Appendix C: Cost of Climate Policy and the Waxman-Markey American Clean Energy and Security Act of 2009 (H.R. 2454)[1]

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Abstract

The American Clean Energy and Security Act (H.R.2454) passed the House of Representatives after the completion of the main report (MIT Joint Program Report 173). In this Appendix we provide an analysis of the Act's provisions as they relate to key features governing the cap-and-trade system, the renewable electricity standard (RES), limits on new coal power plants and support for carbon capture and storage(CCS), applying the Emissions Prediction and Policy Analysis (EPPA) model used in the main report. While the overall economy-wide target in H.R. 2454, of no more than 161 billion metric tons of CO_2-equivalent released through 2050, is similar to the 167 bmt case analyzed in the main report, other features of the Bill significantly affect projections of its cost. We find that the large allowance for outside credits could reduce the cost if indeed these are forthcoming (and inexpensive). Other provisions, such as how the revenue and allowances will be distributed, will have important distributional consequences as well, but their analysis is beyond the scope of the study presented here.

Our central estimate shows the CO_2-e price starting at $21 per ton in 2015 and rising to about $84 by 2050. We decompose the welfare costs into a total cost including H.R. 2454 and recent legislation that was motivated in part for its GHG benefits (the Energy Independence and Security Act of 2007 and American Recovery and Reinvestment Act of 2009) vs. the additional cost of H.R 2454 itself given these preexisting measures. The national welfare cost of reaching the emissions targets outlined in H.R. 2454, attributable to the bill itself, rise from about 0.1 percent to 1.45 percent over the period 2015-2050. We estimate average annual net present value cost of H.R. 2454 of about $400 per household over this horizon, but given different assumptions about the availability of offsets this estimate ranges from as low as $180 to as high as $470. A rough comparison of costs with analyses by the CBO, EIA and EPA shows results in the same general range, though our estimates are higher.

Contents

[1] This is an appendix to Paltsev *et al.* (2009): The Cost of Climate Policy in the United States, MIT Joint Program on the Science and Policy of Global Change, *Report 173* (http://globalchange.mit.edu/pubs/abstract.php?publication_id=1965).

C1. FEATURES OF H.R. 2454 AND IMPLEMENTATION IN THE EPPA MODEL

We rely on a version of the bill as passed by the House of Representatives on June 26, 2009, recognizing that final legislation will depend on details of a Senate bill and reconciliation with the House version. H.R. 2454 is composed of five main titles. Title I deals with clean energy, setting up a combined efficiency and renewable electricity standard as well assistance for various advanced technologies. Title II focuses further on energy efficiency, creating a number of programs and standards for buildings, lighting, and appliances. Title III establishes a cap-and-trade system for greenhouse gases (GHGs). Title IV addresses the transition to a clean economy and competitiveness issues. Title V deals with agricultural and forestry related offsets.

General Provisions

Title III, establishing the cap-and-trade system, is the main focus of our analysis. The cap covers seven GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Covered entities include large stationary sources emitting more than 25,000 tons of GHGs per year, producers (i.e., refineries) and importers of all petroleum fuels, distributors of natural gas to residential, commercial and small industrial users (i.e., local gas distribution companies), producers of “F-gases,” and other specified sources. The cap is intended to ultimately cover 84.5% of total U.S. GHG emissions. The cap gradually reduces aggregate GHG emissions for all covered entities to 3% below 2005 levels in 2012, 17% below 2005 levels in 2020, 42% below 2005 levels in 2030, and 83% below 2005 levels in 2050. Commercial production and imports of HFCs are to be covered under a separate cap, which we do not assess. Previous analysis of such a separation suggests that it raises the costs of meeting the targets by a substantial amount considering that HFC emissions represent a small share of the GHG total. The bill also establishes economy-wide goals for all sources.

For the capped sectors, the bill lays out year-by-year allowances. We simplify the policy by assuming that a cap-and-trade system covers all emissions, and so the allowance path is prescribed to align with the economy-wide reduction goals laid out in the bill: 80% of 2005 levels by 2020, 58% by 2030, and 17% by 2050. We thus assume that measures directed at sectors not covered by the cap will be effective at achieving reductions, in a manner as economically efficient as if they were under the cap (i.e. the marginal costs of reduction in the capped and uncapped sectors would be comparable). With banking and borrowing, the most important aspect of the allowance path is its cumulative emissions over the life of the policy (2012-2050), which are 161 billion metric tons (or, gigatons, Gt) CO_2-e. Since the cap and trade system is covering an estimated 85% of US emissions we expect the additional 15% coverage to have a relatively small effect on the overall costs. Allowances for covered sectors alone amount to 132 Gt CO_2-e of cumulative emissions. The allowance path and economy-wide goals are presented in **Figure C1**. The highly non-linear sectoral allowance path in the early years reflects the fact that not all sectors are immediately covered by the cap, and so actual allowances are proportionately lower. In our simplified path, representing the national economy goals, all sectors are covered from the start.

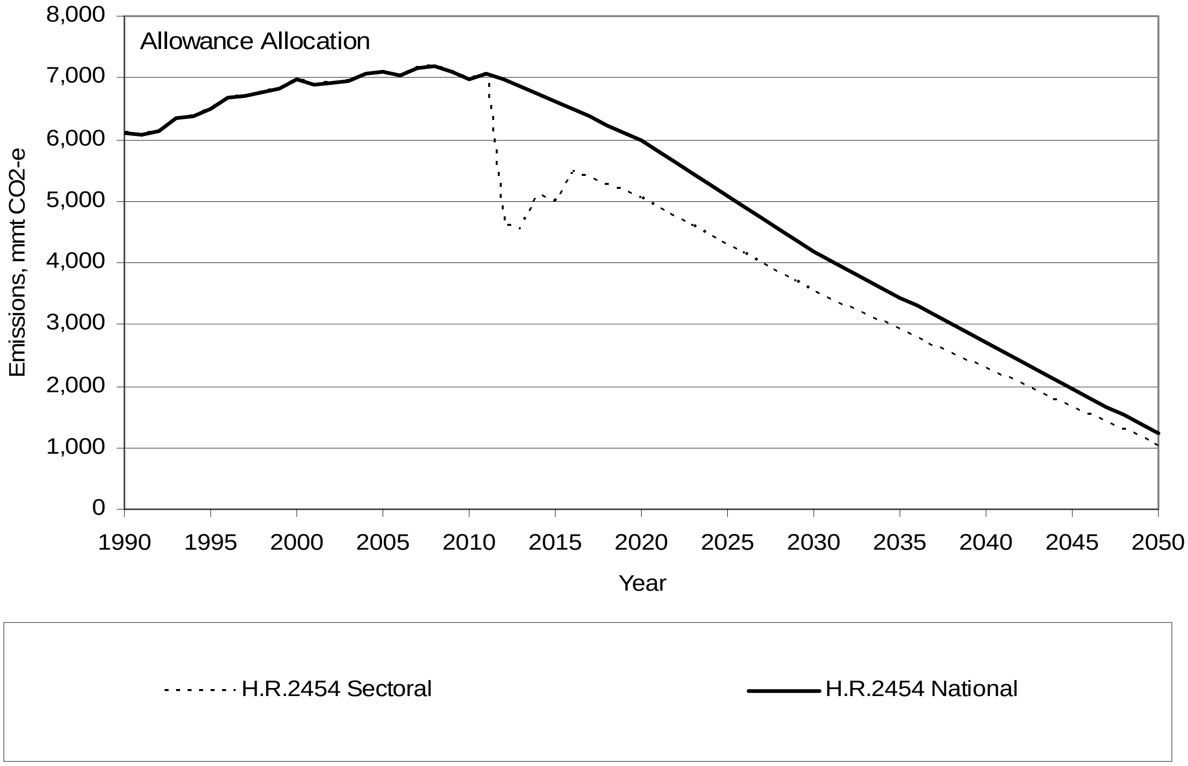

Figure C1. Allowance Allocation for Covered Sectors and National Emissions Goals.

Cost Containment

Several cost-containment measures are included in the bill. Up to two billion tons (or gigatons—Gt) of credit offsets can be used each year in lieu of allowances—1 Gt from domestic sources and 1Gt from international sources. However, if the domestic supply of offsets is insufficient, EPA can raise the international limit up to 1.5 Gt, but the 2 Gt total limit still applies. For international offsets, beginning in 2018, 1.25 offset credits would be required for each ton of emissions compliance. The EPA would determine the list of eligible offset projects based on recommendations from an Offsets Integrity Advisory Board. Title V of the bill establishes an offset program specific to domestic agriculture and forestry sources, to be administered by the Secretary of Agriculture.

While credits are allowed, the actual amount forthcoming in any year will depend on how they are defined, the extent to which their definition will avoid the traditional bureaucracy of credit programs, and the competition for them from foreign cap-and-trade programs. Until these features are resolved one can only speculate on how they will influence offset supply. We thus consider two offset paths:

(1) Full Offsets - we add 2 Gt to the total national allowances in each year, at a specified cost per ton CO_2-e.

(2) Medium Offsets - we impose a gradual path of offset use that builds up to 2 Gt by 2050, similarly at a specified cost.

The reasoning behind the latter path is that, even if the full level of offsets were available, the process of setting up a program to evaluate and approve them will be slow. Under these assumptions, cumulative emissions within the U.S. national cap are 239 Gt CO_2-e from 2012 to 2050 with full offsets and 203 Gt CO_2-e with medium offsets. These allowance-plus-offset paths are presented in **Figure C2**. To indicate the effect of the offset provision on the mitigation task, the allowed emissions path if there were no offsets is also shown in the figure.

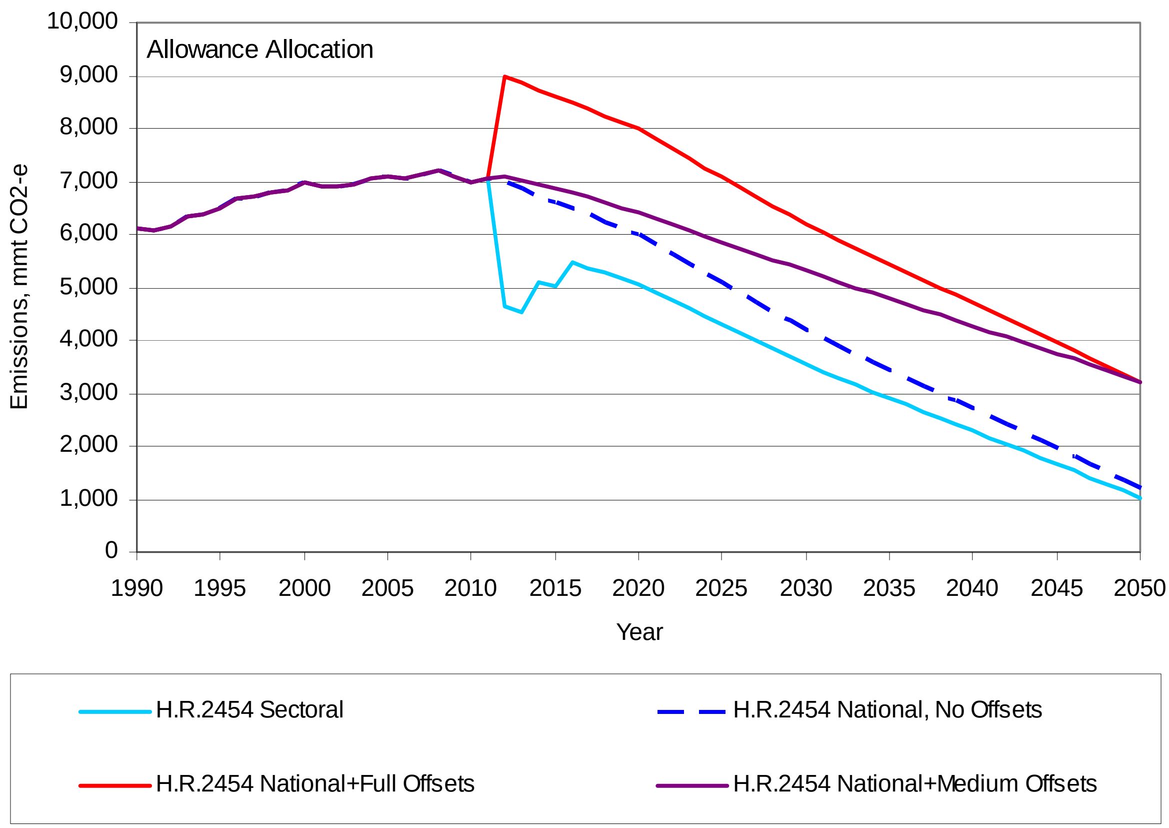

Figure C2. National Emissions Goals with Alternative Offset Paths.

We further assume offsets have a cost to the economy, and implement this assumption by transferring abroad the value of allowances purchased internationally. Our default assumption is that the average cost of these credits is $5 per effective ton of offsets CO_2-e in 2015, rising at 4% per year thereafter.[2] Later we provide the results with alternative assumptions about the cost of offsets: $15 per ton at the start and if available at no cost throughout.

Another cost containment provision is banking and borrowing. In the bill, banking of allowances is unlimited and a two-year compliance period allows unlimited borrowing from one

[2] The bill specifies that 1.25 tons of foreign reductions are required to produce 1 ton of effective offsets. The $5/ton initial offset price means the actual payment per ton of foreign reduction is $4.

year ahead without penalty. Limited borrowing (15%) from two to five years ahead is also allowed, but with interest. We consider the allowance banking and borrowing provisions in our analysis. In general, we find no need for aggregate borrowing, and so there is no need to implement an explicit restriction on it. Also included in the bill is a strategic allowance reserve auction that sets aside a small percentage of allowances (1% in 2012-2019, 2% in 2020-2029, and 3% in 2030-2050) to be auctioned to contain short run allowance price spikes. The initial minimum price level for the auction would be set at $28 in 2012, and rise at 5% plus inflation for 2013 and 2014. Beginning in 2015, the reserve auction trigger price would be 60% above the rolling 36-month average of the market price of allowances. There are additional limits on the amount auctioned from the reserve each year and the amount each entity can purchase. The EPPA model simulates the economy on 5-year time steps and so it is not possible for us to consider the short-run dynamics under which this provision might be important. We assume all of this reserve is released to the market.

Title III also describes how allowances will be distributed, either through an auction or distribution at no cost. A large portion of allowances or auction revenues are distributed so as to return the value to lower and middle income households and to offset increases in energy costs. Emission allowances are also distributed to aid energy intensive, trade-vulnerable industries and domestic refiners and to support investment in clean technologies including carbon capture and storage (CCS), advanced vehicle technology, and energy R&D through various mechanisms including funding a State Energy and Environmental Development (SEED) program. These features of the bill are important in determining its distributional effects among income groups, but because EPPA has a single representative agent, they are not relevant to our analysis.

Renewables and Efficiency

Title I lays out a combined efficiency and renewable electricity standard which requires retail electric suppliers that sell more than 4 million megawatt hours of electricity to meet a growing percentage of their load with electricity generated from renewable resources and from electricity savings. The combined renewable electricity and electricity savings requirement begins at 6% in 2012 and gradually rises to 20% in 2020, where it stays until 2039. An interesting and potentially important aspect of the bill is the calculation of the base against which this percentage applies. In particular, the base is total electricity production minus: (1) electricity from non-qualified hydroelectric facilities, (2) electricity from nuclear generation built after the passage of this bill, (3) the proportion of electricity generated from fossil fuel plants that is equal to the proportion of GHGs those plants capture and geologically store, and (4) electricity from small utilities (those that sell less than 4 million MWh per year).[3] If RES requirement is not met there is an Alternative Compliance Payment of $25 per MWh (2.5 cents per kWh).

[3] The characteristics of the base are crucial to the economics of this provision. For example, if the cap-and-trade policy led to complete phase out of fossil generation at some point, replaced by nuclear and fossil with CCS, the requirement would be 20% of a base of zero.

With regard to the shares of renewables and efficiency improvement, the bill specifies that 75% of the requirement should be met by renewable energy while the remainder can come from reductions in electricity demand. The Federal Regulatory Commission can lower the renewables share to 60% upon petition from a state governor, but we do not consider this method of relaxing the target in our simulations. For purposes of simulating the renewable electricity standard (RES) in EPPA, the first simulation year is 2015, at which point the bill sets the RES at 9.5%, and this rises to 20% in 2020-2039. We further assume the target of 20% extends to 2050. In modeling the expansion of renewables required by the combined efficiency and renewables standard we take account of renewable supply that may already be in place in the baseline due to state RES programs and the American Recovery and Reinvestment Act of 2009 by implementing an estimate drawn from analysis by the Energy Information Administration (EIA, 2009).

The Bill does not specify a method for defining the contribution of electric demand reduction. It is possible to imagine its measurement, alternatively, in terms of the absolute reduction from the base-year level, as the reduction from a forecast baseline, or as the estimated savings from utility demand management programs. We model the contribution as the reduction from our projected, no-policy baseline. Reductions in excess of the contribution required to meet the efficiency component of RES can occur in our simulations simply because of the pass-through of higher generation costs in the electricity price. In these circumstances this 25% of the RES target is met through these electricity savings, at no additional cost.

Other Provisions

Sec. 782 of H.R. 2454 requires that a certain percentage of allowances in each year go toward the deployment of CCS technology. That percentage is 1.75% in 2015 and 5% in 2020-2050. To model this provision, we multiply the number of allowances going to CCS each year by the carbon price in that year and give the resulting amount of money to CCS technologies as a subsidy. We did not model additional bonus allowance provisions for CCS specified in the bill. We have modeled the performance standards for coal-fueled power plants as specified in Sec. 116 by ensuring that no new coal plants without CCS are built after 2025.

The bill has still other provisions that we do not consider. Other sections of Title I and Title II provide supports for energy efficiency and advanced technologies other than coal with CCS. Title I establishes State Energy and Environment Development (SEED) Accounts for energy efficiency and renewable energy deployment, and promotes clean energy investment, smart grid advancement and transmission planning and siting. Title II sets energy efficiency standards for buildings, lighting, appliances, and transportation and requires EPA to promulgate carbon emission standards for heavy-duty vehicles and off-road vehicles, such as construction equipment, trains, and large ships. These details are mostly below the level of detail of the EPPA model. Some of these features of the bill may be important for removing barriers to adoption of new technologies. Others may set standards that are redundant, given that the economy-wide cap will require substantial gains even without these standards. In general, the EPPA model assumes barriers will be overcome and so if these additional programs are an essential part of making that happen, any program costs associated with them are an additional macroeconomic cost beyond what we estimate in the model. If they go beyond what the cap would require, then they also would add to the cost by diverting abatement action to these more costly activities.

C2. ESTIMATES OF EMISSIONS PRICE AND COST UNDER H.R. 2454

We turn now to our estimates of the impacts of H.R. 2454 in terms of actual emissions reductions, CO_2-e prices, economy-wide welfare costs, and costs per average household. For a discussion of these and other cost concepts, see Appendix B of this report. Note that our analysis encompasses only the cost of emissions mitigation and so does not consider potential welfare improvements from ancillary benefits of emissions mitigation or from climate damages avoided. Our main results include the RES requirement and the cost of acquiring offsets. Because of the uncertainty about the offsets we show results for the two offset cases defined above. Later we with different assumptions about offset cost.

We present two views of the cost of the policy measures that would contribute to the achievement of the emissions target in H.R. 2454. A total cost measure includes the influence of other measures: the Energy Independence and Security Act of 2007 (EISA) which introduced biofuels and CAFE standards, the American Recovery and Reinvestment Act of 2009 (ARRA) which included subsidies to renewables, and state-level RES policies. This total cost is roughly consistent, assuming Medium Offsets, with the 203 bmt case in the main body of this report. The analysis of the cost implications of H.R. 2454 then treats the costs of these existing measures as sunk and considers only the incremental effort required to bring emissions down to the Bill's specified target. EISA and ARRA measures were implemented explicitly as fuels and technology requirements. As a result they impose a welfare cost on the economy but there is no explicit CO_2 price associated with these measures.

Emissions

Reference and policy emissions are presented in **Figure C3**. Estimates of the total cost of recently-imposed measures and H.R. 2454 are based on the Reference-No Policy baseline. The reduction effort required of H.R. 2454 then is defined in terms of a baseline that takes account of the reductions attributable to earlier measures, noted in the Figure as Reference+EISA+ARRA. Note that the banking of allowances over time leads to the emissions profiles that differ from the allowance paths in Figure C2. With banking and offsets the nominal national goal of 17% of 2005 emissions in 2050 (or 83% reduction) is not actually achieved. In the medium offsets case, emissions in 2050 are still about 68% of the 2005 level. In the full offset case, emissions by 2050 are about 87% of 2005 emissions. As long as the credits result in real reductions elsewhere, these different scenarios will have essentially the same effect on atmospheric concentrations, but they have different implications for what is required in terms of domestic changes in energy supply and use.

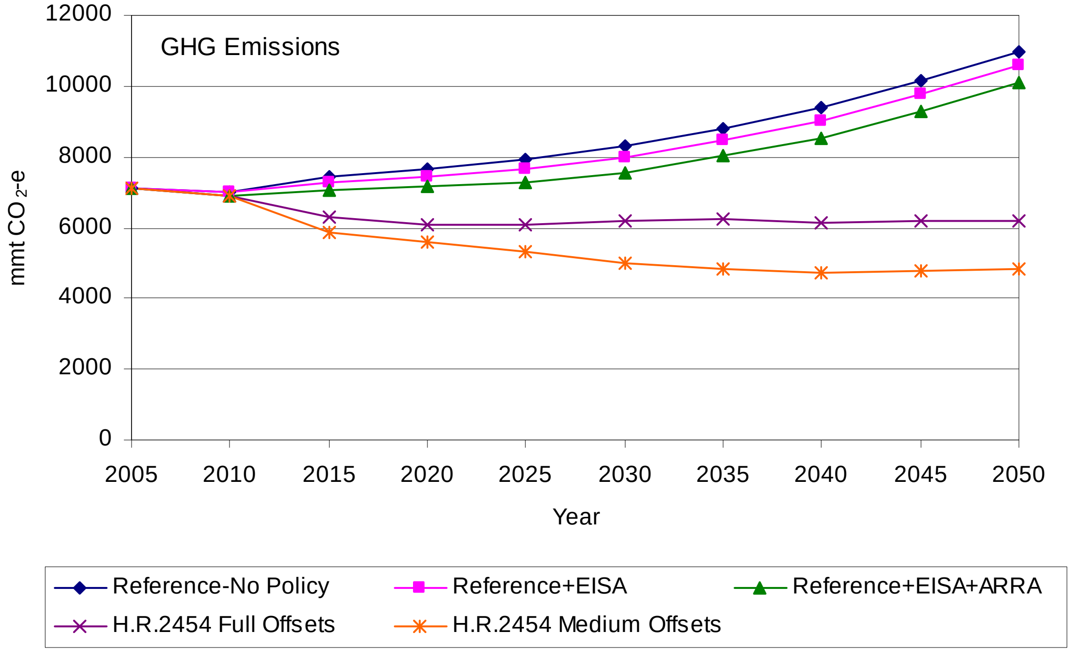

Figure C3. US GHG Emissions With and Without Policies.

Prices and Welfare

CO_2-e price and welfare effects are presented in **Figures C4 and C5** and in **Table C1.** For H.R. 2454 with medium offsets the initial price is \$21/tCO_2-e in 2015 and it rises to around \$84 per tCO_2-e by 2050. Carbon prices are lower than in the closest scenario in the main body of the report (203 bmt), where the price is projected to rise from \$39 to \$155. (H.R. 2454 with medium offsets and the 203 bmt scenario coincidentally results in the same cumulative emissions over 2012-2050.) A scenario with the full amount of offsets decreases the 2015 carbon price to \$7 with a price in 2050 of around \$29 per ton CO_2-e. The welfare costs of H.R. 2454 with medium offsets rise from 0.1% in 2015 to 1.45% in 2050, while the total cost of climate policy including EISA and ARRA is 0.3% in 2015 rising to 1.73% in 2050, again similar to the 203 bmt scenario, where they increase from 0.1% in 2015 to 1.75% in 2050.

The costs are higher and carbon prices are lower than the 203 bmt case due to several reasons: (1) Energy Independence and Security Act of 2007 and American Recovery and Reinvestment Act of 2009 introduce biofuels, CAFÉ standards and subsidies to renewables that reduce GHG emissions. As a result, they cover a part of the cost of reaching targets specified in H.R. 2454; (2) subsidies to CCS and the RES requirements in H.R. 2454 reduce the carbon price but increase the welfare cost of the policy (for more discussion of the interaction of renewable electricity requirement with a cap-and-trade system, see Morris, 2009); (3) our estimate of U.S. natural gas resources has also increased while our estimate of the cost of producing electricity from natural gas combined-cycle generation is lower reflecting recent evidence on resources availability and generation costs.

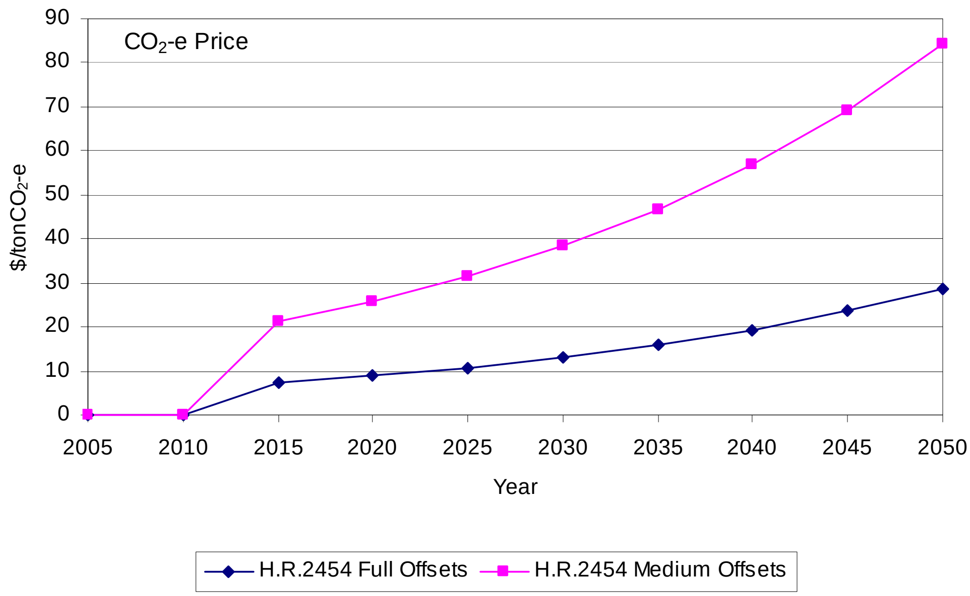

Figure C4. Carbon Prices in H.R. 2454 with Different Offsets.

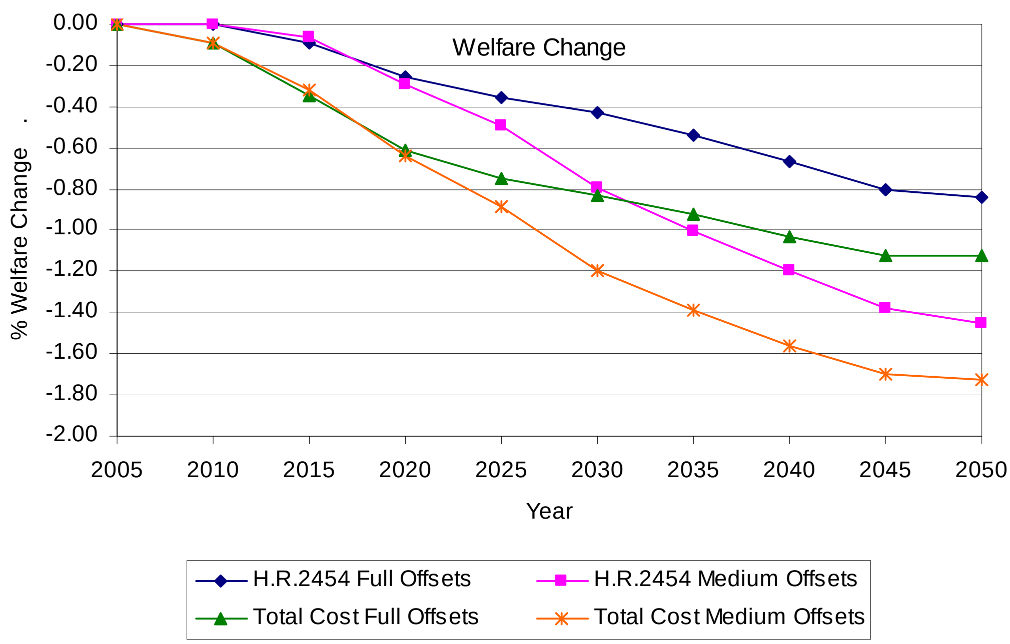

Figure C5. Welfare Change in H.R. 2454 with Different Offsets.

By the end of the analysis period our different offset assumptions affect the estimates of cost substantially. Our estimates of the cost of H.R. 2454 with full offsets leads to 0.8% welfare loss in 2050 while a scenario with medium offsets results in 1.45%. A similar difference appears in welfare costs by 2050 when the total cost of climate policy is considered: – 1.12% in the full offsets scenario and 1.73% with medium offsets. More detailed results for the total cost of climate policy are provided at the end of this note.

Table C1. CO_2-e Price and Welfare Cost with Different Offsets.

	H.R. 2454				Total Cost	
	Price, $/ton CO_2-e		Welfare Cost, %		Welfare Cost, %	
	Med Offsets	Full Offsets	Med Offsets	Full Offsets	Med Offsets	Full Offsets
2010	0.00	0.00	0.00	0.00	-0.09	-0.09
2015	21.31	7.27	-0.07	-0.10	-0.32	-0.35
2020	25.92	8.85	-0.29	-0.26	-0.64	-0.61
2025	31.54	10.76	-0.50	-0.35	-0.89	-0.75
2030	38.37	13.09	-0.79	-0.43	-1.19	-0.83
2035	46.68	15.93	-1.00	-0.54	-1.39	-0.93
2040	56.80	19.38	-1.19	-0.67	-1.56	-1.04
2045	69.10	23.58	-1.38	-0.80	-1.70	-1.12
2050	84.07	28.69	-1.45	-0.84	-1.73	-1.12

Cost per Household

Recent analyses have reported economic cost as a dollar cost per household. We construct this estimate by monetizing the welfare loss and dividing it by the number of households. **Table C2** provides our calculation for this cost of H.R. 2454, using the U.S. 2005 average of 2.57 persons per household, and a population of 296 million. We assume the household size stays the same over time, with the number of households increasing as population grows. The cost per household in 2015 for the medium offsets case is $68 ($97 in the full offset case[4]). This rises to just over $300 (about $280 in the full offset case) in 2020, and to about $2700 ($1560 in the full offset case) per household by 2050.[5] On average for the 2012-2050 period, the cost per household is between $720 and $1200 depending on the offsets assumption.

The RES requirement increases the household cost in the first decade of the policy when the renewable share must increase rapidly. The rapid phase-in of the RES—from about 7% to 15% in just 5 years creates further adjustment costs. The affect of the RES is moderated in later years, partly because the constraint is less binding and partly because the cap-and-trade costs continue to rise as the target tightens, while the RES requirement remains unchanged. However, larger overall losses in early years due to the RES depress the level of saving and investment, and the reduction in investment continues to affect the level of the economy in later years even when the RES is not binding.

Also shown is the total household cost of the H.R. 2454 targets when the effects of the Energy Independence and Security Act (EISA) and American Recovery and Reinvestment Act (ARRA)

[4] The cost per household is higher in the full offset case in early years but lower over the whole period specified in the bill because in early years the payment for the full amount of offsets must be made, while in the medium offsets case these offsets are not available and not paid for. As overall emissions reduction is bigger when full offsets are not available, the medium offsets case is getting more expensive over time. The exact reduction profile is also affected by allowance banking behavior.

[5] To provide a context for these annual costs, the average per-family consumption under the growth scenario imposed here, for the medium offsets case, is $90,000 in 2020 and $150,000 in 2050. Naturally, these costs do not fall evenly on all families. Indeed, the allowance allocation in H.R. 2454 is designed to lower the price impact on low- and middle-income consumers.

are considered. On average for the 2012-2050 period, the total cost per household is between $1200 and $1700.

To the extent the policy represents a long term commitment it is useful to calculate an average annual cost per household over the horizon of the policy. To do this, we discount costs to 2010 at 4% to arrive at a net present value of the cost in each year, and then take the average for the 2015 to 2050 period. In the medium offsets case, this leads to an average net present value cost of H.R. 2454 of about $250 in the full offset case to just over $400 per household in the medium offsets case. The corresponding numbers for the total cost of climate policy are about $450 per household when full offsets are available and about $600 per household in the scenario with medium offsets (for more discussion on the different cost measures, see Section 6 of Appendix B to this report).

Table C2. Cost per Household (in dollars) of H.R. 2454 with Different Offsets, Annual and Discounted to 2010 at 4%.

	H.R. 2454				**Total Cost**			
	Med Offsets		**Full Offsets**		**Med Offsets**		**Full Offsets**	
	Annual	**Discount to 2010**	**Annual**	**Discount to 2010**	**Annual**	**Discount to 2010**	**Annual**	**Discount to 2010**
2010	0	0	0	0	81	81	81	81
2015	68	56	97	80	326	268	355	292
2020	319	215	283	191	704	475	668	451
2025	588	326	419	232	1058	587	889	494
2030	1036	473	556	254	1563	713	1083	494
2035	1433	538	771	289	1994	748	1332	500
2040	1867	576	1043	322	2449	755	1625	501
2045	2354	597	1366	346	2907	737	1918	486
2050	2695	561	1562	325	3225	672	2091	436
Average	**1223**	**404**	**720**	**247**	**1701**	**607**	**1198**	**451**

Electricity Generation

Electricity generation by source for the medium offsets case is presented in **Figure C6**. The reference case, as in the main report, relies heavily on coal. We find that the main response of the electricity sector to the emissions constraint is to shift heavily to natural gas generation. In the 203 bmt scenario, presented in Figure 4c of the main report, new nuclear played a large role. A change in the EPPA model parameters to reflect an increase in domestic natural gas resources and lower NGCC costs contributes to this difference in results between the main report and this appendix. The policy also leads to a substantial reduction in electricity use compared to the reference case without EISA and ARRA measures, more than enough to contribute the 25% of the RES allowed for electricity savings. According to our estimates, EISA and ARRA lead to renewables that almost meet the RES requirements in H.R. 2454. In early years (2020-2035) an additional 1-3% of the requirement must still be met with H.R.2454 measures. We did not consider the scenario in which state governors petition to meet 40% of the RES requirement through efficiency savings, which would make the requirement non-binding in all years.

The bill prohibits new coal plants unless they are far more efficient than existing plants. With high enough CO_2 prices there would be no economic incentive to build new coal plants. We find, however, that with the EISA, ARRA, and offsets there was considerable new investment in conventional coal. We thus implemented in EPPA limits on new investment in coal plants without CCS. Figure C6 reflects those limits, and hence coal generation drops as old plants are retired.

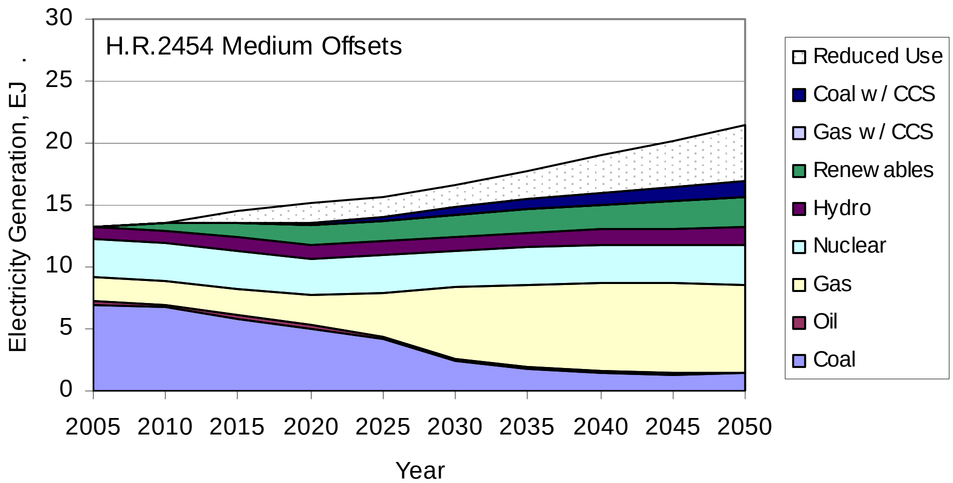

Figure C6. Electricity Generation in H.R. 2454 with Medium Offsets.

Primary Energy

Primary energy by source in the medium offsets case is presented in **Figure C7**. While the share of natural gas increases in the electricity sector substantially as a result of the policy, the overall share of natural gas is not increasing as dramatically in the economy as a whole. Thus the more important factor behind the increase in gas in electricity generation is the lower cost of NGCC which leads to diversion of gas from other sectors.

Petroleum products remain an important energy source for transportation because other alternatives (e.g., biofuels) do not increase by enough to meet increasing demand, and hence oil consumption remains roughly level, but less than in the reference case[6]. Reduced energy use, shown in Figure C7 and calculated as the difference in total primary energy between the reference (without EISA and ARRA) and policy case is a major contributor to meeting the policy target. In the reference, primary energy use increased from about 100 EJ to 140 EJ in 2050 while in this policy case total use in 2050 remains at about 100 EJ.

[6] In a scenario (not shown here) when restrictions on imported biofuels are eliminated and domestic biofuels costs are reduced, starting in 2030 most of oil is replaced with biofuels.

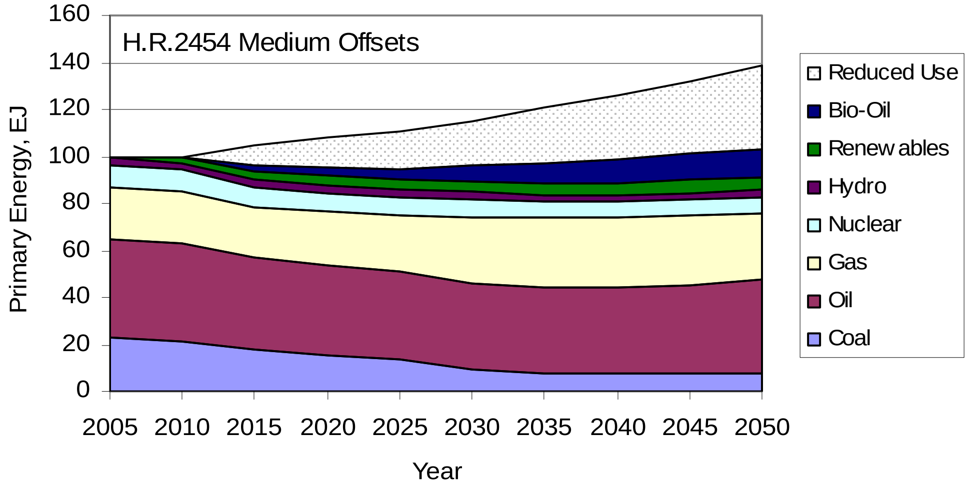

Figure C7. Primary Energy Use in H.R. 2454 with Medium Offsets.

Energy Prices

Energy prices are presented in **Figure C8**, where reference (no climate policy) prices and the impact of the CO_2 charge on producer and consumer prices for fuels are shown. The electricity price includes any CO_2 charge on fossil fuels still being used and added costs for generation to meet the CO_2 and RES requirement.

Producer prices for fuels tend to fall as demand falls, while consumer prices rise because of the embedded CO_2 charge. Coal prices inclusive of the CO_2 charge grow to about $200 per short ton by 2050 from the current prices of just over $30. The producer price falls very little because there is little rent in coal resources. Most of the adjustment occurs in the quantity produced. The reference case shows a substantial increase in natural gas prices, which grow to about $20 per thousand cubic feet (tcf) by 2050. Non-electric sector users reduce gas use in response to the CO_2 policy, while in the electric sector gas increases as it substitutes for coal, leaving little net change in total national use. As a result, the producer prices for gas in H.R. 2454 are not very different from the reference level. Consumer prices for gas are higher ($27 per tcf in 2050). Oil prices also rise in the no policy case so that by 2050 we estimate prices at $160/barrel. Inclusive of the CO_2 price, the cost of using oil rises to around $180, while reduced demand leads to a producer price that is about $20 per barrel less in 2050 than in the reference. The impacts on electricity prices are also substantial and lead to $0.20 per kWh price in the policy scenario compared to $0.13 per kWh in the reference case.

The bill distributes allowances to local gas and electricity distribution companies. The value of these allowances would likely go to rate payers. Whether this would lead to a lower electricity and natural gas rates or be distributed in a lump-sum or some other manner is unclear. In our study all allowance value is distributed in a lump-sum manner to households, consistent with the intent of the legislation to direct allowance value to consumers. If local distribution companies choose to use the allowances to lower the rates, the electricity and natural gas prices would be lower that we report here. However, failure to fully reflect carbon cost in rates would reduce the efficiency of the program and increase the overall cost of the policy.

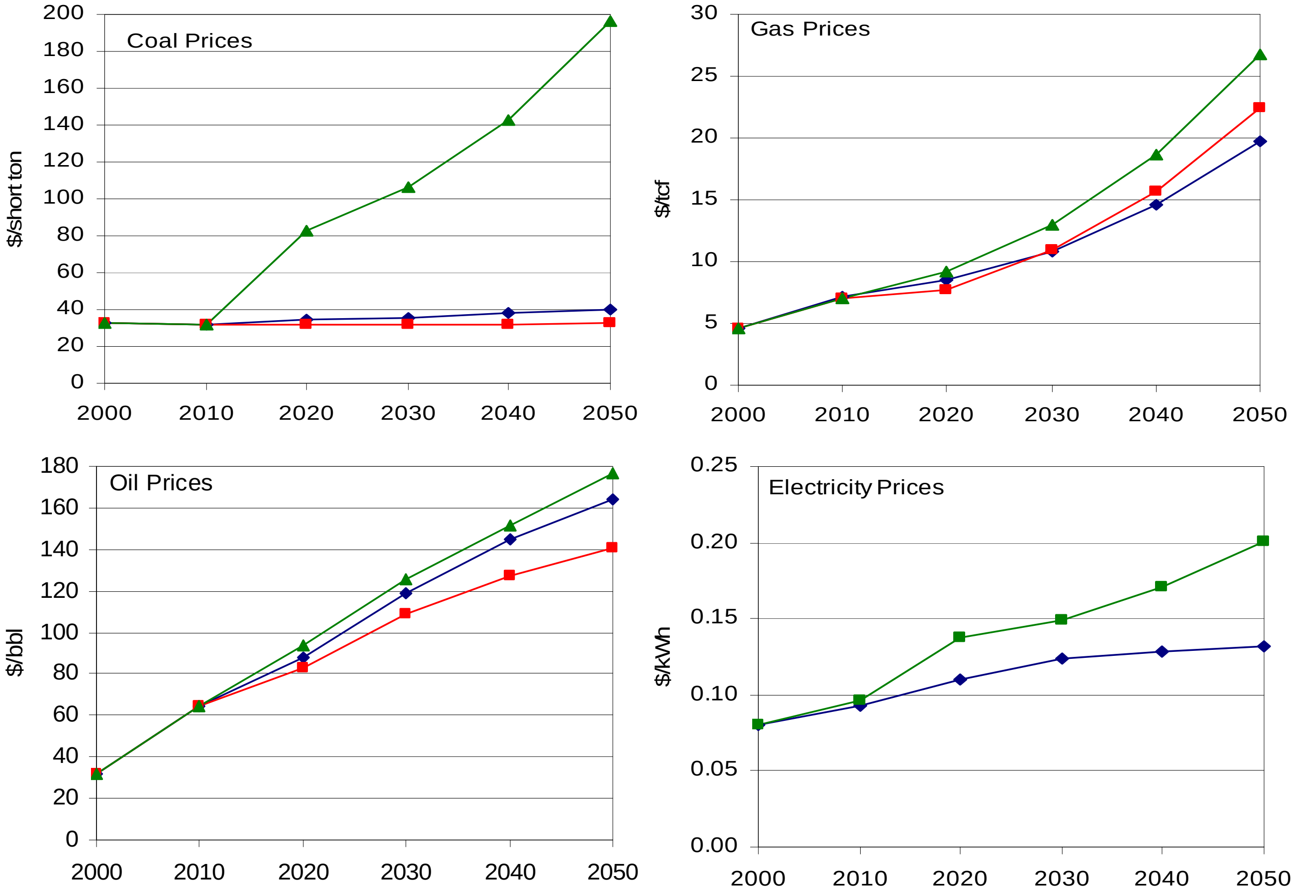

Figure C8. Energy Prices in H.R. 2454 with Medium Offsets (reference prices in blue, consumer prices in green, and producer prices in red).

C3. RESULTS WITH DIFFERENT OFFSET COSTS

The offset costs are a key uncertainty. Lacking a definition of what would qualify as an offset and the potential competition from cap-and-trade systems abroad, little can be done in the way of analysis to evaluate the cost of offset supply to the U.S. market. Here we attest the sensitivity of our results in two scenarios, one where the costs of offsets start at 15$ per tCO_2-e in 2015 and rise at 4% and another where there is no cost to offsets. Results for cost per household are presented in **Table C3**.

Assuming that offsets would come at no cost reduces the cost per household in 2020 (discounted to 2010 at 4%) to $127 with Full Offsets and around $202 with Medium Offsets (compared to $191 and $215 in the scenario presented in Table C2). The higher cost of offsets increases the burden. The corresponding 2020 numbers for the scenario with offsets starting at $15 are $223 and $241. For different assumptions about the availability and cost of offsets, the cost per household ranges from as low as $180 if all the offsets allowed are available at no cost to about $470 if a medium number of offsets are available at a higher price. As the economy meets the same target, the results for CO_2 prices and energy composition do not change with different costs of offsets[7].

Table C3. Cost per Household (in dollars, discounted to 2010 at 4%) of H.R. 2454 with Offsets at Zero Cost or Starting a $15 per ton and increasing at 4%, Annual and Discounted to 2010 at 4%.

	Annual				Discounted to 2010			
	Zero Cost		Starting at $15		Zero Cost		Starting at $15	
	Full Offsets	Medium Offsets	Full Offsets	Medium Offsets	Full Offsets	Medium Offsets	Full Offsets	Medium Offsets
2015	24	58	111	87	20	48	91	72
2020	187	299	330	357	127	202	223	241
2025	299	546	575	672	166	303	319	373
2030	408	962	1056	1185	186	439	482	541
2035	591	1324	1495	1650	222	497	561	619
2040	819	1726	1945	2171	253	532	600	669
2045	1093	2148	2492	2768	277	544	632	701
2050	1239	2420	2899	3245	258	504	604	676
Average	**549**	**1122**	**1283**	**1428**	**182**	**371**	**424**	**469**

C4. THE POLICY HORIZON AND OTHER UNCERTAINTIES

H.R. 2454 specifies a policy through 2050. We assume full banking through 2050 but we assume no foresight beyond 2050. Hence, the allowance bank at 2050 is zero. As we showed in the main report, depending on how economic agents look forward, or not, the near term results are affected. We should also point out, however, that if the policy is adhered to through 2050 it seems likely it will be extended beyond that horizon, which could lead to a positive bank in 2050 as agents see the extension coming. If so, that would then require greater reductions and higher costs through 2050. Here the role of future technology is critical. As shown in Gurgel *et al.* (2007) the existence of a known backstop in a forward looking model can lead to a lower near term cost. Agents looking ahead realize that in NPV terms abatement will be less expensive, and so they delay abatement. An important aspect of these scenarios is that some near-backstop technologies such as nuclear (electricity) and biofuels (transportation) have not yet entered, and so they remain an unexploited abatement option as of 2050. However, for these options to lead to lower near terms costs, there would have to be the ability to borrow, and that is restricted in H.R. 2454, requiring a substantial interest payment that would tend to offset any economic

[7] Emissions, energy mix and carbon prices are different if the offsets cost is higher than the cost of abatement within covered sectors. Depending on relative costs, there will be a decreased (or zero) usage of offsets. In the scenario with full offsets starting at $15, the full amount of offsets is available but not used to the full degree.

advantage of borrowing. Thus, without consideration of the post-2050 period it is hard to say whether expectations of continuation of the policy would raise costs or leave them unchanged.

While it should be obvious, it is useful to emphasize that there are many uncertainties in estimates of this kind. We have already noted the importance of the supply of offsets. Technology costs themselves are uncertain as is the rate of economic and emissions growth in the baseline. Additionally, though we believe their influence on costs is small, there are other provisions of the bill that we have not been able to include in the analysis.

C5. COMPARISON TO OTHER ANALYSES OF H.R. 2454

The Congressional Budget Office (CBO, 2009), the Energy Information Administration (EIA, 2009) and the Environmental Protection Agency (EPA, 2009) also have conducted analyses of H.R. 2454. The CBO focused on estimating the average household costs and reported numbers for 2020; the EIA applied its NEMS model to the task, and EPA utilized two different economic models. We could compare many different aspects of these model results, but since they all report an average household cost and carbon price, these provide a convenient basis for comparison. While average household cost is seemingly a well defined concept, there are some subtle differences in reported estimates.

The Congressional Budget Office (CBO, 2009) reported a household cost just for 2020 and estimated it to be $175. EIA calculates an undiscounted 2020 cost per household of $142 for the basic case and a range of $32 to $382 across all cases. The EPA 2020 undiscounted cost per household is $84 in one model and $105 in the other. Our estimate is $319 per household in 2020. We and the EPA analysis report costs in 2005 dollars and the EIA original estimate is in 2007 dollars which we have converted to 2005 dollars. The CBO reported in 2010 dollars, undiscounted but reduced to reflect real GDP growth.[8] The rationale for the CBO approach apparently was that households today would compare the expense to their income today, failing to realize that incomes were projected to grow. This convention essentially discounts the 2020 estimate by the rate of growth of GDP. We reported costs, discounted to 2010 by 4%, and our estimate for 2020 in those terms is $215. EPA reports a net present value average annual household cost, as we do, which summarizes costs over the full horizon of the bill. Their estimate is $80 in one model and $111 in the other (EPA used a discount rate of 5%). The similar estimate from our EPPA model is about $400 ($250 in the scenario when the full amount of offsets is utilized).

We can also compare CO_2 prices over time in the EPA and EIA analyses. EIA simulates the policy only to 2030, but assume a positive bank of allowances is held at the end of 2030 on expectation that the policy continue and costs would rise faster than their assumed discount rate. EIA's CO_2-e prices, converted from 2007 to 2005 dollars, are $34/ton$CO_2$-e in 2020 and $69/ton$CO_2$-e in 2030 for its basic case, and across all cases they range from $21 to $99 in 2020 and $44 to $203 in 2030. In the EPA's base analysis allowance costs start at $13 in 2015 and rise

[8] We do not have CBO's estimate of 2010 inflation and so could not convert these to 2005 dollars.

to $70 in 2050, and they report an alternative scenario with different technology assumptions that increases the allowance price by 15%, and an alternative offset scenario that increases prices by 89% relative to their base analysis. CBO reports a carbon price of $28 in 2020. EPPA's prices for the H.R. 2454 medium offsets case are $26 in 2020 and $38 in 2030.

C6. CONCLUSIONS

H.R. 2454 would be an important step toward reducing U.S. greenhouse gas emissions. We attempted to include several of the most important features of the bill including the Renewable Electricity Standard (RES) and provisions affecting CCS and coal generation. We also explain the lower cost of H.R. 2454 compared to similar reductions in the main report as a result of the Energy Independence and Security Act of 2007 and the American Recovery and Reinvestment Act of 2009. These two pieces of legislation included measures that would already reduce greenhouse gas emissions, thereby lowering our estimate of the cost of H.R. 2454, but the total costs of climate policy is similar to those described in the main body of the MIT Joint Program report 173.

An uncertainty in cost estimates of H.R. 2454 is the availability and price of offsets. In our case with medium offsets, the CO_2-e price starts at $21 per ton in 2015 and rises to $84 in 2050. The welfare cost rises to 1.45 percent in 2050, from about 0.1 percent in 2015. The average cost per household in this case is about $70 in 2015, around $300 in 2020, and rises to $2700 in 2050. The net present value average annual cost for the period of 2012-2050, the horizon over which the policy is specified, is about $400. For different assumptions about the availability and cost of offsets, the cost per household ranges from as low as $180 if all the offsets allowed are available at no cost to about $470 if a medium number of offsets are available at a higher price.

We find that nuclear, carbon capture and storage, and biofuels are less likely to make a major contribution to abatement over this period than we had estimated in previous studies of U.S. abatement costs. Nuclear and CCS costs have risen substantially as plans to actually build plants have progressed. As in the main report, we believe producing electricity with these technologies would cost 70 to 80% more than building a pulverized coal plant—the least expensive alternative if CO_2 were not a concern. Biofuel and biomass energy also appears less likely to be a good low CO_2 alternative. Recent analyses have highlighted the fact that a full life cycle accounting of greenhouse gas implications of even advanced cellulosic technologies may lead to greater emissions than fossil fuels at least in the near term. We have reflected this fact by raising substantially the cost of biofuels, and so it does not play a substantial role.

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.

The climate impacts of H.R. 2454 are difficult to assess as they depend on the efforts of the rest of the world, particularly, China and India. Our previous analyses show that failure to take any action, or failure to substantially involve the developing countries would lead to very substantial warming over the century (for the climate impacts of the scenarios with different participation by developed and developing countries, see Paltsev *et al.*, 2007), but engaging developing countries might require large financial transfers (Jacoby *et al.*, 2008).

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Table C4. Reference + EISA + ARRA	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMY WIDE INDICATORS										
Population (million)	296	310	326	341	357	374	390	406	422	439
GDP (billion 2005$)	12614	13486	15696	17743	20056	22911	26192	29792	33810	38349
% Change GDP from Reference	0.00	-0.11	-0.31	-0.40	-0.45	-0.46	-0.44	-0.42	-0.37	-0.33
Market Consumption (billion 2005$)	8653	9192	10736	12006	13493	15384	17564	19959	22638	25665
% Change Consumption from Reference	0.00	-0.11	-0.33	-0.44	-0.50	-0.52	-0.50	-0.48	-0.42	-0.37
Welfare (billion 2005$)	10168	10813	12858	14524	16506	18957	21710	24690	28020	31795
% Change Welfare from Reference (EV)	0.00	-0.09	-0.25	-0.35	-0.39	-0.40	-0.39	-0.37	-0.32	-0.28
CO_2-E Price (2005$/t$CO_2$-e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRICES (index, 2005=1.00)										
Petroleum Product (exclusive of carbon charge)	1.00	1.10	1.23	1.38	1.56	1.77	1.95	2.11	2.23	2.36
Natural Gas (exclusive of carbon charge)	1.00	1.04	1.13	1.24	1.37	1.56	1.81	2.09	2.46	2.82
Coal (exclusive of carbon charge)	1.00	1.00	1.02	1.04	1.07	1.09	1.12	1.15	1.18	1.22
Electricity (inclusive of carbon charge)	1.00	1.09	1.28	1.33	1.40	1.46	1.49	1.50	1.52	1.54
GHG EMISSIONS (mmt CO_2-e)										
GHG Emissions	7109.1	6895.5	7052.8	7141.0	7266.1	7567.4	8017.9	8551.4	9288.3	10075.3
CO_2 Emissions	5992.3	5841.5	5977.4	6060.8	6160.1	6425.5	6838.4	7328.3	8012.8	8733.1
CH_4 Emissions	588.9	546.8	549.3	545.1	541.8	547.0	550.9	557.4	565.3	577.0
N_2O Emissions	388.3	353.2	339.6	324.3	311.9	305.6	306.1	308.7	317.4	333.4
Fluorinated Gases Emissions	140.6	155.0	187.4	211.7	253.4	290.3	323.6	358.2	393.9	433.0
PRIMARY ENERGY USE (EJ)										
Coal	22.8	21.6	22.0	22.1	22.9	24.7	27.1	29.6	32.4	35.3
Petroleum Products	41.7	41.4	42.1	42.9	43.1	44.3	47.1	49.8	53.3	57.1
Natural Gas	22.4	22.1	23.2	23.6	23.9	24.4	24.5	24.3	23.7	23.3
Nuclear (primary energy eq)	9.3	9.1	8.8	8.6	8.3	8.1	8.0	7.9	7.8	7.7
Hydro (primary energy eq)	2.9	3.0	3.1	3.0	2.9	2.9	2.9	2.9	3.0	3.1
Renewable Elec. (primary energy eq)	0.0	2.1	3.4	3.8	4.2	4.4	4.6	4.9	5.1	5.4
Biomass Liquids	0.0	0.0	2.1	2.6	3.6	4.2	4.1	4.3	4.2	4.2
Total Primary Energy Use	99.3	99.3	104.7	106.5	108.9	112.9	118.3	123.7	129.5	136.0
Reduced Use from Reference	0.0	-0.2	0.1	1.2	1.6	2.0	2.4	2.7	2.8	2.9
ELECTRICITY PRODUCTION (EJ)										
Coal w/o CCS	6.9	6.7	6.9	7.1	7.6	8.3	9.3	10.3	11.4	12.5
Oil w/o CCS	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Gas w/o CCS	2.1	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Nuclear	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Hydro	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2
Renewables	0.0	0.7	1.1	1.3	1.5	1.6	1.7	1.9	2.0	2.1
Gas with CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal with CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Electricity Production	13.2	13.6	14.3	14.6	15.3	16.2	17.3	18.5	19.8	21.1

Table C5. Climate Policy including H.R. 2454 with Medium Offsets	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMY WIDE INDICATORS										
Population (million)	296	310	326	341	357	374	390	406	422	439
GDP (billion 2005$)	12614	13486	15648	17646	19909	22679	25861	29348	33233	37648
% Change GDP from Reference	0.00	-0.11	-0.62	-0.94	-1.17	-1.47	-1.70	-1.91	-2.07	-2.15
Market Consumption (billion 2005$)	8653	9192	10715	11950	13396	15220	17325	19637	22224	25175
% Change Consumption from Reference	0.00	-0.11	-0.52	-0.91	-1.21	-1.58	-1.86	-2.08	-2.24	-2.27
Welfare (billion 2005$)	10168	10812	12849	14481	16425	18806	21492	24395	27634	31334
% Change Welfare from Reference (EV)	0.00	-0.09	-0.32	-0.64	-0.89	-1.19	-1.39	-1.56	-1.70	-1.73
CO_2-E Price (2005$/t$CO_2$-e)	0.00	0.00	21.31	25.92	31.54	38.37	46.68	56.80	69.10	84.07
***PRICES** (index, 2005=1.00)*										
Petroleum Product (exclusive of carbon charge)	1.00	1.10	1.22	1.35	1.51	1.70	1.85	1.95	2.04	2.14
Natural Gas (exclusive of carbon charge)	1.00	1.04	1.06	1.14	1.29	1.61	1.92	2.30	2.77	3.29
Coal (exclusive of carbon charge)	1.00	1.00	1.00	0.99	1.00	0.98	0.98	0.99	0.99	1.00
Electricity (inclusive of carbon charge)	1.00	1.09	1.46	1.55	1.62	1.68	1.80	1.93	2.09	2.26
***GHG EMISSIONS** (mmt CO_2-e)*										
GHG Emissions	7109.1	6897.0	5866.3	5575.1	5322.7	4994.5	4819.8	4746.8	4784.4	4843.7
CO_2 Emissions	5992.3	5842.9	5295.2	5033.0	4803.7	4502.4	4342.2	4275.9	4310.3	4360.8
CH_4 Emissions	588.9	546.8	335.2	325.7	313.6	296.1	286.8	282.1	282.2	285.3
N_2O Emissions	388.3	353.2	225.2	206.3	195.6	186.7	181.8	180.2	183.7	189.9
Fluorinated Gases Emissions	140.6	155.0	11.2	10.6	10.3	9.9	9.5	9.1	8.6	8.2
***PRIMARY ENERGY USE** (EJ)*										
Coal	22.8	21.6	18.0	15.5	13.3	9.1	7.8	7.5	7.6	8.0
Petroleum Products	41.7	41.4	38.6	38.4	37.6	36.9	36.3	36.4	37.8	39.2
Natural Gas	22.4	22.1	22.0	22.4	24.3	28.3	29.5	29.8	29.4	28.2
Nuclear (primary energy eq)	9.3	9.1	8.6	8.2	7.8	7.7	7.3	7.0	6.9	7.1
Hydro (primary energy eq)	2.9	3.0	3.1	3.0	2.9	2.9	2.9	2.9	3.0	3.0
Renewable Elec. (primary energy eq)	0.0	2.1	3.4	4.4	4.3	4.4	4.4	4.6	5.1	5.4
Biomass Liquids	0.0	0.0	2.3	3.2	4.7	6.3	8.6	10.5	11.4	12.1
Total Primary Energy Use	99.3	99.3	96.0	95.2	94.8	95.8	96.8	98.8	101.1	103.1
Reduced Use from Reference	0.0	-0.2	8.7	12.5	15.7	19.2	23.8	27.5	31.2	35.9
***ELECTRICITY PRODUCTION** (EJ)*										
Coal w/o CCS	6.9	6.7	5.9	5.1	4.3	2.4	1.8	1.5	1.3	1.4
Oil w/o CCS	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Gas w/o CCS	2.1	1.9	2.2	2.4	3.5	5.8	6.7	7.2	7.4	7.1
Nuclear	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.2
Hydro	0.9	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.4
Renewables	0.0	0.7	1.2	1.6	1.7	1.7	1.8	2.0	2.2	2.4
Gas with CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal with CCS	0.0	0.0	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.3
Total Electricity Production	13.2	13.6	13.5	13.6	14.1	14.8	15.5	16.0	16.5	16.9

Table C6. Climate Policy including H.R. 2454 with Full Offsets	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
ECONOMY WIDE INDICATORS										
Population (million)	296	310	326	341	357	374	390	406	422	439
GDP (billion 2005$)	12614	13486	15679	17692	19985	22813	26045	29581	33518	37983
% Change GDP from Reference	0.00	-0.11	-0.42	-0.69	-0.80	-0.88	-1.00	-1.13	-1.23	-1.28
Market Consumption (billion 2005$)	8653	9192	10720	11965	13432	15301	17443	19789	22414	25400
% Change Consumption from Reference	0.00	-0.11	-0.47	-0.79	-0.95	-1.06	-1.19	-1.32	-1.40	-1.39
Welfare (billion 2005$)	10168	10812	12846	14486	16448	18876	21593	24526	27796	31528
% Change Welfare from Reference (EV)	0.00	-0.09	-0.35	-0.61	-0.75	-0.83	-0.93	-1.04	-1.12	-1.12
CO_2-E Price (2005$/t$CO_2$-e)	0.00	0.00	7.27	8.85	10.76	13.09	15.93	19.38	23.58	28.69
***PRICES** (index, 2005=1.00)*										
Petroleum Product (exclusive of carbon charge)	1.00	1.10	1.22	1.36	1.52	1.72	1.88	1.98	2.08	2.18
Natural Gas (exclusive of carbon charge)	1.00	1.04	1.10	1.19	1.34	1.53	1.85	2.29	2.80	3.51
Coal (exclusive of carbon charge)	1.00	1.00	1.01	1.01	1.02	1.03	1.03	1.03	1.03	1.04
Electricity (inclusive of carbon charge)	1.00	1.09	1.35	1.45	1.49	1.57	1.67	1.79	1.92	2.11
***GHG EMISSIONS** (mmt CO_2-e)*										
GHG Emissions	7109.1	6897.0	6293.9	6094.1	6073.1	6167.7	6160.0	6031.6	6137.4	6093.2
CO_2 Emissions	5992.3	5842.9	5684.6	5511.2	5505.9	5607.9	5612.7	5494.8	5597.4	5550.5
CH_4 Emissions	588.9	546.8	360.8	353.2	346.7	345.7	336.6	328.2	327.2	324.0
N_2O Emissions	388.3	353.2	236.5	217.9	208.7	202.5	199.0	197.3	202.1	208.6
Fluorinated Gases Emissions	140.6	155.0	12.6	12.3	12.2	12.1	12.1	11.7	11.2	10.6
***PRIMARY ENERGY USE** (EJ)*										
Coal	22.8	21.6	20.0	17.8	17.1	17.0	15.1	13.3	13.0	12.3
Petroleum Products	41.7	41.4	41.0	41.1	41.4	42.7	44.6	45.0	48.3	49.9
Natural Gas	22.4	22.1	23.1	23.5	24.7	25.7	27.7	29.0	29.1	29.0
Nuclear (primary energy eq)	9.3	9.1	8.7	8.4	8.0	7.6	7.3	6.9	6.6	6.2
Hydro (primary energy eq)	2.9	3.0	3.1	3.0	2.9	2.8	2.8	2.8	2.8	2.8
Renewable Elec. (primary energy eq)	0.0	2.1	3.3	4.8	4.7	4.8	4.8	4.6	4.5	4.4
Biomass Liquids	0.0	0.0	2.1	3.1	3.9	4.3	4.7	7.2	7.0	8.5
Total Primary Energy Use	99.3	99.3	101.2	101.6	102.7	104.9	107.0	108.8	111.3	113.2
Reduced Use from Reference	0.0	-0.2	3.5	6.1	7.9	10.1	13.7	17.5	21.0	25.7
***ELECTRICITY PRODUCTION** (EJ)*										
Coal w/o CCS	6.9	6.7	6.4	5.8	5.7	5.8	5.0	4.3	3.8	3.2
Oil w/o CCS	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Gas w/o CCS	2.1	1.9	2.1	2.2	2.8	3.3	4.5	5.7	6.2	6.8
Nuclear	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Hydro	0.9	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3
Renewables	0.0	0.7	1.1	1.7	1.8	1.9	2.0	2.0	2.1	2.1
Gas with CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal with CCS	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	1.0	1.4
Total Electricity Production	13.2	13.6	14.0	14.1	14.8	15.5	16.3	17.0	17.6	18.0