Economic Insights from Modeling Analyses of H.R. 2454 — the American Clean Energy and Security Act (Waxman-Markey)

Executive Summary

Economic models are an important tool for evaluating the potential impact of proposed legislation on our economy. This brief compares modeling analyses of the House-passed clean energy and climate bill (H.R. 2454) conducted by seven different groups including government agencies, non-governmental organizations and an academic institution. It identifies key similarities and differences among these analyses and draws the following conclusions:

- ***GDP will continue to grow robustly with the passage of the House bill.***
- ***Household income grows robustly across all models with many models finding relatively modest impacts.***
- ***The availability of low-carbon technologies to generate electricity is crucial to minimizing the costs of achieving the greenhouse gas (GHG) reduction targets in the House bill.***
- ***The more offsets included in the program, the lower the costs.***
- ***The degree to which the modeling analyses accurately reflect key provisions in the House bill will impact their estimates of costs.***

Introduction

Models have been extensively used to evaluate the economic consequences of different policy choices for addressing global climate change. But it is important to understand both the limitations of these models and the insights that can be gleaned from their results. Model results depend critically upon the structure and assumptions in the models, as well as the data that are used as inputs to the model.

The cost analyses of climate policies examined in this brief rely on models that use complex systems of mathematical equations and large amounts of data to simulate the workings of our energy system and economy. These models are valuable tools for exploring the economic implications of alternative policy choices and for generating insights about how our current economy might respond to legislative proposals. They cannot, however, predict future events, nor can they produce reliably precise projections of the consequences of specific policy.

The models examined in this brief along with the specific policy scenarios that are the focus of this comparison are the following[1]:

- **U.S. Energy Information Administration (EIA)—"basic" policy case;**
- **U.S. Environmental Protection Agency (EPA)—ADAGE Scenario 2;**
- **National Black Chamber of Commerce (NBCC)—core policy case[2];**

- **American Council for Capital Formation-National Association of Manufacturers (ACCF-NAM)—High Cost and Low Cost cases;**
- **Massachusetts Institute of Technology (MIT)—Medium Offsets and Full Offsets cases;**
- **Natural Resources Defense Council (NRDC)—NEMS core policy case; and**
- **Heritage Foundation—policy case.**

Recent history shows that predicting future energy costs and economic activity is difficult. The enormous volatility in both gasoline and natural gas prices over the past two years underscores how perilous any predictions can be. Economic growth also plays a large role in determining the costs of climate policy. The Energy Information Administration recently reported that carbon emissions from energy use dropped 2.8 percent in 2008 from 2007 levels, due largely to the decline in economic activity as well as higher energy prices. Beyond such short-term challenges, there is even greater uncertainty in attempting to predict outcomes that occur in 30 or 40 years, both in terms of technologies that might be available and the costs of using those technologies. In the past, prior estimates of the cost of regulation were often many times greater than the actual observed costs once a program was put in place.[3]

Those seeking to understand the economic impacts of proposed climate legislation should view these analyses as providing useful insights into the measures and assumptions that drive the economic costs of the proposed legislation either higher or lower. These studies can be informative about the relative importance of key policy design issues—the role of carbon capture and storage (CCS) or expanded nuclear generation, the significance of offsets, and the significance of rebating the value of allowances to consumers. Given the long time frames and large uncertainties, these models are far less useful in estimating the actual cost of particular legislation.

This policy memo summarizes some of the modeling analyses that have been used to better understand the economic impacts of the American Clean Energy and Security (ACES) Act (H.R. 2454). This bill was originally introduced by Representatives Waxman and Markey in March of 2009, and was passed by the U.S. House of Representatives on June 26, 2009. To encourage the transition to a clean energy economy, the ACES Act includes an economy wide cap-and-trade regime for the major greenhouse gases, a federal renewable electricity and efficiency standard, performance standards for new coal-fired power plants, R&D support for electric vehicles, and provisions related to building and appliance efficiency standards.

In capping GHG emissions, the ACES Act requires reductions for covered entities of 3 percent in 2012, 17 percent in 2020, 42 percent in 2030, and 83 percent in 2050 below 2005 levels.[4] The bill would utilize the value of emission allowances to mitigate the cost impact to consumers and workers, to aid businesses in transitioning to clean energy technologies, to support technology development and deployment, and to support activities aimed at building communities that are more resilient to climate change. In an effort to address concerns about high compliance costs for regulated firms and related high energy prices for consumers in the early years of the program, the bill includes the following additional measures:

- **Up to 2 billion tons of offsets can be used for compliance system wide—1 billion from domestic sources and 1 billion from international sources.** For international offsets, beginning in 2018, 1.25 offset credits would be required to be surrendered for each ton of emissions compliance.
- **Unlimited banking of emissions allowances, next-year borrowing with no interest, and borrowing of allowances from 2-5 years beyond the compliance year, but with specified limits.**

- **Strategic allowance reserve auction to contain costs by making additional allowances available if prices exceeded specified thresholds.** The reserve would be filled with a small percentage of allowances (1-3 percent depending on the year) from future years and additional offsets. The initial minimum price level for the strategic reserve auction would be set at $28 in 2012.

The modeling analyses of the ACES Act capture some of these key policy elements (e.g., the impacts of emission reduction targets, banking, and use of offsets), but cannot incorporate all of them. For example, the strategic reserve auction—an important cost containment feature of the bill—is not directly modeled in any of the analyses.

Furthermore, none of the analyses of the House-passed bill included here is an integrated assessment that includes both the costs and benefits of taking action, such as the avoided impacts from climate change, gains in energy security, or new jobs associated with emerging technologies. Therefore, the analyses profiled in this review present only one side of the story—the costs of the policy, not the benefits of the policy.

Few, if any, of the experts who work closely with models believe that specific model projections regarding future energy costs or GDP impacts under any given policy will prove accurate. But the modeling results are interesting and useful for the broader insights they reveal. They can help those designing and voting on legislation to understand the relative importance of various provisions they are considering. For example, the modeling analyses reviewed in this paper demonstrate that one of the most important drivers of overall cost is the availability and use of offsets. Thus if the goal of keeping costs low is to be achieved, careful attention must be paid to ensure that the legislation creates an offset program that is designed in an effective manner. At the

Table 1

Summary of Key Modeling Results

Modeling Exercise	2020		2030		2050	
	Allowance Price (2007$)	GDP Impact (% change from BAU)	Allowance Price $2007	GDP Impact (% change from BAU)	Allowance Price $2007	GDP Impact (% change from BAU)
EIA-"Basic" case	$31.75	-0.33%	$64.83	-0.81%	—	—
EPA-Scenario 2 ADAGE	$17.33	0.13%	$28.19	-0.37%	$74.77	-1.30%
NBCC	$29.37	-0.80%	$47.98	-1.00%	$128.26	-1.50%
ACCF-NAM Low	$47.50	-0.20%	$123.21	-1.80%	—	—
ACCF-NAM High	$61.24	-0.40%	$158.85	-2.40%	—	—
Heritage	$28.39	-0.83%	$99.81	-2.83%	—	—
NRDC-NEMS	$27.75	-0.25%	$56.66	-0.78%	—	—
MIT Medium Offsets	$27.53	-0.55%	$40.75	-1.02%	$89.29	-1.86%
MIT Full Offsets	$9.40	-0.29%	$13.90	-0.43%	$30.47	-0.96%

same time, if offsets markets do not ramp up quickly, or if high demand pushes their price up significantly, the costs of meeting reduction targets could rise.

The following section summarizes key policy insights with respect to potential program costs from the various modeling analyses of the House-passed bill. Table 1 presents a summary of key results from each of the studies examined in this brief and Table 2, at the end of this brief, provides a more detailed comparison of results.

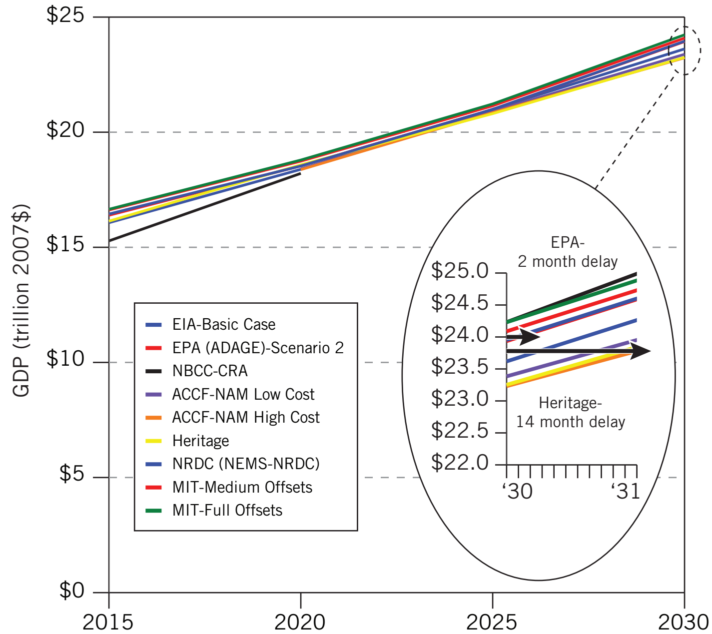
Key Insights

GDP will continue to grow robustly with the passage of the House bill.

Across all models, GDP growth over the period covered by these analyses will be robust with or without climate policy. While many of the studies report the dollar estimates that result from small percentage reductions in GDP in 2030 or beyond, it is important to put these numbers into context. The economy of the United States is very large and even small changes when reported in absolute terms can sound large. For example, in EIA's analysis of its "basic" policy case[5] of the House-passed bill, GDP still grows by 47 percent over 15 years, increasing from $16 trillion in 2015 to $23.6 trillion in 2030 (in constant 2007 dollars).[6] Compared to the no-policy (reference) case, EIA projects that the House-passed bill would reduce GDP by 0.3 percent in 2020 and by 0.8 percent in 2030. Based on EIA's analysis, the House-passed bill would have the impact in 2030 of delaying GDP reaching the level it would in the no-policy (reference) case by just over four months.

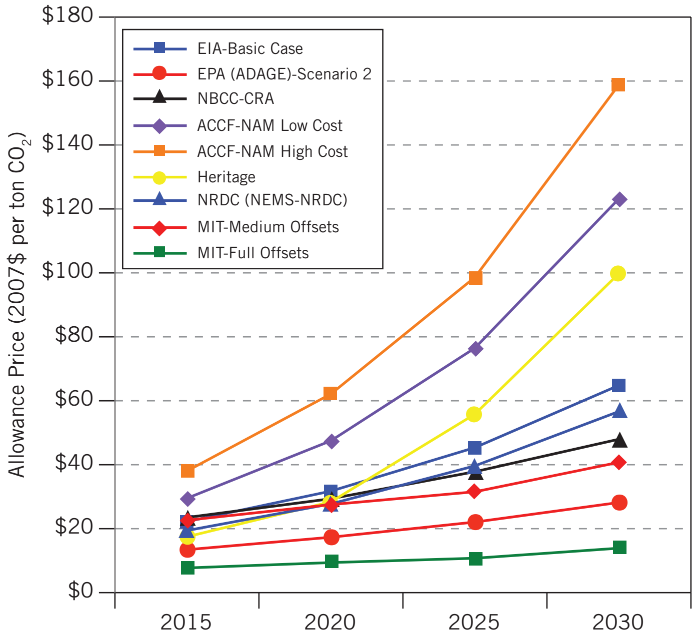
Essentially the same holds true across all of these analyses. Reductions in GDP in 2030 range from a low of 0.4 percent (EPA) to a high of 2.8 percent (Heritage) relative to the no-policy (reference) case developed by each model. Those models that are more optimistic about the availability of offsets and about the availability and costs of low-carbon technologies (EIA, EPA, MIT and NRDC) tend toward lower costs, while those that impose constraints on offsets and assume slower and more expensive low-carbon technology (NBCC, ACCF-NAM and Heritage) tend to produce higher costs. Across all models, regardless of assumptions, the model results suggest that even with climate policy, GDP continues to grow substantially. (See Figure 1 for a comparison of GDP impacts over time.)

Figure 1—GDP Impacts over Time



Like projected GDP, projected allowance prices are also commonly used as an indicator of overall program cost and they generally receive a great deal of attention. Across the various studies reviewed, allowance price projections vary widely (see Figure 2). High prices are usually the result of scenarios with highly restrictive offset assumptions and delayed technology deployment. Nevertheless, even in studies that produced the highest allowance prices, growth in GDP continues.

Figure 2—Projections of Allowance Prices



Household income grows robustly across all models with many models finding relatively modest impacts.

While the U.S. economy still continues to grow robustly with climate policy, as evidenced by the growth in GDP, there is concern about the effects of such policy on consumers, both in the aggregate and at the household level. Climate legislation is expected to result in increased energy prices that will be experienced directly by consumers. In an effort to minimize these impacts, the House-passed bill includes a provision that electricity consumers (residential, commercial and industrial) receive the value of free allowances (phased out in 2030). This is achieved by giving allowances to electricity and natural gas distribution companies and requiring that they pass the value of these allowances on to rate-payers to compensate for cost increases. The bill also sets aside 15 percent of total allowances, the value of which is intended to be provided directly to low and moderate income households.

Impacts on household consumption[7] are computed by taking into account higher prices for energy and for goods produced with energy, but also the rebates to consumers and other factors such as changes in investment and wage income. These studies show reductions in consumption in 2020 that range from 0.01 percent (NRDC) to 1.1 percent (NBCC) relative to each model's no-policy (reference) case. With the phase-out of utility rebates in 2030, household consumption impacts range from a loss of 0.3 percent (EIA) to 1.1 percent (NBCC). To put impacts on consumption into context, EIA's analysis shows a reduction in consumption of 0.29 percent in 2030, but over the 2015 to 2030 timeframe, consumption would still grow by 27.4 percent, rather than the 27.5 percent in the no-policy (reference) case.

Gasoline price increases are also a specific concern that is sometimes raised about the impact of clean energy legislation on households.[8] According to EIA's analysis, in its no-policy (reference) case, gasoline prices are projected to increase from $2.82 per gallon in 2007 to $3.82 in 2030. In EIA's "basic" policy case, the House-passed bill results in gasoline prices increasing to $4.18 per gallon by 2030, 36 cents more than in the no-policy case. Of the total price increase, over 70 percent is from market forces in the no-policy (reference) case with the remaining 30 percent due to limits contained in the legislation. According to EIA's results, gasoline price increases attributable to the policy case would amount to about 2 cents per gallon per year.

The availability of low-carbon technologies to generate electricity is crucial to minimizing the costs of achieving the GHG reduction targets in the House bill.

Across the studies examined, the availability and costs of a range of technology options is a key factor in determining how emission reduction targets are reached and at what cost. While all of the studies place some constraints on the growth of nuclear, renewable, biomass or coal use with carbon capture and storage (CCS), those studies with the most stringent constraints tend to have significantly higher allowance prices and economic impacts. In particular, the ACCF-NAM analysis (both Low and High Cost cases) constrains the growth of nuclear generation and CCS to levels well below those reached in other studies. EIA, in one of its sensitivity cases, also assumes a "high cost" case (the costs of nuclear, coal with CCS and biomass are 50 percent higher than its "basic" policy case) which results in allowance prices in 2030 increasing by about ten percent compared to its "basic" policy case. Similarly, ACCF-NAM's analysis includes "low cost" and "high cost" cases (with different constraints on capacity growth of low-carbon technologies) that result in allowance prices increasing by over 30 percent between the low and high cost cases.

Unfortunately, the cost and availability of future low carbon technology is not something that can be known with certainty, especially in the distant years included in the models (e.g., 2030 and beyond). Nevertheless, technology incentives, like those contained in the House-passed bill, should help reduce the costs and increase the speed of deployment and will play an important role in determining the costs of climate policy. The Heritage Foundation's analysis, for example, does not include any of the incentive payments for CCS deployment contained in the House bill, and therefore assumes that CCS is more expensive. As a consequence, it finds no deployment of this technology through 2030, even with relatively high projected allowance prices ($100 per ton by 2030). In the analyses by other groups, CCS technology on coal plants is phased in by 2020 due largely to the financial incentives contained in the House bill. Sensitivity analysis that constrains or accelerates the availability of low-carbon technology provides useful insights into the relative importance of these technologies and moreover, the importance of key policies like the technology incentives contained in the bill. These assumptions, however, should be clearly identified and where key constraints on provisions of the bill are imposed, they should be highlighted and the basis for such constraints detailed.

The more offsets included in the program, the lower the costs.

Offsets allow firms to utilize less expensive emission reductions from sources outside the cap to "offset" more expensive reductions required under the cap. They are a critically important variable in determining the cost of meeting reduction targets in the House-passed bill. Offsets will be a particularly important abatement strategy in the early years of the program until new low- and zero-carbon technologies become less expensive and more widely available.

Five of the policy cases compared in this brief (EIA, EPA, NBCC, NRDC, and MIT Full Offsets case) do not place constraints on offsets beyond those contained in the bill. These (along with MIT's Medium Offsets case) have the lowest allowance prices of the studies examined in our comparison. Four of the analyses (ACCF-NAM's High and Low Cost cases, Heritage and MIT Medium Offsets) impose constraints on offset availability beyond those contained in the bill.[9] The three highest allowance price estimates come from this group that constrains the availability of offsets (MIT Medium Offsets case is the exception).

MIT's two policy cases (the Medium Offsets and High Offsets cases) provide insights into the impact of different assumptions about offsets. They compare full offsets available immediately with a phased in approach which allows full offset use by 2050. In 2030 when offsets are partially phased in, allowance prices are $41 per ton (Medium Offsets case) compared to $14 per ton in the Full Offset case. In addition, EIA conducted a sensitivity analysis which showed allowance prices increased from $65 per ton in its "basic" policy case to over $100 per ton in 2030 (a 63 percent increase) if international offsets were unavailable.

Because there are no limits on the number of offsets or allowances that can be banked (i.e., bought or created in one year and held for use in a later year), the result is that large numbers of offsets are banked in early years when the carbon cap is relatively lenient and allowance prices are low. These banked offsets and allowances are held for future years when prices are expected to be higher and the cap is more stringent. A consistent insight from all of the modeling analyses is that the availability of large numbers of offsets in the early years of the policy will keep allowance prices and GDP costs low over the entire forecast.

The degree to which the modeling analyses accurately reflect key provisions in the House bill will impact their estimates of costs.

The House bill contains scores of provisions, many of which would be difficult or impossible to model, and others whose inclusion would be unlikely to change the fundamental results. Nevertheless, analyses that are proffered as estimating the economic impact of a bill should reflect its key provisions. Most of the analyses included in this brief capture the most important features of the House bill. However, both the Heritage Foundation and MIT analyses exclude from their studies one key provision, the bonus allowances for initial deployment of CCS.[10]

Given the limitations of the models used, the energy efficiency provisions in the bill are another area where the studies vary widely. EIA, EPA, ACCF-NAM, and NRDC have included most of the key efficiency provisions. The analyses by NBCC, MIT and the Heritage Foundation have more limited treatment of these provisions. Finally, none of the studies are able to explicitly model the strategic reserve provisions contained in the bill.

Model Summaries

Energy Information Administration (EIA)

Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009[11]

Modeling Framework and Reference Case

EIA was created by Congress as an independent statistical and analytical agency located within the U.S. Department of Energy. Because of its statutory independence, EIA includes the following disclaimer in its reports "the analysis presented … is strictly its own and should not be construed as representing the views of the U.S. Department of Energy or the Administration."[12] EIA's analysis of the House-passed bill uses the National Energy Modeling System (NEMS), the principal tool used by EIA in its energy and economic projections.

The reference case (the no-policy or business-as-usual case) used by EIA is the updated Annual Energy Outlook 2009 (AEO 2009) released in April 2009. This updated reference case includes the effects of the American Recovery and Reinvestment Act (ARRA) and updated projections for a deeper economic recession. It also accounts for the Energy Improvement and Extension Act of 2008, the Energy Independence and Security Act of 2007 (EISA), and the Energy Policy Act of 2005. The reference case also includes the Corporate Average Fuel Economy (CAFE) standards included in EISA, but not the acceleration of those standards recently proposed by EPA and the National Highway Traffic Safety Administration. Several versions of the AEO2009 reference case exist each with its own estimate of future emissions. Notably, as AEO2009 was updated, projected emissions in each update were reduced because of the inclusion of additional policies and because of lower economic activity. Lower emission levels can contribute to lower cost projections.

The Congressional Budget Office's Analysis of H.R. 2454, the American Clean Energy and Security Act of 2009

The Joint Committee on Taxation (JCT) and the Congressional Budget Office (CBO) are jointly responsible for estimating the impacts of proposed legislation on the federal budget over a ten-year window. Typically, JCT is responsible for estimating the impacts of changes in the tax code, while CBO is responsible for estimating the impacts of changes in government spending. CBO released a report in June 2009 that summarized the results of both the JCT and CBO findings. It found that, if passed, HR 2454 would reduce the federal deficit by roughly $24 billion for the period between 2010 and 2019.

The projected price of carbon allowances plays an important role in CBO's estimate. CBO did not conduct its own modeling runs to develop price estimates, but rather conducted an analysis of existing modeling efforts to generate a "middle of the road" estimate. CBO used the updated April 2009 AEO to determine baseline emissions and determined the emission reductions that HR 2454 would require. CBO then examined six existing estimates of the impacts of the bill (five of which are included here) and determined the average sensitivity of carbon emissions to carbon allowance prices. CBO aggregated the results to determine how high allowance prices would have to rise, in combination with the efficiency, renewable, and other provisions of the bill, in order to reduce emissions enough to meet the targets. Using this methodology, CBO estimated that carbon allowance prices would start at $11 per ton in 2011 and rise to $26 per ton in 2019.[13]

Relying on EPA cost estimates, as well as input from outside experts on the timing and availability of international offsets, CBO further estimated that domestic offset use would be 230 million tons in 2011 and rise to 300 million tons by 2020. It estimated that international offsets would cover 340 million tons in 2020. CBO estimated that, without offsets, allowance prices in 2012 would be $35 higher.

More recently, CBO Director Elmendorf, in testimony to the Senate Committee on Energy and Natural Resources (October 14, 2009), presented an extended set of results, based on a similar review of existing modeling efforts, including GDP and household impacts. GDP impacts in comparison to the reference case range from reductions of 0.2 percent to 0.7 percent in 2020 to 1.1 percent to 3.4 percent in 2050 from the substantial growth experienced in the no-policy case through 2050. Household purchasing power would be less than that in the no-policy (reference) case by $160 in 2020 and $925 in 2050, but would also still grow substantially during this period.[14]

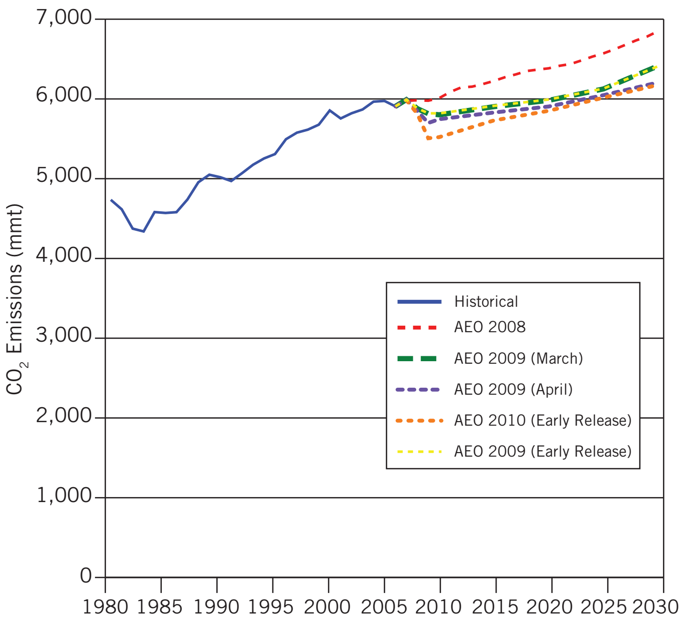
Figure 3 illustrates the differences in the AEO reference case emissions projections.

Both the NEMS model and EIA's AEO2009 reference case are used as the starting point for several of the other analyses presented in this comparison.

Key Assumptions

EIA's analysis models the key elements of the House-passed bill including: the cap-and-trade provisions; the return of allowance value to electricity and natural gas consumers, energy-intensive, trade-exposed sectors, and to low-income households; most of the energy efficiency and renewable provisions; the incentives for CCS; and the use of offsets.[15] EIA's "basic" policy case assumes that low-carbon technologies (including nuclear, coal with CCS, and renewables) are available on a time scale consistent with the market conditions and emission reduction requirements of the bill without encountering any obstacles. It assumes that the use of domestic and international offsets "is not overly constrained by cost, regulation, or the pace of negotiations with key countries covering key sectors."[16] In anticipation of tighter caps and higher allowance prices beyond the 2030 forecast horizon, EIA's "basic" policy case imposes the

Figure 3—Changes in AEO Reference Case Emissions



assumption that 13 billion metric tons of emission reductions are banked cumulatively by 2030.[17] This means that sources will overcomply with the cap prior to 2030.

In addition to the "basic" policy case, EIA's report includes the results of five other principal scenarios and five additional sensitivity cases. These contain varying assumptions about the availability of offsets, the costs at which alternative technologies become available, the rate at which these technologies are adopted, and many other key factors.

Key Findings[18]

Because of the availability of offsets and the growth of low-carbon technologies for the electric power sector in its "basic" policy case, the impacts on the economy and on household consumption are relatively modest. The economic impacts in this scenario are far less than the ACCF-NAM analysis which also uses NEMS, but which places constraints on both of these key factors (offsets and low-carbon technologies). In contrast, the economic impacts in EIA's "basic" policy case are slightly greater than EPA's core policy scenario which had a somewhat higher use of offsets and similar deployment of alternative technologies. In part, the difference in outcomes can be explained by the difference in the modeling structure underlying NEMS compared to the computable general equilibrium models used by EPA.[19]

Key results from EIA's analysis include:

Allowance prices in the "basic" policy case fall generally near the middle of the range of forecasts of the models included in this brief at just under $32 per ton in 2020 increasing to nearly $65 per ton in 2030.

GDP continues to grow robustly despite the costs associated with complying with the "basic" policy case. In this case, real GDP increases from $13.9 trillion in 2010 to $23.6 trillion in 2030, a 70 percent increase over this period. Compared to the no-policy case, the House-passed bill is predicted to lower GDP by 0.33 percent in 2020 and by 0.81 percent in 2030. Overall, GDP growth is still robust, growing between 2007 and 2030 at an annual rate of 2.36 percent under the House bill, as compared to 2.40 percent in the no-policy (reference) case. This means that in 2030, GDP levels would be about four months behind what it otherwise would have been.

Household impacts are also relatively modest, in part, due to the provisions in the House bill that provide emission allowances to compensate for price increases to electricity customers. In EIA's "basic" policy case, average household consumption grows by 27 percent, from $92,840 in 2015 to $118,281 in 2030. EIA estimates that average household consumption would be 0.1 percent lower in 2020 and 0.3 percent lower in 2030 in comparison to the no-policy (reference) case.

EIA's modeling incorporates the effects on low-carbon technologies from both the technology-specific provisions contained in the House bill (e.g., incentives for deployment of

CCS, renewable portfolio standard) as well as from the carbon price created by the cap-and-trade provisions. In the "basic" policy case, this results in considerable deployment of these technologies over time: about 78 GW of CCS capacity is brought on-line by 2030, accounting for over 400 billion tons (over 13 percent) of the reduction in emissions in 2030. Nuclear generation nearly doubles between 2015 and 2030 under this scenario, as compared to the no-policy (reference) case in which nuclear generation only increases by 7 percent. Growth in renewable electricity also expands under EIA's "basic" policy case, growing by 34 percent from 2015 to 2030 under the House bill compared to a 24 percent increase in the no-policy (reference) case.

Finally, offsets play a major role in EIA's "basic" policy case, accounting for about 1,820 million metric tons (mmt) of the 3,968 mmt of reductions in 2030. In the "basic" case the availability of offsets, particularly international offsets, is key to keeping allowance prices and GDP impacts low. Particularly in the early years, the availability of low-cost offsets allows firms to continue operations without resorting to more extensive use of expensive low-carbon energy options such as renewable technologies and CCS. In one of EIA's other cases that assumed no international offsets were available, total domestic offset use reached 669 mmt in 2030, resulting in significantly higher costs. Under this scenario, allowance prices increased to over $106 per ton, and GDP relative to the no-policy (reference) case was reduced by 1.14 percent in 2030.

Environmental Protection Agency (EPA)

Analysis of the American Clean Energy and Security Act of 2009: H.R. 2454 in the 111th Congress [20]

Modeling Framework and Reference Case

EPA used two main models to assess the economic impacts of the bill passed by the House Energy and Commerce Committee—the Intertemporal General Equilibrium Model (IGEM) run by Dale Jorgenson Associates and the Applied Dynamic Analysis of the Global Economy (ADAGE) model run by RTI International. The two models yield similar results, with ADAGE finding slightly higher compliance costs than IGEM. These models allow EPA to run its analyses out to the year 2050. In addition, EPA used the IPM model, developed and run by ICF International, to produce more detailed near-term energy market results. This discussion and the detailed results presented in Table 2 focus on the core policy scenario (Scenario 2) run using the ADAGE model.

For its no-policy (reference) case, EPA used the March AEO 2009 forecast as its baseline. While it reflects provisions contained in the Energy and Independence Security Act of 2007 (EISA) and the most recent economic downturn, it does not include the impacts of the American Recovery and Reinvestment Act of 2009 (ARRA), updated projections for a deeper recession, or the recently announced joint proposal by EPA and NHTSA for greater reductions in greenhouse gas emissions from light-duty vehicles. If the no-policy (reference case) were updated to include these developments, its emission projections would be lower and thus the projected compliance costs would be somewhat lower as well.

Key Assumptions

In its core policy case, EPA takes into consideration the major features of the House-passed bill including: the cap-and-trade provisions, the explicit allocation of allowance value to electricity users and energy-intensive trade-exposed industries (EITEs), many of the measures affecting energy efficiency and renewables, the incentives for start-up and deployment of CCS technology, and the use of offsets. With regard to technology, EPA assumes that the growth of nuclear power generation cannot exceed about 150 percent of the no-policy (reference) case by 2050.

EPA's analysis includes several sensitivity scenarios which examine, among other things, the effects of removing the bill's energy efficiency provisions, placing additional constraints on the growth of nuclear power, and eliminating international offsets.

Key Findings

EPA's modeling analysis projects modest impacts on the growth of GDP and household consumption compared to the other analyses examined in this brief. Sensitivity analysis focused on the impact of three factors. The availability and use of international offsets appears, by far, to have the biggest impact. Limiting the reduction in electricity demand due to energy efficiency measures and limiting the expansion of nuclear generating capacity have far less of an impact.

Key results from EPA's analysis include:

In the core policy case (ADAGE Scenario 2), allowance prices are among the lowest of any of the analyses reviewed in this comparison. Allowances start at $17 per ton in 2020 and increase to $28 per ton in 2030 and to $75 per ton by 2050.

GDP continues to grow substantially throughout the period covered by the analysis. In the core policy case, real GDP grows by 163 percent, from $14.1 trillion in 2010 to $37.1 trillion by 2050. In the core policy case, growth in GDP is reduced by 0.37 percent below the no-policy (reference) case in 2030 and by 1.3 percent below the baseline level in 2050. This implies that economic growth under the House bill would lag growth in the no-policy (reference) case by less than two months in 2030 and by about 6.5 months in 2050.

Household consumption also grows dramatically over the time period covered by the analysis. It grows from $97,931 in 2015 to $174,559 in 2050, an increase of 78 percent. The reduction in household consumption is 0.31 percent in 2030 and 0.78 percent in 2050 compared to the no-policy (reference) case. While household electricity prices are projected to increase by 13 percent in 2030 and 35 percent in 2050 relative to the no-policy (reference) case, household energy expenditures increase by a lesser amount. This is due to reduced energy demand—a combination of consumer response to higher electricity prices and the energy savings from energy efficiency programs—as well as consumer rebates in the early years of the program.

Offsets play a major role in meeting the emissions reduction targets. In its core policy case, 1527 mmt offsets are used in 2030, growing to 1839 mmt in 2050. Like the EIA analysis, offsets account for a large fraction of emissions reductions. In 2030, offsets account for more than half of the reductions required in that year, and for about 40 percent of reductions in 2050. Because of their assumed lower costs, the majority of offsets are from international sources. A sensitivity analysis eliminating international offsets showed that allowance prices would increase by 89 percent without this source of offsets.

Primary energy use in the core policy scenario falls in the early years and only rebounds to the 2010 no-policy (reference) case levels by 2035. However, even in the no-policy (reference) case, the use of primary energy relative to overall economic output is falling over time. In this case, energy intensity per dollar of GDP declines by 55 percent from 2010 to 2050—the House bill brings about a further 5 percent decline.

In EPA's core scenario, by 2030 the share of renewable electricity is double what it would be in the no-policy (reference) case and the share of nuclear-generated electricity is over 70 percent higher. CCS deployment, which would not occur in the no-policy (reference) case, begins in 2020, reaching 43 GW of capacity in 2030, accounting for 7 percent of electricity generation. All of these low- and zero-carbon technologies expand rapidly by 2050 as a tighter cap and higher allowance prices drive the use of these more expensive sources of energy.

In addition to the core policy case, EPA also ran several sensitivity cases, including one that did not model any of the energy efficiency provisions. In this case (Scenario 3), EPA found that the GDP impacts were only slightly larger, declining by 1.34 percent below the no-policy (reference) case by 2050. This mild impact may be a result of the fact that the CGE model used in this analysis is structured to assume that markets tend to deploy optimal amounts of efficiency without the need for government incentives.

Another EPA scenario examined the impacts of limiting nuclear deployment to the levels reached in the no-policy (reference) case. In this case (Scenario 5), nuclear generation remained low, less than half of what the core policy case predicted for 2050. Under this scenario, GDP costs increased substantially to 1.64 percent of GDP by 2050, indicating that nuclear power plays an important role as a backstop technology in the EPA analysis.

National Black Chamber of Commerce (NBCC)

Impact on the Economy of the American Clean Energy and Security Act of 2009[21]

Modeling Framework and Reference Case

The National Black Chamber of Commerce contracted with CRA International to analyze the impacts of the House bill.[22] CRA used a combination of its global computable general equilibrium model, the Multi-Sector, Multi-Region Trade (MS-MRT) model and its integrated macroeconomic Multi-Region National and electric utility sector North American Electricity and Environment (MRN-NEEM) models. CRA's modeling framework allows the analysis to be extended out to 2050.

The NBCC's no-policy (reference) case is based on EIA's original Annual Energy Outlook of March 2009, which did not include the impacts of the American Recovery and Reinvestment Act of 2009, updated projections for a deeper recession, or the proposed increase in mileage standards for light duty vehicles. As a result, the reductions required in the NBCC's analysis are slightly greater than those models that have incorporated EIA's update of its AEO.

Key Assumptions

NBCC's core policy case is focused primarily on the cap and trade aspects of the bill along with the renewable energy and efficiency standards. It does not explicitly model several of the energy efficiency provisions (e.g., efficiency standards, building codes) contained in the bill. It does include provisions for support of CCS, rebates allowance value to consumers and to industrial sectors, and does not constrain the availability of offsets.

NBCC's analysis also performs a number of sensitivity analyses. It looks at low- and high-cost scenarios which assume higher and lower electricity demand, different assumptions about the costs of international offsets, and different cost assumptions and capacity constraints on the growth of low-carbon technologies. The analysis also includes a scenario where no international offsets were available.

Key Findings

The NBCC's analysis projects allowance prices that fall well within the mid-range of those included in this comparison, but result in economic losses in 2020 that far exceed all but one of the other models reviewed in this study (Heritage Foundation is similar). These economic losses occur despite the fact that the core policy case in this analysis relies more heavily on offsets than any of the other analyses included in this paper with the exception of MIT's Full Offset case (for details, see Table 2). The higher costs reported in this study may be due, in part, to the limited introduction of low-carbon electricity generating technologies and also to the underlying structure of the model.

Key results from the NBCC's analysis include:

Allowance prices start at $29 per ton in 2020, reach $48 per ton in 2030, and rise to over $128 per ton by 2050. This puts NBCC's allowance price projections in the middle of the range of all the model scenarios compared in this brief, but well above the other CGE model studies we examined. For example, in MIT's Full Offset scenario, which makes full use of the allowable offsets, allowance prices are under $10 ton in 2020 and $14 ton in 2030. One contributing factor to this is that NBCC's baseline (AEO 2009 March release) projects higher emissions levels, which makes meeting any particular target more difficult.

Like the other models in this comparison, GDP in the NBCC's core policy case grows significantly through 2050. Nonetheless, the GDP impact in the NBCC's core policy case is large compared to the losses (relative to the reference cases) projected by the other models in this brief. For example, while allowance prices are similar to EIA's, the resulting GDP impact in 2020 in the NBCC's study is more than double that in EIA's analysis (a reduction of 0.80 percent compared to 0.33 percent). GDP impacts in NBCC's analysis increase over time resulting in GDP reductions of 1.00 percent in 2030 and 1.50 percent in 2050, compared to the no-policy case.

Household consumption increases substantially in absolute terms over the forecast period, but is 1.10 percent less in both 2020 and 2030, and 1.40 percent less in 2050, compared to the reference case.

The NBCC's analysis makes greater use of offsets in its core policy case than any other of the models reviewed in this paper except for MIT's Full Offset case. It utilizes 1.8 of the 2 billion tons allotted in 2020 and the full 2 billion tons by both 2030 and 2050. It also utilizes the provision in the House bill allowing greater use of international offsets if the cap on domestic offsets is not reached. Despite this heavy reliance on international offsets, the NBCC's economic impacts are substantially higher than other studies that utilize far fewer international offsets (e.g., EIA, EPA and NRDC).

Despite substantial increases in allowance prices, the NBCC's analysis introduces limited new generation from low-carbon sources of electricity (coal with CCS and nuclear and renewable power). Generation from these sources is far less than in EIA's analysis despite similar allowance prices, and is substantially less than EPA's analysis which has far lower allowance prices.

High capital costs appear to be the cause of the low deployment rates for these low-carbon technologies. The capital costs of these technologies begin at a level significantly higher than in other models. Compared to the ACCF-NAM analysis, for example, the NBCC's overnight capital cost assumptions for low-carbon generation technologies are 15-60 percent higher.[23] The NBCC's analysis also assumes that the overnight capital costs of nuclear, renewable, and CCS generation bottom out in 2035 or earlier.[24] This means that, despite their increased use and the cost advantage these technologies enjoy as a result of the carbon cap, innovation in low- and zero-carbon generating technologies stops by 2035.

Massachusetts Institute of Technology (MIT)

Costs of Climate Policy and the Waxman-Markey American Clean Energy and Security Act of 2009 (H.R. 2454): Appendix C [25]

Modeling Framework and Reference Case

The MIT analysis uses its Emissions Prediction and Policy Analysis model (EPPA), which is a global computable general equilibrium model. The no-policy (reference) case used in the MIT study was constructed from the "Early Release" of the AEO 2009, issued in January 2009. The authors incorporated the effects of the Energy Independence and Security Act of 2007 as well as the American Recovery and Reinvestment Act. The resulting overall economic growth rates are similar to those in the March AEO 2009, but higher than those in the April update used for EIA's baseline (see Figure 3).

Key Assumptions

In modeling the House bill, the MIT analysis captures the core elements of the cap-and-trade provisions including the targets and the use of offsets, but it does not include many of the specific energy efficiency provisions, the bonus incentive allowances for early deployment of CCS, or the detailed allocations of allowance value, including allowances to energy-intensive, trade exposed industries. MIT's analysis focuses on two scenarios, its Full Offsets case which assumes that offsets would be used to the fullest allowable extent (2,000 mmt each year) and its Medium Offsets case which assumes a gradual ramp up to utilizing the full 2,000 mmt of offsets in 2050.[26] MIT's assumptions about low-carbon technologies also influence their results. This analysis assumes relatively high capital costs for nuclear and CCS and therefore these technologies play a limited role. In contrast, the MIT authors have recently lowered their estimates of the costs of natural gas generation and increased their estimates of domestic gas resources which lead to increased utilization of this fuel.[27]

Key Findings:

MIT's analysis shows the significant role that offsets play in determining economic impacts. In addition, its assumptions about the relatively high cost of low-carbon sources of electricity strongly influence its outcomes.

Key findings in the MIT analysis include:

Allowance prices in the Full Offsets case are the lowest of all the simulations we examined, starting at $9 per ton in 2020 and rising to just over $30 per ton in 2050. In the Medium Offsets case, allowance prices fall squarely into the mid-range of the analyses examined in this brief. Allowances are priced at $28 per ton in 2020, $41 per ton in 2030 and $89 per ton in 2050.

GDP grows significantly in both policy cases. For example, in the Full Offsets case, GDP grows 182 percent from $14.3 trillion in 2010 to $40.3 trillion in 2050. Compared to other modeling analyses examined in this brief, GDP losses relative to the no-policy (reference) case are modest. In the Full Offsets case, GDP is 0.43 percent below the no-policy case in 2030 and 0.96 below in 2050. In the Medium Offsets case, GDP is 1.02 percent below the no-policy level in 2030 and 1.86 percent below in 2050.

Losses in household consumption are also comparatively modest—decreasing by 0.54 percent below the no-policy (reference) case in 2030 and 1.03 percent below in 2050 in the Full Offsets case. In the Medium Offsets case household consumption is reduced by 1.07 percent in 2030 and 1.91 percent in 2050 below no-policy (reference) case levels.

Natural gas consumption increases significantly over the timeframe of both scenarios, rising by 27 percent in the Medium Offsets case and 30 percent in the Full Offsets case. This suggests that natural gas is acting as a bridge fuel in the medium-term, substituting for more carbon-intensive fuels and that low allowance prices keep natural gas viable over the longer term. It also reflects the lower prices and expanded supply of this source of energy in MIT's no-policy (reference) case.

Electricity production from nuclear power remains essentially flat over the forecast horizon in both policy cases as well as the no-policy case. Nuclear generation in both the Full and Medium Offsets cases is substantially lower than in any of the other models included in this comparison study.

CCS production in both MIT scenarios is quite low in 2030 compared to the other studies, contributing only 55.6 billion kWh in the Full Offsets case and 166.7 billion kWh in the Medium Offsets case. It increases to a more robust 388.9 billion kWh by 2050 in the Full Offsets scenario and 361.1 billion kWh in the Medium Offsets case. The low early penetration rate is likely due to the low price of allowances and the fact that the study does not include the bonus allowance provisions in the House-passed bill for the initial deployment of CCS technology. Both of the MIT scenarios show lower CCS deployment than all the other modeling efforts examined here, except for the Heritage Foundation which showed zero CCS generation.

Renewable generation is also relatively modest, reaching 833.4 billion kWh in 2030 and 944.5 billion kWh in 2050 in the Full Offsets case, while the Medium Offsets case shows 777.8 billion kWh in 2030 and 1055.6 billion kWh in 2050. In 2050, these are the lowest renewable generation rates by a significant margin compared to the other two studies that report results in this year.

American Council for Capital Formation—National Association of Manufacturers (ACCF-NAM)

Analysis of the Waxman-Markey Bill—The American Clean Energy and Security Act of 2009: Using the National Energy Modeling System [28]

Modeling Framework and Reference Case

The ACCF-NAM's analysis was prepared by SAIC using a version of EIA's National Energy Modeling System (NEMS), NEMS/ACCF-NAM 2. NEMS was modified to reflect ACCF-NAM's views on the likely availability of emissions reduction technologies, new energy sources, and carbon offsets. As the ACCF/NAM report notes, their analysis sets limits on how much new technology can be deployed over the next 20 years, how many offsets will be available, and how much banking will occur. The cost of the new technologies is the same in both the high and low cost cases, but the capacity constraints are more stringent in the High Cost case. Their analysis uses the April version of AEO2009 which takes into consideration the impacts of the low-carbon programs contained in the American Recovery and Reinvestment Act of 2009. The analysis relies on the NEMS model version that extends to 2030.

Key Assumptions

For its analysis, ACCF-NAM developed its own policy cases. These were based on the best judgment of ACCF and NAM regarding the likely availability and timing of emissions reduction technologies and new energy sources. The analysis focuses on two policy cases—a High Cost and a Low Cost case. Both cases put a hard limit on the rate of adoption of certain low-carbon electricity technologies which cannot be exceeded. The limits in the High Cost scenario are significantly tighter. Specifically:

- The constraint on nuclear power limits capacity additions to 10 GW (High Cost) or 25 GW (Low Cost) by 2030. In comparison, EIA in AEO 2009 predicts nearly 10 GW of capacity addition by 2030 under its no-policy (reference) case and nearly 95 GW of additions by 2030 under the House-passed bill in its "basic" policy case.
- Coal and natural gas technologies with CCS are each limited to 15 GW/30 GW (High/Low Cost cases) of capacity additions by 2030.
- Wind and biomass annual capacity additions are limited to 5 GW/10GW per year for wind and 3 GW/5 GW per year for biomass (High Cost/Low cost cases). For context, 8.7 GW of wind capacity was added in 2008.[29]
- The ACCF-NAM policy cases also place a constraint limiting offsets to 1000 mmt per year, of which 50 mmt are assumed to be international offsets and 950 mmt are assumed from domestic sources. The analysis uses 1000 mmt of offsets in every year and assumes that 5,000 mmt of allowances are banked by 2030.

Key Findings

The ACCF-NAM analysis has by far the highest allowance prices of any of the modeling scenarios examined in this comparison. Even its Low Cost case results in an allowance price 25 percent higher than the study (Heritage Foundation) with the next highest allowance price (see Figure 2). In comparison to the other two studies which rely on the NEMS model (EIA and NRDC), it appears that the key assumptions limiting offsets (particularly international offsets) and assumed constraints on low-carbon sources of electricity (particularly coal and natural gas with CCS and nuclear) are responsible for higher allowance prices and larger economic impacts.

Key findings in the ACCF-NAM analysis include:

Allowance prices in 2020 are $48 per ton and $61 per ton for the Low Cost and High Cost cases and increase to $123 per ton and $159 per ton in 2030. To put these in context, using the same basic model (NEMS), EIA's analysis includes a High Cost sensitivity scenario that has an allowance price around $72 per ton in 2030, less than half the High Cost case in ACCF-NAM's analysis. The allowance price in ACCF-NAM's Low Cost case in 2030 is at least $23 per ton greater than any other core policy case examined in our study.

Despite these high allowance prices, GDP in the High Cost case still grows from $18.4 trillion in 2020 to $23.2 trillion in 2030, an increase of 26.1 percent. Compared to the other studies examined in this comparison, GDP losses are among the highest, with reductions of 1.80 percent and 2.40 percent in 2030 in the Low and High cost cases, respectively, compared to the no-policy (reference) case. With these relatively large losses in the High Cost case, GDP would achieve the same levels reached in the no-policy (reference) case 12.5 months later.

As specified in the House bill, the impact on household consumption is reduced by rebates to energy users, including households, through 2030. Nonetheless, household income is 0.60 percent and 1.00 percent (Low Cost and High Cost cases, respectively) less in 2030 compared to the no-policy (reference) case. Both cases result in greater household impacts in 2030 than the other two studies that use the NEMS modeling system (EIA reports a 0.45 percent reduction, while NRDC reports a 0.56 percent loss.).

In both policy cases and for both 2020 and 2030, the number of offsets is significantly constrained below that allowed by the House-passed bill. In 2030, for example, only 50 million tons of international and 950 million tons of domestic offsets are allowed to be used. In 2030 only the Heritage Foundation's study results in fewer offsets being employed.

Nuclear deployment is also significantly constrained in the ACCF-NAM analysis. Nuclear generation is projected to decline between 2020 and 2030 in the High-Cost case, despite rising electricity prices. Although the capital cost assumptions made by ACCF-NAM for nuclear power are similar to other analyses, assumed restrictions on deployment keep levels below that found in most of the other studies.

While offsets, nuclear power and CCS[30] technology are constrained in the ACCF-NAM analysis, renewable electricity consumption increases sharply despite its relatively higher costs. In both the Low and High Cost cases, total renewable electricity generation far outstrips other scenarios, reaching 1752 and 1472 billion kWh by 2030 in the Low and High Cost cases, respectively. Total renewable generation in 2030 is twice as high as some of the other analyses.

Natural Resources Defense Council (NRDC)

A Clean Energy Bargain: More Jobs, Less Global Warming Pollution, and Greater Security for Less than the Cost of a Postage Stamp[31]

Modeling Framework and Reference Case

NRDC conducted its analysis using the NEMS model, but like ACCF-NAM, it also modified key assumptions in the model, as highlighted below.[32] The resulting NEMS-NRDC model used the March 2009 AEO for its no-policy (reference) case, modified to reflect the extension of the renewable energy production tax credit contained in the stimulus bill. As a result, its baseline projections for emissions and GDP will be slightly higher than simulations that used the updated AEO 2009 (April). Like all analyses based on NEMS, their study includes projections out through 2030.

Key Assumptions

NRDC's analysis examined the key elements of the House-passed bill including its cap-and-trade provisions and the allocation of allowances. Its core policy scenario differed from the House-passed bill in several areas:

- Energy efficiency provisions were modeled using EIA's High Technology Case which assumes more optimistic assumptions about the speed and cost of technological improvements.
- Carbon Capture and Storage provisions were modeled as per ton payments that decline over time as the installed base of CCS plants increases.
- Increased auto efficiency standards of 42 mpg in 2020 and 55 mpg in 2030 were included which makes assumptions

about improved fuel efficiency beyond the period covered by the recently proposed federal standards (35.5 miles per gallon in 2016).

NRDC also conducted a number of sensitivity analyses that further altered assumptions, including one that doubled the overnight capital costs of nuclear. In addition, in their core policy case, it is assumed that just under 5,000 mmt of allowances are banked cumulatively through 2030.

Key Findings

The results from NRDC's analysis show costs and economic impacts generally in the middle of the range of estimates included in this brief. Their results are driven by enhanced energy efficiency economy-wide, substantial use of offsets permitted under the House bill, along with the expanded use of CCS technology and moderate growth in renewable energy.

Key findings from NRDC's analysis include:

Allowance prices in this analysis increase from $28 per ton in 2020 to $57 per ton in 2030. Compared to other analyses using the NEMS model, these prices are close to but slightly lower than EIA's analysis and substantially lower than ACCF-NAM's analysis.

GDP increases during the timeframe of the analysis from $14.1 trillion in the reference case in 2010 to $24.0 trillion in 2030, a 70 percent increase over this period. In its core policy case, GDP declines by 0.25 percent in 2020 and by 0.78 percent in 2030 compared to the no-policy (reference) case.

Household income also grows considerably during the period of the analysis. In the no-policy (reference) case, it grows from $93,923 in 2015 to $114,064 in 2030, an increase of 21.4 percent. Under the core policy case, household income would be 0.01 percent lower in 2020 and 0.45 percent lower in 2030 than the no-policy (reference) case.

Use of offsets is mid-range compared to the other modeling scenarios. NRDC's forecast predicts offset use of just under 1000 mmt in 2020, rising to over 1500 mmt by 2030.

Energy efficiency gains reduce increases in energy demand by over half, from an increase of 13 percent by 2030 in the no-policy (reference) case, to a 7 percent increase in the core policy case.

Nuclear deployment is moderate, rising about 38 percent from 2015 to 2030. It exceeds that projected in the ACCF-NAM and Heritage analyses, but is substantially less than EIA or EPA project in their core policy cases. Generation from renewables is similarly moderate, rising to 989 billion kWh in 2030.

Generation from CCS facilities is higher in the NRDC model than any of the other models examined in this brief. At 811 billion kWh in 2030, it is 40 percent higher than the next highest model and more than twice that of any of the others. Incentive payments to CCS deployment serve to lower costs, enabling CCS to compete with other, more expensive low-carbon technologies.

Heritage Foundation

The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009[33]

Modeling Framework and Reference Case

The Heritage Foundation's analysis uses the IHS Global Insight long-term macroeconomic model combined with an energy module based on the IHS Global Insight energy module and extends the analysis through 2035. The analysis relies on its own IHS Global Insights November 2008 no-policy reference case which is likely higher than a 2009 reference case. For comparison, emissions in the AEO 2008 reference case are over 9 percent higher in 2030 than the April AEO updated reference case. Higher emission levels in the reference case can contribute to higher cost estimates of meeting specific emission targets.

Key Assumptions

Several important details of how the House bill was modeled are unclear in the Heritage documentation, including which version of the bill it analyzes.[34] We infer from their public materials that their analysis differs from the text of the House-passed bill in the following ways:

- Offsets were limited annually to 15% of the cap annually, roughly half of the allowable levels, divided equally between international and domestic sources.
- Efficiency standards for building, lighting, appliances, and other end uses were not included in the analysis.
- The analysis only covers CO_2 emissions from the energy sector, and excludes other greenhouse gases and non-energy CO_2 emissions.
- The analysis does not include any of the incentives for CCS deployment contained in the bill.

Key Findings

Allowance prices begin in the medium range in 2020, about $28 per ton, but grow quickly, reaching just under $100 in 2030. These prices appear to be driven by the limited use of offsets and the restrictions on technology alternatives.

GDP grows by 59 percent in the no-policy (reference) case, increasing from $14.7 trillion in 2012 to $23.3 trillion in 2030. GDP impacts in the single policy case are predicted to be relatively large, with reductions of 0.83 percent in 2020 and 2.83 percent in 2030 from the levels experienced in the no-policy (reference) case.

Household disposable income also increases over the timeframe included in the analysis. It grows by 31 percent from 2016 to 2030 in the policy case. Compared to the no-policy (reference) case, reductions in household income in the policy case are projected to be 0.96 percent in 2020, recovering somewhat to a decline of 0.52 percent by 2030.

Offset use is relatively low, restricted to 15 percent of the total cap level in any given year. This limit is reached in 2018 and all subsequent years, resulting in fewer offsets used in 2030 (510 mmt) than in 2020 (730 mmt). The number of offsets used in Heritage's analysis is far below that allowed in the House legislation, decreases from 2020 to 2030, and is well below the amount used in any of the other analyses (e.g., 490 mmt below ACCF-NAM's analysis, which has the next lowest amount in 2030). In addition to limits on offsets, there is no mention of banking in the analysis, which is allowed under the House bill. The ability of regulated sources to bank emission allowances for future use is what drives a large portion of offset demand in other studies, especially in early years of the program, and results in lower compliance costs over the longer term.

CCS deployment is assumed to be zero throughout this analysis despite the incentives for deployment included in the House-passed bill. In addition, nuclear power is assumed to grow more slowly than most of the other analyses examined here, increasing by 12 percent between 2012 and 2035.[35] The growth in renewable electricity generation also begins low and remains low throughout the analysis. This results from the assumption that the existing use of non-hydro renewables is in excess of market conditions due to existing regulations (e.g., state renewable performance standards) and would not likely change over time. Due to a lack of other alternatives, this analysis projects a relatively high rate of natural gas consumption compared to other models.

Table 2

Modeling results

2015	EIA "Basic" Case	EPA (ADAGE) Scenario 2	NBCC	ACCF-NAM Low Cost	ACCF-NAM High Cost	Heritage	NRDC-NEMS	MIT-Medium Offsets	MIT-Full Offsets
Covered Sector emissions less offsets (mmt CO_2e)	4,649	4,534	4,347	4,453	4,383	5,370	5,565	5,604	3,866
Allowance Price (2007$)	$22.22	$13.43	$23.50	$29.50	$38.03	$17.47	$19.42	$22.63	$7.72
International Offsets (mmt CO_2e)	258	1,072	1,500	50	50	218	0	131	1,000
Domestic Offsets (mmt CO_2e)	189	172	158	950	950	218	281	131	1,000
GDP Impact (% chg from BAU)	-0.28%	0.08%	-0.70%	-0.40%	-0.50%	-0.89%	-0.32%	-0.31%	-0.11%
Consumption Impact (% chg from BAU)	-0.21%	-0.08%	-1.00%[1]	n.a.	n.a.	-1.35%[2]	-0.08%[3]	-0.20%	-0.15%
Consumption Impact per household (2007$)[4]	$(191)	$(74)	$(744)[1]	n.a.	n.a.	$(1,134)[2]	$(73)[3]	$(178)	$(136)
Coal Prices (% chg)[5]	103%	62%	135%	139%	182%	90%	91%	131%	44%
Electricity Prices (% chg)[6]	5%	11%	12%	4%	5%	14%	0%	14%	5%
NG Prices (%chg)	11%	7%	11%	15%	24%	8%	9%	8%	2%
Total CCS Capacity (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CCS Generation (Billion kWh)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Nuclear Generation (Billion kWh)	831.5	831.5	831.0	831.0	831.5	838.0	831.5	833.4	833.4
Total Renewable Generation (Billion kWh)	764.1	505.5	491.0	1011.0	916.7	537.0	637.2	638.9	611.1
Total Natural Gas Consumption (Quads Btu)	22.1	23.1	22.8	21.4	22.5	24.9	21.0	20.9	21.9

2020	EIA "Basic" Case	EPA (ADAGE) Scenario 2	NBCC	ACCF-NAM Low Cost	ACCF-NAM High Cost	Heritage	NRDC-NEMS	MIT-Medium Offsets	MIT-Full Offsets
Covered Sector emissions less offsets (mmt CO_2e)	4,254	3,928	4,182	4,083	4,127	4,858	4,726	5,155	3,575
Allowance Price (2007$)	$31.75	$17.33	$29.37	$47.50	$61.24	$28.39	$27.75	$27.53	$9.40
International Offsets (mmt CO_2e)	966	1,257	1,500	50	50	365	585	210	1,000
Domestic Offsets (mmt CO_2e)	286	186	259	950	950	365	341	210	1,000
GDP Impact (% chg from BAU)	-0.33%	0.13%	-0.80%	-0.20%	-0.40%	-0.83%	-0.25%	-0.55%	-0.29%
Consumption Impact (% chg from BAU)	-0.14%	-0.11%	-1.10%	-0.10%	-0.30%	-0.96%	-0.01%	-0.47%	-0.34%
Consumption Impact per household (2007$)	$(137)	$(112)	$(793)	$(118)	$(250)	($857)	($5)	$(454)	$(332)
Coal Prices (% chg)	146%	81%	163%	224%	295%	150%	131%	154%	51%
Electricity Prices (% chg)	3%	13%	18%	5%	8%	23%	2%	17%	9%
NG Prices (%chg)	9%	8%	13%	-3%	0%	15%	9%	8%	2%
Total CCS Capacity (GW)	13.1[7]	25.0	0.0	7.6	4.2	0.0	13.6	7.5	0.0
Total CCS Generation (Billion kWh)	97.5[7]	186.2	0.0	56.6	31.3	0.0	101.3	55.6	0.0
Total Nuclear Generation (Billion kWh)	940.1	862.1	867.0	1,016.0	939.9	892.0	881.9	833.4	833.4
Total Renewable Generation (Billion kWh)	878.4	585.2	652.0	1,274.0	1,143.1	669.0	800.0	750.0	777.8
Total Natural Gas Consumption (Quads Btu)	21.5	22.4	22.6	21.2	22.1	24.4	20.7	21.2	22.3

CALCULATIONS:

a. For the MIT policy cases, the following calculations were made:

Energy prices for both coal and natural gas are reported in the study as indices net of allowance prices. To convert those data to prices including allowances, we converted the index prices to levels using BAU price data from the report. We then converted allowance prices to dollars per unit using the conversion factors: 2.048 tons per CO_2 per short ton of coal and 0.0552 tons CO_2 per tcf of natural gas.

Energy consumption data was converted from exajoules to quadrillion BTU using 1 Quad = 1.055 EJ.

Electricity generation for CCS, nuclear and renewable generation was converted from exajoules to kWh using the conversion factors of 1 Quad = 1.055 EJ and 3412 BTU per kWh. (apply to all 3 generations)

b. For the ACCF-NAM, NRDC, and MIT studies, CCS generation was calculated from capacity using the formula: Generation = GW capacity*8760 hrs per year*.85 (capacity factor)/1000.

2030	EIA "Basic" Case	EPA (ADAGE) Scenario 2	NBCC	ACCF-NAM Low Cost	ACCF-NAM High Cost	Heritage	NRDC-NEMS	MIT-Medium Offsets	MIT-Full Offsets
Covered Sector emissions less offsets (mmt CO_2e)	2,739	3,353	3,508	3,175	3,316	3,395	3,546	3,865	2,995
Allowance Price (2007$)	$64.83	$28.19	$47.98	$123.21	$158.85	$99.81	$56.66	$40.75	$13.90
International Offsets (mmt CO_2e)	1,320	1,242	1,204	50	50	255	999	565	1,000
Domestic Offsets (mmt CO_2e)	501	285	796	950	950	255	535	565	1,000
GDP Impact (% chg from BAU)	-0.81%	-0.37%	-1.00%	-1.80%	-2.40%	-2.83%	-0.78%	-1.02%	-0.43%
Consumption Impact (% chg from BAU)	-0.29%	-0.31%	-1.10%	-0.60%	-1.00%	-0.52%	-0.45%	-1.07%	-0.54%
Consumption Impact per household (2007$)	$(345)	$(389)	$(862)	$(730)	$(1,248)	($553)	($512)	$(1,211)	$(613)
Coal Prices (% chg)	287%	118%	248%	565%	756%	545%	248%	214%	71%
Electricity Prices (% chg)	19%	13%	24%	31%	50%	77%	7%	15%	8%
NG Prices (%chg)	21%	10%	17%	56%	74%	52%	17%	22%	5%
Total CCS Capacity (GW)	77.9	43.4	50.0	53.6	30.0	0.0	108.9	22.4	7.5
Total CCS Generation (Billion kWh)	580.7	323.0	362.0	399.1	223.1	0.0	811.1	166.7	55.6
Total Nuclear Generation (Billion kWh)	1,548.2	1,355.8	1,181.0	1,046.0	928.0	921.0	1,144.5	833.4	833.4
Total Renewable Generation (Billion kWh)	1,020.9	745.3	746.0	1,752.0	1,472.0	863.0	988.7	777.8	833.4
Total Natural Gas Consumption (Quads Btu)	21.1	21.1	21.3	23.1	24.3	18.1	20.0	26.8	24.4

2050	EIA "Basic" Case	EPA (ADAGE) Scenario 2	NBCC	ACCF-NAM Low Cost	ACCF-NAM High Cost	Heritage	NRDC-NEMS	MIT-Medium Offsets	MIT-Full Offsets
Covered Sector emissions less offsets (mmt CO_2e)		2,371	2,389					2,844	2,844
Allowance Price (2007$)		$74.77	$128.26					$89.29	$30.47
International Offsets (mmt CO_2e)		1,240	1,000					1,000	1,000
Domestic Offsets (mmt CO_2e)		599	1,000					1,000	1,000
GDP Impact (% chg from BAU)		-1.30%	-1.50%					-1.86%	-0.96%
Consumption Impact (% chg from BAU)		-0.78%	-1.40%					-1.91%	-1.03%
Consumption Impact per household (2007$)		$(1,367)	$(1,048)					$(3,082)	$(1,667)
Coal Prices (% chg)		300%	651%					420%	135%
Electricity Prices (% chg)		35%	48%					47%	37%
NG Prices (%chg)		31%	36%					40%	32%
Total CCS Capacity (GW)		59.9	199.0					48.5	52.2
Total CCS Generation (Billion kWh)		446.0	1,420.0					361.1	388.9
Total Nuclear Generation (Billion kWh)		2,081.2	1,656.0					888.9	833.4
Total Renewable Generation (Billion kWh)		1,213.1	1,298.0					1,055.6	944.5
Total Natural Gas Consumption (Quads Btu)		18.8	20.5					26.7	27.5

NOTES

[1] *Referred to as purchasing power in this study.*
[2] *Referred to as disposable income in the study.*
[3] *This study refers to consumption as median annual income per household.*
[4] *Consumption impact per household is a measure of the cost of H.R. 2454 to the average U.S. household. It reflects the dollar value associated with the percentage reduction in consumption compared to the reference or business-as-usual (BAU) case. In absolute terms, however, household consumption is growing over time in each of these studies.*
[5] *Coal prices are delivered prices.*
[6] *Electricity prices are average residential prices.*
[7] *For EIA's analysis, in all years CCS technology is applied to coal only.*

[1] Where policy cases analyzing additional sensitivities are discussed, they are specifically identified throughout the text. Titles of the exact studies examined are included in the model write-ups contained later in this brief.

[2] The NBCC study refers to its core policy case as its "reference" case. The term reference case is used throughout this brief to describe the "no-policy" case. To avoid confusion, we will refer to NBCC's main policy case as its "core policy case."

[3] See, for example, Harrington, Winston, Richard D. Morgenstern, and Peter Nelson. 1999. On the Accuracy of Regulatory Cost Estimates. Washington, DC. RFF Discussion Paper 99-18, January. Hodges, Hart. 1997. Falling Prices: Cost of Complying with Environmental Regulations Almost Always Less than Advertised. Economic Policy Institute. Washington, DC. Goodstein, Eban. 1999. The Tradeoff Myth: Fact and Fiction about Jobs and the Environment. Washington, DC. Island Press.

[4] Entities covered by the proposal would include: large stationary sources emitting more than 25,000 tons per year of GHGs, producers (i.e., refineries) and importers of all petroleum fuels, distributors of natural gas to residential, commercial and small industrial users (i.e., local gas distribution companies), producers of "F-gases," and other specified sources.

[5] EIA defines its "basic" policy case as one where low-carbon technologies are developed and employed without encountering any major obstacles and where the use of offsets is not severely constrained.

[6] Unless otherwise indicated, all dollar figures are inflation-adjusted to 2007 using the implicit GDP deflator.

[7] Real consumption is a broad and commonly used measure of consumers' economic well-being.

[8] It is important to note that energy price increases are not the same as energy cost increases. Energy efficiency improvements mean that less energy is needed, for example, to heat a home or fuel a vehicle. If energy price increases are accompanied by sufficient energy efficiency improvements, energy costs can remain stable or even decline.

[9] Different studies provide different justifications for why offsets may be constrained or costs may be higher. Possible reasons include: the ability of the offset market to ramp up quickly enough to meet the immediate demand shown by the models, the real costs of those offsets, and the availability of those offsets especially over the long haul if other countries begin competing for them.

[10] As discussed above, the Heritage Foundation also excludes longer-term allowances provided under the bill to support CCS deployment. This is included in MIT's analyses.

[11] EIA. 2009. Energy Market and Economic Impacts of H.R. 2454, the American Clean energy and Security Act of 2009. July. Retrieved from: http://www.eia.doe.gov/oiaf/servicerpt/hr2454/pdf/sroiaf(2009)05.pdf

[12] EIA. 1999. Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009. July. Page ii.

[13] CBO. 2009. Congressional Budget Office Cost Estimate - H.R. 2454, the American Clean Energy and Security Act of 2009. June 5.

[14] In this analysis, CBO looked at the distributional impact of the bill and found that households in the lowest income quintile would see an average *net gain* of $125 in 2020 and $355 in 2050. CBO. 2009. The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions. September.

[15] The analyses examined here were conducted at various stages of the legislative process. Analyses completed before final passage of ACES by the House of Representatives are noted as such in the text. Analyses without such an indication examine the bill based on what was passed.

[16] EIA. 2009. Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009. July. Page 5.

[17] The assumption that the emissions bank has a positive balance in 2030 is made to reflect the reality that H.R. 2454 will require continued emissions reductions beyond the end of the NEMS modeling horizon, i.e. beyond 2030, and that allowance prices are expected to continue to rise. The higher the assumed bank in 2030, the greater will be the emissions reductions made prior to 2030 and also the near-term costs of the program.

[18] This section focuses on the results of EIA's "basic" policy case. EIA is careful to point out that the "basic" case is not necessarily intended to represent the most likely future scenario. EIA presents a range of scenarios in order to present the degree of uncertainty involved, and results across EIA's scenarios vary nearly as widely as the results across the modeling efforts presented here.

[19] Different types of models are used in the studies compared in this brief and it is important to note that the difference in outcomes can be partially explained by the differences in the model structures and modeling (as opposed to policy) assumptions. For a discussion of the types of models commonly used to assess the economic impact of climate policy and the implications of their differences for results, see the Pew Center website http://www.pewclimate.org/global-warming-basics/faq_s/glance_faq_economics.cfm.

[20] EPA. 2009. EPA Analysis of the American Clean Energy and Security Act of 2009—H.R. 2454 in the 111th Congress. June 23. Retrieved from: http://epa.gov/climatechange/economics/pdfs/HR2454_Analysis.pdf

[21] CRA International. 2009. Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454). Prepared for the National Black Chamber of Commerce. August. Retrieved from: http://www.nationalbcc.org/images/stories/documents/CRA_Waxman-Markey_Aug2008_Update_Final.pdf

[22] CRA analyzed the bill as it was introduced to the House Energy and Commerce Committee.

[23] Capital costs for electricity generating capital do not vary between ACCF-NAM's high and low cost cases.

[24] Overnight capital costs refer to the cost of building a facility, not including the cost of financing, or what it would cost if it could be done overnight.

[25] MIT. 2009. Appendix C: Cost of Climate Policy and the Waxman-Markey American Clean Energy and Security Act of 2009 (H.R. 2454). Published as an appendix to The Cost of Climate Policy in the United States, MIT Joint Program on the Science and Policy of Global Change, Report 173. Retrieved from: http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt173_AppendixC.pdf

[26] The MIT report focuses somewhat more on the Medium Offsets case. This discussion also highlights the Full Offsets case because it provides a useful point of comparison.

[27] MIT. 2009. Appendix C: Cost of Climate Policy and the Waxman-Markey American Clean Energy and Security Act of 2009 (H.R. 2454). Page 11.

[28] SAIC. 2009. Analysis of the Waxman-Markey Bill "The American Clean Energy and Security Act of 2009" (H.R. 2454) Using the National Energy Modeling System (NEMS/ACCF-NAM2). Prepared for the American Council for Capital Formation and the National Association of Manufacturers. retrieved from: http://www.accf.org/media/dynamic/3/media_387.pdf

[29] American Wind Power Association. 2008 Market Update. Retrieved from http://www.awea.org/pubs/factsheets/Market_Update_Factsheet.pdf

[30] Integrated Gasification Combined Cycle with CCS and natural gas combined cycle also with CCS are each constrained to a build limit in 2030 of 15 and 30 GW in the Low and High Cost cases.

[31] NRDC. 2009. A Clean Energy Bargain—More Jobs, Less Global Warming Pollution, and Greater Security for Less Than the Cost of a Postage Stamp. December. Retrieved from: http://www.nrdc.org/globalWarming/cap2.0/files/ebargain.pdf

[32] NRDC also utilized the MARKAL model to look at the impacts of the House-passed bill. This brief focuses only on their analysis using the NEMS-NRDC model in order to compare it to other studies by different groups using NEMS or variants thereof.

[33] The Heritage Foundation. 2009. The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009. August 6. Retrieved from: http://www.heritage.org/Research/Energyandenvironment/cda0904.cfm

[34] The Heritage study's documentation indicates that the analysis assumes allowance allocations based on a proposal written by Representatives Waxman and Markey on May 14, 2009. Since the bill passed the House Energy and Commerce Committee on May 21, this implies that the analysis is based on the bill introduced to the Committee.

[35] Data supplied by Heritage Foundation. Source: Personal Correspondance with David Kreutzer, Heritage Foundation. October 28, 2009.

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This report was made possible through a generous grant from the Doris Duke Charitable Foundation, but the views expressed herein are solely those of the Pew Center on Global Climate Change and its staff.

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