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Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454

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Summary

This report examines seven studies that project the costs of H.R. 2454 to 2030 or beyond. It is difficult (and some would consider it unwise) to project costs up to the year 2030, much less beyond. The already tenuous assumption that current regulatory standards will remain constant becomes more unrealistic as time goes forward, and other unforeseen events (such as technological breakthroughs) loom as critical issues which cannot be modeled. Hence, ***long-term cost projections are at best speculative, and should be viewed with attentive skepticism.*** The finer and more detailed the estimate presented, the greater the skepticism should be. In the words of the late Dr. Lincoln Moses, the first Administrator of the Energy Information Administration: "There are no facts about the future."

But if models cannot reliably predict the future, they can indicate the sensitivity of a program's provisions to varying economic, technological, and behavioral assumptions that may assist policymakers in designing a greenhouse gas reduction strategy. The various cases examined here do provide some important insights on the costs and benefits of H.R. 2454 and its many provisions.

- If enacted, the ultimate cost of H.R. 2454 would be determined by the response of the economy to the technological challenges presented by the bill.
- The allocation of allowance value under H.R. 2454 will determine who ultimately bears the cost of the program.
- The cases generally indicate that the availability of offsets (particularly international offsets) is potentially the key factor in determining the cost of H.R. 2454.
- The interplay between nuclear power, renewables, natural gas, and coal-fired capacity with carbon capture and storage technology among the cases emphasizes the need for a low-carbon source of electric generating capacity in the mid- to long-term. A considerable amount of low-carbon generation will have to be built under H.R. 2454 in order to meet the emission reduction requirement.
- Attempts to estimate household effects (or other fine-grained analyses) are fraught with numerous difficulties that reflect more on the philosophies and assumptions of the cases reviewed than on any credible future effect.

Finally, H.R. 2454's climate-related environmental benefit should be considered in a global context and the desire to engage the developing world in the reduction effort. When the United States and other developed countries ratified the 1992 United Nations Framework Convention on Climate Change (UNFCCC), they agreed both to reduce their own emissions to help stabilize atmospheric concentrations of greenhouse gases and to take the lead in reducing greenhouse gases. This global scope raises two issues for H.R. 2454: (1) whether the bill's greenhouse gas reduction program and other provisions would be considered sufficiently credible by developing countries so that schemes for including them in future international agreements become more likely, and (2) whether the bill's reductions meet U.S. commitments to stabilization of atmospheric greenhouse gas concentrations under the UNFCCC, and whether those reductions occur in a timely fashion so that global concentrations are stabilized at an acceptable level.

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Background

As Congress continues the debate on an appropriate response to the climate change issue, multiple bills have been introduced that would require reductions in greenhouse gas (GHG) emissions. Of these, H.R. 2454, (the American Clean Energy and Security Act of 2009) has received particular attention. Introduced by Representatives Waxman and Markey, H.R. 2454 passed the House of Representatives on June 26, 2009. Several analyses have been done on the impact of the cap-and-trade provisions, and as of September 2009, seven studies had been released. They are presented below in no particular order.

Environmental Protection Agency: A comprehensive analysis has been conducted by the U.S. Environmental Protection Agency (EPA). The report is entitled: *EPA Analysis of the American Clean Energy and Security Act of 2009: H.R. 2454 in the 111th Congress* (June 23, 2009).[1] Beyond a "core" analysis of H.R. 2454, the report employs a suite of models and reference cases, along with some useful sensitivity analyses. This report will focus on cases from three of the models.

- The first model is ADAGE: a computable general equilibrium (CGE) model developed by RTI International.[2] The "core" analysis case employing the ADAGE model is designated EPA/ADAGE.
- The second model is IGEM: a CGE model developed by Dale Jorgenson Associates.[3] The "core" analysis case employing the IGEM model is designated EPA/IGEM.
- The third model is IPM: a dynamic, deterministic linear programming model of the U.S. electric power sector developed by ICF Resources. The case employing the IPM model is designated EPA/IPM in this report.[4]

Energy Information Administration: A second comprehensive analysis has been conducted by the Energy Information Administration (EIA). The report is entitled *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009* (August 4, 2009).[5] The analysis employs EIA's NEMS model: a macroeconomic forecasting model with extensive energy technology detail.[6] In addition to conducting a "basic case"[7] analysis of H.R. 2454 using its updated *2009 Annual Energy Outlook (AEO) Reference*, EIA also conducts some useful sensitivity analyses that focus on the upside risk of decreased offset supply (and thus,

[1] The EPA report and supporting model runs are available at http://www.epa.gov/climatechange/economics/economicanalyses.html.

[2] For more information on the ADAGE model, see http://www.rti.org/adage.

[3] For more information on the IGEM model, see http://www.economics.harvard.edu/faculty/jorgenson/files/IGEM%20Documentation.pdf.

[4] For more information on the IPM model, see http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html.

[5] EIA's report and supporting model runs are available at http://www.eia.doe.gov/oiaf/servicept/hr2454/index.html?featureclicked=2&

[6] For more on the NEMS model, see http://www.eia.doe.gov/oiaf/aeo/overview/index.html.

[7] The EIA "Basic Case" should not be confused with the "business-as-usual" projection (i.e., the projection in the absence of controls established by the bill). The "business-as-usual" case is also referred to as the "baseline," "basecase" or "reference case." This report uses the term "reference case."

increased allowance prices) under H.R. 2454. The basic case H.R. 2454 analysis is designated EIA/NEMS in this report.[8]

National Black Chamber of Commerce: A third analysis has been conducted for the National Black Chamber of Commerce by Charles River Associates (CRA) International. The report is entitled *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009).[9] The analysis employs CRA's MRN-NEEM macroeconomic model with extensive electric power sector detail.[10] CRA conducted three scenarios: reference,[11] high, and low. The "reference" scenario analysis is designated NBCC/CRA. In cases where the reference scenario projections were not presented, the low or high case scenario figures (designated NBCC/CRA/LOW and NBCC/CRA/HIGH) are used instead.

Heritage Foundation: A fourth analysis has been conducted by The Heritage Foundation, based on projections from the Global Insight model—a macroeconomic model with energy sector modeling. Focused on the economic impacts of H.R. 2454, the results were first disseminated in a series of "WebMemos" as H.R. 2454 was developed, then released in a report.[12] The analysis is limited to carbon dioxide emission reductions from the energy sector and is designed as HF/GI in this review.

Congressional Budget Office: A fifth series of legislative analyses have been conducted by the Congressional Budget Office (CBO) on various aspects of H.R. 2454 during its movement through the House of Representatives.[13] These analyses address budgetary, household, and other impacts of the bill, and are incorporated in this report.

American Council for Capital Formation/National Association of Manufacturers: A sixth analysis has been conducted for the American Council for Capital Formation (ACCF) and National Association of Manufacturers (NAM) by Science Applications International Corporation. The report is entitled *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)*.[14] The report states that it includes assumptions about renewable portfolio standards and energy efficiency standards.[15] Employing EIA's NEMS model, the ACCF/NAM study presents a

[8] EIA notes in its report that while it can place a probability on its various scenarios, "both theory and common sense suggest that cases that reflect an unbroken chain of either failures or successes in a series of independent factors are inherently less likely than cases that do not assume that every thing goes either wrong or right." (p. ix).

[9] CRA International, *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 (May 2009).

[10] For more information on the MRN-NEEM model, see http://www.crai.com/uploadedFiles/RELATING_MATERIALS/Publications/BC/Energy_and_Environment/files/MRN-NEEM%20Integrated%20Model%20for%20Analysis%20of%20US%20Greenhouse%20Gas%20Policies.pdf.

[11] While the CRA study uses the term "reference" to refer to their middle policy scenario, this report uses the term "reference case" in general to refer to the "business-as-usual" scenario.

[12] The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

[13] CBO's various studies on H.R. 2454 and related issues are available on its website at http://www.cbo.gov/publications/collections/collections.cfm?collect=9.

[14] Science Applications International Corporation (SAIC), *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)*, A report by the American Council for Capital Formation and the National Association of Manufacturers (August, 2009).

[15] The report also states that its results include the impact of low carbon fuel standards—which are not included in H.R. 2454 as introduced, reported by any House Committee, or passed by the House.

"low cost" case with several restrictions on technology availability, and is designed as ACCF-NAM/NEMS in this review. The analysis also includes a "high cost" sensitivity case that uses some of the most constrained and high-cost assumptions of any of the analyses presented here, and is discussed here as appropriate

Massachusetts Institute of Technology: A seventh analysis has been conducted by the Massachusetts Institute of Technology (MIT) Joint Program on the Science and Policy of Global Change. The report is an appendix to a more comprehensive analysis of cap-and-trade programs released in April 2009.[16] The appendix is titled: *Appendix C: Analysis of the Waxman-Markey American Clean Energy and Security Act of 2009 (H.R. 2454)*. The appendix employs MIT's EPPA CGE model and presents sensitivity analyses of H.R. 2454's offset provisions. The case that incorporates a gradual increase in available offsets (entitled "H.R. 2454 with Medium Offsets") is designated MIT/EPPA in this report.[17]

Beyond these more comprehensive studies of H.R. 2454, there have been numerous more focused efforts, generally targeting specific economic issues. These reports are generally presented in short presentation formats with limited documentation. Most have to do with electricity price impacts and are discussed at an appropriate time later in the report.

Beyond specific caveats each of these analyses has, there are some more general caveats the reader should keep in mind when comparing them to each other:

First, the different studies analyze the impact of H.R. 2454 at different stages of its development. The NBCC/CRA analysis is of the bill as introduced in April 2009. The EPA analyses is of the bill as reported by the Energy and Commerce Committee in May 2009. The EIA, ACCF/NAM, and MIT analyses are of the bill as passed by the House. The version analyzed by the Heritage Foundation depends on the date of the WebMemo or other presentation of the results, although its allowance allocation scheme is generally based on a memorandum by Representatives Waxman and Markey dated May 14, 2009.[18] Likewise, analyses by CBO reflect the legislative point in the debate where the analysis was done. At each stage of the legislative process, changes were made to the bill that affect the compliance costs and the distribution of allowance value.

Second, H.R. 2454 is a comprehensive energy and environmental bill (not just a cap-and-trade bill), and the studies differ in terms of the scope of their analyses. The NBCC analysis focuses on the cap-and-trade program (including bonus allowances for carbon capture and storage, and the impact of free allowance allocations on regional and U.S. welfare impacts) and the combined renewable energy and energy efficiency standard for electricity (RES) in Title I of the bill. The EPA analyses include these areas, along with State Energy and Environmental Development (SEED) accounts, and an explicit analysis of the allocation of allowances to trade-exposed, energy-intensive industries. The EIA analysis includes the cap-and-trade program, the combined energy efficiency and renewable energy standard for electricity, carbon capture and sequestration provisions, and various energy efficiency provisions (e.g., lighting standards). The Heritage

[16] Sergey Paltsev, et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change, Report No. 173 (April 2009).

[17] The H.R. 2454 with medium offsets scenario is summarized on p. C19. For more information on the EPPA model, see http://web.mit.edu/globalchange/www/eppa.html.

[18] Representatives Henry A. Waxman and Edward J. Markey, *Proposed Allowance Allocation* (May 14, 2009).

Foundation study is limited to carbon dioxide emissions from the energy sector; other sectors are not incorporated in their analysis. The ACCF-NAM analysis discusses the impact of H.R. 2454 in terms of the cap-and-trade provisions, renewable portfolio standards, energy efficiency standards, and supposed low-carbon fuel standards. The MIT analysis includes the combined renewable energy and energy efficiency standard for electricity in Title I along with the cap-and-trade provisions in Title III.

Third, the studies examined in this report are published with different levels of documentation, making comparative analysis difficult. Each study's sponsor has selected features or impacts it is particularly interested in highlighting, and presentations of projections that emphasize those points. In order to increase the comparability of the various cases examined here, CRS has converted all publicly available data presented by the cases to 2005 dollars (where appropriate) and interpolated missing data where possible. Likewise, where studies have stated they used specific projections as a reference case (such as EIA's Annual Energy Outlook 2009 projections), CRS has assumed those assumptions have not been altered except as specifically stated by the study. In some cases, the authors of the reports were contacted in order to clarify assumptions or results. Finally, CRS has attempted to present projections in the most comparable fashion possible.

Fourth, a special note with respect to the RES is appropriate. As noted above, seven cases (EPA/ADAGE, EPA/IGEM, NBCC/CRA, EIA/NEMS,ACCF-NAM/NEMS, CBO, and MIT/EPPA) clearly included the RES in their analyses. EPA and CRA do not highlight any significant cost increases directly resulting from implementing RES, while EIA states that no additional costs are entailed by compliance with the RES as sufficient renewable energy is incorporated in the baseline. Likewise, CBO finds that the RES requirement is not binding. ACCF-NAM/NEMS only includes it as one reason for increasing energy prices. However, the MIT/EPPA case finds the RES raises household costs, particularly in early years when the RES is increasing rapidly. MIT found the effect moderates in later years, but the overall losses in the early years depress the level of savings and investment that continues to affect the economy in later years.[19]

Overview of the Major Cap-and-Trade Provisions of H.R. 2454[20]

As passed by the House, Title III of H.R. 2454 would amend the Clean Air Act to set up a cap-and-trade system that is designed to reduce greenhouse gas (GHG) emissions from **covered** entities 17% below 2005 levels by 2020 and 83% below 2005 levels by 2050. Covered entities are phased into the program over a four-year period from 2012 to 2016. When the phase-in schedule is complete, the cap will apply to entities that account for 84.5% of U.S. total GHG emissions. By including other provisions contained in the legislation (e.g., a separate cap-and-trade program for hydrofluorocarbons (HFCs)), the World Resources Institute (WRI) estimates that the overall potential net reductions in GHG emissions from the economy as a whole (as

[19] Paltsev, et al. p. C10.

[20] For more information on all provisions of H.R. 2454, see CRS Report R40643, *Greenhouse Gas Legislation: Summary and Analysis of H.R. 2454 as Passed by the House of Representatives* , coordinated by Mark Holt and Gene Whitney.

opposed to just covered entities) from H.R. 2454 could range from 28%-33% below 2005 levels in 2020 and 75%-81% in 2050.[21]

The market-based approach adopted by H.R. 2454 would establish an absolute **cap** on the emissions from covered sectors and would allow **trading** of emissions permits ("**allowances**") among covered and non-covered entities.[22] The bill achieves its broad coverage through an upstream compliance mandate on petroleum, most fluorinated gas producers and importers, a downstream mandate on electric generators and industrial sources, and a midstream mandate on natural gas local distribution companies (LDCs).[23] Generally, the emissions cap would limit greenhouse gas emissions from entities that produce or import more than 25,000 metric tons annually (carbon dioxide equivalent) of greenhouse gases (or produce or import products that when used will emit more than 25,000 metric tons of greenhouse gases).

Emission Allowance Allocation

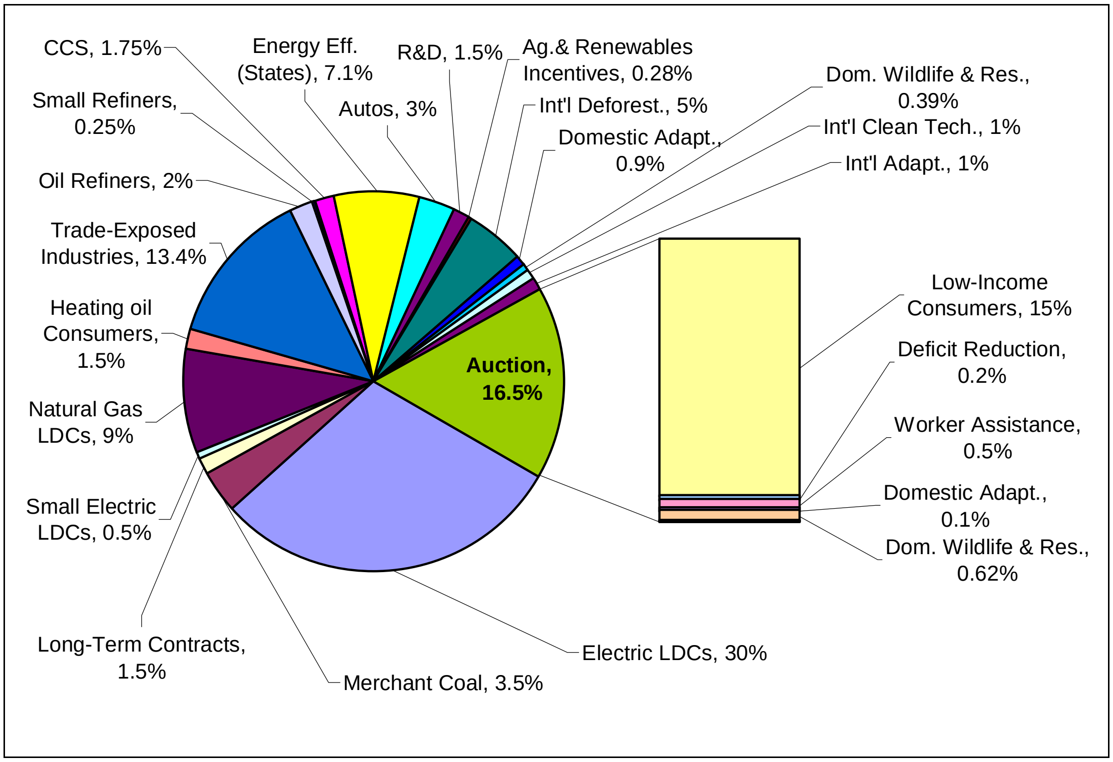
If left unmitigated, any greenhouse gas cap-and-trade program (as well as a carbon tax alternative) would be regressive. In an attempt to mitigate this distributional problem, H.R. 2454 allocates a substantial percentage of the allowances available for the benefit of energy consumers and low-income households. In some cases, these allowances are allocated at no cost to entities such as LDCs, with the express purpose of mitigating energy cost increases; in other cases, such as low-income assistance, the allowances are **auctioned** by EPA and the proceeds distributed to eligible recipients. As the program proceeds, between 2026 and 2035, the energy cost relief, along with other free allocations are phased out in favor of more government auctioning with most of the proceeds returned to households on a per-capita basis. See **Figure 1** and **Figure 2** for a summary of how emission allowances are distributed in 2016 and 2030, respectively.

[21] John Larsen and Robert Hellmayr, *Emission Reductions Under the American Clean Energy and Security Act of 2009* (World Resources Institute, May 19, 2009).

[22] See "Common Terms" box for definitions of terms in boldface.

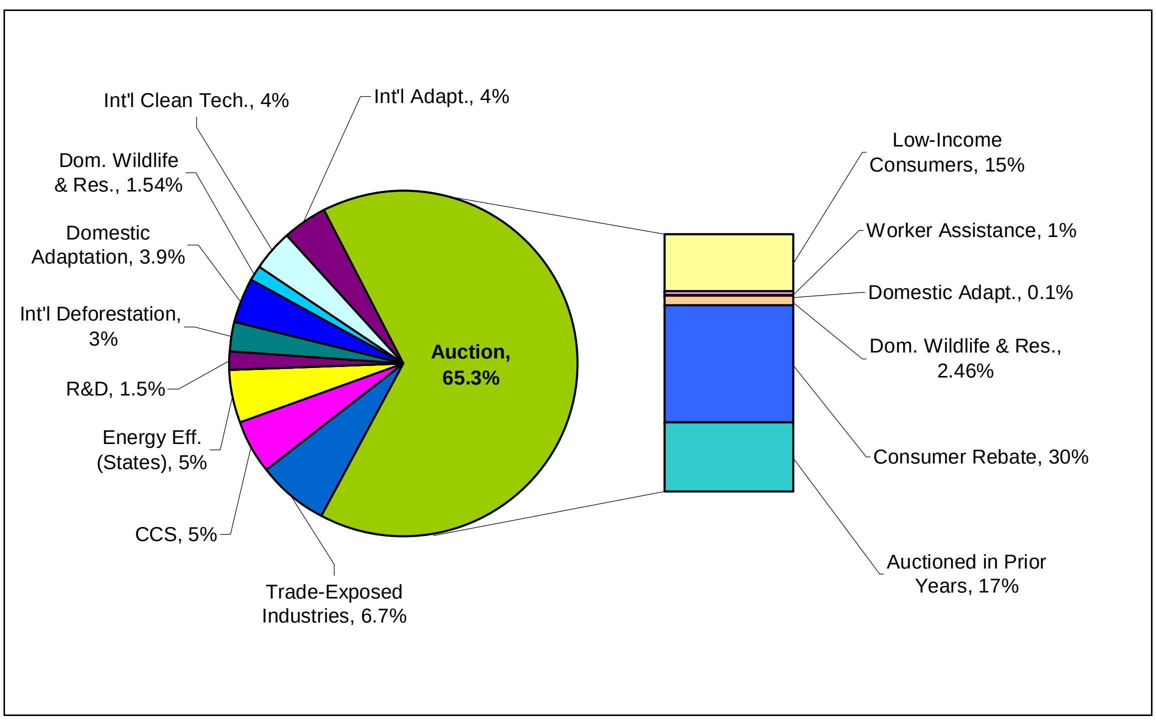
[23] Title III sets up a separate cap-and-trade program for hydrofluorocarbons (HFCs).

Figure 1. Simplified Emission Allowance Distribution—2016



Source: Prepared by CRS

Figure 2. Simplified Emission Allowance Distribution—2030



Source: Prepared by CRS

H.R. 2454's allocation scheme also attempts to smooth the economy's transition to a less carbon-intensive future through free allowance allocations to energy-intensive, trade-exposed industries, merchant coal-fired electric generators, and petroleum refiners. Bonus allotments of allowances are allocated for emission reductions achieved by carbon capture and storage technology. Except for carbon capture and storage, these free allocations of allowances are phased out by the early to mid-2030s.

Finally, H.R. 2454's allocation scheme attempts to address greenhouse gas emissions by providing allowances to help prevent further tropical deforestation and to fund climate adaptation activities.

Price Control

Because allowance prices can be volatile, cap-and-trade bills generally provide some mechanisms to address either potential price fluctuations, or allowance prices more generally. H.R. 2454 does not have a "safety valve"—an alternative compliance option that permits covered entities to pay an excess emissions fee instead of reducing emissions. Instead, the legislation addresses cost control through five main mechanisms: (1) unlimited banking and limited borrowing, (2) a two-year compliance period, (3) a strategic reserve auction with a pool of allowances available at a minimum reserve price, (4) periodic auctions with a reserve price, and (5) broad limits on the use of **offsets**.

With respect to allowance price volatility, the bill includes two design elements that may dampen volatility to some degree. First, the bill allows entities to borrow (without interest) allowances from the year immediately following the current year, effectively creating a rolling two-year compliance period. Second, EPA is directed to hold strategic reserve auctions. A strategic reserve of allowances borrowed from future years is auctioned off in the early years of the program. This increases the availability of allowances early, but maintains the overall emissions cap. The strategic reserve auction would include a reserve price: $28/allowance in 2012 that would increase annually in 2013 and 2014. Starting in 2015, the reserve price would be 60% above the 36-month rolling average allowance price.

Regular auctions mandated by the bill also have a reserve price: $10 (in 2009 dollars) in 2012, increasing at 5% real annually. An auction reserve price would help create an allowance price floor, and may help dampen allowance price spikes. The auctions, along with the other mechanisms listed above, attempt to bracket volatility. Whether they would work is subject to debate, particularly with respect to short-term price volatility.

As will be discussed further later in the report, with respect to overall cost control, analysis indicates that an important cost control mechanism in the cap-and-trade program is the availability of domestic and international offsets. The bill limits the availability of domestic and international offsets to two billion tons of emissions annually—divided equally between domestic and international pools. According to analyses done by EPA, EIA, the Congressional Budget Office, and CRA International, the availability of these offsets reduces projected allowance prices under the program by half or more.[24]

[24] U.S. Environmental Protection Agency, EPA Preliminary Analysis of the Waxman-Markey Discussion Draft: The American Clean Energy and Security Act of 2009 in the 111th Congress (April 20, 2009); Energy Information Administration, Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of (continued...)

Another concern with respect to a cap-and-trade program is potential allowance market abuse and manipulation. The size of a U.S. carbon market could be in the hundreds of billions of dollars, and is likely to involve all of the financial instruments, particularly derivatives, that any other commodity market includes. To provide oversight of the newly created carbon allowance market, the bill has detailed provisions for Federal Energy Regulatory Commission (FERC) oversight of the cash allowance market, and enhanced Commodity Futures Trading Commission (CFTC) oversight of allowance derivatives. With respect to the latter, the bill would remove energy commodities (including carbon allowances) from the category of "exempt commodity" and require that over-the-counter transactions be cleared through a clearing house (a standard feature of a futures exchange). In addition the CFTC is required to establish position limits, thus setting ceilings on the number of energy contracts that any person could hold.

Additional Provisions

Besides the two emission caps created under Title III, the bill contains other provisions in Titles III and IV to reduce greenhouse gas emissions and potential carbon leakage. Among the most important of these provisions are (1) prevention of tropical deforestation, (2) performance standards for uncovered entities that emit over 10,000 metric tons annually, (3) discounted international offsets after 2017; and (4) programs designed to reduce potential carbon leakage.

First, H.R. 2454 has a supplemental greenhouse gas reduction program that requires EPA to use some of the allowances available under the cap-and-trade program to fund international projects to reduce deforestation. The goal of the program is to achieve 720 million metric tons of additional emission reductions in 2020 (about 10% of U.S. 2005 emissions), and a total of 6 billion metric tons by 2025 (about equal to U.S. emissions in 1990). If achieved, this would have a significant effect on the net emission reductions achieved in the early years of the program, as suggested by the WRI study cited earlier.

Second, as noted above, not all greenhouse gas emitting sources are covered by the Title III cap-and-trade programs. Under other provisions of Title III, stationary sources not covered by the Title III caps are potentially subject to greenhouse gas performance standards. WRI estimates that standards for uncapped sources could reduce emissions from such sources by about 115 million metric tons annually.

Third, as passed, the cap-and-trade program requires that international offsets submitted for compliance beginning in 2018 be discounted (i.e., it takes 1.25 offset credits to equal 1.00 allowance). Depending on the number of international offsets used for compliance after 2017, the discount factor could add up to 375 million metric tons of reductions annually, according to WRI.

Fourth, H.R. 2454 takes two primary approaches to mitigating the potential impact of carbon leakage on the net greenhouse gas reductions to be achieved under the bill.[25] The first is the

(...continued)

2009 (August 4, 2009); Congressional Budget Office, Congressional Budget Office Cost Estimate: H.R. 2454, American Clean Energy and Security Act of 2009 (as Ordered Reported by the House Committee on Energy and Commerce) (June 5, 2009); and, CRA International, 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 (May 2009).

[25] For a full discussion of carbon leakage, see CRS Report R40100, *"Carbon Leakage" and Trade: Issues and Approaches*, by Larry Parker and John Blodgett.

allocation of allowances at no cost to energy-intensive, trade-exposed industries, as identified above. The second is an international reserve allowance scheme that essentially imposes a shadow allowance requirement on importers of energy-intensive, trade-exposed products, creating a *de facto* tariff. Basically, the scheme would require importers of energy-intensive products from countries with insufficient carbon policies to submit a prescribed amount of "international reserve allowances," or IRAs, for their products to gain entry into the United States. Based on the greenhouse gas emissions generated in the production process, IRAs would be submitted on a per-unit basis for each category of covered goods from a covered country.

Whether the international reserve allowance scheme would actually work is unclear. The daunting administrative, informational, and analytical resources necessary to implement such a program would create significant issues in any attempt to implement it. Likewise, it is not clear that the World Trade Organization (WTO) implications of the provision have been fully exposed and accommodated.

Common Terms

Allowance. A limited authorization by the government to emit 1 metric ton of carbon dioxide equivalent. Although used generically, an *allowance* is technically different from a *credit*. A credit represents a ton of pollutant that an entity has reduced in excess of its legal requirement. However, the terms tend to be used interchangeably, along with others, such as *permits*.

Auctions. Auctions can be used in market-based pollution control schemes to allocate some, or all of the allowances. Auctions may be used to: (1) ensure the liquidity of the credit trading program; and/or (2) raise (potentially considerable) revenues for various related or unrelated purposes.

Banking. The limited ability to save allowances for the future and shift the reduction requirement across time.

Cap-and-trade program. An emissions reduction program with two key elements: (1) an absolute limit ("cap") on the emissions allowed by covered entities; and (2) the ability to buy and sell ("trade") those allowances among covered and non-covered entities.

Coverage. Coverage is the breadth of economic sectors covered by a particular greenhouse gas reduction program, as well as the breadth of entities within sectors.

Discount rate. See discussion on page 40.

Emissions cap. A mandated limit on how much pollutant (or greenhouse gases) an affected entity can release to the atmosphere. Caps can be either an *absolute cap*, where the amount is specified in terms of tons of emissions on an annual basis, or a *rate-based cap*, where the amount of emissions produced per unit of output (such as electricity) is specified but not the absolute amount released. Caps may be imposed on an entity, sector, or economy-wide basis.

Greenhouse gases. The six gases recognized under the United Nations Framework Convention on Climate Change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFC), and perfluorocarbons (PFC). H.R. 2454 also includes nitrogen trifluoride (NF_3).

Leakage. The shift in greenhouse gas (GHG) emissions from an area subject to regulation (e.g., cap-and-trade program) to an unregulated area, so reduction benefits are not obtained. This would happen, for example, if a GHG emitting industry moved from a country with an emissions cap to a country without a cap.

Offsets. Emission credits achieved by activities not directly related to the emissions of an affected source. Examples of offsets would include forestry and agricultural activities that absorb carbon dioxide, and reductions achieved by entities that are not regulated by a greenhouse gas control program.

Reference case. The "business-as-usual" projection, or "baseline" for each case in the absence of new controls established by new legislation or regulation.

Revenue recycling. How a program disposes of revenues from auctions, penalties, and/or taxes. Revenue recycling can have a significant effect on the overall cost of the program to the economy, as well as to specific sectors, regions, or income brackets.

Sequestration. Sequestration is the process of capturing carbon dioxide from emission streams or from the atmosphere and then storing it in such a way as to prevent its release to the atmosphere.

Earlier Versions of the Bill

There are six key changes between the cap-and-trade provisions of a draft version of the bill circulated by its sponsors, and H.R. 2454 as introduced, as reported by the House Committee on Energy and Commerce, and the House-passed version:

- The introduced version (and subsequent versions) of the bill contains a less stringent cap on emissions for covered sources in the early years of the program compared to the initial discussion draft.
- The original discussion draft discounted domestic and international offsets by 20% (requiring 1.25 tons of offsets to equal 1 ton of covered emissions). As

introduced, reported, and passed, only international offsets are discounted, and only after 2017.

- The distribution of allowances was somewhat modified between the reported and House-passed versions to include allocations for early actions, small electric LDCs, small refineries, and other stakeholders.
- Further, the allocation for all electric LDCs was modified to prohibit any LDC from receiving more allowances than it needs to offset increased electricity costs resulting from the bill.
- The reported version of the bill made the International Reserve Allowance scheme a discretionary program that could not begin before 2025. The version as passed by the House made the implementation mandatory unless positive action was taken by the Congress to halt it. In addition, the definition of covered goods under the provisions was expanded from primary goods (e.g., iron and steel) to include other energy-intensive items, including items "manufactured for consumption."
- Significant changes were made to the offset provisions from the reported version to the version passed by the House. These include establishing a separate program for offsets from domestic agriculture and forestry to be administered by the U.S. Department of Agriculture, with all other offsets administered by EPA (in earlier versions, all offsets were administered by EPA); and the establishment of "term offset credits" to address concerns over the permanence of some offset projects.

Introduction: Models Cannot Reliably Predict the Future Costs of a Climate Change Program

Lessons from SO_2 Cap and Trade Program

During the Clean Air Act debate in 1990 on the Title IV sulfur dioxide (SO_2) cap-and-trade program, CRS found it difficult to analyze the cost of the bill beyond the first 10 years (1990-2000), and considered any breakdown of 2000 data on a state-by-state basis as "not useful for any more than illustrative purposes."[26] As stated in 1990:

> It is difficult (and some would consider it unwise) to project costs up to the year 2000, much less beyond. The already tenuous assumption that current regulatory standards will remain constant becomes more unrealistic, and other unforeseen events (such as electric utility deregulation) loom as critical issues which can not be modeled. Hence, ***cost projections beyond the year 2000 are at best speculative, and are more a function of each model's assumptions and structure than they are of the details of proposed legislation*. Projections this far into the future are based more on philosophy than analysis.**[27] [emphasis in original]

[26] See CRS Report 90-63, *Acid Rain Control: An Analysis of Title IV of S. 1630*, by Larry Parker (January 31, 1990), p. 13. (Available from the author.)

[27] Ibid., p. 16.

The history of resulting SO_2 cap-and-trade program costs has proven illuminating. As indicated in **Table 1**, the 2010 cost estimates for the SO_2 cap-and-trade program made in 1990 proved to be substantially higher than what is now estimated to be the program's actual costs. Indeed, the EPA-ICF low estimate—the estimate closest to the projected actual number—is both 50% higher than the actual number, and the estimate least focused-on in the original ICF report.[28] It is interesting that none of the analyses were willing to "speculate" with assumptions that would have created a 2010 cost estimate lower than EPA's then-current projection.[29]

Equally interesting is that the "best" 2000 estimate was off by almost the same 50% that the 2010 estimate was.[30] Like the 2010 estimates, the assumptions either underestimated the ingenuity and creativity of companies in responding to the SO_2 requirements, or mis-read the economics of the cap-and-trade process. As explained below by Chestnut and Mills in 2005, the gross over-estimates are essentially the product of the models' failure both to fully incorporate the flexibility that the cap-and-trade program provided participants and to explore the potential for technological breakthroughs and enhancements:

> Costs are lower than originally predicted primarily because flexibility occurred in areas that were thought to be inflexible and technical improvements were made that were not anticipated. Factors contributing to the lower costs included lower transportation costs for low-sulfur coal (attributed to railroad deregulation), productivity increases in coal production leading to favorable prices for low-sulfur and mid-sulfur coal, cheaper than expected installation and operation costs for smokestack scrubbers, and new boiler adaptations to allow use of different types of coal. It appears that Title IV has worked as expected to provide the flexibility and incentives for producers to find low-cost compliance options. [footnote omitted] Banking opportunities also induced early reductions in emissions for some facilities. Harrington et al. (2000) compared estimates of actual costs of many large regulatory programs to predictions of those costs made while the regulatory programs were being developed and found a tendency for predicted costs to overstate the actual implementation costs, especially for market-based programs such as the SO_2 trading program. They cite technological innovation and unanticipated efficiency gains as key factors leading to lower than predicted costs. They noted that unit costs are often more accurately predicted than total costs because predicted emission reductions are sometimes overstated, but they report that predicted unit costs and total costs were both overstated for Title IV.[31]

[28] The only 2010 national utility cost estimate mentioned in the summary of findings is for the High Case: "Longer-term costs reach about $5 billion [1988 dollars] per year by 2010 under both the High House and Senate cases, due to the provisions requiring new source emissions to be offset." The Low House and Senate cases for 2010 are not mentioned. See EPA-ICF: ICF Resources Incorporated, *Comparison of the Economic Impacts of the Acid Rain Provisions of the Senate Bill (S. 1630) and the House Bill (S. 1630)*, Prepared for the U.S. Environmental Protection Agency (July 1990), p. 21.

[29] The implementation of the SO_2 provisions of the Clean Air Interstate Rule (CAIR) will significantly increase the stringency of the SO_2 cap for 23 states and the District of Columbia and will likely prevent EPA from estimating actual Title IV compliance costs in 2010 because of program interaction.

[30] In its 1990 analysis, CRS concurred with the range of estimates provided by the EPA-ICF analysis for 2000. As suggested above, CRS did not estimate the costs for 2010. See CRS Report 90-63, *Acid Rain Control: An Analysis of Title IV of S. 1630*, by Larry Parker (January 31, 1990), p. 56. (Available from the author.)

[31] Lauraine G. Chestnut and David M. Mills, "A fresh look at the benefits and costs of the US acid rain program," *Journal of Environmental Management* 77 (2005) p. 255.

Table 1. Representative Sample of 1990 Estimates of Annual Compliance Cost for SO_2 Cap-and-Trade Program

(billions, 2005$)

	2000	2010
EPA-ICF	$2.7-$3.6	$3.4-$8.0
NCAC-Pechan	$4.4-$4.6 (annual average for 2000-2009)	no estimate
EEI-TBS[a]	$7.1-$8.7	$7.9-$11.2
Estimated Actual Costs 2000-2007: Ellerman, et al. 2010: EPA	$1.9 (annual average for 2000-2007)	$2.2

Source: EPA-ICF: ICF Resources Incorporated, *Comparison of the Economic Impacts of the Acid Rain Provisions of the Senate Bill (S. 1630) and the House Bill (S. 1630)*, Prepared for the U.S. Environmental Protection Agency (July 1990); Pechan: E.H. Pechan & Associates, *Clean Air Act Amendment Costs and Economic Effects: A Review of Published Studies*, Prepared for the National Clean Air Coalition, National Clean Air Fund (October 1990); TBS: Temple, Barker & Sloane, Inc., *Economic Evaluation of H.R. 3030/S. 1490 "Clean Air Act Amendments of 1989": Title V, The Acid Rain Control Program*, Prepared for the Edison Electric Institute (August 30, 1989). **Estimated 2000-2007 actual cost** from A. Denny Ellerman, Paul L. Joskow, and David Harrison, Jr., *Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases*, prepared for the Pew Center on Global Climate Change (November 2007) p. 15. **Estimated 2010 actual cost** from: EPA, *Acid Rain Program Benefits Exceed Expectations*, Figure 4, p. 3. Available at http://www.epa.gov/airmarkets/cap-trade/docs/benefits.pdf. All estimates converted to 2005 dollars using the GDP implicit price deflator.

a. Analysis of original Administration bill. EPA estimated that the final bill was $400 million (1988 dollars) annually more expensive than the original proposal. See EPA, Office of Air and Radiation, *Clean Air Amendments: Cost Comparison* (January 23, 1990).

An Illustrative Example from Analyses of H.R. 2454

There is no reason to believe that cost estimates for greenhouse gas reductions will be any more accurate than the 1990 SO_2 estimates; indeed, they are likely to be less reliable. This is not to say that they will be too high; they may be too low. To illustrate, CRS examines some results of the modeling efforts with respect to the costs of H.R. 2454. To frame this illustration, we focus on the three primary drivers of greenhouse gas emissions: (1) population, (2) incomes (measured as per capita gross domestic product [GDP]), and (3) intensity of greenhouse gas emissions relative to economic activities (measured as metric tons of greenhouse gas emissions per million dollars of GDP). As shown in the following formula, a country's annual greenhouse gas emissions are the product of these three drivers:

$$(\textit{Population}) \text{ x } (\textit{Per Capita GDP}) \text{ x } (\textit{Intensity}_{ghg}) = \textit{Emissions}_{ghg}$$

This is the relationship for a given point in time; over time, any effort to change emissions alters the exponential rates of change of these variables. This means that the rates of change of the three left-hand variables, measured in percentage of annual change, sum to the rate of change of the right-hand variable, emissions.

Using the three drivers, **Table 2** provides the essential assumptions from four analyses of H.R. 2454 for the year 2050. The Heritage Foundation analysis is not included because it covered only the energy sector and only until 2035; the EIA and ACCF/NAM analyses are not included because they only project to 2030. Examining the "business-as-usual" reference cases, a range of assumptions are employed by the models. As suggested by the formula above, the differing assumptions result in different 2050 baseline GHG emissions: 8.4 billion metric tons for EPA/ADAGE, 8.4 billion metric tons for EPA/IGEM, 9.7 billion metric tons for NBCC/CRA, and 10.1 billion for MIT/EPPA—a 20% difference from the lowest to the highest. Interestingly, major sources of disagreement in the reference cases include per capita GDP and population projections—two variables that are generally not the focus of greenhouse gas reduction strategies.

Table 2. Reference Case and H.R. 2454 Analyses for 2050

Model	Population (millions)	Difference from lowest to highest model	GDP per capita (2005$)	Difference from lowest to highest model	GHG Intensity (GHG/ GDP)[a]	Difference from lowest to highest model
Reference Case Scenario						
EPA/ADAGE	400	12%	$88,531	10%	237	12%
EPA/IGEM	446		$80,207		234	
NBCC/CRA	432		$87,921		255	
MIT/EPPA	440		$87,355		263	
H.R. 2454 Scenario						
EPA/ADAGE	400	12%	$87,382	11%	132	27%
EPA/IGEM	446		$78,563		146	
NBCC/CRA	432		$86,602		115	
MIT/EPPA	440		$85,759		129	

Source: ADAGE and IGEM model assumptions from the "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. The NBCC/CRA model assumptions are based on Figure 3.20 and Table B-4 of the report and EIA's AEO 2009 Early Release. The MIT model assumptions are based on the table on p. C-19 of the report. All estimates converted to 2005 dollars using the GDP implicit price deflator.

a. Measured in metric tons of greenhouse gas emissions per million dollars of GDP.

Moving to the H.R. 2454 scenario as modeled, the variability in the results widens for two of the three drivers (the 2050 reference case population remains constant in the three models), but the range of projected 2050 greenhouse gas emissions estimates narrows: 4.6 billion metric tons for EPA/ADAGE, 5.1 billion metric tons EPA/IGEM, 4.3 billion metric tons for NBCC/CRA, and 4.8 billion metric tons for MIT/EPPA—a 19% difference. The models' assumptions about the flexibility and responsiveness of the U.S. economy resulted in some interesting reversals in 2050 between the base case and H.R. 2454 scenario that narrow this range: (1) the CRA and MIT models, which have the highest GHG intensity assumption in the reference case, have the lowest GHG intensity under H.R. 2454. (2) In contrast, the EPA/IGEM model, which has the lowest GHG intensity assumption in its reference cases, has the highest GHG intensity result under H.R. 2454.

Because of these different views of the economy, the economic impact of the bill is almost lost in the differences in the models' reference case assumptions. As indicated in **Table 2**, the EPA/ADAGE, NBCC/CRA, and MIT/EPPA model projections of the country's 2050 GDP per capita under H.R. 2454 are greater than the *reference case* projections of EPA/IGEM. According to the EPA/ADAGE model, the 2050 GDP per capita of the country is reduced by 1.3% under H.R. 2454; 2.0% according to the EPA/IGEM projection, 1.5% according to the NBCC/CRA analysis, and 1.8% according to the MIT/EPPA analysis.

In some ways, the above comparison underestimates the uncertainty involved because all the analyses are linked to some degree to the 2009 EIA Annual Energy Outlook (AEO) reference case projection. The AEO projections have changed over time (and will continue to do so in the future). **Figure 3** below presents the changes in the three drivers (substituting energy intensity for greenhouse gas intensity) and resulting baselines from EIA's reference case projections over the past four years. As indicated, projected 2030 greenhouse gas emissions have dropped by almost a quarter over that four-year period. Most of this reduction results from less optimistic assumptions about GDP growth per capita and a small improvement in energy efficiency that overwhelmed an increasing population projection. **If the analyses reviewed in this report were conducted using EIA's 2006 reference case projections, instead of its 2009 projections, the compliance costs associated with the program would be significantly higher**.

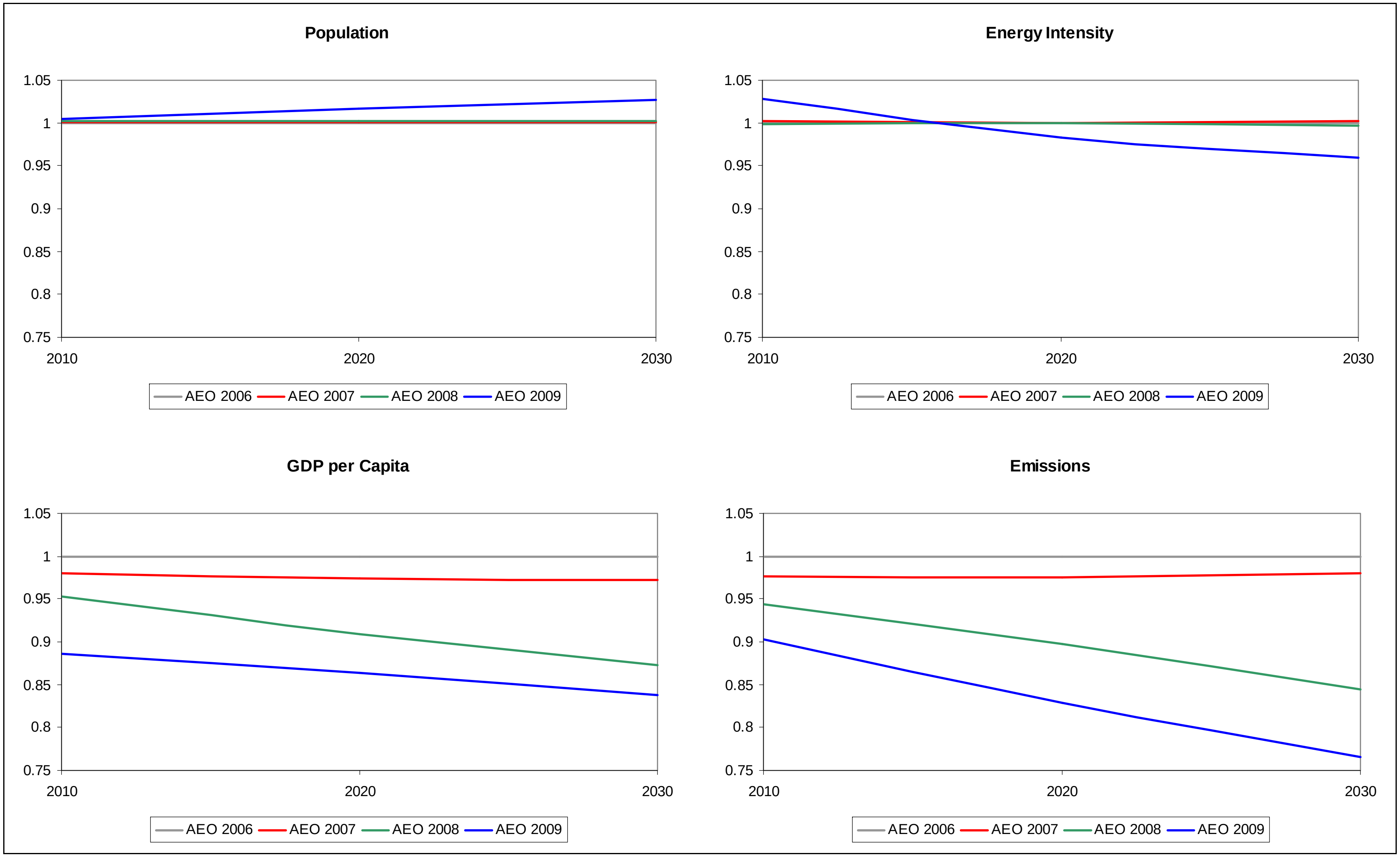
The uncertainty about the future direction of the basic drivers of greenhouse gas emissions and the economy's responsiveness (economically, technologically, and behaviorally) illustrate the inability of models to reliably predict the ultimate macroeconomic costs of reducing greenhouse gases. Policy relevant analysis provides insight into the features and design of proposals that increase or reduce compliance cost and under what economic, technological, and behavior conditions, and that identify potential intended and unintended consequences on the economy. Models cannot accurately predict the future, but they can indicate the sensitivity of a program's provisions to varying economic, technological, and behavioral assumptions that may assist policymakers in designing a greenhouse gas reduction strategy.

Major Points of this Section

- Past history shows that models cannot reliably predict the future.
- The models of H.R. 2454 do not agree on the key drivers of emissions in the reference (business-as-usual) case—in many instances, these differences overwhelm the results under the policy (H.R. 2454) case.
- Models can inform policymakers by providing insight into design features that increase or reduce compliance costs.

Figure 3. Changes in EIA's Annual Energy Outlook (AEO) Reference Case Projections for Major Economic Indicators

Indexed to AEO 2006 Reference Case



Source: Energy Information Administration, *Annual Energy Outlook* (various years).

Likelihood for More Noise in Greenhouse Gas Reduction Cost Estimates

The potential for noise is greater in estimating the costs of a GHG program than the simple three driver illustration presented above. In its analysis of H.R. 2454, EPA presents four pages of bullets identifying various limitations on its modeling exercise and four pages of additional "qualitative" considerations.[32] This is a good indicator of the modeling complexity in attempting to estimate the impact of a greenhouse gas reduction bill. These modeling limitations reflect the inherent complexity of such strategies that cannot be quantified or predicted.

Complexity of the Problem

Compared with the complexity of implementing a greenhouse gas cap-and trade scheme, the SO_2 program was simple. Conceptually, a CO_2 tradable permit program could work similarly to the SO_2 program. However, significant differences exist between the acid rain process and possible global warming factors that affect current abilities to model responses. For example, the acid rain program involves up to 3,000 new and existing electric generating units that contribute two-thirds of the country's SO_2. This concentration of sources (and the fact that they are stationary) makes the logistics of allowance trading administratively manageable and enforceable. The imposition of the allowance requirement is straightforward. The acid rain program is a "downstream" program focused on the electric utility industry. The allowance requirement is imposed at the point of SO_2 emissions so the participant has a clear price signal to respond to. The basic dynamic of the program is simple, although not necessarily predictable.

A comprehensive greenhouse gas cap-and-trade program would not be as straightforward to implement. Greenhouse gas emissions sources are not concentrated. Although over 80% of the greenhouse gases generated comes from fossil fuel combustion, only about 34% comes from electricity generation. Transportation accounts for about 28%, direct residential and commercial use about 11%, agriculture about 7%, and direct industrial use about 19%.[33] Thus, small dispersed sources in transportation, residential/commercial, agriculture, and the industrial sectors are far more important in controlling greenhouse gas emissions than they are in controlling SO_2 emissions. This greatly increases the economic sectors and individual entities that may be required to reduce emissions.

It also affects the operation of a cap-and-trade program, as the diversity of sources creates significant administrative and enforcement problems for a tradable permit program if it is meant to be comprehensive. A downstream approach is impractical for a comprehensive greenhouse gas program where the transportation sector and dispersed residential, commercial, and agricultural sources emit almost half the total emissions. One alternative is to move the imposition point more "upstream" in those sectors, as is done by H.R. 2454. This complicates the economics of the program as the price signal has to work its way through multiple paths to the particular entities—

[32] U.S. Environmental Protection Agency, *EPA Analysis of the American Clean Energy and Security Act of 2009: H.R. 2454 in the 111th Congress – Appendix* (June 23, 2009), pp. 12-15, 46-49.

[33] U.S. Environmental Protection Agency, *U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2007* (April 15, 2009), p. ES-14.

utilities, consumers, industry—that are the ultimate sources of the greenhouse gases. Arguably, the primary purpose of an economic mechanism, such as a cap-and-trade program, is to put a price on greenhouse gas emissions. In the case of a comprehensive cap-and-trade program, the impact of that price signal will not be simple or straightforward, with unintended consequences likely.[34] In addition, attempts by analysts to capture the general equilibrium effects of the program's interaction with the overall economy add a layer of assumptions and opaqueness to the analysis that can hide insights the analysis may have on program design and implementation.

Flexibility of Cap-and-Trade Program

The flexibility envisioned by most GHG cap-and-trade proposals exceeds that of the SO_2 program. Acid rain is a regional problem that resulted in independent responses by the United States and Canada. The United States chose a cap-and-trade program that included important flexibility mechanisms like banking; Canada chose a variety of approaches and the entire process was later codified by treaty. Offsets (emission reductions made by entities not directly covered by the program) are not a major component of the SO_2 program. Uncovered industrial entities that want to participate in the program must become covered entities with their own baselines and monitoring equipment. The SO_2 program also sets up a small reserve of allowances to reward reductions through conservation and renewable energy efforts. With the sulfur dioxide cap-and-trade system being limited to the United States, there is no international trading in the acid rain program.

In contrast, most GHG cap-and-trade proposals (including H.R. 2454) expand the number of emission mitigation opportunities—effectively increasing the number of allowances—by permitting offsets from a wide variety of sources, including agricultural practices, forestry projects, sequestration activities, and alternative energy projects.[35] These diverse sources multiply as the trading extends globally and as other non-CO_2 greenhouse gases are included in the supply mix. Finally, the interaction of these various supply sources and the demand of other countries also reducing emissions (or who may decide to reduce in the future) provide for an almost infinite number of possible scenarios. Crucially, as noted earlier, the availability of offsets has a significant impact on compliance costs, while contributing significant complications to the verification and accounting process.

Importance of Technology to Future Results

The three-driver analysis illustrated the importance of reducing the greenhouse gas intensity of the economy to reducing overall greenhouse gas emissions. The other two drivers, population and economic growth, are generally not elements targeted for reduction under greenhouse gas reduction programs (indeed, by any federal program).

The key factor in reducing the intensity driver over the long run is technology development. This is recognized in most greenhouse gas reduction bills, including H.R. 2454, with substantial

[34] This is particularly true if allowances are allocated to upstream entities at no cost. See Sergey Paltsev, et al., *Assessment of U.S. Cap-and-Trade Proposals,* MIT Joint Program on the Science and Policy of Global Change (April 2007), p. 5.

[35] Including offsets as a compliance option would not affect the cap, but would change the mix of activities performed to achieve the reduction target. See CBO, *The Use of Offsets to Reduce Greenhouse Gases* (August 3, 2009).

funding, incentives, regulatory standards, and price signals to encourage both accelerated deployment and the initiation of efforts to develop new generations of technology. **The effectiveness of these initiatives and price signals would be pivotal to the ultimate cost of any reduction strategy, particularly in the long term.** As stated by Houghton:

> Technology change is a particularly critical component of the climate change debate. For example, the cost of meeting stabilization levels is very sensitive to assumptions about future technologies. If assumed technology improvements lead to relatively low emissions, then it is relatively inexpensive to meet stabilization levels, and vice versa. Furthermore, technology research and development is a very significant policy instrument in the portfolio of options.[36]

Increasing Problems with *Ceteris Paribus* Analysis[37]

As was the case with analyses of the SO_2 cap-and-trade program, current studies of greenhouse gas reduction proposals assume that, in the absence of new legislation, EPA would take no action in this area between now and the year 2050, and no future initiatives would be enacted in related areas, such as energy policy. This seems unlikely. Indeed, the potential for a future requirement to reduce greenhouse gas emissions may already be having an effect on decisions by industry and consumers. As noted by EIA in its analysis of S. 2191 of the 110th Congress:

> While forecasting policy change is beyond EIA's mandate, an argument can be made that, all else being equal, public and industry awareness of climate change as a major policy issue can potentially impact energy investment decisions even if no specific policy change actually occurs. Any adjustment to reflect the influence of climate change as an unresolved policy issue, while raising costs in the Reference Case, would generally reduce the estimated incremental impact resulting from the full implementation of a given policy response.[38]

Changing Reference Cases By Changing Laws

In its analysis of the Lieberman-Warner cap-and-trade bill of the 110th Congress (S. 2191), CRS noted that policy baselines for greenhouse gas emissions can be shifted significantly through new initiatives, and used the enactment of the 2007 Energy Independence and Security Act (EISA) as an example. In conclusion, CRS noted that "More changes are likely over the 40-year time frame of S. 2191."[39] This conclusion has been verified in the course of one year with the passage of the American Recovery and Reinvestment Act (ARRA) in February 2009.

ARRA contains many energy provisions that could lead to reductions in greenhouse gas emissions, including new federal funding, loan guarantees, and tax credits to stimulate investments in energy efficiency and renewable energy activities.[40] The passage of ARRA

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[36] John Houghton, "Introduction," *Energy Economics* 28 (2006), p. 535.

[37] From Latin, roughly meaning all else being held the same. In analysis, this refers to the practice of holding certain variables constant to isolate the effect of the variable being analyzed.

[38] Energy Information Administration, *Energy Market and Economic Impact of S. 2191, the Lieberman-Warner Climate Security Act of 2007* (April 2008) p. viv.

[39] CRS Report RL34489, *Climate Change: Costs and Benefits of S. 2191/S. 3036*, by Larry Parker and Brent D. Yacobucci.

[40] For more information on the energy provisions of ARRA, see CRS Report R40412, *Energy Provisions in the American Recovery and Reinvestment Act of 2009 (P.L. 111-5)*, coordinated by Fred Sissine.

motivated EIA to develop a new Annual Energy Outlook 2009 (AEO2009) baseline to reflect the provisions of ARRA and to update the rapidly changing macroeconomic outlook for the United States and global economies in general. Focusing on the projected effects of ARRA, among the results of this reworking of the AEO2009 baseline were (1) a 27,700 megawatt (MW) increase in projected renewable electric generating capacity by 2030, (2) a 4,900 MW reduction in the projected increase in nuclear power capacity, and (3) an 11,300 MW reduction in overall electric generating capacity. The net result is a projected reduction in 2030 of 36.5 million metric tons of energy-related carbon dioxide emission from the level estimated by EIA without ARRA.[41]

Changing Reference Cases By Changing Regulation[42]

Estimating the cost of H.R. 2454's cap-and-trade program, as compared to the baseline without new legislation, requires one to make an assumption regarding "business as usual" – i.e., what constitutes the baseline level of regulation in the absence of new legislation. The current baseline includes no federal controls on CO_2; for any future cost projection, however, the baseline appears likely to be influenced by ongoing and future EPA initiatives that rely on existing legislative authority.

The Clean Air Act (CAA) is a powerful tool that can be used to regulate emissions of greenhouse gases from mobile sources of all kinds, their fuels (with the exception of jet fuel), and both large and small stationary sources. The possibilities for regulation of GHGs through existing CAA authority have been outlined in a number of places: for a CRS discussion of the existing authorities, see CRS Report R40585, *Climate Change: Potential Regulation of Stationary Greenhouse Gas Sources Under the Clean Air Act*, by Larry Parker and James E. McCarthy, and CRS Report R40506, *Cars and Climate: What Can EPA Do to Control Greenhouse Gases from Mobile Sources?*, by James E. McCarthy.

Regulating GHG emissions under existing CAA authority would require EPA to make a finding that greenhouse gases "cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare."[43] Such an endangerment finding was proposed by EPA on April 24, 2009, as a first step toward the proposal and promulgation of GHG emission standards for motor vehicles.[44]

EPA has also discussed its intended actions. On May 22, 2009, the agency along with the Department of Transportation published a *Federal Register* notice outlining the agency's intention to promulgate GHG emission standards for motor vehicles under Section 202 of the Act;[45] these standards are expected to be promulgated by March 2010. In a recent document, EPA

[41] Department of Energy, Energy Information Administration. *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*, Report #: SR-OIAF/2009-03, (April 2009) p. 35.

[42] This section prepared by James McCarthy, Specialist in Environmental Policy.

[43] The quoted language appears in Section 202 of the act, dealing with motor vehicles. Similar language can be found in Section 111 (stationary sources), Section 211 (fuels), Section 213 (nonroad engines and vehicles), Section 231 (aircraft), and Section 615 (protection of the stratosphere).

[44] U.S. EPA, "Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act," 74 *Federal Register* 18886, April 24, 2009.

[45] Environmental Protection Agency and Department of Transportation, "Notice of Upcoming Joint Rulemaking to Establish Vehicle GHG Emissions and CAFE Standards," 74 *Federal Register* 24008, May 22, 2009.

stated that the agency's promulgation of motor vehicle standards will trigger the best available control technology requirements for emissions of GHGs from new stationary sources, such as power plants, under the Prevention of Significant Deterioration program, in Sections 165 and 169 of the Act.[46]

The Administrator has substantial discretion in defining what emission limits should be set, and what sections of the act she might use to control GHGs. Greenhouse gases could be defined as criteria air pollutants, or not. They could be controlled in mobile sources of all kinds. They could be subject to New Source Performance Standards (NSPS), Prevention of Significant Deterioration (PSD), or Maximum Available Control Technology (MACT) requirements. Each of these has its own standard-setting process and criteria.

To some extent, the important question may be how the Administrator would define the source categories. If all power plants are considered in the same category, then the act's authority could be used to require the use of natural gas or cleaner fuels (or at least to set emission standards based on the emissions from plants using such fuels). If coal-fired plants were their own category or a technological approach were taken, the best technology could be carbon capture and sequestration (CCS). How the sources would be categorized would be at the discretion of the Administrator.

The Administrator would also get to make technical judgments concerning whether technologies are "available" or "achievable." These judgments would be crucial in determining how much technology-forcing the regulations would do.

Indeed, it can be argued that the potential for new regulations casts doubts as to most of the "business-as-usual" reference cases presented here. A regulatory approach to greenhouse gas control has the potential of being significantly more expensive than the program established by H.R. 2454. Thus, H.R. 2454 may be a cost-effective option if the alternative is regulatory action by EPA. As noted by MIT in their study:

> Another important consideration in estimating the cost of H.R. 2454 is that under the U.S. Supreme Court ruling in *Massachusetts vs. EPA* CO_2 was found to be a pollutant, and therefore could require EPA regulation under the Clean Air Act. H.R. 2454 would supersede such EPA regulations. At this point it is unknown what EPA would require under this ruling but such regulations could be a costly way to reduce emissions. An argument can therefore be made that H.R. 2454 should be compared against such an EPA regulatory approach, and the bill could be a more efficient way to achieve the emission reduction target.[47]

[46] See "EPA Acknowledges GHG Vehicle Rules Will Trigger Utility CO2 Permit Limits," *InsideEPA*, August 19, 2009. The article refers to EPA Administrator Lisa Jackson's August 12, 2009 response to a petition from three environmental groups in the matter of a PSD permit issued to Louisville Gas and Electric Co. by the Kentucky Division for Air Quality, Petition No. IV-2008-3.

[47] Paltsev, et al., p. C17.

Major Points of this Section

- Addressing greenhouse gas emissions is a highly complex problem, with many different variables—a cap-and-trade program for greenhouse gases will be much larger and more complex than the existing SO_2 cap-and-trade program.
- The effects of flexibility provisions of cap-and-trade legislation (e.g., offset supply, strategic auctions) may be difficult to model.
- Technology development will be a key factor in cost control.
- Noise in the models is further driven by constantly changing statutes and regulations.
- If EPA pursues greenhouse gas controls through existing regulatory authority (mainly the Clean Air Act), the results could be more expensive than an equivalent cap-and-trade program.

Measuring the Noise: A Web of Cost Measures

Because of the economic and regulatory complexities and interactions noted above, analysts have generally chosen to focus on estimating the macro-economic effects of proposals, such as GDP impacts. There are two components of macro-economic cost measures: (1) the direct abatement (or compliance) cost of a greenhouse gas reduction program, and (2) the general equilibrium effects of a greenhouse gas reduction program (i.e., the interactions of the direct abatement costs with the rest of the economy).

The most common measure presented is Gross Domestic Product (GDP). GDP measures the total value of goods and services produced within a nation's borders.[48] Although it is commonly used as a measure of quality of life, this application is problematic. Generally, it includes only those items for which there is a value defined in a market, and does not take into account some activities that have economic value, but no market valuation (e.g., leisure time, environmental quality, etc.). Thus, GDP is intended to be a measure of economic activity, not quality of life.

A second measure sometimes presented is consumption effects (sometimes called welfare effects). Unfortunately, the models do not measure consumption or welfare effects in a consistent fashion (the primary advantage of using GDP). This problem is discussed later in the section on "Impact on Households." In addition, like GDP, none of the definitions of consumption or welfare currently employed quantify any benefits from improved environmental quality.

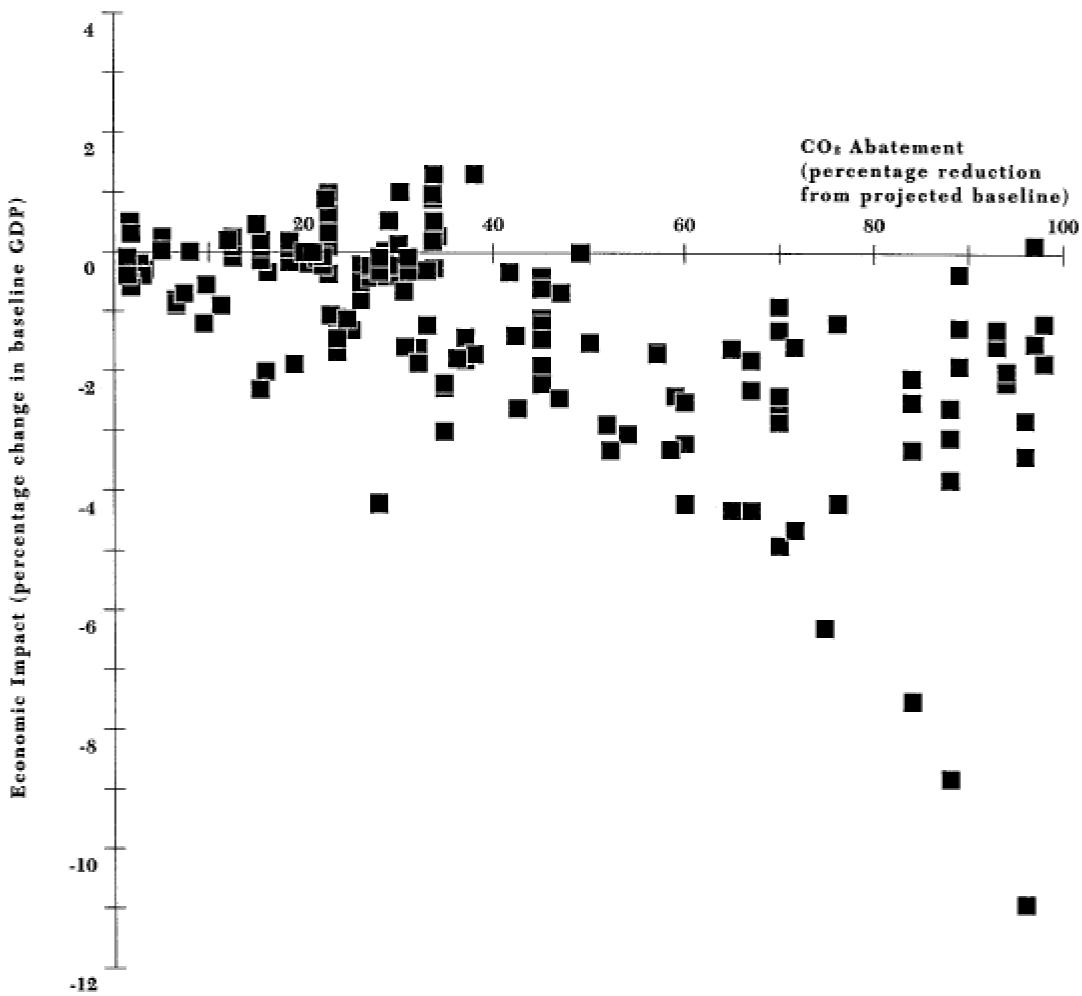
A third measure often presented is allowance prices. Allowance prices reflect to some degree the aggregate marginal cost of reductions as estimated by the models. Marginal cost is the cost of reducing the last ton (and, therefore, the most expensive) of greenhouse gases required by the program at a specific point in time. Marginal costs are very useful to affected entities in choosing what reduction strategy would be the most cost-effective in achieving reductions required by the cap-and-trade program. Marginal costs are not average costs and therefore cannot be simply multiplied by the greenhouse gases reduced to estimate total compliance cost. They also need to be put into the context of the overall reduction achieved at the given point and time being examined.

[48] It has four basic components: private consumption (including most personal expenditures of households); investments by business and households in capital (including new house purchases); government expenditures on goods and services (but not transfer payments, such as Social Security); and net imports.

However, allowance prices in most analyses are not equal to marginal costs of achieving the specified reductions in a specific year because of program provisions, such as banking. Banking activity reflects the assumed foresight of affected entities to the likelihood of increasing allowance prices (in real terms) as the cap tightens. As indicated by the experience with the SO_2 program, entities will bank substantial allowances early and use them later as the program's requirements tighten. This results in allowance prices being higher than marginal costs in the early years of the program, and lower in later years. This ability to time-shift reduction requirements and compliance costs means that allowance price projections reflect the assumed foresight of affected entities as much as they do actual marginal costs.

In examining cost measures, aggregate welfare indicators such as GDP may be overemphasized. As illustrated above in **Table 2**, aggregate, macroeconomic cost results for H.R. 2454 are generally lost in the uncertainty about future conditions. Focusing on aggregate macroeconomic measures may lead readers to miss valuable insights into the analyses' assumptions and their conclusions about the costs or benefits of certain compliance strategies. For example, **Figure 4** below shows a **1997** scatter-plot by World Resources Institute (WRI) of 162 predicted impacts estimates from 16 different economic models of the U.S. economy as a result of a CO_2 abatement program. As indicated, the vast majority of estimates fall with a range of 0%-4% of GDP, regardless of the reduction requirement. **Over-emphasis on GDP or other aggregate cost measures can obscure fundamental technological, economic, or behavioral insights the analyses may have in helping policymakers craft legislation. Instead, the analysis becomes a "black box" exercise with little enlightenment function.**

Figure 4. Predicted Impacts of Carbon Abatement on the U.S. Economy (162 Estimates from 16 Models)



Source: Robert Repetto and Duncan Austin, *The Costs of Climate Protection: A Guide for the Perplexed*, World Resources Institute, 1997.

This resulting "fog" is inherent when analysts choose to include the general equilibrium effects of a program in their cost measure—a fog that can limit the explanatory value of the analysis. While supporting use of aggregate welfare cost measures, MIT notes:

> GE [general equilibrium] effects can stem from interactions with pre-existing distortions (e.g., taxes), from externally induced terms-of-trade effects, from the fact that the domestic policy itself creates terms-of-trade effects, and from other rigidities in the economy. Many aspects of model structure produce GE effects that are not easy to separately measure because of the inherent interactions in the economy.[49]

[49] Sergey Paltsev, et al., *Assessment of U.S. Cap-and-Trade Proposals*, MIT Joint Program on the Science and Policy of Global Change (April 2007), p. 27. "Terms-of-trade" is the relative price of a country's exports compared to its imports on international markets.

Generally, the cases examined here have not chosen to separate the two components of macroeconomic cost measures: (1) the direct abatement (or compliance) cost of a greenhouse gas reduction program, and (2) the general equilibrium effects of a greenhouse gas reduction program (i.e., the interactions of the direct abatement costs with the rest of the economy).[50] The availability of accurate compliance cost estimates would allow policymakers to put current greenhouse gas reduction proposals in the context of other environmental initiatives—be they acid rain or toxic air pollutants—and, indeed, to the overall environmental agenda, and greatly increase the transparency of the analyses' insights. It would also help relieve confusion between compliance costs, average costs (per ton reduced), and the other commonly presented costs, such as allowance prices.[51] It is argued that an aggregate macroeconomic cost measure provides a more complete view of the economic impact of proposed legislation, and helps identify potential unintended economic effects of compliance strategies. This may be true, particularly if, for example, auction revenues are being recycled via a reformed tax code. **However, as indicated here, aggregated macroeconomic cost measures, such as GDP, can also be interpreted to merely show that the United States has a massive economy that can absorb substantial shocks with limited long-term effect.**

Three Perspectives: Getting Out of the Noise

Breaking through the fog of analyses and cost indicators, cost estimates to reduce greenhouse gas emissions vary greatly and focus attention on an estimator's basic beliefs about the problem and the future, in addition to simple, technical differences in economic assumptions. In a previous report, CRS identified three "lenses" through which people can view the global climate change issues, and their influence on cost analysis.[52] These are summarized in **Table 3**. None of these perspectives is inherently more "right" or "correct" than another; rather, they overlap and to varying degrees complement and conflict with one another. People generally hold to each of the lenses to some degree.

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[50] EPA does break out compliance costs (called "abatement costs") from the general equilibrium effects of H.R. 2454. However, as noted by EPA, its compliance cost estimates are overestimates of actual costs. Further, the overestimation increases as the tonnage reduction requirement and marginal costs increase. CBO does provide a breakdown of estimated compliance costs (called "net economywide costs"), but does not conduct an analysis of the general equilibrium effects of H.R. 2454.

[51] For a good discussion of the confusion that can arise from mixing cost measures, see Anne E. Smith, Jeremy Platt, and A. Denny Ellerman, "The Cost of Reducing SO_2 (It's Higher Than You Think)," *Public Utilities Fortnightly* (May 15, 1998), pp. 22-29.

[52] CRS Report 98-738, *Global Climate Change: Three Policy Perspectives*, by Larry Parker and John Blodgett.

Table 3. Influence of Climate Change Perspectives on Policy Parameters

Approach	Seriousness of problem	Risk in developing mitigation program	Costs
Technology	Is agnostic on the merits of the problem. The focus is on developing new technology that can be justified from multiple criteria, including economic, environmental, and social perspectives.	Believes any reduction program should be designed to maximize opportunities for new technology. Risk lies in not developing technology by the appropriate time. Focus on research, development, and demonstration; and on removing barriers to commercialization of new technology.	Viewed from the bottom-up. Tends to see significant energy inefficiencies in the current economic system that currently available (or projected) technologies can eliminate at little or no overall cost to the economy.
Economic	Understands issue in terms of quantifiable cost-benefit analysis. Generally assumes the status quo is the baseline from which costs and benefits are measured. Unquantifiable uncertainty tends to be ignored.	Believes that economic costs should be examined against economic benefits in determining any specific reduction program. Risk lies in imposing costs in excess of benefits. Any chosen reduction goal should be implemented through economic measures such as tradable permits or emission taxes.	Viewed from the top-down. Tends to see a gradual improvement in energy efficiency in the economy, but significant costs (usually quantified in terms of GDP loss) resulting from global climate change control programs. Typical loss estimates range from 0-4% of GDP.
Ecological	Understands issues in terms of their potential threat to basic values, including ecological viability and the well-being of future generations. Such values reflect ecological and ethical considerations; adherents see attempts to convert them into commodities to be bought and sold as trivializing the issue.	Rather than economic costs and benefits or technological opportunity, effective protection of the planet's ecosystems should be the primary criterion in determining the specifics of any reduction program. Focus of program should be on altering values and broadening consumer choices.	Views costs from an ethical perspective in terms of the ecological values that global climate change threatens. Believes that values such as intergenerational equity should not be considered commodities to be bought, sold, or discounted. Costs are defined broadly to include aesthetic and environmental values that economic analysis cannot readily quantify and monetize.

However, different combinations of these perspectives lead to different cost estimates. An illustration of this can be seen in the contrast between the H.R. 2454 results obtained by the American Council for Capital Formation/National Association of Manufacturers (ACCF/NAM) high cost case and the "high technology" sensitivity case conducted by EIA using the same model: EIA's NEMS model. **Table 4** summarizes the general approach of the two analyses according to the three perspectives identified above. In its sensitivity case, EIA mimics H.R. 2454's various technology and efficiency provisions by employing its High Technology baseline that has more aggressive technology development assumptions than its reference case, and also includes banking, and phased-in offsets. In contrast, ACCF/NAM is not confident that new technology, new energy sources, and market mechanisms (e.g., carbon offsets, banking) will be sufficiently available to achieve H.R. 2454's emission targets. Accordingly, ACCF/NAM's High Cost case assumptions differ substantially from EIA's High Technology sensitivity analysis by discouraging banking, restricting the availability of offsets to half that allowed in H.R. 2454, and significantly restricting availability of various low- and non-carbon technologies beyond what is embedded in the NEMS base case.

Table 4. General Perspective of ACCF/NAM-High Cost and EIA-High Technology Assumptions

	EIA High Technology	ACCF/NAM-High
Technology	Assumes no constraints on technology availability beyond those embedded in the NEMS model	Assumes significant constraints on further low- and non-carbon technology availability beyond that embedded in NEMS
Economic	Assumes aggressive technology development, efficient decision-making via banking, and phasing in of offsets to the levels allowed in H.R. 2454 (2 billion metric tons)	Assumes short-term decision-making with a 10% discount rate; total offsets allowed limited to 1 billion metric tons annually (50 million from international sources)
Ecological	Assumes decisions made in favor of technology and efficiency because of H.R. 2454's incentives, regulations, and price signal	Assumes none—total GHG emissions are not presented

Source: Energy Information Administration (EIA),*Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009* (August 4, 2009); Science Applications International Corporation, *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-NAM 2)*, a report by the American Council for Capital Formation and the National Association of Manufacturers (2009).

As indicated by **Table 5**, the widely different cost assumptions provided the expected results, although both analyses remained in the 0-4% GDP range common for greenhouse gas reduction analysis. Allowance price estimates diverge significantly by 2030, but this cost measure tends to exaggerate differences between results and should not be confused with average costs or program costs. This is particularly true for analyses of H.R. 2454, as ACCF/NAM did not publish its environmental results in terms of greenhouse gases reduced; thus, one can not compare the allowance price with what is being reduced over time. Unfortunately, the analyses do not present sufficient sensitivity analysis and other information to determine whether it is the economic assumptions (e.g., discount rates and offset availability), the behavioral assumptions (e.g., impact of efficiency programs), the technology assumptions (e.g., availability), or what combination of these assumptions that explains the differences in results.

Table 5. Selected Results from EIA's "High Technology" and ACCF-NAM's "High Cost" Cases

	Year	EIA High Technology	ACCF-NAM High Cost
GDP per capita Reduction From Reference Case	2020	0.06%	0.4%
	2030	0.31%	2.4%
Allowance Price (2005$)	2020	$26	$58
	2030	$54	$150
Total GHG Emissions	2020	6.8 (5.8 net of offsets)	not presented
	2030	6.1 (4.0 net of offsets)	not presented

Source: Energy Information Administration (EIA), *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009* (August 4, 2009); Science Applications International Corporation, *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-NAM 2)*, a report by the American Council for Capital Formation and the National Association of Manufacturers (2009). All estimates converted to 2005 dollars using the GDP implicit price deflator.

Some attempts have been made to sort out the importance of various assumptions in analyzing the costs of greenhouse gas reduction proposals, beginning with Repetto and Austin's effort for the World Resources Institute (WRI) in 1997, with more recent efforts by Barker, Qureshi and Kohler in 2006 and Barker and Jenkins in 2007.[53] Dr. Repetto has set up a website where people may answer seven key questions about the cost and benefit assumptions they feel are most reasonable and find out how their choices would affect GDP.[54] Through meta-analysis of the results from multiple independent studies, the role of various assumptions and methodologies are quantified.[55] In general, these studies found seven underlying assumptions affecting results: (1) the efficiency of the economic response;[56] (2) availability of non-carbon technology;[57] (3) availability of the Kyoto mechanisms;[58] (4) method of revenue recycling; (5) method of incorporating technological advancements; (6) inclusion of non-climate-related environmental benefits; and (7) inclusion of climate-related benefits. **None of the models reviewed in this report quantify any environmental benefits in their analyses.**

[53] Robert Repetto and Duncan Austin, *The Costs of Climate Protection: A Guide for the Perplexed*, World Resources Institute (1997); Terry Barker, Mahvash Saeed Qureshi, and Jonathan Kohler, *The Costs of Greenhouse Gas Mitigation with Induced Technological Change: A Meta-Analysis of Estimates in the Literature*, Tyndall Centre for Climate Change Research (July 2006); and Terry Barker and Katie Jenkins, *The Costs of Avoiding Dangerous Climate Change: Estimates Derived from a Meta-Analysis of the Literature*, A Briefing Paper for the Human Development Report 2007 (May 2007).

[54] http://www.climate.yale.edu/seeforyourself/.

[55] As defined by Repetto on the "See For Yourself" website: "The meta-analysis was based on more than 1,400 policy simulations performed with the various models. It used statistical regression analysis to ascribe differences among models in the predicted economic cost of a given percentage reduction of greenhouse gas emissions to differences among models in specific assumptions. Though some of the models related only to the U.S. economy, others to the world economy, the meta-analysis found that both sets of models produced the same results."

[56] In this regard, Computable General Equilibrium Models (CGE) generally assume efficient economic responses to programs while macroeconomic models allow time for the economy to adjust, resulting in higher short-term costs.

[57] Some models include a "backstop" technology in unlimited amounts at a specified high price.

[58] Offset credits from the Clean Development Mechanism (CDM) and Joint Implementation (JI).

Major Points of this Section

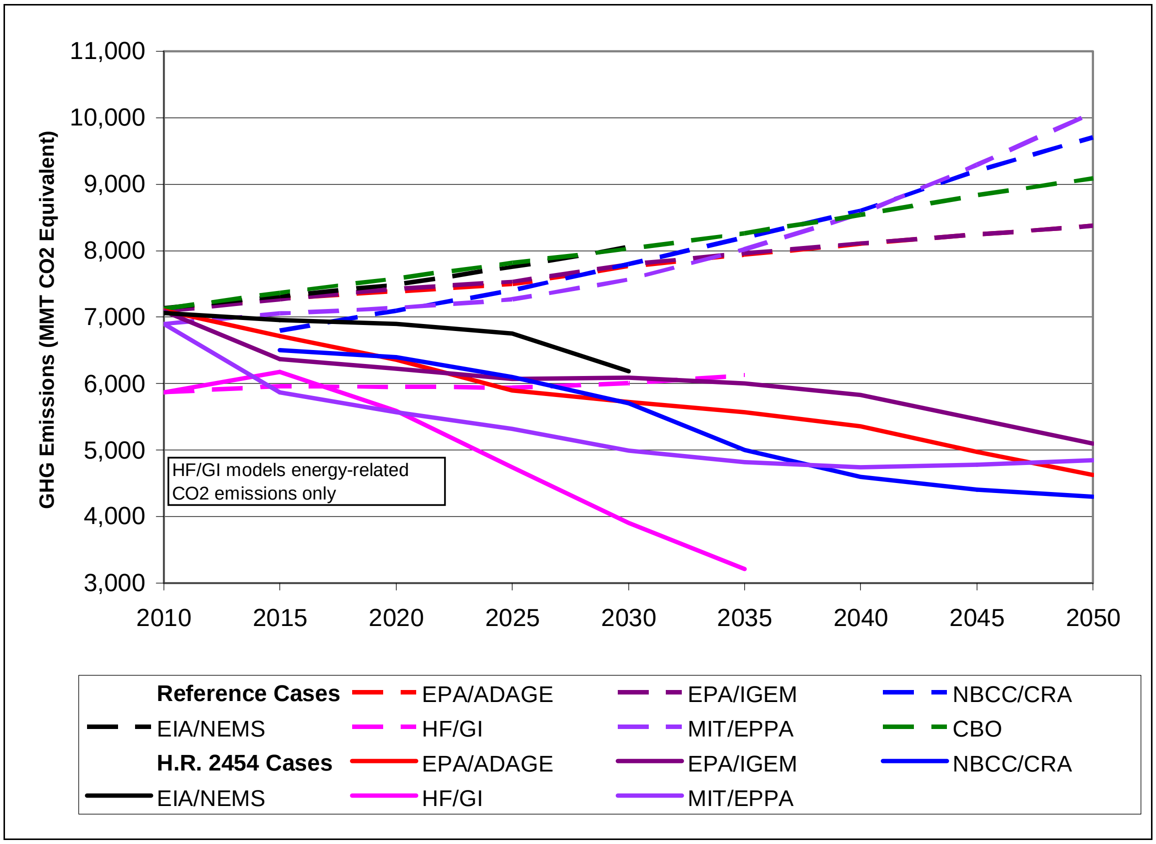
- The "cost" of a cap-and-trade program can be counted in different ways: (1) direct abatement/compliance costs; and (2) effects on the overall economy. Further, those results may be presented in different units and/or over different time frames.
- Various cost measures have their own limitations.
- The preferred cost measure (and time frame) may be driven by one's perspective of the problem.

Results for H.R. 2454

Impact on Greenhouse Gas Emissions

Figure 5 and **Figure 6** present U.S. greenhouse gas emissions under H.R. 2454 as estimated by the cases that presented such data, relative to their baseline assumptions. The range might seem surprising, given the emission cap defined in the bill. The cause of the range is largely two-fold: (1) estimated emissions growth in the roughly 15% of the economy not covered under the bill, (2) estimated use of international offsets to meet emission reduction requirements—international offsets would reduce total global emissions but would not reduce emissions within the United States.

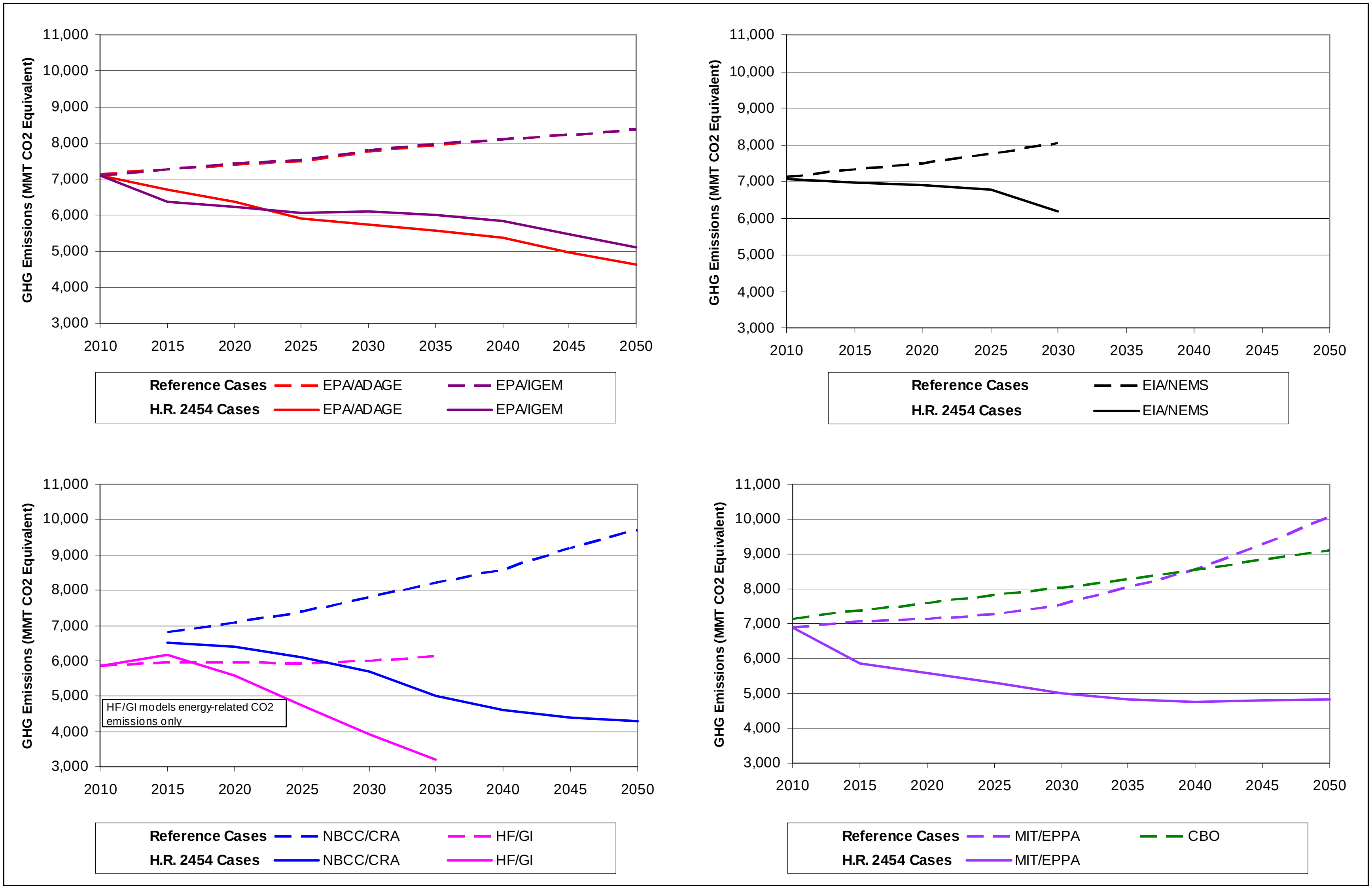
Figure 5. Total Estimated U.S. Greenhouse Gas Emissions Under H.R. 2454



Sources: EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). CBO: CBO, *CBO Cost Estimate: H.R. 2454 American Clean Energy and Security Act of 2009 As ordered reported by the House Committee on Energy and Commerce*, (June 5, 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Note: HF/GI emission estimates are for energy-related carbon dioxide emissions only.

Figure 6. Total Estimated U.S. Greenhouse Gas Emissions Under H.R. 2454, by Case



Source: See **Figure 5**.

The steepest reduction path is for HF/GI. It should be noted that the HF/GI emissions path is for energy-related CO_2 emissions only. However, if one adds a reasonable estimate for the covered and non-covered emissions excluded from the HF/GI analysis, HF/GI would probably still have the most stringent interpretation of the bill's requirements. This is most likely due to the no banking and declining offset supply assumed in the HF/GI case. HF/GI also has the least baseline growth of any of the cases presented here, reducing the overall emission reductions it requires. Indeed, with its relatively low offset price, the baseline and offset price assumptions combine to result in a slight rise in U.S. emissions under H.R. 2454 before 2018, at which point the declining availability of offsets assumed by HF/GI forces the analysis to increase domestic emission reductions to meet the increasing stringency of the cap.

The case that results in the most reductions from baseline levels is NBCC/CRA. This result is despite the very generous offset availability assumptions used by NBCC/CRA in its analysis, and is driven in part by the fact that NBCC/CRA has one of the highest projections for emissions in the reference case.

The highest emissions permitted under the bill are estimated by the EIA/NEMS case. This higher emissions level is likely the result of a substantial use of international offsets. For example, in 2030, EIA estimates 23% and 46% more international offsets than EPA's IGEM and ADAGE cases, respectively. Further, for 2030, EIA estimates more than three times the number of *total* offsets in the HF/GI case.

Impact on Non-Greenhouse Gas Emissions

None of the reports reviewed here presented the effects of H.R. 2454 on conventional air pollutants, such as sulfur dioxide and nitrogen oxides, or on hazardous air pollutants, such as mercury. However, some data were available in the Data Annex of the EPA/IPM analysis and the data spreadsheets from the EIA analysis. The probable reason for not presenting such data in their reports is the current uncertainty about future regulation of these pollutants. EPA is likely to proceed with more stringent regulation of conventional air pollutants over the next decade. The Clean Air Interstate Rule is undergoing revision with respect to sulfur dioxide and nitrogen oxides and EPA is currently proceeding with developing a Maximum Achievable Control Technology (MACT) rule for mercury. **Table 6** presents the data contained in these two cases' data appendices. The EIA case assumes the continuation of a CAIR-like regulatory structure for sulfur dioxide and nitrogen oxides, and it would appear that the EPA/IPM does also. As indicated, the EPA/IPM projects a 7%-8% reduction in sulfur dioxide and a 8%-9% reduction in nitrogen oxides in 2025 from H.R. 2454 along with about a 15% reduction in mercury emissions. In contrast, EIA/NEMS projects about an 8% increase in sulfur dioxide emission under H.R. 2454 in 2025, but reductions of about 19% and 27% in nitrogen oxide and mercury emissions respectively. EIA states that the increase in SO_2 emission results from utilities being disinclined to invest in SO_2 scrubbers because of GHG requirements, and SO_2 banking behavior.

Table 6. Estimated Emissions of Conventional Air Pollutants from Electric Utilities in 2025

	EPA/IPM		EIA/NEMS	
	Reference Case	**H.R. 2454 Case**	**Reference Case**	**Basic H.R. 2454 Case**
SO_2 (million short tons)	3.9	3.7	3.7	4.0
NO_x (million short tons)	2.3	2.1	2.1	1.7
Hg (tons)	34	29	29	21

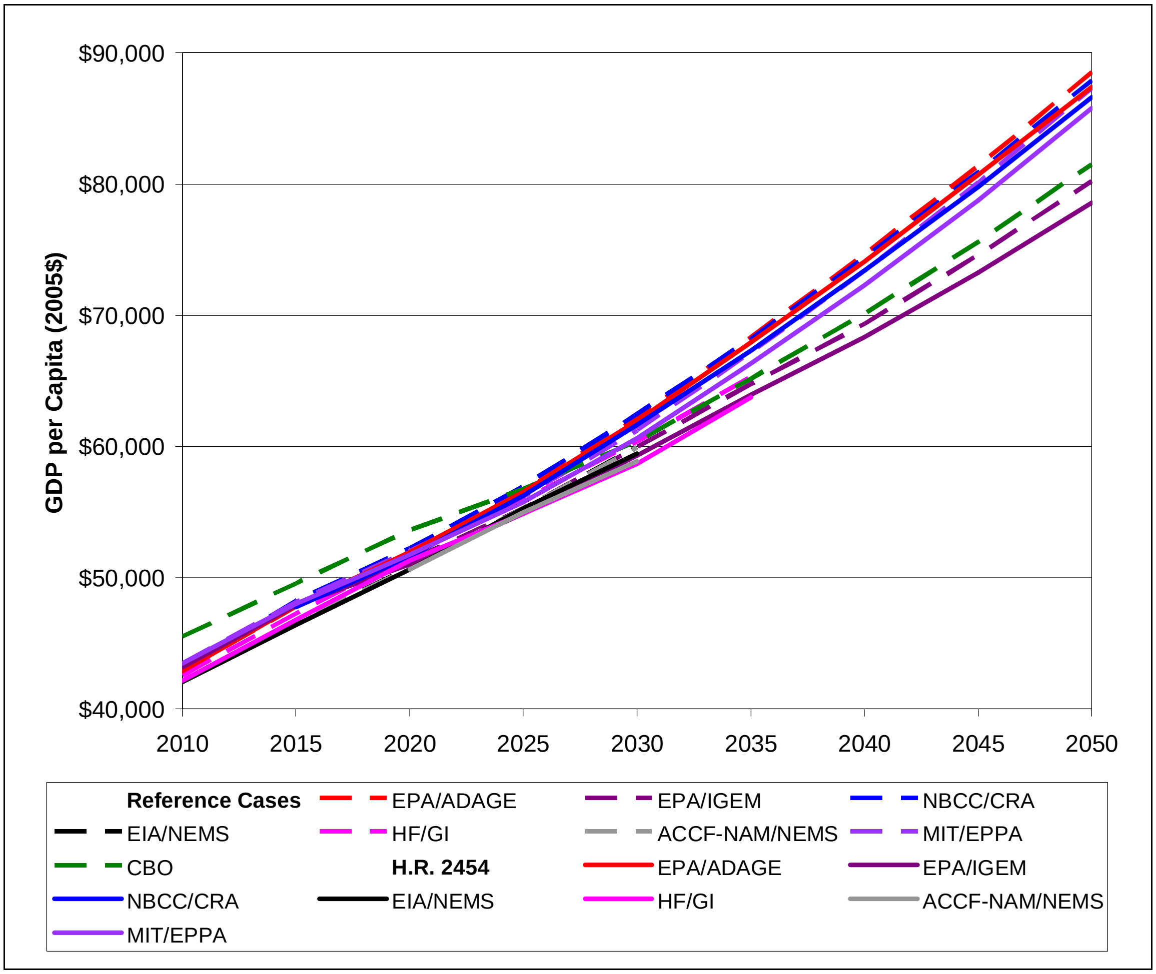
Source: EPA/IPM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009), http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html.

Impact on GDP Per Capita[59]

Figure 7 and **Figure 8** present the estimated GDP per capita in the baseline and H.R. 2454 scenarios for the various cases. As suggested by the discussion of "noise" earlier, uncertainty about the future size of the economy is greater than the impact of H.R. 2454. Indeed, they are so intertwined as to make the results nearly meaningless in one sense. In another sense, the figures indicate the cases' consistent expectations that the economy continues to grow under H.R. 2454, albeit at a slower rate than under their respective reference cases.

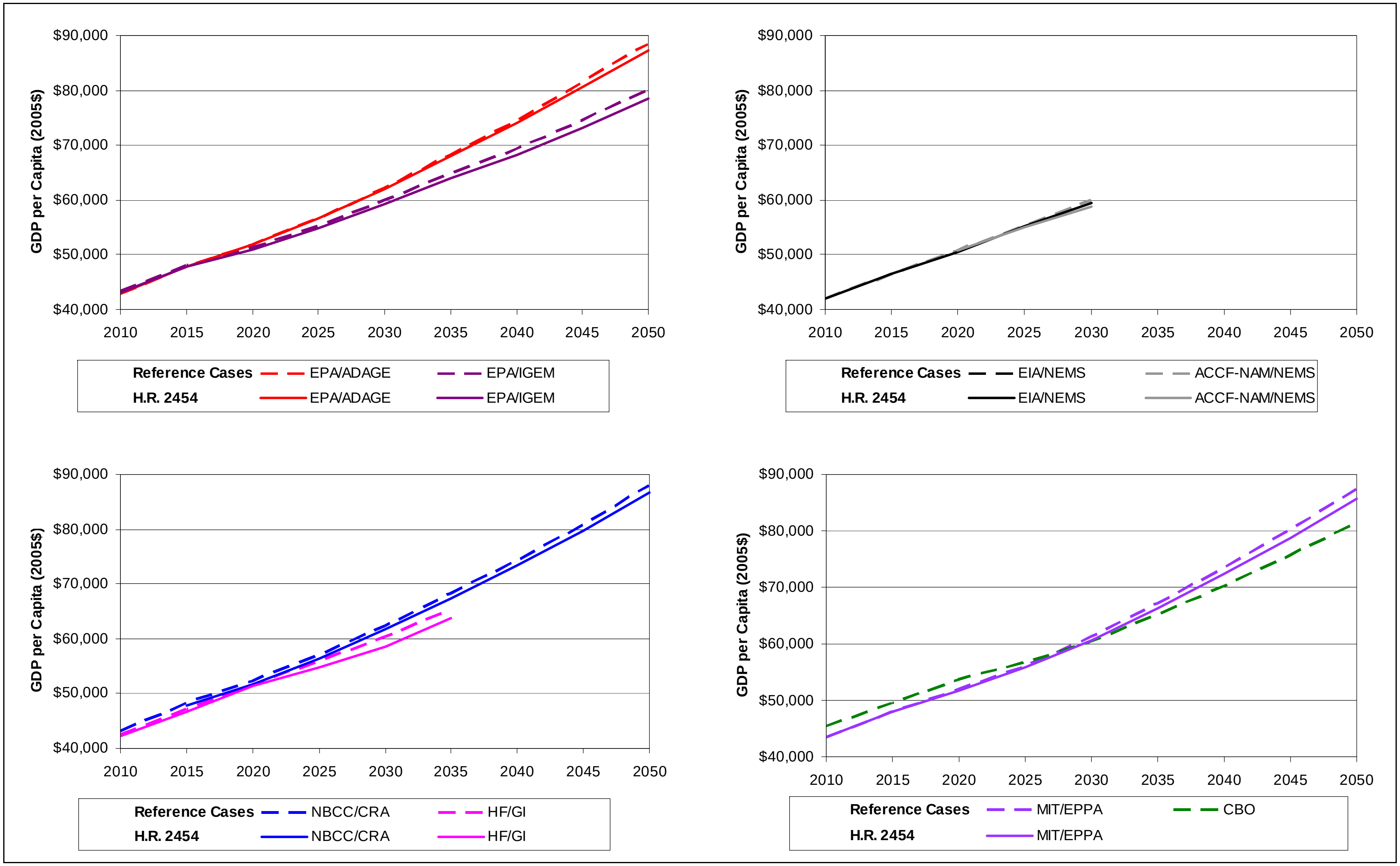
[59] In this report, all dollar estimates are in constant 2005 dollars, unless otherwise noted.

Figure 7. GDP per Capita (2005$) Under H.R. 2454



Sources: EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). CBO: CBO, *CBO Cost Estimate: H.R. 2454 American Clean Energy and Security Act of 2009 As ordered reported by the House Committee on Energy and Commerce*, (June 5, 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Figure 8. GDP per Capita (2005$) Under H.R. 2454, by Case



Source: See **Figure 7**.

To sort the situation out a little further, **Figure 9** and **Figure 10** show percentage reductions in GDP per capita from H.R. 2454 (relative to the cases' respective reference cases) according to the seven cases presented here.

With the exception of the HF/GI cases, all projections for all years between 2020 and 2050 fell into a range between a 0.1% increase (EPA/ADAGE for 2015 and 2020) and a 2.1% decrease (EPA/IGEM for 2050). As indicated in **Figure 9** and **Figure 10**, the HF/GI case produced estimated percentage GDP per capita reductions in 2030 that were at least 50% greater than those of all other cases, and over twice as high as the estimates from four of the six other cases.[60]

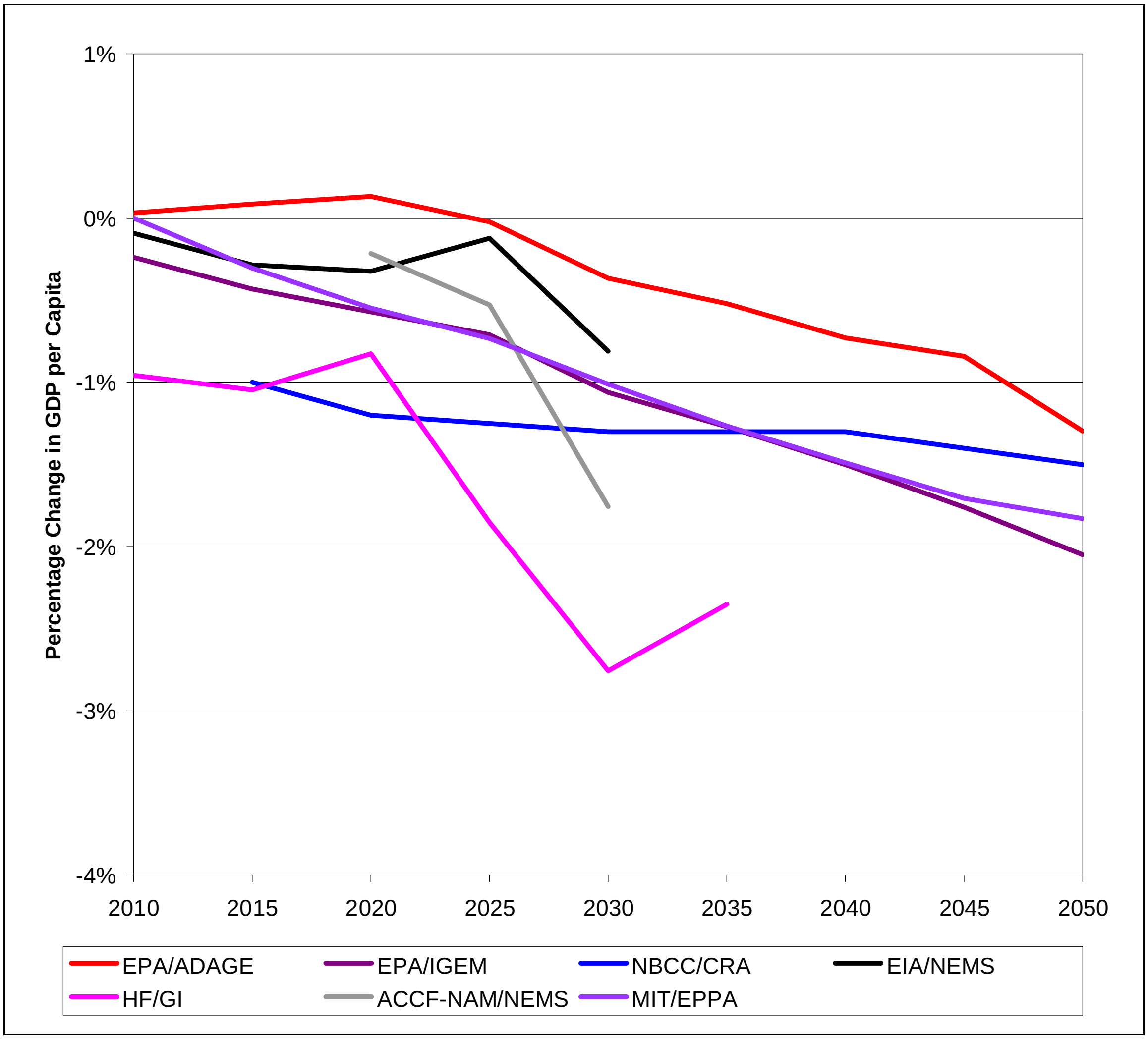
The HF/GI case used the most constrained offset supply of any of the analyses, particularly in the out-years. Further, HF/GI modeled only energy-related CO_2 reductions, thus removing from the analysis potential low-cost emissions reductions from non-CO_2 gases.

The only year for which GDP per capita estimates were presented for all cases is 2030. The two cases that use EIA's NEMS model, the EIA/NEMS and ACCF-NAM/NEMS analyses show a steep trajectory for percentage GDP per capita reductions between 2025 and 2030. However, the NEMS model does not provide projections beyond 2030. Therefore, it is unclear whether this trajectory would continue beyond 2030, ultimately resulting in projections similar to those of the HF/GI case, or whether the curve would flatten out or rise over time.[61] In this regard, it should be noted that the EIA/NEMS case builds up a 13 billion allowance bank (based on EPA's analyses of banking behavior) in anticipation of the increasingly stringent caps and rising allowance prices to 2050; in contrast, HF/GI does not permit any banking. Results for the other four cases (EPA/ADAGE, EPA/IGEM, NBCC/CRA, and MIT/EPPA) show a much shallower decline rate, with an overall decline in GDP per capita of between 1.3% and 2.1% in 2050 (relative to the baselines).

[60] It should be noted that some sensitivity analyses conducted by EPA, EIA, MIT, and ACCF-NAM resulted in GDP losses in the range projected by HF/GI. Most of these sensitivity cases involved assumptions that severely restricted or eliminated international credit availability.

[61] For example, model may assume that certain options do not become available until a specified year, leading to higher costs before the assumed year and lower costs later.

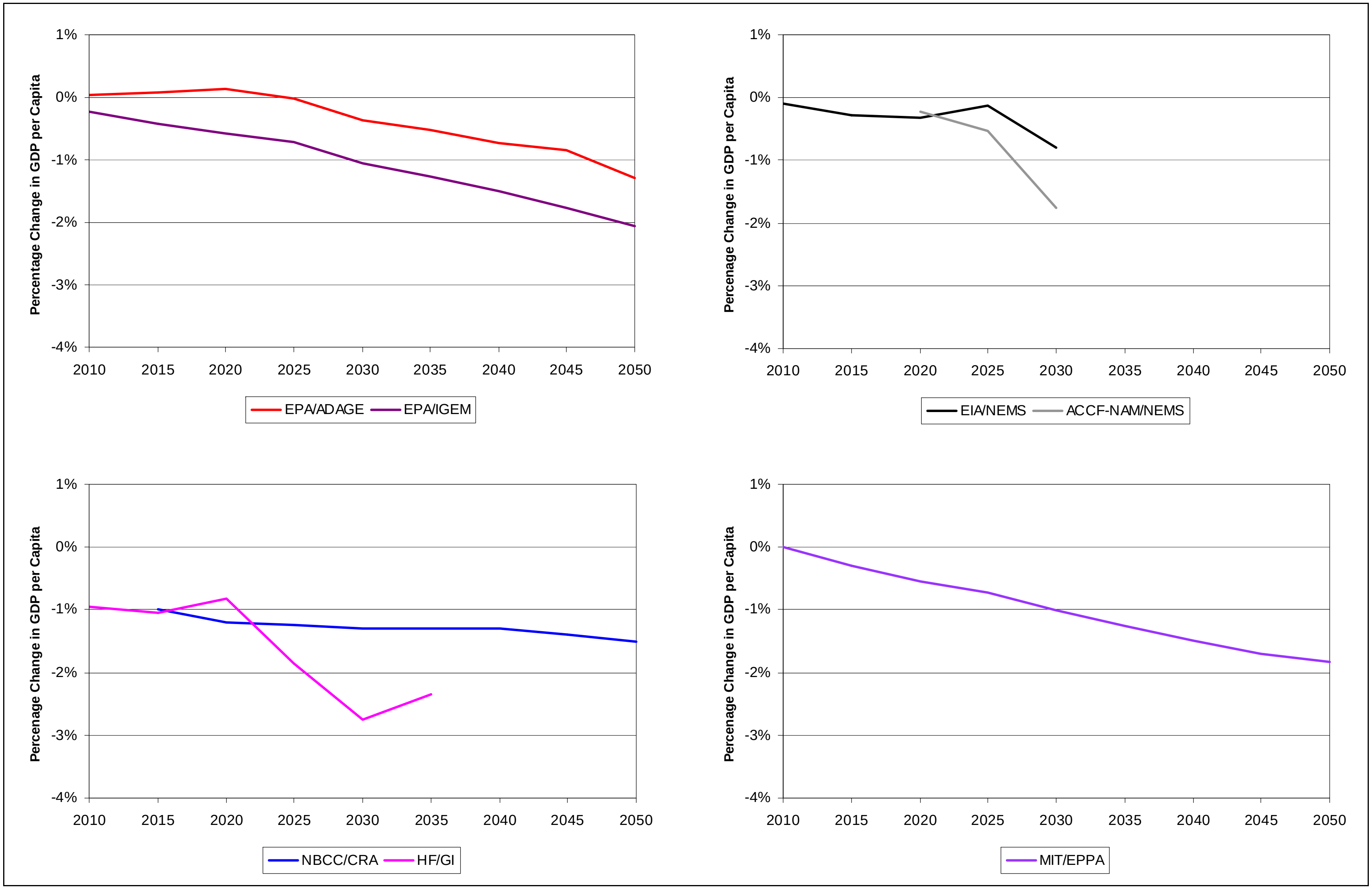
Figure 9. Percentage Change in GDP per Capita Under H.R. 2454 Relative to the Reference Case



Note: Reductions are relative to each model's reference case baseline.

Sources: CRS Analysis of data from each model. EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Figure 10. Percentage Change in GDP per Capita Under H.R. 2454 Relative to the Reference Case, by Case



Source: See **Figure 9**.

Allowance Price Estimates

Figure 12 and **Figure 13** present the estimated allowance prices for each of the cases examined here. It is clear from the figures that assumptions about offset use and banking have a fundamental influence on projected prices. For example, as noted earlier, the HF/GI case does not include banking and limits the use of offsets to 15% of the allowance pool (far below what H.R. 2454 allows).[62] Likewise, the ACCF-NAM/NEMS case limits offsets to a total of one billion metric tons each year (95% from domestic sources and 5% from foreign sources). These two cases result in the highest allowance price estimates by 2025. Further, while most cases assume that use of foreign offsets will outpace domestic offsets in earlier years, the ACCF-NAM/NEMS case assumes that domestic offsets dominate (the HF/GI and MIT/EPPA cases do not differentiate between domestic and foreign offsets).

Along with the HF/GI and ACCF-NAM/NEMS cases, the EIA/NEMS case shows the most rapid increase in allowance prices between 2020 and 2030. This is likely a key factor in the rapid increase in percentage GDP loss shown above in **Figure 9** and **Figure 10**. In each of these cases, the banking behavior assumed may have some influence on the slope. The HF/GI case does not allow banking, while the ACCF/NAM/NEMS case limits banking to 5 billion metric tons. The EIA/NEMS case allows more banking, requiring a total bank of 13 billion metric tons in 2030.[63] In contrast, the EPA/IGEM case projects that the total bank of allowances would peak at roughly 20 billion metric tons in 2029. As noted above, banking allows firms to spread their costs and decision-making over time, generally raising allowance prices in early years and lowering them in later years.

Of the remaining cases (EPA/ADAGE, EPA/IGEM, NBCC/CRA, MIT/EPPA, and CBO), allowance prices generally fall within a band (between $13 and $21 in 2015), and increase at a steady rate through 2050 (between 4% and 6% annually). For EPA, MIT, and CRA, these smooth allowance price curves are likely part of the reason for the relatively smooth projections for GDP loss under these cases in **Figure 9** and **Figure 10**; CBO did not project GDP effects.

Under the HF/GI case offset prices are well below allowance prices from 2020 onward. This suggests that, if available, more offsets would be purchased than the 15% assumed in the HF/GI case. Indeed, the knee in the HF/GI allowance price "curve" is the result of the low-cost offsets being fully utilized by 2018, resulting in a shift in marginal costs to higher utility emissions control costs (mostly natural gas capacity substitution for coal-fired capacity). All of the cases generally agree that the availability of offsets significantly lowers the cost of the program; conversely, if offsets are unavailable, the cost of the program will likely increase significantly, as discussed later.

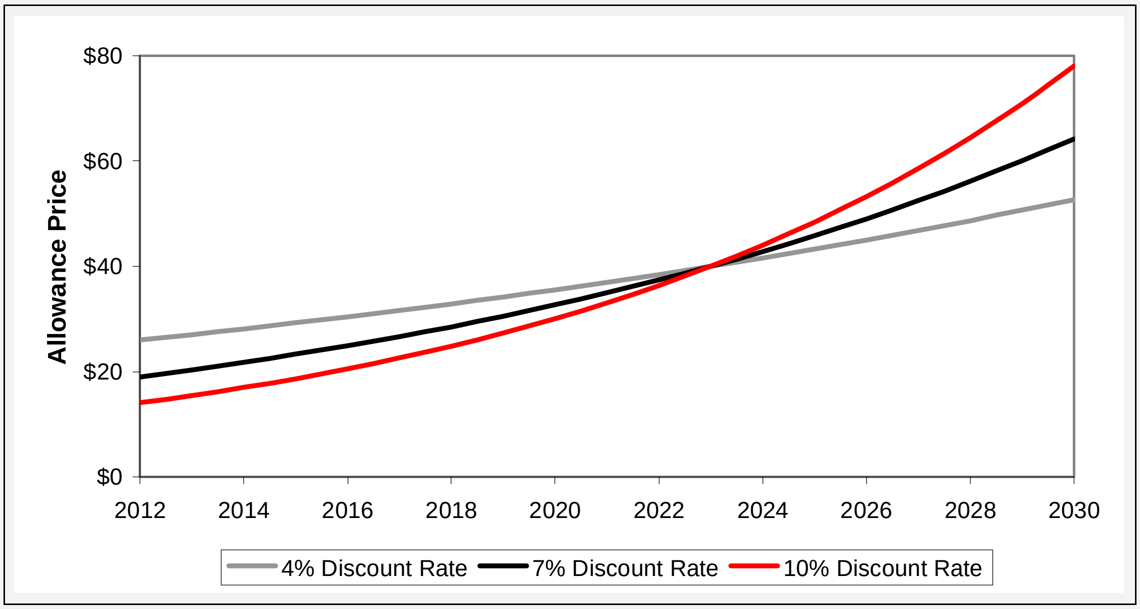
[62] For example, as written H.R. 2454 would allow an entity to meet up to approximately 30% of its requirement using offsets in 2012, a percentage that increases to roughly 67% by 2050.

[63] As the NEMS model does not make projections beyond 2030, in its modeling EIA assumed that a total bank of 13 billion metric tons would be maintained in 2030. "In anticipation of increasingly stringent caps and rising allowance prices after 2030, covered entities and investors are assumed to amass an aggregate allowance bank of approximately 13 BMT by 2030 through a combination of offset usage and emission reductions that exceed the level required under the emission caps.": EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009), p. viii. Sensitivity analysis by EIA indicated that if this bank were not required, allowance prices would decrease by about one third in 2020 and 2030.

The Role of Discount Rates

Economic analyses use discount rates to show how entities (e.g., individuals, businesses, government) evaluate the opportunity cost of money (or goods or services) over time. A high rate of time preference, resulting in a high discount rate, would show that an entity strongly values money in the present over the same amount in the future. A lower discount rate would show that an entity is less partial to current dollars over future dollars. A high discount rate generally leads to (or implies) short-term investment, while a lower discount rate generally leads to more long-term investment. In the case of allowance prices, applying different discount rates to the same underlying function for compliance costs will lead to differing banking behavior and resulting allowance price curves. A low discount rate would generally lead to higher prices in early years, as covered entities bank more allowances, and lower prices in later years as those banked allowances are used. A higher discount rate would lead to lower prices in early years—as there is little demand for excess allowances for banking—and higher prices in later years. **Figure 11** shows how a given discount rate can affect the path of allowance prices.

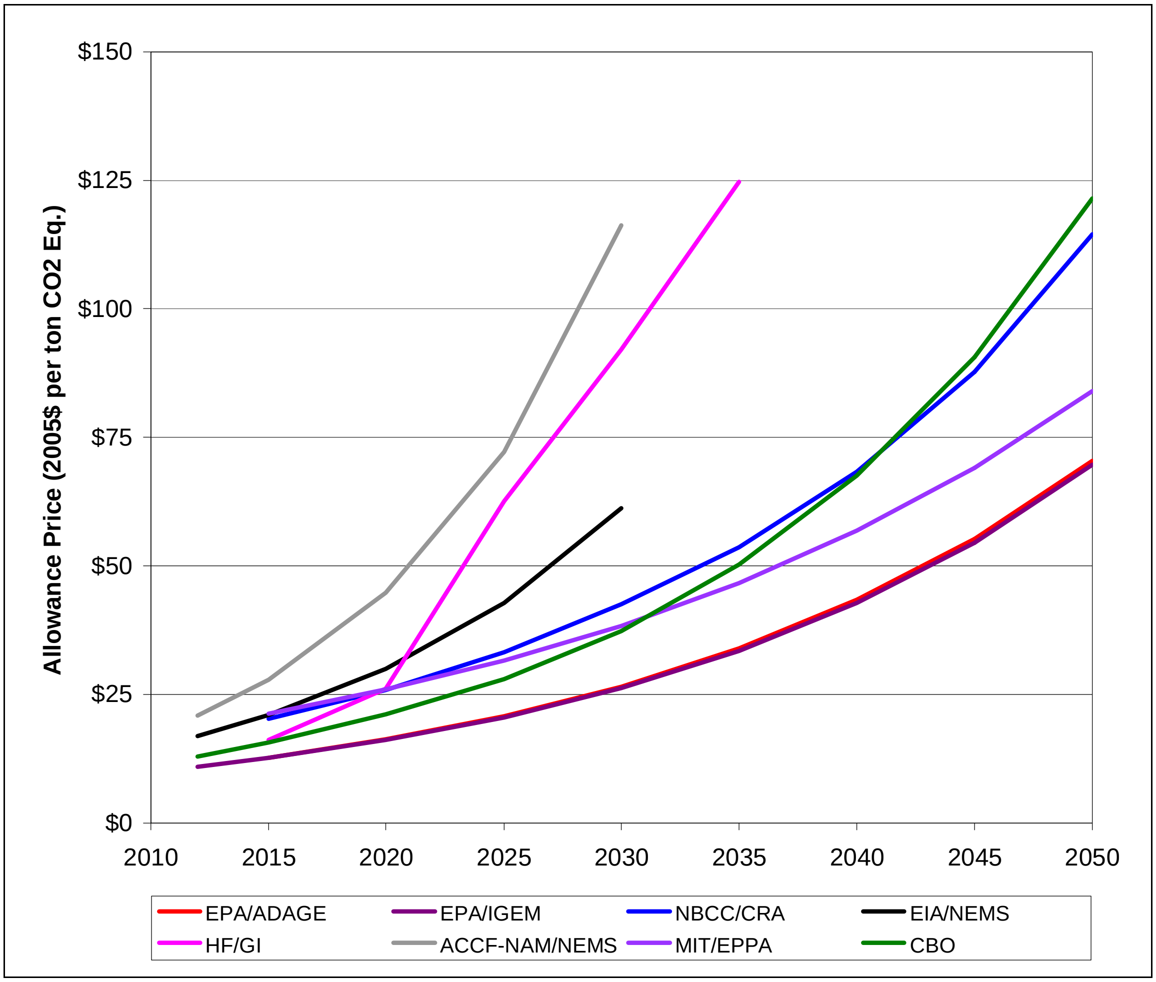
Figure 11. Illustration of Different Discount Rates



Source: CRS.

Notes: Allowance prices and discount rates are for illustrative purposes only, and do not represent any of the models or cases discussed in this report.

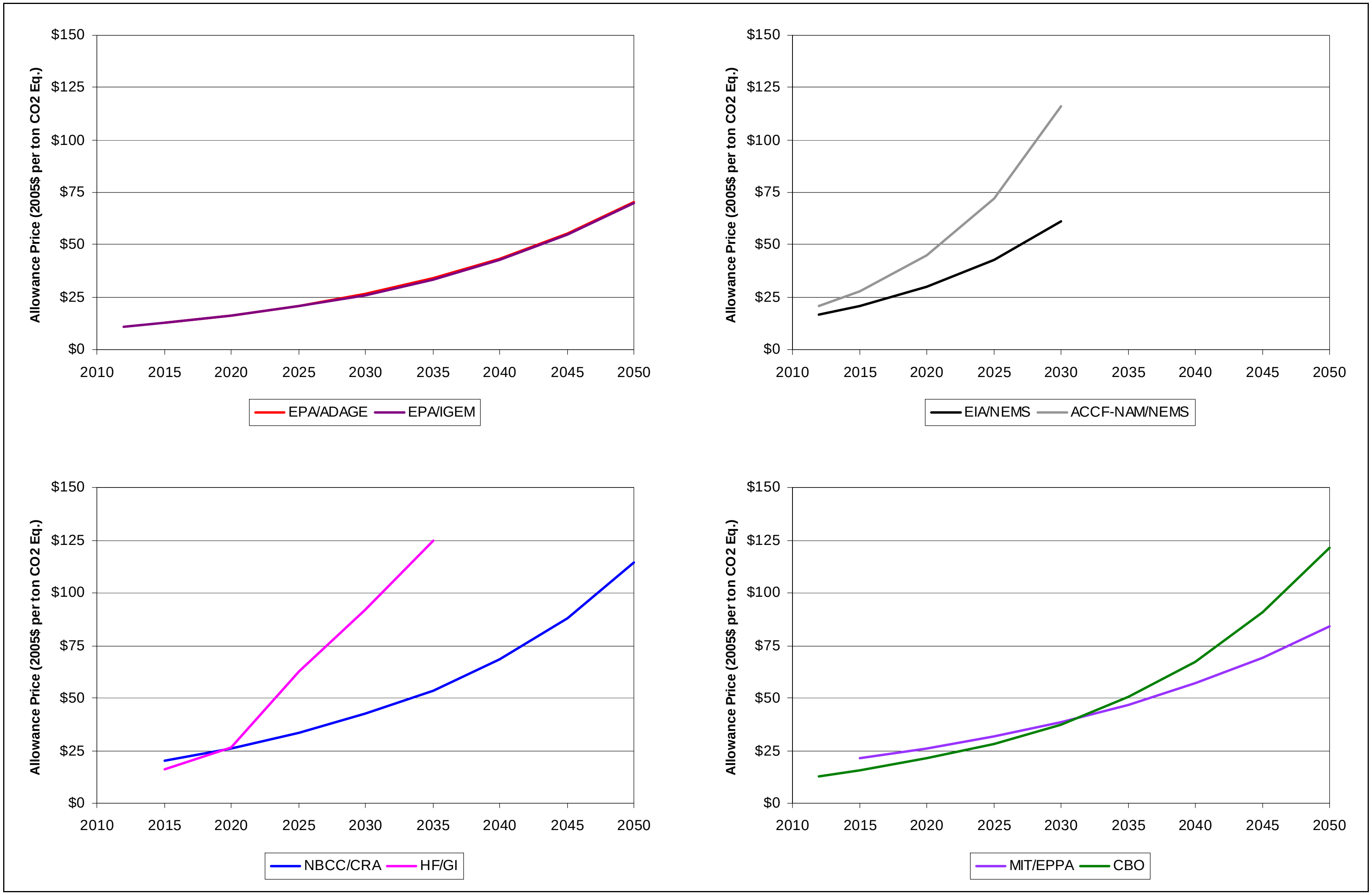
Figure 12. Projected Allowance Prices Under H.R. 2454



Sources: EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). CBO: CBO, *CBO Cost Estimate: H.R. 2454 American Clean Energy and Security Act of 2009 As ordered reported by the House Committee on Energy and Commerce*, (June 5, 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Note: Estimates converted to 2005$ using GDP implicit price deflator.

Figure 13. Projected Allowance Prices Under H.R. 2454, by Case



Source: See **Figure 12**.

Allowance Value Estimates

The total value of allowances distributed each year could approach or exceed hundreds of billions of dollars, depending on the price of allowances in any given year under H.R. 2454. Each year, between 1% and 3% of allowances are taken off the top and held in a strategic reserve to help mitigate any volatility in the allowance market. Then the remaining allowances are allocated to various entities. As discussed above, in earlier years, those allowances are largely allocated at no cost to various covered and non-covered entities. In 2016, 17% of (non-strategic reserve) allowances are auctioned, a percentage that increases to 65% by 2030. **Table 7** shows the estimated value of allowance allocations and auction revenues under H.R. 2454's allocation scheme, using allowance prices from the EPA/IGEM case. Under the EPA/IGEM case, total annual allowance value approaches $100 billion by 2040. A higher allowance price estimate would lead to proportionately higher allowance values and auction revenues, while assuming a lower allowance price would do the opposite. **Figure 14** shows the annual total no-cost allowance value and auction revenues using the EPA/IGEM case.

As will be discussed in further detail below, total allowance value should not be confused with GHG abatement costs under the bill (see "Importance of Allowance Value Distribution"). These numbers instead represent potential wealth transfers in a given year.

As indicated in **Table 7**, a substantial amount of allowance value is allocated each year under H.R. 2454, even using a relatively low estimate for allowance prices. **Figure 14** below shows the split between auction value and no-cost allocations in a given year (again using IGEM prices). As can be seen from the chart, a large share of no-cost allocations are phased out between 2026 and 2030, in favor of greater and greater auctions. This preference for no-cost allowances in early years is aimed at easing the transition to the GHG reduction program both for covered entities and for energy consumers (individuals and businesses).

Table 7. Allocation of Estimated Annual Allowance Value in Selected Years Under H.R. 2454 Using Allowance Prices from EPA/IGEM Model

Million 2005$

	2012	2016	2020	2030	2040	2050
Allowance Price ($2005)	**$10.80**	**$13.13**	**$15.95**	**$25.99**	**$42.33**	**$68.95**
Allocations at No Cost						
Energy Consumers/Producers						
Elec. Local Distribution Companies (LDCs)	$18,547	$21,367	$23,712	$0	$0	$0
Merchant Coal Electric Producers	$2,164	$2,493	$2,767	$0	$0	$0
Long-Term Electricity Purchase Contracts	$931	$1,072	$1,190	$0	$0	$0
Eligible Co-generation Facilities	$173	$0	$0	$0	$0	$0
Small Electric LDCs	$247	$356	$395	$0	$0	$0
Natural Gas LDCs	$0	$6,411	$7,115	$0	$0	$0
Heating Oil/Propane - States	$927	$1,069	$1,186	$0	$0	$0
Oil refiners (general)	$0	$1,425	$1,581	$0	$0	$0
Small oil refiners	$0	$178	$198	$0	$0	$0
Energy-Intensive, Trade-Exposed Industries	$989	$9,568	$10,618	$5,981	$0	$0
Technology Deployment						
Carbon Capture and Storage	$0	$1,247	$3,953	$4,453	$4,689	$3,461
Energy and Efficiency Investments - States	$4,971	$5,022	$4,767	$4,480	$4,717	$3,482
Advanced Automotive Technology	$1,484	$2,137	$791	$0	$0	$0
Energy Innovation Hubs	$223	$321	$356	$401	$422	$312
Advanced Energy Research	$519	$748	$830	$935	$985	$727
Other Public Purposes						
Supplemental Ag. and Renewable Energy	$139	$199	$0	$0	$0	$0
Int'l Deforestation / Leakage Prevention	$2,473	$3,562	$3,953	$2,672	$1,876	$1,385
Domestic Adaptation	$445	$641	$711	$3,473	$3,658	$2,700
Domestic Wildlife / Natural Resource Adaptation	$190	$274	$304	$1,372	$1,444	$1,066
Int'l Clean Tech Deployment	$495	$712	$791	$3,563	$3,751	$2,769
Int'l Adaptation	$495	$712	$791	$3,563	$3,751	$2,769
Early actors	$495	$0	$0	$0	$0	$0
No Cost Allocations - Subtotal	**$35,907**	**$59,516**	**$66,007**	**$30,892**	**$25,294**	**$18,671**

	2012	2016	2020	2030	2040	2050
Allocation of Auction Revenue						
Low-Income Consumers	$7,420	$10,686	$11,858	$13,359	$14,068	$10,384
Climate Change Worker Assistance	$247	$356	$395	$891	$938	$692
Domestic Adaptation	$49	$71	$79	$89	$94	$69
Domestic Wildlife / Natural Resource Adaptation	$304	$438	$486	$2,191	$2,307	$1,703
Energy Efficiency and Renewable Energy Training	$371	$0	$0	$0	$0	$0
Auctioned in Prior Years[a]	$0	$0	$0	$15,160	$16,933	$0
Deficit Reduction	$5,167	$170	$228	$0	$0	$0
Consumer Rebate	$0	$0	$0	$26,481	$34,153	$37,708
Auction - Subtotal	**$13,559**	**$11,721**	**$13,046**	**$58,171**	**$68,492**	**$50,557**
Strategic Reserve Auction	**$500**	**$720**	**$1,613**	**$1,836**	**$2,901**	**$2,141**
Total	**$49,966**	**$71,956**	**$80,667**	**$90,899**	**$96,687**	**$71,368**

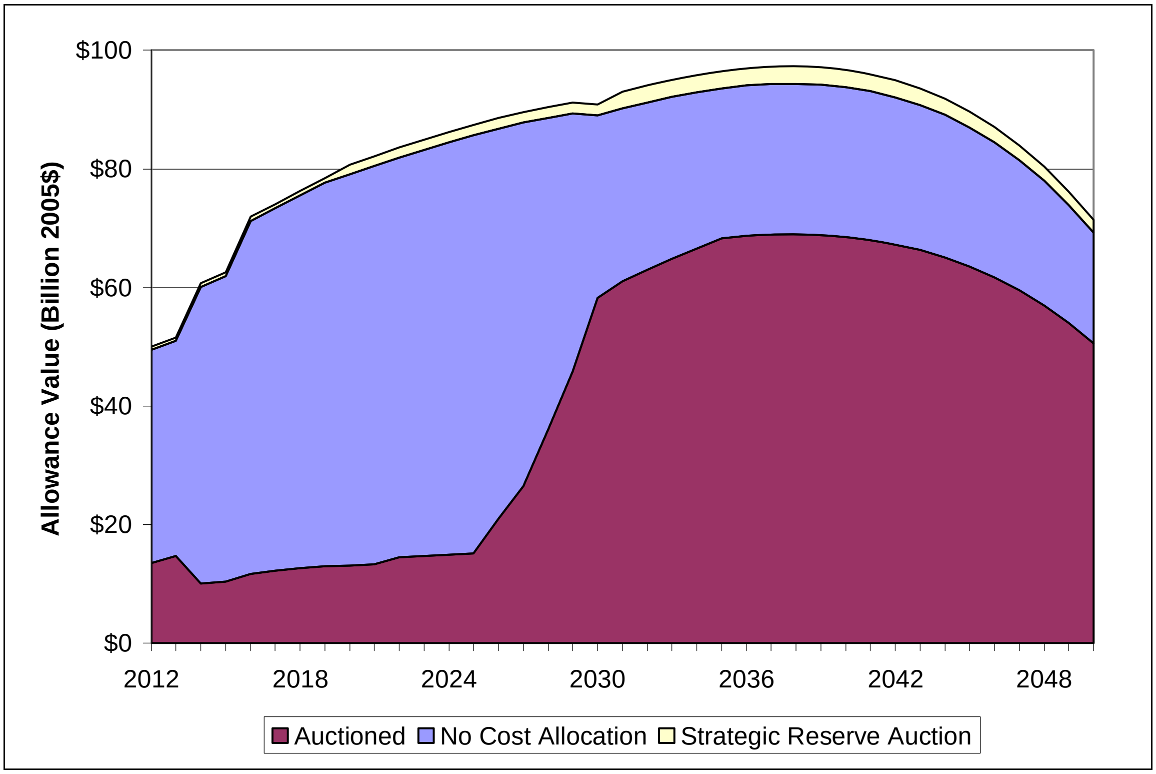
Source: CRS analysis of H.R. 2454 using allowance price estimates from EPA/IGEM model. EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html.

Notes: Auction subtotal includes allowances from the given vintage year that were auctioned in prior years for either deficit reduction or consumer rebates.

a. Although these allowances are auctioned early, they may not be used for compliance purposes until their vintage year. For example, if allowances from vintage year 2030 are auctioned in 2015, they may not be used to meet a covered entity's allowance requirement until 2030 (or after). Therefore, the market value of those allowances in 2015 will likely be below allowances that can actually be used in 2015. CRS assumed that by the vintage year, allowances will have the value of allowances from the same vintage year.

Figure 14. Estimated Allowance Value Using the EPA/IGEM Model

Billion 2005$



Source: CRS analysis of H.R. 2454 using allowance price estimates from EPA/IGEM model. EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html.

Effects of Key Design Elements in H.R. 2454

Availability of Offsets

H.R. 2454 would allow covered entities to cover a large percentage (roughly 30% in 2012) of their emissions using offsets. That percentage increases over time (to roughly 67% in 2050), as the bill allows covered entities to offset up to 2 billion tons of GHGs annually. Covered entities can offset 1 billion tons of emissions from domestic offsets and 1 billion tons from international offsets each year. Further, if the supply of domestic offsets is below 0.9 billion tons, the remainder can be made up with international offsets, up to an additional 0.5 billion tons (i.e., if there are only 0.5 billion tons of domestic offsets, the bill allows 1.5 billion tons of international offsets, for a total of 2 billion). The potential for low-cost offsets is limited somewhat by the fact that after 2017, international offsets are discounted by 20%—five international offsets are required to offset four tons of emissions (no such limitation applies to domestic offsets).

As mentioned above, the cases generally agree that the availability of offsets plays a key role in the cost of the program. Those main cases and sensitivity cases that assume significant penetration of offsets into the program generally result in lower allowance prices and overall costs to the economy. Conversely, limited offset availability generally leads to higher prices. The cases also generally agree that it will take time for international and domestic offset supply to ramp up, and that offset limits in the bill are generally not reached until 2025, if at all. Beyond those points of general agreement, the cases do not agree on how many offsets will be available or when, or what their price will be.

Along with technology development, the availability and price of offsets is one of the critical factors determining the costs of H.R. 2454. As stated by EIA,

> GHG allowance prices are sensitive to the cost and availability of emissions offsets and low- and no-carbon generating technologies.... Higher allowance prices occur if international offsets are unavailable, particularly if it is also the case that low- or no-emission baseload electricity supply technologies cannot be expanded beyond the Reference Case level.[64]

CBO found that H.R. 2454's offset provisions reduce allowance prices significantly from a case with no offsets, and that allowing even greater offsets than H.R. 2454's provisions further reduces allowance prices.

> Allowance prices would be lower if firms were allowed to use more offset credits to meet the bill's compliance obligations and if those offsets were cheaper than the costs of lowering emissions. Under the bill, the use of offsets lowers the allowance price by about 70 percent. Doubling the extent to which international offsets could be used in lieu of allowances in each year would decrease the allowance price by about 30 percent more.[65]

Four studies, EPA/IGEM, NBCC/CRA, EIA/NEMS, and CBO modeled the effects of allowing no international offsets (the CBO analysis assumed no offsets, international or domestic). As shown in **Table 8**, excluding international offsets from each model's core projections raises allowances prices in 2030 by more than half, regardless of the model. Under CBO's analysis, eliminating all offsets more than triples the 2030 allowance price.

Table 8. Effect of Offset Limitations on Allowance Prices

	2030 Allowance Price (2005$)			
	Core Projection	Limited Offsets Case	% Increase in Allowance Price	Limitation
EPA/IGEM	$26	$50	90%	No International Offsets
NBCC/CRA	$42	$120	180%	No International Offsets
EIA/NEMS	$61	$100	65%	No International Offsets
CBO	$37	$130	250%	No Offsets

Source: EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). CBO: CBO, *The Use of Offsets to Reduce Greenhouse Gases*, (August 3, 2009).

Table 8 clearly shows the role of inexpensive offset credits in reducing allowance prices. The relationship between offset supply and allowance prices can be seen in **Figure 15**, **Figure 16**, and **Figure 12**. The HF/GI case assumes the heaviest constraint on offset supply, and is the only case

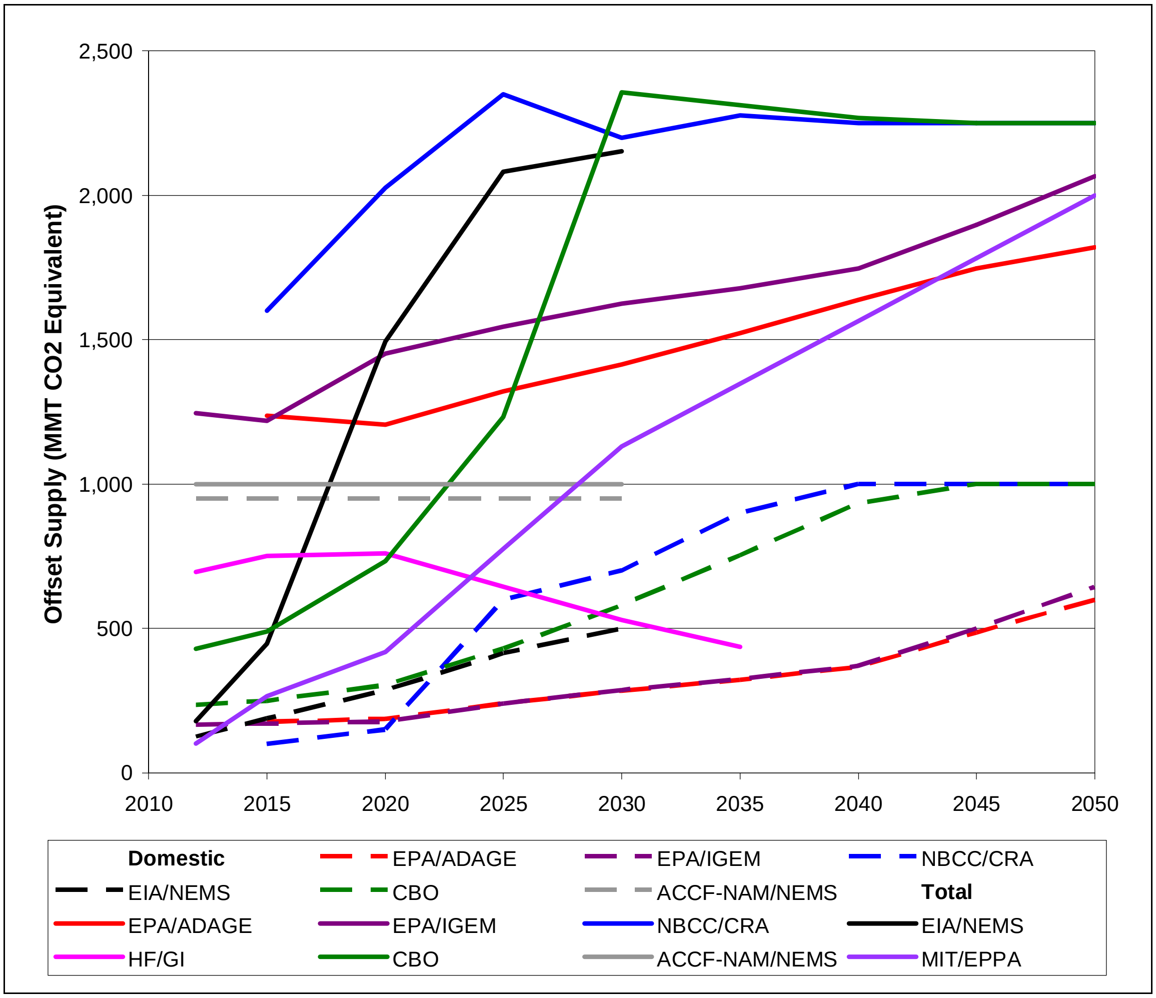
[64] EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009* (August 4, 2009), p. xii.

[65] CBO, *CBO Cost Estimate: H.R. 2454 American Clean Energy and Security Act of 2009 As ordered reported by the House Committee on Energy and Commerce*, (June 5, 2009), p.18.

where total offset supply decreases after 2020. This limited and decreasing offset supply coincides with a rapid increase in allowance prices after 2020. As noted above, the ACCF/NAM/NEMS and the HF/GI cases assume the most limited offset supplies of all of the models, and result in the highest allowance prices.

If offsets are not available in the quantities assumed by the cases—the costs of the program will likely increase dramatically. However, as noted by EIA earlier, the likelihood of either full offset use or no offset use whatsoever seems low; it is more likely that if offset use is limited (by either price or availability), it will fall somewhere between those extremes.

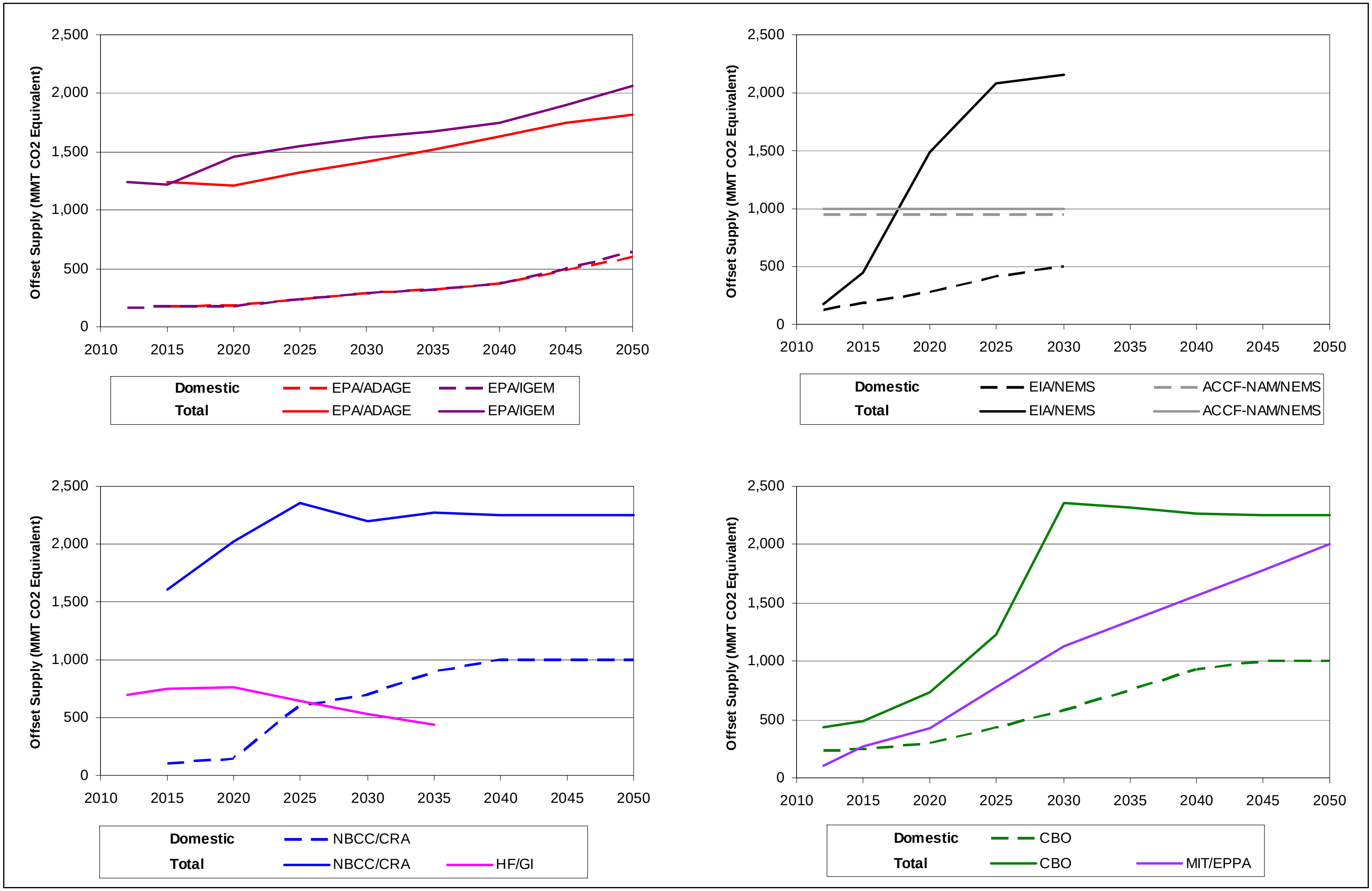
Figure 15. Estimated Offset Usage Under H.R. 2454



Source: EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). CBO: CBO, *CBO Cost Estimate: H.R. 2454 American Clean Energy and Security Act of 2009 As ordered reported by the House Committee on Energy and Commerce*, (June 5, 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Note: In some models, offset usage exceeds the 2 billion tons permitted in the bill (1 billion domestic and 1 billion foreign). This is due to the fact that after 2017, international offsets are discounted by 20% (i.e. it takes five international offsets to equal four allowances), and the fact that if domestic offset supply is less than 0.9 billion, the remainder may be made up using international offsets (up to 0.5 billion). To offset 2 billion tons of covered emissions, up to 2.375 billion offsets would be needed (0.5 billion domestic offsets, plus 1.875 billion international offsets)—a level nearly reached in 2025 in the NBCC/CRA case and in 2030 in the CBO case.

Figure 16. Estimated Offset Usage Under H.R. 2454, by Case



Source: See **Figure 15**.

Impact of Banking

Experience with the acid rain program strongly indicates that participants bank allowances in the face of price uncertainty. In the case of greenhouse gas reductions, the availability of domestic and international offsets also interacts with the banking provisions. As noted earlier, the HF/GI case did not include banking: this fact helps explain its dramatically increasing allowance prices. All other cases include banking, to some degree.

The cases suggest two important results from banking. First, as noted earlier, banking has a flattening effect on allowance prices as participants buy more than they need early, raising prices, and use them later, lowering prices from the levels they would be otherwise. Second, and perhaps more critically, banking allows participants more control over the scheduling of reduction efforts. Given the pivotal nature of technology development to the ultimate success of any greenhouse gas reduction program, the ability to delay making major capital investments is very important. In the EPA/ADAGE and EPA/IGEM cases, entities bank allowances heavily until around 2030 (depending on the scenario). This is possible because of the availability of domestic and international offsets. In the EIA/NEMS case, it is modeled in a manner to ensure a 13 billion allowance bank remains at the end of 2030 as a proxy to reflect allowance needs in the post-2030 period (EIA/NEMS does not project beyond 2030).

Impact of Strategic Reserve Auction

None of the cases modeled the strategic reserve auction. Some of the cases, like EPA's and CBO's, assume that the trigger for the auction never occurs and that the strategic allowance reserve is never used. The practical result in this case is a slight tightening of the emissions cap. Other cases, such as MIT's, simply ignore the provision and allocate the allowances as if the provision did not exist.

Major Points of this Section

- Predicting greenhouse gas emissions is extremely difficult—the range of baseline emissions projections for 2050 in the cases exceeds the range of emissions predicted for 2050 under H.R. 2454.
- There will be non-greenhouse gas emissions (e.g., SO_2, NO_x, and Hg) effects that may be even more difficult to quantify.
- The GDP effects of the bill are lost in the noise of the baseline GDP projections—for most cases, overall GDP losses relative to the reference case fall in a range of 0-2% from 2012 to 2050. In 2050, most cases project a total GDP loss of between 1.3% and 2.1% in 2050. GDP losses approach 3% for 2030 in the HF/GI case.
- Allowance prices (and thus compliance costs and allowance value) are driven by several assumptions in the cases. These include the use/supply of offsets (especially international offsets), the role of banking, and the role of technology.
- Total allowance value is potentially very large, likely nearing or exceeding $100 billion per year (2005$).

Technology Issues

A frontier area in model development is creating fuller representations of technology advancement. A substantial amount of technological change occurs within the economy without direct policy intervention—the free enterprise system provides significant rewards for those who develop cost-effective alternatives and introduce them into the market.[66] Technological change is a very complex subject and can also be induced through a variety of policy levers, including prices (such as allowance prices), subsidies, and technology mandates or standards, along with both publicly and privately funded research and development.[67] However, analyses do not provide a consistent relationship between policy levers and evolution of new technology, so this "induced technological change" (ITC) is not fully represented in the models used here, although it is a critical part of H.R. 2454. Observing that no single factor dominates the process of technology change—a process that includes roles for market incentives, research and development, learning-by-doing, and spillovers from other industries engaged in these activities, L. Clarke, et al. state:

> The lesson from these observations is to be cautious in interpreting the policy conclusions of models that assume only a single source of technological progress or that neglect critical factors such as spillovers. This includes virtually all formal models in use today, implying a need both for more comprehensive treatments of technological change and more research to understand the nature and magnitude of any distortions of policy conclusions from models with limited representations of technological change.[68]

The model's inability to reliably project technological change is a major source of over- or under-estimation of costs. H.R. 2454 includes numerous incentives for technology development—incentives for which no model has (or could be expected to have) estimated the collective effect.

Availability of Electric Generating Technology

Predicting when and how quickly lower-carbon electric generating technology will be available is a difficult but critical issue. Indeed, the cases examined here do not agree on the availability of current electric generating technology, such as nuclear or wind power, much less emerging technologies, such as carbon capture and storage (CCS), or the potential for breakthroughs over the next 40 years. The general lack of detailed technology descriptions in the CGE models does not help in this regard. For example, the EPA/IGEM's presentation of the energy sector and technology options is too aggregated to be analyzed in terms of technology development under H.R. 2454.

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[66] Generally expressed in terms of autonomous energy efficiency improvement (or AEEI), these effects are generally estimated using historical data.

[67] For an overview of induced technological change, see Lawrence H. Goulder, *Induced Technological Change and Climate Policy*, Pew Center on Global Climate Change (October 2004).

[68] Leon Clarke, John Weyant, and Alicia Birky, "On the Sources of Technological Change: Assessing the Evidence," *Energy Economics* 28 (2006) p. 593.

Current Technologies

Several currently available technologies emit less greenhouse gas (or none) compared to a conventional coal-fired facility. Those technologies include electric generation from wind, biomass, landfill gas, nuclear, geothermal, and natural gas. Some of these sources, such as biomass and natural gas, have some repowering or cost-effective cofiring potential with respect to coal-fired generation.[69]

The cases do not provide much insight on the likely mix of these technologies under H.R. 2454. Some cases, like ACCF-NAM/NEMS and HF/GI strictly define the availability of these technologies; while others, like the EPA/ADAGE and EIA/NEMS cases, allow the model to meet the requirements without any additional constraints. **Table 9** identifies some of the technology-availability limits assumed in the different model runs, along with the resulting capacity built to meet electricity demand to 2030. Because the ACCF-NAM/NEMS, MIT/EPPA, and HF/GI cases heavily constrain the availability of most alternatives to natural-gas generation, it is not surprising that a substantial amount of natural gas capacity is assumed to be built under these cases during this time period. This result is confirmed by sensitivity analysis conducted by EIA that shows a movement to natural gas if the availability of nuclear power, renewable power, and coal with CCS are constrained.[70] In contrast, the EPA/IPM and EPA/ADAGE cases indicate little or no new construction of natural gas-fueled generating capacity. Instead, these cases allow a mix of renewable power (including wind and biomass), nuclear power, and coal-fired capacity with CCS to meet future demand. Finally, EIA/NEMS, and NBCC/CRA cases show a moderate role for natural gas during this time frame.

[69] As stated by EIA with respect to biomass: "The increase in biomass generation in the ACESA cases comes from a combination of increased cofiring of biomass in existing coal plants and the addition of new dedicated biomass plants. In most cases, cofiring dominates, particularly in the early years of the projections. However, as new dedicated biomass plants are added, they play a larger role in later years. Cofiring is generally an economic way to reduce CO_2 emissions without investing in new capacity, but as the allowance price increases throughout the projections, the economics begin to shift towards less CO_2-intensive generation." p. 23.

[70] As stated by EIA: "If new nuclear, renewable, and fossil plants with CCS are not developed and deployed in a timeframe consistent with emissions reduction requirements under ACESA, covered entities are expected to respond by increasing their use of offsets, if available, and by turning to increased natural gas use to offset reductions in coal generation." EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009), p. x.

Table 9. Projections of Construction of Generating Capacity to 2030

Case	Nuclear Power	Renewable Power	Natural Gas-Fired	Coal with CCS	Baseline Year
EPA/ADAGE	69 GW (built)	77 GW (built)	little	43 GW (built)	2010
EPA/IPM (2025)	1 GW (built)	41 GW (built)	5 GW (built)	16 GW (new) 9 GW (retrofit) (built)	2010
NBCC/CRA/LOW	42 GW (built)	76 GW (built)	59 GW (built)	3 GW (built)	not stated
HF/GI	17 GW (limit)	92 GW (limit)	substantial (built)	insignificant (limit)	not stated
EIA/NEMS/BASIC	100 GW (built)	120 GW (built)	40 GW (built)	68 GW (built)	2007
ACCF-NAM/NEMS/LOW	25 GW (limit)	15 GW/year (limit)	substantial (built)	30 GW (limit)	not stated
MIT/EPPA	0 GW (built)	about 73 GW (built)	about 145 GW (built)	21 GW (built)	2010
EIA AEO April 2009 Baseline	10.6 GW	87.5 GW	138.9 GW	36.6 GW (no CCS)	2007

Source: EPA/ADAGE and EPA/IPM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Notes: "Limit" means the analysis limited the amount of capacity that could be built—it is not necessarily the amount the model determined would be built if the limitation was removed. **"Built"** is the amount the model projected to be built. **"About"** is an estimate by CRS of the additional capacity necessary for the increased electricity production projected by the model between 2010 and 2030 under H.R. 2454 in the absence of capacity data being provided. The estimates were calculated assuming an 80% capacity factor for biomass, 90% for nuclear power and coal, 48% for renewables, and 85% for natural gas.

The interplay between nuclear power, renewables, and coal-fired capacity with CCS among the cases emphasizes for the need for a low-carbon source of electric generating capacity in the mid- to long-term. As indicated, a considerable amount of low-carbon generation will have to be built under H.R. 2454 to meet the reduction requirement. The amount of capacity constructed depends on the models' reference case assumptions about future supply and demand and need for capacity replacement/retirement under H.R. 2454, along with the degree of consumer response to rising prices and incentives contained in H.R. 2454.

To put **Table 9** into historical context, from 1963 to 1985, 78 GW of nuclear power were ordered, constructed and began operation in the United States.[71] For the 19-year period of 1966 through 1984, the country added 464 GW of total generating capacity, including 210 GW of coal-fired capacity, 38 GW of hydropower, 27 GW of natural gas capacity (steam technology), 46 GW of

[71] Compiled from EIA's Reactor Status List available from EIA's website.

oil-fired capacity, and 54 GW of peaking capacity to improve system reliability after the 1965 blackout. In addition to new additions, between 1965 and 1972, about 400 coal-fired generating units were converted to oil to meet environmental requirements. After the 1973 oil embargo, this trend was reversed with 11GW of capacity converted back to coal by 1983.[72] For a more recent time period, from 2001 through 2005, the United States added about 180 GW of new capacity—almost all natural gas-fired.[73]

Beyond construction of new facilities and repowering of existing ones, conservation is likely to play an important role in reducing the need for new construction under H.R. 2454. As indicated above, the amount of generating capacity needed to meet increasing demand to 2030 varies substantially between cases. The impact of electricity conservation, and energy conservation more generally, on H.R. 2454 analyses is discussed later in this section.

Emerging Technologies

The emerging technology receiving the most attention in the cases is carbon capture and storage (CCS). This is not surprising. The cases generally agree that the long-term viability of coal-fired electric generation is dependent on developing CCS. Indeed, the cases' various projections of coal consumption derive directly from the cases' assumptions about the introduction and commercialization of CCS. The CCS bonus allowance provision received considerable attention in several of the cases. **Table 10** indicates the various assumptions and limits the cases placed on CCS deployment under H.R. 2454. As indicated, H.R. 2454's incentives do not generate massive increases in CCS through at least 2030. In some cases, the restraints on CCS construction assumed by the cases were not reached. Two potential reasons for this result are: (1) projected low allowance prices discourage CCS deployment beyond the amount able to take advantage of the bonus allowance system; (2) other alternatives, such as natural gas, renewables, or nuclear are seen as more cost-effective than CCS. For example, the strong price signal in the EIA/NEMS cases results in an increasing deployment of CCS to 2030, while the somewhat weak price signal of EPA/ADAGE results in CCS deployment peaking with the bonus allowance allocation then declining as the allowance price is inadequate to sustain new deployment.

A discussion of CCS deployment and H.R. 2454's bonus allowance scheme is provided by EPA's analysis.[74] In its analysis, EPA/ IPM found that a price of $40 per ton yielded the highest penetration of new CCS capacity, fully expending the bonus allowance pool. If the price was lowered to $30 per ton, the capacity deployed is also lowered as the bonus is insufficient to encourage commercialization of the technology. If the price was raised to $50 per ton, the incentive is reduced because the bonus pool is depleted faster as more is paid out than is necessary to encourage commercialization. EPA notes that H.R. 2454's reverse auction provision with respect to bonus allocations after the first 6 GW are deployed (whose incentive is fixed in the bill) should determine the appropriate financial incentive for deploying CCS.

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[72] Energy Information Administration, *Fuel Choice in Steam Electric Generation: Historical Overview*, DOE/EIA-0472 (August 1985), pp. 5 and 7.

[73] Environmental Protection Agency, *EPA Analysis of the Low Carbon Economy Act of 2007: S. 1766 in the 110th Congress* (January 15, 2008) p. 49.

[74] U.S. Environmental Protection Agency, *EPA Analysis of the American Clean Energy and Security Act of 2009: H.R. 2454 in the 111th Congress* (June 23, 2009), pp. 86-92.

Table 10. Assumptions/Results about the Availability of CCS

Gigawatts (GW)

Case	2015	2020	2025	2030	Total
EPA/ADAGE (results)	0	25	19	-1	43
EPA/IPM (build limits with no nuclear)	4	27 (new) 5 (retrofit)	21 (new) 8 (retrofit)	not applicable	52 (new) 13 (retrofit)
EPA/IPM (result)	3	4 (new) 3 (retrofit)	9 (new) 6 (retrofit)	not applicable	16 (new) 9 (retrofit)
NBCC/CRA (build limits)	3	7	20	30	60
NBCC/CRA (results)	0	3	0	0	3
HF/GI (build limits)	insignificant	insignificant	insignificant	insignificant	insignificant
EIA/NEMS/BASIC (results)	0	13.2	18.3	37.6	69.1
ACCF-NAM/NEMS/LOW	not presented	not presented	not presented	not presented	30
MIT/EPPA	0	about 7	about 7	about 7	about 21

Source: EPA/ADAGE and EPA/IPM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Note: "About" is an estimate by CRS of the additional capacity necessary for the increased electricity production projected by the model between 2010 and 2030 under H.R. 2454 in the absence of capacity data being provided. The estimates were calculated assuming an 80% capacity factor for biomass, 90% for nuclear power and coal, 48% for renewables, and 85% for natural gas.

Future Technologies

The above discussion focuses on current perspectives on technological alternatives—alternatives that mostly rely on the construction of new facilities, be they nuclear power, biomass power, or coal-fired integrated gasification combined cycle (IGCC) with CCS. Retrofits to existing coal-fired powerplants are restricted to some biomass cofiring, natural gas cofiring, and very limited CCS installations. Only the IPM/EPA case includes any CCS retrofits as a result of H.R. 2454 and the amount is not large compared with the need. [75] As suggested by MIT in its general study of U.S. cap-and-trade proposals in 2007:

[75] The EPA/IPM case list over 4 GW of CCS projects that are in the early phases of planning, design, and/or (continued...)

> The need to phase out coal without CCS indicates the potential value of a CCS technology that could be used to retrofit existing generation plants, extending the life of existing investment and limiting the number of completely new plants that were needed. The capital intensity of these technologies are a concern as we find that the investment demand needed for such expansions crowds out investment in other areas of the economy, and thus increases the welfare cost of the policy.[76]

Such retrofitable post-combustion technologies are in development. For example, an ammonia-based, regenerative process for CO_2 capture from existing coal-fired facilities is being developed by Powerspan.[77] Called ECO_2, two commercial demonstrations (120 MW and 125 MW) have been announced with projected operations to begin in 2011 and 2012.[78] A second, chilled-ammonia-based post-combustion capture process is being developed by Alstom. In collaboration with American Electric Power (AEP) and RWE AG (largest electricity producer in Germany), Alstom has announced plans to demonstrate the technology on a 20 MW slip stream at AEP's Mountaineer plant with the captured CO_2 injected in deep saline aquifers on site.[79] Once commercial viability is demonstrated at Mountaineer, AEP plans to install the technology at its 450 MW Northeastern Station in Oologah, OK, early in the next decade.[80] Other solvent-based post-combustion processes are in the pilot stage.[81] To the extent these and other future retrofittable technologies become available, the mid- and long-term costs and capital investment projected by the cases could be significantly over-stated.

Effectiveness of Research, Development, Demonstration, and Deployment Efforts

One factor that will determine the availability of emerging and future technology is research, development, demonstration, and deployment funding. The potential for such subsidies to accelerate deployment is suggested by the previous discussion of CCS. However, H.R. 2454 contains numerous provisions with respect to technology. As noted in the previous discussion on auction/allowance revenues, technology development will receive substantial funding under H.R. 2454. However, in general, only the bonus allowance incentives for CCS are explicitly modeled in any of the cases.

Two basic questions about H.R. 2454's technology development funding must be answered: 1) how much is enough? and 2) is funding directed toward the right technologies and through the

(...continued)

construction that could potentially capitalize on the funding opportunities available under H.R. 2454. See EPA, *EPA Analysis of the American Clean Energy and Security Act of 2009: H.R. 2454 in the 111th Congress* (June 6, 2009), appendix 6, p. 89.

[76] Sergey Paltsev, et al., *Assessment of U.S. Cap-and-Trade Proposals*, MIT Joint Program on the Science and Policy of Global Change, Report No. 146 (April 2007), pp. 33-34.

[77] Powerspan Corp., *Carbon Capture Technology for Existing and New Coal-Fired Power Plants* (April 15, 2008).

[78] One is to be sited at NRG's W.A. Parish plant in Texas and is to use a 125 MW slip stream. The second is to use a 120 MW slip stream from Basin Electric's Antelope Valley Station. The captured CO_2 is to be sold or used for Enhanced Oil Recovery (EOR).

[79] AEP News Release, *RWE to Join AEP in Validation of Carbon Capture Technology*, (November 8, 2007).

[80] The captured gas is to be used for Enhanced Oil Recovery.

[81] For a useful summary of carbon capture technology, see Steve Blankinship, "The Evolution of Carbon Capture Technology Part 1," *Power Engineering* (March 2008).

most effective policy instruments? The amount provided by the bill exceeds current efforts to develop and deploy reduction and low-carbon technologies, but in many cases focuses on specific technologies as opposed to broad technology development and deployment. The following discusses those issues with respect to electricity and vehicle technology development.

Developing Electricity Technologies

To put H.R. 2454's technology funding efforts into context, two proposed research, development, and demonstration strategies that focus on improving the country's electricity system are summarized below: (1) Electric Power Research Institute's (EPRI) "Full Portfolio" technology scenario; and (2) Coal Utilization Research Council (CURC) and EPRI's Clean Coal Technology Roadmap.

Table 11 presents the Electric Power Research Institute's (EPRI's) estimated combined public and private research and development funding needs to obtain a "full portfolio" of electricity technologies to meet greenhouse gas reduction targets. The technology targets for 2030 are (1) 30% reduction in load growth by efficiency improvements; (2) 70 GW of non-hydro renewables; (3) 64 GW of new nuclear power; (4) new coal-plant efficiency of 49%; (5) CCS widely deployed after 2020; (6) plug-in hybrids as 39% of new car sales; and (7) distributed energy resources at 5% of baseload.[82]

Table 11. Estimated Incremental Annual Combined Public and Private Funding Needs to Achieve EPRI's Full Portfolio

(millions of dollars annually)

	2005-2009	2010-2014	2015-2019	2020-2024	2025-2030	2005-2030 Average Annual
Distribution-enabled technologies	$250	$220	$140	$240	$240	$220
Transmission-enabled technologies	$100	$130	$120	$70	$60	$100
New/Extended Nuclear Power	$500	$520	$370	$370	$400	$430
Advanced coal and Carbon Capture and Storage	$830	$800	$800	$620	$400	$690
Annual Totals	$1,700	$1,700	$1,400	$1,300	$1,100	$1,400

Source: Electric Power Research Institute, *The Power to Reduce CO_2 Emissions: The Full Portfolio* (August 2007).

Note: The report does not state whether these numbers are in real or nominal dollars.

Note: "Distribution-enabled technologies" refers to deploying smart distribution grids and communications infrastructures to support commercialization of end-use energy efficiency, distributed energy resources, and plug-in hybrid electric vehicles.

"Transmission-enabled technologies" refers to deploying transmission grids and energy storage infrastructure to support as much as 20%-30% intermittent renewables in specific regions.

[82] Electric Power Research Institute, *The Power to Reduce CO_2 Emissions: The Full Portfolio*, Discussion Paper (August 2007), p. 2-2. The targets do not reflect economic or potential regulatory and siting constraints.

Table 12 presents the public funding needs for a strategy focused on commercializing various "clean coal" technologies funded over 18 years (2008-2025) as proposed by the Coal Utilization Research Council (CURC) and EPRI. The strategy would provide for several carbon capture and storage demonstration projects along with improvements to combustion technology and development of CCS retrofit technology.

Table 12. Total Public Funding Needs for 2007 CURC-EPRI Clean Coal Technology Roadmap over 18 Years (2008-2025)

(millions of dollars)

	Research and Development (80% Government Share)	Demonstration Projects (50% Government Share)	Totals
FutureGen	$1,180	—	$1,180
Integrated Gasification Combined-Cycle (IGCC)	$920	$2,010	$2,930
Combustion	$460	$2,310	$2,770
Innovations for Existing Plants (IEP)	$380	$600	$980
Sequestration (Storage—high CO_2 scenario)	$180	$740	$920
Fuel Cells	$580	$430	$1,010
Turbines	$390	$210	$600
Totals	$4,090	$6,300	$10,390

Source: Coal Utilization Research Council, *The CURC-EPRI Clean Coal Technology Roadmap*, available at http://www.coal.org/userfiles/File/Final_CURC-EPRI_Roadmap,_2008.pdf.

Note: The report does not state whether these numbers are in real or nominal dollars.

Using the EPA/IGEM estimates for allowance prices, H.R. 2454's allocation for technology development and deployment (over $7 billion annually in 2012, and over $10 billion annually by 2030) exceed the amounts estimated for the strategies identified above in **Table 11** and **Table 12** (combined, roughly $2 billion annually). Several organizations, including EPRI and the Pew Center for Global Climate Change, have called for at least a doubling of DOE's current funding of advanced coal options (2008 funding: $438 million).[83] However, while the above estimates are focused on a broad deployment of technologies, in many cases the bill focuses on specific technologies. For example, a large share (over 40% by 2020) of technology development and deployment funds are focused on two areas: CCS and advanced technology vehicles (and plug-in vehicles in particular). Thus, while H.R. 2454's funding would appear to fill a projected need for public funds to encourage the future availability of useful technology, the particular allocations may or may not be optimal.[84]

[83] See John A. Bewick, "Cultivating Clean Tech: New Models for Energy RD&D," *Public Utilities Fortnightly* (May 2008) pp. 42-48.

[84] As stated by NBCC/CRA: "The stimulus package and ACESA almost exclusively address deployment of known technologies and large-scale demonstration of well-developed new technologies, and do not provide the level of support for the types of basic and applied research necessary to create the breakthroughs on which game-changing (continued...)

Vehicle Technology

As noted, a sizeable portion of H.R. 2454 allowances allocated for research and development are designated for advanced technology vehicles. For example, H.R. 2454 would provide allowances (effectively grants) to automakers and parts manufacturers to develop the capacity to build plug-in hybrid and other advanced vehicles (and parts). Using the EPA/IGEM allowance prices, annual funding for these activities would average roughly $1.25 billion between 2012 and 2025. In comparison, DOE currently spends between $200 million and $400 million for advanced vehicle and hydrogen fuel R&D.[85] Other recent stimulus programs to support similar automotive technology development have had appropriations in the billions of dollars, but have generally been short term, lasting only a few years, as opposed to the 14-year span of the allowance allocation for the automotive sector in H.R. 2454. The effectiveness of these and other funds in accelerating technology development and commercialization—as well as agencies' and firms' capacity to absorb (in some cases) very large funding increases—could have a significant effect on the overall costs of H.R. 2454 and the ultimate success of the program.

Effectiveness of Economic and Regulatory Incentives on Reducing Energy Demand

In addition to the CCS bonus allowance provision, H.R. 2454 contains funding and/or regulatory requirements for zero- or low-carbon electricity technology (such as the renewable energy and efficiency standard), advanced technology vehicles (such as plug-in hybrids), and improvements in energy efficiency (such as new appliance and building efficiency standards). The cases reviewed here suggest that the combination of energy efficiency and conservation provisions and the price signal generated by H.R. 2454 could have a significant impact on energy demand and costs.[86]

Energy efficiency and conservation are key components of H.R. 2454 which includes many incentives, regulatory and financial, to encourage their expansion. As noted earlier, analyses by EPA and EIA developed proxies to stimulate the effects of these provisions in their cases. They, along with MIT provided data about the impact of the bill on fossil fuel consumption and electricity generation that provides some indication of the importance of energy demand reduction to H.R. 2454 compliance strategies.

Table 13 shows the impact of H.R. 2454 on overall electricity generation in terms of billion kilowatt-hours reduced and percentage reduction from both a "business as usual" and a 2007 baseline. Despite a growing economy, demand reduction increases as a percentage of an increasing baseline projection from 2020 to 2030. Compared with electricity generation in 2007, the 2020 reduction resulting from H.R. 2454 ranges from 2.4% for EIA/NEMS to 9.7% for EPA/ADAGE; the 2030 reduction ranges from 8.7% for EIA/NEMS to 13.6% for EPA/ADAGE.

(...continued)

technologies can be built." CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009) p.6.

[85] For more information on advanced vehicle R&D, see CRS Report RS21442, *Hydrogen and Fuel Cell Vehicle R&D: FreedomCAR and the President's Hydrogen Fuel Initiative*, by Brent D. Yacobucci.

[86] With respect to the RES, see discussion on page 4 of this report.

Table 13. Electric Generating Impacts From H.R. 2454

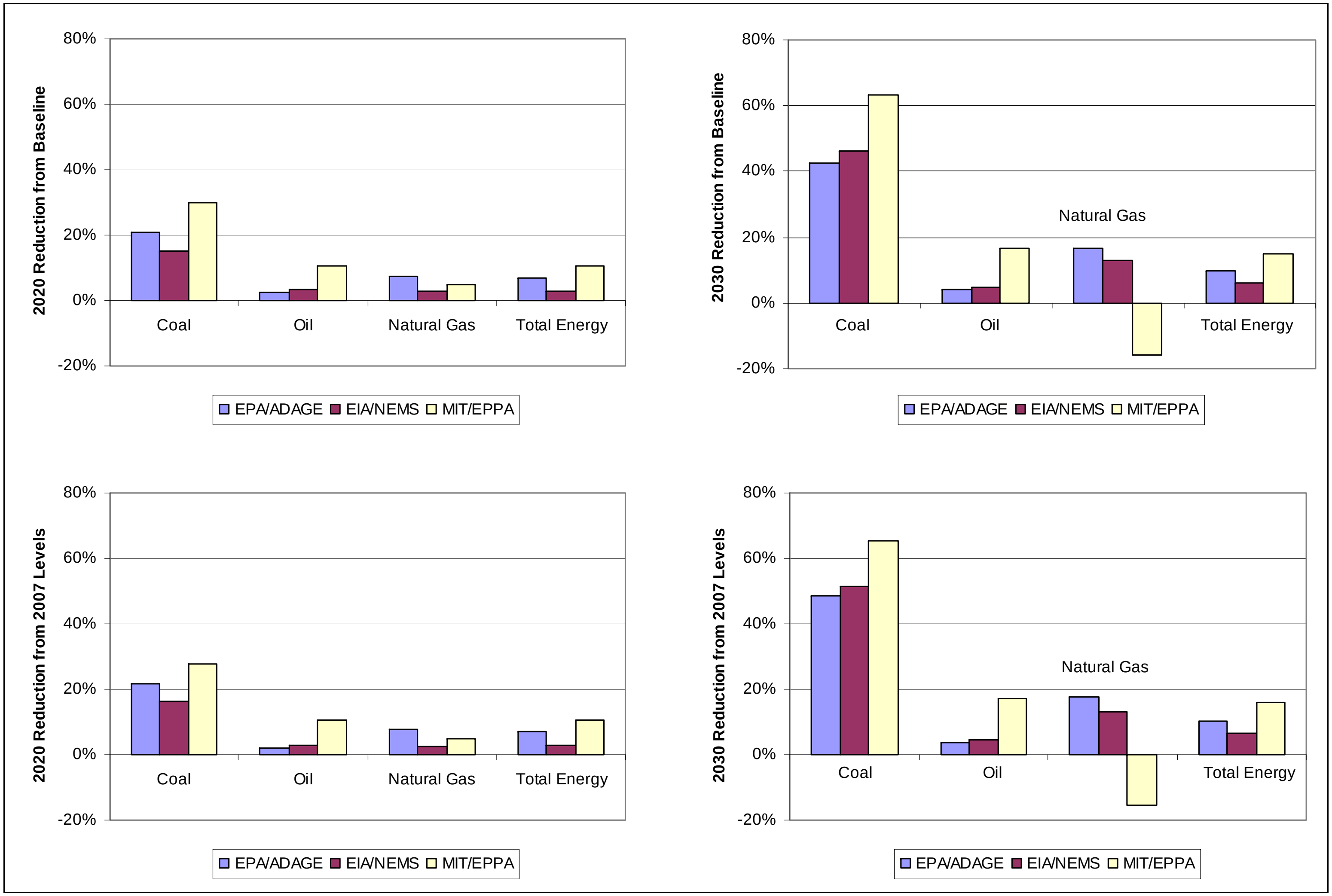
Case	Reduced Generation (Bkwh)		Reduction from Baseline		Reduction from 2007 levels	
	2020	2030	2020	2030	2020	2030
EPA/ADAGE	429	564	9.7%	11.5%	10.3%	13.6%
EIA/NEMS	110	360	2.4%	7.1%	2.6%	8.7%
MIT/EPPA	278	389	6.8%	8.6%	6.7%	9.4%

Source: EPA/ADAGE: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009).

Examining the energy effects more broadly, **Figure 17** shows the reduction in total energy consumption along with a breakdown for each fossil fuel. As indicated, in 2020, total energy consumption is reduced under H.R. 2454 by about 3-11% from both projected 2020 and historic 2007 levels. Consumption of coal, the most carbon-intensive fossil fuel, is reduced about 15% to 30% from both projected 2020 and historic 2007 levels, while the other two fuels are less affected. The MIT/EPPA case projects higher reductions in total energy and fossil fuel consumption in 2020. This result reflects MIT's assumptions about limited low-carbon fuel alternatives, along with nuclear and CCS, and favorable assumptions about future natural gas supply and the cost of natural gas combined-cycle generating technology.

In 2030, the trends generally continue as total energy is reduced about 6% to 16% from both projected 2030 levels and historic 2007 levels. The new feature introduced by the 2030 numbers is the emergence of increased natural gas consumption in the MIT/EPPA case – once again, a reflection of the case's restriction of other energy alternatives and favorable assumptions about natural gas. For the other two cases, the downward trend in natural gas and oil consumption continues.

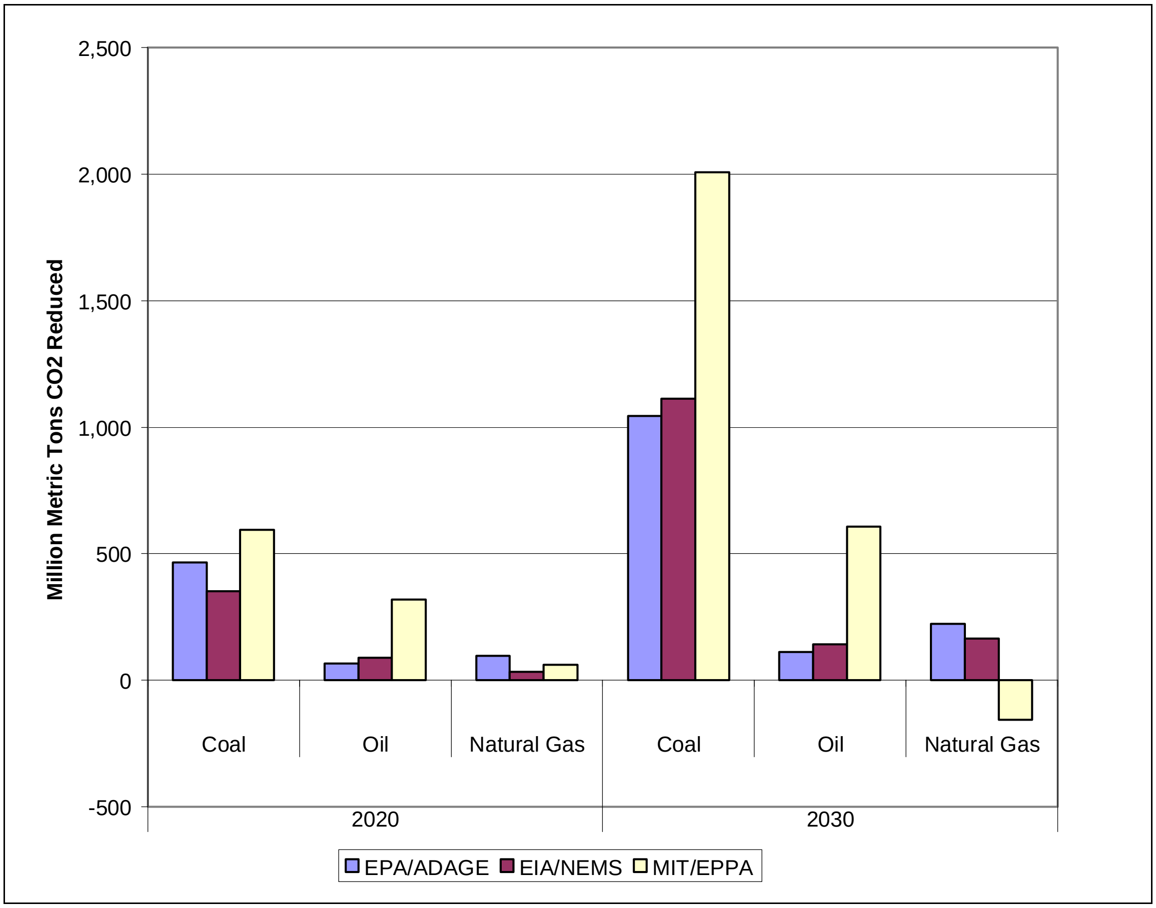
Figure 17. Fossil Energy Consumption Impacts from H.R. 2454



Source: EPA/ADAGE: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). EIA/NEMS: : EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009).

These reductions in energy consumption result in sizeable reductions in carbon dioxide emissions. As indicated in **Figure 18** most of the emissions reductions come from reduced coal consumption.

Figure 18. Emissions Impacts from Reduced Fossil Energy Use



Source: EPA/ADAGE: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al.,*The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). : EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009).

Major Points of this Section

- The models' inability to project technological change is a major source of potential error.
- A considerable amount of low-carbon generation capacity will be needed to meet the bill's reduction requirements—development of lower-carbon electric generation capacity will be a major factor in the effects of H.R. 2454.
- Cases' projections for the fuel mix of new electric generation capacity are largely driven by modelers' assumptions about the availability of technology (e.g., nuclear, renewables, coal with CCS).
- The cases generally agree that the long-term viability of coal-fired electric generation is dependent on the development of CCS.
- While H.R. 2454's funding for technology deployment appears to fill a projected need, the particular allocations in the bill may or may not be optimal, particularly with respect to funding future breakthrough technologies in electricity generation and transportation.
- The greenhouse gas reduction requirement, along with requirements and incentives in the bill for increased energy efficiency, leads to significant reductions in energy usage, both from business-as-usual and 2007 levels.

Economic Issues

Importance of Allowance Value Distribution

The primary mechanism that any market-based system uses to control greenhouse gas emissions is a price signal. Once a price on carbon is determined, the market responds by efficiently reducing carbon emissions to the point where the cost of reducing emissions equals, in the case of a cap-and-trade scheme, the cost of buying an allowance. By creating allowances, each one essentially a license to emit one metric ton of carbon dioxide equivalent, the government is creating an instrument that has value and for which there will be a demand at a given price.

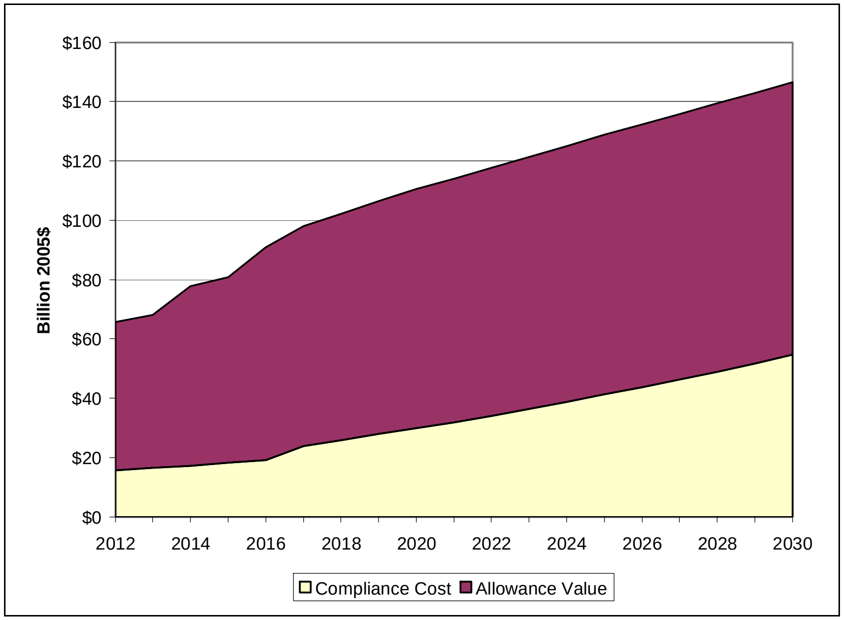
What cap-and-trade does economically is shown in **Figure 19**, using EPA/IGEM's estimates as an example. As indicated, there are two components to the cap-and-trade program. First, there is the compliance cost—the actual cost of reducing emissions. This represents the resources that covered entities use to reduce their emissions to the level specified by the emissions cap.

Second, there is the value, or wealth created by the establishment of valuable permits required for emitting greenhouse gases. As indicated in **Figure 19** below, the allowance value created by H.R. 2454 is projected by EPA to be substantially higher than the compliance costs, particularly in the program's early years. How the government chooses to allocate these valuable instruments would have a significant impact on who pays for the program. This potentially substantial transfer of wealth helps explain the strong debate with respect to allowance allocation.

This situation differs substantially from a traditional regulatory approach for controlling emissions. With traditional regulatory approaches, the discussion of costs would end at compliance costs (the first point above) because traditional approaches use a regulatory mandate to order entities to comply with a requirement instead of employing a price signal. Regulatory approaches also tend to restrict the flexibility covered entities have to comply with the program's mandates. The result is potentially a less efficient compliance program than is possible with a market-based system.

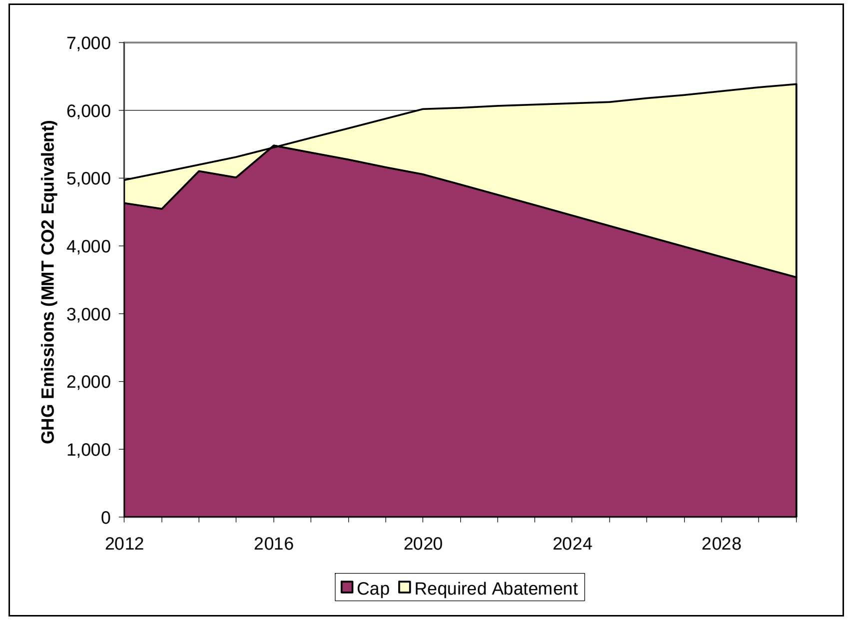
Allowance markets present covered entities with an option of either reducing emissions or buying allowances (or a combination of both) to meet the emission cap. The value created by the establishment of allowances can be used to mitigate the impact of the program on specific entities or groups. If one believes that allowance value is really a cost like resources costs are (and not a means to encourage cost-effective compliance strategies), then one should oppose market-based solutions as being more "costly" than a traditional regulatory approach as any inefficiency introduced by the regulatory system would be more than offset by the allowance "cost" introduced by the market-based system.

Figure 19. Compliance Cost vs. Value of Allowance Pool – EPA/IGEM Model



Source: CRS analysis of H.R. 2454 using allowance price estimates and compliance costs from EPA/IGEM model. EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html.

Figure 20. Required Abatement vs. Total Allowable Emissions (Cap) – EPA/IGEM Model



Source: EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html.

The manner in which allowances are allocated does not reduce the program's compliance cost, it only changes who bears the cost.[87] As stated by W. David Montgomery of CRA International during congressional testimony:

> The allocation of allowances cannot eliminate the cost of a cap and trade program; it can only change who bears the cost. Free allocations can remove some or all of the cost of obtaining allowances that grant permission to emit up to the stated caps; but no matter how allowances are distributed, none of the cost of the actions that must be undertaken to bring emissions down to satisfy the caps can be removed. At best, that distribution can eliminate the cost of purchasing allowances from the government. Nothing can eliminate the cost of reducing emissions from their projected business-as-usual level to the capped level, though there are many ways of hiding or shifting that cost around.[88]

Indeed, free allocation of allowances can increase the cost of the program if it dilutes the price signal, resulting in less economically efficient compliance schemes. As EPA stated in its analysis of H.R. 2454:

> Returning the allowance value to consumers of electricity via local distribution companies in a non-lump sum fashion prevents electricity prices from rising but make the cap-and-trade more costly overall. This form of redistribution makes the cap-and-trade more costly since greater emission reductions have to be achieved by other sectors of the economy. Resulting changes in prices of other energy-intensive goods also influence the overall distributional impacts of the policy. [89]

In the case of H.R. 2454, this diluting effect does not seem to dominate the cost analysis. For example, in analyzing the May discussion draft that preceded the introduction of H.R. 2454, EPA assumed that the cap-and-trade program would allocate its allowances entirely by auction—the most economically efficient means of distributing allowances. In its June analysis of H.R. 2454 as reported by House Energy and Commerce Committee, EPA included scenarios that incorporated the free allocation provisions of the bill in a manner that reduced electricity price increases to consumers and which increased electricity demand and associated emissions. However, in comparing the overall impact of the two versions, the projected allowance prices were less in the reported version than the discussion draft—a result driven primarily by the reported version's less stringent 2020 emissions cap and its provisions permitting expanded use of international offsets.[90] This suggests that, in the case of H.R. 2454, there may be design parameters, particularly the assumed availability of international offsets, that could substantially outweigh whatever economic inefficiencies are introduced by its free allocation scheme.

[87] There is research to suggest that using allowance value to reduce other distorting taxes (e.g., income and payroll taxes), can produce a more efficient tax system, and therefore reduce the overall cost to the economy from the cap-and-trade program. However, H.R. 2454 does not use allowance value to reform the tax system.

[88] W. David Montgomery, Prepared Testimony. Hearing on Allowance Allocation Policies in Climate Legislation. House. Committee on Energy and Commerce, Subcommittee on Energy and Environment, (June 9, 2009), p. 1.

[89] U.S. Environmental Protection Agency, *EPA Analysis of the American Clean Energy and Security Act of 2009: H.R. 2454 in the 111th Congress* (June 23, 2009), p. 49.

[90] The Heritage Foundation found that the less efficient allocation of the reported version of H.R. 2454 overweighed the reduction in the 2020 reduction requirements from the discussion draft. However, the Heritage Foundation did not alter its somewhat restrictive assumptions about the availability of offsets in recalculating H.R. 2454 costs. See The Heritage Foundation, *Son of Waxman-Markey: More Politics Makes for a More Costly Bill*, (May 18, 2009).

In the case of H.R. 2454, there are three factors that affect the efficiency of its allocation system. First, as indicated earlier, H.R. 2454 uses a mixture of free allocation schemes and auctions to distribute allowances. Over time, the distribution becomes increasingly based on auctions with per-capita rebates to consumers. Thus, the allocation system becomes increasingly efficient economically over time with over 65% of allowances auctioned by 2030. Second, there is a significant amount of free allowances allocated for other purposes (state energy efficiency programs, international activities, etc.,) that would have little or no effect on the price signal. Third, the bill contains language that attempts to prevent electricity and natural gas LDCs from using the free allowances provided them to reward increased use of energy. Alternatives include focusing on the fixed component of energy bills and use of allowance value to fund energy efficiency activities (mandated for one-third of natural gas LDCs' allocation).

Of the analyses examined here, the EPA cases assume that the allowances allocated to electricity LDCs do dilute the price signal, resulting in the need for increased emission reductions. However, the scenario most focused on by EPA (scenario 2) incorporates some of the efficiency provisions of H.R. 2454 that counteract this effect. The CRA International analysis assumes that LDCs do distribute the allowances in the manner mandated by the bill, preventing a dilution of the price signal. Disagreeing with EPA's interpretation, CRA International states: "The specific provisions on the use of the allowances do not allow the use of the allowances for rebates based 'solely on the quantity of electricity delivered to such ratepayer.' [footnote to H.R. 2454 omitted] Since the rebate is not to be based on electricity use it should not distort the incentive for consumers to conserve electricity."[91] For EIA, electricity allowances allocated freely to load serving entities are reflected as a reduction in "effective" electricity rates to consumers.[92] When asked by CRS about how its study distributed allowance value, the Heritage Foundation rejected the entire notion *a priori* that allowance value could be used to reduce energy prices. Instead, the Heritage Foundation models the macro-economic and pricing effects of H.R. 2454 as if all the allowances are auctioned, treating the allowance value created by H.R. 2454 as government revenue (similar to a tax) regardless of whether they are formally auctioned or not.[93]

Impact on Energy Prices and Expenditures

Given the divergent projections by the various cases about future electric generating capacity illustrated earlier, it is not surprising that estimates of the energy price impacts of H.R. 2454 vary widely. Also, perhaps more than any other results, the cases were very selective in terms of the results they chose to highlight in their studies and how they chose to present them. Hence, CRS highlighted general themes coming out of the cases to focus on the insights this wide variety of assumptions and calculations has to offer. A further discussion of the impact of energy costs on households and energy-intensive industries is also presented.

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[91] CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009) p. 53.

[92] EIA models the natural gas LDC allowance allocation similarly, except for the 1/3 that is designated for energy efficiency. EIA models this provision by using 1/3 of the value of allowances for programs that accelerate penetration of more efficient technologies and therefore lower gas demand.

[93] The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009) p. 16.

Impact on Residential Electricity Bills: State-Level Attempts

A contentious issue during the debate on H.R. 2454 has been its effect on residential electricity bills. As suggested above, a major focus of H.R. 2454's allowance allocation scheme in the early years of the program is to reduce its *net* effect on residential electricity *bills* (not rates). This emphasis on electricity bills—and the concern that areas more dependent on coal-fired generation would face disproportionately higher cost—has motivated several groups to attempt to provide state-level data on the electricity bill impacts of H.R. 2454. **These efforts are complicated and subject to substantial error due to a lack of data availability, and the general difficulties in attempting to project impacts on a state-level basis.** These difficulties are illustrated below.

Three of the more widely-circulated efforts to project the impact of H.R. 2454 on electricity bills by state are:

- *National Mining Association's (NMA) Electricity Costs Map.* Entitled: "Most States Lose Under H.R. 2454," the one-page map of supposed state-by-state electricity cost increases under H.R. 2454 indicates that some states win while others lose under H.R. 2454. The figures presented in the map are based equally on a state's 2006-2008 electricity sales to all sectors (industrial, commercial, and industrial) and the carbon dioxide emissions emitted by electric generation within the state (including electricity generated for transmission to another state). This approach is not the formula mandated by H.R. 2454 in several important respects: (1) H.R. 2454's electricity rebate is not calculated by state, but by individual LDCs; (2) the rebate is not calculated according to emissions associated with in-state electric generation, but by emissions associated with sales; and (3) H.R. 2454 prohibits allocation of allowances in excess of the amount necessary to compensate consumers for any increased costs, so there can be no "winners" under the rebate scheme. In addition, the map's authors assume there are no cost-effective reduction strategies available to utilities and that the only compliance strategy is to purchase allowances or offsets at CBO's marginal cost of control—$15 an allowance. Thus, the map does not actually reflect either the overall allocation or costs of H.R. 2454, its distribution across states, or likely compliance strategies of affected utilities.[94]
- *M.J. Bradley and Associates' Residential Electricity Bills Map.* Entitled: "Change in Monthly Average Residential Electricity Bills in 2012 under the Waxman-Markey Bill," the four-page analysis of H.R. 2454's (as passed) impact on monthly average residential electricity bills avoids most, but not all, of the pitfalls that the NMA map fell into. By focusing on monthly residential electric bills, the analysis' scope is in line with the thrust of the electricity provisions in H.R. 2454, including the structure of the electricity cost relief. The M.J. Bradley and Associates map makes attempts to allocate H.R. 2454's rebate to consumers according to electricity sales and emissions associated with those sales data

[94] The reader should note that while EIA emissions and electricity sales data were used in the NMA analysis***, it is not an EIA analysis***. As noted by EIA, the data NMA used as one basis of its analysis did not reflect several aspects of H.R. 2454 allocations scheme, including the flow of electricity across state boundaries, H.R. 2454's allocation based on electricity consumption (not generation as presented), the utility-by-utility LDC allocation under H.R. 2454, and H.R. 2454's option to choose different baseline years for allocations than 2006-2008; finally, the calculations do not cover many of the detailed legislative provisions dealing with allocation.

specified by the bill. Unlike the NMA and the NRDC analysis (below), the calculations are based on a nationwide average residential electricity consumption of 1000 kilowatt-hours (Kwh) per month. A major advantage of the M.J. Bradley approach is that the assumptions and calculations are transparent and easily understood. A major short-coming of this analysis is the same as for all these analyses: the focus on state-by-state data, rather than the LDC data required by H.R. 2454, means that intra-state differences in electricity supply and consumption are masked. In addition, like the NMA map, M.J. Bradley also uses allowance prices (EPA's in this case) as the average cost of control.

- *Natural Resources Defense Council's(NRDC) Electric Bills Map*. Entitled: "Climate Bill Cuts Electric Bills: H.R. 2454 saves Americans an average of $6 per month," the one page map summarizes the state level electricity bill impacts of H.R. 2454 based on an analysis conducted by OnLocation Inc. for NRDC using the NEMS model developed by EIA. Unlike the NMA and M.J. Bradley maps, the NRDC estimates are the results of an integrated modeling exercise, although the state-level estimates are the result of off-model calculations by NRDC (the NEMS-NRDC model resolves to the regional level only). A unique part of this analysis is the modeling of the demand response by consumers to both the efficiency provisions of H.R. 2454 and its price signal – a dynamic not addressed by the other two analyses. Other differences with the above analyses involve presentation: the two previous analyses estimate costs in 2012 compared with today's costs; the NRDC analysis estimates average monthly costs (or savings) from 2012-2020 compared with projected baseline conditions. As with the two other analyses, the choice of state-level data does not reflect the LDC-based rebate formula of H.R. 2454.

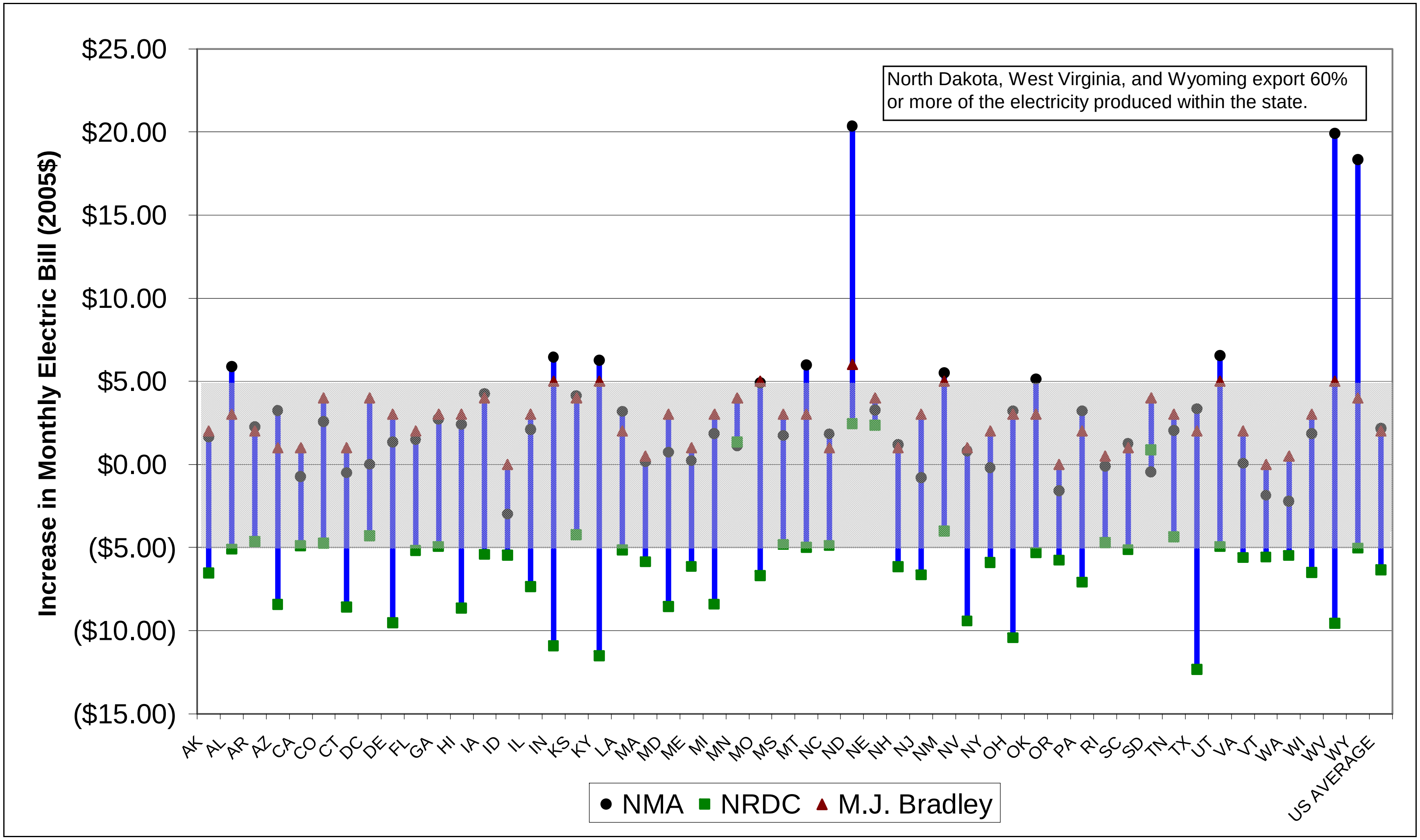
To try and put these maps on a somewhat more level field, CRS adjusted the NMA figures to: (1) reflect residential consumer consumption only; (2) reflect the average state's residential consumer's monthly consumption; and (3) convert the estimate into 2005$. The analysis by M.J. Bradley required no adjustment, presenting residential monthly bills in 2005$. For the NRDC analysis, the results were converted to 2005$. *CRS was unable to separate the aggregate average 2012-2020 projection into a 2012 projection, but notes that much of the savings is likely to occur in the later years of the projections. Also, readers are reminded that the three maps assumed different allowance prices in 2012 (or 2012-2020 in the case of NRDC).*

As indicated in **Figure 21**, the U.S. average residential electric bill in 2012 would increase about $2 a month under the NMA and M.J Bradley analyses, compared with an average eight-year savings of over $6 a month under the NRDC analysis. The analyses for individual states generally range from a $5 increased cost monthly, to a $5 savings monthly. Three notable outliers are created by the NMA methodology that focused on in-state generation rather than electricity sales. North Dakota, West Virginia, and Wyoming export a substantial portion of their in-state generation to other states, leading to artificially high estimates. Likewise, states that are net importers of electricity may have artificially low estimates. The NMA methodology does not account for this, resulting in some clearly erroneous results; for example, North Dakota's residential electricity bills rising over $20 a month while South Dakota's residential electricity bills are slightly declining.

Overall, the attempts to provide state impact data provide the reader with little insight into the effects of H.R. 2454 on individual states. Arguably, a more useful way of looking at the residential rates is to consider consumers' electricity usage, electricity supply, and the electricity efficiency opportunities provided by H.R. 2454's various programs and price signal. The data presented do suggest that the rebate formula would reduce the increase in average residential electric bills nationwide in the early years of the program to about $2 a month (assuming allowance prices in the $12-$15 range), with opportunities to reduce future bills if the energy efficiency provisions work as designed.

Figure 21. Estimated Increase (or Decrease) in Monthly Residential Electric Bills

2012, except for NRDC



Source: CRS analysis of data from: National Mining Association, "Most States Lose Under H.R. 2454," (2009); M.J. Bradley and Associates, "Change in Monthly Average Residential Electricity Bills in 2012 under the Waxman-Markey Bill," (2009); Natural Resources Defense Council, "Climate Bill Cuts Electric Bills: H.R. 2454 saves Americans an average of $6 per month" (2009).

Impact on Energy Prices

A presentation issue of particular importance is illustrated by the above discussion on residential electricity bills. In general, the energy consumer assistance contained in H.R. 2454 is focused on reducing the overall impact of energy price increases on households, both through rebates and through encouraging energy efficiency. This assistance is not designed to attenuate the price signal that consumers would receive from higher electricity or natural gas rates. In sectors where consumers would be receiving rebates or incentives to conserve (electricity and natural gas use), simply presenting the rate increases and not the projected assistance is providing only half the story, particularly in the short-term when the rebates are at their maximum. Thus, the discussion below needs to be placed in the overall context of H.R. 2454 and its various allowance value transfers and energy efficiency incentives. In some cases, as illustrated above, the assistance can have a significant effect on overall energy bills, particularly through 2026. In other cases, such as gasoline prices, the costs are not mitigated – the rate increase accurately reflects the impact on consumers.

Natural Gas Rates

Some of the most confusing results presented by the cases are for natural gas prices. The results are based on different baselines, indices, and target categories (e.g., utility, industrial, residential, "average"). Generally, the cases included allowance costs; however, as noted earlier, the cases do not agree on the effect of H.R. 2454's natural gas LDC free allocation scheme on rates.[95]

A representative sample of the results is presented in **Table 14**. In general, the incremental impact of H.R. 2454 on natural gas prices depends on the degree to which natural gas-fired generation is used to back out existing coal-fired capacity and to meet future demand. As discussed above, the cases fall into three categories with respect to future natural gas-fired generation: (1) little or no increased generation; (2) modest increased generation; or (3) substantial increased generation. Of the three cases included in the first category, the EPA/ADAGE case projects a small increase in overall natural gas rates, rates that include allowance costs. Under EPA/ADAGE, natural gas rates began to rise more steeply after 2030, reaching about 31% above baseline levels by 2050.

[95] The MIT/EPPA results did not include carbon costs and, therefore, are not included here.

Table 14. Selected Estimates of Natural Gas Rate Impacts from H.R. 2454

	2020 (percentage over/under baseline levels)	2030 (percentage over baseline levels)	Allowance Costs Included in Price?	Consumer Rebate Included?
ACCF-NAM/NEMS Residential Rates	-3%	56%	Probably	not stated
ACCF-NAM/NEMS Industrial Rates	33%	87%	Probably	not stated
NBCC/CRA Residential Rates	14%	16%	Yes	No
EIA/NEMS Residential Rates	3%	17%	Yes	Yes
EIA/NEMS Industrial Rates	13%	23%	Yes	Yes
EPA/ADAGE Average Rates	9%	10%	Yes	Yes
HF/GI Residential Rates	not stated	55% in 2035	Yes	No

Source: EPA/ADAGE: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009. HF/GI: Heritage Foundation, *Son of Waxman-Markey: More Politics Makes for a More Costly Bill* (June 16, 2009).

Notes: "Probably" is based on ACCF-NAM's use of the ACCF-NAM/NEMS model for estimates.

The two cases that project modest additional natural gas-fired capacity—EIA/NEMS and NMA/CRA—vary in their residential rate results in the short-term (2020) but are substantially the same by 2030. The difference between the two cases in 2020 may be at least partly due to their differing treatment of H.R. 2454's LDC rebate. By including the rebate in its case, EIA/NEMS's short-term rate increases are reduced by the rebate, while NBCC/CRA's rates are not. However, by 2030, the rebate has been phased out, and that difference has been effectively removed. NBCC/CRA goes on to project more steeply increasing natural gas rates, reaching 34% above baseline levels in 2050.

In contrast to the cases above, the ACCF-NAM/NEMS and HF/GI cases (which project substantial increases in natural gas-fired capacity) estimate minor increases in residential natural gas prices in 2020 (possibly due to the LDC rebate), but substantial increases (over 50%) in both residential and industrial rates by 2030. These results are consistent with each cases' high allowance prices and their substantial use of natural gas for future generation and backing-out of existing coal-fired capacity.

Petroleum Prices (Retail Gasoline)

Retail gasoline price is the major focus in most of the cases. Unlike natural gas or electricity costs, H.R. 2454 provides no rebates for any higher gasoline bills resulting from its provisions.

Table 15 presents a representative sample of projected increases in gasoline prices resulting from implementation of H.R. 2454.[96] As indicated, NBCC/CRA and EPA/ADAGE estimate the 2030 impact of H.R. 2454 on gasoline prices at around a quarter per gallon over baseline levels. EIA/NEM's estimate is a little higher at about 34 cents a gallon. Consistent with their higher allowance costs, ACCF-NAM/NEMS and HF/GI cases project substantially higher prices. However, in its report, ACCF-NAM states that their analysis includes the impact of low carbon fuel standards – a provision that would substantially impact gasoline prices, if H.R. 2454 contained such a provision.[97] H.R. 2454 does not.[98] If the ACCF-NAM/NEMS did indeed model such a provision, their estimates of gasoline price impacts would be substantially overstated.

Cases that projected prices to 2050 indicate a steadily increasing gasoline price, with NBCC/CRA estimating a 59-cent-per-gallon increase over baseline levels by 2050.

Table 15. Selected Estimates of Gasoline Price Impacts from H.R. 2454

	2020 (2005$)	2030 (2005$)	Allowance Price Included?	Consumer Rebate Included?
ACCF-NAM/NEMS Retail Gasoline	$0.29/gal	$0.73/gal.	Yes	n/a
NBCC/CRA Retail Gasoline	$0.13/gal	$0.21/gal	Yes	n/a
EIA/NEMS Retail Gasoline	$0.22/gal	$0.34/gal	Yes	n/a
EPA/ADAGE Retail Gasoline	about $0.18/gal	about $0.24/gal	Yes	n/a
HF/GI Retail Gasoline	not stated	58% higher than baseline levels in 2035	Yes	n/a

Source: EPA/ADAGE: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). HF/GI: Heritage Foundation, *Son of Waxman-Markey: More Politics Makes for a More Costly Bill* (June 16, 2009).

Notes: n/a: not applicable. H.R. 2454 has no provision for consumer rebates for increased gasoline prices. It should be noted that ACCF-NAM states that their analysis includes the impact of low carbon fuel standards – a provision that would substantially impact gasoline prices, if H.R. 2454 contained such a provision. H.R. 2454 does not. If the ACCF-NAM/NEMS did indeed model such a provision, their estimates of gasoline price impacts would be substantially overstated.

[96] The MIT/EPPA results did not include carbon costs and, therefore, are not included here.

[97] SAIC, *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)*, report by the ACCF and NAM (2009), p. 3.

[98] A discussion draft circulated by the bill's sponsors before introduction did contain provisions to establish a low carbon fuel standard, but neither the introduced, reported, nor House-passed versions of H.R. 2454 contained those provisions.

Electricity Rates

The above section on "Impact on Residential Electricity Bills: State-Level Attempts"presents estimates on the impact of H.R. 2454 on residential electricity bills. This section provides estimates of the electric rate impact of H.R. 2454. A representative sample of those estimates is provided in **Table 16**. As indicated, in those cases that included the consumer rebate in their calculation of electricity rate, the 2020 rate impacts are minimal. However, as discussed previously, H.R. 2454 does not permit LDCs to "reward" increased electricity usage by lowering rates, so these estimates may reflect the requirements of the various models, rather than the language of H.R. 2454, and should be read in concert with the previous discussion of electricity bills.

Table 16. Selected Electricity Rate Impacts of H.R. 2454

	2020 (percentage over/under baseline levels)	2030 (percentage over baseline levels)	Allowance Price Included?	Consumer Rebate Included?
ACCF-NAM/NEMS Residential Rates	5%	31%	Probably	not stated
ACCF-NAM/NEMS Industrial Rates	13%	49%	Probably	not stated
NBCC/CRA Residential Rates	16%	22%	Yes	No
EIA/NEMS Residential Rates	0%	17%	Yes	Yes
EIA/NEMS Industrial Rates	2%	24%	Yes	Yes
EPA/ADAGE Average Rates	13%	13%	Yes	Yes
HF/GI Electricity Rates	not stated	90% in 2035	Yes	No
MIT/EPPA	17%	15%	Yes	No

Source: : EPA/ADAGE: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). Sergey Paltsev, et al., *The Cost of Climate Policy in the United States,* MIT Joint Program on the Science and Policy of Global Change, Report No. 173 (April 2009) p. c-19. ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). HF/GI: Heritage Foundation, *Son of Waxman-Markey: More Politics Makes for a More Costly Bill* (June 16, 2009).

Notes: "Probably" is based on ACCF-NAM's use of the ACCF-NAM/NEMS model for estimates.

For 2030, when the rebates have been phased-out, the electricity rate increases escalate. This trend toward increasing electricity rates continues in the cases that projected to 2050, with NBCC/CRA's residential rate increase projected to be 49% above baseline levels in 2050.

Impact on Households

There are three factors to consider when examining the various cases' "household effects" estimates: (1) what welfare measure is the case using to determine the effect; (2) what definition of household is the case using to illustrate the effect, and (3) what accounting methods is the case using in presenting its estimate. These factors are briefly discussed below.

Definition of Welfare Effects

As noted earlier in this report, the term "welfare effects" is not consistently defined across the various studies examined. This problem becomes acute when one gets to the subject of household effects. A uniform calculation of a household's increased or reduced welfare from enacting H.R. 2454 would be a useful contribution to the policy debate. The lack of such a definition has contributed to a jumble of differing estimates that shed little light on the underlying fundamental issues.

The studies reviewed here use four different types of measures in determining household effects: (1) welfare change (MIT/EPPA); (2) consumption-based change (EPA/ADAGE, EPA/IGEM, EIA/NEMS, NBCC/CRA [called purchasing power]) , (3) income-based change (household income (ACFF-NAM/NEMS), or disposable income (HF/GI)), and (4) economy-wide costs (CBO)). Even within these categories, the accounting can be different; thus, comparisons across the different measures are problematic at best. None of these measures included any environmental benefits in the calculation of welfare effects.

The broadest measure of welfare is "welfare change" as used by MIT. Welfare change refers to the difference between a household's welfare with and without enactment of H.R. 2454: As explained by MIT:

> For many economists the preferred measure of total economic costs of greenhouse gas abatement or of other policy measures is the change in consumer welfare, measured in terms of "equivalent variation", as this measure considers the GHG price and the amount of abatement and can include the effect of interactions with other policy measures to the extent these other policy measures are modeled. And, whereas the CO_2 price measures the marginal cost, a welfare measure takes into account the fact that many of the reductions likely cost less than the last ton abated. Welfare is also generally a measure that is broader than just market activity and as such the change in welfare includes changes in both labor and leisure time. Leisure is considered a good and in models like EPPA it is represented by the monetary value of the non-working time. In coming up with a measure of change in welfare any reductions (increases) in the amount of work time are offset by increases (decreases) in the amount of leisure time.[99]

The most common measure of household effects is consumption change (called purchasing power in the NBCC/CRA case). Consumption is a major component of GDP and consumption change is related to the welfare change measured above. The primary difference between the two is that consumption change focuses on market impacts and therefore does not include the impact of policy on leisure time. As a result, this measure generally registers greater losses than the welfare indicator because it does not capture any increases in non-market activities (i.e., leisure) resulting from decreases in consumption from higher prices. This is particularly true if percentages are presented since consumption is a smaller measure to begin with than welfare.

However, it should be noted that consumption is not defined uniformly across the various models that present consumption estimates. For example, the EPA/IGEM model accounts for consumer durables like housing as investments, rather than as consumption (as they are treated in

[99] Sergey Paltsev, et al., *The Cost of Climate Policy in the United States,* MIT Joint Program on the Science and Policy of Global Change, Report No. 173 (April 2009), p. B-2.

EPA/ADAGE and the U.S. National Income Accounts (NIA)). This makes examining such figures across cases even more problematic.

The third category is income-based measures and these can be subject to a significant range of interpretation. National income is a measure of the total net value of all goods and services, representing the sum of wages, profits, rents, interest, and pension payments. Personal income measures gross income from employment (e.g., wages), self-employment, investment income, dividends, and transfer payments (such as Social Security). In contrast, disposable income measures personal income minus taxes – i.e., the income individuals have available to spend or save.

Disposable income, in particular, is a hard concept to directly reconcile with the welfare and consumption measures discussed above. Disposable income is a well-defined term in national income accounting, but in a modeling exercise it is highly sensitive to many assumptions unrelated to the direct cost of the bill. For example, how a model characterizes allowance value, either as a tax (and therefore reducing disposable income) or as a transfer payment (and therefore having no effect on disposable income), can have a significant effect on the "welfare" estimate, given the amount of the allowance value created by H.R. 2454. Thus, readers should carefully examine the dynamics of a modeling exercise that employs disposable income (or any other measure for that matter) as a measure of welfare to determine what is actually being measured.

The fourth category is economy-wide costs. As defined by CBO, this term includes four factors with respect to H.R. 2454: (1) purchase of international offset credits; (2) cost of producing domestic offset credits; (3) resource costs associated with reducing emissions; and (4) allowance value that would be directed overseas. CBO assumes that allowance value is a pure transfer flowing back to U.S. households "both in the form of direct relief and indirectly through allocations to businesses and government (all of which would eventually benefit households in people's various roles as consumers, workers, shareholders, and taxpayers).... "[100] The term does not include the potential indirect general equilibrium effects that H.R. 2454's costs could trigger.

Definition of Household

Although used interchangeably in many instances, the U.S. Census Bureau's definitions of a household and a family are different. According to the 2008 U.S. Census Bureau survey:[101]

- A household includes the related family members and all the unrelated people, if any, such as lodgers, foster children, wards, or employees who share the housing unit. A person living alone in a housing unit, or a group of unrelated people sharing a housing unit such as partners or roomers, is also counted as a household. Currently the average number of people per household is 2.56.
- A family is a group of two people or more (one of whom is the householder) related by birth, marriage, or adoption and residing together; all such people (including related subfamily members) are considered as members of one family. Currently, the average number of people per family is 3.16.

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[100] Congressional Budget Office, *The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454*, (June 19, 2009) p. 7.

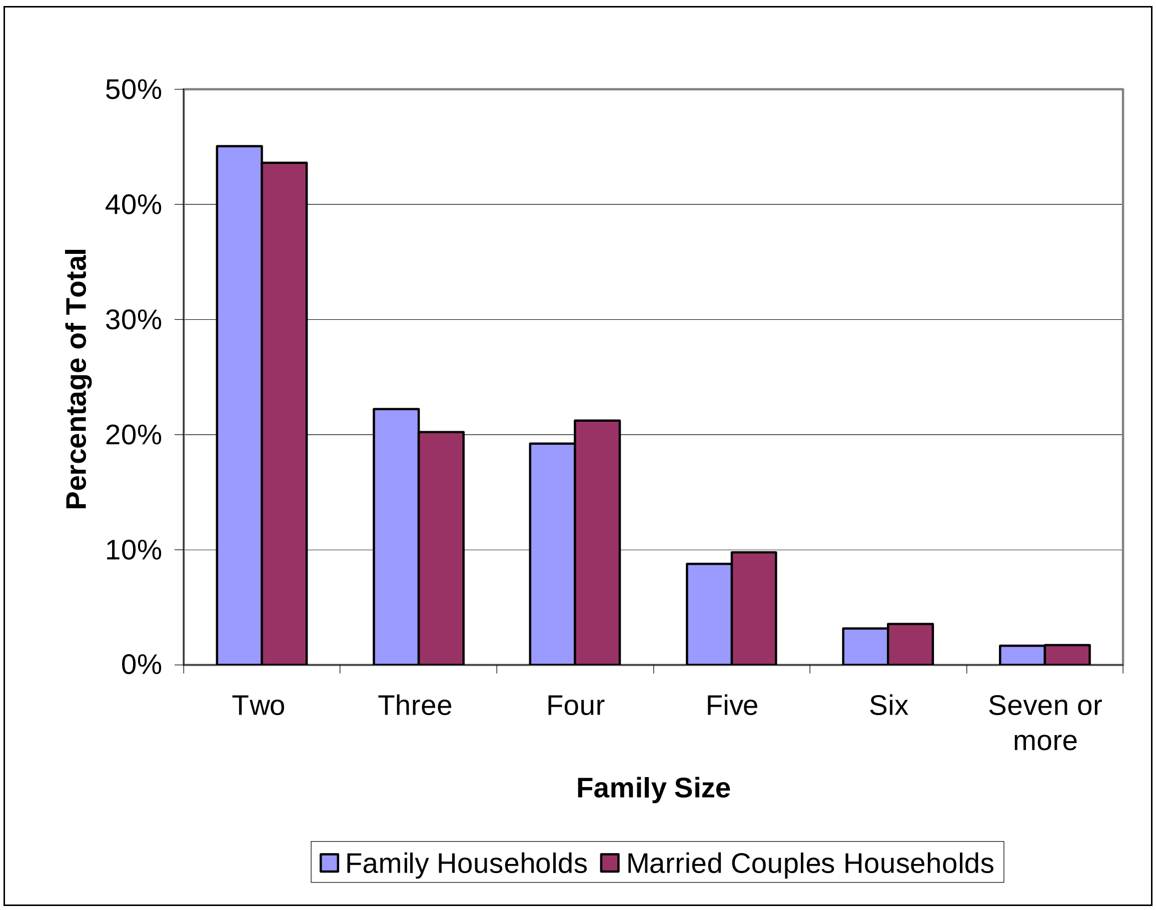
[101] For more information on the 2008 survey , see the U.S. Census Bureau website at http://www.census.gov/population/www/socdemo/hh-fam/cps2008.html

- A family household is a household maintained by a householder who is in a family (as defined above), and includes any unrelated people (unrelated subfamily members and/or secondary individuals) who may be residing there. Currently the average number of people per family household is 3.22.
- A married couple household, as defined for census purposes, is a husband and wife enumerated as members of the same household. The married couple household may or may not have children living with them. Currently, the average number of people per married couple is 3.22.

All of the cases, except for the HF/GI case use the U.S. Census Bureau definition of household in calculating household effects. Thus, a household is defined as about 2.5-2.6 people. The HF/GI case uses a household with 4 people as the basis of its calculations.

To put these numbers in context, **Figure 22** provides 2008 Census Bureau data on family household and married couple household size. As indicated, in 2008, the HF/GI case's measure of household size represented about one-fifth of the family households and married couple households in the country. The average household figure used by the other studies represented the mid-point of two-thirds of the country's family household and married couple household size.

Figure 22. Household Size



Source: U.S. Census Bureau website at http://www.census.gov/population/www/socdemo/hh-fam/cps2008.html, Table F2.

Accounting Method

The data for household effects in the various cases are presented in either discounted or undiscounted form. As noted earlier, discounting is a way in which economics expresses time, and is a standard convention when examining a stream of economic data across time. With respect to household effects, discounting costs accounts for the fact that program costs will occur in the future when incomes are expected to be higher. For the purposes of this section, CRS has generally presented data in undiscounted form, partly because the discount rates of the studies vary substantially.

A second accounting issue is the context in which the household effects estimates are presented. Most of the cases here present their household effects estimates in the economic context of the year in which they would occur; i.e., effects in 2020 are presented in terms of its impact on a 2020 economy. Two cases, CBO and NBCC/CRA scaled their estimates in the context of the 2010 economy. In its discussion of results below, CRS attempts to normalize the various cases' household effects estimates in the context a 2010 economy.

The Results for 2020

Because household estimates are problematic for reasons suggested above, CRS focuses on those effects estimated for the year 2020***. Any estimate beyond that point, or any cumulative estimate to 2030 or beyond, should be viewed with the utmost skepticism.***

The household effect estimates as presented by the various cases are provided in **Table 17**. CRS did two adjustments to the data provided: (1) all estimates were converted to 2005 dollars, and (2) a second calculation of the HF/GI estimate was made using the U.S. Census average household figure to make the HF/GI estimate comparable to the other estimates presented on a household size basis. The data as presented indicate a divide between estimates of $319 and less, and those that are least twice that threshold. In particular, the NBCC/CRA and the HF/GI (household adjusted and not) cases have household effects substantially higher than the estimates by MIT, EPA, EIA, CBO and ACCF-NAM. Indeed, the estimates by EPA, EIA, ACCF-NAM/NEMS, and CBO are a quarter (or less) of the higher estimates.

Table 17. Estimated 2020 Household Effects Under H.R. 2454

Case	Household Size	Projected Household Effect in 2020 (2005$)	Measure Used in Estimate	Context of Household Effect
EPA/IGEM	2.6	$84	Consumption	2020 economy
EPA/ADAGE	2.6	$105	Consumption	2020 economy
ACCF-NAM/NEMS	2.6	$111	Household Income	2020 economy
EIA/NEMS	2.6	$134	Consumption	2020 economy
CBO	2.6	$156	Net Economy-Wide Cost	2010 economy
MIT EPPA	2.6	$319	Welfare Effects	2020 economy
NBCC/CRA	2.6	$739	Purchasing Power	2010 economy
HF/GI Adjusted Household	2.6	$985	Disposable Income	2020 economy
HF/GI	4	$1,539	Disposable Income	2020 economy

Source: EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). CBO: Congressional Budget Office, *The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454*, (June 19, 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

However, as noted above, the estimates presented here are not strictly comparable, both because of the measure used to determine the effect and the accounting method used. In particular, the estimates by CBO and NBCC/CRA are in terms of the 2010 economy; i.e., the estimated impact in 2020 has been scaled to represent an equivalent impact in terms of the size of the 2010 economy.[102] The reason for this is that a 2020 economy will be substantially larger than the 2010 economy, and therefore, it is difficult to put a 2020 impact into today's context.

Based on the CBO documentation, CRS has estimated the imputed real discount rate as a proxy for the scaling methodology used by CBO to place its 2020 household effects estimates in the context of a 2010 economy. Based on CBO's projections of GDP growth, population growth, and inflation, that imputed real discount rate is estimated at 2%. As indicated by **Table 18**, the threshold point is lowered to $262 and the divide between the different cases is even more pronounced, but the general order of results is not significantly affected.

[102] It should be noted that CBO and NBCC/CRA use different methodologies to scale their 2020 impacts into a 2010 economy—methodologies that are not strictly compatible.

Table 18. Estimated 2020 Household Effects Under H.R. 2454 (Adjusted by CRS)

Case	Household Size	Projected Household Effect in 2020 (2005$)	Measure Used in Estimate
EPA/IGEM	2.6	$69	Consumption
EPA/ADAGE	2.6	$86	Consumption
ACCF-NAM/NEMS	2.6	$91	Household Income
EIA/NEMS	2.6	$110	Consumption
CBO	2.6	$156	Net Economy-Wide Cost
MIT EPPA	2.6	$262	Welfare Effects
NBCC/CRA	2.6	$739	Purchasing power
HF/GI Adjusted Household	2.6	$808	Disposable Income
HF/GI	4	$1,262	Disposable Income

Source: CRS analysis of data from: EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009,* (August 2009). ACCF-NAM/NEMS: SAIC, *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)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). CBO: Congressional Budget Office, *The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454*, (June 19, 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Impact on Industry and Carbon Leakage

The impact of any price increases from H.R. 2454 on households, industries, and businesses would depend on their responsiveness to the price signal, the distribution of safety net funds under H.R. 2454, and the impact of various other provisions of the bill that mandate, or could be used to encourage, conservation and new technology development. Simple attempts by some presentations to break down the cost by industrial sector or by state "*should be viewed with attentive skepticism*"[103] for at least two reasons. First, baseline forecasts are even less accurate at a sector level than they are at an aggregate national level. As noted by Winebrake and Sakva, sector level baseline forecasts have significantly higher errors compared with aggregate estimates, nor have sector estimates improved over the past two decades:

> We find that low errors for total energy consumption are concealing much larger sectoral errors that cancel each other out when aggregated. For example, 5-year forecasts made between 1982 and 1998 demonstrate a mean percentage error for total energy consumption of 0.1%. Yet, this hides the fact that the industrial sector was overestimated by an average of 5.9%, and the transportation sector was underestimated by an average of 4.5% We also

[103] As noted by CRS with respect to acid rain costs estimates in 1990. See CRS Report 90-63, *Acid Rain Control: An Analysis of Title IV of S. 1630*, by Larry Parker. (Available from the author.)

> find no evidence that forecasts within each sector have improved over the two decades studied here.[104]

Second, with respect to industry, the effect of H.R. 2454 is likely to be very site-specific, as the primary impact may be indirect in terms of added energy costs, not direct compliance costs. An industry-by-industry approach masks the interplay of companies that would be affected differently by H.R. 2454.

Most industries face a competitive market (sometimes international in scope) both in terms of producers of the same products and producers of substitute products. Also, in some cases, an industry may face a fairly elastic demand for its product. Thus, most industries are price sensitive, and therefore any increase in manufacturing costs hurts the competitiveness of a firm. This complex situation is further complicated for energy-intensive industries in the case of H.R. 2454 as competitors within the same industry may experience different energy price increases (particularly for electric power), depending on their individual energy needs and power arrangements. Thus, individual facilities within the same industry will be affected differently by H.R. 2454 and other unforeseen events in the future. For example, an aluminum plant receiving power from a hydro-electric facility may not be affected the same way as a similar plant with a power contract with a coal-fired power supplier.

This differential effect on individual companies under H.R. 2454 could have several potential impacts. First, as noted above, it may affect the competitive balance of specific facilities in the United States. Second, investment decisions by industries could be affected, particularly with respect to technology. New, more efficient technology is emerging for some processes. The combination of current price signals being sent from the energy markets and potential signals from H.R. 2454 could speed their development. If commercialized, new technology could reduce the impact of H.R. 2454 and, indeed, improve competitiveness. Not surprisingly, none of the cases presented here have sufficient industry sector detail to examine this possibility, nor did any attempt to develop proxies to explore the possibilities for industrial technology over the next 40 years.

Assistance to Energy-Intensive, Trade-Exposed Industries

International carbon leakage is the shift in GHG emissions from a country subject to regulation (e.g., cap-and-trade program) to an unregulated country, so no emissions reduction benefits are obtained. This would happen, for example, if a GHG-emitting industry moved from a country with an emissions cap to a country without a cap. H.R. 2454 includes two mechanisms for addressing this issue: (1) a free allowance allocation to energy-intensive, trade-exposed industries, and (2) an International Reserve Allowance scheme designed to impose a *de facto* tariff on the importation of energy-intensive goods into the United States from countries without "comparative" carbon policies.

Free Allowance Allocation to Energy-Intensive, Trade-Exposed Industries

Both EPA and EIA explicitly examined the impact of H.R. 2454's free allowance allocation to energy-intensive, trade-exposed industries. In the EPA/ADAGE analysis, energy intensive

[104] James J. Winebrake and Denys Sakva, "An Evaluation of Errors in US Energy Forecasts: 1982-2003," *Energy Policy* 34 (2006), p. 3475.

manufacturing output is projected to decline by 0.3% from base case level in 2015 and by 0.7% in 2020 without H.R. 2454's free allocation scheme. With the free allocation scheme, energy intensive manufacturing output is projected to increase by 0.04% in 2015 from base case levels, and then decline by 0.3% from base case level in 2020.[105] The free allocation scheme then phases out in the 2020s.

The EIA/NEMS analysis of energy-intensive trade-exposed industries indicates the free allocation to those industries reduces the impact of H.R. 2454 that they would otherwise bear. As stated by EIA:

> Receiving these permits ameliorates the impact of increased energy prices and therefore industries face energy prices that are not impacted by the permit values. As a result, when energy prices increase, the reductions in output of these trade- and energy-vulnerable industries are less than overall manufacturing impacts and mirror the impacts (in terms of percentage change from the Reference Case) of total industrial shipments. In past EIA analysis of industrial impacts of energy price increases, these energy-intensive industries typically experience larger losses compared to overall manufacturing.[106] [footnotes omitted]

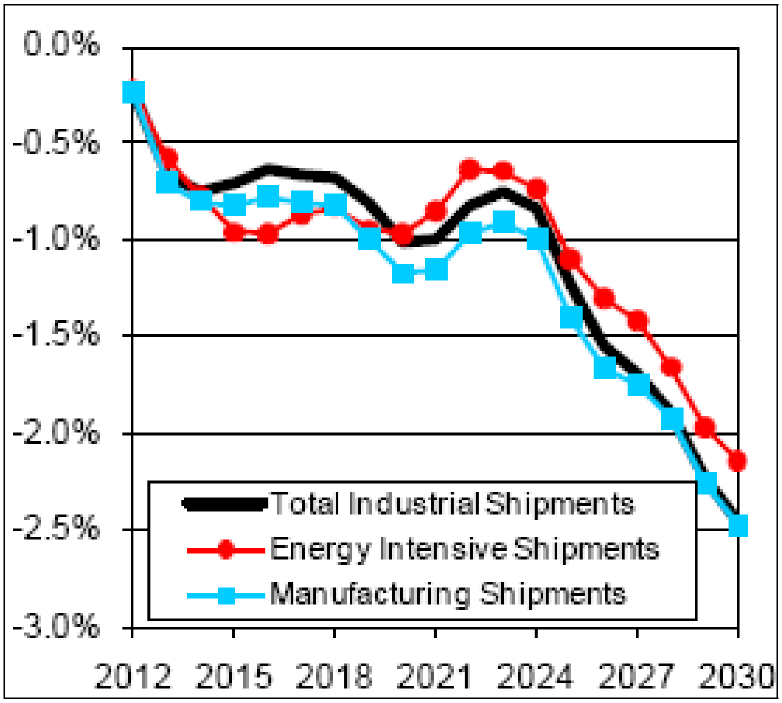
The overall effect of the free allocation over time can been seen in **Figure 23** from the EIA report. As indicated, the impact on energy-intensive, trade-exposed industries is comparable to industry as a whole, suggesting that the allowance allocation has a positive effect in alleviating any disadvantage they may have from being exposed to international competition from countries without comparable carbon policies.

[105] U.S. Environmental Protection Agency, *EPA Analysis of the American Clean Energy and Security Act of 2009: H.R. 2454 in the 111th Congress – Appendix* (June 23, 2009), p. 42.

[106] EIA, Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009 (August 2009), p. 44.

Figure 23. Industrial Impacts in the H.R. 2454 Basic Case, 2012-2030

(percent change from Reference Case)



Source: EIA, Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009 (August 2009), p. 45.

International Reserve Allowances

None of the cases examined the potential impact of the International Reserve Allowance (IRA) provisions contained in H.R. 2454. Indeed, the only analysis of an IRA scheme that has been done at all is one conducted by EPA (ADAGE) with respect to Title VI of S. 2191, introduced in the 110th Congress.[107] In that report, EPA's sensitivity analysis indicated that if countries without legally binding commitments to reduce greenhouse gases commit to maintaining their 2015 levels beginning in the year 2025, and to returning their emissions to 2000 levels by 2050, no international emission leakage occurred. Imports of energy-intensive goods were projected to fall under this scenario, while exports expanded as developing countries coped with their new emission limits.

In a worst case scenario, EPA's 2008 sensitivity analysis looked at a no-international-actions-to-2050 scenario. In this scenario, the International Reserve Allowance provisions of S. 2191 were assumed to be triggered because of the lack of international action. Emissions from countries without legally binding commitments were estimated to rise by 350 million metric tons of CO_2e by 2030 and 385 million metric tons by 2050—less than 1% of their basecase levels under ADAGE. It would have been equivalent to U.S. emission leakage rates of approximately 11% in 2030 and 8% in 2050. These emissions compared with increases of 361 million metric tons and

[107] EPA, *EPA Analysis of the Lieberman-Warner Climate Security Act of 2008: S. 2191 in 110th Congress* (March 14, 2008).

412 million metric tons for 2030 and 2050 respectively if the IRA provisions were not implemented. EPA described the impact of the IRA program on leakage as "minimal."[108]

The projected impact on imports was more significant. Without the International Reserve Allowance Requirement, imports from countries without legally binding commitments were projected to increase 5.4% in 2030, rising to 7% in 2050. In contrast, under the IRA provisions, imports were estimated to increase about 1% in 2030 and decline about 5% in 2050. U.S. exports declined in both cases as countries used more of their domestic manufacturing.[109]

If the EPA projections for S. 2191 are transferable to H.R. 2454, the differential effect of IRA provisions on trade versus emissions leakage could present problems if the scheme is brought before the World Trade Organization (WTO).

Major Points of this Section

- The allocation of allowance value in the bill could approach or exceed $100 billion per year (2005$), and will significantly exceed the compliance cost of the program. How those allowances are allocated will determine to a large degree who bears the cost of the program.
- Attempts to quantify the effects of the bill on household electric bills are complicated by several factors (beyond those that apply to the macroeconomic results) that include differences between state-level data and the LDC-level allocation in the bill, and the particular provisions of the bill included in the analysis.
- All of the cases predict higher energy prices over the baseline, but the magnitude of those price increases depends on the particular assumptions in the model on availability of technology and the role of other provisions in the bill that may blunt or magnify those price increases.
- Determining the overall effects on households is driven by three key considerations: (1) what welfare measure is chosen; (2) how a household is defined; and (3) what accounting methods are used to produce an estimate. These differences result in a wide range of estimated household costs—costs that vary over an order of magnitude (far more than the relative differences for other variables such as change in GDP).
- Predicting impacts to particular industries or sectors is even more difficult than economy-wide projections, as sector-level forecasts have produced significantly higher errors than aggregate estimates. Analysis by EPA and EIA suggests that the free allocation of allowances to energy-intensive, trade-exposed industries is effective in mitigating—but not eliminating—the increased cost of a program on them, and the negative effects on industrial output.

Ecological Issues

Climate Change Benefits

None of the cases examined here attempt to quantify or monetize the benefits of reducing greenhouse gases. This hole in reports designed to discuss the impacts of H.R. 2454 is not surprising. Like the cost estimates discussed above, benefit estimates are fraught with uncertainty. Thus, this discussion should be considered illustrative—more research and resources devoted to benefits analysis are necessary before more comprehensive reports will be available.

[108] EPA, *EPA Analysis of the Lieberman-Warner Climate Security Act of 2008: S. 2191 in 110th Congress* (March 14, 2008) p. 84.

[109] EPA, *EPA Analysis of the Lieberman-Warner Climate Security Act of 2008: S. 2191 in 110th Congress* (March 14, 2008) p. 85.

Monetizing Benefits: Some Illustrations

Monetizing benefits from reducing air pollutants has been attempted for decades. For example, during the debate in the 1980s on controlling sulfur dioxide, EPA conducted an illustrative analysis of the health benefits of promulgating a 1-hour sulfur dioxide National Ambient Air Quality Standard (NAAQS) as part of its Regulatory Impact Analysis (RIA).[110] Based on partial analysis of health impacts, EPA's illustrative exercise put the potential health benefits from stringent sulfur dioxide control at between zero and $385 billion (1984$) annually. These health-based benefits were in addition to a CRS partial estimate of welfare benefits from reducing sulfur dioxide that exceeded $4 billion (1985$) annually.[111]

Because climate change is a global problem, monetizing benefits from reducing greenhouse gases is difficult. Indeed, some consider the effort impossible, bordering on the unethical. The complexity of the global response is magnified by the need to value benefits that accumulate over 100 years or more. Discount rates—economics' approach to valuing benefits or costs that accrue in a future time period—used in attempts to value long-term damage from climate change range from 0 to 4-5% in the literature.[112] Indeed, the effect of discounting is so great on a long-term marginal damage estimate of climate change that "using standard assumptions about discounting [i.e., 4-5%] and aggregation, the marginal damage costs of carbon dioxide emissions are unlikely to exceed $50 tC [$14 tCO_2], and probably much smaller."[113] Indeed, estimates of the Social Cost of Carbon (SCC)—the marginal damage resulting from the addition of one more ton of CO_2—span over three orders of magnitude: from zero to over a $500 a ton.[114]

However, most current attempts to monetize environmental benefits are incomplete. The matrix presented in **Table 19** illustrates the problem. Most studies that attempt to monetize climate risks focus on the market impact of predictable, average changes in climate (the "easiest to measure" box of **Table 19**). Only a few attempt to value non-market impacts or extreme events and fewer still consider catastrophes or socially contingent impacts.[115] In reviewing 28 studies the UK Government had analyzed in re-examining its estimate of an appropriate Social Cost of Carbon, Ackerman and Stanton observed:

> That is, all of the studies that estimate the social cost of carbon base their numbers on an incomplete picture of climate risks—often encompassing only the simplest and most predictable corner of the vast, troubling canvas that has been painted by climate science. There is, of course, no way to assign monetary values to the global response to the possibility of widespread droughts across large parts of Asia, or an increase in the probability of a sudden change in ocean currents that would make the UK as cold as Canada, but in the

[110] Office of Air and Radiation, Environmental Protection Agency. *Regulatory Impact Analysis on the National Ambient Air Quality Standards for Sulfur Oxide (Draft)*. Research Triangle Park (1987), appendix B.

[111] *The Clean Air Standards Attainment Act: An Analysis of Welfare Benefits From S. 1894,* CRS Report 88-298 ENR (April 15, 1988) by Larry Parker (available from the author). For a further discussion of benefits, see CRS Report 90-72 ENR, *Potential Benefits of Enacting Clean Air Act Amendments* by John Blodgett. (Available from the author).

[112] Richard S.J. Tol, "The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties," *Energy Policy* (2005), pp. 2064-2074.

[113] Ibid., p. 2064.

[114] For a discussion of SCC uncertainty and the UK shadow cost of carbon, see Simon Dietz, *Review of DEFRA paper: "The Social Cost of Carbon and the Shadow Price of Carbon; What They Are, and How to Use Them in Economic Appraisal in the UK"* Review Comments (September 2007).

[115] Frank Ackerman and Elizabeth Stanton, *Climate Change—the Costs of Inaction,* Report to Friends of the Earth England, Wales and Northern Ireland (October 11, 2006), p. 26.

> understandable absence of such impossible monetary values, it is important to remember the disclaimer from the DEFRA [Department for Environment, Food & Rural Affairs] review: all estimates of the SCC [Social Cost of Carbon] omit some of the most important unpriced risks of climate change. The same disclaimer applies to virtually any quantitative economic estimate of climate impacts.[116]

Table 19. Matrix of Climate Risks

	Type of Impact (to the right)	Market Impacts	Non-market physical Impacts	Socially contingent Impacts
Predictability (below)	*Examples of impacts (to the right and below)*	Agricultural output, health costs, property loss	Deaths, extinctions, ecosystem damages	Migration, response to food & water shortages
Averages	Temperature, sea levels, atmospheric CO_2 steadily rising	***(Easiest to measure)***		
Extremes	Increased frequency and strength of heat waves, storms, droughts, floods			
Catastrophes	Polar ice sheets melting, "turning off" major ocean currents			***(Hardest to measure)***

Source: Tom Downing and Paul Watkiss, Overview: The Marginal Social Cost of Carbon in Policy Making: Applications, Uncertainty, and a Possible Risk Based Approach, *DEFRA International Seminar on the Social Costs of Carbon* (2003), as adapted by Frank Ackerman and Elizabeth Stanton, *Climate Change—the Costs of Inaction,* Report to Friends of the Earth England, Wales, and Northern Ireland (October 11, 2006).

The matrix also indicates the moral dilemma presented by efforts to monetize damages—a dilemma magnified by the issue of intergenerational discounting. The notion that premature deaths, extinctions, and other such potential impacts are less important because they occur in some future generation is, for some, morally problematic. Criticizing the UK government attempt to put a price on climate change, the UK House of Commons Select Committee on Environmental Audit stated:

> Furthermore, given the inherent difficulties in putting a price on climate change, the Government's first priority in deciding on the merits of potential policies and construction projects ought to be deciding how they affect UK carbon budgets, and only secondly on what the monetary value of resulting carbon emissions would be.[117]

Besides moral considerations, one's valuation of the social cost of carbon is dependent on one's assumptions about the emissions path the world is on.[118] This is due to the relationship between atmospheric concentrations of GHGs and radiative forcing (i.e., the higher the atmospheric concentration, the less the effect of one more ton on warming), the relationship between climate

[116] Ibid., p. 26.

[117] The United Kingdom Parliament, Select Committee on Environmental Audit, *Third Report* (February 26, 2008), in press.

[118] Simon Dietz, *Review of DEFRA paper: "The Social Cost of Carbon and the Shadow Price of Carbon; What They Are, and How to Use Them in Economic Appraisal in the UK"* Review Comments (September 2007) pp. 5-10.

change and economic impacts (i.e., the higher the damage, the less the effect of one more ton on that damage), and discounting (impacts occurring earlier are valued more than impacts occurring later).[119] This phenomenon is illustrated in *The Stern Review* on the economics of stabilizing climate change.[120] As shown in **Table 20**, the SCC declines as the path of emissions is projected to result in less severe damages. Such estimates would increase over time as the damage got closer and closer.

Table 20. *The Stern Review* Estimates of Social Cost of Carbon for Three Emissions Paths

Stabilization Scenario	Social Cost of Carbon (per metric ton, 2005$)
Business-as-usual (no effort to stabilize emissions beyond basecase levels)	$95
On a path to stabilize GHG concentrations at 550 ppm	$34
On a path to stabilize GHG concentrations at 450 ppm	$28

Source: Sir Nicholas Stern, *The Economics of Climate Change: The Stern Review* (2006) p. 304. Estimates converted to 2005$ using the GDP implicit price deflator.

In an attempt to respond to the implications of climate change and *The Stern Review*, the UK Government has instituted a shadow price for carbon to be used in official cost-benefit analyses.[121] A shadow price is a little different from a Social Cost of Carbon value. The latter is an attempt to determine the marginal damage resulting from the addition of one more ton of CO_2—it indicates what people should be willing to pay now to avoid the future damage caused by more carbon emissions. In contrast, a shadow price represents a cost or benefit from a good when the market price is a poor indicator of economic value or there is no market at all. The UK shadow price of carbon is based on the Social Cost of Carbon of a 550 ppm stabilization goal as determined in *The Stern Review*, plus consideration of abatement costs and the value of UK leadership in encouraging global participation and from being out front in developing new technology. The result is a shadow price of about $45 a ton in 2012 (2005$), rising 2% annually thereafter in real terms.

Using this shadow price of carbon and the UK Green Book[122] discount rates of 3.5% for the first 30 years and 3.0% afterward, the net present value (NPV) of H.R. 2454's estimated reductions over the life of the program (2012-2050) would range from $4.3 trillion (EPA/ADAGE case) to $5.4 trillion (NBCC/CRA case) in 2005 dollars. To complete this illustrative exercise, NBCC/CRA case estimates the net present value of the welfare effects (i.e., consumption) of H.R. 2454 at $2.6 trillion (5% discount rate, 2005$)

[119] Ibid., p. 6.

[120] Sir Nicholas Stern, *The Economics of Climate Change: The Stern Review* (2006).

[121] UK Department for Environment, Food, and Rural Affairs, *The Social Cost of Carbon And The Shadow Price of Carbon: What They Are, And How To Use Them In Economic Appraisal In The UK* (December 2007).

[122] HM Treasury, *The Green Book: Appraisal and Evaluation in Central Government,* (2003), Appendix 6, p. 97.

Not surprisingly, the estimates illustrated here have been criticized by some (including the UK Parliament) for being too low and incomplete, and for discounting future generations. For example, if one objects to the discount of future generations, an undiscounted flow of benefit estimates based on the UK shadow price of carbon from H.R. 2454's estimated reductions ranges from $8.6 trillion (EPA/ADAGE) to $12.4 trillion (NBCC/CRA) in 2005 dollars.

Likewise, others have criticized the estimates as too large and inflated. For example, in its 2008 assessment of new average fuel economy standards, the Bush Administration's U.S. National Highway Traffic Safety Administration (NHTSA) chose to value carbon reductions at $7 a ton and employ a 7% discount rate.[123] Applied to the reduction estimated under H.R. 2454, the resulting NPV would be about one order of magnitude lower than the UK shadow price-based estimates. Thus, reminiscent of EPA's illustrative calculation of the health benefits of a 1-hour sulfur dioxide standard, the illustration here results in a range of climate-related benefits from reducing greenhouse gases under H.R. 2454 at between zero and $200 billion annually (2005$).[124]

As illustrated with the long-term cost estimates presented in this report, attempts to monetize climate-related benefits currently reflect much about the philosophies and assumptions of the people doing the estimating. As stated in *The Stern Review*: "It is very important ... to stress that such estimates [NPV of climate change policy benefits] reflect a large number of underlying assumptions, many of which are very tentative or specific to the ethical perspectives adopted."[125] Likewise, these modeling exercises may be useful for conducting sensitivity analysis to gage the potential impact of various policy options and assumptions.

Putting Emission Reductions under H.R. 2454 into Context

It is difficult to put the actions of one country's emissions reduction plan in the context of a fragmented global effort to address climate change. One useful perspective is provided by MIT's general study of cap-and-trade bills conducted in 2008.[126] Using the MIT Integrated Global System Model (IGSM), MIT explored the climate response to different stabilization goals being discussed in the international community. It developed parameterizations of IGSM that

[123] For a discussion of NHTSA's rationale for its estimate, see Department of Transportation, National Highway Traffic Safety Administration, *Average Fuel Economy Standards: Passengers and Light Trucks: Model Years 2011-2015*, Notice of Proposed Rulemaking (April 2008) pp. 216-222. In its final rule for model year 2011, the Obama Administration used a different price and discount rate.

[124] A zero or near-zero estimate could result from one of three lines of thought: (1) denial that climate change is occurring; (2) belief that the potential benefits of a warmer climate cancel out the damages from that change; or (3) the damages will not be great (at least for the United States) and are far in the future—justifying a low damage evaluation and a high discount rate. It appears that NHTSA employed the final line of thought in its proposed rulemaking. As stated by NHTSA: "Although no estimates of benefits to the U.S. itself that are likely to result from reducing CO_2 emissions are currently available, NHTSA expects that if such values were developed, the agency would employ those rather than global benefit estimates in its analysis. NHTSA also anticipates that if such values were developed, they would be lower than comparable global values, since the U.S. is likely to sustain only a fraction of total global damages resulting from climate change." Department of Transportation, National Highway Traffic Safety Administration, *Average Fuel Economy Standards: Passengers and Light Trucks: Model Years 2011-2015*, Notice of Proposed Rulemaking (April 2008) p. 220.

[125] Sir Nicholas Stern, *The Economics of Climate Change: The Stern Review* (2006) p. 304.

[126] Sergey Paltsev, et al., *Assessment of U.S. Cap-and-Trade Proposals*, MIT Joint Program on the Science and Policy of Global Change, Report No. 146 (April 2007). Readers are urged to consult the report for details on the analysis discussed here.

represented each of three major atmosphere-ocean general circulation models (AO GCMs) that would help illustrate the uncertainty in translating emission trends into an estimate of climate change: those of the Goddard Institute for Space Studies (CISS-SB), the Geophysical Fluid Dynamics Laboratory (GFDL-2.1), and the National Center for Atmospheric Research (CCSM3).

MIT simulated the climate effects of six different policy scenarios through 2100. Four of these are of interest in exploring H.R. 2454:

- (1) a reference scenario that assumes no specific global climate policy ("Reference");
- (2) a global participation scenario ("Global Participation, 203 bmt case"),
- (3) a global participation scenario where abatement efforts in developing countries are delayed until 2050 ("Developing Countries Delayed");
- and (4) a partial participation scenario where no abatement efforts occur in developing countries ("Developed Only").

Under scenarios 2, 3, and 4, developed countries (including the United States) are assumed to have reduced emissions by 50% below 1990 levels by 2050 (and held them there through 2100). This assumption is in the ballpark of U.S. reductions anticipated under H.R. 2454 (given the projected substantial use of foreign offsets). For developing countries, scenario 2 assumes their emissions reductions begin in 2025, with emissions returning to their 2015 levels, and with additional reductions beginning in 2035 with emissions returning to their 2000 levels, and are held there; scenario 3 assumes emissions reductions are delayed until 2050, at which point they return to 2000 levels; and scenario 4 assumes developing country emissions are not stabilized at all.

The climate effects of these scenarios as simulated by MIT IGSM replication of the three AO GCMs identified above is shown in **Figure 24**. As indicated by the red line, the impact of H.R. 2454, combined with that of the other developed countries (all of which have ratified the Kyoto Protocol), is to reduce by 0.5 degrees C the projected 3.5 degrees C to 4.5 degrees C increase in global mean temperatures suggested by the simulations. If the United States chose not to reduce, the impact would be to move the red, green, and blue lines closer to the reference case line. With respect to the red line, it should be noted that, in 2000, the United States' greenhouse gas emissions were about 40% of the developed world's total emissions. In terms of the effect of any U.S. reductions on global mean temperatures, that is about all that can be said in isolation. As noted by MIT:

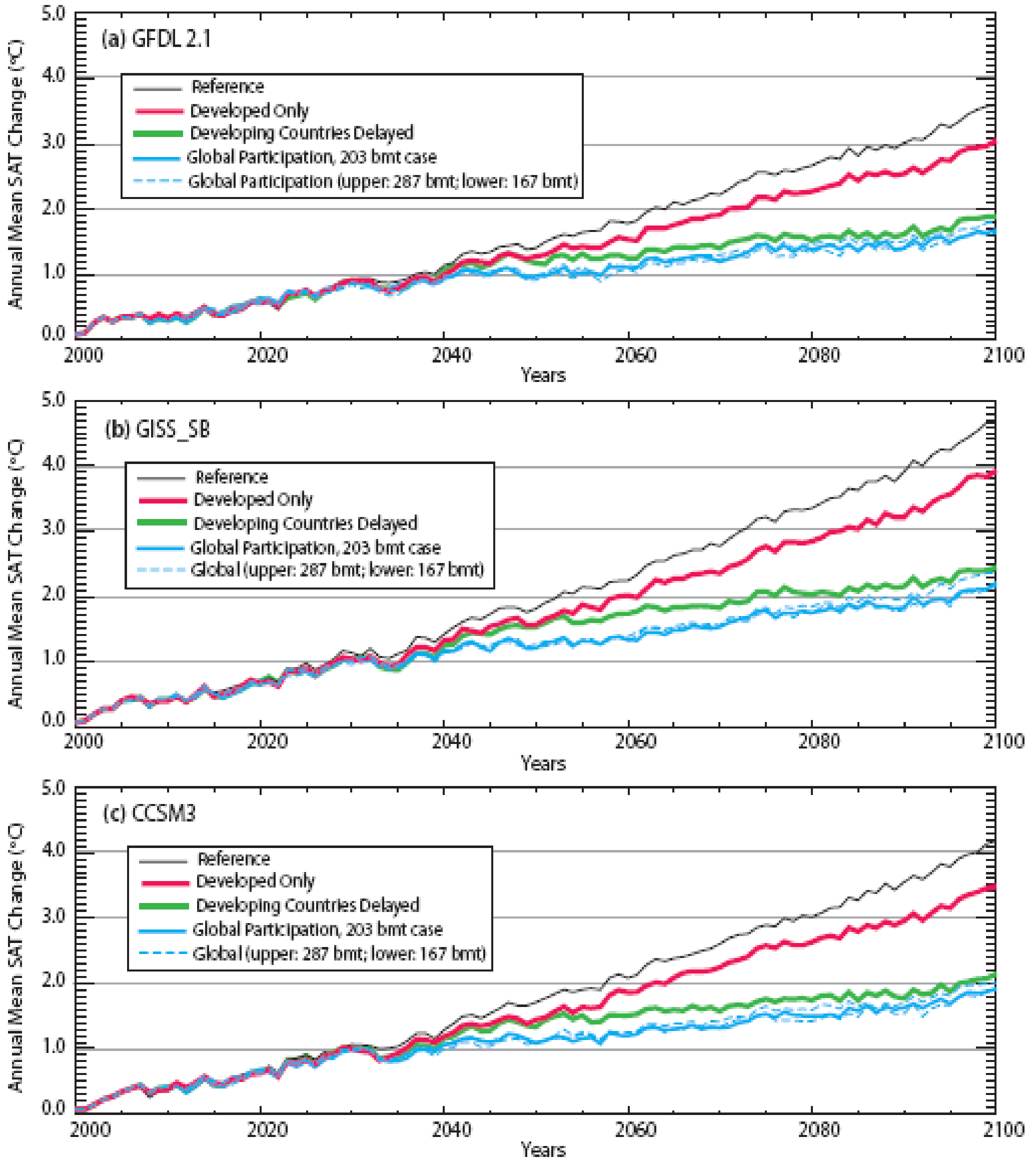
> ...it is not possible to connect specific U.S. policy targets with a particular global concentration or temperature target, and therefore the avoided damages, because any climate gains depend on efforts in the rest of the world.... If a cooperative solution is at all possible, therefore, a major strategic consideration in setting U.S. policy targets should be their value in leading other major countries to take on similar efforts.[127]

Thus, H.R. 2454's climate-related environmental benefit should be considered in a global context and the desire to engage the developing world in the reduction effort. It is in this context that the United States and other developed countries agreed both to reduce their own emissions to help

[127] Ibid., p. 55.

stabilize atmospheric concentrations of greenhouse gases and to take the lead in reducing greenhouse gases when they ratified the 1992 United Nations Framework Convention on Climate Change (UNFCCC). **This global context raises two issues for H.R. 2454: (1) whether H.R. 2454's greenhouse gas reduction program and other provisions would be considered sufficiently credible by developing countries so that schemes for including them in future international agreements become more likely, and (2) whether H.R. 2454's reductions meet U.S. commitments to stabilization under the UNFCCC and occur in a timely fashion so that global stabilization may occur at an acceptable level.**

Figure 24. Global Mean Surface Air-Temperature Increase in Six Scenarios Using the MIT IGSM



Source: Sergey Paltsev, et al., *Assessment of U.S. Cap-and-Trade Proposals*, MIT Joint Program on the Science and Policy of Global Change, Report No. 146 (April 2007) p. 51. Available at http://mit.edu/globalchange. Used by permission. Readers are urged to consult the report for details on the analysis discussed here.

Non-Climate Change Air Quality Benefits

As noted earlier, the estimates of emission reductions from non-greenhouse gas air pollutants suffer because of difficulties in determining a "business as usual" baseline. However, values have been assigned to these pollutants from time to time. For example, in the notice of proposed rulemaking for the new average fuel economy standard, the Department of Transportation assigned emission damage costs of $3,900 a short ton for nitrogen oxides, $16,000 a short ton for sulfur dioxide, and $164,000 a short ton for particulate matter—all pollutants that are also emitted from coal-fired generating facilities.[128] This may be an incomplete set of pollutants that would be reduced by H.R. 2454. Other benefits may occur from reductions of pollutants such carbon monoxide.

In promulgating the Clean Air Mercury Rule for electric generating units in 2005, EPA estimated the direct benefits of reducing mercury emissions by 70% at as little as $400,000 annually. But the agency did not include the results of two peer-reviewed studies (one of which it had funded) in its estimates. One of the two studies estimated the benefits of mercury control at $1.3 billion annually; the second study estimated the benefits at $5.2 billion annually.[129]

Major Points of this Section

- None of the cases examined in this report attempted to quantify the benefits of reducing greenhouse gas emissions under H.R. 2454, but doing so is at least as difficult as projecting costs, particularly given the very long time periods (100 years or more) that make the results even more sensitive to modelers' assumptions and perspectives.
- Because of these differences in perspective and techniques, estimates of the social cost of carbon span three orders of magnitude.
- The potential benefits of H.R. 2454's climate-related environmental benefit should be considered in a global context and the desire to engage the developing world in the reduction effort.

Conclusion

This report examines seven studies that project the costs of the cap-and-trade provisions of H.R. 2454 to 2030 or 2050. It is difficult (and some would consider it unwise) to project costs up to the year 2030, much less beyond. The already tenuous assumption that current regulatory standards will remain constant becomes more unrealistic, and other unforeseen events (such as technological breakthroughs) loom as critical issues which cannot be modeled. Hence, ***long-term cost projections are at best speculative, and should be viewed with attentive skepticism. The finer and more detailed the estimate presented, the greater the skepticism should be.*** In the words of the late Dr. Lincoln Moses, the first Administrator of the Energy Information Administration: "There are no facts about the future."[130]

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[128] Department of Transportation, National Highway Traffic Safety Administration, *Average Fuel Economy Standards: Passengers and Light Trucks: Model Years 2011-2015,* Notice of Proposed Rulemaking (April 2008), p. 182.

[129] For more information, see CRS Report RL32868, *Mercury Emissions from Electric Power Plants: An Analysis of EPA's Cap-and-Trade Regulations*, by James E. McCarthy, pp. 11-13.

[130] Lincoln E. Moses, Administrator, Energy Information Administration, *Annual Report to Congress—1977, Volume 2,* (1978).

But if models cannot predict the future, they can indicate the sensitivity of a program's provisions to varying economic, technological, and behavioral assumptions that may assist policymakers in designing a greenhouse gas reduction strategy. The various cases examined here do provide some important insights on the costs and benefits of H.R. 2454 and its many provisions.

First, if enacted, the ultimate cost of H.R. 2454 would be determined by the response of the economy to the technological challenges presented by the bill. The bill provides numerous price, research and development, deployment, and regulatory incentives for technology innovation. The potential for new technology to reduce the costs of H.R. 2454 is not fully analyzed by any of the cases examined, nor can it be. The process of technology development and dissemination is not sufficiently understood at the current time for models to simulate that process with any long-term confidence. In the same vein, it is difficult to determine whether the various incentives provided by the bill are directed in the most optimal manner, as in many cases the bill focuses on specific technologies.

Second, the distribution of allowance value (either through free allocations or auction revenue) under H.R. 2454 will determine who bears much of the program's cost. The allowances created by H.R. 2454 (essentially licenses to emit a metric ton of carbon dioxide equivalent) will have market value based on supply and demand. Total allowance value could approach or exceed $100 billion (2005$) annually—significantly more than the projected costs to comply with the bill's emissions reduction requirement. H.R. 2454 transfers that value to a wide range of covered and non-covered entities. Entities receiving that value will bear less of the program's costs compared with those who do not. The major impact of H.R. 2454's allowance allocation scheme is not in changing the costs required to comply with the program's reduction requirement; instead, it is in changing who bears those costs.

Third, the cases studied generally indicate that the availability of offsets (particularly international offsets) is a major factor in determining the cost of H.R. 2454. Sensitivity analyses generally found that eliminating international offsets would raise allowance prices by 60% or more. In general, those studies that assumed restrictive (and in some cases, declining) offset supply projected higher allowance prices. Cases that ramped up availability of offsets generally projected lower allowance prices. No case assumed that the full amount of offsets permitted under H.R. 2454 would be available or used immediately in 2012.

Fourth, the interplay between nuclear power, renewables, natural gas, and coal-fired capacity with carbon capture and storage (CCS) among the cases emphasizes the need for a low-carbon source of electric generating capacity in the mid- to long-term. A considerable amount of low-carbon generation will have to be built under H.R. 2454 in order to meet the reduction requirement. The cases presented here do not agree on the amount of new generating capacity necessary under the bill, or the mix of fuels and technologies that would be employed. The estimated amount of capacity constructed depends on the cases' assumptions about the need for new capacity and replacement/retirement of existing capacity under H.R. 2454, along with consumer demand response to the rising prices and incentives contained in the bill. Here again, technological development will be critical.

Fifth, attempts to predict household effects (or conduct other fine-grained analyses) are fraught with numerous difficulties; estimates generated reflect more on the philosophies and assumptions of the cases reviewed than on any credible future effect. Decisions about appropriate welfare measure, household size, and discounting, and, indeed, the value of government services in general, dwarf any insight that could be gained from such estimates. For example, estimates of household effects in the studies reviewed vary by an order of magnitude, even when normalized by household size and accounting method. Likewise, fine-grained analysis of effects on specific states and/or economic sectors are similarly suspect.

Sixth, H.R. 2454's climate-related environmental benefit should be considered in a global context and the desire to engage the developing world in the reduction effort. When the United States and other developed countries ratified the 1992 United Nations Framework Convention on Climate Change (UNFCCC), they agreed both to reduce their own emissions to help stabilize atmospheric concentrations of greenhouse gases and to take the lead in reducing greenhouse gases. **This global scope raises two issues for H.R. 2454: (1) whether the bill's greenhouse gas reduction program and other provisions would be considered sufficiently credible by developing countries so that schemes for including them in future international agreements become more likely, and (2) whether the bill's reductions meet U.S. commitments to stabilization under the UNFCCC and occur in a timely fashion so that global stabilization may occur at an acceptable level.**

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