Analysis of The Lieberman-Warner Climate Security Act (S. 2191) Using The National Energy Modeling System (NEMS/ACCF/NAM)

A Report by the
American Council for Capital Formation
and the
National Association of Manufacturers

Analysis Conducted by
Science Applications International Corporation (SAIC)

ACCF
AMERICAN COUNCIL FOR CAPITAL FORMATION

NAM National Association of Manufacturers

Table of Contents

List of Figures

List of Tables

Analysis of the
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EXECUTIVE SUMMARY

The American Council for Capital Formation (ACCF) and the National Association of Manufacturers (NAM) believe it important to fully and realistically examine the potential costs that enactment of Lieberman-Warner Climate Security Act (S. 2191) would impose on the U.S. economy. It is becoming increasingly recognized that the cost to U.S. consumers and employers of implementing greenhouse gas (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 climate change policy to minimize the impacts on economic growth and maximize the benefits to the environment. Greenhouse gas reduction policies need to include consideration of impacts on energy security, economic growth, and U.S. competitiveness. This project is designed to assist in this effort.

This analysis was undertaken using the National Energy Modeling System (NEMS) model, the model used by the U.S. Energy Information Administration (EIA) for its energy forecasting and policy analysis. The ACCF and NAM applied assumptions about the cost and availability of new energy technologies, oil prices, and other key factors. The NEMS/ACCF/NAM[1] study's findings indicate substantial and growing impacts to consumers and the economy of meeting the increasingly stringent emission targets through 2030 established by the Lieberman-Warner Climate Security Act.

Among the NEMS/ACCF/NAM study's 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/metric ton CO_2 in 2020, rising to between \$227 to \$271/metric ton CO_2 in 2030.

- The cost of the allowances raises energy prices for residential consumers by:
    - Natural gas: 26% to 36% in 2020, and 108% to 146% in 2030;
    - Electricity: 28% to 33% in 2020, and 101% to 129% in 2030.

- These and other increased energy costs slow the economy by \$151 billion to \$210 billion in 2020 and \$631 billion to \$669 billion in 2030 (in 2007 dollars). This in turn leads to job losses of between 1.2 million to 1.8 million in 2020 and 3 million to 4 million by 2030.

- Manufacturing slows, the value of shipments falls by 3.2 % to 4% in 2020 under the low and high cost cases; by 2030 the value of shipments falls by 8.3 % to 8.5% under the two cases. The higher energy costs, lower economic activity and fewer jobs in turn lowers average household income by \$739 to \$2,927 in 2020 and between \$4,022 and \$6,752 in 2030 (in 2007 dollars).

[1] The term "NEMS/ACCF/NAM" is used in this report to distinguish NEMS runs conducted in this project from those conducted by EIA.

As noted in a November, 2007 Congressional Budget Office study, *Issues in Climate Change:*[2]

> "Obtaining allowances—or taking steps to cut emissions to avoid the need for such allowances—would become a cost of doing business for firms that were 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 such costs to their customers (and their customers' customers) in the form of higher prices. By attaching a cost to CO2 emissions, a cap-and-trade program would thus lead to price increases for energy and energy-intensive goods and services that contribute the most to those emissions. 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. Indeed, 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—that is, they would impose a larger burden, relative to income, on low-income households than on high-income households."

As mentioned above, the ACCF/NAM analysis investigates 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 greenhouse gas emissions. These assumptions include the availability of nuclear power technology, the availability of carbon capture and storage for more efficient 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).

[2] Statement of Peter R. Orszag, Director, *Issues in Climate Change*, Presentation for the CBO Director's Conference on Climate Change, November 16, 2007, page 11.

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INTRODUCTION

The American Council for Capital Formation and the National Association of Manufacturers (ACCF and NAM)[3] contracted with Science Applications International Corporation (SAIC)[4] to analyze legislation introduced by Senators Joseph Lieberman and John Warner, the Lieberman-Warner Climate Security Act (S. 2191), to substantially reduce U.S. greenhouse gas (GHG) emissions over the 2012-2050 period. This study uses the National Energy Modeling System (NEMS), the model employed by the U.S. Energy Information Administration (EIA) when asked by Congress and other federal agencies to analyze new energy and environmental policy initiatives. This study was performed by SAIC, independent of any EIA analysis and without any input from EIA or its staff.[5]

The ACCF/NAM believes it is important to fully examine the potential costs that enactment of S. 2191 will impose on the U.S. economy. It is becoming increasingly recognized that the cost to U.S. industries and citizens 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 climate change policy to minimize the impacts on economic growth and maximize the benefits to the environment. Greenhouse gas reduction policies should not be undertaken without considering their impacts on energy security, economic growth, and U.S. competitiveness. This project is designed to assist in this effort.

The study offers insights on the results, including economic costs, using input assumptions provided by ACCF and NAM. These input assumptions are likely to differ from those to be used by the EIA in its report on S. 2191 using the NEMS model. This analysis employs two sets of input assumptions for the NEMS model reflecting the variability in the potential availability of emission reduction technologies, new energy sources and market mechanisms (carbon offsets) by 2030. The use of alternative assumptions in this project is intended to assist consideration and preparation for a range of potential results.

In addition to providing economic impacts for the U.S. as a whole, this project also provides the potential economic costs of S. 2191 at the state and household level for citizens and businesses in every state. Two-page reports have been prepared for each state to show the cost impact of S. 2191 under the "High" and "Low" cost scenarios using the input assumptions provided by ACCF and NAM and the NEMS outputs for different census regions in the country.[6] Summaries of the national results and those for every state are included in the reports.

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[3] The American Council for Capital Formation (ACCF) (www.accf.org) is a nonprofit, nonpartisan organization dedicated to the advocacy of tax and environmental policies that encourage saving and investment. The ACCF was founded in 1973 and is supported by the voluntary contributions of corporations, associations, foundations, and individuals. The mission of the ACCF is to promote economic growth through sound tax, environmental, and trade policies.
The National Association of Manufacturers (NAM) is the nation's largest industrial trade association, representing small and large manufacturers in every industrial sector and in all 50 states. Headquartered in Washington, D.C., the NAM has 11 additional offices across the country. Visit the NAM's award-winning web site at www.nam.org for more information about manufacturing and the economy.

[4] SAIC is a leading provider of scientific, engineering, systems integration and technical services and solutions to all branches of the U.S. military, agencies of the Department of Defense, the intelligence community, the Department of Homeland Security, the Department of Energy and other U.S. government civil agencies, as well as customers in selected commercial markets.

[5] SAIC is a policy-neutral, non-advocacy organization. SAIC executed the NEMS model in this project using input assumptions provided by ACCF and NAM. Analysis provided in this report is based on the output from the NEMS model as a result of the ACCF/NAM input assumptions. The input assumptions, opinions and recommendations in this report are those of ACCF and NAM, and do not necessarily represent the views of SAIC. .

[6] Costs are measured as impact on GDP

METHODOLOGY

NEMS Model

NEMS is a publicly available, national, economy-wide, integrated energy model that analyzes energy supply, conversion, and demand. It is used by EIA to provide U.S. energy market forecasts through 2030 in its flagship publication, the *Annual Energy Outlook (AEO)*. NEMS is also the principal energy policy analysis tool used by EIA to report to Congress regarding the projected impact on U.S. energy markets and the economy of GHG policies in proposed legislation. SAIC is a leading consultant to EIA on the design and implementation of NEMS, and has over 100 staff years supporting the model. The diagram below shows the 12 energy industry sectors/sub-modules modeled by NEMS.

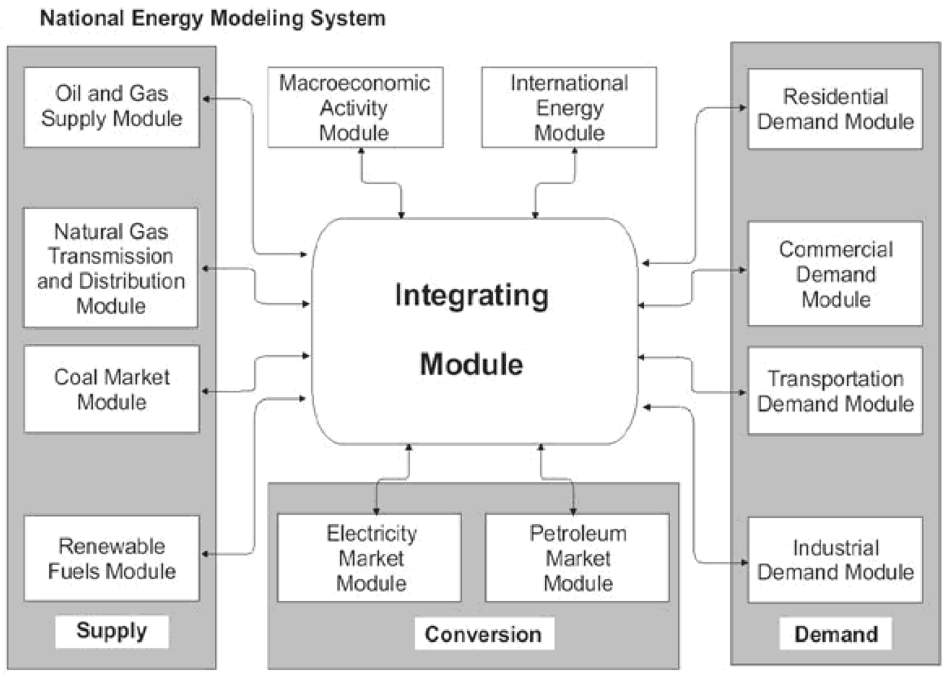

Figure 1: National Energy Modeling System

NEMS provides a common analytical tool for gaining valuable insights into the likely implications of alternative GHG reduction policy options. Using the model relied on by Congress also ensures that the discussion will focus on the merits of assumptions and policy choices rather than methodology. In the end, the use of NEMS in this study supports and supplements congressional consideration of alternatives and enhances opportunities to identify commonalities, strengthen the legislation, and find solution paths.[7]

The Importance of Assumptions Used In the Modeling

NEMS results are dependent on model input assumptions related to technology, cost, performance, and other factors. EIA generally performs NEMS runs using its own assumptions, and those consistent with current government laws and regulations as specified in the *AEO*, as well as assumptions included in congressional or federal agencies' requests. As with any forecast, the assumptions are the best judgment of the requestor or EIA staff, but may not necessarily be the same assumptions that would be used by others.

In its report on S. 280[8], EIA emphasized the importance of assumptions, in particular the "sensitivities" and "uncertainties" with respect to the market penetration achieved by key technologies and market mechanisms

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[7] Two additional key information items on the operation of the NEMS model are included at Appendix 1 regarding: (1) How the model accounts for supply-side energy conversion efficiency; and, (2) Sensitivity of the model to supply-side technology capital costs for power generation.

[8] Energy Information Administration, "Energy Market and Economic Impacts of S. 280, the Climate Stewardship and Innovation Act of 2007", EIA Report #: SR-OIAF/2007-04, July 2007

(carbon offsets) by 2030. Specifically, EIA stated that "Sensitivity analyses suggest that the economic impacts can change significantly under alternative assumptions regarding costs and availability of new technologies. In addition, the cost and availability of offsets outside of the energy sector, both domestically and internationally, is a significant area of uncertainty."[9]

We too want to emphasize the importance of the input assumptions relative to the results provided by the NEMS model. Providing NEMS results using alternative sets of assumptions is the centerpiece - - indeed the purpose - - of this study. Applying alternative input assumptions - - different from those EIA will likely use in its analysis of S.2191 - - in the model used by EIA and relied on by Congress provides insights on implications of a range of possible outcomes that may occur as the economy adjusts to mandatory carbon constraints under provisions of S.2191. The desire is to enhance understanding and analysis.

Analysis Using Alternative Assumptions

The ACCF/NAM believe there is legitimate uncertainty regarding whether the emissions reduction technologies, new energy sources and market mechanisms (carbon offsets) anticipated for achieving GHG emission reductions will be fully available by the period analyzed (2012 – 2030). While they will likely make some level of contribution to meeting GHG limits, the ACCF/NAM believe that, for a variety of reasons including limitations in technology advancements as well as societal concerns and regulatory requirements, it is unlikely that they will make the full level of contribution required to achieve emissions reduction targets in S. 2191 by 2030.

It is important to note that, while the NEMS model is the most robust model of the U.S. economy for energy forecasting, it forecasts only economic decisions and does not predict, or include in its calculations, technical, societal and political decisions. These considerations must be externally imposed on the NEMS model.

Accordingly, for executing NEMS model runs in this project (referenced as "NEMS/ACCF/NAM"[10]), the ACCF/NAM provided alternative assumptions regarding the regarding the likely availability of emissions reduction technologies, new energy sources and market mechanisms by 2030. Analyses were performed under two scenarios on the variability and uncertainty in the availability of these items by 2030. These analyses allow examination of the impacts at different levels of limited availability.

The model runs used input assumptions under two scenarios provided by ACCF/NAM - - High Cost, and Low Cost scenarios.[11] The scenarios used in the model runs include variable input assumptions on the following items: Caps on available nuclear capacity; Caps on sequestered coal-fired (IGCC) generation; Caps on sequestered natural gas-fired (NGCC) generation; Caps on biomass and wind powered generation; and, Availability of Offsets. These caps reflect the considered opinion of ACCF/NAM and others of the likely availability of these technologies given engineering, technical and socio-political constraints. In addition, construction costs (capital requirement build estimates) were updated from those in the *AEO* to reflect current costs for power generation facilities for nuclear, IGCC, NGCC, supercritical PC, IGCC and NGCC with sequestration, wind (on-shore and off-shore) and biomass. Further, the oil price profile was modified in the High Cost case. Cellulosic ethanol and natural gas prices, were not constrained, nor were allowance prices constrained. Banking of CO_2 allowances was not implemented for the NEMS/ACCF/NAM modeling. (see Figure 2). The NEMS/ACCF/NAM modeling included modifications to the *AEO* as a result of the new "Energy Bill", H.R. 6[12].

[9] EIA Report #: SR-OIAF/2007-04, page 60.

[10] The term "NEMS/ACCF/NAM" is used in this report to distinguish NEMS runs conducted by SAIC in this project from those conducted by EIA.

[11] Costs scenarios reflect the impact on GDP.

[12] When the NEMS/ACCF/NAM model runs were performed, *AEO2008* was available only in preliminary form, and was still undergoing modification by EIA relative to H.R. 6. The NEMS/ACCF/NAM model runs used *AEO2007*, plus the economic growth rate in *AEO2008*, together with the key elements of H.R. 6 that could be modeled.

ACCF/NAM CASE SPECIFICATIONS
(Alternative Assumptions under Two Scenarios)

	CASE #1 High Cost Scenario	CASE #2 Low Cost Scenario
TECHNOLOGY BUILD CONSTRAINTS (2030 Build Limits)		
NUCLEAR	10 GW	25 GW
IGCC w sequestration	25 GW	50 GW
BIOMASS	Max 3 GW/year	Max 5 GW/year
WIND	Max 3 GW/year	Max 5 GW/year
NGCC w sequestration	25 GW	50 GW
TECHNOLOGY TOTAL CAPITAL REQUIREMENT (2008 $/kW)		
NUCLEAR	3,410	3,410
IGCC	2,640	2,640
NGCC	1,100	1,100
SUPERCRITICAL PC	2,200	2,200
IGCC w SEQ	3,696	3,696
NGCC w SEQ	2,090	2,090
WIND - ONSHORE	2,000	2,000
WIND OFFSHORE	3,800	3,800
BIOMASS	3,968	3,968
OTHER SPECIFICATIONS		
OFFSETS	15% - 20%	Greater than 20%
OIL PRICE PROFILE	AEO2007 High Profile Side Case	AEO2008 Ref Price Profile
NATURAL GAS PRICES	Not Constrained	Not Constrained
CELLULOSIC ETHANOL	With HR6 – Not Constrained	With HR6 – Not Constrained
BANKING	No Banking	No Banking
HR6 (Key items that could be modeled)	YES	YES
ALLOWANCE PRICES (Annual Growth)	Not Constrained	Not Constrained

Figure 2: ACCF/NAM Case Specifications

Provisions of S. 2191

Key provisions of the Lieberman-Warner Climate Security Act (S. 2191) include:

1. Establishes an emission cap of 5775 million metric tons (MMT) CO_2 for covered sectors/gases by 2012, declining to 1732 $MMTCO_2$ by 2050
2. Coverage includes:
   - Facilities that use more than 5,000 tons coal/year
   - Natural gas upstream cap; covers all natural gas users
   - Petroleum and coal-based production and processing facilities and import facilities
   - Chemical facilities that produce or import fuels that emit more than 10,000 CO_2e/year
3. Allows use of offsets beginning in 2012, with covered entities allowed to satisfy up to 15% of total allowance requirements by submitting offset allowances from domestic sources. Entities can submit an additional 15% in offset allowances obtained in foreign markets with provisions similar to those in the U.S.
4. Provides a low carbon fuel standard on transportation fuels with carbon intensity to decline by 5% by 2015, and by 10% by 2020. (Not modeled)
5. Allowance trading, borrowing and banking are permitted
6. Creates a Carbon Market Efficiency Board to monitor emissions trading.(not modeled)

CO_2 Emissions by Energy Consuming Sector: Comparison of Business as Usual with the S.2191 Cap Overlaid

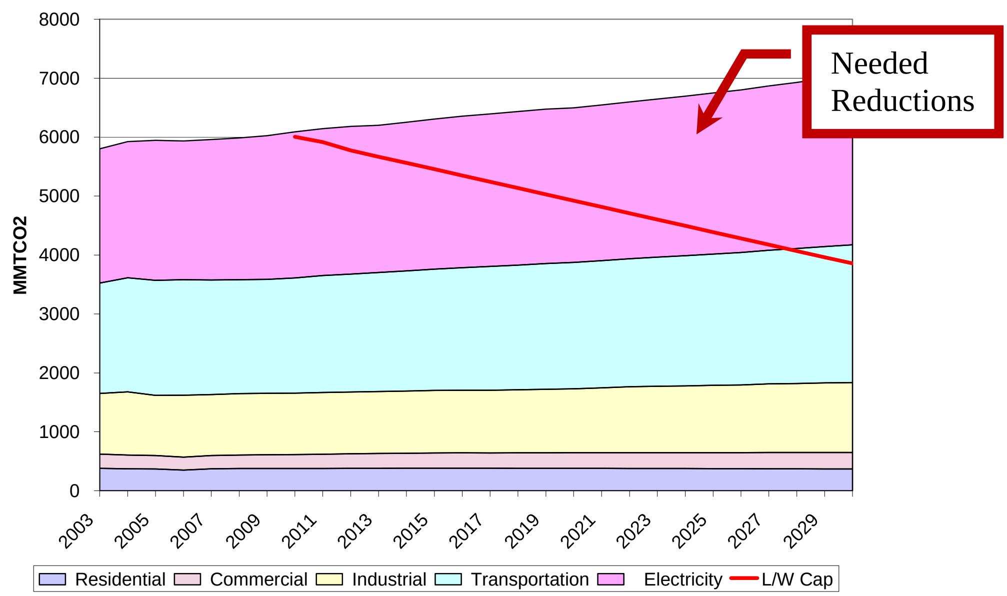

Figure 3: Comparison of Business as Usual with the S.2191 Caps

Overall CO_2 emissions from energy production and consumption grow to almost 7,000 $MMTCO_2$ by 2030. Targets proposed under S. 2191 would constrain emissions to a path shown as the descending red line in Figure 3. Based on analysis of S. 2191, emissions would need to be cut to 5,775 $MMTCO_2$ by 2012, another 4,922 $MMTCO_2$ by 2020, and another 3,856 $MMTCO_2$ by 2030.

Regulated entities will have a number of options for achieving CO_2 emissions reductions, including zero CO_2 emitting technologies such as nuclear or wind generation, new technologies such as CCS, carbon offset projects that reduce CO_2 emissions by an amount equivalent to that emitted, or purchasing CO_2 emissions permits on a tradable market. S. 2191 allows companies to invest in carbon offset projects or to purchase CO_2 emissions up to 30 percent of the targeted emissions (15 percent from domestic sources; another 15 percent from foreign sources with provisions similar to those in the U.S.). Consequently, it would be possible for the economy to generate 30 percent more emissions than targeted by S. 2191 as long as such emissions are offset by carbon sinks.

RESULTS OF THE ANALYSIS

Using the input assumptions and two scenarios provided by ACCF/NAM the model runs generated results to showing the economic effects of S. 2191 provisions at the national level and for every state. The study assumes federal preemption. The absence of federal preemption would risk higher costs.

NEMS/ACCF/NAM Results at the National Level

National results for key variables are presented in Table 1 below for the years 2014, 2020 and 2030 and for the baseline forecast.. The baseline incorporates key provisions of HR6, but does not incorporate provisions of S. 2191. All impacts of S. 2191 are measured against the baseline.

	Baseline			Low Cost Case			High Cost Case		
	2014	2020	2030	2014	2020	2030	2014	2020	2030
GDP (Billion 2007$)	$ 16,419	$ 19,448	$ 24,674	$ 16,284	$ 19,297	$ 24,043	$ 16,151	$ 19,238	$ 24,005
Loss in GDP (Billion 2007$)				$ 135	$ 151	$ 631	$ 269	$ 210	$ 669
% Loss				0.8%	0.8%	2.6%	1.6%	1.1%	2.7%
Employment (Millions)	151.52	156.74	166.96	150.66	155.53	163.91	149.66	154.94	162.90
Job Loss (Millions)				0.85	1.22	3.04	1.86	1.80	4.05
% Loss				0.6%	0.8%	1.8%	1.2%	1.2%	2.4%
Industrial Output (Billion 2007$)	$ 7,865	$ 8,044	$ 8,230	$ 7,695	$ 7,844	$ 8,002	$ 7,575	$ 7,726	$ 7,904
Loss in Industrial Output (Billion 2007$)				$ 170	$ 200.0	$ 228.21	$ 289.93	$ 317.67	$ 326.09
% Loss				2.2%	2.5%	2.8%	3.7%	3.9%	4.0%
Coal Mining Output (Billion 2007$)	$ 27.64	$ 27.64	$ 32.05	$ 21.48	$ 18.28	$ 8.57	$ 22.27	$ 18.36	$ 8.56
Loss in Coal Mining Output (Billion 2007$)				$ 6.17	$ 9.36	$ 23.47	$ 5.38	$ 9.28	$ 23.49
Primary Metals (Billion 2007$)	$ 188.02	$ 196.22	$ 195.52	$ 170.15	$ 167.16	$ 117.22	$ 162.52	$ 159.59	$ 103.35
Loss in Primary Metals Output (Billion 2007$)				$ 17.87	$ 29.06	$ 78.30	$ 25.50	$ 36.63	$ 92.16
Carbon Allowance Price (2007$ / Ton CO2)	$ -	$ -	$ -	$ 36.69	$ 54.59	$ 227.52	$ 38.36	$ 64.28	$ 271.27
Average Household Income (2007$)	$ 98,606	$ 112,504	$ 137,390	$ 97,597	$ 111,765	$ 133,368	$ 95,827	$ 109,578	$ 130,637
Loss (2007$)				$ 1,010	$ 739	$ 4,022	$ 2,779	$ 2,927	$ 6,752
				1.0%	0.7%	2.9%	2.8%	2.6%	4.9%
Energy Expenditures (Billion 2007$)	$ 1,058	$ 1,114	$ 1,319	$ 1,222	$ 1,372	$ 2,358	$ 1,412	$ 1,637	$ 2,829
				$ 164	$ 258	$ 1,038	$ 354	$ 522	$ 1,510
				15.5%	23.2%	78.7%	33.5%	46.9%	114.5%
Retail gasoline prices (2007 $/gallon)	$ 2.14	$ 2.13	$ 2.32	$ 2.42	$ 2.56	$ 4.10	$ 3.22	$ 3.59	$ 5.67
				13%	20%	77%	50%	69%	145%
Residential Electricity Price (2007$ Cents/Kwh)	9.3	9.5	10.2	10.6	12.2	20.5	10.7	12.7	23.3
% diff				13%	28%	101%	14%	33%	129%
Industrial Electricity Prices (2007 Cents/Kwh	5.8	5.9	6.6	7.0	8.4	16.0	7.1	8.9	18.8
%diff				21.8%	41.3%	141.5%	22.6%	49.3%	184.5%
Residential Natural Gas Prices (2007$/Mcf)	$ 10.92	$ 11.29	$ 12.67	$ 12.87	$ 14.25	$ 26.33	$ 13.18	$ 15.40	$ 31.13
% diff				18%	26%	108%	21%	36%	146%
Industrial Natural Gas Prices (2007 $/Mcf)	$ 5.96	$ 6.30	$ 7.44	$ 8.10	$ 9.38	$ 20.87	$ 8.34	$ 10.48	$ 25.61
				$ 2.13	$ 3.09	$ 13.43	$ 2.38	$ 4.18	$ 18.17
% diff				36%	49%	180%	40%	66%	244%
Electric Utility Coal Prices (2007 $/Ton)	$ 33.82	$ 32.30	$ 33.77	$ 100.43	$ 136.38	$ 480.28	$ 105.91	$ 157.80	$ 585.84
				$ 66.61	$ 104.08	$ 446.51	$ 72.09	$ 125.50	$ 552.08
% diff				197%	322%	1322%	213%	389%	1635%

Table 1: Summary of Results for the United States

The results at the national level are further provided in a two-page summary included at Appendix 2.

CO2 Allowance Prices

Key Finding: *Given two alternative sets of assumptions used for this study and unlimited allowance price potential, the model derives allowance cost profiles that would be required to meet the emissions goals established by S. 2191. While the two cases differ, with the Low Cost case being price-displaced by 1 to 3 years further into the future, both ultimately call for very high price levels to satisfy the emissions cap profile. The 2020 levels range from $55/ton (Low Cost case) to $64/ton (High Cost case). Due, in part, to offset availability limits, the 2030 levels would be significantly higher -- ranging from $227/ton (Low Cost case) to $271/ton (High Cost case).*

Based on the particular set of technology input assumptions used by the model (e.g., capital costs, operating costs, etc.), the technology market penetration constraints that the ACCF/NAM cases impose, and the cost and availability of offsets, the NEMS/ACCF/NAM model derives the CO_2 allowance cost profile required to achieve the S. 2191 emissions goals to 2030. This cost profile is calculated so as to adjust fossil fuel prices to the extent needed by the model to add and dispatch an annual inventory of technologies required to meet the emissions goal profile.

In constant 2007 dollars, the price of CO_2 allowances (what companies must pay to emit CO_2) could reach between $55 and $64 per metric ton of CO_2 (MT) by 2020 and could increase to between $227/MT and $271/MT by 2030 (see Figure 4). In both cases, the purchase of relatively inexpensive offsets significantly constrains allowance prices until the early 2020s (more offsets being made available in the low-cost case), followed by a rapid increase in prices as offset availability levels off and the CO_2 emissions goal continues to become more restrictive. The steepest parts the price curves reflect significant retirement of conventional coal-fired power generation with replacement by more expensive advanced coal and natural gas generation technologies that capture and sequester CO_2, other gas-fired technology, nuclear power, and renewable generation technologies.

The revenues obtained from the sale of CO_2 allowances in the two cases are not lost to the economy, but flow into the coffers of the selling entities (e.g., U.S. treasury or state treasuries) and can be redistributed based on specific policies. The modeling performed for this study only assumed that the revenues would ultimately flow to the U.S. government and displace other forms of taxation, and did not make policy-oriented redistribution judgments. The incremental costs associated with modifying the energy infrastructure via selection and dispatch of more costly technologies (than selected in the reference case) represents the real cost of implementing S2191.

Some may question the "acceptability" of levels to which these cases assess the CO_2 allowance prices. If an upper limit is imposed an on allowance prices (e.g., $100/ton) as a "relief value," then after the upper limit is reached (between 2023 to 2026), the model will be constrained to using only the $100/ton value to increase fossil fuel prices. For the cases reported here, such a price level would not be high enough to appropriately influence the technology addition and dispatch solution set required to meet the S.2191 emissions goals; in other words, after the allowance price limit would be met, CO_2 emissions would no longer decline and would start increasing for the remainder of the projection period. Since the model calculates allowance prices and emissions for all years in the projection, we know that the $100/ton level (constant $2007) will be met sometime in year 2023 for the "high-cost case" and year 2026 for the "Low-Cost case." This "relief value" actually provides another approach to explain the impact of different constraint scenarios – identification of the year after which the goal can't be met or the number of years difference between the cases when the model begins to diverge from the goal.

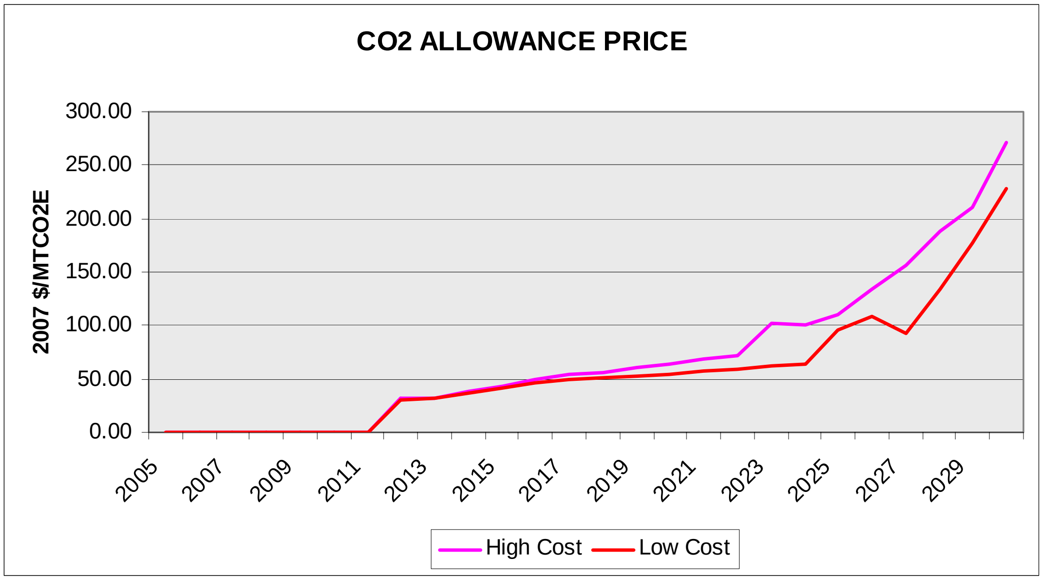

Figure 4: CO_2 Allowance Price

Impact on Jobs

Key Finding: *Based on the allowance price profiles derived for the two ACCF/NAM cases, S. 2191 is projected to yield 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 (Low Cost case) to 1.8 million (High Cost case) jobs/year, and from 3 million jobs (Low Cost case) 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 (see Figure 5). 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 (see Figure 5). 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.

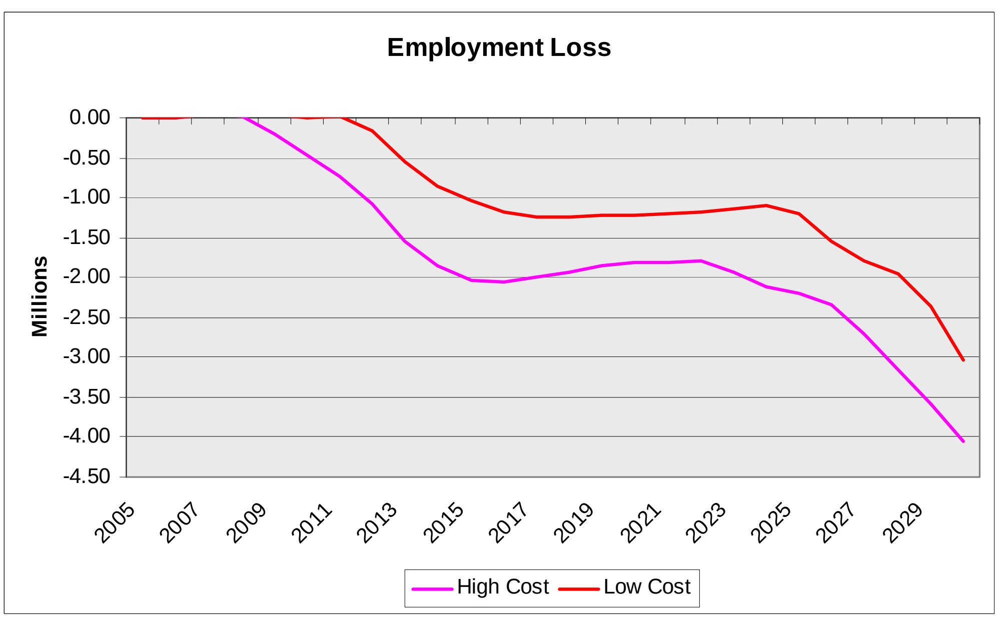

Figure 5: Employment Loss

Impact on Household Income

Key Finding: *S. 2191 is projected to yield significant household income loss resulting from higher payments for fuels and electricity. Higher energy prices would have ripple impacts on prices throughout the economy and would impose a financial cost of $739 to $2,927 per year by 2020 on national households, rising to $4,022 to $6,752 per household by 2030.*

Figure 6 compares household income loss for the two ACCF/NAM cases. Both income loss profiles are similar in shape as impacted by the projected allowance price profiles. For the Low Cost case, an initial decline of $1,172 is followed by an extended period of level valuation from 2015 to 2025, which is then followed by a steep decline to $4,022. For the High Cost case, an initial decline of $3,049 is followed by an extended period of level valuation from 2015 to 2023, which is then followed by a steep decline to $6,752 in 2030.

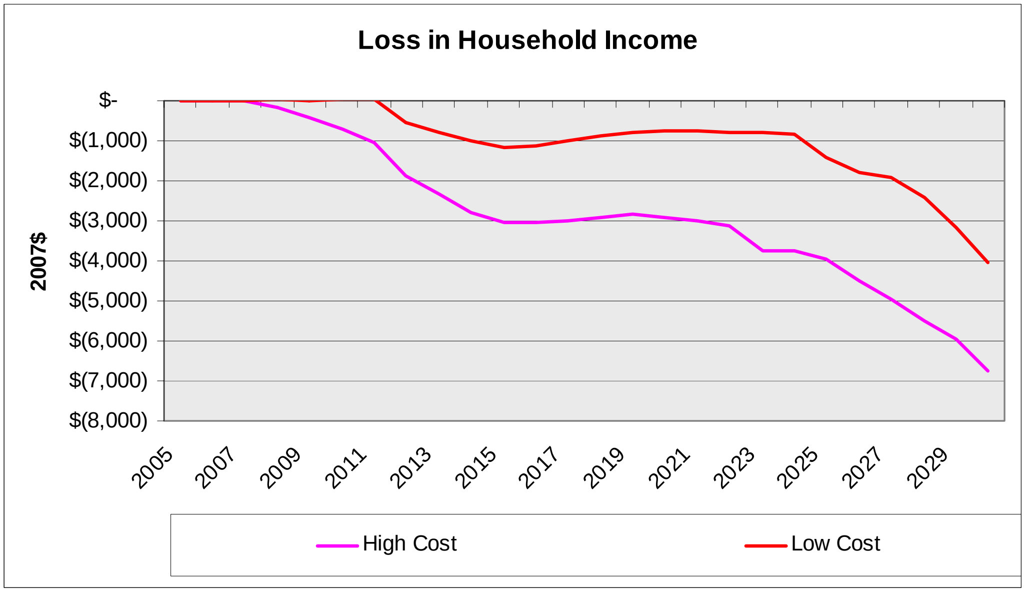

Figure 6: Household Income Loss

Impact on Energy Prices

Key Finding: *S. 2191 is projected to yield significant energy price increases by 2030 based primarily on the inclusion of the cost of carbon (as quantified by CO_2 allowance price profiles) as a price component for fossil fuels, as well as the construction and operation of a more costly suite of energy conversion technologies that help satisfy emission limits. A revamped power generation sector is projected to increase the cost of electricity to the residential sector between 101 (Low Cost case) and 129 percent (High Cost case) by 2030, while the natural gas price increase is projected to range between 108 (Low Cost case) to 146 percent (High Cost case).*

In order to influence technology selection and utilization to control CO_2 emissions, the model translates a CO_2 tax into an incremental adjustment of fossil fuel prices. The tax is based on the fuel price levels required by the model to annually add and dispatch energy conversion supply technologies so as to meet annual emissions goals for covered sectors. Adjustments are made on the basis of the contribution of carbon to the total energy content of a fuel; therefore, the impact on coal is much greater than natural gas. The allowance price profiles discussed previously were calculated in this manner with the resultant impacts on fuel prices shown in Figures 7 through 10.

In constant 2007 dollars, most energy prices are projected to increase under S. 2191, particularly, coal, oil, and natural gas – directly reflecting the impact of increasing CO_2 allowance prices. The price of gasoline would increase between 13 and 50 percent in 2014 and by 20 to 69 percent by 2020. For example, motorists would pay an additional $0.28 to $1.07 dollars per gallon in 2014 and an additional $0.43 to $1.46 per gallon by 2020 (see figure 7). Heating oil prices in the Northeast would increase by 19 to 60 percent by 2014, by 28 to 81 percent by 2020, and by 104 to 178 percent by 2030 (see Figure 8). In addition, US residential consumers would see electricity prices rise between 101 and 129 percent by 2030 (see Figure 9), while the residential natural gas price increase is projected to range between 108 to 146 percent (see Figure 10).

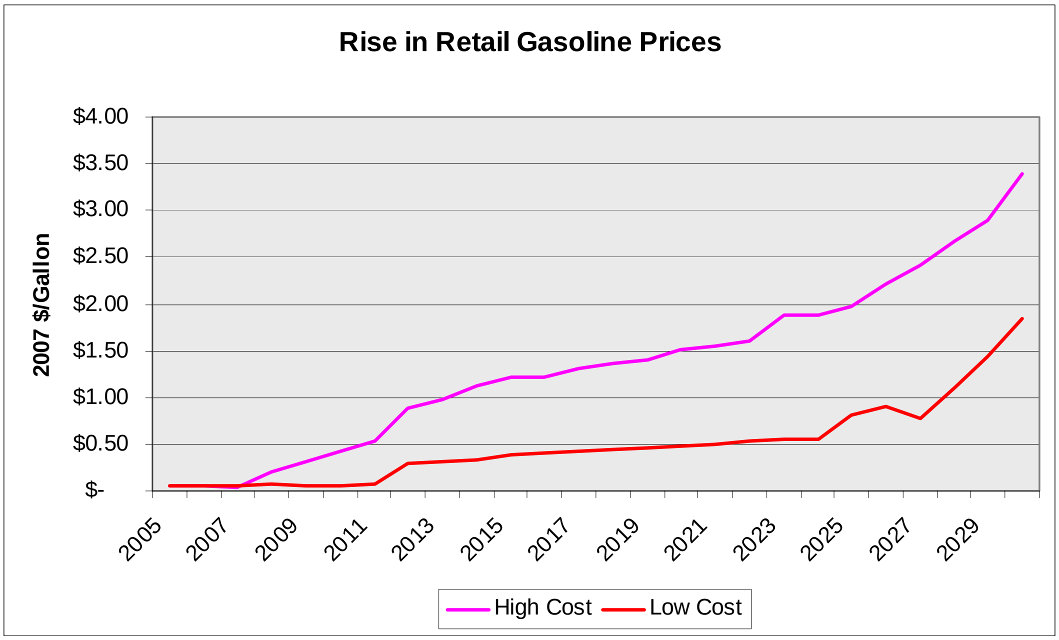

Figure 7: Retail Gasoline Price Increase

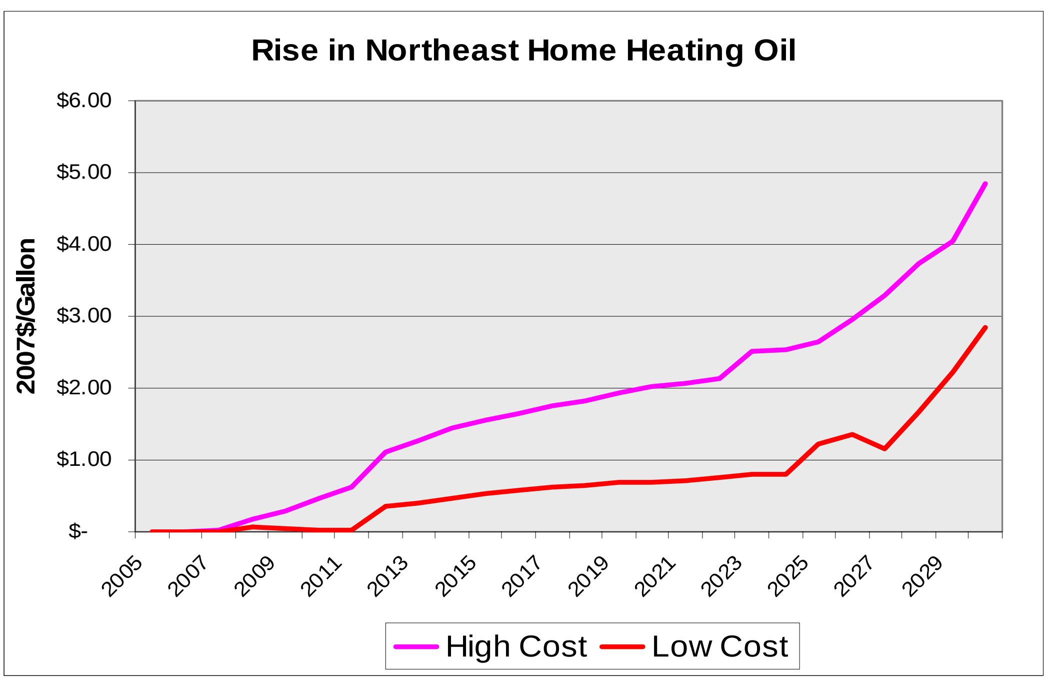

Figure 8: Northeast Heating Oil Price Increase

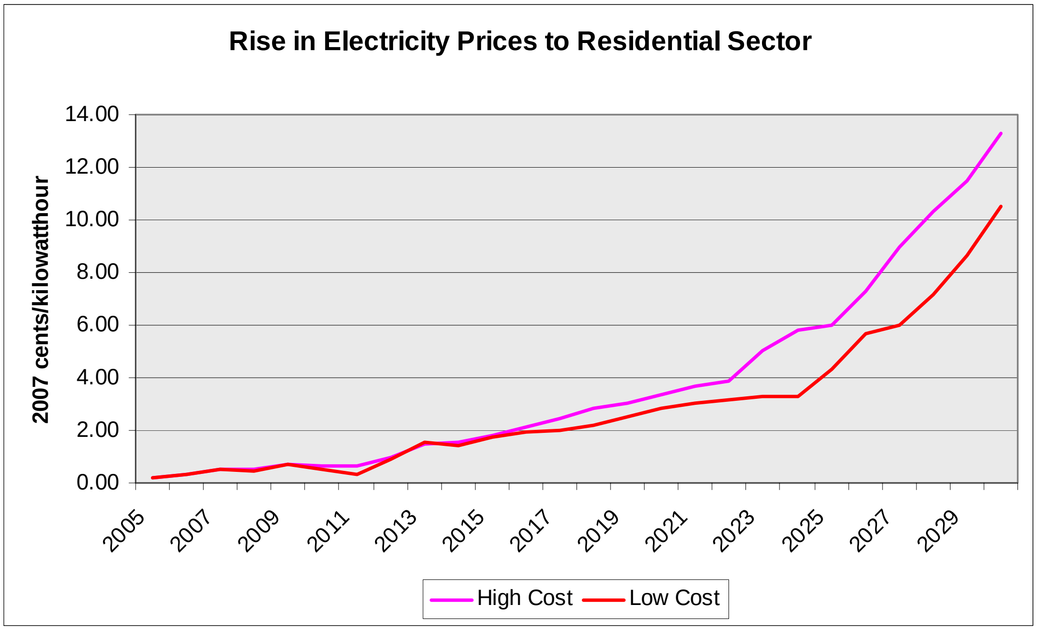

Figure 9: Residential Electricity Price Increase

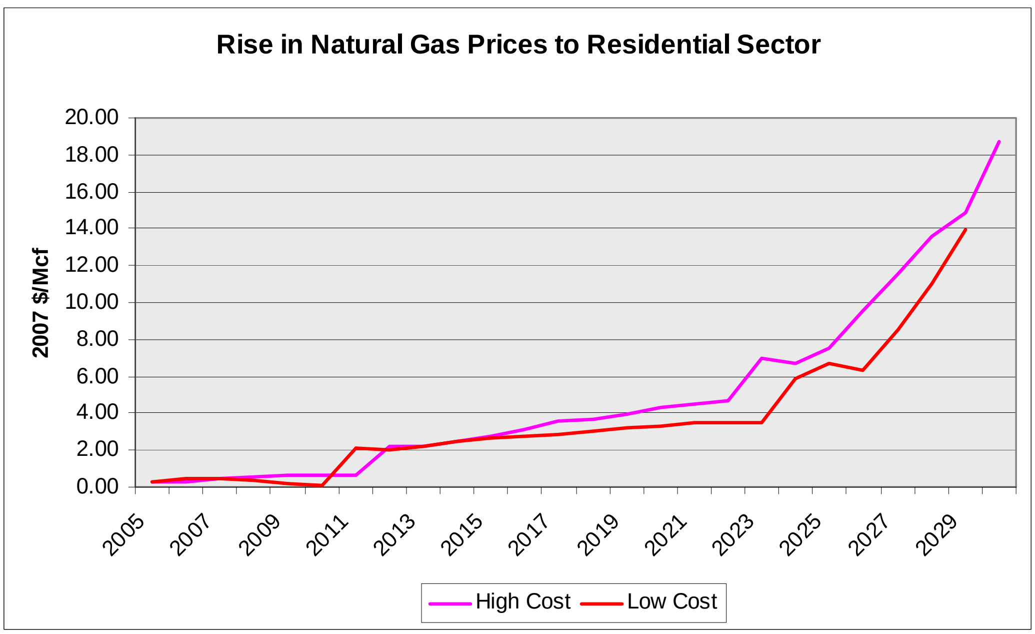

Figure 10: Residential Natural Gas Price Increase

Factors Contributing to Higher Electricity Prices

S. 2191 would reduce GHG emissions from all sectors of the economy (transportation, residential, commercial, and industry); however, as the largest emitter of GHGs, the primary impact would fall on the electricity production sector. S. 2191 would result in the electric industry shutting down (or retrofitting) a significant portion of existing, conventional coal-based generation and/or using expensive, as yet unproven technology, to capture and store CO_2 in geologic repositories. To meet the stringent goals of S. 2191, the electric industry would also have to substitute high cost technologies, such as wind, for conventional generation. This is true in both the Low and High Cost cases.

Impact on Total Energy Expenditures
Key Finding: *By 2030, gross US energy expenditures are projected to increase 79% in the Low Cost case and 115% in the High Cost case over the ACCF/NAM baseline case. These significant increases reflect the impacts of increased fuel costs (primarily resulting from CO_2 allowance prices) and changes to energy conversion technology infrastructure costs. However, these results do not reflect any direct redistribution of allowance revenues back to these sectors.*

Figure 11 presents the ACCF/NAM model results for the total non-renewable US energy expenditures for the residential, commercial, and industrial sectors, plus the renewable and non-renewable expenditures for the transportation sector. The High and Low Cost cases are compared with the baseline; inherent in these results is the inclusion of the CO_2 allowance price impacts on fuel costs. Starting in 2012, increases are projected to range from 13 percent for the Low Cost case to 26 percent for the High Cost case. By 2020, this range becomes 23 percent to 47 percent, and the projected results for 2030 range from 79 percent to 115 percent.

Please note that the curves in Figure 11 do not account for the revenues generated from the sale of CO_2 allowances by the different entities established in S. 2191 and their potential redistribution back into the different energy sectors. Therefore, the results presented here are gross expenditures.

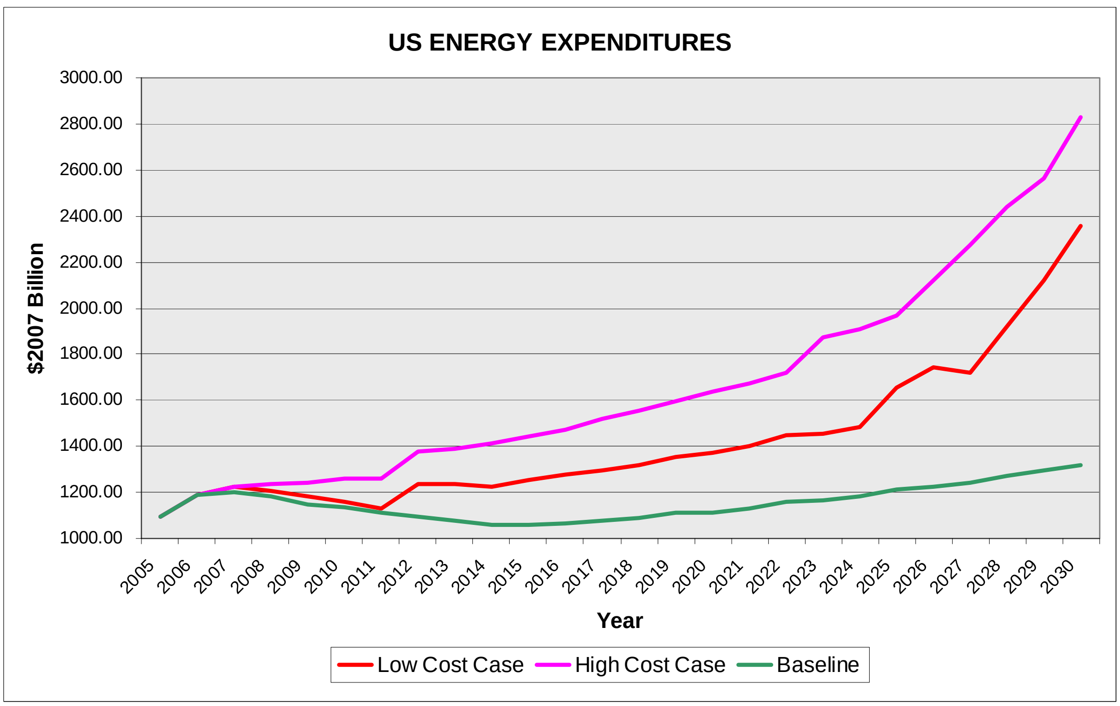

Figure 11: Increase in U.S. Energy Expenditures

Utility Electricity Generation by Fuel Type
Key Finding: *Constraints on nuclear, fossil with sequestration, and renewables generation capacity growth (see Figure 2: ACCF/NAM Case Specifications) results in a significant redistribution of generating capacity from coal to natural gas, nuclear and renewables generation sources. This redistribution is accompanied by a marked reduction in net utility generating capacity over the projection period relative to the Baseline projection; this results from significant demand-side energy efficiency improvements and reduced growth of electricity demand.*

Figures 12 through 14 show the breakdown of net electric utility power generation by fuel type for the Baseline, Low Cost, and High Cost cases, respectively. In the Low and High Cost cases, the rate of decline in coal retirements varies in its rapidity through around 2022, but then converges post 2022 (slowest decline in the low cost case and highest decline in the high cost case prior to 2022). Total generation supplied to the grid declines between the reference case and the two cases, due to a combination of less-expensive demand-side energy efficiency improvements and increased on-site power generation. Such declines represent real revenue loss for the utilities. In 2030, total electricity generation from utility sources is projected to markedly decline from 4,565 billion kW-hrs in the baseline case to 3,765 billion kW-hrs in the Low Cost case (17.5% decline) and to 3,643 billion kW-hrs in the High Cost case (20 percent decline).

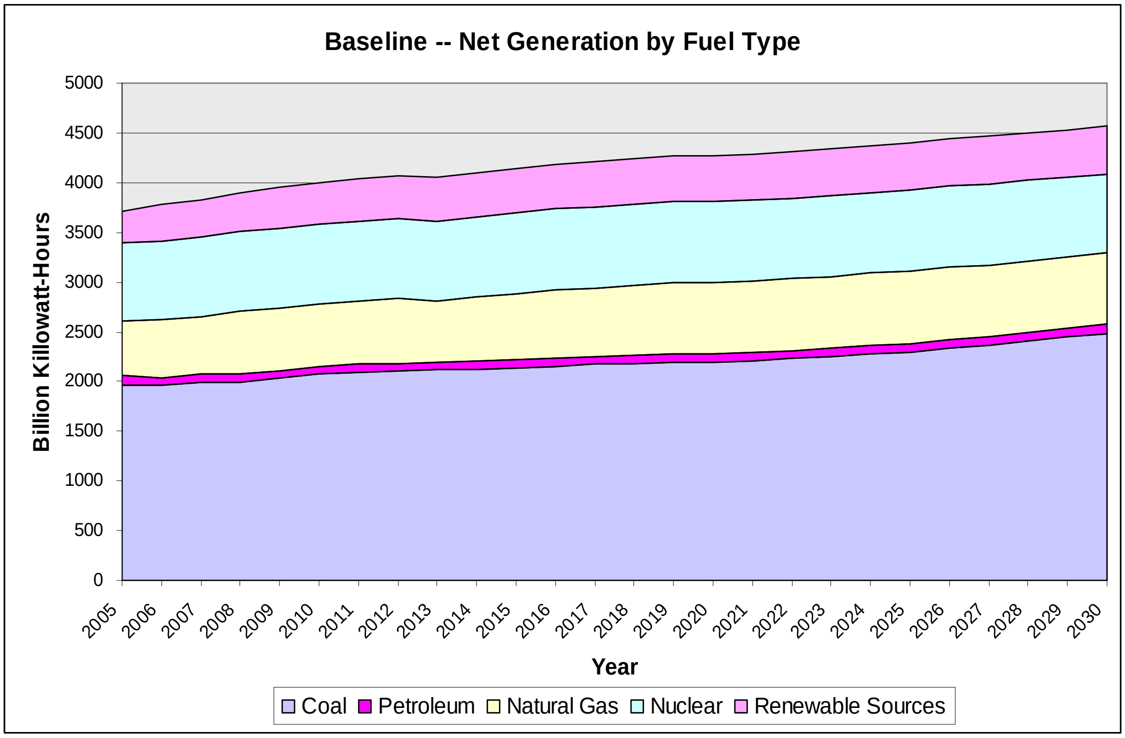

Figure 12: Baseline - - Electricity Generation by Fuel Type

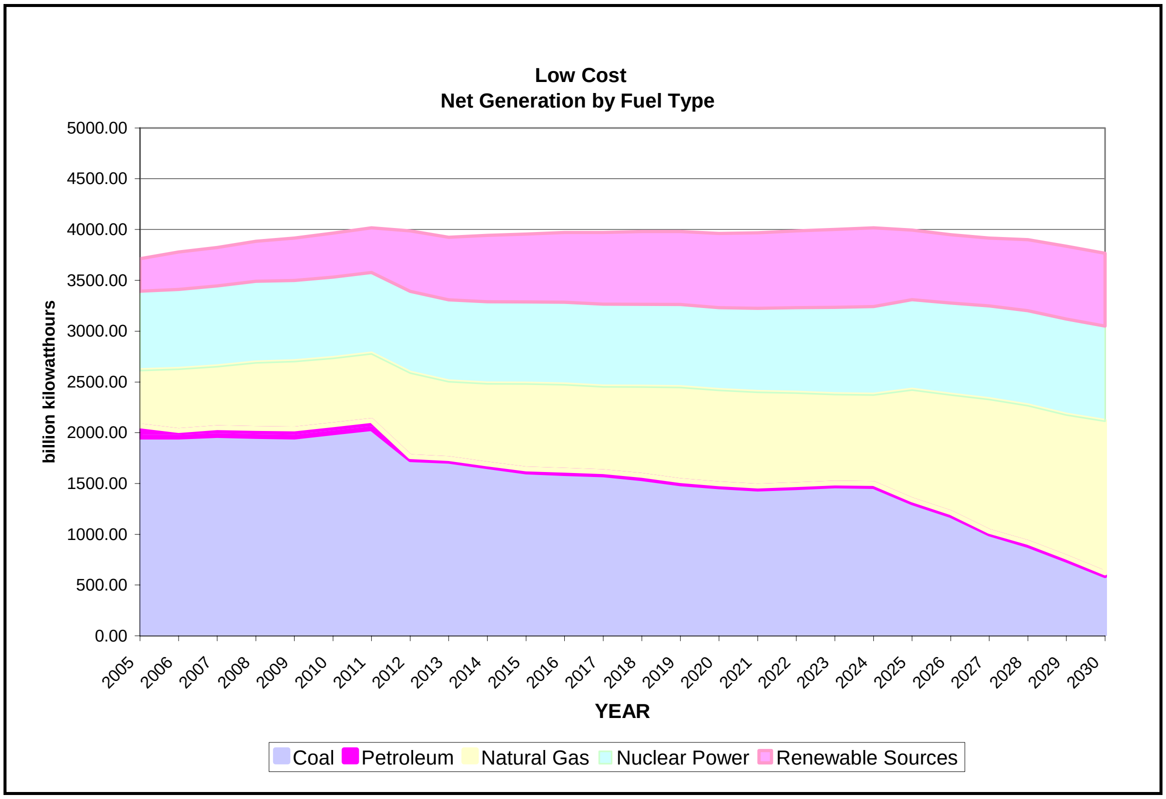

Figure 13: Low Cost Case - - Electricity Generation by Fuel

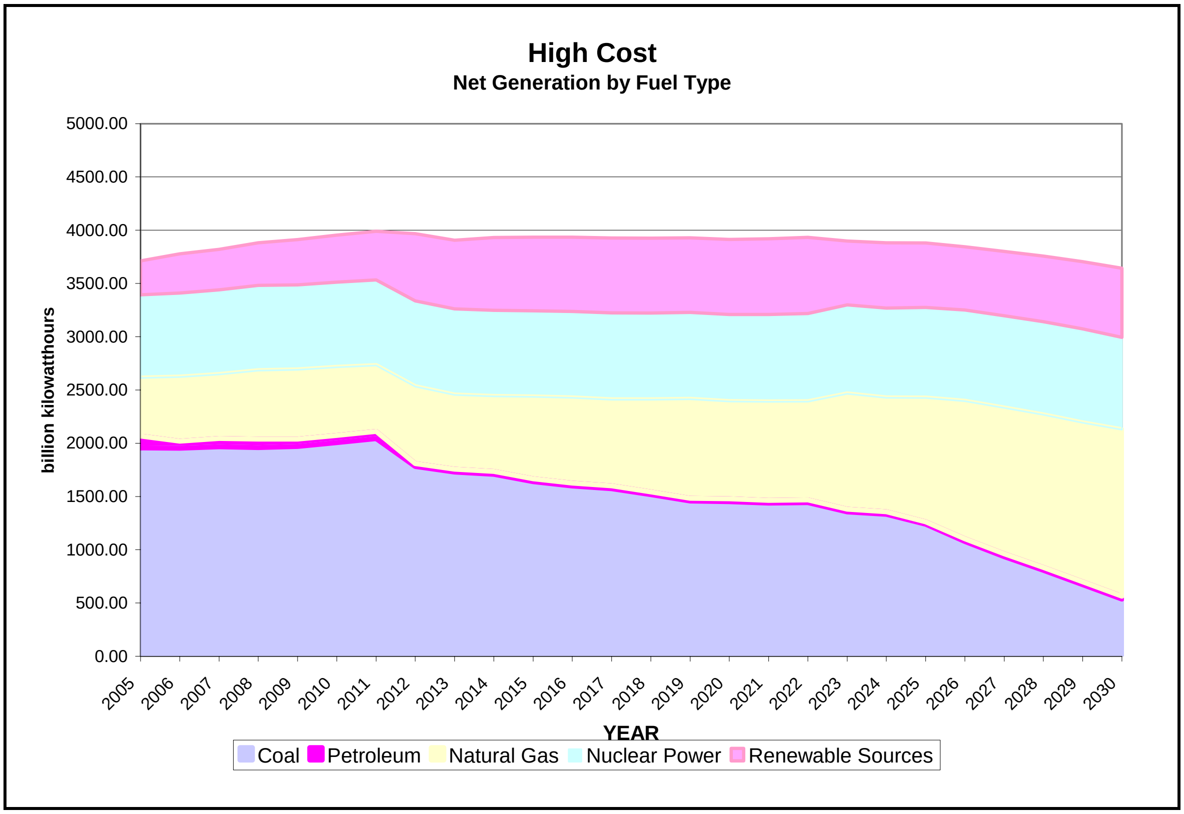

Figure 14: High Cost Case - - Electricity Generation by Fuel

Low Cost Scenario –

- Coal generation gradually declines from 2012 (1,735 BkWh) until 2020 (1,465 BkWh) and remains roughly level until 2024. Coal continues to play a dominant role in electric generation until about 2024 when it begins to drop significantly to help meet emissions goals, ultimately dropping to 591 BkWh by 2030.
- Natural gas generation grows very gradually from 2012 (823 BkWh) until 2024 (871 BkWh). After 2024, natural gas generation rapidly increases and becomes the predominant fuel for generation, ultimately reaching 1,491 BkWh by 2030.
- Renewable generation shows strong growth over the forecast, but is limited by the 5 GW per year additional capacity growth limits on wind and biomass as established by the scenario assumptions. Renewable generation grows from 596 BkWh in 2012 to a peak of 774 BkWh in 2024, tapering off to 717 BkWh in 2030.
- Nuclear generation is limited to moderate growth due to assumptions regarding the market penetration that can be achieved by new capacity (25 GW maximum); the model only added 19 GW of new generation capacity by 2030. Nuclear generation grows from 804 BkWh in 2012 to 938 BkWh in 2030.

High Cost Scenario –

- Coal generation gradually declines from 2012 (1,782 BkWh) until 2020 (1,452 BkWh) and remains roughly level until 2022. Coal continues to play a dominant role in electric generation until about 2022 when it begins to drop markedly to meet emissions goals, ultimately dropping to 536 BkWh by 2030.
- Natural gas generation steadily climbs from 2012 (722 BkWh) and begins to ratchet up significantly after 2020 (915 BkWh), and very significantly after 2022 as coal generation falls. After 2025, natural gas becomes the predominant fuel for generation ultimately reaching 1,564 BkWh by 2030.
- Renewable generation shows strong growth over the forecast, but is limited by the 3 GW per year additional capacity growth limits on wind and biomass as established by the scenario assumptions. Renewable generation grows from 631 BkWh in 2012 to a peak of 714 BkWh in 2022, tapering off to 649 BkWh in 2030.

Impact on Gross Domestic Product

Key Finding: *Due to the higher projected energy expenditures in different sectors of the economy, the ACCF/NAM model projects a loss of household income, lower commercial and industrial output, and lower employment over the projection period that results in reduced gross domestic product (GDP). The Low Cost case results project a loss of 0.8 percent in 2020 and 2.5% in 2030. The High Cost case results project a loss of 1.1 percent in 2020 and 2.6% in 2030. Overall impacts are moderated by CO_2 allowance revenues assumed to flow to the U.S. treasury to increase the tax base.*

As presented previously, both the High and Low Cost cases result in projections of very high CO_2 allowance price levels that commensurately raise fuel prices. These higher fuel prices "force" the economy to undergo a significant shift in fuel conversion technology selection/utilization and fossil fuel consumption to satisfy the S.2191 emissions cap goals through 2030. Due to the higher energy expenditures in different sectors of the economy, the ACCF/NAM model projects a loss of household income, lower commercial and industrial output, and lower employment over the projection period that results in reduced gross domestic product (GDP). GDP is projected to drop between $151 billion (Low Cost case) and $210 billion (High Cost case) per year by 2020 and $631 billion and $669 billion by 2030.

Since the model assumes that a portion of the revenues collected from the sales of CO_2 allowances flow back to the U.S. treasury as collected taxes, the overall impact to the economy as a whole is somewhat moderated. Note that this modeling effort has not made any attempt at directing the use of the collected revenues to further stimulate economic activity.

To put these numbers in perspective, the U.S. spent $581 billions on social security payments and $371 billions on Medicare for retirees in 2007. Slower growth in the productivity of the labor force and lower levels of investment overall are responsible for lower levels of GDP. Labor productivity as measured by dollar of output per person falls between 0.8% and 1.5%.

Table 2 shows the impact on manufacturing, a key component of GDP. By 2030, some of the largest hit sectors are transportation ($212 to $292 billion), chemical manufacturing ($88 to $107 billion), petroleum and coal products ($34 to $69 billion), and metals ($78 to $92 billion).

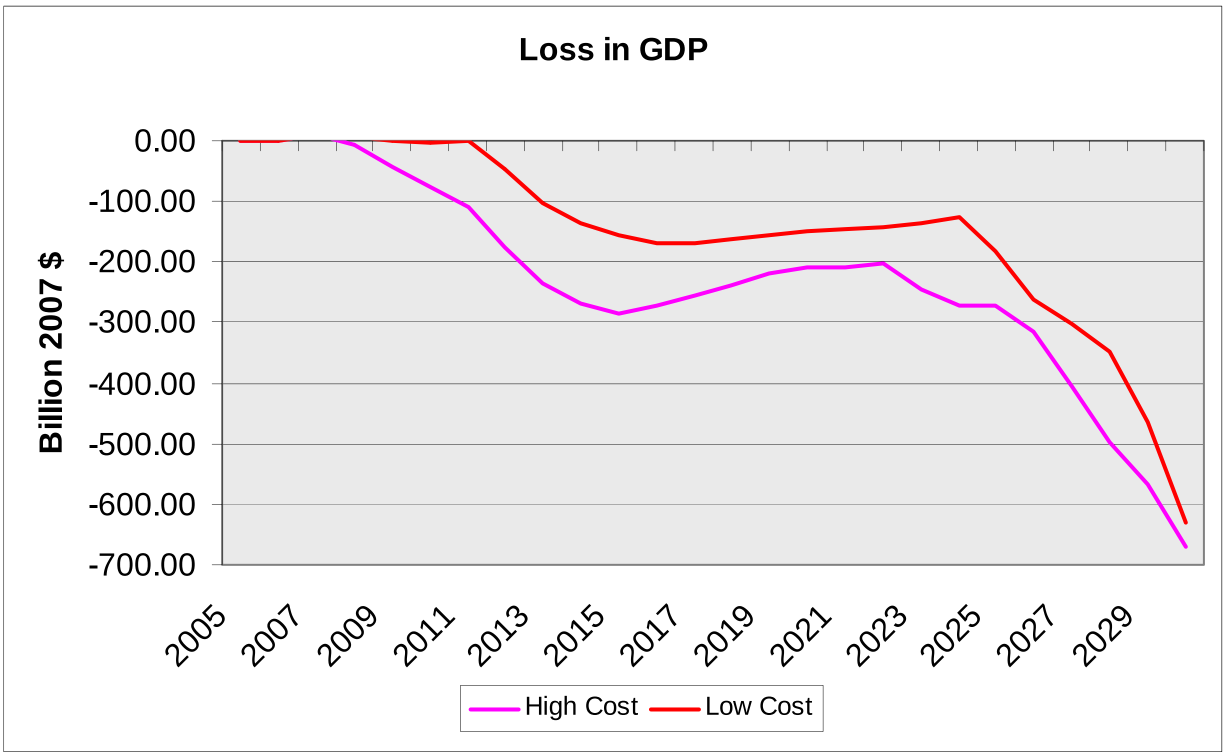

Figure 15: Loss in U.S. Gross Domestic Product

Manufacturing Sector	Baseline 2020	Baseline 2030	Low Case 2020	Low Case 2030	High Case 2020	High Case 2030
Food Products	$ 692.06	$ 809.27	-$10.44	-$45.15	-$16.57	-$59.12
Beverages and Tobacco Products	$ 125.12	$ 125.16	-$4.39	-$9.05	-$6.69	-$13.08
Textile Mills and Products	$ 65.60	$ 53.41	-$2.88	-$7.04	-$3.57	-$8.97
Apparel	$ 26.17	$ 16.40	$0.10	-$0.25	-$0.24	-$0.40
Wood Products	$ 116.43	$ 116.20	-$5.31	-$25.07	-$6.45	-$29.08
Furniture and Related Products	$ 112.59	$ 134.16	-$1.69	-$4.46	$3.07	$0.09
Paper Products	$ 213.37	$ 229.16	-$10.48	-$23.92	-$14.94	-$30.32
Printing	$ 97.20	$ 100.74	-$0.40	-$0.80	-$0.79	-$1.15
Chemical Manufacturing	$ 738.58	$ 853.56	-$38.48	-$88.22	-$42.68	-$107.24
Petroleum and Coal Products	$ 335.14	$ 353.50	-$11.87	-$33.94	-$30.77	-$69.38
Plastics and Rubber Products	$ 264.90	$ 300.57	-$15.51	-$51.25	-$17.34	-$59.56
Leather and Leather Products	$ 4.12	$ 3.02	$0.00	$0.00	$0.00	$0.00
Stone, Clay, and Glass Products	$ 137.37	$ 145.22	-$13.97	-$37.97	-$16.34	-$45.60
Primary Metals Industry	$ 196.22	$ 195.52	-$29.06	-$78.30	-$36.63	-$92.16
Fabricated Metal Products	$ 372.59	$ 414.27	-$10.51	-$30.47	-$8.97	-$29.91
Machinery	$ 458.12	$ 526.84	-$20.62	-$44.69	-$24.42	-$52.22
Computers and Electronics	$ 1,208.90	$ 1,706.10	-$22.81	-$91.50	-$18.94	-$80.10
Transportation Equipment	$ 1,091.84	$ 1,263.98	-$65.90	-$211.56	-$150.25	-$292.64
Electrical Equipment	$ 175.41	$ 205.46	-$3.63	-$7.06	-$4.71	-$7.38
Miscellaneous Manufacturing	$ 274.27	$ 372.48	$1.22	-$3.53	-$3.28	-$20.32
Total Industrial Value of Shipments	$ 8,775.76	$10,146.56	-$277.84	-$838.22	-$352.64	-$865.94

Table 2: Impact on the Value of US Manufacturing (Billion 2007 $)

NEMS/ACCF/NAM Results at the State Level

For each state, a two-page report was prepared to show the impact of S. 2191 on the state under the "High" and "Low" cost scenarios using the assumptions provided by ACCF/NAM. The two-page reports describe the potential higher energy costs and resultant impacts in each state on jobs, household income, economic growth, industrial production, low income and elderly citizens, and state budgets. (A sample two-page report is included at Appendix 3). To prepare the state-specific analyses, the regional NEMS/ACCF/NAM results were post-processed based on historical trends/relationships and population projections from the Census Bureau to get population and gross state product weighted results for economic growth, household income, jobs, industrial production, emissions, and prices at the state[13].

Tables summarizing the impacts for each of the 50 states are provided below.

[13] NEMS reports all of these results by census regions.

Table 3: Loss in Employment (Thousands of Jobs)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	-17	-45	-26	-60
Alaska	-2	-6	-4	-9
Arizona	-23	-64	-35	-85
Arkansas	-11	-30	-17	-40
California	-130	-338	-196	-450
Colorado	-21	-57	-31	-76
Connecticut	-14	-33	-21	-44
Delaware	-4	-11	-6	-15
DC	-3	-8	-4	-10
Florida	-78	-221	-118	-294
Georgia	-41	-117	-62	-155
Hawaii	-5	-12	-7	-16
Idaho	-6	-16	-9	-22
Illinois	-48	-118	-72	-157
Indiana	-24	-59	-36	-79
Iowa	-13	-31	-19	-42
Kansas	-11	-28	-17	-37
Kentucky	-16	-41	-24	-55
Louisiana	-17	-46	-25	-61
Maine	-5	-13	-8	-17
Maryland	-27	-76	-40	-101
Massachusetts	-25	-62	-38	-83
Michigan	-37	-91	-56	-122
Minnesota	-22	-56	-34	-75
Mississippi	-10	-27	-16	-36
Missouri	-23	-57	-34	-76
Montana	-4	-11	-6	-15
Nebraska	-8	-19	-11	-25
Nevada	-10	-27	-15	-36
New Hampshire	-5	-13	-8	-18
New Jersey	-31	-74	-47	-99
New Mexico	-7	-20	-11	-27
New York	-66	-156	-99	-208
North Carolina	-39	-110	-59	-147
North Dakota	-3	-7	-4	-9
Ohio	-44	-107	-66	-143
Oklahoma	-14	-39	-22	-52
Oregon	-14	-35	-21	-47
Pennsylvania	-44	-104	-66	-139
Rhode Island	-4	-10	-6	-14
South Carolina	-18	-52	-28	-69
South Dakota	-3	-8	-5	-11
Tennessee	-23	-60	-35	-80
Texas	-93	-251	-140	-335
Utah	-10	-28	-15	-37
Vermont	-3	-7	-4	-9
Virginia	-36	-101	-54	-135
Washington	-24	-62	-36	-82
West Virginia	-7	-20	-11	-27
Wisconsin	-23	-56	-34	-74
Wyoming	-2	-6	-3	-8

Table 4: Household Income Impact (2007$)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	-$805	-$3,431	-$2,611	-$6,257
Alaska	-$1,095	-$4,548	-$3,552	-$8,294
Arizona	-$822	-$3,382	-$2,665	-$6,167
Arkansas	-$733	-$3,088	-$2,378	-$5,631
California	-$1,244	-$5,163	-$4,032	-$9,414
Colorado	-$977	-$4,019	-$3,167	-$7,328
Connecticut	-$1,472	-$6,417	-$4,774	-$11,701
Delaware	-$1,003	-$4,226	-$3,250	-$7,705
DC	-$1,267	-$5,342	-$4,109	-$9,740
Florida	-$918	-$3,868	-$2,976	-$7,053
Georgia	-$941	-$3,966	-$3,051	-$7,231
Hawaii	-$1,090	-$4,524	-$3,532	-$8,249
Idaho	-$789	-$3,247	-$2,558	-$5,920
Illinois	-$1,116	-$4,625	-$3,617	-$8,434
Indiana	-$899	-$3,728	-$2,916	-$6,798
Iowa	-$916	-$3,866	-$2,970	-$7,050
Kansas	-$947	-$3,994	-$3,069	-$7,283
Kentucky	-$794	-$3,383	-$2,575	-$6,169
Louisiana	-$794	-$3,343	-$2,574	-$6,095
Maine	-$807	-$3,517	-$2,617	-$6,414
Maryland	-$1,191	-$5,022	-$3,863	-$9,157
Massachusetts	-$1,341	-$5,842	-$4,346	-$10,653
Michigan	-$933	-$3,867	-$3,024	-$7,051
Minnesota	-$1,066	-$4,497	-$3,455	-$8,201
Mississippi	-$770	-$3,280	-$2,496	-$5,980
Missouri	-$891	-$3,758	-$2,887	-$6,852
Montana	-$709	-$2,918	-$2,299	-$5,321
Nebraska	-$961	-$4,056	-$3,116	-$7,396
Nevada	-$1,013	-$4,167	-$3,283	-$7,598
New Hampshire	-$1,157	-$5,040	-$3,749	-$9,190
New Jersey	-$1,381	-$5,854	-$4,478	-$10,675
New Mexico	-$727	-$2,990	-$2,356	-$5,452
New York	-$1,211	-$5,134	-$3,927	-$9,362
North Carolina	-$836	-$3,525	-$2,712	-$6,428
North Dakota	-$840	-$3,542	-$2,722	-$6,459
Ohio	-$902	-$3,739	-$2,924	-$6,819
Oklahoma	-$810	-$3,409	-$2,625	-$6,216
Oregon	-$913	-$3,789	-$2,959	-$6,909
Pennsylvania	-$1,018	-$4,314	-$3,299	-$7,866
Rhode Island	-$1,124	-$4,900	-$3,645	-$8,934
South Carolina	-$778	-$3,279	-$2,522	-$5,978
South Dakota	-$921	-$3,887	-$2,986	-$7,087
Tennessee	-$906	-$3,859	-$2,937	-$7,037
Texas	-$1,044	-$4,395	-$3,384	-$8,015
Utah	-$919	-$3,780	-$2,979	-$6,893
Vermont	-$901	-$3,925	-$2,920	-$7,157
Virginia	-$1,073	-$4,522	-$3,479	-$8,246
Washington	-$1,083	-$4,497	-$3,512	-$8,200
West Virginia	-$677	-$2,855	-$2,196	-$5,206
Wisconsin	-$913	-$3,786	-$2,961	-$6,904
Wyoming	-$894	-$3,678	-$2,898	-$6,707

Table 5: Loss in Gross State Product (Million 2007$)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	-$1,857	-$6,848	-$2,573	-$8,085
Alaska	-$461	-$1,700	-$639	-$2,007
Arizona	-$2,605	-$9,608	-$3,610	-$11,344
Arkansas	-$1,072	-$3,953	-$1,485	-$4,667
California	-$19,957	-$73,603	-$27,657	-$86,903
Colorado	-$2,657	-$9,800	-$3,683	-$11,571
Connecticut	-$2,407	-$8,878	-$3,336	-$10,482
Delaware	-$691	-$2,549	-$958	-$3,010
DC	-$1,017	-$3,750	-$1,409	-$4,427
Florida	-$8,053	-$29,699	-$11,159	-$35,066
Georgia	-$4,461	-$16,452	-$6,182	-$19,425
Hawaii	-$666	-$2,456	-$923	-$2,900
Idaho	-$560	-$2,064	-$776	-$2,437
Illinois	-$7,024	-$25,905	-$9,734	-$30,586
Indiana	-$2,979	-$10,987	-$4,128	-$12,972
Iowa	-$1,450	-$5,349	-$2,010	-$6,316
Kansas	-$1,310	-$4,831	-$1,815	-$5,703
Kentucky	-$1,737	-$6,406	-$2,407	-$7,564
Louisiana	-$2,144	-$7,907	-$2,971	-$9,336
Maine	-$561	-$2,069	-$777	-$2,443
Maryland	-$3,014	-$11,117	-$4,177	-$13,126
Massachusetts	-$4,055	-$14,954	-$5,619	-$17,656
Michigan	-$4,789	-$17,664	-$6,637	-$20,856
Minnesota	-$2,900	-$10,696	-$4,019	-$12,629
Mississippi	-$1,000	-$3,686	-$1,385	-$4,353
Missouri	-$2,701	-$9,963	-$3,744	-$11,763
Montana	-$365	-$1,346	-$506	-$1,589
Nebraska	-$893	-$3,295	-$1,238	-$3,890
Nevada	-$1,304	-$4,809	-$1,807	-$5,678
New Hampshire	-$673	-$2,482	-$932	-$2,930
New Jersey	-$5,384	-$19,855	-$7,461	-$23,443
New Mexico	-$838	-$3,091	-$1,162	-$3,650
New York	-$11,974	-$44,160	-$16,593	-$52,140
North Carolina	-$4,335	-$15,989	-$6,008	-$18,878
North Dakota	-$303	-$1,119	-$420	-$1,321
Ohio	-$5,563	-$20,518	-$7,710	-$24,225
Oklahoma	-$1,491	-$5,499	-$2,066	-$6,492
Oregon	-$1,750	-$6,454	-$2,425	-$7,620
Pennsylvania	-$6,100	-$22,496	-$8,453	-$26,561
Rhode Island	-$545	-$2,010	-$755	-$2,374
South Carolina	-$1,761	-$6,494	-$2,440	-$7,668
South Dakota	-$384	-$1,415	-$532	-$1,671
Tennessee	-$2,805	-$10,347	-$3,888	-$12,216
Texas	-$11,996	-$44,242	-$16,624	-$52,236
Utah	-$1,090	-$4,018	-$1,510	-$4,745
Vermont	-$287	-$1,059	-$398	-$1,250
Virginia	-$4,287	-$15,809	-$5,940	-$18,666
Washington	-$3,384	-$12,479	-$4,689	-$14,734
West Virginia	-$656	-$2,421	-$910	-$2,858
Wisconsin	-$2,721	-$10,035	-$3,771	-$11,848
Wyoming	-$320	-$1,180	-$444	-$1,394

Table 6: Change in Retail Gasoline Prices (2007$)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	$0.27	$2.19	$2.29	$5.22
Alaska	$0.28	$2.17	$2.44	$5.58
Arizona	$0.28	$2.27	$2.35	$5.20
Arkansas	$0.27	$2.24	$2.32	$5.32
California	$0.27	$2.10	$2.35	$5.39
Colorado	$0.29	$2.28	$2.36	$5.23
Connecticut	$0.27	$2.31	$2.34	$5.44
Delaware	$0.28	$2.29	$2.37	$5.42
DC	$0.31	$2.56	$2.65	$6.08
Florida	$0.25	$2.08	$2.16	$4.94
Georgia	$0.24	$1.96	$2.03	$4.64
Hawaii	$0.30	$2.39	$2.68	$6.14
Idaho	$0.29	$2.28	$2.36	$5.23
Illinois	$0.28	$2.28	$2.36	$5.41
Indiana	$0.26	$2.13	$2.20	$5.05
Iowa	$0.27	$2.17	$2.23	$5.10
Kansas	$0.27	$2.22	$2.28	$5.22
Kentucky	$0.28	$2.31	$2.41	$5.50
Louisiana	$0.27	$2.24	$2.32	$5.32
Maine	$0.27	$2.25	$2.28	$5.31
Maryland	$0.29	$2.38	$2.46	$5.64
Massachusetts	$0.27	$2.25	$2.28	$5.31
Michigan	$0.27	$2.17	$2.25	$5.15
Minnesota	$0.29	$2.31	$2.37	$5.43
Mississippi	$0.27	$2.18	$2.27	$5.19
Missouri	$0.27	$2.15	$2.21	$5.05
Montana	$0.29	$2.34	$2.42	$5.37
Nebraska	$0.27	$2.21	$2.26	$5.19
Nevada	$0.30	$2.37	$2.45	$5.44
New Hampshire	$0.26	$2.21	$2.23	$5.20
New Jersey	$0.26	$2.20	$2.22	$5.18
New Mexico	$0.27	$2.19	$2.26	$5.02
New York	$0.27	$2.31	$2.33	$5.44
North Carolina	$0.26	$2.15	$2.23	$5.10
North Dakota	$0.28	$2.25	$2.30	$5.28
Ohio	$0.27	$2.23	$2.31	$5.30
Oklahoma	$0.27	$2.17	$2.25	$5.16
Oregon	$0.27	$2.13	$2.39	$5.47
Pennsylvania	$0.27	$2.27	$2.29	$5.35
Rhode Island	$0.27	$2.31	$2.33	$5.43
South Carolina	$0.25	$2.08	$2.15	$4.94
South Dakota	$0.28	$2.24	$2.29	$5.25
Tennessee	$0.27	$2.21	$2.30	$5.26
Texas	$0.27	$2.23	$2.31	$5.30
Utah	$0.28	$2.27	$2.35	$5.21
Vermont	$0.26	$2.23	$2.26	$5.25
Virginia	$0.27	$2.21	$2.29	$5.25
Washington	$0.26	$2.07	$2.32	$5.31
West Virginia	$0.28	$2.30	$2.39	$5.47
Wisconsin	$0.28	$2.31	$2.39	$5.48
Wyoming	$0.27	$2.15	$2.23	$4.94

Table 7: Change in Residential Electricity Prices (2007 Cents per KWh)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	1.46	9.16	3.59	15.10
Alaska	0.83	3.72	1.69	5.64
Arizona	0.84	9.56	2.98	14.90
Arkansas	0.75	8.08	3.14	14.38
California	0.84	3.79	1.72	5.75
Colorado	0.78	8.85	2.76	13.79
Connecticut	0.87	6.43	2.50	10.04
Delaware	1.28	9.13	4.03	15.03
District Of Columbia	1.17	8.37	3.70	13.78
Florida	1.24	8.88	3.93	14.63
Georgia	1.14	8.13	3.60	13.39
Hawaii	1.15	5.15	2.34	7.81
Idaho	0.61	6.93	2.16	10.81
Illinois	1.47	9.79	3.56	17.48
Indiana	1.21	8.04	2.92	14.35
Iowa	1.67	10.20	3.77	14.95
Kansas	1.50	9.19	3.39	13.47
Kentucky	1.16	7.24	2.84	11.93
Louisiana	0.78	8.42	3.27	14.99
Maine	0.98	7.26	2.82	11.34
Maryland	1.15	8.21	3.63	13.52
Massachusetts	0.89	6.61	2.57	10.33
Michigan	1.44	9.58	3.48	17.09
Minnesota	1.49	9.13	3.37	13.38
Mississippi	1.51	9.46	3.70	15.59
Missouri	1.37	8.38	3.09	12.28
Montana 2	0.72	8.23	2.57	12.83
Nebraska	1.31	8.03	2.96	11.77
Nevada	0.89	10.17	3.17	15.85
New Hampshire	0.97	7.16	2.78	11.18
New Jersey	0.69	7.61	2.93	13.53
New Mexico	0.86	9.82	3.06	15.31
New York	0.92	10.16	3.91	18.05
North Carolina	1.21	8.67	3.83	14.27
North Dakota	1.27	7.79	2.88	11.42
Ohio	1.45	9.62	3.50	17.17
Oklahoma	0.73	7.90	3.07	14.07
Oregon	0.46	2.08	0.94	3.15
Pennsylvania	0.63	6.94	2.67	12.34
Rhode Island	0.90	6.63	2.58	10.35
South Carolina	1.15	8.26	3.65	13.61
South Dakota	1.46	8.94	3.30	13.09
Tennessee	1.31	8.22	3.22	13.55
Texas	0.89	9.55	3.71	17.00
Utah	0.68	7.75	2.42	12.08
Vermont	0.99	7.33	2.85	11.45
Virginia	1.15	8.21	3.63	13.51
Washington	0.41	1.85	0.84	2.80
West Virginia	0.92	6.60	2.92	10.86
Wisconsin	1.43	9.49	3.45	16.93
Wyoming	0.69	7.89	2.46	12.29

Table 8: Change in Residential Natural Gas Prices (2007$/MMBtu)

State	LOW CASE PROJECTION		HIGH CASE PROJECTION	
	2020	2030	2020	2030
Alabama	$0.95	$11.97	$4.68	$21.20
Alaska	$0.26	$4.29	$1.57	$7.22
Arizona	$0.92	$14.81	$5.30	$24.58
Arkansas	$0.84	$10.73	$4.17	$19.00
California	$0.53	$8.59	$3.15	$14.46
Colorado	$0.59	$9.49	$3.39	$15.76
Connecticut	$0.69	$11.32	$4.21	$19.72
Delaware	$0.69	$9.09	$3.57	$16.12
District Of Columbia	$0.86	$11.34	$4.45	$20.12
Florida	$1.03	$13.65	$5.36	$24.21
Georgia	$0.75	$9.88	$3.88	$17.53
Hawaii	$1.37	$22.33	$8.19	$37.60
Idaho	$0.65	$10.46	$3.74	$17.37
Illinois	$0.82	$10.34	$4.00	$18.05
Indiana	$0.86	$10.91	$4.22	$19.05
Iowa	$0.83	$10.82	$4.16	$18.76
Kansas	$0.84	$10.86	$4.18	$18.83
Kentucky	$0.75	$9.38	$3.67	$16.62
Louisiana	$0.83	$10.59	$4.12	$18.75
Maine	$0.58	$9.57	$3.56	$16.67
Maryland	$0.75	$9.90	$3.88	$17.56
Massachusetts	$0.65	$10.66	$3.96	$18.57
Michigan	$0.66	$8.41	$3.26	$14.69
Minnesota	$0.78	$10.14	$3.90	$17.58
Mississippi	$0.77	$9.67	$3.78	$17.12
Missouri	$0.90	$11.70	$4.50	$20.28
Montana 2	$0.58	$9.33	$3.34	$15.49
Nebraska	$0.74	$9.62	$3.70	$16.68
Nevada	$0.73	$11.68	$4.18	$19.40
New Hampshire	$0.65	$10.58	$3.93	$18.43
New Jersey	$0.59	$8.66	$3.35	$15.26
New Mexico	$0.63	$10.16	$3.63	$16.87
New York	$0.79	$11.60	$4.48	$20.44
North Carolina	$0.76	$10.00	$3.92	$17.73
North Dakota	$0.69	$8.94	$3.44	$15.50
Ohio	$0.88	$11.07	$4.29	$19.34
Oklahoma	$0.77	$9.79	$3.80	$17.32
Oregon	$0.56	$9.14	$3.35	$15.38
Pennsylvania	$0.73	$10.68	$4.13	$18.83
Rhode Island	$0.65	$10.60	$3.94	$18.47
South Carolina	$0.76	$10.05	$3.94	$17.82
South Dakota	$0.79	$10.19	$3.92	$17.67
Tennessee	$0.76	$9.60	$3.75	$17.00
Texas	$0.74	$9.36	$3.64	$16.57
Utah	$0.57	$9.15	$3.27	$15.18
Vermont	$0.56	$9.21	$3.42	$16.04
Virginia	$0.78	$10.26	$4.03	$18.20
Washington	$0.52	$8.37	$3.07	$14.10
West Virginia	$0.59	$7.73	$3.03	$13.71
Wisconsin	$0.87	$10.97	$4.25	$19.15
Wyoming	$0.58	$9.34	$3.34	$15.50

APPENDIX 1: ADDITIONAL INFORMATION ON THE OPERATION OF THE NEMS MODEL

1) How is supply-side energy conversion efficiency accounted for in NEMS?

Each supply-side technology used by NEMS (e.g., nuclear, natural gas combined cycle) incorporates a design specification that accounts for temporal changes in technology efficiency based on commercial implementation experience and technology improvement expectation. Efficiency values are specified for the year that a technology is assumed to become commercially available for deployment and for some year in the future (different for each technology) that accounts for improvements associated with experiential learning and continued technology R&D. The model interpolates to establish annual efficiency improvements for each supply-side technology.

2) What is the sensitivity of the model to supply-side technology capital costs for power generation?

For capacity expansion decision-making in any given year of the projection, NEMS calculates an associated present-value cost of each competing technology based on **capital cost, fixed & variable operating and maintenance costs** (O&M), and projected **fuel consumption costs**. In concert with specified operating and environmental constraints, the model chooses the least-cost mix of technologies to meet projected energy demand for the projection period. Therefore, relative differences in technology capital costs directly impact the cost-competitiveness of each technology and the extent to which annual capacity is added for each. Commercialization-year capital costs are user-specified for each technology type and the model projects learning-based cost reductions based on the total capacity added for each technology over the projection period. Therefore, the relative technology capital costs often change over the projection period depending on the relative levels of technology deployment.

With regard to operating dispatch decisions, NEMS only chooses the mix of plants that minimizes fuel, variable O&M, and environmental costs, subject to meeting electricity demand and environmental constraints.

APPENDIX 2: SUMMARY OF THE NEMS/ACCF/NAM ANALYSIS OF S. 2191 AT THE NATIONAL LEVEL

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United States
Economic Impact from the Lieberman-Warner Proposed Legislation to Reduce Greenhouse Gas Emissions

Understanding the economic impacts of the Lieberman-Warner Climate Security Act[1] (L/W bill) can help guide choices on climate change policy.[2] In this study, the L/W bill was analyzed under low and high cost cases with respect to a baseline that projects the future in the absence of the bill. The L/W bill would enforce a nationwide cap and trade program for the emissions of greenhouse gases (GHGs) and would reduce GHG emissions covered by the bill to 4,992 Million Metric Tons of CO_2 ($MMTCO_2$) by 2020 and 3,856 $MMTCO_2$ by 2030 (Figure 1). L/W sets targets that would reduce GHG emissions to 15% below 2005 levels by 2020; 30% below 2005 levels by 2030; and 70% below 2005 levels by 2050. Covered emissions are assumed to include everything from combustion of fossil fuels in the United States, plus non-CO_2 GHG emissions included in the L/W cap. The price of carbon permits (what companies must pay to emit CO_2) could reach between $55 and $64 per metric ton of CO_2 (MT) by 2020 and could increase to between $227/MT and $271/MT by 2030.[3]

Impact on Jobs

Under L/W, the United States would lose between 1.2 and 1.8 million jobs in 2020 and between 3 and 4 million jobs in 2030. The primary cause of job losses would be lower industrial output due to higher energy prices, the high cost of complying with required emissions cuts, and greater competition from overseas manufacturers with lower energy costs.

Impact on Disposable Household Income

Higher energy prices would have ripple impacts on prices throughout the economy and would impose a financial cost of $739 to $2,927 per year by 2020 on national households, rising to $4,022 to $6,752 by 2030 (Figure 3).

L/W's Impact on Energy Prices

Most energy prices would rise under L/W, particularly, coal, oil, and natural gas. The price of gasoline would increase between 60% and 144% by 2030, while electricity prices would increase by 77% to 129%. Table 1 shows the increase in gasoline and electricity prices faced by US households. US consumers would pay between 84% and 146% more for their natural gas by 2030.

Figure 1. US CO_2 Emissions and S. 2191 Targets

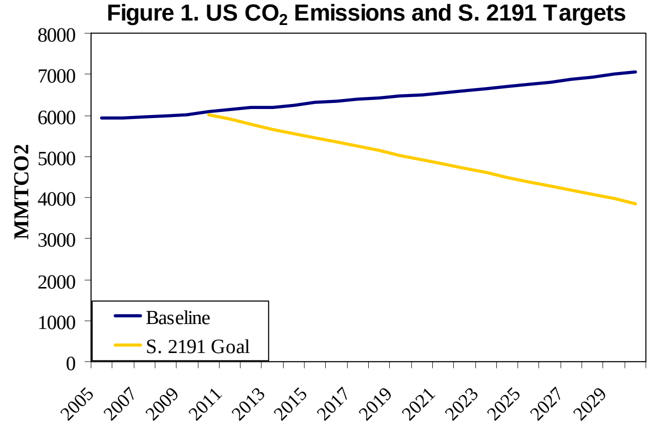


Figure 2: Loss in Employment Relative to Baseline (Millions of Jobs)

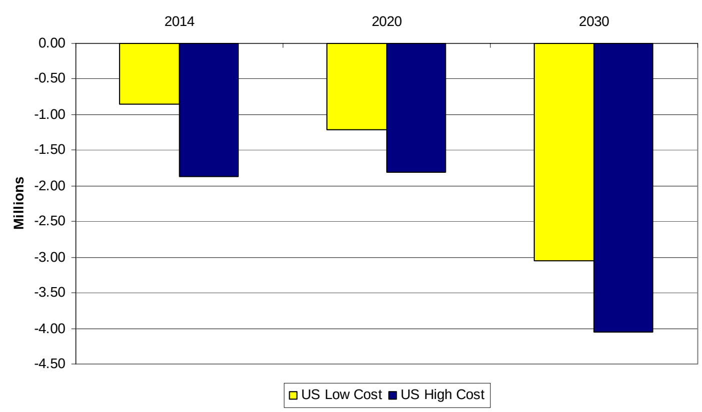
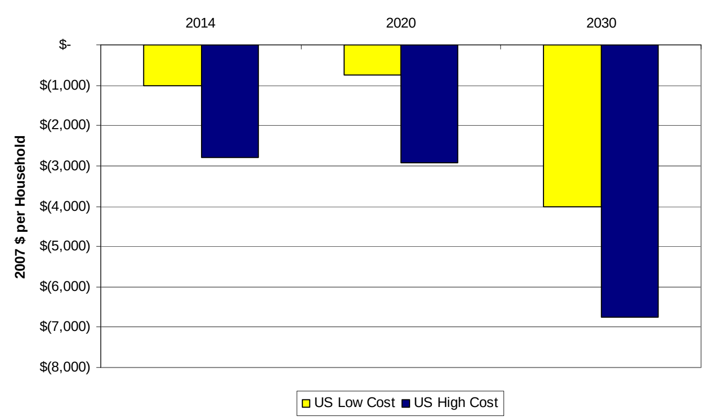


Figure 3: Household Impact Relative to Baseline (Annual Dollars Lost per Household)



[1] S. 2191

[2] The study used the National Energy Modeling System (NEMS) and assumptions provided by AACF and NAM for this analysis. NEMS is used by the US Energy Information Administration for energy forecasting and policy analysis. "Low" refers to the Low Cost Case, which assumes higher nuclear capacity, less constraint on new generating technologies, etc. Both cases use higher capital costs than the baseline. "High" refers to the High Cost Case, which assumes low nuclear additions, constrained new generation technologies, high oil prices etc. (See the full report for all assumptions)

3. All dollar figures in this summary are reported in constant 2007 dollars.

Factors Contributing to Higher Electricity Prices

L/W would reduce GHG emissions from all sectors of the economy (transportation, residential, commercial, and industry); however, as the largest emitter of GHGs, the primary impact would fall on the electric sector. L/W would result in the electric industry shutting down most carbon-based generation and/or using expensive, as yet unproven technology, to capture and store CO_2. To meet the stringent goals of L/W, the electric industry would also have to substitute high cost technologies, such as biomass and wind, for conventional generation.

Impact on Economic Growth

High energy prices, fewer jobs, and loss of industrial output are estimated to reduce gross domestic product (GDP) by between $151 billion and $210 billion per year by 2020 and $631 billion and $669 billion by 2030 (Figure 4).

Impact on Industry

Some major economic sectors will be adversely hit by emission caps (Figure 5). By 2020, primary metals output would be reduced by between 15% and 19%; stone, glass, and clay products would be reduced by between 10% and 12%; motor vehicle manufacturing would be reduced by between 6% and 14%; and paper products would be reduced by between 5% and 7%. In addition the general shift away from coal would result in a 35% reduction in coal production and electricity production would fall around 12%. These losses would be significantly higher by 2030 and would have a lasting impact on the economic base of the US.

Impact on Low Income Families

The impacts of L/W will be felt especially by the poor, who spend more of their income on energy and other goods than other income brackets. By 2020, higher energy prices mean that low income families (with average incomes less than $18,500) will spend between 19% and 22% of their income on energy under L/W compared to a projected 17% without L/W. Others on fixed incomes, such as the elderly will also suffer disproportionately.

Table 1: Percentage Energy Price Increase Relative to Baseline

Sector	Year	US Low	US High
Electricity (Residential)	2014	13%	14%
	2020	28%	33%
	2030	101%	129%
Gasoline	2014	13%	50%
	2020	20%	69%
	2030	77%	145%
Natural Gas (Residential)	2014	18%	21%
	2020	26%	36%
	2030	108%	146%

Figure 4: Annual Impact of GDP Relative to Baseline (Billion 2007$)

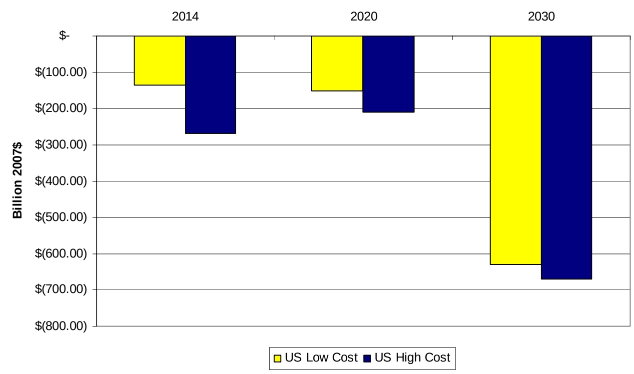


Figure 5: Impact on Industrial Value of Shipments Percentage Change from Baseline in 2020

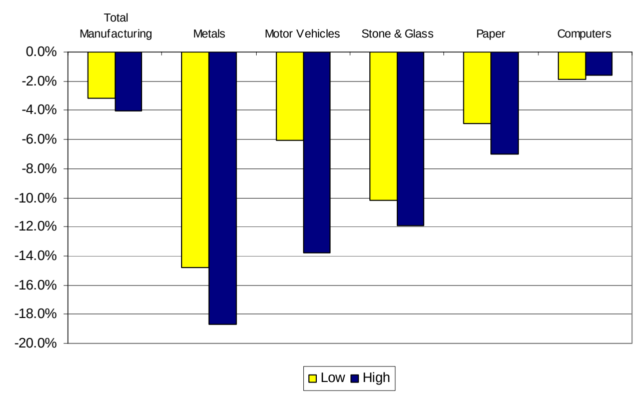
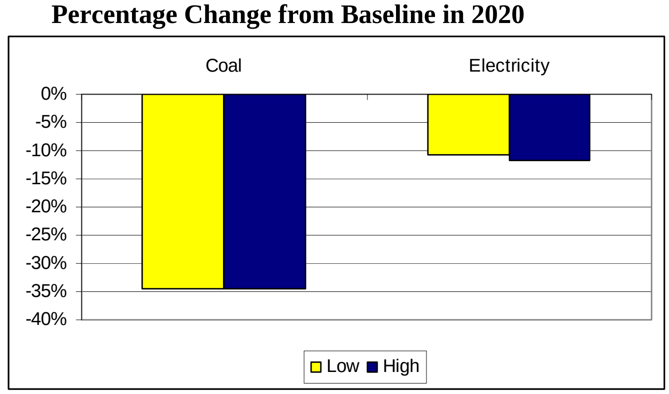


Figure 6: Impact on Production Percentage Change from Baseline in 2020



APPENDIX 3: SUMMARY OF THE NEMS/ACCF/NAM ANALYSIS OF S. 2191 AT THE STATE LEVEL

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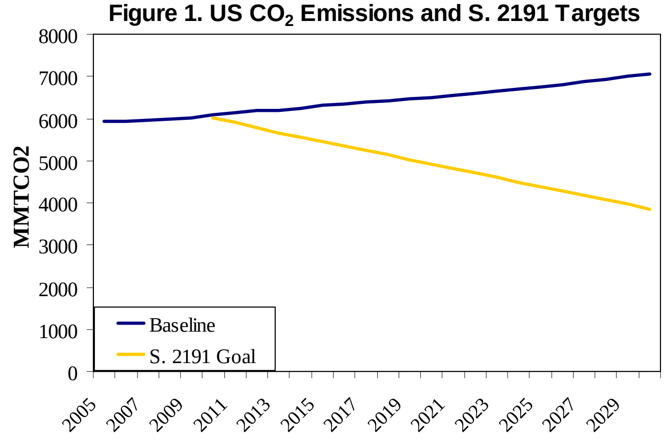
Alabama
Economic Impact on the State from the Lieberman-Warner Proposed Legislation to Reduce Greenhouse Gas Emissions

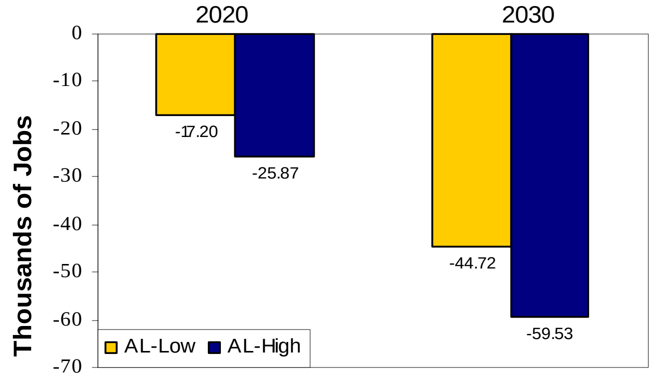
Understanding the economic impacts of the Lieberman-Warner Climate Security Act[1] (L/W bill) can help guide choices on climate change policy.[2] In this study, the L/W bill was analyzed under low and high cost cases with respect to a baseline that projects the future in the absence of the bill. The L/W bill would enforce a nationwide cap and trade program for the emissions of greenhouse gases (GHGs) and would reduce GHG emissions covered by the bill to 4,992 million metric tons of CO_2 ($MMTCO_2$) by 2020 and 1,732 $MMTCO_2$ by 2050 (Figure 1). By 2020 L/W would result in approximately a 15% reduction in GHG emissions from 2005 levels for those sectors of the economy covered by the bill. By 2050, the emissions reduction would be 33% compared to 2030. Covered emissions are assumed to include everything from combustion of fossil fuels in the United States, plus non-CO_2 GHG emissions included in the L/W cap. The price of carbon permits (what companies must pay to emit CO_2) could reach between $55 and $64 per metric ton of CO_2 (MT) by 2020 and could increase to between $227/MT and $271/MT by 2030.[3]

Figure 1. US CO_2 Emissions and S. 2191 Targets



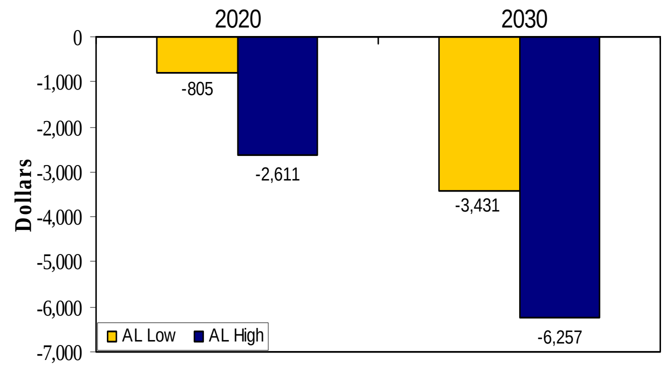
Impact on Jobs
Under L/W, Alabama would lose 17,200 to 25,874 jobs in 2020 and 44,721 to 59,530 jobs in 2030 (Figure 2). The primary cause of job losses would be lower industrial output due to higher energy prices, the high cost of complying with required emissions cuts, and greater competition from overseas manufacturers with lower energy costs.

Figure 2. Loss in Employment



Decrease in Disposable Household Income
Higher energy prices would have ripple impacts on prices throughout the economy and would impose a financial cost on households. Alabama would see disposable household income reduced by $805 to $2,611 per year by 2020 and $3,431 to $6,257 by 2030 (Figure 3).

Figure 3. Loss of Disposable Income per Household



L/W's Impact on Energy Prices
Most energy prices would rise under L/W, particularly coal, oil, and natural gas. The price of gasoline in Alabama would increase between 74% and 144% by 2030, while electricity prices would increase by 122% to 159%. Table 1 shows the increase in electricity, gasoline, and natural gas prices faced by a typical Alabama household compared to national household increases. Alabama residents would pay between 99% and 142% more for their natural gas by 2030.

[1] S. 2191
[2] The study used the National Energy Modeling System (NEMS) and assumptions provided by AACF and NAM for this analysis. NEMS is used by the US Energy Information Administration for energy forecasting and policy analysis. "Low" refers to the Low Cost Case, which assumes higher nuclear capacity, less constraints on new generating technologies, etc. Both cases use higher capital costs than the baseline. "High" refers to the High Cost Case, which assumes low nuclear additions, constrained new generation technologies, high oil prices, etc. (See the full report for all assumptions).
[3] All dollar figures in this report are presented in constant 2007 dollars.

Factors Contributing to Higher Electricity Prices

L/W would reduce GHG emissions from all sectors of the economy (transportation, residential, commercial, and industry); however, as the largest emitter of GHGs, the primary impact would fall on the electric sector. L/W would result in the electric industry shutting down most carbon-based generation and/or using expensive, as yet unproven technology, to capture and store CO_2. To meet the stringent goals of L/W, the electric industry would also have to substitute high cost technologies, such as biomass and wind, for conventional generation.

Impact on Economic Growth

High energy prices, fewer jobs, and loss of industrial output are estimated to reduce Alabama's gross state product (GSP) by between $1.9 and $2.6 billion per year by 2020 and $6.8 and $8.1 billion by 2030 (Figure 4).

Impact on Industry

Alabama's major economic sectors will be affected by emission caps (Figure 5).[4] The current two largest sectors, transportation manufacturing and paper manufacturing, show decreases in output of 5.9% to 13.2% and 4.8% to 6.5%, respectively in 2020. All manufacturing sectors will suffer output losses of between 3.5% and 5.9% by 2020, while output from energy intensive sectors fall between 7.5% and 9.5%. Alabama's coal production would fall between 18.5% and 22.1%, although due to its low cost of generation, electricity supply could rise slightly over the baseline forecast (Figure 6). These continued losses will have a lasting effect on the economic base of Alabama.

Impact on Low Income Families[5]

The impacts of L/W will be felt especially by the poor, who spend more of their income on energy and other goods than other income brackets. By 2020, higher energy prices mean that low income families in Alabama (with average incomes of $12,945) will spend between 22% and 25% of their income on energy under L/W compared to a projected 19% without L/W. Others on fixed incomes, such as the elderly will also suffer disproportionately.

Impact on State Budgets[6]

The increases in Alabama's energy costs under L/W will impact expenditures throughout the state. Specifically, Alabama's 2,069 schools and universities and 134 hospitals will likely experience a 62% to 71% percent increase in energy costs by 2020 and a 215% to 267% increase by 2030. For government entities, costs for services, including public transportation and vehicle fleets, such as school buses, will also rise under L/W.

Table 1: Change in Energy Prices at Household (% change from baseline)

Sector	Year	AL Low	AL High
Electricity (Residential)	2020	32%	40%
	2030	122%	159%
Gasoline (Retail)	2020	21%	70%
	2030	74%	144%
Natural Gas (Residential)	2020	25%	35%
	2030	99%	142%

Figure 4. Loss in Gross State Product

Figure 5: Impact on Industrial Value of Shipments Percentage Change from Baseline in 2020

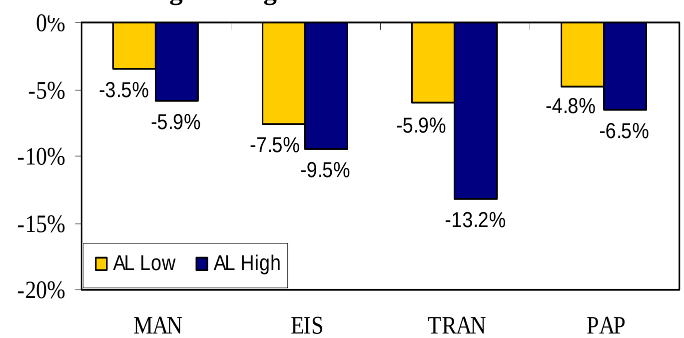
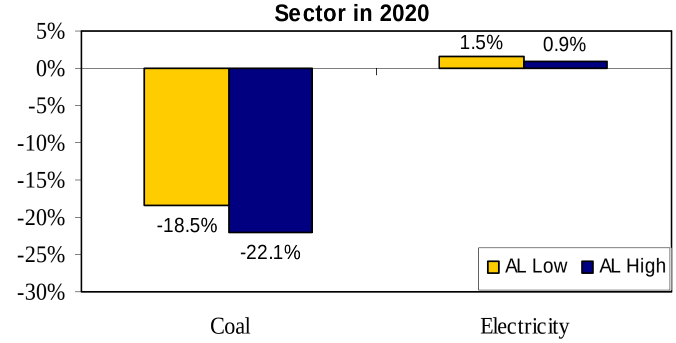


Figure 6. Percent Change in Production by Sector in 2020



[4] MAN = Manufacturing, EIS = Energy Intensive Sectors; TRAN = Transportation equipment manufacturing; PAP = Paper products manufacturing.

[5] These projections assume that the energy expenditures by income quintile in the state are the same as the average for the census division, since there is insufficient data to accurately calculate this quantity on the state level.

[6] These projections assume that the expenditures on schools and hospitals are the same as the average for the census region, since there is insufficient data to accurately calculate these quantities on the state level.