs, and developed supply and carbon-reduction curves for 2015 and 2030. Table II-1 summarizes the potential carbon reduction contributions from the various areas,[2] based on the middle range of the carbon conversions, and Figure II-2 shows the contributions through 2030. Approximately 57 percent of the total carbon reduction contribution is from EE and about 43 percent is from RE. Energy efficiency measures can allow U.S. carbon emissions to remain about level through 2030, whereas the renewable technologies can provide large reductions in carbon emissions below current levels.

Table II-1
Potential Carbon Reductions

Application	Potential Carbon Reductions (MtC/yr.)
Energy Efficiency	688
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Biofuels	58
Biomass	75
Geothermal	83

Source: American Solar Energy Society, 2007.

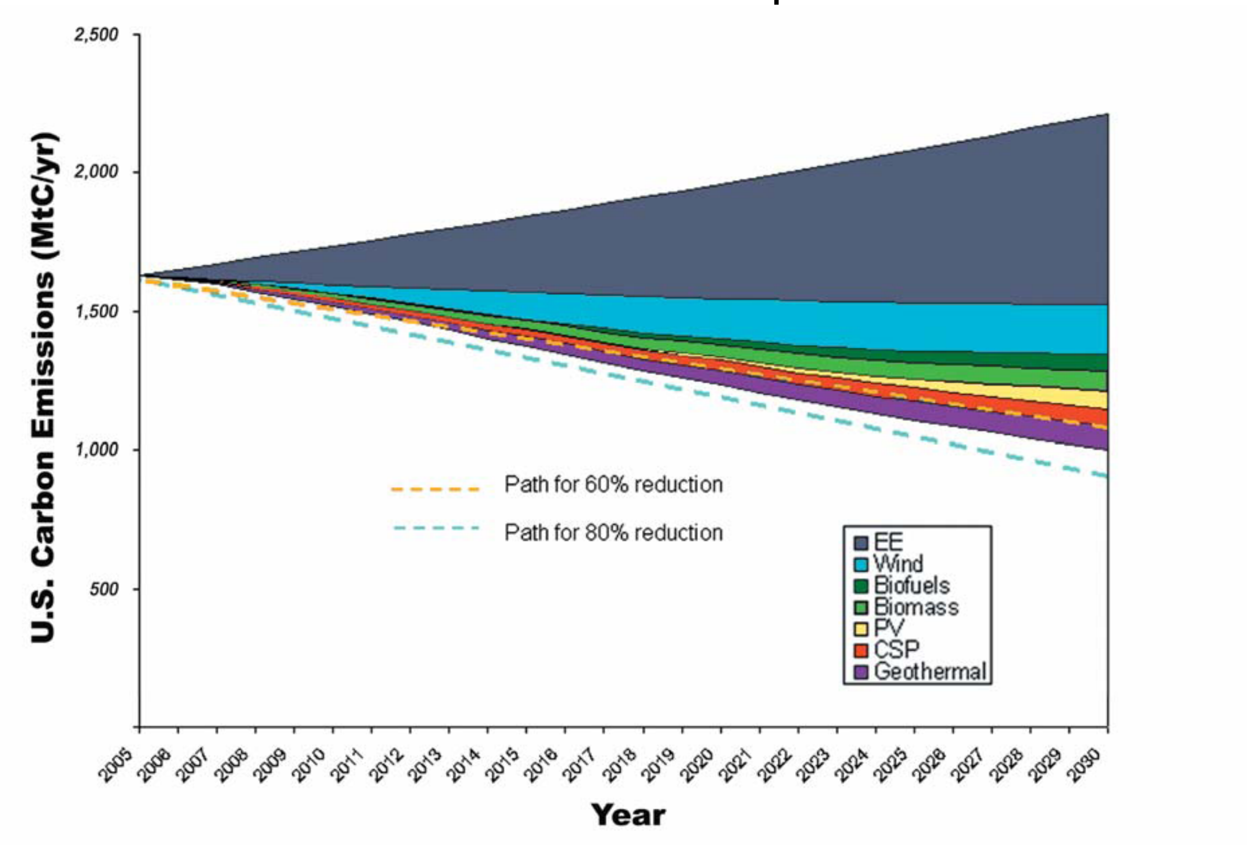
The U.S. is rich in RE resources, and Figure II-3 shows how the various potential renewable contributions in 2030 are distributed throughout the country. The carbon-reduction potentials for the year 2030 total between 1,000 and 1,400 MtC/yr, or an average of about 1,200 MtC/yr based on a mid-range value for electricity-to-carbon conversion. This would put the U.S. on target to achieve the necessary carbon-emissions reductions by mid-century, but a sustained national commitment that includes effective policy measures and continued R&D will be needed to realize this potential. Integration of these technologies in the marketplace could reduce this potential somewhat due to competition and overlap in some U.S. regions. On the other hand, even greater wind and solar contributions may be possible through greater use of storage and high-efficiency transmission lines.

TCC focused on the use of renewable energy in the electricity and transportation sectors, since these are responsible for nearly three-quarters of U.S. carbon emissions from fossil fuels. The results show that RE has the potential to provide approximately 40 percent of the U.S. electric energy requirements projected for 2030 by the Energy Information Administration (EIA). After reducing the EIA electricity projection by taking advantage of energy efficiency measures, renewables could provide about 50 percent of the remaining 2030 U.S. electricity requirements. There are uncertainties associated with these estimates, and, because TCC utilized individual technology studies, there is uncertainty associated with combining them. Nevertheless, the results indicated that

[2]Energy efficiency contributions in the buildings, transportation, and industry sectors were combined into one number.

EE&RE technologies have the potential to provide most, if not all, of the U.S. carbon emissions reductions that will be needed to help limit the atmospheric concentration of carbon dioxide to 450 to 500 ppm.

Figure II-2
Potential Carbon Reductions Required in 2030



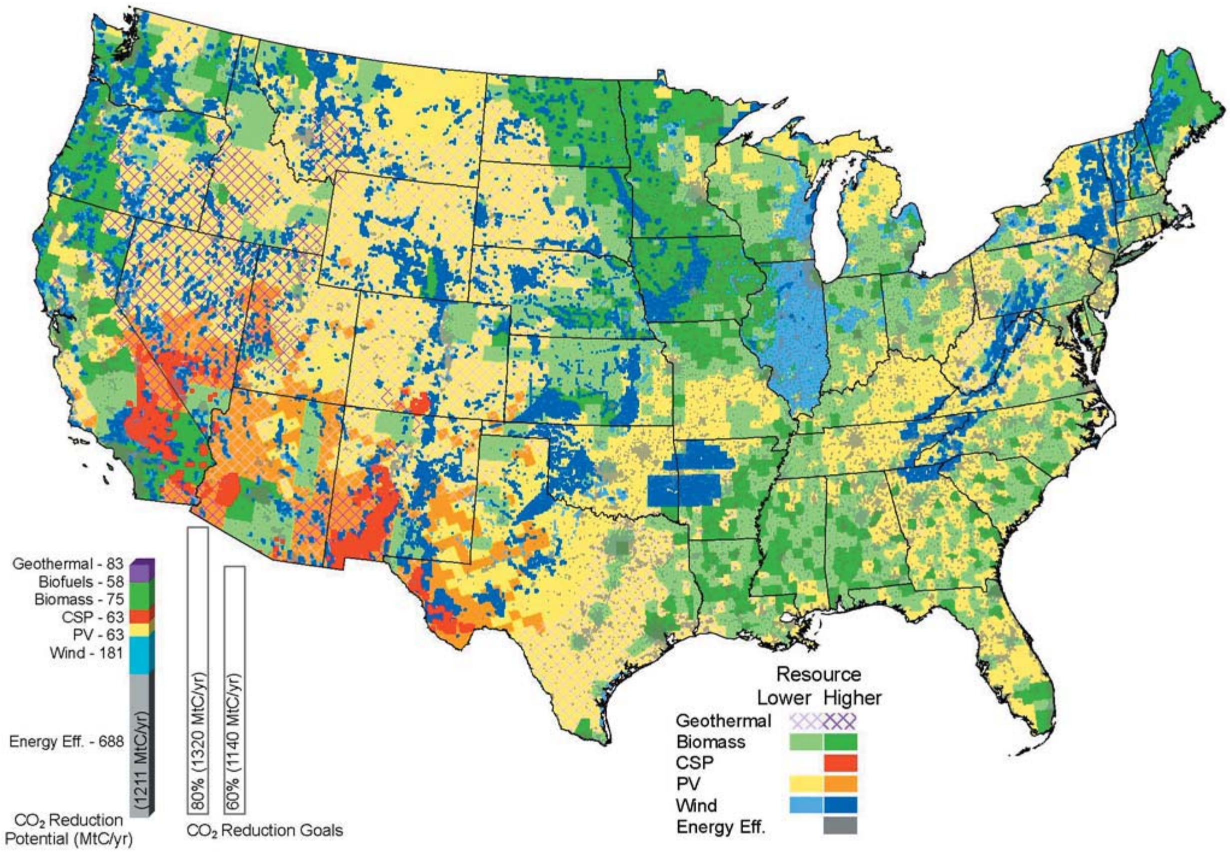
Source: American Solar Energy Society, 2007.

II.B. Energy Efficiency

Overall Energy Efficiency

TCC assessed total energy efficiency savings in the buildings, vehicles, and industrial sectors. The buildings sector provided about 40 percent of the savings and the other two sectors provided about 30 percent each. Energy efficiency improvements in buildings result from better building envelope design, daylighting, more efficient artificial lighting, and enhanced efficiency standards for building components and appliances. Improvements in transportation result from lighter-weight vehicles, public transit, improved aerodynamics, and more efficient propulsion systems. Energy reductions in industry accrue from heat recovery, more efficient motors and drives, and the use of cogeneration (also called combined heat and power or CHP) systems that provide both heat and electricity.

Figure II-3
Potential Contributions From Energy Efficiency and Renewable Energy by 2030[3]



Source: American Solar Energy Society, 2007.

For efficiency savings in electricity, TCC used results from the "five-lab study" conducted by the Interlaboratory Working Group.[4] Electricity savings resulted from efficiency improvements in the buildings and industry sectors. For estimates of efficiency savings associated with natural gas and petroleum, TCC used analyses performed at the Rocky Mountain Institute.[5] Natural gas savings accrued from more efficient industrial process heat and space and water heating in buildings, and oil savings resulted primarily from transportation improvements such as lighter-weight vehicles, improved aerodynamics, and more efficient propulsion systems.

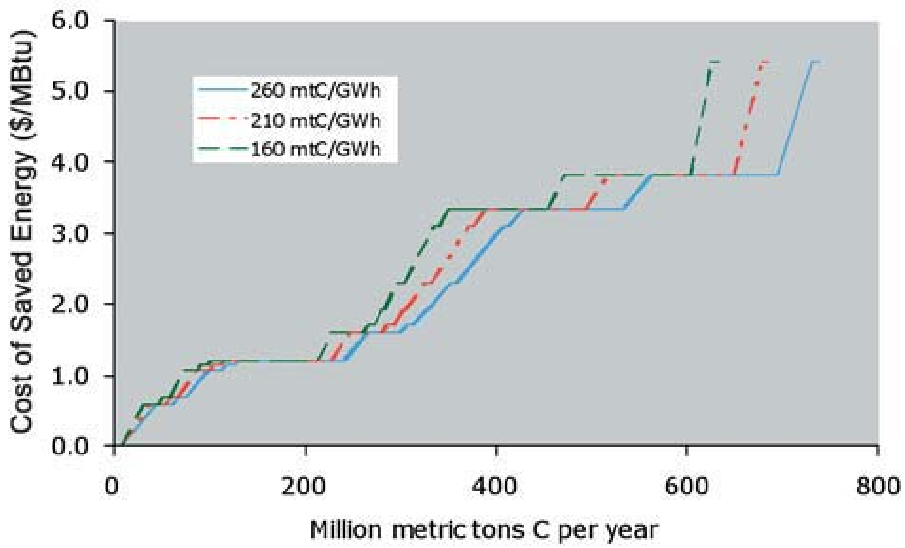
TCC estimated a reduction in electrical energy of 1,040 TWh in 2030. At the lower (national average) conversion of 160 metric tons of carbon per GWh, this provides a carbon savings of 166 MtC/yr. At the upper (coal) conversion of 260 metric tons of carbon per GWh, the carbon savings is 270 MtC/yr. The cost of saved electrical energy ranges from 0 to 4 ¢/kWh, and oil and gas savings were estimated to total 470 MtC/yr at

[3]CSP and wind are based on deployment scenarios; other renewables indicate resource locations.
[4]*Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond*, Interlaboratory Working Group, Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory, ORNL/CON 476, 2000.
[5]Amory Lovins, et al., *Winning the Oil Endgame,* Rocky Mountain Institute, Snowmass, Colorado, 2004.

costs of saved energy ranging from $0 to $5 per MBtu. TCC thus estimated the total carbon savings to be between 636 and 740 MtC/yr, with an average of 688 MtC/yr.

The study aggregated the carbon savings from all sources to produce the carbon reduction curve in Figure II-4, which shows the cost of saved energy in dollars per MBtu/yr. plotted against MtC/yr. The curves include the high carbon and low carbon cases for electricity and the midrange values and shows that to achieve higher carbon reductions requires increasingly expensive options. However, all of these are at costs below $6/MBtu.

Figure II-4
Cost of Saved Energy Versus Carbon Displacement



Source: American Solar Energy Society, 2007.

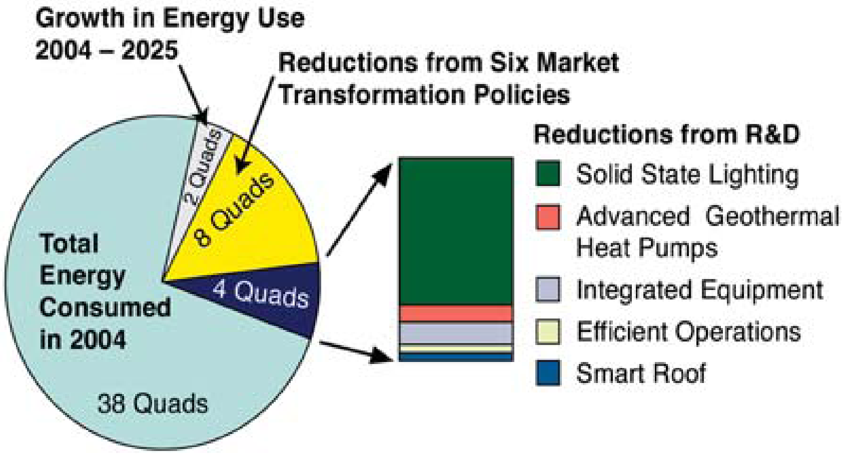
Buildings

Energy consumed in the buildings sector -- including residential, commercial, and industrial buildings -- is responsible for approximately 43 percent of U.S. carbon emissions. TCC focused on reductions in energy use and carbon emissions that can be accomplished through six market transformation policies and from R&D advances. The market transformation policies are:

- Improved building codes for new construction
- Improved appliance and equipment efficiency standards
- Utility-based financial incentive programs
- Low-income weatherization assistance
- The Energy Star® program
- The Federal Energy Management Program

TCC estimated that these policies would result in a reduction of eight quads of energy use by 2025, and R&D advances could result in an additional four quads of savings. The study predicted that the major R&D advance would be solid-state lighting, with advanced geothermal heat pumps, integrated equipment, more efficient operations, and advanced roofs providing smaller contributions -- Figure II-5.

Figure II-5
52 Quads Buildings Sector Energy Use in 2025



Source: American Solar Energy Society, 2007.

Using data from the Pew Center, TCC estimated that this would be equivalent to an annual savings of 198 MtC/yr by 2025, and that adding the impact of solar water heating would save another 0.3 quads or 6.7 MtC/yr.[6] This results in total estimated carbon savings of approximately 205 MtC/yr by 2025.

Approximately 40 percent of the total carbon savings is from buildings. Using the midrange carbon value, this corresponds to a carbon savings from building energy efficiency of 275 MtC/yr in 2030, compared to a value of 205 MtC/yr in 2025 in the buildings paper. These numbers are fairly consistent, considering that new buildings constructed between 2025 and 2030 should have much higher efficiency than the building stock they replace. In any case, the buildings sector clearly represents an important opportunity for carbon reduction.

II.C. Renewable Energy

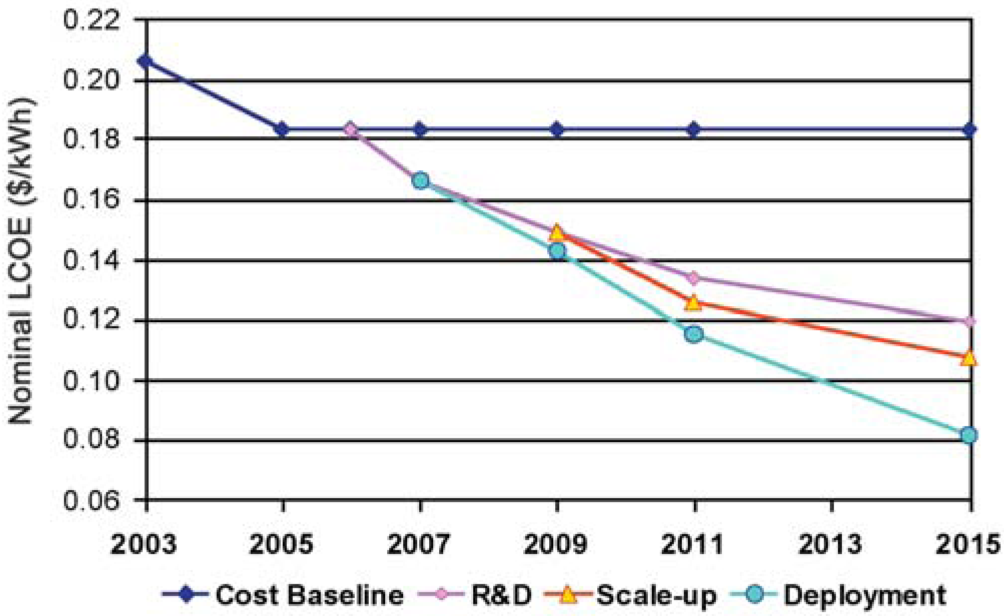
II.C.1. Concentrating Solar Power

TCC analysis of Concentrating Solar Power (CSP) assumed that single-axis tracking parabolic trough solar collectors would provide solar electricity.[7] As part of a

[6]M. Brown, F. Southworth, and T. Stovall, *Towards a Climate-Friendly Built Environment*, Pew Center on Global Climate Change, Arlington, Virginia, 2005.
[7]Although there are other means of using CSP to produce electricity, such as two-axis tracking parabolic dishes with Stirling engines and solar power towers with two-axis tracking heliostats, parabolic troughs have a track record of producing 350 MW for over 15 years in the southwestern U.S. and are also used in Europe.

study for the Western Governors Association (WGA), analysts evaluated the solar resource in the Southwest and then applied various practical filters.[8] After they applied these filters, they found that CSP could provide nearly 7,000 GW of capacity, or about seven times the current total U.S. electric capacity. When distance to transmission lines was factored in, TCC identified 200 GW of optimal locations. Analysts expect decreases in technology costs through R&D, scale-up (economies of scale for larger plants), and deployment (or learning-curve benefits), and the expected cost reductions are shown in Figure II-6.

Figure II-6
CSP Cost Reduction Curves to 2015*



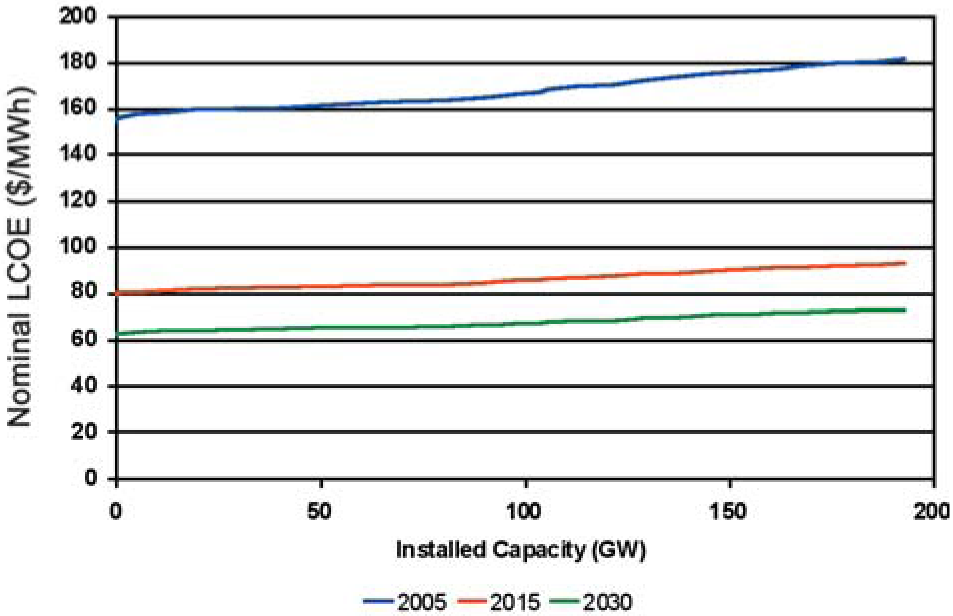
*LCOE is levelized cost of energy, or the total costs (nominal costs are those that are adjusted for inflation) divided by the total kWh generated over a power plant's lifetime.
Source: American Solar Energy Society, 2007.

This 200 GW of capacity is illustrated in a supply curve (Figure II-7) that plots cost of the technology versus installed capacity. These supply curves were estimated for three different technology costs for the years 2005, 2015, and 2030. In each case, the graph shows how much deployed capacity occurs at different costs of CSP electricity. The electricity costs depend on the quality of the resource and proximity to transmission lines, and sites with the highest solar resource that are located closest to transmission lines provide the lowest cost electricity. As capacity increases (as utilities and others develop sites with less solar energy or that are further from transmission lines, for example), the cost of CSP-generated electricity increases. These curves assume that 20 percent of existing transmission capacity is available for use by the CSP

[8]Western Governors' Association, *Clean and Diversified Energy Initiative Solar Task Force Report,* Solar Task Force, January 2006. They excluded land with a solar resource of less than 6.75 kWh/m2/day and applied other environmental and land use exclusions. They also eliminated land having a slope of more than 1%.

plants. Otherwise, cost estimates for new lines are estimated at $1,000 per MW per mile. Actual deployed capacity would be a function of time, but the technology costs are likely to decrease, as shown in Figure II-6.

Figure II-7
Capacity Supply Curves For CSP



Source: American Solar Energy Society, 2007.

A market study using NREL market deployment tools[9] competed CSP with thermal storage against wind, nuclear, and fossil fuel options. Based on the assumption of an extension of the 30 percent investment tax credit, this analysis found that 30 GW of CSP could be deployed in the Southwest by 2030.

Because TTC was interested in determining what could be achieved in a carbon-constrained world, the authors ran the model with a carbon value of $35 per ton of CO_2.[10] This analysis demonstrated that 80 GW of CSP could be economically deployed by 2030, which represents about a 200-fold increase over current installed U.S capacity -- this deployment is shown in Figure II-8.

The impact that this level of deployment would have on carbon emissions depends on what form of electricity is displaced. The number of GWh produced is a function of the plant capacity factor, and TCC assumed plants with six hours of thermal storage and a corresponding capacity factor of 43 percent. The 80 GW of power

[9]The Concentrating Solar Deployment System Model (CSDS) and the Wind Deployment System Model (WinDS); see N. Blair, W. Short, M. Mehos, and D. Heimiller, *Concentrating Solar Deployment Systems (CSDS) -- A New Model for Estimating U.S. Concentrating Solar Power Market Potential*, presented at the ASES SOLAR 2006 conference, July 2006.
[10]This is a relatively high price, but at one point during the analysis it was exceeded in the volatile European carbon market.

deployed by 2030 would correspond to an annual electricity production of 301,344 GWh/yr.[11] Neglecting the small amount of CO_2 released in the construction and operation of a CSP plant and multiplying the 301,344 GWh/yr by 160 metric tons per GWh for the low-end value and 260 metric tons per GWh for the high-end yields a carbon reduction estimate of 48 to 78 MtC/yr by 2030, with an average of 63 MtC/yr.

Figure II-8
Market Deployment of 80 GW of CSP*

*Assuming a 30 percent investment tax credit and a carbon value of \$35 per ton of CO_2.
Source: American Solar Energy Society, 2007.

II.C.2. Photovoltaics

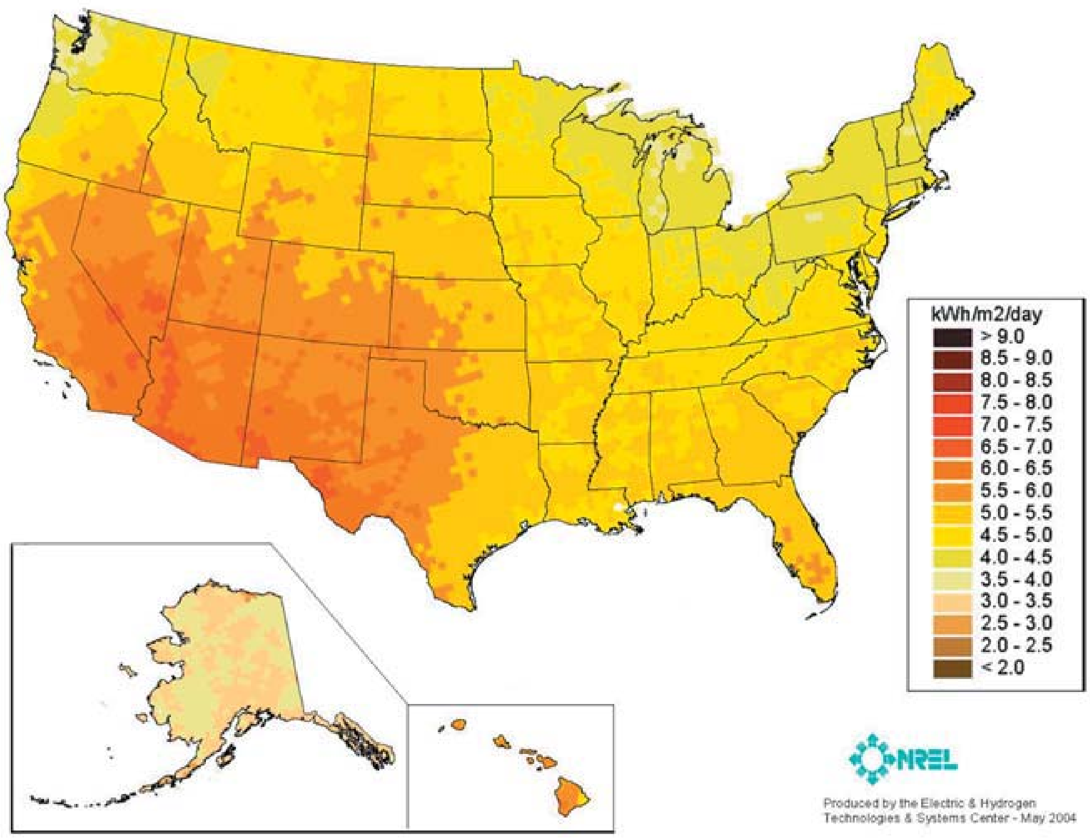
Although photovoltaic (PV) modules can be used in central station applications, they are more commonly deployed on building rooftops. This latter application allows the modules to compete against the retail price of electricity, which includes the cost of transmission and distribution, thus partially offsetting the higher price of PV. Whereas parabolic troughs require high levels of direct radiation so that it can be focused onto the receiver tube, rooftop PV modules are stationary and do not concentrate sunlight. They thus capture both diffuse and direct radiation and can operate outside the

[11] 80 GW x 8,760 hrs/yr x 0.43.

Southwest. Figure II-9 shows the total solar radiation resource on a surface facing south and at a tilt equal to the local latitude.

After rooftops are filtered for shading and inappropriate orientation, estimates of roof area suitable for PV in the U.S. range between 6 billion and 10 billion square meters. TCC estimated what could be captured by 2030 by using the lower value for suitable roof area. Current costs of PV are high but are declining rapidly as manufacturing techniques improve and the market grows.

Figure II-9
U.S. Map of the Solar Resources for PV



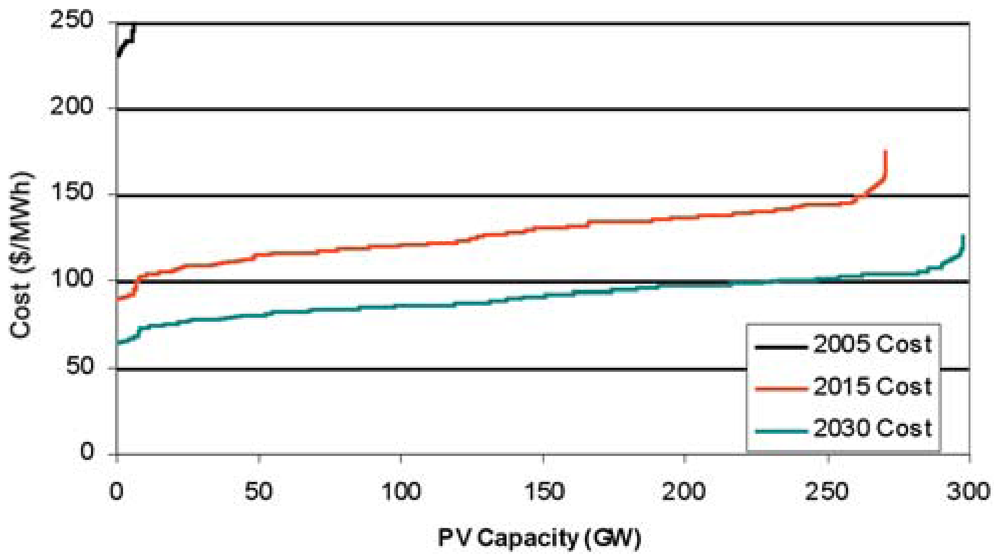
Source: American Solar Energy Society, 2007.

Figure II-10 shows estimated PV supply curves for technology costs based on year 2005, 2015, and 2030 values. It shows costs in excess of 28 ¢/kWh for current technology, and capacity as high as 300 GW for costs ranging from 6 to 12 ¢/kWh. Analysis suggests that 10 percent of electric grid energy by 2030 could be supplied by PV without creating grid management issues, and this would be equivalent to 275 GW.[12] However, there are concerns about how rapidly the PV industry could scale up and produce such a large quantity of modules.

[12]Based on the EIA projection for 2030 grid electricity, less the impact of energy efficiency measures.

The PV industry has developed a roadmap that sets a deployment goal of 200 GWp in the U.S. by 2030, and TCC used this lower value as a potential scenario.[13] It is difficult to estimate PV deployment rates because these will depend on national commitment, policy incentives, and other factors. However, TCC estimated how the deployment of 200 GWp of PV could occur through 2030. Figure II-11 shows scenarios for both the PV production capacity and installations through 2030 for achieving 200 GWp of deployment. It indicates that the high growth rate of PV production will increase slightly and then decline, and PV installations will occur much more rapidly nearer to 2030 due to the expected decrease in prices.

Figure II-10
PV Capacity Supply Curves Based on Year 2005, 2015, and 2030 Values



Source: American Solar Energy Society, 2007.

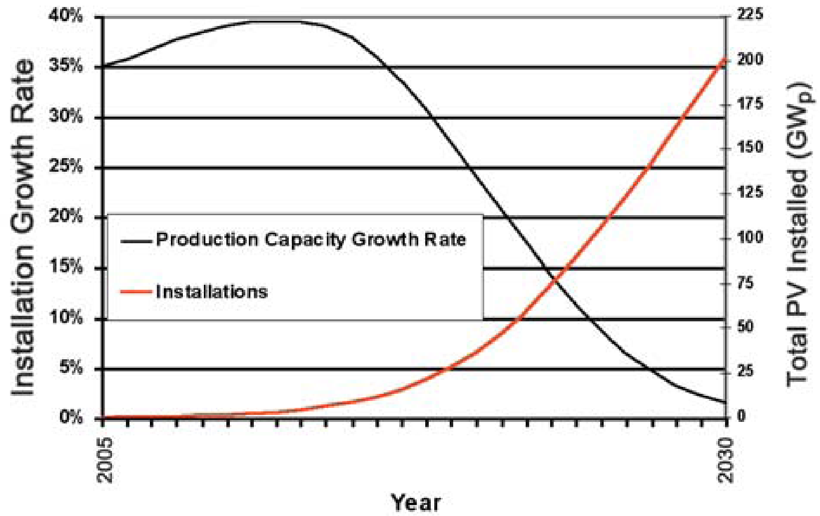
Rooftop PV modules are not typically designed to track the sun, and TCC assumed that the PV systems are grid-connected and use no battery storage, so the average power output is much less than the peak capacity. The average capacity factor used was 17 percent. Compared to the average U.S. electric mix, the annual carbon reduction at the low-end conversion of 160 metric tons per GWh by 2030 is therefore 200 GW x 8,760 hrs x 0.17 x 160 metric tons C/GWh, or 48 MtC/yr. The value at 260 metric tons of carbon per GWh is 78 MtC/yr. The resulting range is 48 to 78 MtC/yr, with an average of 63 MtC/yr.[14]

[13] *Our Solar Power Future*, U.S. Photovoltaics Industry, 2004. Available at http://www.seia.org/roadmap.pdf.

[14] This value is coincidentally the same as the CSP value, despite the differences in peak power outputs and capacity factors, which offset each other.

The 200 GWp of PV would represent 7 percent of U.S. grid electric energy by 2030, accounting for the impact of energy efficiency measures. The 200 GW potential represents about a 500-fold increase over currently installed capacity in the U.S., a much larger expansion than for the other renewable technologies considered by TCC.

Figure II-11
PV Production and Field Deployment Scenario to 2030



Source: American Solar Energy Society, 2007.

II.C.3. Wind Power

Over the last several years, wind power has experienced the highest deployment of nonhydro RE technologies: U.S. capacity currently exceeds 10,000 MW, and 2,500 MW was installed in 2005. Figure II-12 shows how this wind resource is distributed throughout the U.S. It is concentrated in the Rocky Mountain and Great Plains states, but the resource is also very high along the Sierras and the Appalachians. The U.S. is well endowed with wind sites of class 3 and higher. Wind power costs are currently competitive at about 4 ¢/kWh and are expected to decrease to less than 3 ¢/kWh by 2030.

TCC used a market simulation model, WinDS, that was developed by NREL.[15] The TCC model runs assumed that the existing production tax credit of 1.9 cents per kWh would be renewed until the year 2010 and would then be phased out linearly until 2030; offshore wind was not considered. The results of this simulation showed the market deployment curve given in Figure II-13.

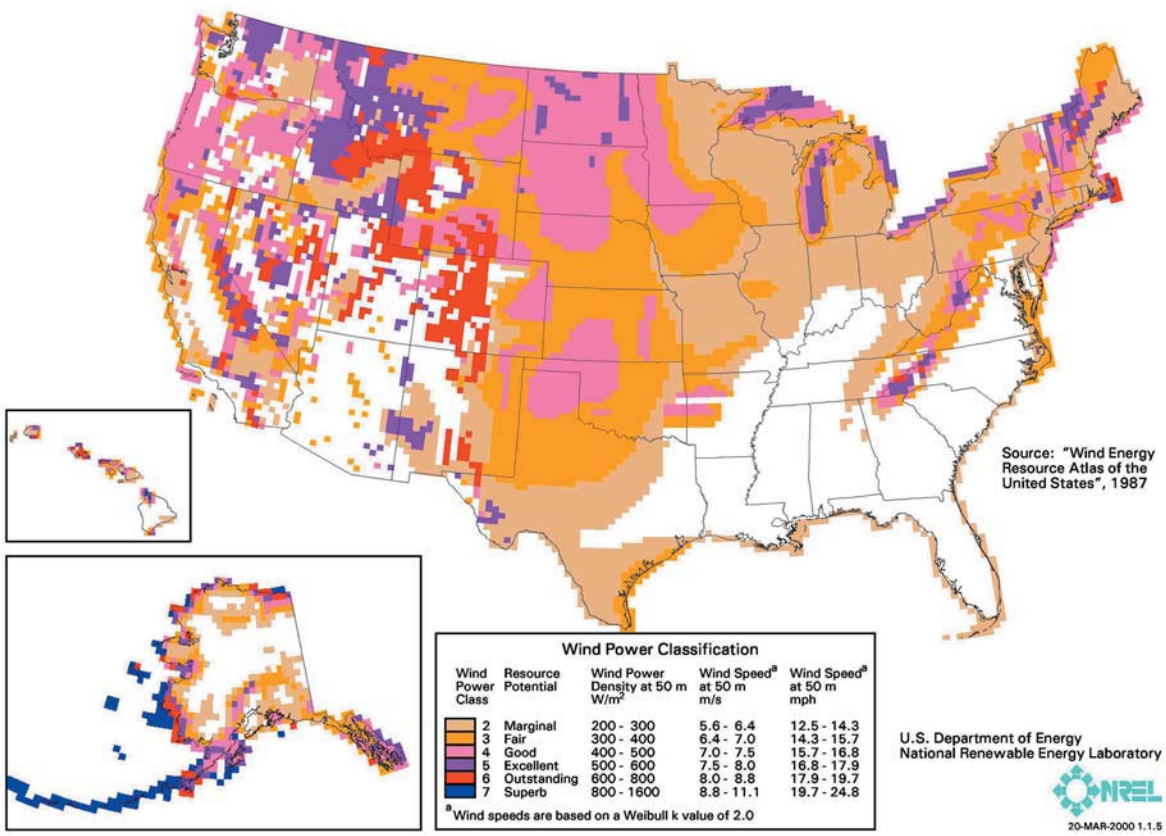
Wind capacity was limited to 20 percent of expected national grid electric energy, or 245 GW, because analysts believed that dispatchability could become difficult at higher penetrations without storage, even though the market simulation model indicated

[15]This model analyzes various regions in the U.S. with GIS representations of wind resources and transmission lines, compares the economics of wind to other energy options, and selects the least-cost alternative.

that higher amounts are possible. This represents about a 25-fold increase over current U.S. wind capacity, and a map illustrating what this deployment could look like is shown in Figure II-14.

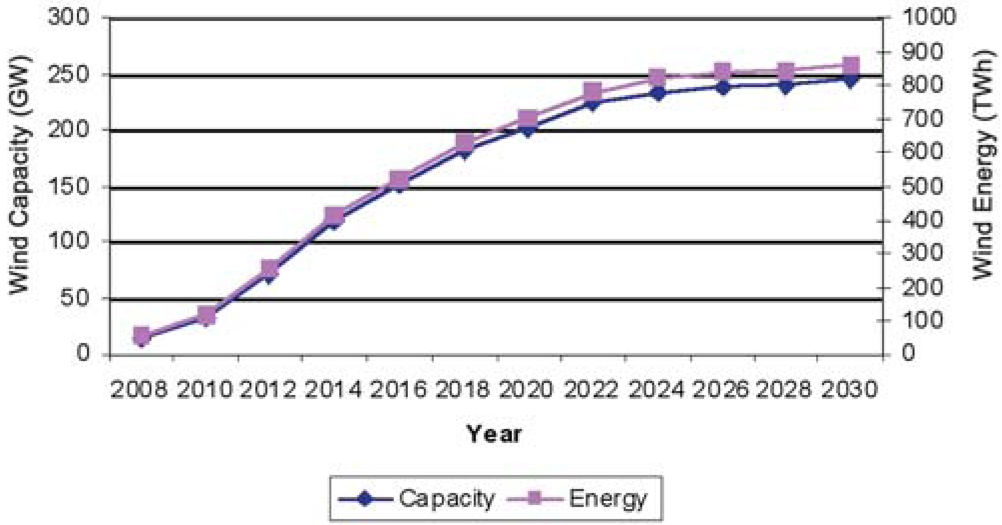
TCC assumed that, unlike PV, wind will have a rapid market penetration in the near term due to its competitive cost, and will then level off as less favorable wind locations are exploited and as grid dispatchability issues become significant. Capacity factors for wind vary from 30 percent for Class 3 wind (14.3 to 15.7 mph) to 49.6 percent for Class 7 (19.7 to 24.8 mph). Assuming an average capacity factor of 40 percent, 245 GW corresponds to an annual carbon reduction of 245 GW x 8760 hrs x .40 x 160 metric tons C/GWh, or 138 MtC for the low-end carbon conversion case. The high-end conversion would yield 224 MtC/yr, and thus the range for wind is 138 to 224 MtC/yr, with an average of 181 MtC/yr.

Figure II-12
Wind Resource Map



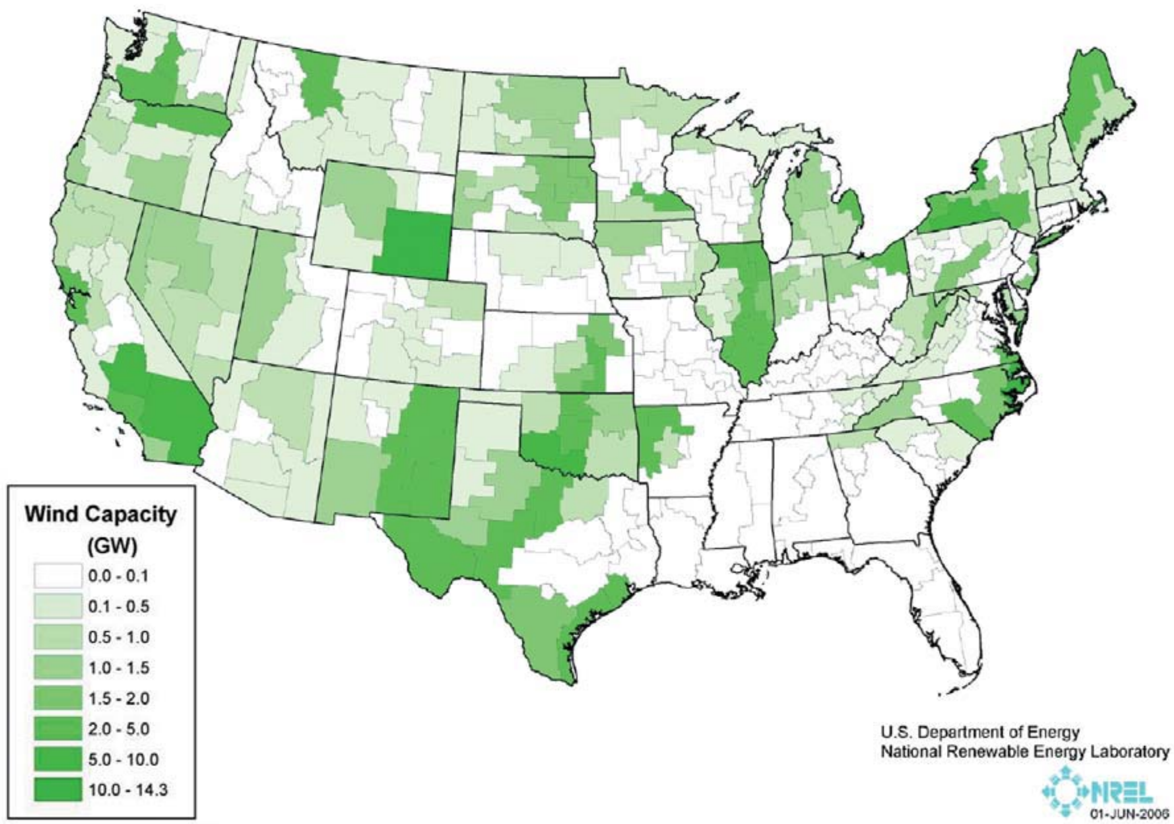
Source: American Solar Energy Society, 2007.

Figure II-13
Wind Market Penetration to 2030 Based on Market Simulation Model



Source: American Solar Energy Society, 2007.

Figure II-14
Approximate Wind Locations for 20 percent Penetration of Electric Grid



Source: American Solar Energy Society, 2007.

II.C.4. Biomass

TCC used the Oak Ridge National Laboratory Billion Ton Study[16] conclusions regarding the amount of biomass available nationwide in 2025 (which is an aggressive scenario based on improved farm practices and land use for energy crops) and assumed that the ratio of electric output to biomass would be the same as that found in the WGA Clean and Diversified Energy Study of biomass electricity potential by 2015 in 18 western states.[17] The U.S. lignocellulosic (nonfood crop) biomass resource is shown in Figure II-15, which illustrates that the resource is concentrated in the corn belt and urban centers.

Resources considered in TCC included agricultural residues (e.g., corn stalks and wheat straw), wood residues (from forests and mill wastes), and urban residues (e.g., municipal solid waste and landfill methane).[18] TCC assumed that the generation of electricity from biomass would employ the lowest-cost power plant option. For plants rated at 15 MWe or more, this tended to be integrated gasification/combined cycle (IGCC), and for plants rated at less than 15 MWe, this tended to be either a stoker with a steam turbine or a gasifier-internal combustion engine combination.

The WGA study estimated that the 170 million metric tons of biomass available annually in 18 western states could produce 32 GW of electricity by 2015. However, only about 15 GW of this is available at a cost of less than 8 ¢/kWh, so TCC used 15 GW as the electric output corresponding to 170 million metric tons of biomass.

TCC assumed that the same ratio of power production to dry biomass would exist in 2025, 1.25 billion ton national resource, thus yielding 110 GW. This represents about a tenfold increase over current biomass electricity capacity. Using a capacity factor of 90 percent, the 110 GW corresponds to an annual carbon reduction of 110 GW x 8760 hrs/yr x 0.9 x 160 metric tons C/GWh, or 139 MtC for the low-end carbon case. For the high-end case, the result is 225 MtC, and the average is 183 MtC/yr. This would be at estimated costs ranging from 5 to 8 ¢/kWh.[19] Further, biomass can provide base load power, so it could compete directly against coal plants and thus provide a carbon displacement closer to the higher estimate.[20]

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[16]R. Perlack, L. Wright, et al., *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply,* Oak Ridge National Laboratory, Oak Ridge, Tennessee, 2005, ORNL/TM-2005/66.

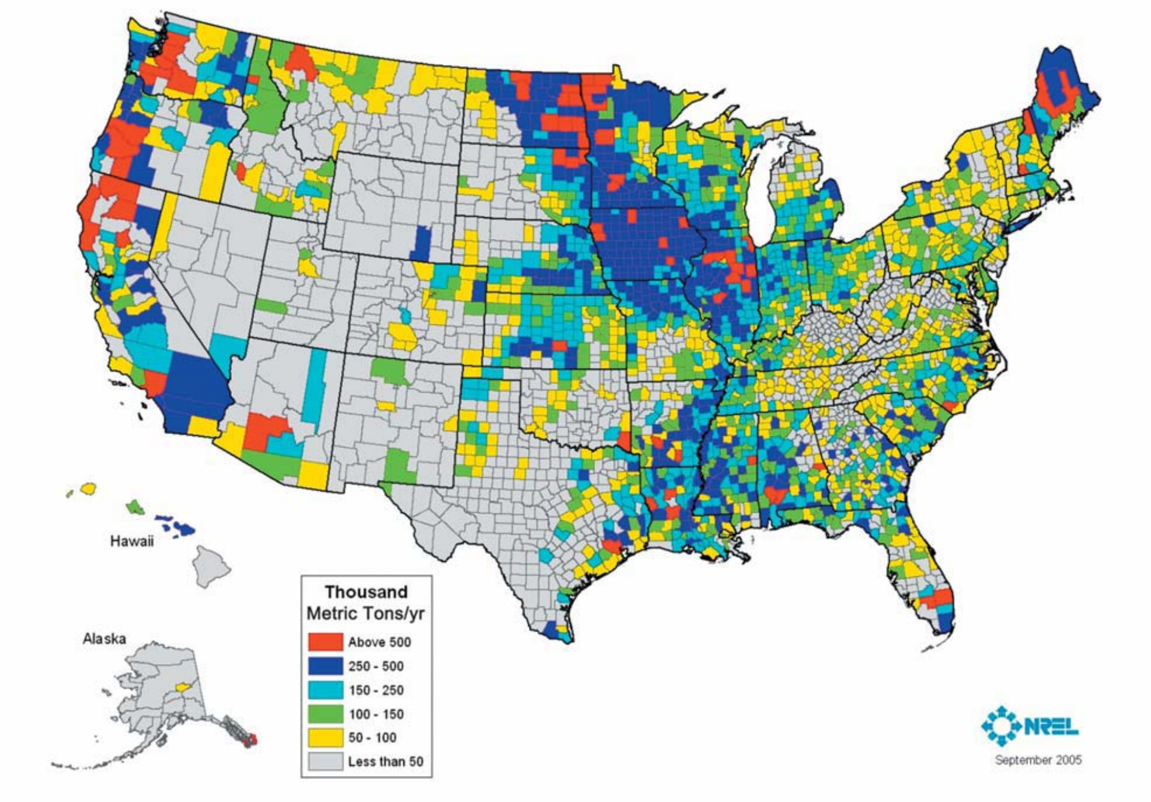
[17]Western Governors' Association, op. cit.

[18]In addition, although it is not included in Figure 19, the Billion Ton Study included future energy crops like switchgrass.

[19]The WGA analysis was only for the year 2015, although the western resource was assumed to be fairly well exploited by that date, and the national resource is a year-2025 estimate. Thus, using these results for 2030 should be conservative.

[20]Although TCC involved a separate study of biofuels, it also considered the implications of using biomass to produce liquid fuels instead of electricity. It concluded that the carbon displacement would be significantly less than for the electricity production case. Thus, from the standpoint of reducing carbon emissions, it is preferable to use biomass to produce electricity. This would especially be the case if carbon were captured and sequestered from the biomass, which TCC did not assume. Biofuels have

Figure II-15
U.S. Biomass Resources



Source: American Solar Energy Society, 2007.

II.C.5. Biofuels

Transportation produces about a third of U.S carbon emissions. Although using biomass to produce electricity can produce larger carbon reductions than using biomass to make liquid fuels, there are other RE technologies available to produce electricity, and there is considerable national interest in displacing imported oil. Thus, TCC analyzed the use of crop residues and energy crops for producing cellulosic ethanol.

The study considered only one means for producing ethanol from these crops -- biological conversion via fermentation. Figure II-16 shows the target cost reductions for ethanol production from this process. These are wholesale costs and are given in terms of gallons of gasoline equivalent and account for the fact that a gallon of ethanol contains only about two-thirds as much energy as a gallon of gasoline. Figure II-17 shows ethanol supply curves for 2015 and 2030.

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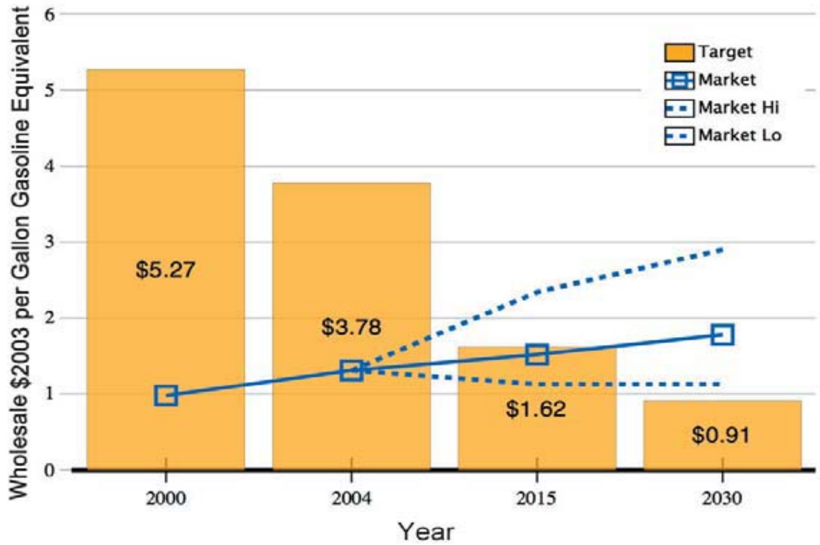
high values as a replacement for imported oil, however, and TCC noted that biomass will be used for a combination of electricity and biofuels.

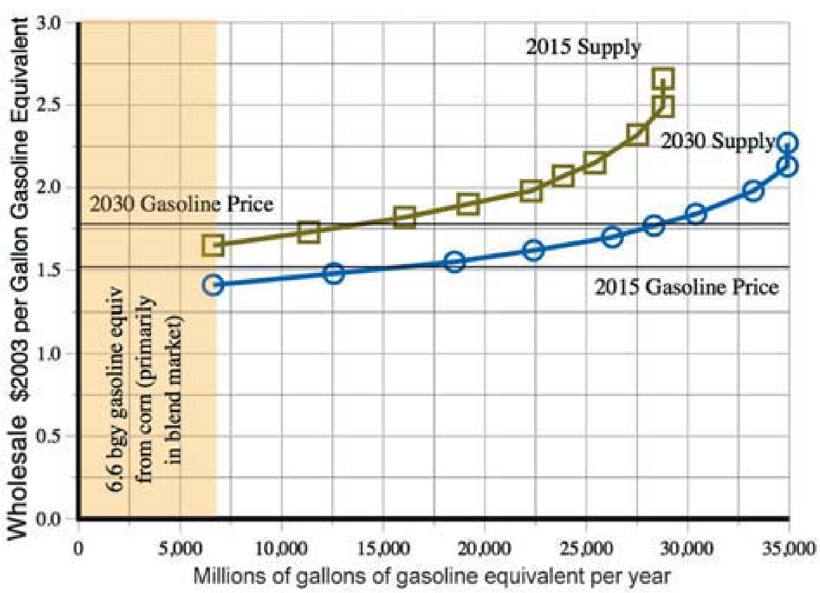
Figure II-16
Target Costs to 2030 of Cellulosic Ethanol From Fermentation



Source: American Solar Energy Society, 2007.

While there is the potential to displace 70 MtC/yr by 2030, TCC estimated that only 58 MtC/yr could be displaced economically. This would save 28 billion gallons of gasoline in 2030, which is about 20 percent of current U.S. consumption, and would correspond to about a tenfold increase over current ethanol production. If these savings were combined with more efficient vehicles and plug-in electric hybrids, the result could represent a significant portion of the future U.S. liquid fuel requirements.

Figure II-17
Cellulosic Ethanol Supply Curves for 2015 and 2030



Source: American Solar Energy Society, 2007.

II.C.6. Geothermal Power

There are currently 2,800 MW of geothermal electricity design capacity in the U.S., although the current peak production is about 2,200 MW owing to declines in steam pressure at the world's largest plant, The Geysers, in California. Geothermal power plants use hydrothermal resources, which are naturally occurring reservoirs of hot water and steam located within a few thousand feet of the surface, and most of the U.S. plants are located in California and Nevada. They use hot water or steam from below the surface to drive either a Rankine steam cycle or, for lower temperature resources, a Rankine power cycle using a fluid with a lower boiling point than water, such as isobutane or pentane. Exploitation of future geothermal resources is focused on drilling to greater depths than current plants, and Figure II-18 shows a map of temperatures at a 6-kilometer (km) depth.

The WGA Clean and Diversified Energy Study estimated that there will be about 6,000 MW of new power available from hydrothermal resources by 2015 and a total of 13,000 MW available by 2025.[21] The power potential increases as other resource types are included that have thus far not been exploited to produce geothermal electricity. So-called "enhanced geothermal systems," or EGS, involve the use of water injection under pressure to add water and permeability to rock that is hot but dry or lacking in porosity. TCC divided this into "sedimentary EGS," the expansion of existing hydrothermal reservoirs, or "basement EGS," deep, hot dry rock. There is also considerable interest in using hot water from depleted oil and gas wells near the Gulf Coast. TCC estimated that 100 GW (at costs of under 10 ¢/kWh) would be available from the various resources by 2050:

- 27 GW from hydrothermal
- 25 GW from sedimentary EGS
- 44 GW from oil and gas fields
- 4 GW from basement EGS

Runs of EIA's National Energy Modeling System (NEMS) indicated that geothermal plants could produce one-half of the 100 GW, or 50 GW, by 2030. This represents about a 20-fold increase over current U.S. geothermal electric capacity.[22]

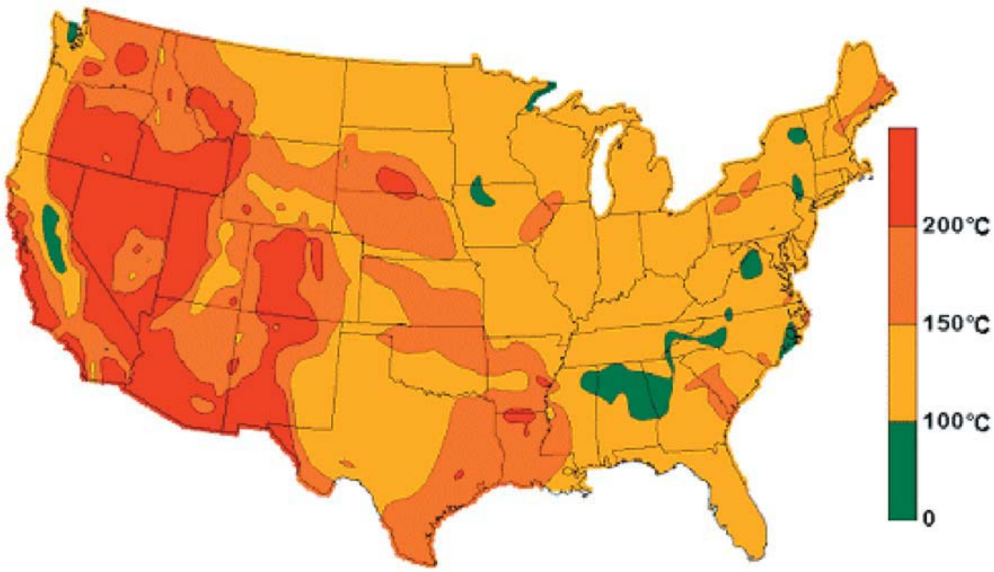
Assuming continued R&D to lower costs and using a 90 percent capacity factor, which is conservative for existing geothermal plants, the carbon displacement by 2030 is 50 GW x 8760 hrs x 0.90 x 160 metric tons C/GWh, or 63 MtC/yr for the low-end carbon case. The result for the high-end conversion is 103 MtC/yr, and the mid-range value is 83 MtC/yr. A geothermal plant can provide base load power and can thus compete against coal plants. So the high-end value may be realistic for geothermal, although TCC used the mid-range estimate. On the other hand, a substantial amount of the geothermal resource assumed in the study is non-hydrothermal. The assumption that new resources will be successfully exploited adds significantly to the uncertainty of

[21] Western Governors' Association, op. cit

[22] In the absence of a DOE program to reduce costs, this would decrease to 30-35 GW.

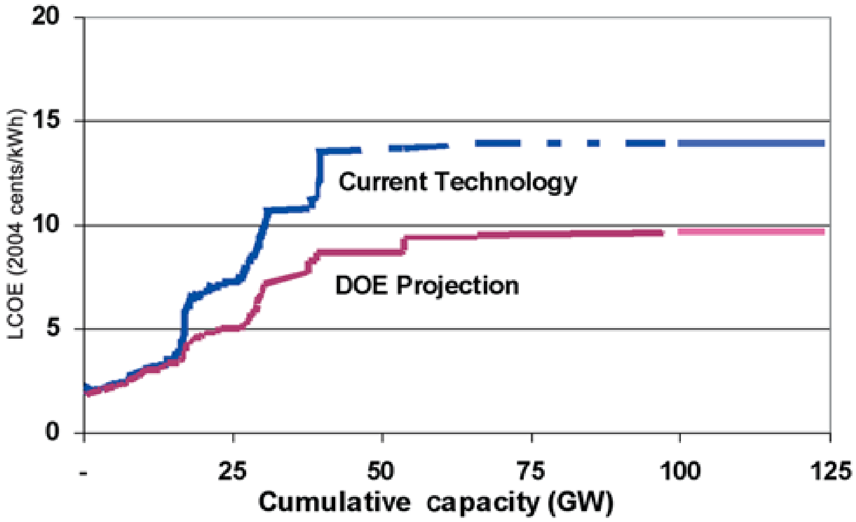
the estimates, and most high-temperature hydrothermal resources in the U.S. have already been exploited. Supply curves are shown in Figure II-20.

Figure II-18
Temperatures at 6-km Depth



Source: American Solar Energy Society, 2007.

Figure II-20
Geothermal Supply Curves



Source: American Solar Energy Society, 2007.

III. PREVIOUS STUDIES OF THE ECONOMIC AND JOBS IMPACTS OF CLIMATE CHANGE LEGISLATION

Numerous studies of the economic and jobs impacts of GHG control legislation have been conducted over the past decade, and they often reached very different conclusions. These are summarized below in three categories: More recent studies conducted in 2009 and 2008, EIA analyses of specific proposals, and legacy studies conducted prior to 2008.

III.A. Recent Studies

U.S. Environmental Protection Agency, 2009

EPA noted that the American Clean Energy and Security Act of 2009 (H.R. 2454) establishes an economy wide cap and trade program and creates other incentives and standards for increasing energy efficiency and low-carbon energy. The analysis focused on the bill's cap and trade program, the energy efficiency provisions, and the competitiveness provisions.[23] Sensitivity analyses were conducted for H.R. 2454 without energy efficiency provisions, H.R. 2454 without rebates, H.R. 2454 with reference level nuclear, and H.R. 2454 with no international offsets.[24] EPA's major findings included:

- H.R. 2454 transforms energy production and consumption: Increased energy efficiency and reduced energy demand mean that energy consumption levels that would be reached in 2015 without the policy are not reached until 2040 with the policy.
- The share of low- or zero-carbon primary energy (nuclear, renewables, and CCS) rises substantially under the policy to 18 percent of primary energy by 2020, 26 percent by 2030, and 38 percent by 2050, whereas without the policy the share would remain steady at 14 percent. Increased energy efficiency and reduced energy demand reduces primary energy needs by 7 percent in 2020, 10 percent in 2030, and 12 percent in 2050.
- Offsets and electric power supply and use represent the largest sources of emissions abatement.
- Across all scenarios modeled without constraints on international offsets, the allowance price ranges from \$13 to \$15/tCO_2e in 2015 and from \$16 to \$19/tCO_2e in 2020.
- Across all scenarios modeled that vary constraints on international offsets, the allowance price ranges from \$13 to \$24/tCO_2e in 2015 and from \$16 to \$30/tCO_2e in 2020.

[23]U.S. Environmental Protection Agency, Office of Atmospheric Programs, *EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the 111th Congress*, June 23, 2009.
[24]Several provisions outside of the cap and trade program were not modeled in this analysis (e.g. lighting standards are not in the analysis, and the renewable electricity standard is not included in economy-wide modeling but is modeled as a sensitivity in power sector analysis).

- Offsets have a strong impact on cost containment, and the annual limit on domestic offsets is never reached.
- While the limits on the usage of international offsets (accounting for the extra international offsets allowed when the domestic limit is not met) are not reached, usage of international offsets averages over 1 billion tCO_2e each year.
- Without international offsets, the allowance price would increase 89 percent relative to the core policy scenario.
- The cap and trade policy has a relatively modest impact on U.S. consumers, assuming the bulk of revenues from the program are returned to households. Average household consumption is reduced by 0.03-0.08 percent in 2015, 0.10-0.11 percent in 2020, and 0.31-0.30 percent in 2030, relative to the no policy case.[25]
- Average household consumption will increase by 8-10 percent between 2010 and 2015 and 15-19 percent between 2010 and 2020 in the H.R. 2454 scenario.
- In comparison to the baseline, the 5 and 10 year average household consumption growth under the policy is only 0.1 percentage points lower for 2015 and 2020.
- Average annual household consumption is estimated to decline by $80 to $111 dollars per year relative to the no policy case, which represents 0.1 to 0.2 percent of household consumption.
- These costs include the effects of higher energy prices, price changes for other goods and services, impacts on wages, and returns to capital, but do not account for the benefits of avoiding the effects of climate change.
- A policy that failed to return revenues from the program to consumers would lead to larger losses in consumption.

While this EPA analysis contained a set of scenarios that cover some of the important uncertainties involved in modeling the economic impacts of a comprehensive climate policy, there are still remaining uncertainties that could significantly affect the results. EPA's major economic findings are summarized in Figure III-1.

U.S. Congressional Budget Office, 2009

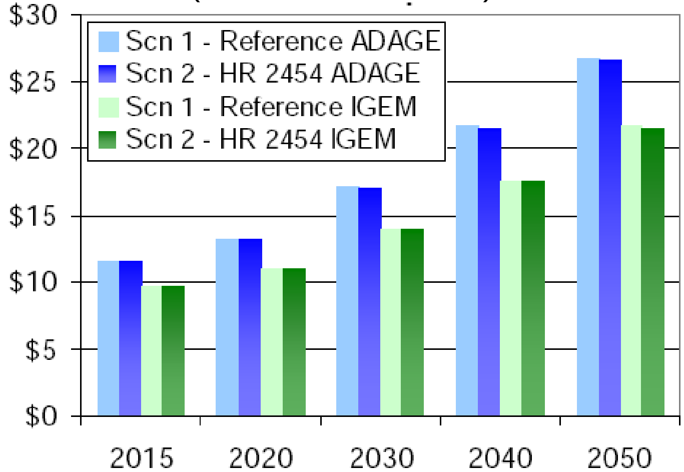
CBO analyzed H.R. 2454, the American Clean Energy and Security Act of 2009, as reported by the House Committee on Energy and Commerce on May 21, 2009, which would create a cap-and-trade program for GHG emissions.[26] It examined the average cost per household that would result from implementing the GHG cap-and-

[25]Annual net present value cost per household (at a discount rate of 5 percent) averaged over 2010-2050 under the core scenario.

[26]U.S. Congressional Budget Office, *The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454*, June 19, 2009.

trade program under H.R. 2454, as well as how that cost would be spread among households with different levels of income.[27]

Figure III-1
U.S. Consumption
(Trillion 2005 Dollars)



Source: U.S. Environmental Protection Agency, 2009

Reducing emissions to the level required by the cap would be accomplished mainly by reducing demand for carbon-based energy by increasing its price. Those higher prices would reduce households' purchasing power, but the distribution of emission allowances would improve households' financial situation. The net financial impact of the program on households in different income brackets would depend in large part on how many allowances were sold, how the free allowances were allocated, and how any proceeds from selling allowances were used. The net impact would reflect both the added costs that households experienced because of higher prices and the share of the allowance value that they received in the form of benefit payments, rebates, tax decreases or credits, wages, and returns on their investments.

CBO estimated that the net annual economy-wide cost of the cap-and-trade program in 2020 would be $22 billion -- about $175 per household. That figure includes the cost of restructuring the production and use of energy and of payments made to foreign entities under the program, but it does not include the economic benefits and other benefits of the reduction in GHG emissions. Households in the lowest income quintile would see an average net benefit of about $40 in 2020, while households in the highest income quintile would see a net cost of $245. Added costs for households in the second lowest quintile would be about $40 that year; in the middle quintile, about $235; and in the fourth quintile, about $340. Overall net costs would average 0.2 percent of households' after-tax income.

[27]The analysis did not include the effects of other aspects of the bill, such as federal efforts to speed the development of new technologies and to increase energy efficiency by specifying standards or subsidizing energy-saving investments.

Gross compliance costs would consist of the cost of emission allowances, the cost of both domestic and international offset credits, and the resource costs incurred to reduce the use of fossil fuels:

- The cost of the allowances. The cost of acquiring allowances would become a cost of doing business. In most cases, firms required to hold the allowances would not bear that cost; rather, they would pass it onto their customers in the form of higher prices.
- The cost of both domestic and international offset credits. Like the cost for allowances, the cost of acquiring offset credits would be passed on by firms to their customers in the form of higher prices.
- The resource costs associated with reducing emissions. The resource costs would include the value of the additional resources required to reduce emissions, by making improvements in energy efficiency, or by changing behavior to save energy.

According to CBO's estimates, the gross cost of complying with the GHG cap-and-trade program would be about $110 billion in 2020 (measured in terms of 2010 levels of consumption and income), or about $890 per household. Of that gross cost, 96 percent would be the cost of acquiring allowances or offset credits. The reminder would be the resource costs associated with reducing emissions.

Although households and governments would pay for the cost of the allowances in the form of higher prices, those allowances would have value and would be a source of income. The ultimate effects of the cap-and trade program on U.S. households would depend on policymakers' decisions about how to allocate that value. Allowances would be allocated among businesses, households, and governments, and the value of those allowances would ultimately be conveyed to households in various ways:

- About 30 percent of the allowance value -- $28 billion -- would be allocated in a fairly direct manner to U.S. households to compensate them for their increased expenditures.
- Roughly 50 percent of the allowance value -- $47 billion -- would be directed to U.S. businesses to offset their increased costs.
- About 10 percent of the allowance value would be allocated to the federal government and to state governments.
- Finally, H.R. 2454 would direct the federal government to spend 7 percent of the allowance value overseas, funding efforts to prevent deforestation in developing countries, to encourage the adoption of more efficient technologies, and to assist developing countries.

Taking into the account the costs of complying with the cap ($110 billion), the allowance value that would flow back to U.S. households ($85 billion), and the additional transfers and costs discussed above (providing net benefits of $2.7 billion), the net economy-wide cost of the GHG cap-and-trade program would be about $22 billion, about $175 per household -- Table III-1. Four factors account for that net cost:

- The purchase of international offset credits ($8 billion)
- The cost of producing domestic offset credits ($3 billion)
- The resource costs associated with reducing emissions ($5 billion)
- The allowance value that would be directed overseas ($6 billion)

Table III-1
Total Cost and Average Cost of the GHG Cap-and-Trade Program in H.R. 2454

	Total Cost (Billions of dollars)	Share of Allowance Value (Percent)	Average Cost per Household (Dollars)
Gross Costs of Complying with the Cap			
Cost of Allowances and Offsets			
Market Value of Allowances	91.4	100.0	740
Domestic and International Offsets	13.3	n.a.	110
Resource Costs	4.9	n.a.	40
Total Gross Cost	109.6	n.a.	890
Disposition of Allowance Value to Domestic Entities			
Allocation of Allowances to Households			
Low-income rebate and tax credit	-13.7	15.0	-110
LDC residential customers	-14.5	15.8	-115
Allocation of Allowances to Businesses			
Trade-exposed industries	-14.1	15.4	-115
LDC nonresidential customers	-27.1	29.7	-220
Other	-5.5	6.0	-45
Allocation of Allowances to Government			
Deficit reduction	-1.0	1.1	-10
Energy efficiency and clean energy technology	-6.9	7.5	-55
Other public purposes	-2.3	2.5	-20
Total	-85.0	93.0	-690
Other Transfers			
Low-Income Rebate and Tax Credit Not Covered by Allowance Allocation	-2.8	n.a.	-25
Automatic Indexing of Taxes and Transfers	-8.7	n.a.	-70
Net Income to Providers of Domestic Offsets	-2.7	n.a.	-20
Total	-14.3	n.a.	-115
Additional Government Costs			
Low-Income Rebate and Tax Credit Not Covered by Allowance Allocation	2.8	n.a.	25
Automatic Indexing of Taxes and Transfers	8.7	n.a.	70
Total	11.6	n.a.	95
Net Economywide Cost	21.9		175
Memorandum: Source of Net Economywide Cost			
International offsets	7.8	n.a.	65
Production cost of domestic offsets	2.7	n.a.	20
Resource costs	4.9	n.a.	40
Allowance value going overseas	6.4	7.0	50
Total	21.9	n.a.	175

Source: U.S. Congressional Budget Office, 2009.

Each of those components represents costs that would be incurred by U.S. households as a result of the cap-and-trade program but would not be offset by income resulting from the value of the allowances or from additional payments (such as increases in Social Security benefits) that would be triggered by the program. Estimates of the average net cost to households under H.R. 2454 do not reveal the wide range of effects that the cap-and-trade program would have on households in different income brackets, different sectors of the economy, and different regions of the country. In order to provide greater insight into some of those variations, CBO estimated the effect of the GHG cap-and-trade program on the average household in each fifth (quintile) of the population arrayed by income.

CBO estimated that households in the lowest income quintile would see an average net benefit of about $40, while households in the highest income quintile would see a net cost of approximately $245. Households in the second lowest quintile would see added costs of about $40 on average, those in the middle quintile would see an increase in costs of about $235, and those in the fourth quintile would pay about an additional $340 per year. Overall, costs for households would average 0.2 percent of their average after-tax income.

The Brookings Institution, 2009

This 2009 report from the Brookings Institution estimated that Waxman-Markey (WM) would have severe impacts on the U.S. economy.[28] These include (prices and costs in 2008 dollars):

- An annual U.S. GDP decrease of about 1.75 percent in 2030. Based on EIA forecasts, this indicates that WM will reduce U.S. GDP in 2030 by about $430 billion -- a loss of about $3,100 per U.S. household per year – and things get worse after 2030.
- By 2018, WM would cause the loss of about 700,000 jobs.
- Inflation would be 4-5 percent higher over the next two decades.
- The impact on the coal industry would be devastating: By 2025, the cost of coal would more than double, increasing 110 percent; coal production in 2025 would be 40 percent lower, and by 2025, employment in the coal sector would decline by 50 percent.
- The petroleum sector would also be severely affected: By 2025, crude oil costs would increase 40 percent; crude oil production in 2025 would decline by more than 40 percent, and by 2025, jobs in the crude oil sector would decline by nearly 40 percent.
- CO_2 prices would increase continuously: $45/ton in 2020, $80/ton in 2030, $100/ton in 2040, and more than $120/ton in 2020.
- Allowance values increase rapidly, reaching over $320 billion per year by 2025
- Finally, over the next four decades, WM would result in a wealth transfer via allowances of $9.2 trillion.

[28]The Brookings Institution, *Consequences of Cap and Trade*, June 2009.

The authors noted that the U.S. Congress continues to debate a potential cap-and-trade program for the control of GHG emissions. The economic effects of such a bill remain in dispute, with some arguing that a cap-and-trade program would create jobs and improve economic growth and others arguing that the program would shift jobs overseas and hit households with large energy price increases.

Brookings used a global economic model to evaluate different emission reduction paths and to develop insights for policymakers about how to the design the C&T program to lower the costs of achieving long-run environmental goals. The study examined GHG emissions reduction paths that are broadly consistent with proposals by President Obama and with Waxman-Markey, and also evaluated two cost minimizing paths that reach similar goals. The study estimated that alternative paths to reach an emission reduction target of 83 percent below 2005 levels by 2050:

- Reduce cumulative U.S. emissions by 38 percent to 49 percent, about 110 to 140 billion metric tons CO_2
- Reduce personal consumption by 0.3 percent to 0.5 percent -- about $1 to $2 trillion in discounted present value, 2010 to 2050
- Reduce the level of U.S. GDP by around 2.5 percent relative to what it otherwise would have been in 2050
- Reduce employment levels by 0.5 percent in the first decade, with large differences across sectors
- Create an annual value of emission allowances of over $300 billion by 2030, and a total value of over $9 trillion, 2012 - 2050

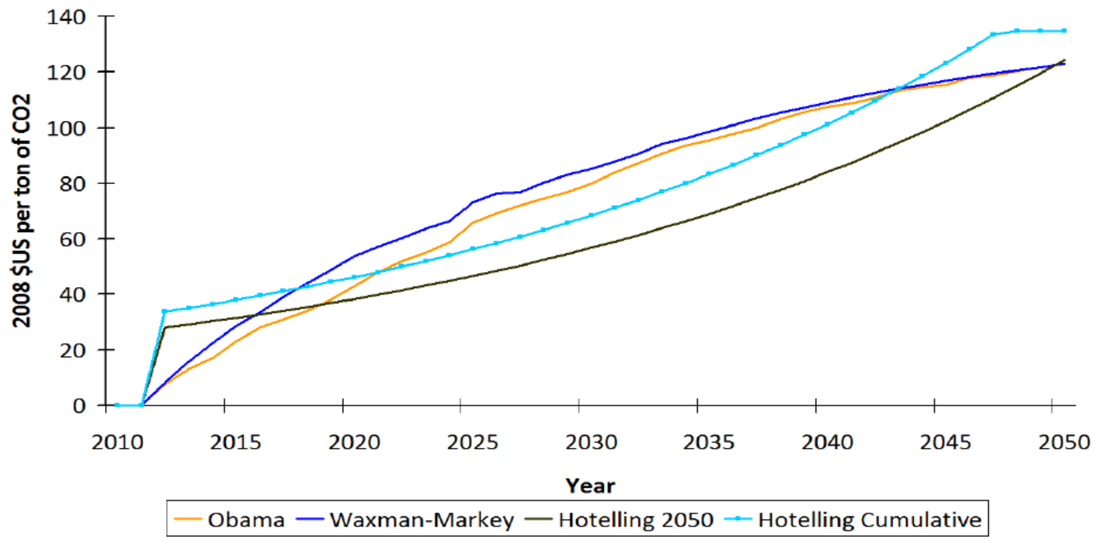
The authors examined four scenarios:

- Obama – GHG emissions 14 percent lower by 2020
- Waxman-Markey -- GHG emissions 20 percent lower by 2020 and 40 percent lower by 2030
- Hotelling 2050 -- Least cost path to 83 percent reduction by 2050
- Hotelling Cumulative -- least cost path with the same cumulative emissions as Obama

The major findings are illustrated below.

Carbon prices would increase continuously, from $45/ton in 2020 to more than $120/ton by 2050.

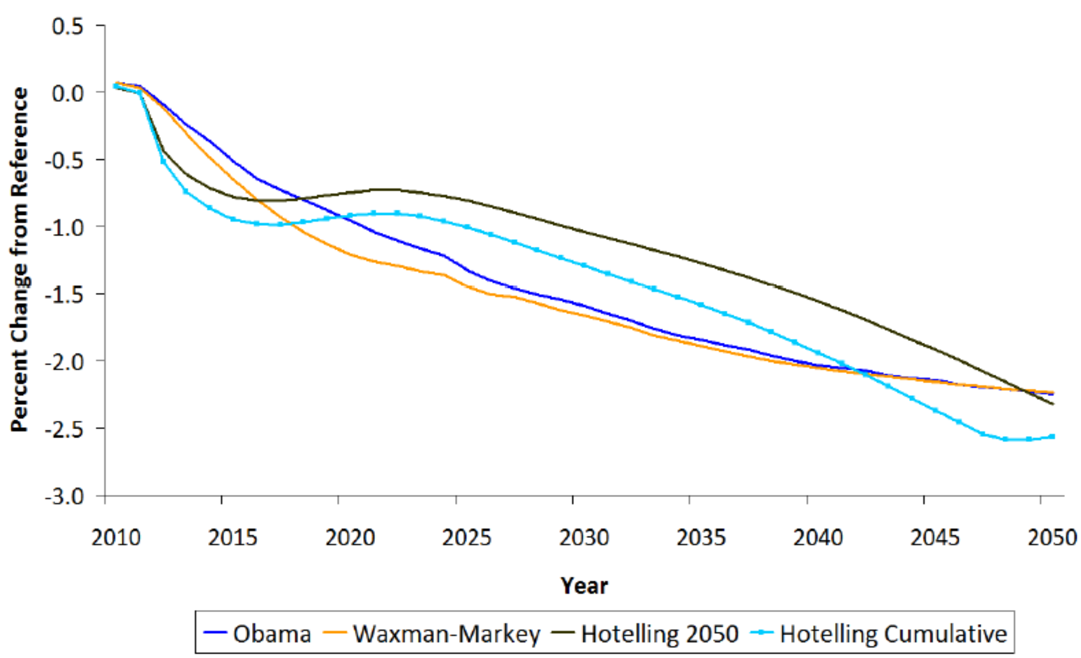
Figure III-2
Carbon Prices Under Alternative Policies



Source: The Brookings Institution, 2009

U.S. GDP would decline continuously.

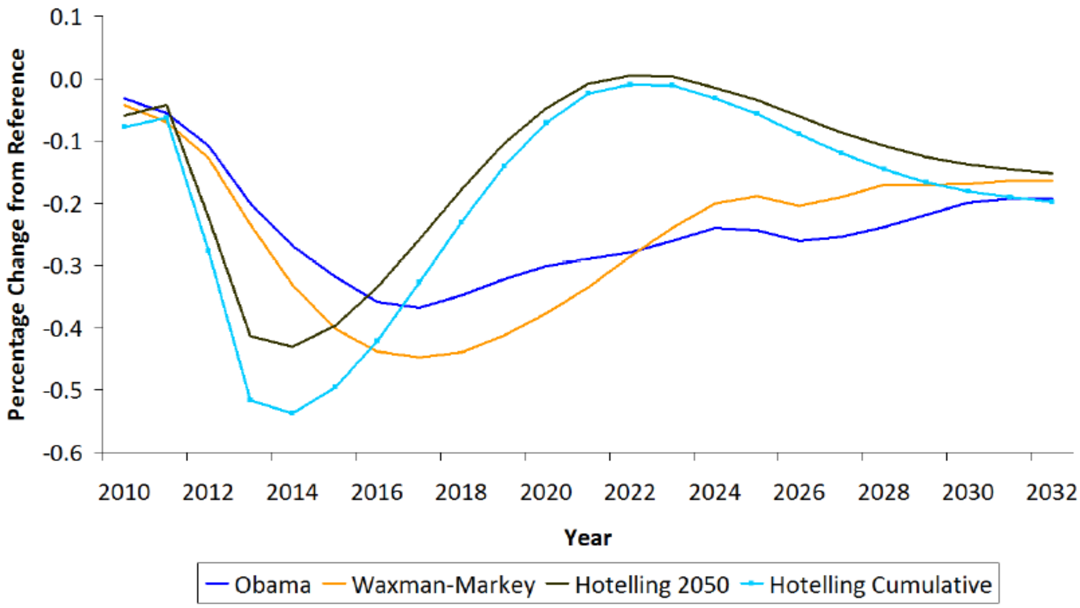
Figure III-3
Effect of Alternative Policies on US GDP



Source: The Brookings Institution, 2009

Total employment would be reduced.

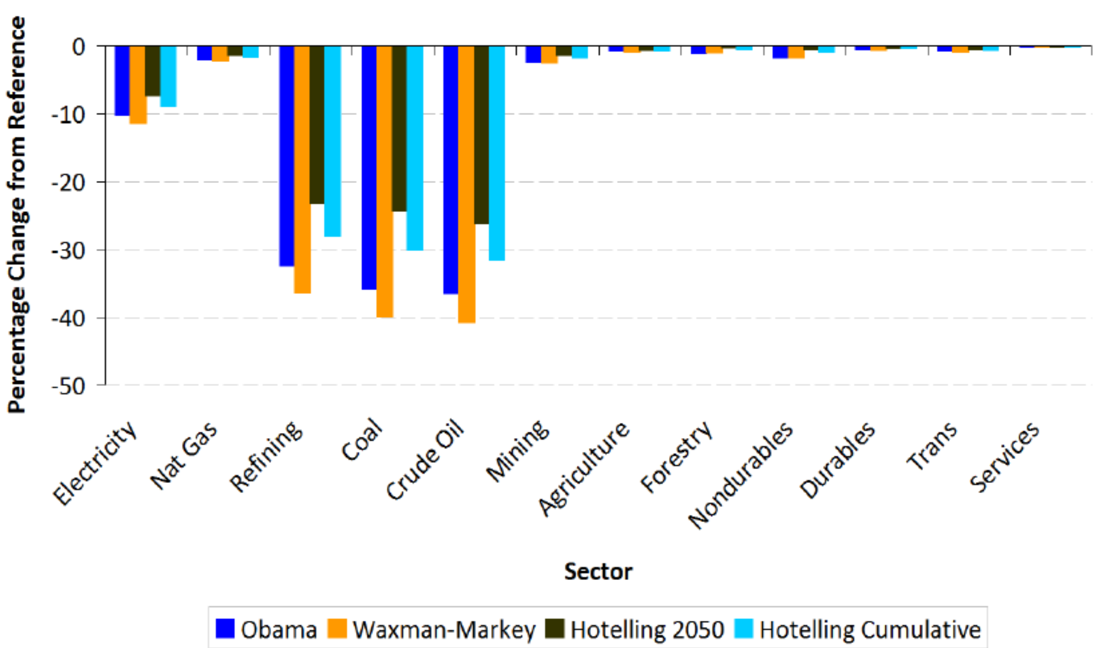
Figure III-4
Effect of Alternative Policies on US Employment



Source: The Brookings Institution, 2009

The U.S. domestic coal and petroleum sectors would be devastated.

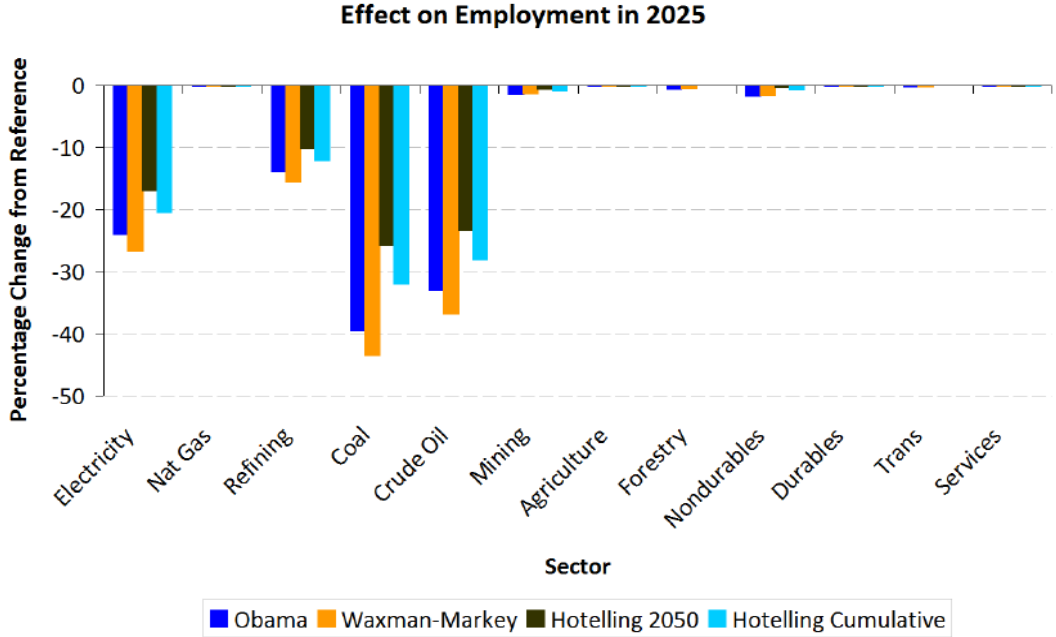
Figure III-5
Effect on Production in 2025



Source: The Brookings Institution, 2009

Employment in the U.S. domestic coal and petroleum sectors would decline drastically.

Figure III-6



Source: The Brookings Institution, 2009

National Black Chamber of Commerce, 2009

In this report the National Black Chamber of Commerce analyzed the potential economic impacts of the American Clean Energy and Security Act of 2009 (ACESA).[29] The study examined key sections of the bill, particularly those provisions related to GHG cap-and-trade, renewable energy, and offsets, and focused on how these could affect performance of the U.S. economy.

The most important conclusion is that ACESA will have significant cost – see Table III-2. Therefore, the judgment about what action to take cannot be made simply on the grounds that a cap-and-trade program will create additional jobs and stimulate economic growth – it will not – but on whether the benefits are worth the cost. And it needs to be recognized that the benefits of any action by the U.S. alone are limited because of the relatively small share that the U.S. will contribute to global emissions over the next century.

The NBCC analysis found that businesses and consumers would face higher energy and transportation costs under ACESA, which would lead to increased costs of other goods and services throughout the economy. As the costs of goods and services rise, household disposable income and household consumption would fall. Wages and returns on investment would also fall, resulting in lower productivity growth and reduced

[29]National Black Chamber of Commerce, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R.2454)*, report prepared by CRA International, May 2009.

employment opportunities. Impacts would differ across regions of the economy, depending on how local energy costs will change, whether local industries will be favored or harmed, and allocation formulas. It is not possible to avoid these costs through any free distribution of carbon allowances.

Table III-2
Summary of Projected Economic Impacts
(change from projected baseline)

	2015	2020	2030	2040	2050
CO_2 Allowance Price (2008$/metric ton)	$22	$28	$46	$74	$124
Change in U.S. jobs (Millions)	-2.3	-2.7	-2.5	-2.5	-3.0
Change to Average Worker's Annual Wages: *Assumes Partial Wage Adjustment* ($2008)	-$170	-$270	-$390	-$600	-$960
Change in U.S. Purchasing Power ($2008 per Household)	-$730	-$800	-$830	-$850	-$940
Percentage Change in U.S. GDP	-1.0%	-1.2%	-1.3 %	-1.3 %	-1.5%
Percentage Change in Natural Gas Retail Rates*	10% ($1.20/MMBtu)	14% ($1.60/MMBtu)	16% ($2.30/MMBtu)	25% ($3.70/MMBtu)	34% ($5.40/MMBtu)
Percentage Change in Motor Fuel Cost	3% (12¢/Gallon)	4% (14¢/Gallon)	5% (23¢/Gallon)	7% (37¢/Gallon)	11% (59¢/Gallon)
Percentage Change in Electricity Retail Rates*	7.3% (1.1¢/ kWh)	16% (2.0¢/ kWh)	22% (2.8¢/ kWh)	34% (4.5¢/ kWh)	45% (6.1¢/ kWh)

* Percentage increases in utility bills will be smaller to the extent there are free allowance allocations to load-serving entities and natural gas local distribution companies and/or reduced energy consumption.

Source: National Black Chamber of Commerce, 2009.

Although the wise use of revenues from an auction or carbon tax can ameliorate impacts on some segments of the economy, the cost of bringing emissions down to levels required by the caps cannot be avoided. It is this cost of bringing down emissions that the NBCC analysis estimated, in terms of reductions in GDP and household consumption. Allocations shift who bears the burden across industries, regions, and income groups, as do decisions about how to spend or return to taxpayers the revenues from allowance auctions.

Just as it is impossible to eliminate the cost of reducing emissions to levels consistent with the cap through allocations or revenue recycling, it is impossible to bring about a net increase in labor earnings through measures that impose a net cost on the economy. NBCC found that the cap-and-trade program would lead to increases in spending on energy efficiency and renewable energy, and as a result that significant numbers of people would be employed in "green jobs." However, estimates of jobs created in these activities are incomplete if not supplemented by estimates of the reduced employment in other industries and the decline in average salaries that would result from higher energy costs and lower overall productivity in the economy.

This study found that even after accounting for green jobs, there is a substantial and long-term net reduction in total labor earnings and employment. This is the unintended but predictable consequence of investing to create a “green energy future.” Further, the costs estimated in this study would be much higher if it were not for the assumed use (and availability) of international offsets authorized by the bill. Specific economic impacts resulting from ACESA include the following:[30]

- Carbon Allowance Costs – ACESA would reduce GHG emissions through decreased use of conventional energy. As the cap progressively tightens, the cost of reducing emissions becomes more expensive and the cost of CO_2 allowances increases. In 2015, the cost of a CO_2 allowance is estimated to be \$22/mtCO_2. By 2030, the allowance cost could increase to \$46/mtCO_2, and by 2050, the allowance cost could reach \$124/mtCO_2.
- Utility Rates and Utility Bills – retail natural gas rates would rise by 10 percent ($1.20 per MMBtu) in 2015, by 16 percent ($2.30 per MMBtu) in 2030, and by 34 percent ($5.40 per MMBtu) in 2050. Retail electricity rates would increase by 7.3 percent (1.1 cents per kWh) relative to baseline levels in 2015, by 22 percent (2.8 cents per kWh) in 2030 and by 45 percent (6.1 cents per kWh) in 2050.
- Transportation Fuel Costs - After an estimated 12 cents per gallon increase in 2015, costs of using motor fuels are estimated to increase by 5 percent (23 cents per gallon) in 2030 and increase by 11 percent (59 cents per gallon) in 2050, relative to baseline levels.
- Employment – a net reduction in U.S. employment of 2.3 million to 2.7 million jobs in each year through 2030. These reductions are net of gains in “green jobs.” While all regions of the country would be adversely impacted, the West, Oklahoma/Texas, and the Mississippi Valley regions would be disproportionately affected.
- Wages – Declines in workers’ wages will become more severe with time. The earnings of an average worker would be approximately $170 less by 2015, $390 less by 2030, and $960 less by 2050.
- Household Purchasing Power -- the average U.S. household’s annual purchasing power is estimated to decline by $730 in 2015, by $830 in 2030, and by $940 in 2050. These changes are calculated against 2010 income levels and would be larger if stated against projected future baseline income levels.
- Overall Economic Activity -- In 2015, GDP would be 1.0 percent ($170 billon) below the baseline level, driven mainly by declining consumption. In 2030, GDP would be 1.3 percent ($350 billon)

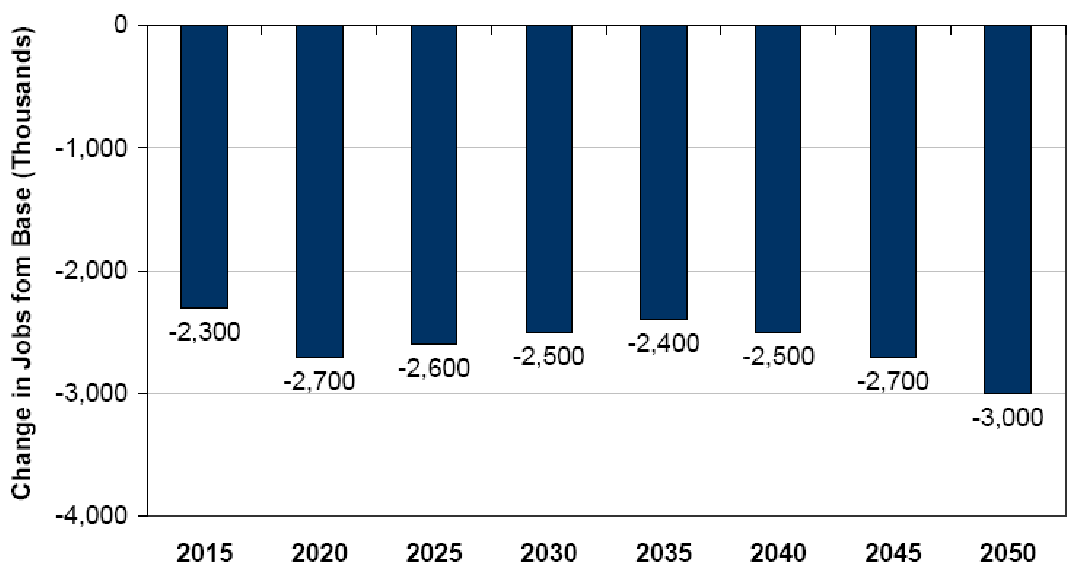
[30]All costs in this report are expressed in terms of 2008 dollars.

below the baseline level. In 2050, GDP would be 1.5 percent ($730 billon) below the baseline level.

- Green jobs versus effects on total employment -- ACESA would depress total employment from baseline levels. The bill would divert resources currently used to produce goods and services into the work of obtaining energy from sources that are more costly than fossil fuels. It would thus lower the sum of goods and services produced by the economy and hence the output per unit of labor.
- Worker compensation will decline as productivity falls. Although part of the decline in total compensation will show up as a decrease in earnings per worker, many factors inhibit decreases in average compensation. Another result of lowered productivity is likely, therefore, to appear in the form of lower employment levels.

Figure III-7 illustrates the employment impacts ASCEA. The actual number of jobs that would have to be shed depends on whether higher-paying or lower-paying jobs are the ones that are eliminated. NBCC assumed that jobs would be shed in equal proportions across the entire wage distribution, and reported the loss in “average jobs.” Figure III-7 shows that in 2015, unemployment is 2.3 million higher than in the baseline. It also shows that there would remain between about 2.5 to 3 million fewer average jobs in the economy far into the future relative to what would otherwise have been possible. Because these estimated employment impacts are based on the general equilibrium requirement that total payments to labor must fall to the new, lower level that can be supported by the reduced overall productivity of the entire economy, they are inclusive of all increases in “green jobs” that will be created by ASCEA.

Figure III-7
Projected Changes To Employment Due To ACESA, Assuming Partial Wage Rate Adjustments



Source: National Black Chamber of Commerce, 2009.

Coalition for Affordable American Energy, 2009

This CAAE report analyzed the potential economic impacts of the climate provisions contained in the Obama Administration's FY 2010 Budget Proposal.[31] The study examined the cap and trade policy described in the Administration's FY 2010 Budget Proposal, including the stated caps on U.S. GHG emissions and proposals for use of the revenues to fund renewable energy programs, the "Making Work Pay" tax credits, and other transfer payments.

The report found that these climate provisions would have significant economic and energy market impacts and that market shares would shift within the energy sector. Natural gas is projected to expand its market share, particularly for power generation. Increased imports of natural gas are estimated to supply most of the increased domestic demand for natural gas, whereas domestic natural gas production is projected to increase slightly. Both oil and coal are estimated to decline in market share. These measures would tend to lower rates of return on investments in the production of domestic oil and petroleum products. With lower rates of return, domestic investment levels would fall. Domestic crude oil and refined products production are projected to decline, while the share of renewable energy is estimated to rise.

The results also indicated that business users and consumers would face higher energy costs and the resulting higher energy production and transportation costs would lead to increased costs of goods and services throughout the economy. As these latter costs rise, household disposable income and household consumption would fall. The cap and trade policy would cause more investment in costly forms of renewable energy, thereby directing funding away from investments with greater potential to enhance productivity, and the economy would grow more slowly and job growth would decline. Overall, the economy would be expected to grow more slowly, leading to substantial differences in disposable income and personal consumption -- Table III-3. Specific economic impacts, beginning in the 2012, include the following:

- CO_2 emissions would be reduced through decreased use of conventional energy. As the cap progressively tightens, the cost of reducing emissions becomes more expensive and the cost of a carbon allowance increases. In 2015, the cost of a carbon allowance is estimated to be \$29/mtCO_2. By 2020, the allowance cost increases to \$66/mtCO_2 and by 2030 the allowance cost could reach \$116/mtCO_2.
- The cost of energy is projected to increase relative to the baseline as a result of the substitution away from less costly conventional fuels. Natural gas demand, primarily for electricity generation, is projected to increase as coal-generated electricity is backed out due to tightening GHG emission caps and motor fuel costs are projected to increase. After a 39 percent increase (\$4.70 per

[31] Coalition for Affordable American Energy, *Impact on the Economy of the Climate Provision in the Obama Administration's FY 2010 Budget*, report prepared by CRA International, April 2009.

MMBtu) in natural gas costs by 2020, natural gas costs increase by 56 percent ($7.20 per MMBtu) by 2025. After an estimated 48 ¢/gal increase in 2020, motor fuel costs increase 19 percent (74 ¢/gal). Electricity costs increase 27 percent (3.6 ¢/ kWh) in 2020, rising by 44 percent (5.8 ¢/kWh) in 2025.

- After an initial net job loss of 800,000 in 2015, net job losses are projected to more than double by 2020 to 1.9 million and continue to increase to 3.2 million jobs by 2025. This estimated employment impact is inclusive of jobs that would be created by the budget proposal. While all regions of the country would be adversely impacted, the Southeast, Oklahoma, Texas, and California would be disproportionately affected.

Table III-3
Summary of Projected Economic Impacts
(Change from Projected Baseline)

	2015	2020	2025	2030
U.S. Job Losses (Millions)	0.8	1.9	3..2	3.2
Change in U.S. Household Purchasing Power ($2008 per Household)	-$1020	-$1,381	-$1,823	-$2127
Percent Change in U.S. GDP	-0.3%	-0.4%	-0.7%	-0.2%
Percent Change in U.S. Investment	-1.3%	+0.6%	+0.3%	+5.6%
Percent Change in Natural Gas Cost	16% ($1.90 /MMBtu)	39% ($4.70 /MMBtu)	56% ($7.2 0/MMBtu)	53% ($7.70 /MMBtu)
Percent Change in Motor Fuel Cost	6% (21 Cents/Gallon)	13% (48 Cents/Gallon)	19% (74 Cents/Gallon)	20% (78 Cents/Gallon)
Percent Change in Electricity Cost	15% (2 Cents/ kWh)	27% (3.6 Cents/ kWh)	44% (5.8 Cents/ kWh)	51% (6.6 Cents/ kWh)

Source: Coalition for Affordable American Energy, 2009.

- Projected impacts on household purchasing power would be severe: Per household purchasing power is estimated to decline by $1,020 in 2015, by $1,381 in 2020, and $2,127 by 2030.
- Aggregate U.S. investment is projected to drop by 1.3 percent below the baseline level in 2015, but then is projected to increase over the 2020 – 2030 timeframe as required investments in lower emitting GHG technologies and energy efficiency improvements are put in place to comply with ever more stringent carbon caps. By 2030, investment is 5.6 percent above the baseline level. The increasingly stringent carbon caps redirect capital from higher to lower productive uses, and this shift would have a large adverse impact on productivity growth.
- By 2025, GDP is estimated to be 0.7 percent ($150 billon) below the baseline level, driven principally through declining consumption.

Commercial transportation services, electric generation, and agriculture would be among the most affected sectors. In 2030, GDP is 0.2 percent ($39 billon) below the baseline level.

There would be significant changes to energy supply and consumption:

- There would be a shift towards the use of natural gas in the next decade in large measure because of increased use of natural gas for electricity generation. By 2025, U.S. demand for natural gas is estimated to increase by 3.0 Tcf relative to the baseline level. This demand increase would result in an estimated cost increase of natural gas to consumers of 56 percent ($7.20 per MMBtu) by 2025. By 2030, the impact on demand lessens to 1.5 Tcf.
- Most of the estimated natural gas demand growth would be met by imports. Increased costs for domestic oil and natural gas producers retard development of domestic natural gas resources. By 2025, natural gas imports rise by 160 percent (2.0 Tcf) above the baseline level, whereas domestic natural gas production increases by only 5 percent (0.7 Tcf).
- The increased costs imposed on U.S.-located refineries to cover facility GHG emissions would not be faced by refineries located outside the U.S., which would put U.S. refineries at a competitive disadvantage.
- Demand for refined products would be reduced, and this decline would fall disproportionately on U.S. producers. U.S. production of refined products is projected to decline relative to baseline levels by 604 - 2,151 MBOE/day (3.9 to 13.6 percent annually), 2020-2030.

Higher energy costs would cause decreases in demand for goods and services and, in addition, as the expected costs of energy services climb, the productivity of capital and labor tend to fall. Business activity is likely to contract, the demand for labor would tend to weaken, and employment is projected to decline relative to the baseline. Figure III-7 illustrates that 2015 job losses are estimated to be 0.8 million, they more than double by 2020 to 1.9 million job losses, and by 2025 - 2030, job losses increase to 3.2 million. These employment impacts are inclusive of jobs that would be created. Figure III-8 indicates that while job losses would be distributed throughout the country, the southeast, California, Oklahoma, and Texas would be disproportionately affected.

Center for American Progress, 2008

This 2008 CAP report advocated a "green economic recovery program to strengthen the U.S. economy over the next two years and leave it in a better position for sustainable prosperity."[32] This initiative was designed to expand job opportunities,

[32]Center for American Progress, *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy*, report prepared by the Department of Economics and the Political Economy Research Institute (PERI) at the University of Massachusetts-Amherst, September 2008.

stimulate economic growth, stabilize the price of oil, fight global warming, and build a green, low-carbon economy. The green economic recovery program would be a down payment on a 10-year policy program recommended by CAP in its 2007 "Progressive Growth" series, which recommended an economic strategy for the next administration.

Figure III-7
Projected Changes to Non-Farm Employment

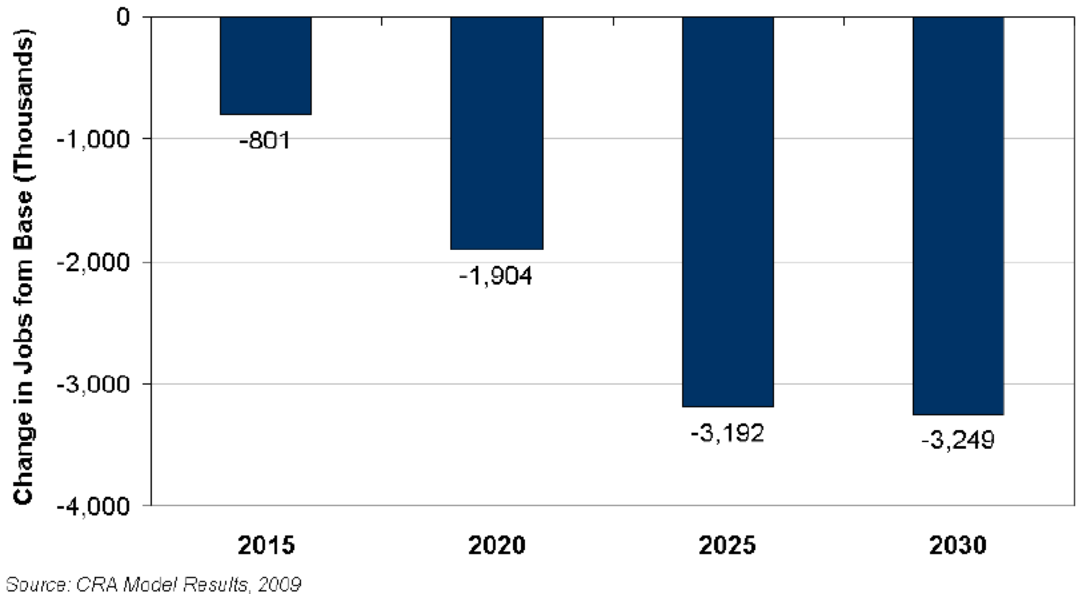
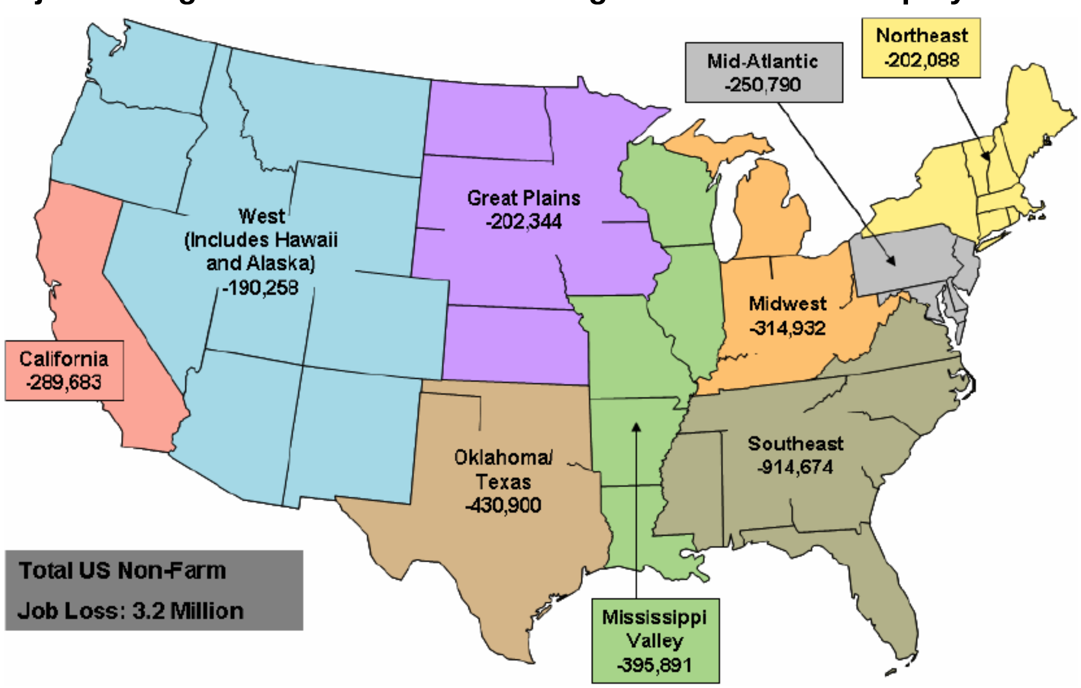


Figure III-8
Projected Regional Distribution of Changes to Non-Farm Employment in 2025



Source: Coalition for Affordable American Energy, 2009.

The report's recommended green economic recovery program would spend $100 billion dollars over two years in six green infrastructure investment areas, and would be paid for with proceeds from auctions of carbon permits under a GHG cap-and-trade program. The authors estimated that the program would create 2 million jobs by investing in six energy efficiency and renewable energy strategies:

- Retrofitting buildings to improve energy efficiency
- Expanding mass transit and freight rail
- Constructing "smart" electrical grid transmission systems
- Wind power
- Solar power
- Next-generation biofuels

Most of the federal spending would be in public building retrofits, public transportation, and building smart grid systems and through the federal government to state and local governments. Investments in renewable energy and energy efficiency are also central to this proposal, and would be funded through a combination of public funds, tax credits, and loan guarantees to encourage private sector investment. CAP recommended that this $100 billion green energy stimulus package should be spent in the six technology areas listed above. The program would allocate the funding through tax credits ($50 billion), direct government spending ($46 billion), and Federal loan guarantees ($4 billion). CAP estimated that this would result in widespread employment gains, lower unemployment, renewed construction and manufacturing work, more stable oil prices, and self-financing energy efficiency. CAP also recommended establishment of numerous new government entities, including:

- A White House National Energy Council
- An Energy Innovation Council
- An Energy Technology Corporation
- A Clean Energy Investment Administration
- A Clean Energy Jobs Corps

The report found that:

- "Green energy" investments generate both more jobs than equivalent investments in other energy technologies and that these jobs also pay higher than average wages.
- The recommended investments in energy efficiency and renewable energy sources would stabilize demand for oil and slow the long-term rise in oil prices.
- The program would reduce U.S. oil demand by one percent and would reduce world oil prices by eight percent.
- The program would create 2 million new jobs and reduce the U.S. unemployment rate by nearly 25 percent.
- The investments in energy efficiency would be self financing.

- Renewable energy does not receive enough federal subsidies compared to fossil fuels.

Heritage Foundation, 2008

This Heritage Foundation report estimated the economic impacts of Senate bill 2191, "America's Climate Security Act of 2007," sponsored by Joseph Lieberman (I-CT) and John Warner (R-VA).[33] S. 2191 imposes strict upper limits on the emission of six GHGs with the primary emphasis on CO_2, and would establish a cap-and-trade system. Heritage estimated the cost of S. 2191 at $800 to $1,300 per household by 2015, rising to $1,500 to $2,500 by 2050. Electricity prices could increase 36 to 65 percent by 2015 and 80 to 125 percent by 2050.

The Heritage analysis found that S. 2191 posed extraordinary perils for the American economy. Arbitrary restrictions predicated on multiple, untested, and undeveloped technologies would lead to severe restrictions on energy use and large increases in energy costs. In addition to the direct impact on consumers' budgets, these higher energy costs will spread through the economy and inject unnecessary inefficiencies at virtually every stage of production and consumption.

S. 2191 extracts trillions of dollars from U.S. energy consumers and delivers this wealth to permanently identified classes of recipients, such as tribal groups and preferred technology sectors, while largely circumventing the normal congressional appropriations process. Unbound by the periodic review of the normal budgetary process, this de facto tax-and-spend program threatens to become permanent -- independent of the goals of the legislation. Heritage found that implementing S. 2191 will be very costly:

- Cumulative GDP losses are at least $1.7 trillion and could reach $4.8 trillion by 2030 (in inflation-adjusted 2006 dollars).[34]
- Single-year GDP losses total at least $155 billion and could exceed $500 billion (in inflation-adjusted 2006 dollars).
- Annual job losses exceed 500,000, and could approach 1,000,000.
- Annual costs of emission permits will be at least $100 billion by 2020 and could exceed $300 billion by 2030 (2006 dollars).[35]
- The average household will pay $467 more each year for its natural gas and electricity (in inflation-adjusted 2006 dollars). This means

[33]Heritage Foundation, *The Economic Costs of the Lieberman-Warner Climate Change Legislation*, Heritage Foundation Center for Data Analysis Report #08-02, May 2008.
[34]The analysis did not extend beyond 2030, at which point S. 2191 mandates GHG reductions to 33 percent below the 2005 level. However, it should be noted that the mandated GHG reductions continue to become more severe and must be 70 per-cent below the 2005 level by 2050.
[35]To put these numbers in perspective, the report noted the taxpayers spent $43 billion on the Department of Homeland Security in 2007, $155 billion on U.S. highways in 2005, and $549 billion on the Department of Defense in 2007.

that the average household would spend an additional $8,870 to purchase energy over the period 2012 through 2030.

- The cost of the allowances will be significant and will lead to large increases in the cost of energy. Because the allowances have an economic effect much like an energy tax, the increase in energy costs creates correspondingly large transfers of income from private energy consumers to special interests.

With S. 2191, there is an initial small employment increase as firms build and purchase the newer more CO2-friendly plants and equipment. However, any "green-collar" jobs created are more than offset by other job losses, and the initial uptick is small compared to the hundreds of thousands of lost jobs in later years.

The slowdown in GDP is seen more dramatically in the decline in manufacturing output. Manufacturing benefits from the initial investment in new energy production and fuel sources, but the sector's declines are sharp thereafter. By 2020, manufacturing output is 2.4 percent to 5.8 percent below what it would be if S. 2191 never becomes law. By 2030, the manufacturing sector has lost $319 billion to $767 billion in output.

Employment growth slows sharply following the boomlet of the first few years and potential employment decreases sharply. In 2025, nearly 500,000 jobs per year fail to materialize and job losses expand to more than 600,000 in 2026. In no year after the boomlet does the economy outperform the base-line economy, and for manufacturing workers, the news is especially grim. That sector would likely continue declining in numbers thanks to increased productivity: The baseline contains a 9 percent decline between 2008 and 2030. Lieberman-Warner accelerates this decrease substantially: Employment in manufacturing declines by 23 percent over that same time period, or more than twice the rate without Lieberman-Warner.

Other, less energy-intensive sectors do not suffer such decreases. Employment in retail establishments ends the 22-year period 2 percent ahead of its 2008 level, despite significant cutbacks on household consumption levels. Employment in information businesses grows by 29 percent over this same time period. Because the distribution of energy-intensive jobs across the country is unequal, some states and congressional districts will be hit particularly hard. Notable among the most adversely affected states are Wisconsin, New Hampshire, Illinois, and Maryland.

The report concluded that the Lieberman-Warner climate change bill is, in many respects, an unprecedented proposal. Its limits on GHGs would impose significant costs on the entire American economy. In addition, complicated tariff rules, dependent on evaluating the GHG restrictions of all trading partners, add another unknowable dimension to the costs, fueling the overall uncertainty. The problems for the U.S. economy are increased by S. 2191's reliance on complex and costly technologies that have yet to be developed. The fact that this large-scale transformation of the economy must occur over relatively tight timeframes only amplifies the costs and uncertainties.

Even under optimistic assumptions, the economic impact of S. 2191 is likely to be serious for the job market, household budgets, energy prices, and the economy overall. The burden will be shouldered by the average American. The bill would have the same effect as a major new energy tax -- only worse. In the case of S. 2191, increases in the tax rate are set by forces beyond legislative control. Under a realistic set of assumptions, the impact would be severe. More significant than the wealth destroyed by S. 2191 is the wealth transferred from the energy-using public to a list of selected special interests. The reported concluded that, overall, S. 2191 would likely be -- by far -- the most expensive environmental undertaking in history.

American Council for Capital Formation and National Association of Manufacturers, 2008

The American Council for Capital Formation (ACCF) and the National Association of Manufacturers (NAM) commissioned this report by SAIC to examine the potential costs that enactment of the Lieberman-Warner (LW) Climate Security Act (S. 2191) would impose on the U.S. economy.[36] They felt that the cost to U.S. consumers and employers of implementing GHG emission reductions is highly dependent on the market penetration achieved by key technologies and the availability of carbon offsets by 2030. Understanding the potential economic impacts at the national, state, and individual household levels can help guide choices on policy to minimize the impacts on economic growth and maximize environmental benefits. GHG reduction policies should consider impacts on energy security, economic growth, and U.S. competitiveness.

The ACCF/NAM analysis was conducted using EIA's NEMS model, and the study applied assumptions about the cost and availability of new energy technologies, oil prices, and other key factors. It found substantial and growing impacts to consumers and the economy of meeting the increasingly stringent emission targets through 2030 established by LW. Among the study's major findings are:

- The CO_2 emissions allowance price needed to reduce energy use to meet the S.2191 targets is estimated at $55 to $64/mt$CO_2$ in 2020, rising to between $227 to $271/mt$CO_2$ in 2030.
- The cost of the allowances raises energy prices for residential consumers by: Natural gas -- 26 percent to 36 percent in 2020, and 108 percent to 146 percent in 2030; Electricity -- 28 percent to 33 percent in 2020, and 101 percent to 129 percent in 2030.
- These increased costs slow the economy by $151 - $210 billion in 2020 and $631 - $669 billion in 2030 (2007 dollars). This causes job losses of 1.2 - 1.8 million in 2020 and 3 - 4 million by 2030.
- Manufacturing slows: The value of shipments falls by 3.2 percent to 4 percent in 2020 and in 2030 by 8.3 - 8.5 percent. Higher energy costs, lower economic activity, and fewer jobs in turn lowers

[36] The American Council for Capital Formation and the National Association of Manufacturers, *Analysis of the Lieberman-Warner Climate Security Act (S. 2191) Using the National Energy Modeling System (NEMS/ACCF/NAM)*, report prepared by SAIC, March 2008.

average household income by $739 - $2,927 in 2020 and between $4,022 and $6,752 in 2030 (2007 dollars).

Obtaining allowances becomes a cost of doing business for firms subject to the CO_2 cap. However, those firms would not ultimately bear most of the costs of the allowances. Instead, they would pass along most costs to their customers in the form of higher prices. By attaching a cost to CO_2 emissions, a cap-and-trade program would thus lead to price increases for energy and energy-intensive goods and services. Such price increases would stem from the restriction on emissions and would occur regardless of whether the government sold emission allowances or gave them away. The price increases would be essential to the success of a cap-and-trade program because they would be the most important mechanism through which businesses and households were encouraged to make investments and behavioral changes that reduced CO_2 emissions. The rise in prices for energy and energy-intensive goods and services would be regressive and would impose a larger burden, relative to income, on low-income households than on high-income households.

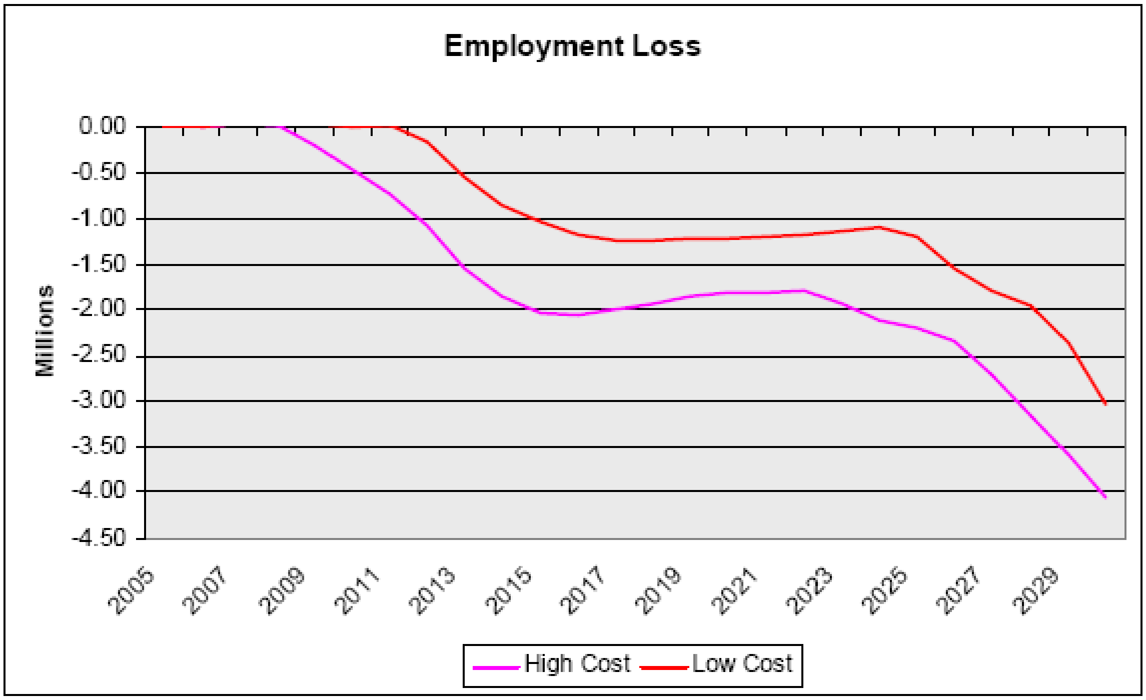
The ACCF/NAM analysis investigated the sensitivity of assumptions that have proven in the past to significantly impact the cost of limiting CO_2 emissions from energy – particularly the availability of improved technology in the early decades of a long-term effort to reduce GHGs. These assumptions include the availability of nuclear power technology, the availability of CCS for coal and natural gas-based power generation technologies, the availability of wind and biomass technologies, and the availability of low-cost offsets (international and domestic).

The study's key finding is that S. 2191 would cause significant employment loss due to the loss of revenues resulting from higher fuel and electricity costs. In 2020, job loss is projected to range from 1.2 million to 1.8 million jobs/year, and from 3 million jobs to 4 million jobs in 2030. Under S. 2191 the U.S. economy would begin to shed approximately 850,000 jobs a year by 2014 under the low cost scenario (Figure III-9). This is primarily a result of higher carbon prices resulting in higher fuel costs for industry and higher cost to industry to comply with emissions limits. As the cap becomes more restrictive and the economy has less freedom to deal with reducing emissions, carbon prices and fuel prices increase rapidly, leading to greater job losses of between 1.2 and 1.8 million jobs in 2020 and between 3 and 4 fewer million jobs in 2030. These job losses are net of the new jobs which may be generated by increased spending on renewable energy, energy efficiency, and carbon capture and storage.

III.B. U.S. Energy Information Administration Reports

EIA has conducted numerous studies of the impact of climate change legislation. Several of the more notable of these are summarized below.

Figure III-9
Estimated Job Losses from Lieberman-Warner



Source: American Council for Capital Formation and National Association of Manufacturers, 2008.

EIA, August 2009

This report examined the energy-related provisions in ACESA that can be analyzed using EIA's National Energy Modeling System (NEMS).[37] The Reference Case used as the starting point for the analysis was an updated version of the *Annual Energy Outlook 2009* (*AEO2009*) Reference Case issued in April 2009. Key provisions of ACESA analyzed include:[38]

- The GHG cap-and-trade program for gases other than HFCs,
- The combined efficiency and renewable electricity standard
- The CCS demonstration and early deployment program
- Federal building code updates
- Federal efficiency standards for lighting and other appliances
- Technology improvements
- The smart grid peak savings program

[37]U.S. Energy Information Administration, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009*, SR/OIAF/2009-05 August 2009.
[38]EIA did not address all the provisions of ACESA, and its analysis did not account for any possible health or environmental benefits that might be associated with curtailing GHG emissions.

While the emissions caps decline through 2050, the modeling horizon in this report runs only through 2030, the projection limit of NEMS.[39] EIA prepared a range of analysis cases, and the six main analysis cases focused on two key areas of uncertainty that impact the analysis results. First, the role of offsets is a large area of uncertainty in any analysis of ACESA. The 2-BMT annual limit on total offsets in ACESA is equivalent to 1/3 of total energy-related 2008 GHG emissions and represents nearly six times the projected growth in energy-related emissions through 2030.

The other major area of uncertainty involves the timing, cost, and public acceptance of low- and no-carbon technologies. For the period prior to 2030, the availability and cost of low- and no-carbon baseload electricity technologies, such as nuclear power and fossil with CCS, which can potentially displace a large amount of conventional coal-fired generation, is a key issue. However, technology availability over an extended horizon is a two-sided issue. R&D breakthroughs over the next two decades could expand the set of reasonably priced and scalable low- and no-carbon energy technologies, with opportunities for widespread deployment beyond 2030. The achievement of significant near-term progress towards such an outcome, however, could significantly reduce the size of the bank of allowances that covered entities and other market participants would want to carry forward to meet compliance requirements beyond 2030.

The main analysis cases discussed in this report are as follows:[40]

- The ACESA Basic Case assumed that key low-emissions technologies, including nuclear, fossil with CCS, and renewables, are deployed in a timeframe consistent with the emissions reduction requirements and that use of offsets is not constrained.
- The ACESA Zero Bank Case is similar to the Basic Case except that no banked allowances are held in 2030.
- The ACESA High Offsets Case is similar to the Basic Case except that it assumed the near immediate use of international offsets.
- The ACESA High Cost Case is similar to the Basic Case except that the costs of nuclear, coal with CCS, and biomass are assumed to be 50 percent higher.
- The ACESA No International Case is similar to the Basic Case, but assumed that the use of international offsets is severely limited.
- The ACESA No International/Limited Case combined the treatment of offsets in the ACESA No International Case with an assumption that deployment of key technologies cannot expand beyond their Reference Case levels through 2030.

[39]As in EIA analyses of earlier cap-and-trade proposals, the need to pursue higher-cost emissions reductions beyond 2030, driven by tighter caps and continued economic and population growth, can be analyzed by assuming that a positive bank of allowances is held at the end of 2030 in all but one case.
[40]EIA also discussed a number of additional analysis cases, including an enhanced CAFE standards case, a 5-percent discount case, a case with limitations to the penetration of nuclear, CCS, and biomass gasification, an accelerated energy technology case, and a higher level of allowance banking case.

EIA found that the reduction in covered emissions is exceeded by the amount of compliance generated through offsets in most of the main analysis cases. Cumulative compliance between 2012 and 2030 ranges from 24.4 BMT to 37.6 BMT CO_2-equivalent emissions in the main analysis cases, representing a 21 - 33 percent reduction from the cumulative covered emissions projected in the Reference Case.

Most reductions in energy-related emissions are expected to occur in the electric power sector. Across the ACESA main cases, the electricity sector accounts for between 80 and 88 percent of the total reduction in energy-related CO_2 emissions in 2030. Reductions in electricity-sector emissions are primarily achieved by reducing conventional coal-fired generation and increasing the use of no- or low-carbon generation technologies. In addition, a portion of the electricity-related CO_2 emissions reductions results from reduced electricity demand. If new nuclear, renewable, and fossil plants with CCS are not deployed in a timeframe consistent with emissions reduction requirements under ACESA, covered entities respond by increasing their use of offsets and by increasing natural gas use to offset reductions in coal generation.

Emissions reductions from changes in fossil fuel use in the residential, commercial, industrial, and transportation sectors are small relative to those in the electric power sector. Taken together, changes in fossil fuel use in these sectors account for between 12 percent and 20 percent of the total reduction in energy-related CO_2 emissions relative to the Reference Case in 2030.

GHG allowance prices are sensitive to the cost and availability of emissions offsets and low-and no-carbon generating technologies. Allowance prices in the ACESA Basic Case are projected at $32/mt in 2020 and $65/mt in 2030. Across all main analysis cases, allowance prices range from $20/mt to $93/mt in 2020 and from $41/mt to $191/mt (2007 dollars) in 2030.

ACESA increases energy prices, but effects on electricity and natural gas bills are mitigated through 2025 by the allocation of free allowances to utilities. Electricity prices in five of the six main ACESA cases range from 9.5¢/kWh to 9.6¢/kWh in 2020, only 3 to 4 percent above the Reference Case level. Average impacts on electricity prices in 2030 are projected to be substantially greater and in 2030 range from 10.7¢/kWh to 17.8 ¢/kWh. ACESA thus increases the cost of using energy, which reduces real economic output and purchasing power, and lowers aggregate demand. The result is that projected real GDP generally falls relative to the Reference Case. Total discounted GDP losses over the 2012 to 2030 time period are $566 billion (-0.3 percent) in the ACESA Basic Case, with a range from $432 billion (-0.2 percent) to $1,897 billion (-0.9 percent) across the main ACESA cases (Table III-4).

Consumption and energy bill impacts can also be expressed on a per household basis. In 2020, the reduction in household consumption is $134 (2007 dollars) in the ACESA Basic Case, with a range of $30 to $362 across all main ACESA cases. In 2030, household consumption is reduced by $339 in the ACESA Basic Case, with a range of $157 to $850 across all main ACESA cases.

Table III-4
Macroeconomic Impacts of ACESA Cases Relative to the Reference Case
(billion 2000 dollars, except where noted)

	Basic	Zero Bank	High Offsets	High Cost	No International	No Int / Limited
Cumulative Real Impacts 2012-2030 (present value using 4-percent discount rate)						
GDP						
Change	-566	-432	-523	-781	-717	-1897
Percent Change	-0.3%	-0.2%	-0.2%	-0.4%	-0.3%	-0.9%
Consumption						
Change	-273	-196	-252	-384	-323	-988
Percent Change	-0.2%	-0.1%	-0.2%	-0.3%	-0.2%	-0.7%
Industrial Shipments (excludes services)						
Change	-910	-753	-480	-958	-1720	-2877
Percent Change	-1.0%	-0.8%	-0.5%	-1.1%	-1.9%	-3.2%
Nominal Revenue Collected 2012-2030[a]	2971	1292	1332	2299	3462	6350
2020 Impacts (not discounted)						
GDP						
Change	-50	-19	-26	-70	-34	-112
Percent Change	-0.3%	-0.1%	-0.2%	-0.5%	-0.2%	-0.7%
Consumption						
Change	-21	-7	-11	-30	-15	-64
Percent Change	-0.2%	-0.1%	-0.1%	-0.3%	-0.1%	-0.6%
Industrial Shipments (excludes services)						
Change	-68	-54	-32	-69	-108	-186
Percent Change	-1.0%	-0.8%	-0.5%	-1.0%	-1.6%	-2.8%
Nominal Revenue Collected[a]	71	44	46	79	118	215
2030 Impacts (not discounted)						
GDP						
Change	-161	-104	-120	-214	-226	-453
Percent Change	-0.8%	-0.5%	-0.6%	-1.1%	-1.1%	-2.3%
Consumption						
Change	-63	-36	-50	-97	-69	-180
Percent Change	-0.4%	-0.3%	-0.4%	-0.7%	-0.5%	-1.3%
Industrial Shipments (excludes services)						
Change	-183	-125	-87	-198	-338	-506
Percent Change	-2.5%	-1.7%	-1.2%	-2.7%	-4.6%	-6.8%
Nominal Revenue Collected[a]	330	205	211	367	556	1030

Source: U.S. Energy Information Administration, 2009.

EIA, April 2008

This report was a response to a request from Senators Lieberman and Warner for an analysis of S. 2191, the Lieberman-Warner Climate Security Act of 2007, a complex bill regulating emissions GHGs through market-based mechanisms, energy efficiency programs, and economic incentives.[41] To analyze the provisions of S. 2191, several alternative cases were prepared:

[41]U.S. Energy Information Administration, *Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007*, SR/OIAF/2008-01, April 2008.

- The S. 2191 Core Case assumed that key low-emissions technologies, including nuclear, fossil with CCS, and various renewables, are deployed in a timeframe consistent with the emissions reduction requirements.
- The S. 2191 No International Offsets Case, is similar to the S. 2191 Core Case, but assumed that use of international offsets is limited.
- The S. 2191 High Cost Case is similar to the S.2191 Core Case except that the costs of nuclear, coal with CCS, and biomass are assumed to be 50 percent higher than in the Core Case.
- The S. 2191 Limited Alternatives Case assumes the deployment of key technologies, including nuclear, fossil with CCS, and various renewables, is held to their Reference Case level through 2030, as are imports of LNG.

EIA's key findings included the following:

- S. 2191 significantly reduces projected GHG emissions compared to the Reference Case. Projected covered emissions in the S. 2191 cases, net of offsets, are 27 percent to 36 percent lower in 2020 and 45 percent to 56 percent lower in 2030.
- The electric power sector accounts for most of the emissions reductions, with new nuclear, renewable, and fossil plants with CCS serving as the key compliance technologies. Electric power accounts for 82 - 87 percent of energy-related CO_2 emissions reductions in 2020 and 82 - 92 percent of such reductions in 2030.
- If new nuclear, renewable, and fossil plants with CCS are not deployed rapidly enough, covered entities are projected to turn to increased natural gas use to offset reductions in coal generation, resulting in markedly higher delivered prices of natural gas.
- Emissions reductions in the residential, commercial, industrial, and transportation sectors are small relative to those in the electric power sector, and energy price increases are not large enough to induce consumers to make large changes in their energy use.
- Coal consumption is significantly reduced, and total coal consumption in 2030 ranges between 62 and 89 percent below the Reference Case level.
- GHG allowance prices are sensitive to the cost and availability of low-carbon generating technologies and emissions offsets. Estimated allowance prices range from \$30 to \$76/mtCO_2e in 2020 and from \$61 to \$156/mtCO_2e in 2030.
- S. 2191 increases energy prices and energy bills for consumers. Relative to the Reference Case, the price of using coal for power generation is 161 - 413 percent higher in 2020 and 305 - 804 percent higher in 2030. The price of electricity is 5 - 27 percent higher in 2020 and 11 - 64 percent higher in 2030. Under S. 2191,

average annual household energy bills, excluding transportation costs, are $30 - $325 higher in 2020 and $76 - $723 higher in 2030.

- S. 2191 increases the cost of using energy, which reduces real economic output, reduces purchasing power, and lowers aggregate demand, and GDP falls relative to the Reference Case. Adverse economic impacts increase over time, and discounted GDP losses, 2009 – 2030, range from $444 billion (-0.2 percent) to $1,308 billion (-0.6 percent) -- Table III-5.
- S. 2191 impacts industrial activity, including manufacturing, to a greater extent than the overall economy. Industrial shipments in 2030 are reduced by $233 - $589 billion (-2.9 to -7.4 percent).

Table III-5
Macroeconomic Impacts of S. 2191 Cases and S. 1766 Update Cases
(billion 2000 dollars, except where noted)

	S. 2191 Cases					
	Core	High Cost	Limited Alternatives	No International Offsets	Limited Alternatives No International	S1766 Update
Cumulative Real Impacts 2009-2030 (Present Value using 4% Discount Rate)						
GDP						
Change	(444)	(729)	(912)	(546)	(1,306)	(66)
Percent Change	-0.2%	-0.3%	-0.4%	-0.2%	-0.6%	-0.03%
Consumption						
Change	(558)	(785)	(946)	(780)	(1,422)	(145)
Percent Change	-0.3%	-0.5%	-0.6%	-0.5%	-0.9%	-0.1%
Industrial Shipments (excludes services)						
Change	(1,340)	(1,723)	(2,031)	(2,430)	(3,684)	(722)
Percent Change	-1.3%	-1.7%	-2.0%	-2.4%	-3.6%	-0.7%
Nominal Revenue collected 2012-2030[a]	2,851	3,650	4,282	4,416	7,659	987

Source: U.S. Energy Information Administration, 2008.

EIA, January 2007

This EIA report responded to a request from Senators Bingaman, Landrieu, Murkowski, Specter, Salazar, and Lugar for an analysis of a proposal that would regulate GHG emissions through a cap-and-trade system. The proposal was modeled using NEMS and compared to the reference case projections from the *Annual Energy Outlook 2006* (AEO 2006).[42] The major findings included:

- The proposal leads to lower GHG emissions, but the intensity reduction targets are not fully achieved after 2025.

[42]U.S. Energy Information Administration, *Energy Market and Economic Impacts of a Proposal to Reduce Greenhouse Gas Intensity With a Cap and Trade System*, SR/OIAF/2007-01, January 2007.

- Relative to the reference case, covered GHG emissions less offsets are 562 $MMTCO_2e$ (7.4 percent) lower in 2020 and 1,259 $MMTCO_2e$ (14.4 percent) lower in 2030 in the Phased Auction case. Covered GHG emissions grow by 24 percent between 2004 and 2030, about half the increase in the reference case.
- Initially, when allowance prices are relatively low, reductions in GHG emissions outside the energy sector are the predominant source of emissions reductions. By 2030, the reduction in energy related CO_2 emissions account for most emissions reductions.
- In 2004 dollars, the allowance prices rise from $\$3.70/mtCO_2$ in 2012 to the safety valve price of $\$14.18/mtCO_2$ in 2030.
- The cost of GHG allowances is passed through to consumers, raising the price of fossil fuels charged and providing an incentive to lower energy use and shift away from fossil fuels.
- The average delivered price of coal to power plants in 2020 increases from $1.39/MMBTU in the reference case to $2.06, an increase of 48 percent. By 2030 the change grows from $1.51/ MMBTU to $2.73/ MMBTU, an increase of 81 percent.
- Electricity prices are lower in the Phased Auction case than in the Full Auction case because the Phased Auction provides a portion of the allowances to the electric power sector for free.
- Relative to the reference case, annual per household energy expenditures in 2020 are 2.6 percent ($41) higher in the Phased Auction case and 3.6 percent ($58) higher in the Full Auction case. By 2030, projected annual household energy expenditures range from 7.0 percent to 8.1 percent ($118 to $136) higher.
- Coal use is projected to continue to grow, but at a much slower rate than in the reference case. Total energy from coal increases by 23 percent between 2004 and 2030, less than half the 53 percent increase projected in the reference case.
- The proposal significantly increases nuclear capacity additions and generation. The projected 47 GW increase in nuclear capacity between 2004 and 2030 allows nuclear to continue to provide about 20 percent of U.S. electricity in 2030.
- The proposal adds significantly to renewable generation. In the reference case, renewable generation is projected to increase from 358 BkWh in 2004 to 559 BkWh in 2030.
- Retail gasoline prices in 2030 are 11 ¢/gal higher in 2030, leading to modest changes in vehicle purchase and travel decisions.
- The Phased Auction and Full Auction cases have similar energy market impacts, but the macroeconomic impacts differ – Table III-6.
- In the Phased Auction case, wholesale energy prices rise steadily and, by 2030, are 12 percent above the reference case levels. This represents 8 percent higher energy prices at the consumer level by 2030 and a 1 percent increase in the CPI.

- In the Phased Auction case, discounted total GDP (2000 dollars) over the 2009-2030 time period is $232 billion (0.10 percent) lower than in the reference case, while discounted real consumer spending is $236 billion (0.14 percent) lower. In 2030, in the Phased Auction case, real GDP is $59 billion (0.26 percent) lower and consumption expenditures are $55 billion (0.36 percent) lower.

Table III-6
Economic Impacts of Phased and Full Auction Cases

Projection	2004	2020			2030		
		AEO2006 Reference	Phased Auction	Full Auction	AEO2006 Reference	Phased Auction	Full Auction
Allocation of Allowance Revenue (billion nominal dollars)							
Private Spending	-	-	39.0	0.0	-	58.6	0.0
States	-	-	21.4	0.0	-	54.9	0.0
Government Spending	-	-	0.0	0.0	-	0.0	0.0
Debt Reduction	-	-	13.3	73.7	-	86.4	199.9
Total Revenue	-	-	73.7	73.7	-	199.9	199.9
Aggregate Prices in the Economy							
WPI – Fuel & Power (1982 =1.0)	1.27	1.77	1.88	1.88	2.49	2.79	2.79
CPI – Energy (1982/84 = 1.0)	1.51	2.19	2.27	2.28	2.96	3.20	3.20
CPI – All Urban (1982/84 = 1.0)	1.89	2.86	2.88	2.87	3.78	3.82	3.80
Inflation Rate, Unemployment Rate and the Federal Funds Rate (percent)							
Inflation	2.68	3.06	3.13	3.10	2.67	2.68	2.68
Unemployment Rate	5.53	4.37	4.44	4.46	4.90	5.01	5.02
Federal Funds Rate	1.35	5.24	5.24	5.16	5.04	4.96	4.86
Components of GDP (billion 2000 dollars)							
GDP	10,756	17,541	17,520	17,503	23,112	23,053	23,018
Disposable Income	8,004	13,057	13,037	12,991	17,562	17,468	17,367
Consumption	7,589	11,916	11,898	11,880	15,352	15,298	15,247
Investment	1,810	3,293	3,291	3,288	4,985	4,990	4,973
Government	1,952	2,464	2,474	2,464	2,838	2,861	2,839
Exports	1,118	3,776	3,759	3,765	6,833	6,785	6,813
Imports	1,719	3,659	3,660	3,647	6,156	6,165	6,121

Source: U.S. Energy Information Administration, 2008.

EIA, June 2003

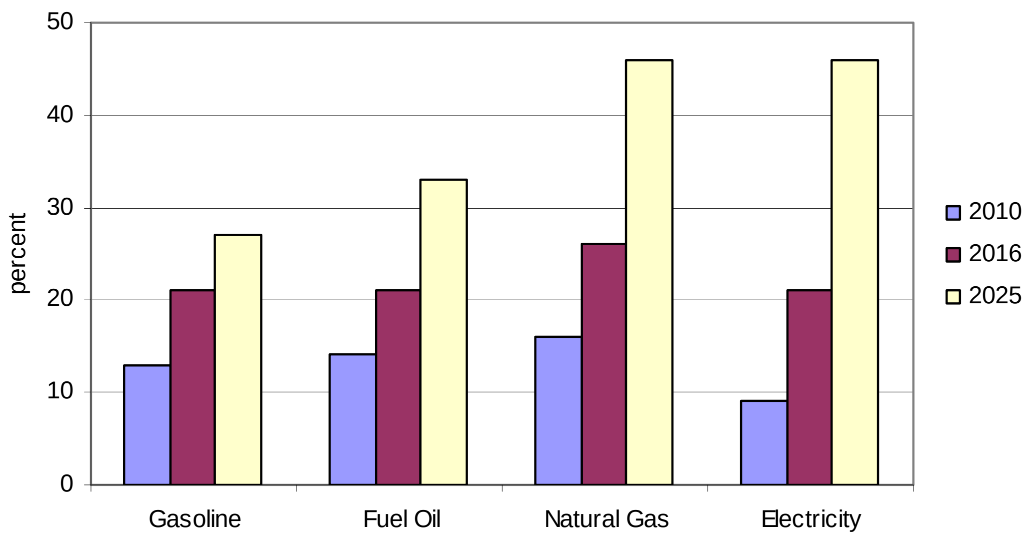
In 2003, Senators John McCain and Joseph Lieberman introduced S. 139, the Climate Stewardship Act of 2003, that proposed a mandatory GHG emissions reduction program. EIA analyzed the impacts of S. 139 on the nation's energy markets and the economy and estimated that they would be significant.[43] The Bill's impact on the U.S. energy sector would be increasingly severe; as shown in Figure III-10:

- In 2010, the national average price of electricity would be nine percent higher than it would be in the absence of McCain-Lieberman; by 2025 the price would be 46 percent higher.

[43]U.S. Energy Information Administration, *Analysis of S.139, the Climate Stewardship Act of 2003*, SR/OAIF/2003-02, June 2003.

- In 2010, the national average price of natural gas would be 16 percent higher than it would be in the absence of McCain-Lieberman; by 2025, the natural gas price would be 46 percent higher.
- In 2010, the national price of fuel oil would be 14 percent higher; by 2025, fuel oil would be 33 percent higher.
- In 2010, the national average price of gasoline would be 13 percent higher; by 2025 it would be 27 percent higher.

Figure III-10
Increases in U.S. Energy Costs Resulting from the McCain-Lieberman Bill



Source: U.S. Energy Information Administration, 2003.

EIA found that the repercussions of these impacts would be felt throughout the entire U.S. economy. As illustrated in Figure III-11, the immediate macroeconomic effects would include:

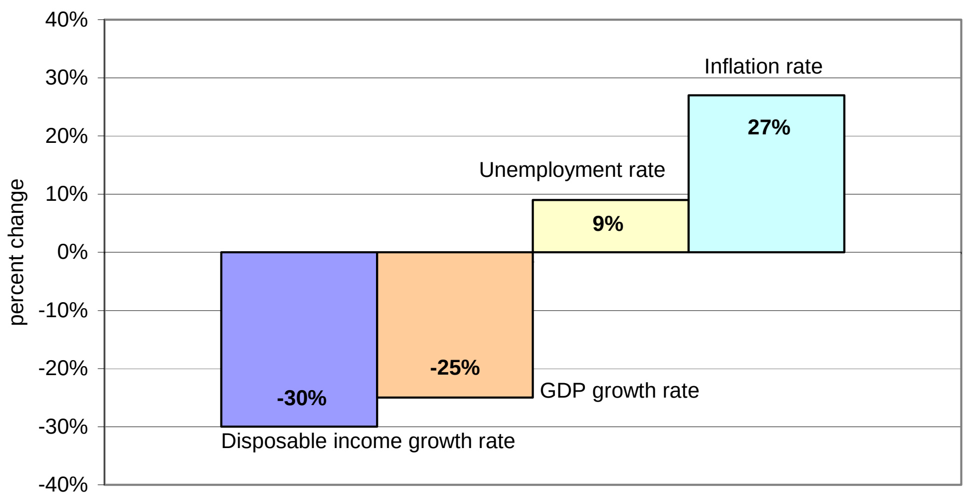
- A decrease of 25 percent in the rate of growth of U.S. GDP and of 30 percent in the rate of growth of disposable income
- A nine percent increase in the U.S. unemployment rate
- A 27 percent increase in the U.S. inflation rate

The impacts would be so large as to, cumulatively, result in a loss of nearly $1.6 trillion (2002 dollars) in GDP and $2,800 (2002 dollars) in disposable income to every person in the U.S.

EIA, October 1998

This study was a comprehensive assessment of the Kyoto Protocol.[44] EIA reported that, under the worst-case scenario, electricity prices could increase 86 percent and the average price of gasoline could increase by as much as 66 cents per gallon by 2010 if the U.S. complies with provisions of the Kyoto climate change treaty. The study found that the Kyoto accord will cost the average household between $335 and $1,740 per year, but that the treaty's impact on energy costs would depend on whether nations agree to an emissions trading system.

Figure III-11
Near-Term (2010-2012) U.S. Economic and Job Impacts of the McCain-Lieberman Bill



Source: U.S. Energy Information Administration, 2003.

The study also estimated that prices of carbon-based fuels will decline as more efficient technologies are developed. EIA's estimates were much higher than those in a report released in March 1988 by the White House Council of Economic Advisers, which concluded that compliance with the treaty would cost the average household between $70 and $110 annually.[45] EIA assumed lower economic growth at the beginning of the agreement than did CEA, and this led to higher projected costs. But the extent of the price increases depended on several factors, including emissions trading and whether consumers are able choose their electricity suppliers.

EIA predicted that consumers would reduce their energy consumption by four percent to 18 percent by 2010 as a result of more efficient equipment and electricity deregulation, and that emissions trading will play a major role in determining the costs

[44]U.S. Energy Information Administration, *Impacts of the Kyoto Protocol on U.S. Energy Markets and the U.S. Economy*, October 1998.
[45]White House Council of Economic Advisers, *The Kyoto Protocol and the President's Policies to Address Climate Change*, July 1998.

of the Kyoto agreement. Under emissions trading, nations that produce greenhouse gases above levels prescribed by the agreement could purchase credits from countries that are below the targets, and "If the United States cannot purchase permits, GDP could fall between $130 billion and $270 billion." EIA projects that GDP will increase to $10 trillion in 2010, compared to $7 trillion in 1998. Coal is expected to suffer the most under the Kyoto accord, and the price for a ton of coal could increase between 153 percent and 800 percent by 2010. This steep increase is expected to lead to a decline in coal demand of 18 percent to 77 percent, and the report found that electric utility demand for coal could decrease from as little as two percent to as much as 77 percent.

Renewable energy and natural gas are expected to compensate for the decline in coal usage. The report stated that gas demand will rise 12 percent above pre-Kyoto projections and that the outlook for renewables is also expected to be more favorable than previous estimates, with energy from wind, solar, and other technologies capturing 22 percent of the power market. Previous EIA estimates predicted renewables would account for nine percent of energy usage by 2010.

III.C. Legacy Studies

Natural Resources Defense Council, 2005

In 2005, NRDC analyzed the jobs impact of the Climate Stewardship Act of 2004 (CSA) -- the McCain-Lieberman bill.[46] The CSA would limit total U.S. emissions of carbon dioxide and five other heat-trapping gases through a tradable permit system. The study found that CSA would have an overall positive effect on U.S. employment.

To assess the employment impacts of the CSA, NRDC used NEMS, augmented by other modeling tools. These systems were used to estimate the impact of the CSA and associated policies on energy prices and costs, investment levels, permit prices, and other energy-related variables. The study then estimated the outcomes of these changes on labor demand in 192 industries through the use of a Leontief input-output model developed by the U.S. Bureau of Labor Statistics. These outcomes were estimated for the period 2010 to 2025, and the employment changes for 192 industries were distributed to the 50 states and the District of Columbia.

NRDC found that CSA creates a small net increase in U.S. employment (Table III-7). At the national level, jobs created outweigh jobs lost by a factor of five by 2015, rising to nearly seven to one by 2025. In the early years of the program, the employment change is near zero (slightly negative) due to the fact that the cost of emissions reductions are already immediately apparent, while the positive effects of energy savings from efficiency policies occur over a longer period. In subsequent years, abatement costs continue to increase gradually; however, since the benefits of energy efficiency improvements increase more rapidly, annual savings in energy costs start to exceed the annual cost of achieving those savings by 2013. This causes an

[46] Natural Resources Defense Council, *Jobs And The Climate Stewardship Act: How Curbing Global Warming Can Increase Employment*, February 2005.

increase in disposable income, which creates jobs as consumers purchase more goods and services other than energy.

Table III-7
Estimated Impact of the Climate Stewardship Act on U.S. Employment

Year	Employment change, policy case minus base case (1000s)	Employment change, percent
2010	-20	-0.01 %
2015	510	0.31 %
2020	602	0.37 %
2025	801	0.48 %

Source: Natural Resources Defense Council, 2005.

Nationally, the largest job gains in absolute terms are in construction, wholesale and retail trade, medical services, and other services. Each of these sectors gains more than 100,000 jobs by 2025, relative to the base case. Similarly, in the manufacturing sector as a whole, jobs increase every year, by an amount ranging from near zero in 2010 to 0.5 percent in 2025. The transition to cleaner, more efficient energy technologies entails job losses in coal mining, oil and gas drilling and refining, electrical generation, and railway transport. The largest losses in absolute terms are in electrical generation, while the largest losses in percentage terms are in coal mining. To mitigate these negative effects of the transition, CSA incorporates incentives for the deployment of advanced coal technologies and transition assistance for displaced workers and adversely affected communities. State employment changes generally follow the pattern of the national changes, with variations that come from the relative importance of different industries in different states. Table III-8 presents the results in 2015 for the 25 states projected to have the largest absolute employment changes. NRDC argued that previous estimates of the likely employment consequences of the CSA have been based on unrealistic economic assumptions, and that when a more realistic policy package is examined, positive employment outcomes appear more likely.

Early Studies of the Impact of the Kyoto Protocol

A number of analyses of the likely impacts of GHG emissions control on the U.S. economy have been conducted in conjunction with assessment of the Kyoto Protocol. Under the December 1997 Kyoto Protocol, industrialized nations agreed to reduce GHG emissions during the 5-year period 2008-2012 to levels that, on average, are 5.2 percent below their 1990 levels. Studies of the potential economic impact of the Kyoto Protocol have been conducted by the Federal government and by private industry, and, as noted, EIA has conducted the most comprehensive government assessment of the Kyoto Protocol.[47]

[47] *Impacts of the Kyoto Protocol on U.S. Energy Markets and the U.S. Economy*, op. cit.

Table III-8
Impact of CSA on Employment in 25 States

State	Job creation (number)	Job creation (%)
California	62,266	0.33%
New York	35,598	0.34%
Texas	32,648	0.29%
Florida	29,187	0.31%
Illinois	23,082	0.32%
Ohio	22,750	0.34%
Pennsylvania	21,362	0.32%
Michigan	18,991	0.34%
North Carolina	15,431	0.32%
Georgia	15,427	0.33%
New Jersey	15,386	0.31%
Massachusetts	13,690	0.33%
Virginia	13,411	0.31%
Indiana	11,536	0.32%
Wisconsin	11,437	0.35%
Minnesota	11,267	0.36%
Missouri	11,009	0.33%
Washington	10,242	0.29%
Tennessee	10,070	0.31%
Maryland	9,799	0.30%
Arizona	9,563	0.33%
Colorado	8,680	0.32%
South Carolina	7,078	0.29%
Connecticut	6,905	0.32%
Oregon	6,629	0.32%
National	**510,317**	**0.31%**

Source: Natural Resources Defense Council, 2005.

Other studies – conducted by the White House Interagency Analytical Team[48], WEFA, Inc.[49], Resources Data International50, Charles Rivers Associates[51], and CONSAD Research Corporation[52] -- estimated the economic effects on the U.S. of reducing GHG emissions under the Kyoto Protocol would be severe and are

[48]*Economic Costs of Stabilizing U.S. Greenhouse Gas Emissions*, Interagency Analytical Team, July 1997.
[49] *Global Warming: The Economic Cost of Early Action,* WEFA, Inc., October 1997.
[50]*The Economic Risks of Reducing the U.S. Electricity Supply,* Resources Data International, November 1997.
[51]*Economic Costs of Global Warming Initiatives,* Charles Rivers Associates, November 1997.
[52]*The Kyoto Protocol: A Flawed Treaty Impacts America, Sectoral and Regional Economic Impact Analysis*. CONSAD Research Corporation, May 1998.

summarized in Table 1. Each study forecast substantial negative impacts on the economy from Kyoto. The three most comprehensive studies were conducted by EIA, WEFA, and CONSAD, and all three analyses predicted severe economic consequences: Losses in GDP in the range of $250 billion to $300 billion, and employment losses in the range of two to three million jobs.

Table 1
Comparison of Estimates of the Impact of the Kyoto Protocol on the U.S. Economy in 2010

	Impact on GDP (billions of dollars)	Impact on Employment (thousands of workers)
White House Interagency Analytical Team	- $20 to $100	--
Energy Information Administration	- $95 to – $375	- 700 to - 2,300
WEFA, Inc.	- $250	- 2,400
Resources Data International	"$1.3 trillion at risk"	--
Charles River Associates	- $90	--
CONSAD Research Corporation	- $300	- 3,200

Source: Management Information Services, Inc., 2009.

Economic Policy Institute, 2002

This EPI study assessed the impact of an alternative approach to climate and energy policy.[53] Based on a review of the literature and of the experience of other nations, it assembled a set of policies that would provide moderate but steady increases in energy efficiency and reductions in carbon emissions, while improving overall economic efficiency. It then estimated the macroeconomic impact of these policies. This alternative policy package has four main elements:

- A modest carbon/energy tax on major energy sources, with most of the revenues returned through cuts in taxes on wages
- A set of policies to promote the development of new energy-efficiency and renewable energy technologies;
- Policies to offset competitive impacts on energy-intensive industries
- Transitional assistance to compensate any workers and communities harmed by the policies.

The policy package is self-funding in that the costs of the transition fund as well as the administration of the technology policies are paid entirely by the tax receipts it generates. The package was designed to minimize the burden on workers and consumers and provide help for those who would suffer if energy production were reduced. The package modeled here stands apart from other studies in the U.S. literature in that it attempts to combine the best elements of a market-based approach, policies to promote investment and technology, competitiveness policies, and equity

[53] James P. Barrett and J. Andrew Hoerner, *Clean Energy and Jobs: A Comprehensive Approach to Climate Change and Energy Policy*, Economic Policy Institute, 2002.

concerns. This study also incorporated the insights of engineering-based analysis of the potential of specific technologies into a macroeconomic model. Relative to the base case, the analysis estimated that the policy package would have the following results:

- U.S. carbon emissions would decline by 27 percent in 2010 and by 50 percent in 2020. Other GHGs and pollutants would also decline.
- GDP would increase 0.24 percent in 2010 and 0.6 percent in 2020.
- An additional 660,000 net jobs would be created in 2010, 1.4 million in 2020. This would increase employment in the service sector and reduce the rate of decline in employment in manufacturing.
- Unemployment would fall and real after-tax wages would rise.
- Oil imports in 2020 would fall from the baseline forecast by an amount slightly higher than current U.S. oil purchases from OPEC.
- Household energy bills would fall every year, by a rising amount.
- The effect on income distribution would be slightly progressive.

However, the study found that these benefits do not come without cost. Employment in coal mining would suffer severely, amounting by 2020 to more than half of all jobs in the coal mining sector. There would also be declines in employment in electric and gas utilities that are numerically larger though smaller in percentage terms. Jobs would also be lost in the production of other fossil fuels and in the rail transportation of coal. Only a portion of this shrinkage can be absorbed by normal turnover. Extremely small job losses were estimated in a few other industries that are either energy-intensive or are suppliers to the energy industries.

Center for a Sustainable Economy and Economic Policy Institute, 2000

This study noted that, because the economy is largely dependent on the consumption of fossil fuels that result in carbon emission byproducts, concerns exist about the economy's ability to reduce these emissions without sacrificing output and employment. Organized labor has expressed legitimate concerns about the effects of climate-change policies on jobs. In addition, various vested interests have attempted to influence the debate with predictions of economic disaster if serious carbon-reducing measures are undertaken, and claims of job losses ranging in the millions have been made. Despite these dire predictions, this research indicates that a responsible approach to addressing carbon emissions can avoid the vast majority of these harmful effects, and can even result in benefits for a large majority of the workforce.[54]

The most efficient way to reduce pollution is to make polluters pay for whatever damages they cause. In this case, that would mean either putting a tax on carbon emissions or using a cap-and-trade system, like the one used to reduce sulfur dioxide emissions from electric utilities. A wide array of other policies can also be used in conjunction with carbon pricing to achieve the desired emissions reductions while

[54]Barrett, James P., and J. Andrew Hoerner, *Making Green Policies Pay Off: Responsible Climate-Change Package Can Benefit Environment, Workforce*. Washington, D.C.: Center for a Sustainable Economy and Economic Policy Institute, April 2000.

avoiding most of the predicted economic pain. It is implausible that the government would institute a carbon-pricing policy without including some of these additional policies. In fact, some of those policies are already in place, and European nations have already gone even further toward reducing greenhouse gas emissions.

In addition to the policies that put a price on carbon emissions, a well-designed policy package would also include measures to return to the public the revenue it raises by cutting other taxes; policies to promote energy efficiency and renewable energy technologies; and transitional assistance, providing a remedy that "makes whole" any who might lose their jobs as a result of the climate policy package.

This report first divides the economy into 498 separate industries. By tracing the impacts of the policy package on each industry -- and using an input-output model to determine how those effects would impact other industries – the authors assessed these policies' overall impact as they ripple through the entire economy. This analysis was linked to government forecasts for the economy with the intention of determining how these policies will ultimately affect the economy. The analysis takes into consideration how many workers are employed in each industry and how many of those workers are unionized in an effort to determine employment impacts.

The report's policy package has two components. The first involves a $50 per ton carbon tax (with an equalizing charge on the electricity produced by nuclear power and large-head hydropower). This revenue would be returned through a per-capita cut in labor (payroll) taxes. The second component is a package of energy-efficiency and renewable energy policies. The goal of the analysis is to determine whether a basic climate policy would increase or decrease the demand for workers and for union labor.

The report found that the vast majority of total jobs and of union jobs are in "winner" industries – industries that would see a net reduction in their real cost of production after energy efficiency improvements. However, the widespread benefits are smaller, on average, than the more concentrated losses. But despite the losses, the net effect is positive, and roughly five jobs are created for each job destroyed. Because unionization rates are higher on average in more energy-intensive industries, the positive effect on union jobs is not as strong, but it is still true that four union jobs are created for every three lost.

These results have several important implications. First, those who claim that climate change cannot be addressed without huge economic costs and massive unemployment are wrong. A responsible climate-change policy package can significantly reduce carbon emissions while simultaneously conferring economic by improving energy efficiency and increasing the demand for labor. A second implication is the importance of revenue recycling. Much of the negative impact of carbon/energy taxes is due to the fact that they assume that the revenue will not be recycled through cuts in other taxes. This is why it is critical that the pricing policy be accomplished either by permits that are sold or by energy taxes, not through permits that are given away to industries at no cost. Third, there are some industries that will be hurt by a climate policy, and will require policies to help these industries adapt or provide compensation. Coal mining and oil imports will fall, and some coal miners will lose their jobs, but this report suggests that a generous transition assistance package would cost less than one percent of the annual energy tax or permit revenues.

Thus, while some industries and some workers will be seriously affected by any efforts to reduce carbon emissions, the results reported here show that the predictions of economic disaster overstate the likely size of these effects. In fact, if done correctly, carbon-reducing policies can bring benefits to most of the economy and its workers.

World Wildlife Federation, 1999

In August 1999, the World Wildlife Fund published a study on the potential economic benefits of implementing climate change policies.[55] This study updated an earlier analysis of how the U.S. could reduce CO_2 emissions 20 percent below 1990 levels by 2010, with substantial net savings in the cost of meeting its energy needs.

The WWF study examined a set of integrated policies and measures under baseline projections of U.S. CO_2 emissions which indicate that it will be very difficult to effect emissions reductions relative to 1990 levels. A variety of policies are targeted within each sector of the economy to stimulate more rapid and widespread use of low-carbon resources and advanced, highly efficient energy-using technologies, techniques, and systems. WWF reported that the U.S. could reduce carbon emissions to its Kyoto Protocol target, and to significantly below that target, and that this can be achieved with overall net savings in the costs of energy and energy-using equipment. It contended that the U.S. can reduce carbon emissions 14 percent below 1990 levels by 2010.

WWF estimated that these polices will produce net economic savings and that annual net savings in energy costs would grow steadily over the coming decade. These savings would average about $46 billion per year for reductions in carbon emission to the Kyoto Protocol target of seven percent below 1990 levels by 2010, and about $43 billion per year for reductions to about 14 percent below 1990 levels. This translates into national energy cost savings that increase through 2010, averaging almost $400 per household per year. Moreover, by 2010, wage and salary earnings would increase by $27 billion, with nearly 900,000 net new jobs created, relative to the baseline. The largest estimated job gains are in services and construction, with additional large gains in education, metal durables, miscellaneous manufacturing, transportation and communications, agriculture, finance, and government.

The study estimated that the large net benefits would be widely and evenly distributed. However, it noted that a just transition for some industries that are likely to face near term losses must be found and that planning for a just transition should be guided by the principle of fair treatment of workers and their communities.

[55]World Wildlife Federation, *America's Global Warming Solutions*, report prepared by the Tellus Institute August 1999.

American Petroleum Institute, 1998

This API study found that if the U.S. is to comply with the Kyoto treaty at the cost predicted by the Clinton White House, electric power plants would have to quickly switch from burning coal to natural gas and the U.S. would have to buy almost all of its emissions allowances from other countries. If these conditions cannot be met, the cost of the treaty will be at least ten times higher than the Administration estimated.[56]

The study was designed to replicate the Administration's economic analysis, discern how the White House reached its optimistic cost estimates, and run a revised economic model with assumptions that industry officials believe are more realistic. The treaty would require the U.S. to reduce carbon dioxide and other greenhouse gas emissions to seven percent below 1990 levels by 2012. Industry officials fear that the treaty could have severe impacts on the U.S. economy, raising energy prices and forcing companies to relocate to countries not bound by the treaty's restrictions. However, the Clinton White House argued that the use of flexible, market-based mechanisms such as international emissions trading and advances in technology could nearly negate the costs of implementation.

But according to this report, when the Clinton Administration's climate policy model is run using "perhaps more realistic assumptions" about technology, fuel switching and emissions trading, CO_2 emissions permit costs appear to be about $170 per ton, roughly ten times what the Administration estimated -- the White House Council of Economic Advisers predicted that implementation of the Kyoto treaty could result in a direct cost of $7 billion to $10 billion to the U.S. economy in 2010, which is about 0.1 percent of GDP. CEA also estimated that carbon emissions permits would likely cost $14 to $23 per metric ton. However, this report contended that to get to the Clinton Administration's estimates, the model has to assume that the U.S. will purchase 82 percent to 88 percent of its emissions permits from other countries through an international emissions trading program. In addition, the Clinton Administration's estimates were contingent on having most of the U.S. utility industry switch from coal to natural gas before 2008, the beginning of the Kyoto treaty's first compliance period.

CONSAD Research Corporation, 1998

CONSAD Research Corporation analyzed the Kyoto Protocol and provided a 50-state disaggregation of job losses and economic dislocation that will result due to policies enacted to implement the Protocol.[57] CONSAD's key findings include:

- Consumers and businesses will face higher energy costs.
- Approximately 3.2 million fewer American workers will be working in the year 2010 as a direct result of the Kyoto Protocol.

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[56]American Petroleum Institute, *A Reconstruction and Reconciliation of Administration Estimates*, July 1998.

[57]CONSAD Research Corporation, *The Kyoto Protocol: A Flawed Treaty Impacts America, Sectoral and Regional Economic Impact Analysis*, May 1998.

- U.S. GDP in 2010 will decline by $325 billion (1998 dollars).
- Key strategic industries (aluminum, pulp and paper, chemicals, and others) will experience persistent employment losses as well as losing market share for these products in international markets.
- There will be an employment shift from high-skilled, well paying jobs in manufacturing to lower-skilled, low wage jobs in services.

Global Climate Coalition, 1997

The Global Climate Coalition found that adherence to the Kyoto Protocol's mandatory emissions reductions would result in drastic increases in unemployment and inflation.[58] The report was one of several studies prepared in conjunction with the White House's climate change conference in October 1997, and other preparatory meetings for the UN global climate change convention in Kyoto in December 1997. The report recommended against the emissions caps, arguing that the effects on the U.S. economy would be devastating, and questioned White House statements that the U.S. could maintain GHGs at 1990 levels in 2010 at no cost by using new technology.

GCC found that mandatory goals, based on a $200/mt carbon permit fee necessary to lower emissions to 1990 levels by 2010, could mean a loss of 2.5 percent in real GDP from baseline estimates. The report disaggregated the loss to a per person and per household basis, as well as to its effect on the economies of energy producing states -- particularly those with coal mines, energy-intensive manufacturing states, and states that produce manufactured products for export. On a per person basis, the costs result in a loss in 2010 of $4,838 per person and $42,601 per household. Cumulatively, for 2001 to 2010, the loss of income per household averages $30,000 (1996 dollars).

According GCC, the requirements would increase the price of energy, forcing consumers to pay from 30 percent to 55 percent more by 2010. For example, residential natural gas costs would rise from $6.01 per million BTU (MMBTU) to $9.03 per MMBTU, electricity would rise from $22.64 per MMBTU to $33.76 per MMBTU, gasoline would rise from $10.31 per MMBTU to $13.27 per MMBTU, and price increases would be substantially higher for commercial and industrial customers. These price increases would also cause inflation in the prices of such necessities as food, medical care, and housing in 2010, as compared to base case estimates: Eight percent for food, 10 percent for medical care, and 12 percent for housing.

Union of Concerned Scientists, 1998

This UCS study analyzed a series of reports produced over the past decade that examined the prospects for technologies for energy efficiency and fuels that produce little or no carbon dioxide.[59] UCS stated that "Our survey of these studies shows that

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[58]Global Climate Coalition, *Global Warming: The Economic Cost of Early Action*, report prepared by WEFA, Inc., October 1997.
[59]Union of Concerned Scientists, *A Small Price to Pay: U.S. Action to Curb Global Warming is Feasible and Affordable*, September 1998.

great technological potential exists for the U.S. to significantly reduce its carbon dioxide emissions. Claims that compliance with the Kyoto Protocol would be prohibitively expensive and would seriously harm the American economy are overblown."

The report found that the U.S. could make significant domestic reductions in GHGs at a modest cost or with net savings to the economy and, since these actions would have low costs or no cost, the competitive position of most U.S. industries "would be largely unaffected." UCS noted that studies concluding that the Kyoto Protocol would cost millions of jobs, lower the U.S. standard of living, and reduce GDP "are based upon pessimistic and unrealistic assumptions about energy technologies and the economy itself." Some of these assessments assume that CO_2 emission reductions can only be achieved by imposing high energy taxes. However, UCS contends that the economic impact of such energy levies could be offset by lowering other taxes, such as on investments. These studies also assume that the economy is as energy efficient as possible and ignore barriers to market penetration of cost-effective, clean technology.

The UCS report indicated that the U.S. does not have to "run away from domestic measures" to implement the Kyoto Protocol, and, according to UCS, relying heavily on emission reductions achieved elsewhere to meet to protocol's targets is not a wise foreign policy for the U.S. Such action would make it more difficult for U.S. negotiators to convince developing countries to commit to binding emission limits. In addition, the U.S. would fail to reap the benefits of domestic emission reductions if it met its Kyoto Protocol target by purchasing emission offsets from overseas.

WEFA, 1998

In 1998, WEFA updated its analysis of the effects on the U.S. of meeting the terms of the Kyoto Protocol.[60] It found that implementing the Protocol would:

- Nearly double the cost of energy and electricity prices.
- Raise gasoline prices by about 65 cents per gallon.
- Cost 2.4 million U.S. jobs.
- Reduce U.S. international economic competitiveness.
- Reduce state tax revenues by nearly $100 billion.
- Significantly reduce family income.

WEFA warned that American families can expect dramatic increases in consumer prices and unemployment if the U.S. adopts an international climate agreement requiring mandatory reductions of GHGs. According to the analysis, mandatory emission goals could result in a loss of GDP equal to $310 billion (1992 dollars) in 2010 alone. On a per-person basis, the Kyoto Protocol would mean a net economic loss of $2,728 per household in 2010. The study also found that 2.4 million American jobs would be lost by 2010 as a result of the treaty. Under the Kyoto restrictions on U.S. emissions, WEFA predicts that

[60]WEFA, Inc., *Global Warming: The High Cost of the Kyoto Protocol*, June 1998.

grocery bills will be nine percent higher, medical bills 11 percent higher, and housing costs 21 percent higher.

American Council for an Energy Efficient Economy, 1997

This report contended that environmental initiatives can support U.S. economic growth, and that reducing CO_2 levels to ten percent below 1990 levels will benefit the economy and the environment.[61] It predicted net economic savings of $58 billion, with an average energy savings of $530 per household, and found that greater use of energy efficiency and renewable energy will create 800,000 additional jobs by 2010.

ACEEE noted that electric utility restructuring could be a serious threat to the emissions goal as cost-cutting companies rely on cheaper, dirtier energy sources. Industry reform could also hinder investment in demand-side energy efficiency, R&D, and investment in cleaner fuel sources such as biomass, fuel cells, and photovoltaics. In order to move U.S. industry away from the "Present Path" described in the report, ACEEE recommended the "Innovative Path," which adopts cap-and-trade, generation performance standards, and RPS. The report also proposed tax incentives for investment, to give rebates to businesses that invest in energy efficiency measures.

The report stated "New policies such as these are essential for reversing the trend towards higher carbon dioxide emissions in the U.S. With U.S. emissions now nearly 9 percent above their level in 1990 and growing rapidly, it is clear that the U.S. will not meet the Administration's current global warming commitment to return emissions to their 1990 levels by 2000. We have to have mandates to drive the market because it tends toward the cheapest source with no regard to environmental impact. Any high incremental up-front capital costs felt by industry will be more than offset by lower fuel and electricity costs due to cheaper operating costs for consumers, a systems charge will increase the price of electricity but lower consumption will set it off."

American Automobile Manufacturers Association, 1997

AAMA found that the Clinton Administration's global climate change policies would cause the U.S. GDP to lose $90 billion by 2010, making it the most expensive environmental protection effort ever advanced by the U.S. government.[62] The study estimated that these policies would in 2010 increase electricity prices 23 percent, cause annual household incomes to decrease by $1,250 (1997 dollars), and cause a reduction in the output of the energy-intensive sectors of three percent relative to baseline production. Electricity prices will increase despite expected cost savings related to industry restructuring because of dramatic increases in fuel prices. By 2010, coal industry output would decline by 37 percent below 1990 levels and cause severe employment impacts in virtually all economic sectors. "These costs would make this

[61]American Council for an Energy Efficient Economy, *Energy Innovations: A Prosperous Path to a Clean Environment*, July 1997.
[62]American Automobile Manufacturers Association, *Economic Costs of Global Warming Initiatives*, report prepared by Charles Rivers Associates, November 1997.

policy the single most expensive environmental protection measure ever adopted by the U.S. government," the report stated. "To find spending on the same scale, one must compare carbon emissions limits to total spending on environmental protection, about 1.8 percent of GDP, or defense, about 4.5 percent of GDP in the recent budgets."

International Confederation of Free Trade Unions, 1997

This ICFTU study argued that "There is a grave danger that environmental and employment policies could point in opposite directions. To avoid this, the debate about a global program for climate change must include a sustainable employment strategy." However, because, according to the ICFTU, few policy-makers have considered the impact on workers and workplaces of reducing GHGs, working people could find themselves either facing dislocation because of global warming or facing large scale changes in employment because of measures taken to reduce emissions.[63]

Since most GHG emissions come from manufacturing, energy production and supply, transportation, and construction, workers in these sectors risk most from proposals to reduce emissions. In the US, job losses could total 900,000 to 1.6 million, with similar levels in other countries. While new jobs in "green" industries will be created, it is not clear what training and adjustments are needed, and employment transition measures linked to target-setting must be clear and equitable.

ICFTU fears that proposals to soften the effect of targets on companies through such mechanisms as "tradable permits," could be disastrous and result in the divisive effect of closures in one country to allow an increase in emissions in another. Developing countries must be encouraged to participate in emissions reductions and must join in setting binding targets, even if they have different goals and timetables. However, industrialized countries, as prime contributors to global warming, have a responsibility to take the lead, both by reducing their own emissions and by providing financial and technical assistance to developing and transition countries. ICFTU states that its over-riding concern is to ensure that action to prevent environmental degradation is consistent with the goals of full employment and the eradication of poverty. This cannot be achieved by market mechanisms or by suppressing workers' concerns about their jobs. The report concluded that careful planning by governments, employers, and trade unions was needed in all countries and the UN, and it recommended large-scale detailed studies of the employment implications of climate change mitigation.

Argonne National Laboratory, 1997

Argonne National Laboratory conducted two analyses of the economic impacts of the Kyoto Protocol. Both studies concluded that increases in energy costs driven by an international agreement to control global warming could economically devastate several major U.S. industries by 2010 without significant benefits to the environment.[64] The

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[63]International Confederation of Free Trade Unions, *Climate Change and Jobs: A Strategy for Sustainable Employment*. Brussels, Belgium, December 1997.
[64]U.S. Department of Energy, Argonne National Laboratory, *The Impact of Potential Climate Change*

first study analyzed the potential impacts of increased energy prices on energy-intensive industries, and was part of a broad Administration effort to predict the costs and benefits of new climate change commitments as U.S. policy positions were developed. It assumed that new GHG control policies will only constrain OECD countries, and that any emissions control mechanism will increase energy costs to some degree. ANL estimated that increasing energy prices driven by new climate commitments could have a serious negative effect on six U.S. industries: Paper and allied products, iron and steel manufacturing, petroleum refining, aluminum production, chemical manufacturing, and cement manufacturing.

However, ANL found that while the economic impacts of increased energy prices could be drastic, global GHGs would not likely be reduced. Instead, manufacturing capacity in these six sectors would move out of the U.S. to developing countries not subject to the UNFCCC agreement, and emissions would continue unabated. Thus: "The conclusion is that higher fuel prices in the U.S. (and other OECD countries) would increase the cost of producing goods in these industries to a level above that of foreign non-participating competitors. As a result, imports from non-participating countries would increase and output and employment in domestic industries would be reduced."

The report stated that these impacts could be "devastating" for several industry sectors. With respect to iron and steel: "The imposition of increased energy costs will devastate the U.S. steel industry without a significant decrease in worldwide energy-related emissions from steel making. Production will be shifted to developing countries and may lead to higher levels of overall pollution due to lower standards in those countries." In petroleum refining: "Energy price increases for OECD refiner production would devastate and probably eliminate the OECD refining sectors. Moreover, the resulting realignment of supply into non-OECD regions would raise net GHG emissions from the global petroleum supply industry." For aluminum production: "The revised economics would cause all of the U.S. capacity to be noncompetitive by 2010." For cement production, 26 million tons of capacity could be shut down by 2010, and "The plant closures will cause job losses.

The second ANL study -- based on the results of a series of workshops -- assumed a stabilization of GHGs at 1990 levels.[65] It determined that six energy-intensive, strategic industries (steel, aluminum, pulp and paper, chemicals, cement, and petroleum refining) would experience devastating consequences under the Kyoto scenario. The study's findings included:

- Twenty to 30 percent of the U.S. basic chemical industry would move to developing countries.
- All primary aluminum plants in the U.S. would close by 2010.
- U.S. steel shipments would be reduced by about 30 percent and about 100,000 jobs would be lost in that industrial sector.

Commitments on Energy Intensive Industries: A Delphi Analysis, June 1997.
[65]U.S. Department of Energy, Argonne National Laboratory, *The Impact of High Energy Price Scenarios on Energy-Intensive Sectors: Perspectives From Industry Workshops*, July 1997.

IV. METHODOLOGY AND ANALYSIS FRAMEWORK

IV.A. The MISI Model

The economic and employment effects of the TCC initiative was estimated using the Management Information Services, Inc. model, data base, and information system. A simplified version of the MISI model as applied in this study is shown in Figure IV-1.

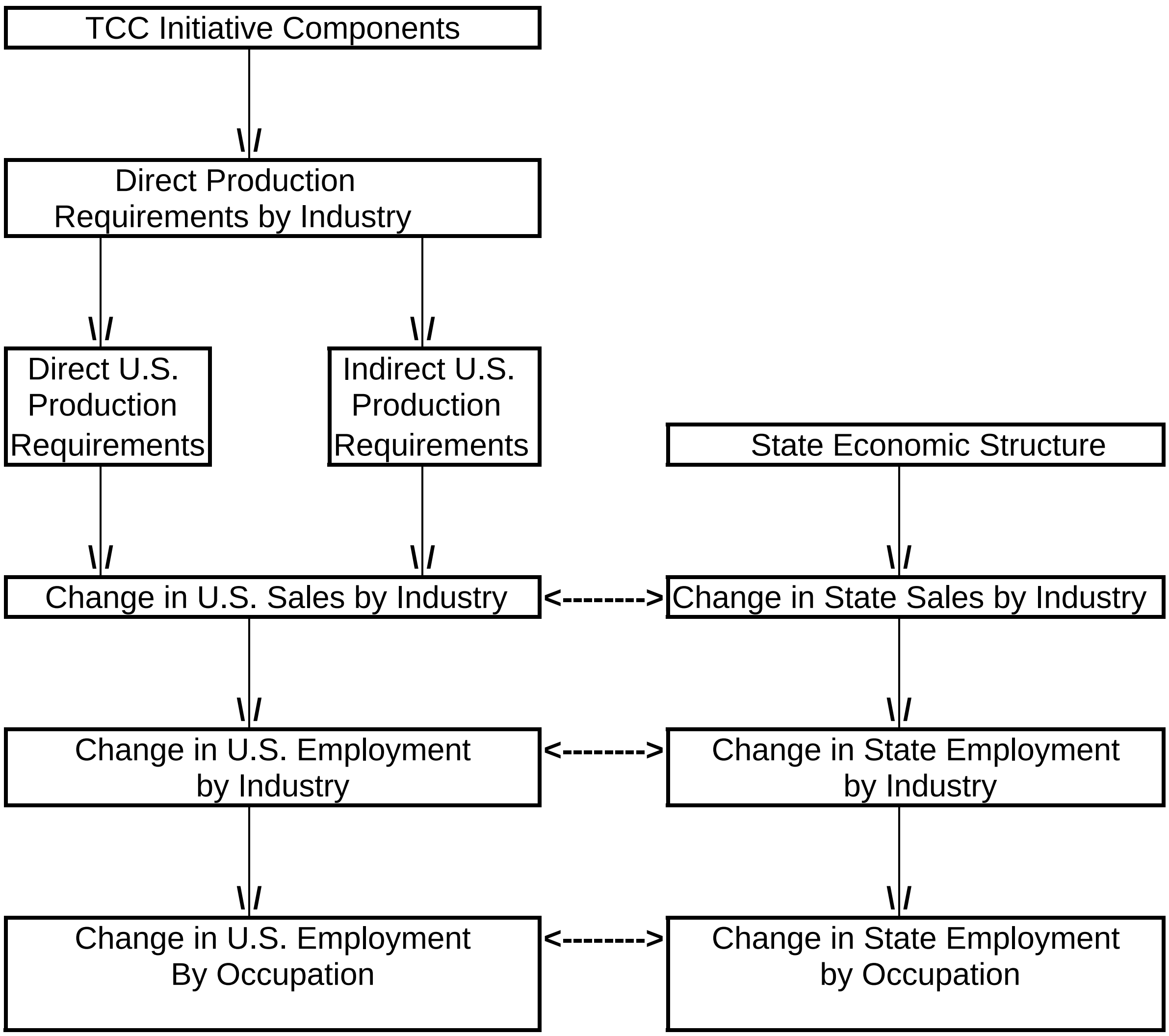
The first step in the MISI model involves the estimation of the direct requirements of the TCC initiative from every supporting industry in the economy. For example, construction of a photovoltaics power system will require a wide range of hardware and services from many industries, whereas production of electric and hybrid vehicles will generate requirements for hardware and services from a very different configuration of industries. Production of a photovoltaics power system will generate large direct requirements in the electrical equipment and components, computer and electronic products, nonmetallic minerals, and related industries, whereas production of electric and hybrid vehicles will generate large direct requirements in the motor vehicle and parts, plastics and rubber products, primary metals, fabricated metal products, and related industries.

The MISI model translates the expenditures for the specified TCC initiative component into per unit output requirements from every supporting industry in the economy. In general, this is determined by four major factors: 1) the specific TCC initiative component, 2) the distribution of expenditures among industries, 3) the specific expenditure/technology configuration, and 4) the direct industry requirements structure. While the MISI model contains 490 commodities and industries, in the work conducted here a 70-order industry scheme will be used -- the 70-order industries are listed in Table IV-1.

Second, the direct output requirements of every supporting industry affected as a result of the TCC initiative are estimated, and they reflect the production and technology requirements implied by the initiative. These direct requirements show, proportionately, how much an industry must purchase from every other industry to produce one unit of output.

Direct requirements, however, give rise to subsequent rounds of indirect requirements. For example, electric and hybrid vehicles will require steel, and steel mills require electricity to produce steel. But an electric utility requires turbines from a factory to produce electricity. The factory requires steel from steel mills to produce turbines, and the steel mill requires more electricity, and so on.

Figure IV-1
Use of the MISI Model to Estimate the Economic, Employment, and Occupational Impacts of the TCC Initiative



Source: Management Information Services, Inc., 2009.

Table IV-1
U.S. Input-Output Industry Codes and Titles, 70-Order

National Industry Codes and Titles by NAICS

Industry Code	Industry Title	NAICS Code
111CA	Farms	111,112
113FF	Forestry, fishing, and related activities	113-115
211	Oil and gas extraction	211
212	Mining, except oil and gas	212
213	Support activities for mining	213
22	Utilities	22
23	Construction	23
311FT	Food and beverage and tobacco products	311, 312
313TT	Textile mills and textile product mills	313, 314
315AL	Apparel and leather and allied products	315, 316
321	Wood products	321
322	Paper products	322
323	Printing and related support activities	323
324	Petroleum and coal products	324
325	Chemical products	325
326	Plastics and rubber products	326
327	Nonmetallic mineral products	327
331	Primary metals	331
332	Fabricated metal products	332
333	Machinery	333
334	Computer and electronic products	334
335	Electrical equipment, appliances, and components	335
3361MV	Motor vehicles, bodies and trailers, and parts	3361-3363
3364OT	Other transportation equipment	3364-3369
337	Furniture and related products	337
339	Miscellaneous manufacturing	339
42	Wholesale trade	42
44RT	Retail trade	44, 45
481	Air transportation	481
482	Rail transportation	482
483	Water transportation	483
484	Truck transportation	484
485	Transit and ground passenger transportation	485
486	Pipeline transportation	486
487OS	Other transportation and support activities	487-492
493	Warehousing and storage	493

Table IV-1 (continued)
U.S. Input-Output Industry Codes and Titles, 70-Order

Industry Code	Industry Title	NAICS Code
511	Publishing industries (includes software)	511
512	Motion picture and sound recording industries	512
513	Broadcasting and telecommunications	513
514	Information and data processing services	514
521CI	Federal Reserve banks, credit intermediation, and related activities	521, 522
523	Securities, commodity contracts, and investments	523
524	Insurance carriers and related activities	524
525	Funds, trusts, and other financial vehicles	525
531	Real estate	531
532RL	Rental and leasing services and lessors of intangible assets	532, 533
5411	Legal services	5411
5412OP	Miscellaneous professional, scientific and technical services	5412-5414, 5416-5419
5415	Computer systems design and related services	5415
55	Management of companies and enterprises	55
561	Administrative and support services	561
562	Waste management and remediation services	562
61	Educational services	61
621	Ambulatory health care services	621
622HO	Hospitals and nursing and residential care facilities	622, 623
624	Social assistance	624
711AS	Performing arts, spectator sports, museums, and related activities	711, 712
713	Amusements, gambling, and recreation industries	713
721	Accommodation	721
722	Food services and drinking places	722
81	Other services, except government	81
GFE	Federal government enterprises	n/a
GFG	Federal general government	n/a
GSLE	State and local government enterprises	n/a
GSLG	State and local general government	n/a
S004	Inventory valuation adjustment	n/a

Notes: n/a - Not applicable

Source: Management Information Services, Inc. and U.S. Department of Commerce, Bureau of Economic Analysis, 2009.

The latter are the indirect requirements. The sum of the direct plus the indirect requirements represents the total output requirements from an industry necessary to produce one unit of output for the TCC initiative. Economic input-output (I-O) techniques allow the computation of the direct as well as the indirect production requirements, and these total requirements are represented by the "inverse" equations in the model. The ratio of the total requirements to the direct requirements is called the input-output multiplier.

Thus, in the third step in the modeling sequence the direct industry output requirements are converted into total output requirements from every industry by means of the input-output inverse equations. These equations show not only the direct requirements, but also the second, third, fourth, nth round indirect industry and service sector requirements resulting from the EE&RE expenditures.

Next, the total output requirements from each industry are used to compute sales volumes, value added (including profits and taxes) for each industry. Then, using data on manhours, labor requirements, and productivity, employment requirements within each industry are estimated. This allows computation of the total number of jobs created within each industry.

The next step requires the conversion of total employment requirements by industry into job requirements for specific occupations and skills. To accomplish this, MISI utilizes data on the occupational composition of the labor force within each industry and estimates job requirements for 800 occupations within 22 occupational groups encompassing the entire U.S. labor force. This permits estimation of the impact of TCC expenditures on jobs for specific occupations and on skills, education, and training requirements.

Utilizing the modeling approach outlined above, the MISI model allows estimation of the effects on employment, personal income, corporate sales and profits, and government tax revenues in the U.S. and in each state. Estimates can then be developed for detailed industries and occupations.

The final step in the analysis (which was not carried out in this study) entails assessing the economic impact on specific cities -- Metropolitan Statistical Areas (MSAs). The MISI approach permits disaggregation to the level of most U.S. MSAs and, if desired, to the county level. Empirically, the basis of the sub-state estimates is the MISI version of the Regional Input-Output Modeling System (RIMS II) developed by the U.S. Commerce Department's Bureau of Economic Analysis (BEA).

The MISI model and data base permit economic impacts to be estimated for any region composed of one or more counties and for any industry in the national I-O table. MISI can estimate the impacts of project and program expenditures by industry on regional output (gross receipts or sales), earnings (the sum of wages and salaries, proprietors' income, and other labor income, less employer contributions to private pension and welfare funds), and employment.

For the MSAs there may be further interest in estimating the impact on requirements for specific occupations. This can be accomplished using the MISI occupation-by-industry matrix, the coefficients of which show the percent distribution of occupational employment among all industries. The 500-by-800 matrix was developed from the *Current Population Survey*, and was modified to conform to the available data.

The methodology employed is state-of-the-art and credible, and has been used by MISI over past three decades in many studies of energy and environmental projects, economic initiatives, proposed legislation, government programs, etc.

Databases and Data Sources

MISI maintains extensive proprietary and nonproprietary databases on the U.S. economy, the state economies, on the Metropolitan Statistical Areas within the states, and on counties in the states. The major public sources of the nonproprietary data include:

- The Bureau of Economic Analysis of the U.S. Commerce Department
- The Bureau of the Census of the U.S. Commerce Department
- The Bureau of Labor Statistics of the U.S. Labor Department
- The Energy Information Administration of the U.S. Energy Department

In addition:

- MISI has proprietary economic forecasting databases for the U.S. and for most states, developed and utilized over the past three decades.
- MISI staff has developed extensive technology-, program-, environmental-, and state-specific economic and statistical databases and satellite models.

Thus, the direct and indirect effects of the RE industry on the national and state economies can be disaggregated into the impact on:

- Industry sales (490 4-digit NAICS industries)
- Jobs (800 occupations and skills)
- Corporate profits
- Federal, state, and local government tax revenues
- Employment and unemployment (by industry and occupation)
- Net growth or displacement of new businesses
- Major economic, technological, social, and environmental parameters and externalities

MISI derives these estimates using quantitative models and databases it has on-line and which have been used by MISI in many other analogous disaggregate regional, economic, technological, and environmental studies. These models and data are unique and proprietary and give MISI substantial estimation capabilities in this area. These models include:

- The U.S. Commerce Department's national input-output model
- A modified version of the Commerce Department's regional econometric forecasting model.
- A modified version of the Regional Input-Output Modeling System (RIMS) supplemented with the Census Bureau/BLS industry-occupation matrix -- adapted to state and sub-state economies by MISI.
- A modified version of the Energy Externalities Simulation (EES) model developed by MISI.

Use of these proprietary models and the associated databases permitted MISI to develop estimates of the economic and employment impacts of each of the mitigation options.

IV.B. Application to the TCC Initiative

The TCC study described how energy efficiency and renewable energy technologies can provide a stream of carbon reductions through 2030 needed to address global warming.[66] Subsequently, costs for the technology deployment during the period were estimated.[67] As discussed in Chapter V, the annualized costs were estimated to range from close to breakeven for wind up to $9.2 billion for the cellulosic ethanol biofuels. In total, the renewable technologies will cost less than $30 billion per year over the period, while the energy efficiency technologies deployed are estimated to save almost $108 billion a year. Together the deployment of these technologies to address climate change is estimated to result in a net savings to the economy of over $82 billion.

These deployment costs and energy savings in the economy will help grow renewable and energy efficiency industries and lead to job creation. However, in this net analysis, we are also concerned about the job losses that will occur due to replacement of existing sources of energy. Taking the detailed estimated annual alternate energy and energy efficiency costs and the detailed annual net cost estimates for each conventional technology, annual net costs were derived in the subsequent TCC study for 2010, 2020, and 2030. While the net energy efficiency savings will decline from an estimated $128 billion in 2010 to just over $16 billion in 2030, the net costs to deploy the photovoltaics technology will increase from $4 billion in 2010 to over $15

[66] *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions From Energy Efficiency and Renewable Energy by 2030*, op. cit.
[67] Charles Kutscher, "Tackling Climate Change: Can we Afford it?" *Solar Today*, March-April, 2008, pp. 29-31.

billion by 2030. The TCC cost study also found that both the wind and biofuels technologies will become cost-competitive over the period as technology costs decline to lower levels than current conventional sources.

These detailed annual costs to provide and save energy in the U.S. economy were used to estimate the size and growth of the domestic alternate energy technology "industries" and the decrease in the conventional energy supplying industry. For 2020 and 2030, the two estimates of the economic activity in the industry attributable to the TCC Initiative (alternate renewable sources and conventional sources) were converted to GDP final demand purchases by industry and applied to the 2007 MISI input-output total requirements table. Because of the consistent annual stream of energy savings from the energy efficiency technology source, the GDP final demand purchases by industry included not only the economic activity in the energy efficiency industry, but also the dollar savings to the economy. By then utilizing the two GDP final demand vectors, the MISI model estimates the direct and indirect economic impacts on the economy by industry, jobs by industry, and jobs by occupation.[68] The gross economic output impacts from the MISI model were netted out by subtracting the conventional industry impacts from the alternate energy industry impacts. The net industry dollar impacts by industry for each technology in 2020 and 2030 were then used to estimate the net number of jobs and the occupational profile of those jobs gained and lost. The jobs concept used here is full-time-equivalent.[69]

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[68]The MISI model includes the core U.S. Department of Commerce, Bureau of Economic Analysis *Input-Output Accounts (2007 Annual Update)* and the detailed U.S. Department of Labor, Bureau of Labor Statistics *Employment by Industry and Occupation* databases (2009) in addition to the *Employment and Earnings* database from the Census Bureau's *Current Population Survey* (2009). In this application of the MISI model, industry detail extended to the 70-order input-output level and occupational detail to the 800-order Standard Occupational Classification level. The MISI Impact Analysis System is currently being used internally by the U.S. Department of Energy and its use in typical energy applications is defined in: *Fuel Efficiency and the Economy*, *American Scientist*, V.93 N.2, March-April 2006, pp. 132-139.

[69]A full-time-equivalent (FTE) job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover. Thus, two workers each working six months of the year would be counted as one FTE job.

V. ECONOMIC AND JOBS ESTIMATES FOR 2020 AND 2030

V.A. Summary of the Cost and Jobs Estimates

To address the potential costs of the TCC initiative, analysts examined the various technology costs that the experts provided in the TCC report.[70] To estimate the equivalent annual cost of deploying each technology, they considered the deployment curve for each -- how many gigawatt-hours of electricity or gallons of cellulosic ethanol or energy saved through efficiency would occur each year between 2005 (the base year of the study) and 2030. They then estimated how much each amount of deployment would cost in the year deployed.

For each technology, they took into account supply curves (which show how costs increase as less ideal resources are tapped) as well as R&D and learning curves (which indicate how costs decline with R&D improvements and experience). Renewable energy plants and efficiency measures deployed in any year will contribute energy for 25 years or more into the future, and standard life-cycle cost-analysis techniques (with an eight percent discount rate) were used to get an equivalent annual cost in 2005 dollars of all that energy per year for each technology. Finally, current and projected costs of the conventional energy displaced were subtracted to derive the net cost.

Table V-1 and Figures V-1 and V-2 summarize the net costs and jobs impact of the TCC initiative in 2020 and 2030:

- Table V-1 shows the net costs and jobs estimates for each year by specific TCC initiative
- Figure V-1 illustrates the jobs impacts of EE and RE
- Figure V-2 shows the jobs impacts of the six RE technologies

Table V-1 shows that the net costs of the EE and RE components of the TCC initiative differ dramatically among technologies and over time. For example:

- In 2020, the net costs are -$67 billion
- In 2030, the net costs are +$4 billion
- In 2020, EE has net savings of $85 billion, while all of the RE technologies except biofuels have net costs
- In 2030, EE has net savings of $17 billion, while all of the RE technologies except wind and biofuels have net costs
- The net savings from EE decline significantly over the forecast period, from $85 billion in 2020 to $17 billion in 2030
- Biofuels net savings increase from -1 billion in 2020 to -$8 billion in 2030
- Biomass costs increase from $3 billion in 2020 to $4 billion in 2030

[70]Kutscher, op. cit.

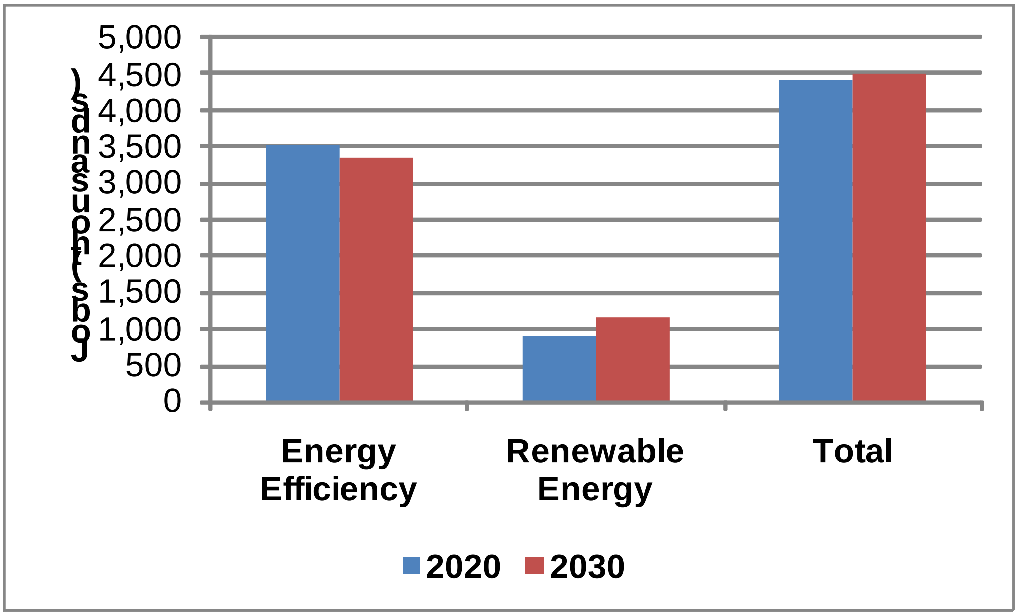
- PV costs increase nearly three-fold, from $5 billion in 2020 to $16 billion in 2030
- Concentrating solar costs decrease 60 percent, from $5 billion in 2020 to $2 billion in 2030
- Geothermal costs increase by over one-half, from $4. billion in 2020 to almost $7 billion in 2030
- Annualized costs over the entire period also differ dramatically, from a -$108 billion for EE to more than $9 billion for biofuels and nearly $7 billion for concentrating solar

Table V-1
Net Costs and Jobs Resulting From the TCC Initiative

	Net Costs			Net Jobs	
	Annualized	2020	2030	2020	2030
	billion 2005 dollars			thousand FTE	
Energy Efficiency	-$107.9	-$84.8	-$17.4	3,533	3,360
Wind	$0.0	$0.3	-$0.4	149	93
Biofuels	$9.2	-$0.5	-$7.6	261	257
Biomass	$2.6	$3.3	$4.5	122	172
Photovoltaics	$4.7	$5.3	$16.0	105	340
Concentrating Solar	$6.6	$5.2	$2.2	156	147
Geothermal	$2.5	$4.0	$6.7	93	144
Total	-$82.3	-$67.2	$4.0	4,419	4,513

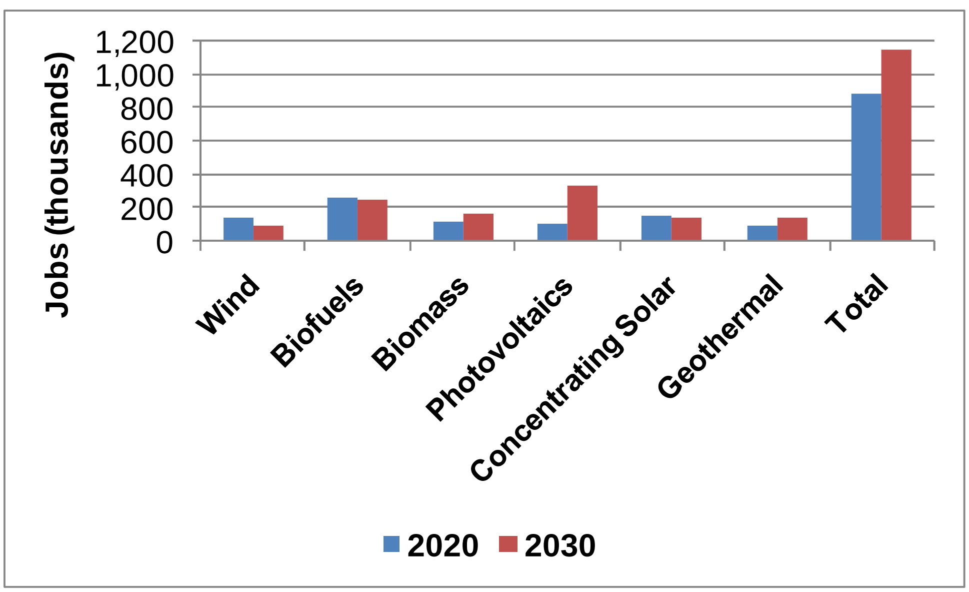
Source: ASES and Management Information Services, Inc., 2009.

Figure V-1
Energy Efficiency and Renewable Energy Jobs Created by the TCC Initiative



Source: Management Information Services, Inc., 2009.

Figure V-2
Renewable Energy Jobs Created by the TCC Initiative



Source: Management Information Services, Inc., 2009.

Table V-1 Figures V-1 and V-2 show that the EE component of the TCC initiative generates many more net jobs than does the RE component:

- In 2020, EE generates more than 3.5 million net jobs, compared to less than 900,000 generated by RE
- In 2030, EE generates more than 3.3 million net jobs, compared to 1.15 million generated by RE
- In 2020, 80 percent of the total net jobs created by the TTC initiative are generated by the EE component
- In 2020, 74 percent of the total net jobs created by the TTC initiative are generated by the EE component

Net job generation differs significantly among the RE components – by technology and time period:

- In 2020, the most jobs are generated by biofuels (261,000), followed by concentrating solar (156,000), wind (149,000), biomass (122,000), PV (105,000), and geothermal (93,000)
- In 2030, the most jobs are generated by PV (105,000), followed by biofuels (257,000), biomass (172,000), concentrating solar (147,000), geothermal (144,000), and wind (93,000)
- In 2030, more jobs are generated than in 2020 for biomass, PV, and geothermal
- In 2020, more jobs are generated than in 2030 for wind, biofuels, and concentrating solar

We thus estimate that the TCC Initiative, while requiring deployment costs in most years for most alternate energy technologies, would have an overwhelmingly positive impact on the U.S. economy. We found that the impact of the TCC Initiative would account for:

- Growth in the wind energy industry that would peak in 2012 and still account for a net addition of 149,000 jobs to the U.S. economy in 2020 and 93,000 jobs in 2030
- A biofuels industry impact growing slowly throughout the period, accounting for 261,000 jobs in 2020 but dropping to 257,000 jobs by 2030
- A biomass industry impact growing strongly during the period resulting in a net addition of 122,000 jobs in 2020 and 172,000 in 2030
- A slowly growing photovoltaics industry impact of 105,000 jobs in 2020 that accelerates rapidly in the 2020's resulting in a net employment impact of 340,000 by 2030
- A steady growth in the impact on the concentrating solar power industry that is beginning to peak in 2030, but accounting for 156,000 jobs in 2020 and 147,000 jobs in 2030

- Consistent impacts to the geothermal industry, with net jobs growing by 93,000 in 2020 and by 144,000 by 2030
- Rapid growth impacts in the energy efficiency industry that would begin immediately and peak in 2025, but in 2020 account for over 3.5 million net jobs and almost 3.4 million net jobs in 2030

V.B. Employment by Industry

The jobs impacts by industry of the TCC initiative are shown in Tables V-2 and V-3 and Figure V-3:

- Table V-2 shows net jobs by industry generated by the TCC initiative in 2020 in the top 24 industries
- Table V-3 shows net jobs by industry generated by the TCC initiative in 2030 in the top 24 industries
- Figure V-3 compares the industry jobs generated in selected industries in 2020 and 2030

Examining the net jobs generated by industry from TCC initiative indicates that the impacts are well distributed throughout the U.S. economy. The industries involved are not surprising, and it is easy to understand the parts they will play in the evolving transformation to a new energy consumption structure and the subsequent economic growth. The top industries showing the largest jobs impacts in 2030 are listed in order with the part they will play:

- Construction -- the industry received an overwhelming direct stimulus from almost all the growing EE and RE sector technologies, in addition to a positive indirect impact from the improvement in overall economic growth due to energy savings
- Farms – the industry was primarily affected by the stimulus of the biomass and biofuels technologies, which require increasing levels of agricultural plant products
- State and local general government – this sector is the county's largest commercial consumer of petroleum and coal products: Vehicle efficiency and the use of cheaper biofuels drastically reduce expenditures and leads to potential expansion of other services and employment
- Miscellaneous professional, scientific, and technical services – the industry and its employees play a large part in driving the new energy and energy efficiency technologies
- Retail trade – the industry is indirectly stimulated by overall growth in the economy
- Truck transportation – the industry in directly impacted by the increase in the biomass and biofuels technology transportation requirements and energy transportation efficiency improvements

Table V-2
Net Jobs by Industry Generated by the TCC Initiative in 2020
(Top 24 Industries)

Industry	**Jobs** (thousands)
Construction	642
State and local general government	279
Miscellaneous professional, scientific and technical services	247
Farms	237
Retail trade	189
Administrative and support services	168
Truck transportation	166
Other services, except government	145
Waste management and remediation services	137
Fabricated metal products	137
Electrical equipment, appliances, and components	135
Nonmetallic mineral products	135
Other transportation and support activities	130
Miscellaneous manufacturing	117
Wholesale trade	111
Food services and drinking places	110
Forestry, fishing, and related activities	109
Motor vehicles, bodies and trailers, and parts	75
Primary metals	65
Chemical products	63
Computer systems design and related services	53
Management of companies and enterprises	53
Other transportation equipment	52
Real estate	47
Total, all industries (including those not listed)	4,419

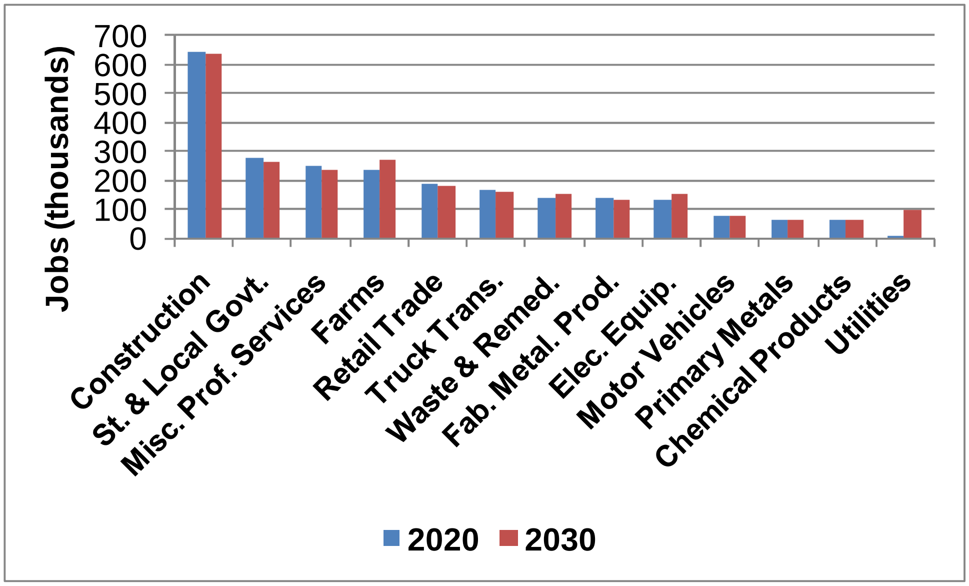
Source: Management Information Services, Inc., 2009.

Table V-2
Net Jobs by Industry Generated by the TCC Initiative in 2030
(Top 24 Industries)

Industry	**Jobs** (thousands)
Construction	636
Farms	272
State and local general government	263
Miscellaneous professional, scientific and technical services	233
Retail trade	178
Truck transportation	161
Administrative and support services	161
Waste management and remediation services	152
Electrical equipment, appliances, and components	151
Miscellaneous manufacturing	142
Other services, except government	142
Fabricated metal products	132
Forestry, fishing, and related activities	132
Nonmetallic mineral products	129
Other transportation and support activities	120
Wholesale trade	107
Food services and drinking places	101
Utilities	96
Motor vehicles, bodies and trailers, and parts	76
State and local government enterprises	70
Computer systems design and related services	68
Primary metals	65
Chemical products	61
Other transportation equipment	52
Total, all industries (including those not listed)	4,513

Source: Management Information Services, Inc., 2009.

Figure V-3
Net Jobs by Industry Generated by the TCC Initiative in 2020 and 2030
(Selected Industries)



Source: Management Information Services, Inc., 2009.

- Administrative and support services - the industry is indirectly stimulated by overall growth in the economy
- Waste management and remediation services – the industry will play a large part in energy efficiency and in supplying biogas
- Electrical equipment, appliances, and components – the industry will be relied upon to supply not only new electrical components and testing equipment to all the alternative electric energy technologies, but will also contribute to efficiencies in the smart grid from generation to final consumer use
- Miscellaneous manufacturing – general manufacturing growth will require this industry's output, and the industry is indirectly stimulated by overall growth in the economy
- Other services, except government - the industry is indirectly stimulated by overall growth in the economy
- Fabricated metal products – the industry will be the primary supplier of parts, products, and systems for the photovoltaic, wind, and concentrating solar technologies
- Forestry, fishing, and related activities – the forestry industry and the agricultural services component of the industry will be playing a major role in supplying the biomass and biofuel feedstocks and will also be conducting agriculture research and development

- Nonmetallic mineral products – the industry supplies at least two major products that will be in high demand in both the solar-related and energy efficiency technologies: Glass and fiberglass
- Other transportation and support activities – transportation energy efficiency improvements will impact this industry
- Wholesale trade – a large sector of the U.S. economy, the industry is indirectly stimulated by overall economic growth
- Food services and drinking places - a large sector of the U.S. economy, the industry is indirectly stimulated by overall economic growth
- Utilities – the industry is the center of attention as electric and gas energy supply technologies change, and the industry will also be stimulated by various customer energy efficiency initiatives
- Motor vehicles, bodies and trailers, and parts – the industry will be positively affected by transportation energy improvements that will stimulate research and development and vehicle sales as the country's rolling stock turns over
- State and local government enterprises – electric co-ops and municipal disposal and recycling segments will be positively affected
- Computer systems design and related services – the industry will be stimulated by the smart grid and other energy efficiency applications
- Primary metals – a direct supplier of metal for finished products, this industry will be indirectly impacted by increased demand from other manufacturing industries
- Chemical products – the industry will be stimulated in particular by the increase in the growth of biofuels and biomass
- Other transportation equipment -- transportation energy efficiency improvements will impact this industry

Figure V-3 shows that, while about 100,000 more net jobs are created in 2030 than in 2020, this varies among industries:

- In some industries, more net jobs are created in 2030 than in 2020 – these include Farms, Waste Management and Remediation Services, Electrical Equipment and Components, and Utilities
- In some industries, more net jobs are created in 2020 than in 2030 – these include Construction, State and Local Government, Miscellaneous Professional, Scientific, and Technical Services, Retail Trade, and Truck Transportation
- In some industries, about the same number of net jobs is created in 2030 as in 2020 – these include Motor Vehicles and Parts, Primary Metals, and Chemical Products

V.C. Jobs by Occupation and Skill

There exists relatively little rigorous and comprehensive research addressing the practical relationship between EE&RE climate change mitigation initiatives and existing jobs or future job creation. Even some research in this area sponsored by various organizations is off the mark, in that it has tended to emphasize jobs creation in classically green activities, such as EE&RE specialists or workers in recycling plants.

However, while these jobs certainly count as jobs related to EE&RE and to climate change mitigation, MISI's data suggests that these types of jobs constitute only a small portion of the jobs created by EE&RE. The vast majority of the jobs created by EE&RE are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. In fact, most of the persons employed in these jobs may not even realize that they owe their livelihood to EE&RE.

There are thousands of EE&RE companies located throughout the United States, and they generate millions of jobs. Given the wide diversity in the size, function, and technologies of these companies, it is impossible to estimate the job profile of the "average" EE&RE firm. However, it is possible to identify the jobs and earnings profiles of typical types of firms involved in EE&RE-related areas of work.

First, firms working in the EE&RE and related areas employ a wide range of workers at all educational and skills levels and at widely differing earnings levels.

Second, in EE&RE companies, few of the employees are classified as renewable energy or energy efficiency specialists. Most of the workers are in occupations such as machinists, engineers, laborers, clerks, bookkeepers, accountants, maintenance workers, cost estimators, etc. All of these employees owe their jobs and livelihoods to EE&RE, but, in general, they perform the same types of activities at work as employees in firms that have little or nothing to do with EE&RE.

For example, the occupational job distribution of a typical wind turbine manufacturing company differs relatively little from that of a company that manufactures other products. Thus, the production of wind turbines and wind turbine components requires large numbers of engine assemblers, machinists, machine tool operators, mechanical and industrial engineers, welders, tool and die makers, mechanics, managers, purchasing agents, etc. These are "RE" workers only because the company they work for is manufacturing a renewable energy product. Importantly, with the current national angst concerning the erosion of the U.S. manufacturing sector and the loss of U.S. manufacturing jobs, it is relevant to note that many RE technologies are growing rapidly.[71] These types of firms can help revitalize the manufacturing sector and provide the types of diversified, high-wage jobs that all states seek to attract.

[71] For example, wind power is the most rapidly growing source of electrical power in the world.

This is also clear from the wide range of functions and tasks that are required by wind energy systems, including:

- Resource Extraction
- Transportation
- Manufacturing
- Integration/Assembly
- Transportation/Shipping
- Wholesales Sales
- Shipping/Transportation
- Retail Sales
- Shipping
- Installation
- Certification
- Activation
- Maintenance and Operation

More generally, while traditional debate on alternative energy has focused on applying new technology to offset traditional energy sources, EE&RE is more than a source of fuel or energy savings. It is source of jobs. As shown here, employment growth in the EE&RE industry varies for the different segments of the industries, but new breakthroughs in EE&RE technologies will come from the growing sectors of the industry, including architectural and engineering services, materials processing, and research and development. In addition, utilities are an area for pioneering a number of alternative energy technologies, including superconducting power lines which reduce the 20 percent loss of electricity due to transmission, solar thermal, photovoltaic, and wind systems, and distributed power technologies which will reduce the losses from transmission and supply more reliable localized power and enable power production all across the electrical grid. Increasingly, however, EE&RE advances will come from all areas of the economy, and may not necessarily be captured by traditional industry sources of energy technologies.

Thus, the vast majority of the jobs created by EE&RE are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. and most of the persons employed in these jobs may not even realize that they owe their livelihood to renewable energy. This is illustrated in Tables V-4 and V-5 and in Figures V-4 and V-5, which show the jobs created by the TCC initiative in 2020 and 2030 within selected occupations. These demonstrate that the TCC initiative will generate:

- More jobs for cashiers than for recyclable materials collectors
- More jobs for order clerks than for architects
- More jobs for executive secretaries than for waste treatment plant operators
- More jobs for janitors than for civil engineers

- More jobs for customer service representatives than HVAC mechanics and installers
- More jobs for accountants and auditors than for roofers
- More jobs for truck drivers than for plumbers
- More jobs for stock clerks than for electrical and electronics engineers
- More jobs for customer service representatives than for welders
- More jobs for inspectors and testers than for sheet metal workers
- More jobs for bookkeeping and accounting clerks than for mechanical engineers
- More jobs for business operations specialists than for electric power line workers

Thus, many workers will be dependent on the TCC initiative for their jobs, although they often would have no way of recognizing the connection unless it is brought to their attention.

Table V-4
Net Jobs by Occupation Generated by the TCC Initiative in 2020
(Selected Occupations)

Occupation	**Jobs** (thousands)
Architects	5
Accountants and Auditors	42
Bookkeeping and Accounting Clerks	66
Business Operations Specialists	32
Cashiers	46
Construction Managers	17
Civil Engineers	12
Computer Software Engineers	18
Computer Support Specialists	15
Computer and IT Managers	9
Customer Service Representatives	60
Electricians	48
Electronics Engineers	8
Executive Secretaries and Administrative Assistants	47
Financial Analysts	6
Glaziers	8
HVAC Mechanics and Installers	17
Industrial Machinery Mechanics	15
Inspectors, Testers, and Sorters	31
Janitors and Cleaners	42
Machinists	27
Management Analysts	18
Marketing Managers	6
Mechanical Engineers	13
Order Clerks	7
Refuse and Recyclable Material Collectors	10
Roofers	34
Plumbers, Pipefitters, and Steamfitters	27
Recyclable Materials Collectors	27
Security Guards	22
Sheet Metal Workers	13
Stock Clerks	35
Training and Development Specialists	7
Truck Drivers	110
Waste Treatment Plant Operators	5
Welders and Solderers	27

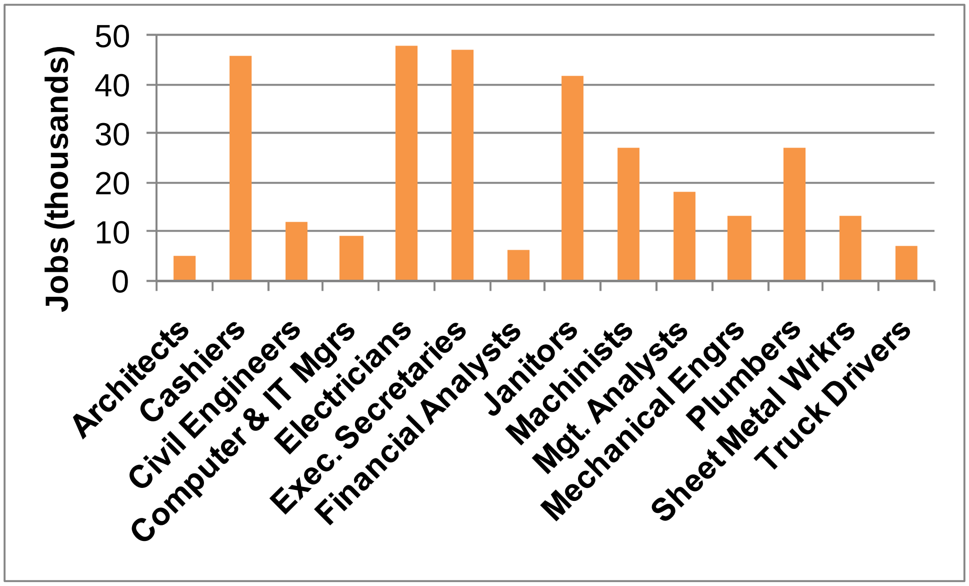
Source: Management Information Services, Inc., 2009.

Table V-5
Net Jobs by Occupation Generated by the TCC Initiative in 2030
(Selected Occupations)

Industry	**Jobs** (thousands)
Agricultural Equipment Operators	12
Architects	5
Bookkeeping And Accounting Clerks	66
Carpenters	73
Cashiers	44
Cement Masons And Concrete Finishers	19
Compliance Officers	8
Computer Software Engineers	20
Computer Systems Analysts	17
Cost Estimators	16
Customer Service Representatives	64
Drywall Installers	11
Electricians	49
Electric Power Line Workers	13
Farm Workers And Laborers	142
Financial Analysts	6
Hazardous Materials Removal Workers	14
Human Resource Specialists	7
Industrial Engineers	14
Industrial Production Managers	11
Operating Engineers	34
Painters	19
Plumbers	35
Power Plant Operators	5
Purchasing Agents	14
Refuse and Recyclable Material Collectors	30
Security Guards	22
Sewer Pipe Cleaners	6
Shipping And Receiving Clerks	30
Structural Iron And Steel Workers	5
Tool And Die Makers	7
Waste Treatment Plant Operators	8
Welders And Solderers	28

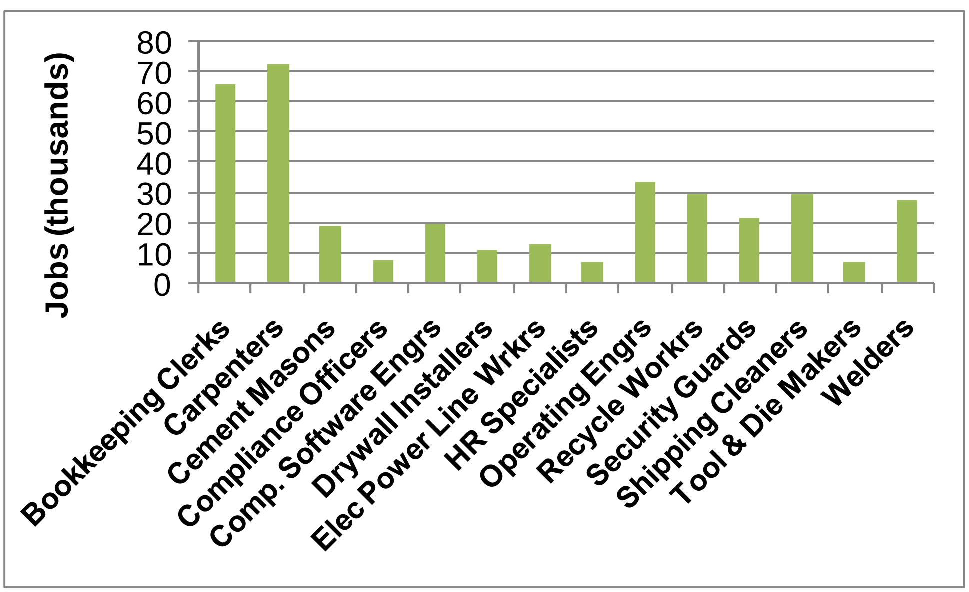
Source: Management Information Services, Inc., 2009.

Figure V-4
Net Jobs by Occupation Generated by the TCC Initiative in 2020
(Selected Occupations)



Source: Management Information Services, Inc., 2009.

Figure V-5
Net Jobs by Occupation Generated by the TCC Initiative in 2030
(Selected Occupations)



Source: Management Information Services, Inc., 2009.

Thus, occupational data demonstrate that the TCC initiative will create a variety of high-paying jobs, many of which take advantage of manufacturing skills currently going unused as manufacturing continues to undergo restructuring in the U.S. Regions with traditional manufacturing economies can recruit EE&RE companies to take advantage of their highly skilled workforces. For example, wind turbine manufacturing requires plant operators, machinists, mechanics, engineers, welders, etc.

As shown in Table V-6, wages and salaries in many sectors of the EE&RE and related industries are higher than U.S. average wages. Although many high-tech industries almost exclusively require highly educated workers with masters or doctoral degrees, as noted, the EE&RE industry requires a wide variety of occupations. Nevertheless, many occupations in the EE&RE industry include jobs which require associate's degrees, long-term on-the-job training, or trade certifications, including engineers, chemists, electrical grid repairers, power plant operators and power dispatchers, chemical technicians, mechanical engineering technicians, and EE&RE technicians, all of which pay higher than U.S. average wages.

Unlike some industries, EE&RE is a realistic target industry for job creation in most states and regions. With a wide variety of the required skills as well as ongoing research into EE&RE technologies, communities can choose to build clusters around different segments of the RE industries. However, states must recognize that they are in fierce competition as communities around the U.S. compete for new emerging energy industries with traditional university-centered research areas, including Palo Alto (Stanford University), Ann Arbor (University of Michigan), Trenton (Princeton University), the Research Triangle in North Carolina, and other university-industry complexes. In addition, states and cities must compete for EE&RE jobs with traditional high-tech metropolitan areas like San Jose, Boston, and Washington D.C., along with metropolitan areas traditionally associated with manufacturing, like Dothan, Alabama. The wide variety of entrance points to the EE&RE industries makes this market easier to penetrate if states can market their strengths in high-tech, research, education, and construction, and other areas to take advantage of the TCC-generated industries and jobs.

Table V-6
Renewable Energy, Energy Efficiency, and Related Occupations: Wages, Educational Requirements, and Growth Forecasts
(Selected Occupations)

Occupation	10 year % Growth Forecast	Median Salary	% With Bachelor's Degree	Education
Materials Scientists	8	$75,800	94	Bachelor's
Physicists	7	93,300	92	Doctoral
Microbiologists	17	64,600	96	Doctoral
Biological Technicians	17	37,200	60	Associate
Conservation Scientists	6	54,800	88	Bachelor's
Chemists	7	64,800	94	Bachelor's
Chemical Technicians	4	40,900	27	Associate
Geoscientists	6	74,700	94	Doctoral
Natural Science Managers	14	101,000	90	Bachelor's
Environmental Eng. Technicians	24	42,800	18	Associate
Soil and Plant Scientists	20	59,100	64	Bachelor's
Mechanical Eng. Technicians	12	47,400	18	Associate
Environmental Sci. Technicians	16	39,100	47	Associate
Biomedical Engineers	31	76,900	60	Bachelor's
Chemical Engineers	11	80,800	92	Bachelor's
Mechanical Engineers	10	78,600	88	Bachelor's
Electrical Engineers	12	77,700	83	Bachelor's
Environmental Engineers	14	76,000	82	Bachelor's
Computer Scientists	26	95,900	67	Doctoral
Life & Physical Sci. Technicians	20	46,100	50	Associate
Utility Plant Operatives	4	54,100	10	OJT
HVAC Technicians	12	38,300	14	OJT
Energy Audit Specialists	18	40,300	18	OJT
Forest & Conservation Workers	6	27,500	8	OJT
Refuse & Recycling Workers	5	26,400	2	OJT
Insulation Workers	6	$30,800	2	OJT

Source: Management Information Services, Inc. and U.S. Bureau of Labor Statistics, 2009.

VI. IMPLICATIONS

The issue of the potential costs and jobs impacts of climate change mitigation policies is current and highly contentious. As discussed in Chapter III, numerous studies have been published contending that such policies could cost the U.S. trillions of dollars and many millions of jobs over the next several decades. Many influential people are skeptical of the impacts of these policies. For example, former Federal Reserve Board Chairman Alan Greenspan cautioned in his memoir that "Cap-and-trade systems or carbon taxes are likely to be popular only until real people lose real jobs as their consequence."[72] More generally, according to Paul Bledsoe, Strategy Director at the National Commission on Energy Policy – an organization that supports climate change mitigation action, "People in Washington have begun to focus on the cost of climate change. But it's important to recognize that legislation to mitigate climate change is going to have significant economic costs, as well."[73] Finally, the U.S. is currently experiencing the worst economic and financial recession in seven decades and, as of September 2009 has lost nearly seven million jobs since the beginning of the recession. Thus, the economic and jobs impact of climate change mitigation policies is a legitimate issue.

The TCC report described how energy efficiency and renewable energy technologies, in an aggressive but achievable scenario, can provide the emissions reductions required to address climate change and can provide the U.S. carbon reductions needed to mitigate global warming by 2030. The research reported here indicates that effective and economically beneficial climate change mitigation policies can be developed. The TCC initiative involves ambitious, aggressive programs in the areas of energy efficiency, wind, biofuels, biomass, photovoltaics, concentrating solar, and geothermal that can, by 2030:

- Effectively reduce U.S. carbon emissions
- Have total, cumulative net costs of near zero
- Generate more than 4.5 million net jobs.

It is important to note that the jobs estimate here is ***net*** jobs. Any ambitious climate change mitigation program will both create jobs and will cause job losses in different sectors, industries, and occupations. However, we estimate that, in total, more than 4.5 million more jobs will be created by the TCC initiative than will be lost. These jobs will be widely dispersed throughout the U.S. in virtually all industries and occupations.

Thus, the major conclusion of this study is that the TCC initiative will be a major net job creator for the U.S. economy.

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[72]Alan Greenspan, *The Age of Turbulence*, Penguin, 2007.
[73]Steven Mufson, "U.S. Looks To Green Europe -- Mistakes There Could Shape American Plans to Curb Carbon Gases, *Washington Post*, April 10, 2007.

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