U.S. Environmental Protection Agency
Office of Atmospheric Programs

Supplemental EPA Analysis of the American Clean Energy and Security Act of 2009

H.R. 2454 in the 111th Congress

1/29/10

Purpose of this Supplemental Analysis

- In a series of letters and conversations between Senator Voinovich and EPA, the Senator requested that EPA produce this supplemental analysis.
- This analysis supplements EPA's June 23, 2009 analysis of H.R. 2454 with:
  - Updated assumptions about international action
    - One development since EPA conducted its analysis of H.R. 2454 is that at the July 9, 2009 Major Economies Forum, "the G8 leaders agreed to reduce their emissions 80% or more by 2050 as its share of a global goal to lower emissions 50% by 2050, acknowledging the broad scientific view that warming should be limited to no more than two degrees Celsius."
    - As requested by Senator Voinovich, this supplemental analysis takes this recent agreement into account.
  - Additional outputs
    - One of the most important additional outputs is the impact of H.R. 2454 and the G8 international action assumptions on global greenhouse gas concentrations and global mean temperature change.
    - This additional output was requested by Senator Voinovich.
    - This supplemental analysis shows that H.R. 2454 and the recent G8 agreement together can limit warming in 2100 to less than 2 degree Celsius (3.6 degrees Fahrenheit) above pre-industrial levels under a climate sensitivity of 3.0.
  - Additional scenarios
    - This supplemental analysis contains 12 new scenarios, including four scenarios requested by Senator Voinovich that restrict the availability of technology and international offsets.
    - The scenarios requested by Senator Voinovich are intended to represent the upper range of costs and are included in the analysis as part of a range of sensitivities designed to highlight important uncertainties and drivers of costs.
      - For example, while not allowing CCS technology before 2030 provides a pessimistic scenario, even without H.R. 2454 there are already more than 4 GW of CCS projects in the early phases of planning, design, and/or construction that could potentially capitalize on the funding opportunities available under H.R. 2454. See slides 44-45 for more detail.
  - Additional model updates
    - This analysis incorporates various improvements to the models that have been made since the June 23, 2009 analysis.

Major Findings

- The American Clean Energy and Security Act of 2009 (H.R. 2454):
  - Establishes an economy wide cap & trade program.
  - Creates other incentives and standards for increasing energy efficiency and low-carbon energy consumption.

- The analysis focuses on the economy wide cap & trade program, the energy efficiency provisions, and the competitiveness provisions.
  - Sensitivity analysis conducted to examine the impacts of:
    - Technology & offsets
    - Alternative 2020 cap levels
    - Energy efficiency provisions
    - Revenue recycling
    - International action & energy-intensive / trade-exposed output based rebates
  - Several provisions outside of the cap & trade program are not modeled in this analysis (e.g. lighting standards are not in the analysis, and the renewable electricity standard is not included in economy-wide modeling but is modeled as a sensitivity in power sector analysis).
  - See Appendix 1 for a full description of the bill and which provisions are modeled in this analysis.

Major Findings

- Compared to EPA's June 23, 2009 analysis of H.R. 2454, the largest changes in this supplemental analysis are driven by the use of updated assumptions about international action consistent with the July 9, 2009 Major Economies Forum where, "the G8 leaders agreed to reduce their emissions 80% or more by 2050 as its share of a global goal to lower emissions 50% by 2050, acknowledging the broad scientific view that warming should be limited to no more than two degrees Celsius." Many of the broader insights from the June 23, 2009 analysis remain unchanged.

- H.R. 2454 and the recent G8 agreement together are expected to limit warming by 2100 to less than 2º C (3.6º F) above pre-industrial levels under a climate sensitivity (CS) of 3.0.
  - The observed temperature increase in 2100 relative to pre-industrial levels is projected to be 1.6º C (2.9º F) under H.R. 2454 and the G8 agreement assuming CS = 3.0, compared to the no-policy result of a 3.5º C (6.3º F) rise in observed average global mean temperature.
  - CO_2e concentrations are projected to rise to 931 ppm by 2100 without policy; however, with H.R. 2454 and the recent G8 agreement, CO_2e concentrations are projected to be 457 ppm in 2100.

- Allowance prices are ~$13 per metric ton CO_2 equivalent (tCO_2e) in 2012 and ~$20/ tCO_2e in 2020 in the core H.R. 2454 scenario (scenario 8)*.
  - This is higher than the allowance price in EPA's June 23, 2009 analysis of H.R. 2454. The difference is primarily driven by the revised assumptions about climate polices adopted by other countries consistent with the recent G8 agreement.
  - Across all scenarios modeled without constraints on international offsets, the allowance price ranges from $9 to $15 per ton CO_2 equivalents (tCO_2e) in 2012 and from $14 to $23 / tCO_2e in 2020.
  - Across all scenarios modeled including those that vary constraints on international offsets, the allowance price ranges from $9 to $45 per ton CO_2 equivalents (tCO_2e) in 2012 and from $13 to $67 / tCO_2e in 2020.

- Competitiveness issues are not directly addressed in this report; however, they are explicitly addressed in the December 2, 2009 interagency report "The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries."
  - The interagency report is available at www.epa.gov/climatechange/economics/economicanalyses.html.
  - Consistent with prior EPA modeling of this issue in its June 23, 2009 analysis of H.R. 2454, the economic modeling in the interagency report shows that the allowance allocations in H.R. 2454 can essentially eliminate any adverse effect that a cap-and-trade program would otherwise have on energy-intensive trade-exposed industries' international competitiveness, and can thereby prevent emission leakage that might otherwise arise if such a program were to reduce the competitiveness of U.S. industry.
  - The modeling also concludes that, even in the absence of the allowance allocations in H.R. 2454, on average, the bill's impact on the competitiveness of energy-intensive trade-exposed industries would be relatively limited. However, some industries would experience greater impacts than others.

* All prices in this analysis are presented in 2005 dollars.

Major Findings

- Offsets have a strong impact on cost containment.
  - The annual limit on domestic offsets is never reached in the core scenario.
  - While the limits on the usage of international offsets (accounting for the extra international offsets allowed when the domestic limit is not met) are not reached, the usage of international offsets averages between 0.76 and 1.0 billion tCO_2e each year in the core scenario.
  - If international offsets were not allowed, the allowance price would increase 54 to 148 percent relative to the core policy scenario.
    - The large range is due to the differing amounts of international offsets usage in the core scenario projected by EPA's two models.
    - If international offsets availability was delayed, instead of being completely eliminated, the impact on allowance prices would be much smaller. A ten or twenty year delay in international offset availability would increase allowance prices by just two to five percent, and the allowance prices in the core scenario are consistent with a slow ramp up of international offset usage.

- With the revised assumptions about international action, the cap & trade policy still has a relatively modest impact on U.S. consumers assuming the bulk of revenues from the program are returned to households.
  - Average household consumption is reduced by .01-.04% in 2015 and 0.01-0.06% in 2020 and 0.16-0.36% in 2030, relative to the no policy case.
  - Average household consumption will increase by 8-10% between 2010 and 2015 and 15-19% between 2010 and 2020 in the core H.R. 2454 scenario (scenario 8).
  - In comparison to the baseline, the 5 year average household consumption growth from 2010 through 2015 under the policy is 0.1 percentage points lower, and the 10 year average household consumption growth from 2010 through 2020 is 0.2 percentage points lower.
  - Average annual household consumption is estimated to decline by $74 to $117 dollars per year* relative to the no policy case. This represents 0.1% – 0.15% of 2010 household consumption.
  - These costs include the effects of higher energy prices, price changes for other goods and services, impacts on wages and returns to capital. Cost estimates also reflect the value of some of the emissions allowances returned to households, which offsets much of the cap & trade program's effect on household consumption.
  - The cost estimates do not account for the benefits of avoiding the effects of climate change.
  - A policy that failed to return revenues from the program to consumers would lead to substantially larger losses in consumption, and a policy that returned the revenues to consumers by lowering other distortionary taxes would result in lower costs.

- While this analysis contains a set of scenarios that cover some of the important uncertainties when modeling the economic impacts of a comprehensive climate policy, uncertainties remain that could significantly affect the results.

* Annual net present value cost per household (discount rate = 5%) averaged over 2010-2050 under the core scenario.

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Changes Since EPA June 23, 2009 Analysis of H.R. 2454

- This supplemental analysis of H.R. 2454 includes updated assumptions about international action on climate change compared to the assumptions used in EPA's June 23, 2009 analysis of H.R. 2454, and updates to the models used by EPA.
  - Updated International assumptions:
    - At the July 9, 2009 Major Economies Forum, "the G8 leaders agreed to reduce their emissions 80% or more by 2050 as its share of a global goal to lower emissions 50% by 2050." For this analysis (scenarios 8 - 17), EPA is using a revised set of assumptions about international action consistent with the G8 agreement:
      - Developed countries (Kyoto group less Russia) follow an allowance path that is falling linearly from the simulated Kyoto emissions levels in 2012 to 83% below 2005 in 2050.
      - Developing countries (rest of world) adopt a policy beginning in 2025 that caps emissions at 2015 levels, and linearly reduces emissions to 26% below 2005 levels by 2050.
      - The combination of U.S., developed, and developing country actions cap 2050 emissions at 50% below 2005 levels.
      - Compared to the June 23, 2009 analysis of H.R. 2454, this new assumption about international action results in greater competing demand for international abatement, higher international offset prices, and higher domestic allowance prices. The higher domestic allowance prices result in greater penetration of CCS, and less traditional fossil generation. The greater amount of international abatement results in lower atmospheric greenhouse gas concentrations, and a smaller increase in global temperatures. (see appendix 6 and 7 for more detailed comparisons between this supplemental analysis and the June 23, 2009 analysis)
  - Updates to the models
    - In the original analysis of H.R. 2454, ADAGE used a constraint on nuclear power based on the CCSP SAP2.1a report; whereas in this supplemental analysis of H.R. 2454, ADAGE used a joint constraint on Nuclear and CCS taken from IPM (see appendix 6 and 7 for more details).
      - The primary impact of this change on modeling results is to delay the construction of new nuclear power as CCS is built instead in the early years in response to the CCS bonus allowances.
    - Updated handling of allocations to energy-intensive / trade-exposed industries, and allocations to LDC's in IGEM (see appendix 6 for details).
      - The primary impact of this change on modeling results is to lower household consumption impacts.
    - Deficit neutrality in real instead of nominal terms in IGEM (see appendix 6 for details).
      - The key differences in targeting real versus nominal government spending to achieve deficit neutrality lie in the labor-leisure results – the macro and industry impacts being virtually the same.

Bill Summary & Analytical Scenarios

H.R. 2454

Bill Summary

- Title III of the American Clean Energy and Security Act of 2009 (H.R. 2454) establishes a cap & trade system for greenhouse gas emissions.
  - The cap gradually reduces covered greenhouse gas emissions to 17 percent below 2005 levels by 2020, and 83 percent below 2005 levels by 2050.
  - Banking of allowances is unlimited, a two-year compliance period allows borrowing from one year ahead without penalty, limited borrowing from two to five years ahead.
  - 1-3% of allowances in each year will be set aside in a Strategic Allowance Reserve, from which allowances will be auctioned 4 times each year. Up to 20% of a covered entity's emissions may be purchased from the reserve in a given year. The strategic reserve is not modeled in this analysis.
  - Offsets are limited to 2,000 million metric tons CO_2 equivalent ($MtCO_2e$) per year.
  - Supplemental emissions reductions from reduced deforestation through allowance set-asides.

- Titles I & II of H.R. 2454 deal with clean energy and energy efficiency, and among other things establish a renewable electricity standard, and energy efficiency programs and standards for buildings, lighting, appliances.
  - Not all provisions in Titles I & II are explicitly modeled in this analysis.

- Title IV addresses competitiveness issues and the transition to a clean energy economy.
  - Creates an output-based allowance allocation mechanism based on H.R. 7146 (Inslee-Doyle bill).
  - Allows for the implementation of an international reserve allowance requirement.
  - The output-based allowance allocation mechanism is included in this analysis, but not in all scenarios. The rest of Title IV is not included in this analysis.

- See Appendix 1 for a discussion of the bill, and which provisions are modeled here.

Analytical Scenarios

Reference and Core Policy Scenarios

EPA's June 23, 2009 analysis of H.R. 2454 included 7 scenarios. This analysis includes 13 additional scenarios. A full description of all scenarios is available in Appendix 1. The assumptions about other domestic and international policies that affect the results of this analysis do not necessarily reflect EPA's views on likely future actions. These scenarios do not account for the American Recovery and Reinvestment Act, which could further advance the deployment of clean energy technologies.

Scenario 1 - EPA 2009 Reference

- This reference scenario is benchmarked to the AEO 2009 forecast (March release) and includes EISA but not ARRA.
  - Identical to the reference scenario used for EPA's June 23, 2009 analysis of H.R. 2454.
  - Does not include any additional domestic or international climate policies or measures to reduce international GHG emissions
  - For domestic projections, benchmarked to AEO 2009 (March release) without the American Recovery and Reinvestment Act of 2009 (ARRA).
  - Does not include the proposed federal greenhouse gas and fuel economy program for passenger cars, light-duty trucks, and medium-duty passenger vehicles.
  - For international projections, used CCSP Synthesis and Assessment Report 2.1 A MiniCAM Reference.

Scenario 8 – Updated H.R. 2454 (core policy scenario)

- This core policy scenario models the cap-and-trade program established in Title III of H.R. 2454.
  - The strategic allowance reserve is not modeled (i.e., these allowances are assumed to be available for use and not held in reserve).
- Provisions explicitly modeled in this scenario:
  - CCS bonus allowances
  - EE provisions (allowance allocations, building energy efficiency codes, and energy efficiency standard component of CERES).
  - Output-based rebates (Inslee-Doyle)
  - Allocations to electricity local distribution companies (LDCs) (used to lower electricity prices)
- Widespread international actions by developed and developing countries over the modeled time period. International policy assumptions are consistent with the agreement among G8 leaders at the July 9, 2009 Major Economies Forum "to reduce their emissions 80% or more by 2050 as its share of a global goal to lower emissions 50% by 2050."
  - Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling linearly from the simulated Kyoto emissions levels in 2012 to 83% below 2005 in 2050.
  - Group 2 countries (rest of world) adopt a policy beginning in 2025 that caps emissions at 2015 levels, and linearly reduces emissions to 26% below 2005 levels by 2050.
  - The combination of U.S., Group 1, and Group 2 actions caps 2050 emissions at 50% below 2005 levels.

Analytical Scenarios

Sensitivity Scenarios

A full description of all scenarios is available in Appendix 1.

Technology and offset sensitivities requested by Senator Voinovich

- **Scenario 9 - V – No Int'l Offsets**
- **Scenario 10 - V – Reference Nuclear & Biomass / Delayed CCS**
- **Scenario 11 - V – Reference Nuclear & Biomass / Delayed CCS – No Int'l Offsets**
- **Scenario 12 - V – IPM electricity sector reductions imposed on ADAGE**

Cap sensitivities

- **Scenario 13 – 20% 2020 Cap**
- **Scenario 14 – 14% 2020 Cap**

Energy efficiency provision sensitivity

- **Scenario 15 – Updated H.R. 2454 scenario 8 w/o energy efficiency provisions**

Allocation sensitivity

- **Scenario 16 – Revenue recycling to reduce labor taxes**

International action sensitivities

- **Scenario 17 – Early developing country action**
- **Scenario 18 – No developing country action**

Key Uncertainties

- There are many uncertainties that affect the economic impacts of H.R. 2454.
- This analysis contains a set of scenarios that cover some of the important uncertainties.*
  - The degree to which CCS and new nuclear power are technically and politically feasible.
  - The availability of international offset projects.
  - The extent and stringency of international actions to reduce GHG emissions by developed and developing countries.
  - The impact of output based rebates to energy intensive and trade exposed industries.

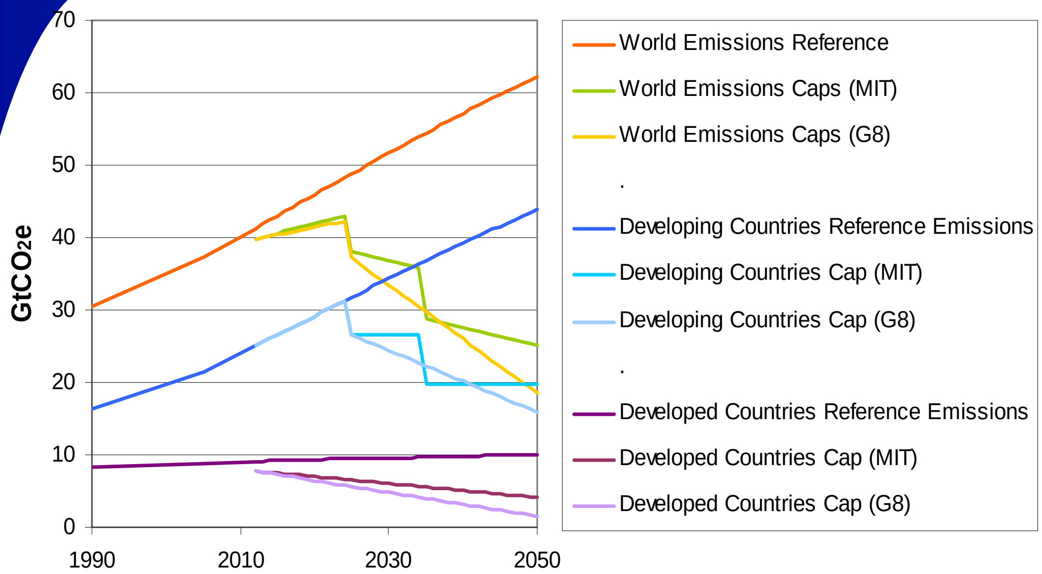
- Some additional uncertainties covered in this analysis outside of the main scenarios include:
  - The impact of the Strategic Allowance Reserve on overall costs.
  - The distributional consequences of H.R. 2454.
  - The availability of domestic offsets.
  - The impact of post-2050 emissions caps.

- Additional uncertainties include but are not limited to:
  - Long-run cost of achieving substantial GHG abatement.
    - Note that because of banking, uncertainty in long run abatement costs can have a significant impact on near term prices.
  - The pace of economic and emissions growth in the absence of climate policy.
  - Possible interactions among modeled and non-modeled policies.
  - The impact of the American Recovery and Reinvestment Act of 2009 on the cost of climate policy.
  - The impact of reducing electricity prices versus lump sum transfers to consumers from local electric distribution companies.
  - The responsiveness of household labor supply to changes in wages and prices (labor supply elasticity).
  - Other parameter uncertainty, particularly substitution elasticities (e.g., the abilities of firms to substitute capital, labor, and materials for energy inputs).

* Note that because of time limitations this analysis does not contain an extensive set of scenarios that would cover some of the additional uncertainties described above.

Global Results:
CO_2e Concentrations and Temperature Changes

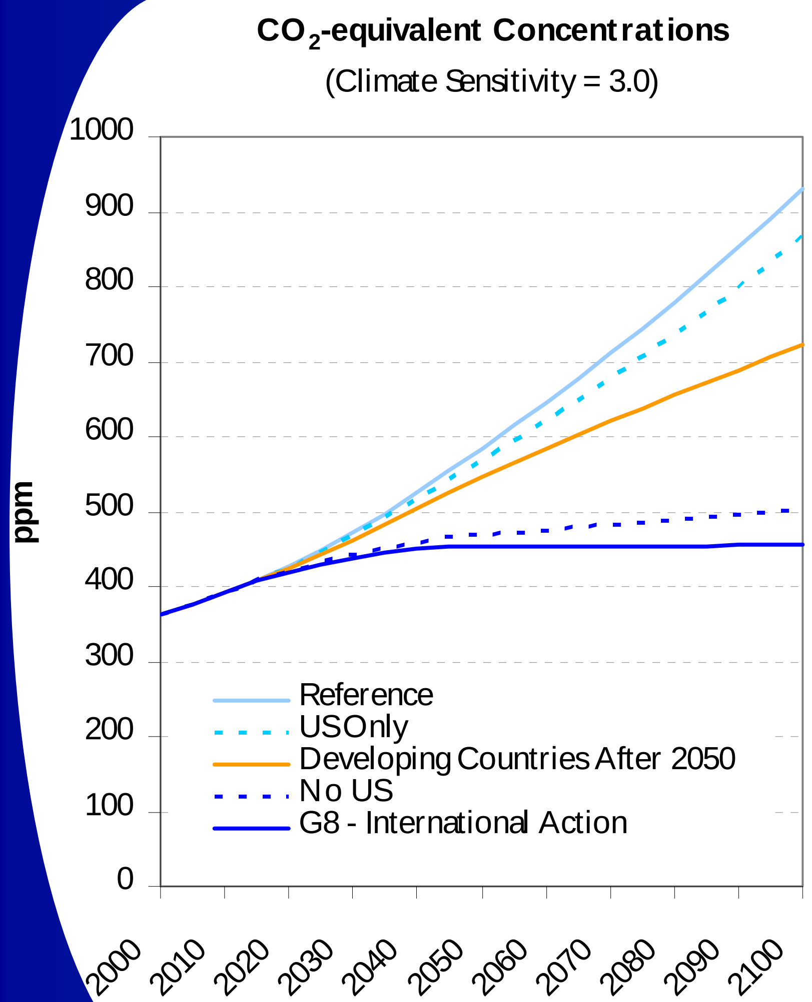
International Action Assumptions



- In previous analyses (including the June 23, 2009 analysis of H.R. 2454), EPA had assumed widespread international actions by developed and developing countries over the modeled time period based on the 2007 MIT report, "Assessment of U.S. Cap-and-Trade Proposals."
  - Developed countries (Kyoto group less Russia) follow an allowance path that is falling gradually from the simulated Kyoto emissions levels in 2012 to 50% below 1990 in 2050.
  - Developing countries (rest of world) adopt a policy beginning in 2025 that returns and holds them at year 2015 emissions levels through 2034, and then returns and maintains them at 2000 emissions levels (8% below 2005 levels) from 2035 to 2050.
  - The combination of U.S., Group 1, and Group 2 actions cap 2050 emissions at 32% below 2005 levels.
- At the July 9, 2009 Major Economies Forum, "the G8 leaders agreed to reduce their emissions 80% or more by 2050 as its share of a global goal to lower emissions 50% by 2050." For this supplemental analysis (scenarios 8 - 16), EPA is using a revised set of assumptions about international action consistent with the G8 agreement:
  - Developed countries (Kyoto group less Russia) follow an allowance path that is falling linearly from the simulated Kyoto emissions levels in 2012 to 83% below 2005 in 2050.
  - Developing countries (rest of world) adopt a policy beginning in 2025 that caps emissions at 2015 levels, and linearly reduces emissions to 26% below 2005 levels by 2050.
  - The combination of U.S., developed, and developing country actions cap 2050 emissions at 50% below 2005 levels.
- This more aggressive international action, while raising the cost of the U.S. climate policy, also benefits the U.S. because it leads to more global greenhouse gas reductions, resulting in smaller increases in temperature.
- These differences in assumed international action must be considered when comparing scenarios 8 – 16 in this supplemental analysis with scenarios 2 – 7 of the June 23, 2009 analysis.

CO_2e Concentrations

Impacts of International Action Assumptions (GCAM & MAGICC)

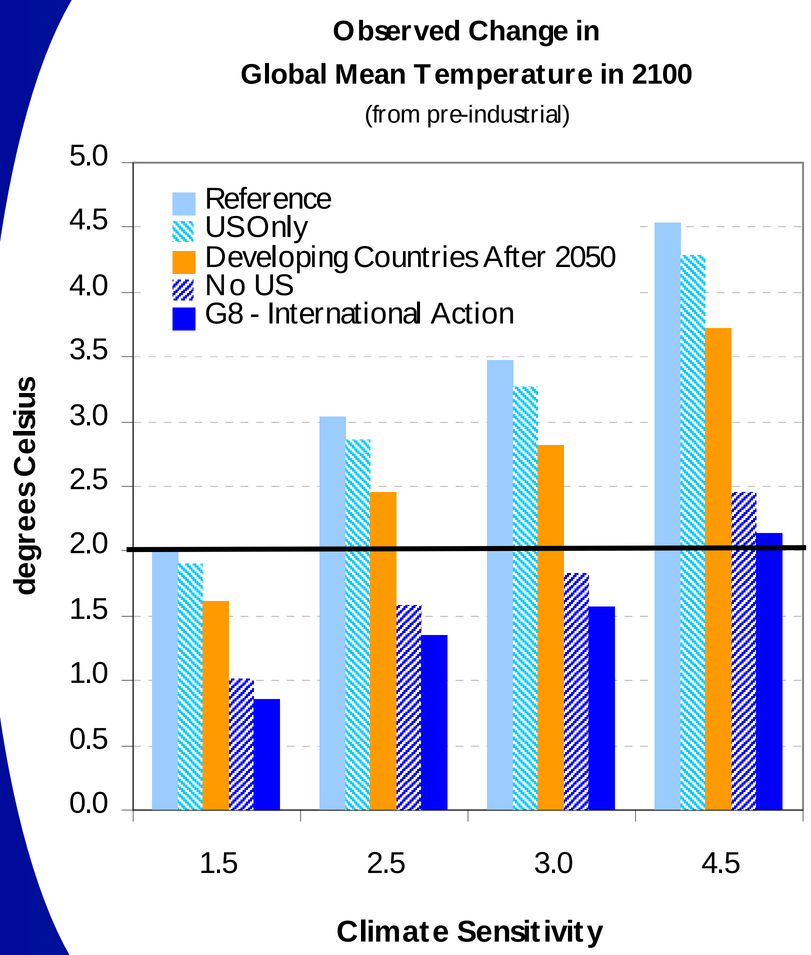


- CO_2e concentrations through 2100 are presented here assuming a climate sensitivity of 3.0 (CS is the equilibrium temperature response to a doubling of CO_2. 3.0 is deemed "most likely" by the IPCC).
- The five scenarios shown here are:
  - **Reference**: no climate polices or measures adopted by any countries.
  - **US Only**: US adopts H.R. 2454, all other countries follow BAU emissions.
  - **Developing Countries After 2050**: US and developed (group 1) countries same as G8 scenario. Developing (group 2) countries adopt policy in 2050 holding emissions constant at 2050 levels.
  - **No US**: US follows BAU emissions, all other counties same as G8 scenario.
  - **G8 - International Assumptions**: Consistent with G8 agreement to reduce global emissions to 50% below 2005 levels by 2050. US adopts H.R. 2454, developed countries (group 1) reduce emissions to 83% below 2005 levels by 2050, and developing (group 2) countries cap emissions beginning in 2025, and return emissions to 26% below 2005 levels by 2050. All countries hold emissions targets constant after 2050.*
- CO_2e concentrations are approximately 457 ppm in 2100 under G8 – international action assumptions.
  - Note that CO_2e concentrations are not stabilized in these scenarios. To prevent concentrations from continuing to rise after 2100, post-2100 GHG emissions would need to be further reduced. (For example, stabilization of CO_2 concentrations at 457 ppm would require net CO_2 emissions to go to zero in the very long run).
- No participation from developing countries before 2050 would increase CO_2e concentrations to 723 ppm in 2100, while reference assumptions produce CO_2e concentrations of 931 ppm in 2100.
- Removing US action from the G8 scenario raises CO_2e concentrations by 46 ppm in 2100 to 503 ppm. Adding US action to the reference scenario lowers CO_2e concentrations by 64 ppm in 2100 to 868 ppm

•Note that the ADAGE and IGEM models do not model post 2050 caps, doing so would likely raise allowance prices by only 2%. See the banking discussion in slides 56-57 for more details.

Global Mean Temperature Change in 2100

Impacts of International Action Assumptions (GCAM & MAGICC)

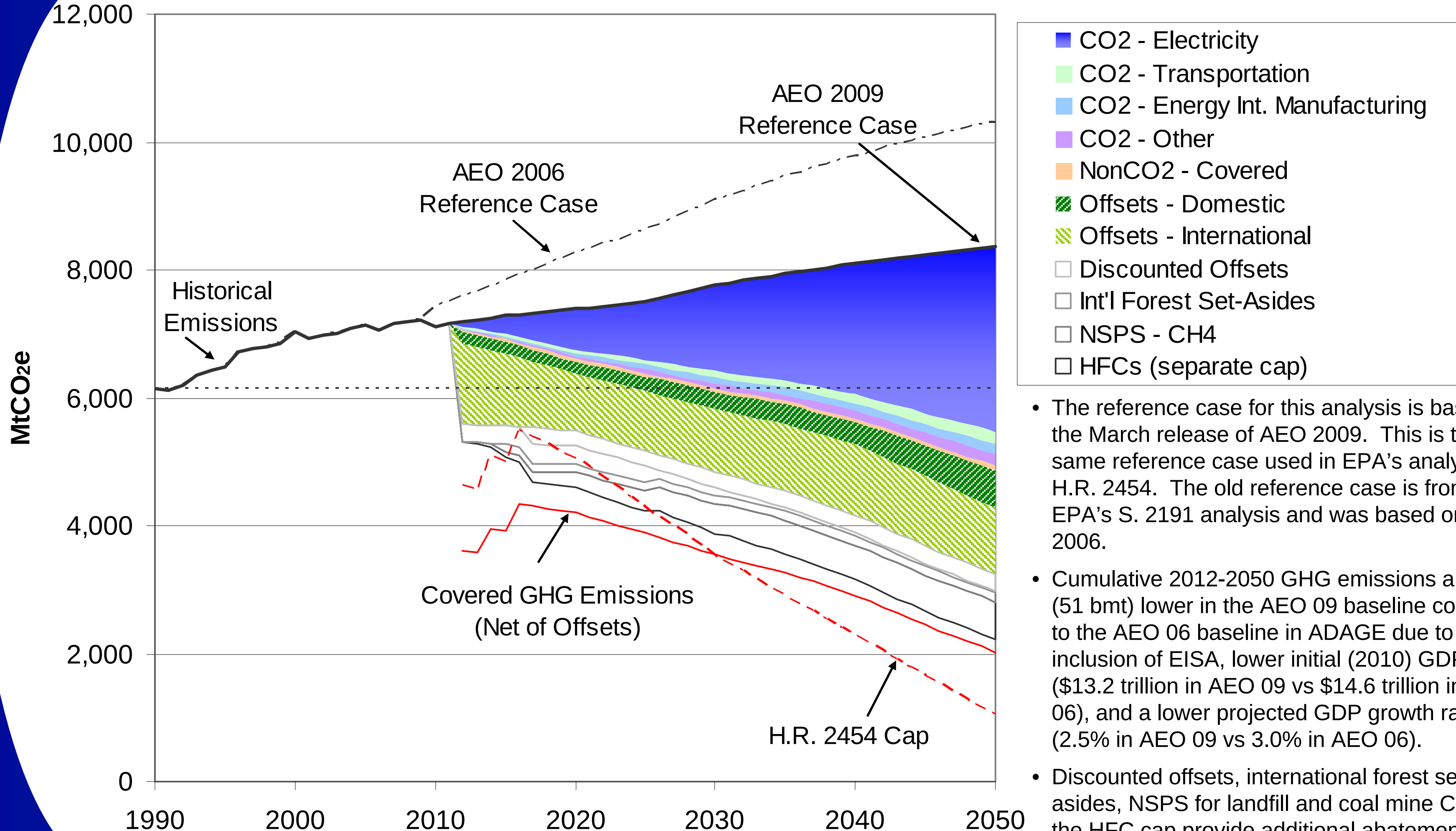


- Bar chart to the left demonstrates projections of observed temperature changes (from pre-industrial time) in 2100 under various assumptions about the climate sensitivity.
- Climate sensitivity (CS) is the equilibrium temperature response to a doubling of CO2. 3.0 is deemed "most likely" by the IPCC.
- Assuming the G8 – international goals (reducing global emissions to 50% below 2005 by 2050) a 2 degree target in 2100 is attainable under a climate sensitivity of 3.0.
- The temperature in 2100 in the 'G8 – International Action' scenario is not stabilized, so the observed change in global mean temperature in 2100 is not equal to the equilibrium change in global mean temperature. There are two reasons for this:
  - First, while the G8 international goals stabilize global GHG emissions at 50% below 2005 levels, CO_2e concentrations and temperature are not stabilized. Determining an equilibrium temperature under any scenario requires assumptions about post-2100 emissions. If emissions remain constant post-2100, CO_2e concentrations will continue to rise. Equilibrium temperature would only be achieved after CO_2e concentrations are in equilibrium.
  - Second, the inertia in ocean temperatures causes the equilibrium global mean surface temperature change to lag behind the observed global mean surface temperature change by as much as 500 years. Even if CO_2e concentrations in 2100 were stabilized, observed temperatures would continue to rise for centuries before the equilibrium were reached.
- Continued GHG emissions reductions after 2100 could stabilize CO_2e concentrations at the 457 ppm levels achieved in 2100 in the G8 scenario.
- In order to achieve an equilibrium temperature change of 2 degrees (assuming CS = 3.0), CO_2e concentrations must be stabilized below 457 ppm, requiring continued abatement beyond the level needed to stabilize concentrations at 2100 levels.
  - It would be possible to reduce CO_2e concentrations after 2100 below 457 ppm by even further reducing GHG emissions in the next century. An 'overshoot' scenario such as this would further reduce the equilibrium temperature change, making it possible to achieve the 2 degrees C target even with a climate sensitivity of 3.0.

Economy-Wide Impacts:
GHG Emissions & Economic Costs

Total US GHG Emissions & Sources of Abatement

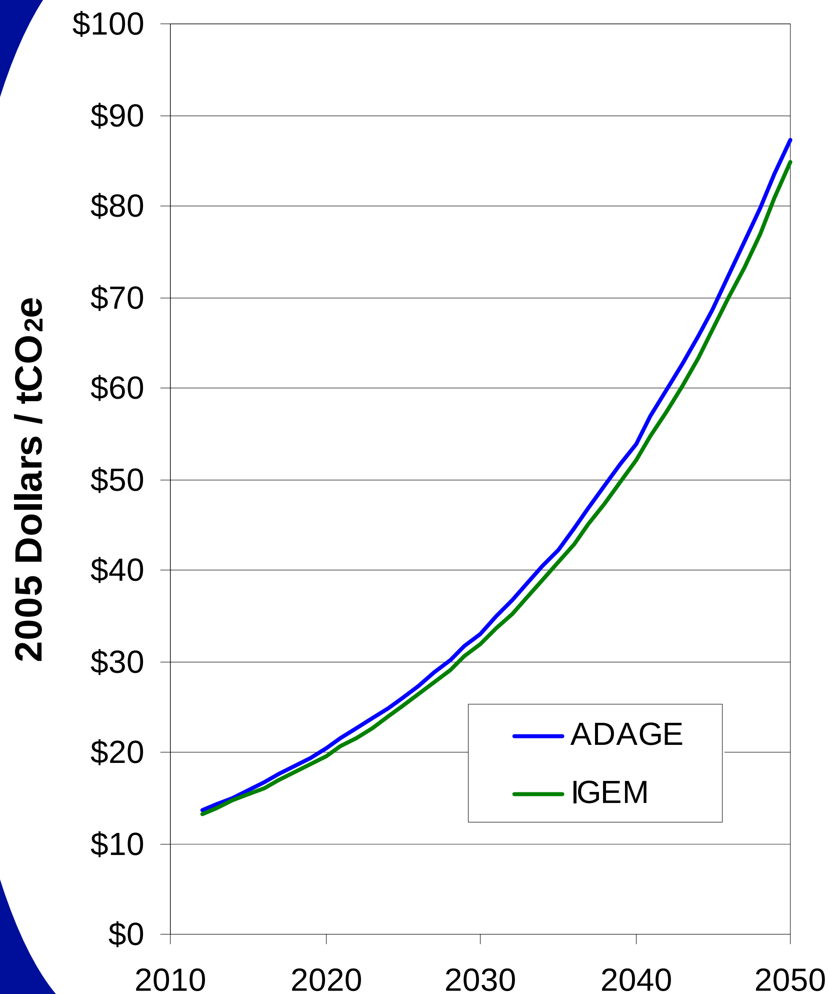
Scenario 1 - Reference & Scenario 8 – Updated H.R. 2454 (ADAGE)



- The reference case for this analysis is based on the March release of AEO 2009. This is the same reference case used in EPA's analysis of H.R. 2454. The old reference case is from EPA's S. 2191 analysis and was based on AEO 2006.
- Cumulative 2012-2050 GHG emissions are 14% (51 bmt) lower in the AEO 09 baseline compared to the AEO 06 baseline in ADAGE due to the inclusion of EISA, lower initial (2010) GDP ($13.2 trillion in AEO 09 vs $14.6 trillion in AEO 06), and a lower projected GDP growth rate (2.5% in AEO 09 vs 3.0% in AEO 06).
- Discounted offsets, international forest set-asides, NSPS for landfill and coal mine CH4, and the HFC cap provide additional abatement that does not help to meet the main cap.

GHG Allowance Prices

Scenario 8 – Updated H.R. 2454



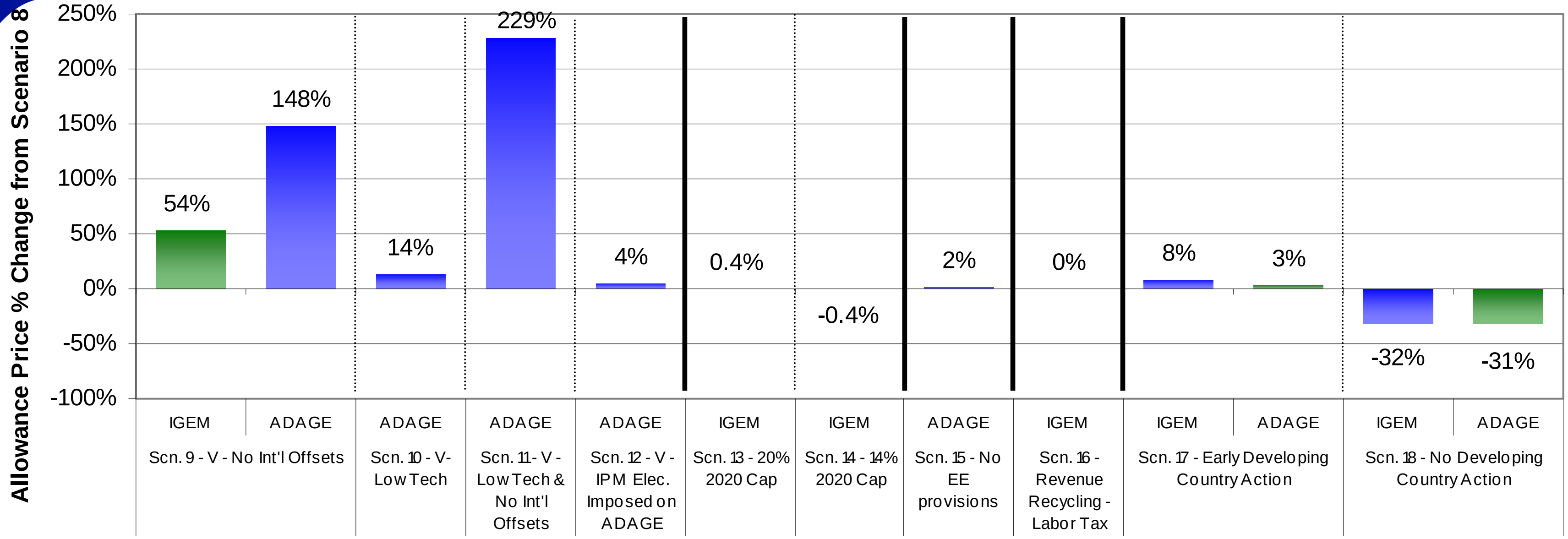
Scn. 8 - Updated H.R. 2454

	2012	2015	2030	2050
ADAGE	$14	$16	$33	$87
IGEM	$13	$15	$32	$85

- The marginal cost of GHG abatement is equal to the allowance price.
- Range of 2030 allowance price in *"scenario 8 – Updated H.R. 2454"* across models is $32 - $33. This range only reflects differences in the models and does not reflect other scenarios or additional uncertainties discussed elsewhere.
- As was the case in EPA's June 23, 2009 analysis of H.R. 2454, the limit on international offsets usage is non-binding in both models, and thus the domestic allowance price is equal to the international offset price (after discounting) and the international offset price acts as a floor on the allowance price.
- When the international offsets limit is non-binding, the differences in allowance prices between the models arises from differing demands for international offsets.
  - The differences between the models in terms of cost and availability of domestic abatement show up in the differing amount of international offsets used instead of differing allowance prices.
  - In scenario 8, ADAGE projects an average 1,040 $MtCO_2e$ of international offsets will be used annually, and IGEM projects average annual international offsets usage to be 757 $MtCO_2e$.
  - See the 'Offsets Usage & Limits' section for further discussion of international offsets.
- Allowance prices are higher than in EPA's June 23, 2009 analysis of H.R. 2454 primarily due to the revised assumptions about climate policies adopted by other countries leading to greater world demand for GHG abatement. See the 'Comparison to EPA's June 23, 2009 analysis of H.R. 2454' for more details.

GHG Allowance Prices & Sensitivities

H.R. 2454 Scenario Comparison – Percentage Change from Scenario 8

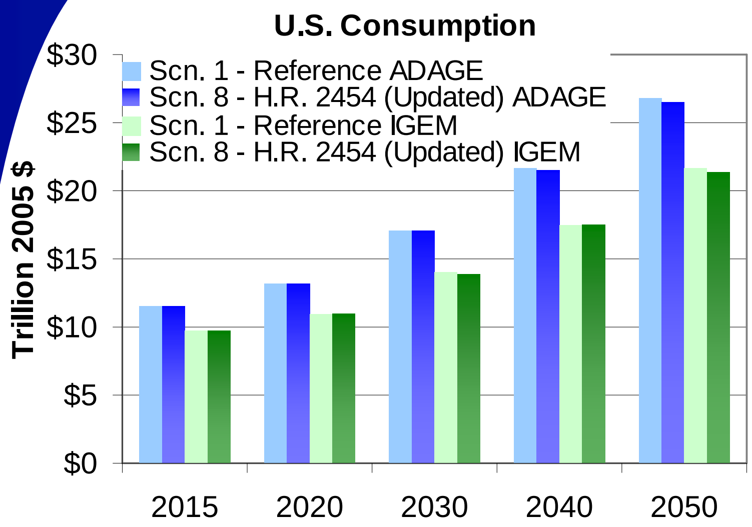


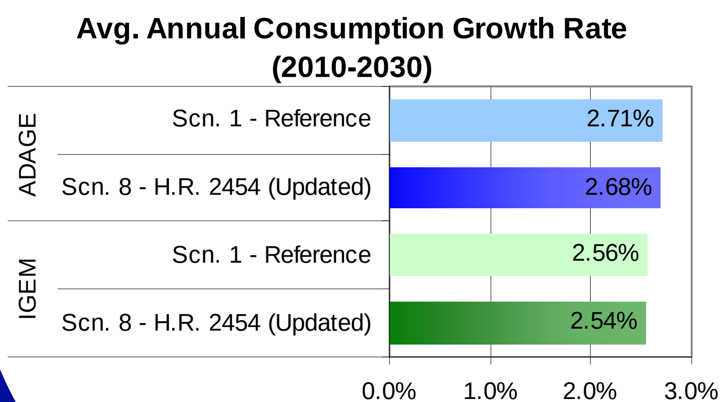
Note: percentage changes apply in all years.

- In most scenarios the limit on international offsets usage is non-binding, and thus the domestic allowance price is equal to the international offset price (after discounting) and the international offset price acts an allowance price floor. Because of this, the impact of these sensitivities on allowance prices is muted by the change in the usage of international offsets and the amount of abatement occurring in the U.S. (e.g. a change that would ordinarily lead to lower allowance prices instead would lead to fewer international offsets.)
- ADAGE shows greater usage of international offsets than IGEM in scenario 8, so removing international offsets in scenario 9 has a much larger impact on allowance prices in ADAGE than in IGEM. It should be noted that allowing no international offsets is an extreme case, if instead international offsets were simply not available for the first ten years, then allowance prices in IGEM would only increase by 2% (see slide 50).
- Scenarios 9 – 11, requested by Senator Voinovich, place limits on technology and international offsets. These scenarios are intended to represent the upper range of costs and are included in the analysis as part of a range of sensitivities designed to highlight important uncertainties and drivers of costs.
  - For example, while not allowing CCS technology before 2030 provides a pessimistic scenario, even without H.R. 2454 there are already more than 4 GW of CCS projects in the early phases of planning, design, and/or construction that could potentially capitalize on the funding opportunities available under H.R. 2454. See slides 44-45 for more detail.
  - Restricting nuclear, biomass, and CCS technologies in scenario 10 increases allowance prices by 14% as domestic abatement becomes more expensive and international offsets usage increases by 24%.
  - In scenario 11, restricting nuclear, biomass, and CCS as well as not allowing international offsets dramatically increases allowance prices as there are few abatement options left in the model.

Consumption

Scenario 1 – Reference & Scenario 8 – Updated H.R. 2454





ADAGE	2015	2020	2030	2040	2050
% Change	-0.01%	-0.06%	-0.36%	-0.67%	-0.97%
Annual Change / HH	-$13	-$62	-$427	-$944	-$1,599
NPV of Change / HH	-$10	-$37	-$153	-$208	-$216

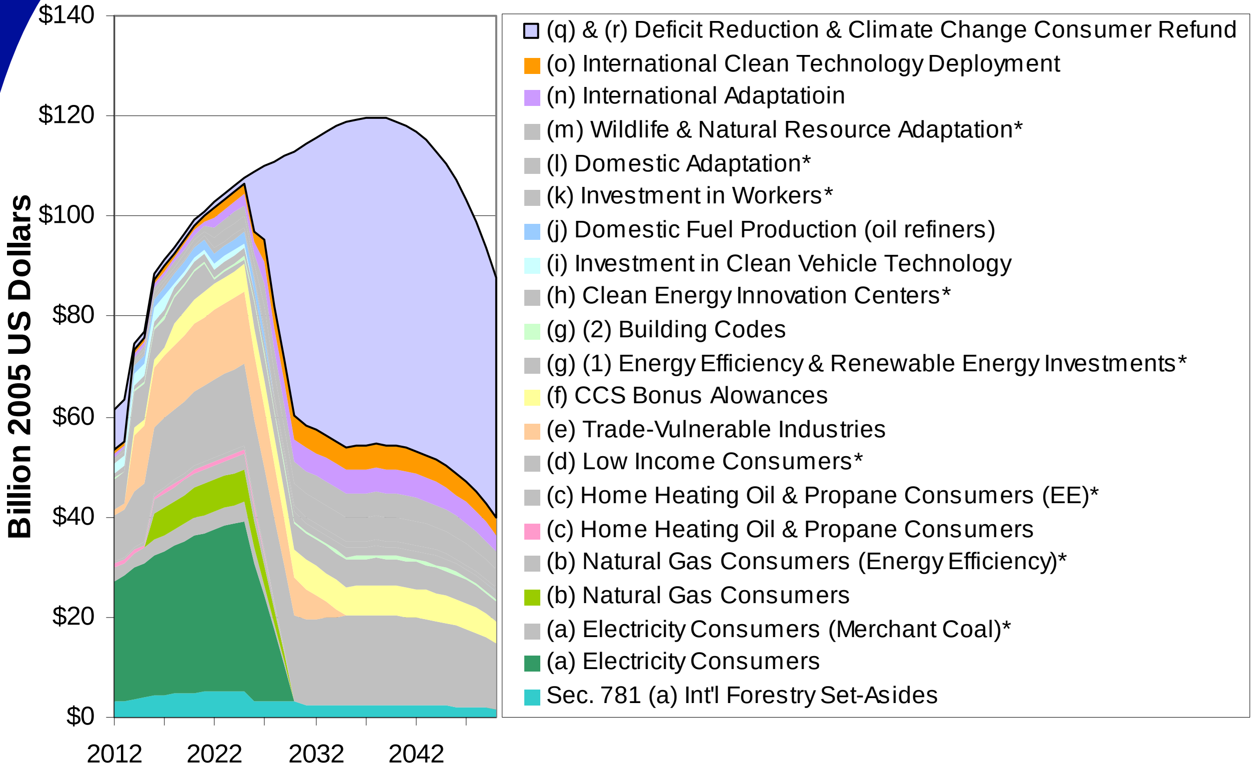
Average Annual Cost per Household (NPV)	**-$117**
Total Cost per Household (2010-2050) (NPV)	-$4,810

IGEM	2015	2020	2030	2040	2050
% Change	-0.04%	-0.01%	-0.16%	-0.66%	-1.03%
Annual Change / HH	-$32	-$8	-$148	-$699	-$1,226
PV of Change / HH	-$24	-$5	-$53	-$154	-$166

Average Annual Cost per Household (NPV)	**-$74**
Total Cost per Household (2010-2050) (NPV)	-$3,015

- The average annual cost per household is the 2010 through 2050 average of the net present value of the per household consumption loss in "*scenario 8 – H.R. 2454 (Updated)*."
- The costs above include the effects of higher energy prices, price changes for other goods and services, impacts on wages and returns to capital, and importantly, the above cost estimates reflect the value of emissions allowances returned lump sum to households, which offsets much of the cap-and-trade program's effect on household consumption. The cost does not include the impacts on leisure.
- This analysis is a cost-effectiveness analysis, not a cost-benefit analysis. As such, the benefits of reducing GHG emissions were not determined in this analysis.
- The $74 - $117 average annual cost per household is the annual cost of achieving the climate benefits that would result from this bill.
- The ADAGE average annual NPV cost per household is 5% higher in scenario 8 compared to scenario 2 from the June 23, 2009 analysis. The IGEM value is lower than scenario 2 from the June analysis because of changes to the model. Taking these changes into account the IGEM average annual NPV cost per household in scenario 8 is 9% higher than a scenario 2 with the equivalent model updates (see appendix 6 for details).
- Across all scenarios, the highest average NPV cost per household is -$418 in ADAGE scenario 11, requested by Senator Voinovich, without international offsets and restricted nuclear, bioelectricity and CCS.
- See Appendix 1 for a discussion of consumption accounting differences between ADAGE and IGEM and of composition of GDP.
- See Appendix 6 for a more detailed discussion of the average annual NPV cost per household calculation, and additional consumption cost metrics.

Value of Allocated & Auctioned Allowances (IGEM)

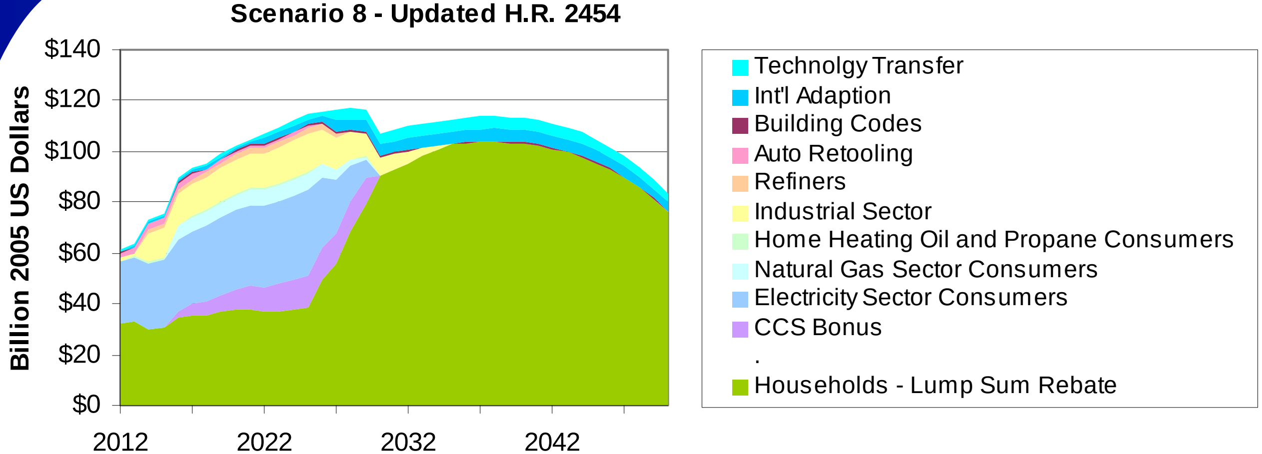


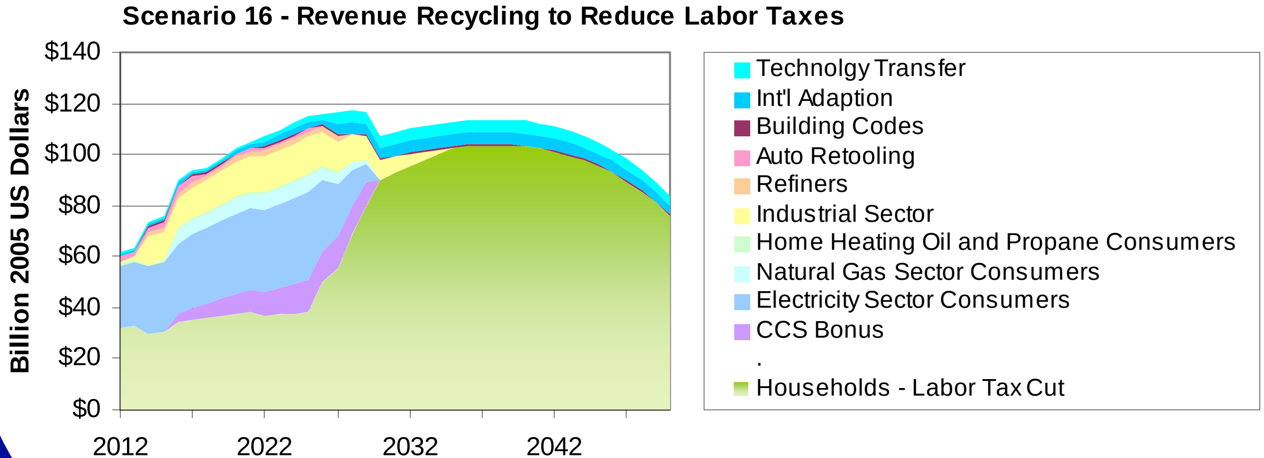
- H.R. 2454 Sec. 321 amends the Clean Air Act by inserting “Sec. 782. Allocation of Emissions Allowances.” Parts (a) through (o) of this section allocate allowances for various purposes. Additionally, Sec. 781 (a) is added to allocate allowances for supplemental emissions reductions.
- The allowance price used in this figure is from the IGEM “*scenario 8 HR 2454.*”
- Except where noted by an *, the uses of allowances shown here are modeled within IGEM in that the appropriate sector receives the value of the allowances, although not all of the effects of the programs specified are modeled.
- * and shown in gray, indicates that the specified allocation is not explicitly modeled in IGEM. These allowances are instead allocated lump sum to households.
- ADAGE models all of the specified uses of allowances captured in IGEM, and also models the energy efficiency provisions in subsections (b), (c) and (g).

- Both of the computable general equilibrium models used in this analysis have a single representative agent household. Any auction revenue returned to households clearly accrue to households. Additionally, any private sector revenues from allocated allowances also accrue to the employee-shareholder households. Since the model only has a single representative agent household, the differing distributional impacts of various allocation schemes are not reflected in the models.
- If auction revenues that are modeled as being returned to households lump sum were instead used for another purpose, they would increae costs unless they address a specific market failure. For example, if these auction revenues were instead used to lower distortionary taxes, the costs of the policy would be lower.

Value of Allocated & Auctioned Allowances

Scenario Comparison (IGEM)

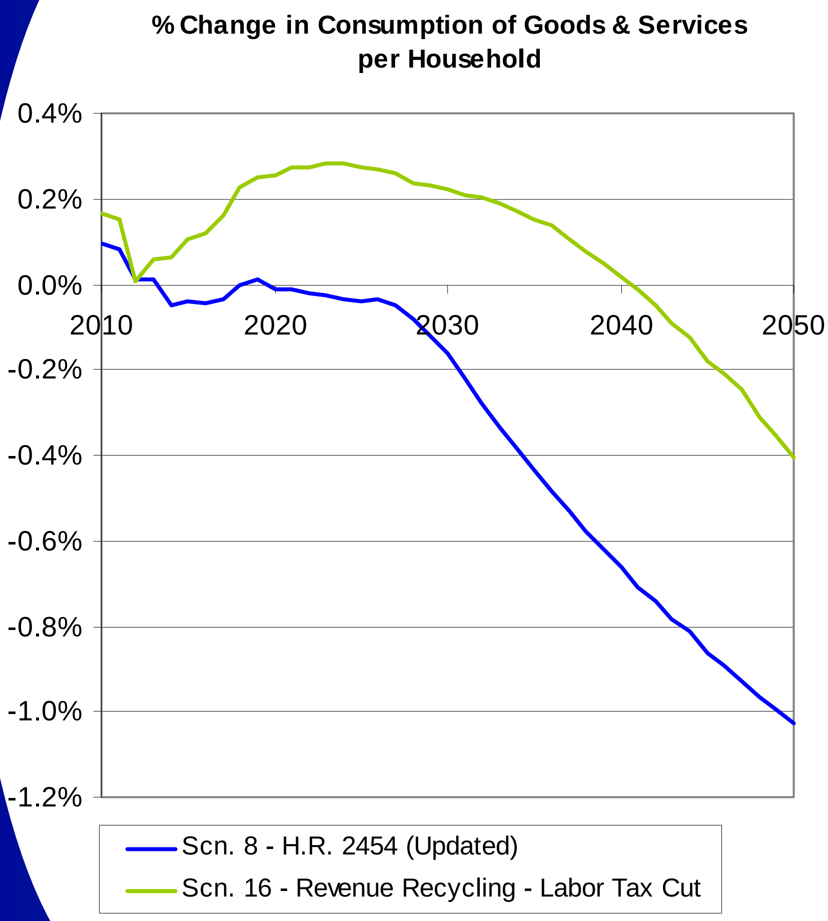




- Note that the CCS Bonus allowance value is shown in the year the bonus allowances are used, not the year they are originally dated.
- All allowance values that are not explicitly represented by IGEM are included in the allowance value returned to households.
- In scenario 8 the allowance value that is returned to households is returned via lump sum payments.
- In scenario 16 the allowance value that is returned to households is returned via a reduction in the labor tax rate.

Value of Allocated & Auctioned Allowances

Scenario Comparison (IGEM)



- Returning allowance value to households via a reduction in the labor tax rate can increase consumption relative to other scenarios that do not return allowance value via reductions in tax rates. In Scenario 16, auction revenue is returned to the representative household in the form of an 0.6 percentage point reduction in the labor tax rate faced by that household.
  - While the reduction in the labor tax rate averages 0.6 percentage points over all years, the reduction varies over time as the value of allowances devoted to reducing the labor tax rate varies.
    - The reduction is 0.5 percentage points in 2012, 0.5 percentage points in 2020, 0.9 percentage points in 2030, 0.8 percentage points in 2040, and 0.5 percentage points in 2050.
  - Returning allowance value through a decrease in the labor tax rate increases wages, encourages more work over leisure, and raises consumption and GDP relative to what would occur in a policy scenario without such recycling;
  - In fact, the modeling suggests that, as a result of such reductions in labor taxes, consumption could even increase relative to reference case levels over the next several decades.
  - Since the model only has a single representative agent household, it cannot analyze the distributional impacts of returning allowance value to households via reductions in labor taxes. However, the economic literature highlights that there tends to be a trade-off between achieving particular distributional objectives and the aggregate economic gains from such revenue recycling. While the economic gains from reducing labor tax rates tend to be higher the higher the targeted tax rates--because higher rates distort economic activity more than lower rates assuming a constant labor supply elasticity across all households—the direct benefit of revenue recycling that targets the highest tax rates without consideration to the effect on average tax rates, will also disproportionately accrue to higher income households (Mirrlees, 1971; Auerbach and Hines, 2002).
  - The consumption impact in Scenario 16 is sensitive to assumptions about how labor supply responds to changes in the real wage. See next slide for more discussion.

Further Discussion (IGEM)

- The first stage of the household decision process is the allocation of full consumption over time, where full consumption is the consumption of both goods & services as well as leisure.
  - This intertemporal allocation of consumption is what results in a slight increase in consumption in the initial years of the policy.
  - Because the intertemporally optimizing households with perfect foresight in the model see higher prices in the future, they desire to consume relatively more today as compared to a more expensive future (additionally there can be less motivation to invest today for a less productive future).
  - This effect is common to all intertemporally optimizing CGE models (as opposed to recursive dynamic CGE models).
- The second stage of the household decision process is the allocation of full consumption between leisure and goods and services.
  - The parameter that governs this decision, the compensated elasticity of labor supply, plays a dominant role in model outcomes, and in particular is the driving force behind the relatively large impacts of recycling auction revenues through reduced labor taxes in IGEM.
  - Unfortunately there is not a consensus in the literature about what value this parameter should take.
    - In ADAGE, this consumption-leisure parameter is adopted from values of related parameters in the empirical literature.
    - Much of the empirical literature examines the effect of a real wage increase on the willingness to supply additional labor hours without simultaneously considering the impact on labor force participation.
    - Attempts to combine both impacts in a single parameter have yielded estimates ranging from 0.1 to 0.6 for the compensated elasticity of labor supply.
    - IGEM estimates the time-varying compensated elasticity of labor supply as part of a comprehensive model of household behavior and finds values ranging from 0.8 to 1.0.
- The implication of this is that the gains and losses in consumption may be exaggerated due to the assumption about how labor supply responds to changes in the real wage.
  - Reviews of empirical studies suggest roughly 1/3 the responsiveness in IGEM (Fuchs et al 1991; Blundell et al1999), though a more recent study including labor force participation decisions suggest closer to 2/3 the responsiveness in IGEM (Fullerton and Metcalf 2001).
  - A sensitivity analysis using a less (1/3) responsive labor supply for a similar policy found both consumption gains and losses were more than 70% smaller than the base case (Jorgenson et al 2008).

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- Blundell, R. and T. MaCurdy. 1991. Labor Supply: A Review of Alternative Approaches. In *Handbook of Labor Economics*, edited by O. Ashenfelter and D. Card. New York: Elservier
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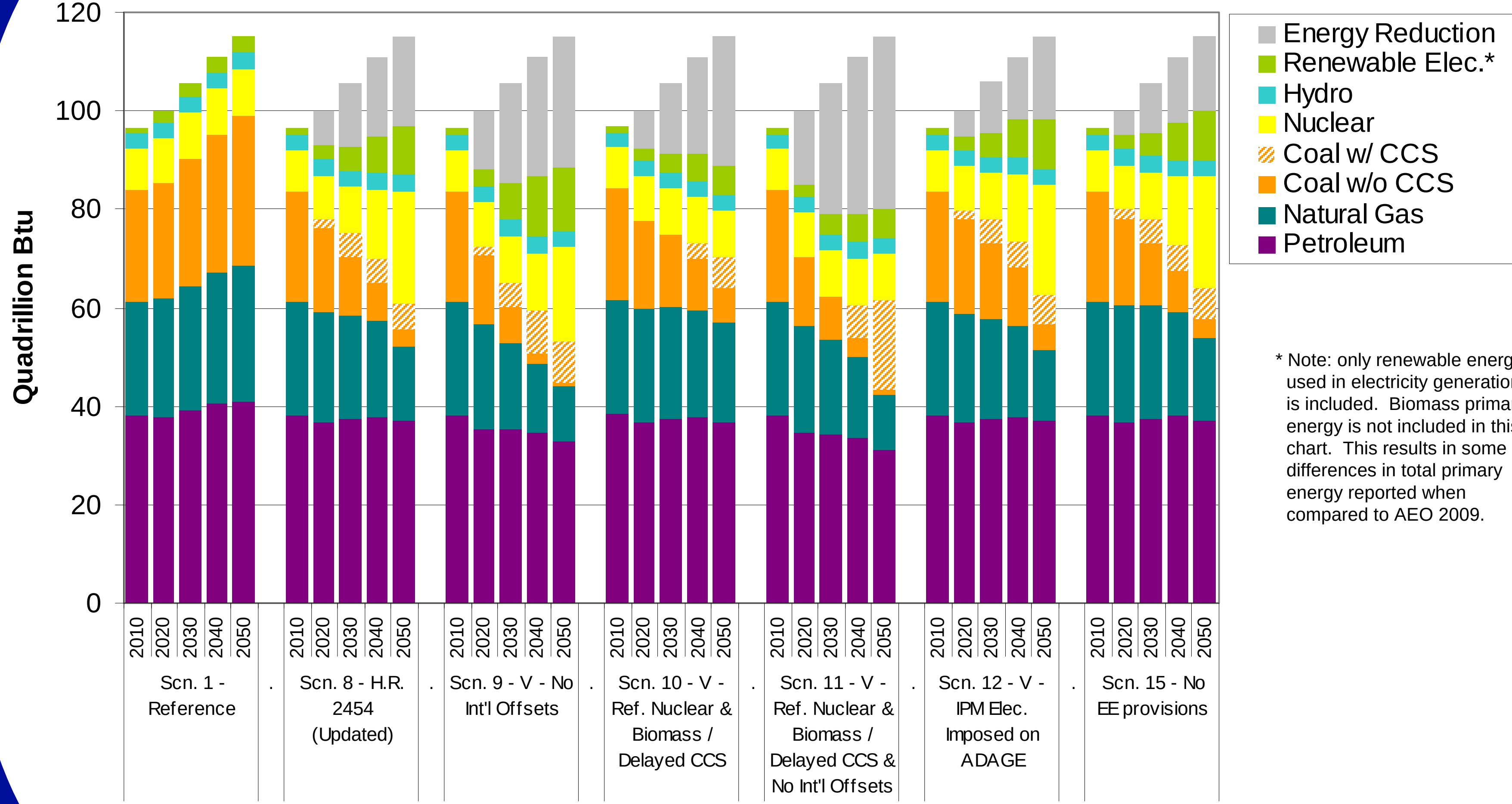
Energy Sector Modeling Results from Economy-Wide Modeling

Primary Energy

H.R. 2454 Scenario Comparison (ADAGE)



* Note: only renewable energy used in electricity generation is included. Biomass primary energy is not included in this chart. This results in some differences in total primary energy reported when compared to AEO 2009.

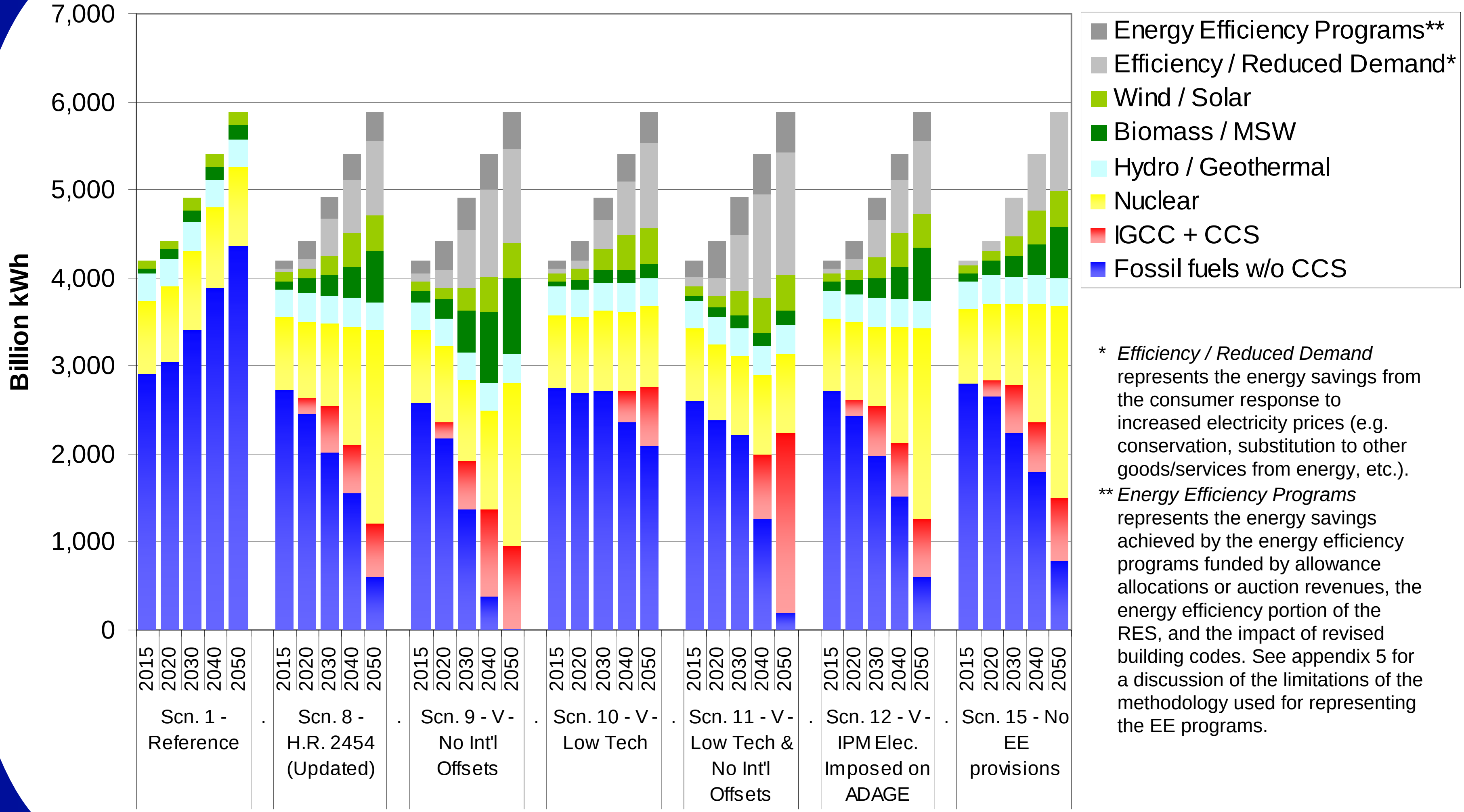
Primary Energy

H.R. 2454 Scenario Comparison (ADAGE)

- The structure of energy consumption is transformed in the policy scenarios.
- A joint constraint on nuclear power and CCS in ADAGE is based on the constraint used in IPM (see Appendix 6 and Appendix 7 for more detail).
- In the reference scenario, primary energy use is 99 quadrillion Btu in 2015, and grows 7% by 2030 and 17% by 2050.
  - In scenario 8, primary energy use falls to 95 quadrillion Btu in 2015 and to 93 quadrillion Btu in 2020, then gradually rebounds to 97 quadrillion btu by 2050.
  - In scenario 9 without international offsets, primary energy use falls to 92 quadrillion Btu in 2015 and is at 89 quadrillion Btu in 2050.
  - In scenario 10 with nuclear power and bioelectricity constrained to reference case levels and CCS not available until after 2030, primary energy use falls to 95 quadrillion Btu in 2015 and is at 89 quadrillion Btu in 2050.
  - In scenario 11 with nuclear power and bioelectricity constrained to reference case levels and CCS not available until after 2030 and no international offsets; primary energy use falls to 90 quadrillion Btu in 2015 and continues to fall to 79 quadrillion Btu in 2030 before leveling off.
  - In scenario 12 with the ADAGE electricity sector constrained to match the emissions reductions estimated in IPM, primary energy use falls to 96 quadrillion Btu in 2015, is still 96 quadrillion Btu in 2030, and is 98 quadrillion Btu in 2050.
  - In scenario 15 without the energy efficiency provisions, primary energy use falls to 96 quadrillion Btu in 2015 and to 95 quadrillion Btu in 2020, then gradually rebounds to 100 quadrillion Btu by 2050.
- In the reference case, low- or zero- carbon energy (including nuclear, renewables, and CCS) makes up a steady 14% of total primary energy.
  - In scenario 8, low- or zero- carbon energy makes up 18% of primary energy by 2020, 24% by 2030, and 43% by 2050.
  - In scenario 9, low- or zero- carbon energy makes up 20% of primary energy by 2020, 30% by 2030, and 50% by 2050.
  - In scenario 10, low- or zero- carbon energy makes up 16% of primary energy by 2020, 18% by 2030, and 28% by 2050.
  - In scenario 11, low- or zero- carbon energy makes up 17% of primary energy by 2020, 21% by 2030, and 46% by 2050.
  - In scenario 12, low- or zero- carbon energy makes up 18% of primary energy by 2020, 24% by 2030, and 43% by 2050.
  - In scenario 15, low- or zero- carbon energy makes up 18% of primary energy by 2020, 24% by 2030, and 42% by 2050.

U.S. Electricity Generation

H.R. 2454 Scenario Comparison (ADAGE)



* *Efficiency / Reduced Demand* represents the energy savings from the consumer response to increased electricity prices (e.g. conservation, substitution to other goods/services from energy, etc.).

** *Energy Efficiency Programs* represents the energy savings achieved by the energy efficiency programs funded by allowance allocations or auction revenues, the energy efficiency portion of the RES, and the impact of revised building codes. See appendix 5 for a discussion of the limitations of the methodology used for representing the EE programs.

U.S. Electricity Generation

H.R. 2454 Scenario Comparison (ADAGE)

- Most growth in generation in the reference case comes from traditional fossil fuels (cumulative capacity additions of 80 GW by 2030, 207 GW by 2050). The reference case also sees a small amount of new nuclear (12 GW by 2030), and renewables (28 GW of wind/solar/biomass/MSW by 2030, 31 GW by 2050).
- In the policy scenarios a joint constraint on nuclear power and CCS is based on the constraint used in IPM (see Appendix 5 and Appendix 6 for more detail).
- In *"scenario 8 – Updated H.R. 2454"* cumulative capacity additions above reference case levels by 2030 are 43 GW of renewables, 72 GW of CCS, and 2 GW of nuclear. By 2050 cumulative capacity additions above reference levels are 134 GW of renewables, 162 GW of nuclear, and 82 GW of CCS.
- Price induced energy efficiency and reduced demand combined with the energy efficiency programs decrease required electricity generation in *"scenario 8 – Updated H.R. 2454"* by 7% in 2030 and 20% in 2050.
- CCS deployment on fossil-fuel generation begins in 2020 with 25 GW of CCS capacity in *"scenario 8 – Updated H.R. 2454"* in response to the CCS bonus allowances.
- In scenario 9 without international offsets, the allowance price is 148% higher, resulting in a greater reduction in electricity generation (21% in 2030, 25% in 2050); a greater amount of renewables (85 GW by 2030, 172 GW by 2050); a greater amount of CCS in 2050 (75 GW by 2030, 126 GW by 2050); and a lesser amount of nuclear (0 GW by 2030, 121 GW by 2050).
- In scenario 10, nuclear power and bioelectricity are held to reference levels and CCS is not allowed until after 2030, resulting in a 14% increase in allowance prices. This results in a similar reduction in electricity generation (7% in 2030, 12% in 2050); fewer renewables (34 GW by 2030, 77 GW by 2050); and less CCS in 2030, and a similar amount of CCS in 2050 (0 GW by 2030, 91 GW by 2050); and a greater amount of remaining traditional fossil generation.
- In scenario 11, nuclear power is held to reference case levels and CCS is not allowed until after 2030 and international offsets are not allowed resulting in a 229% increase in allowance prices. This results in a greater reduction in electricity generation (22% in 2030, 24% in 2050); fewer renewables (40 GW by 2030, 77 GW by 2050); and a greater amount of CCS in 2050 (0 GW by 2030, 272 GW by 2050).
- In scenario 12, emissions reductions in the ADAGE electricity sector are constrained to match IPM, resulting in a 4% increase in allowance prices. This results in in a similar reduction in electricity generation (7% in 2030, 12% in 2050); similar renewables (42 GW by 2030, 135 GW by 2050); and a similar amount of CCS (75 GW by 2030, 89 GW by 2050).
- In scenario 15 without the energy efficiency programs, electricity demand falls by 3% in 2020, 9% in 2030, and 15% in 2050 relative to the reference case; compared to a fall of 7% in 2020, 13% in 2030, and 20% in 2050 in scenario 8 with the energy efficiency programs.
- Note: ADAGE does not represent dispatch or shifting of generation between existing fleet units, so all capacity change figures are derived directly from changes in generation. Because of this, ADAGE may overstate capacity reductions and expansions.

Scenario 8 & 15

H.R. 2454 Energy Efficiency Provisions Discussion

Calculated demand impacts and costs

- Impacts on electricity and natural gas demand, and associated costs, were calculated for the following energy efficiency provisions: allowance allocations to energy efficiency, building codes, and the energy savings component of the Combined Efficiency and Renewable Electricity Standard. See appendix 5 for further detail.
- Electricity demand reductions are estimated to grow to 4.8% of reference case demand by 2020 and increase to 7.1% of AEO reference case demand in 2050.
- Natural gas demand reductions are estimated to grow to 5.4% of reference case demand by 2030, and decrease to 4.7% of reference case demand in 2050.
- Above impacts were incorporated within ADAGE '*scenario 8 – H.R. 2454*'.
- Cost impacts were calculated, and applied to the manufacturing and services sectors within ADAGE.

Modeled economic impacts

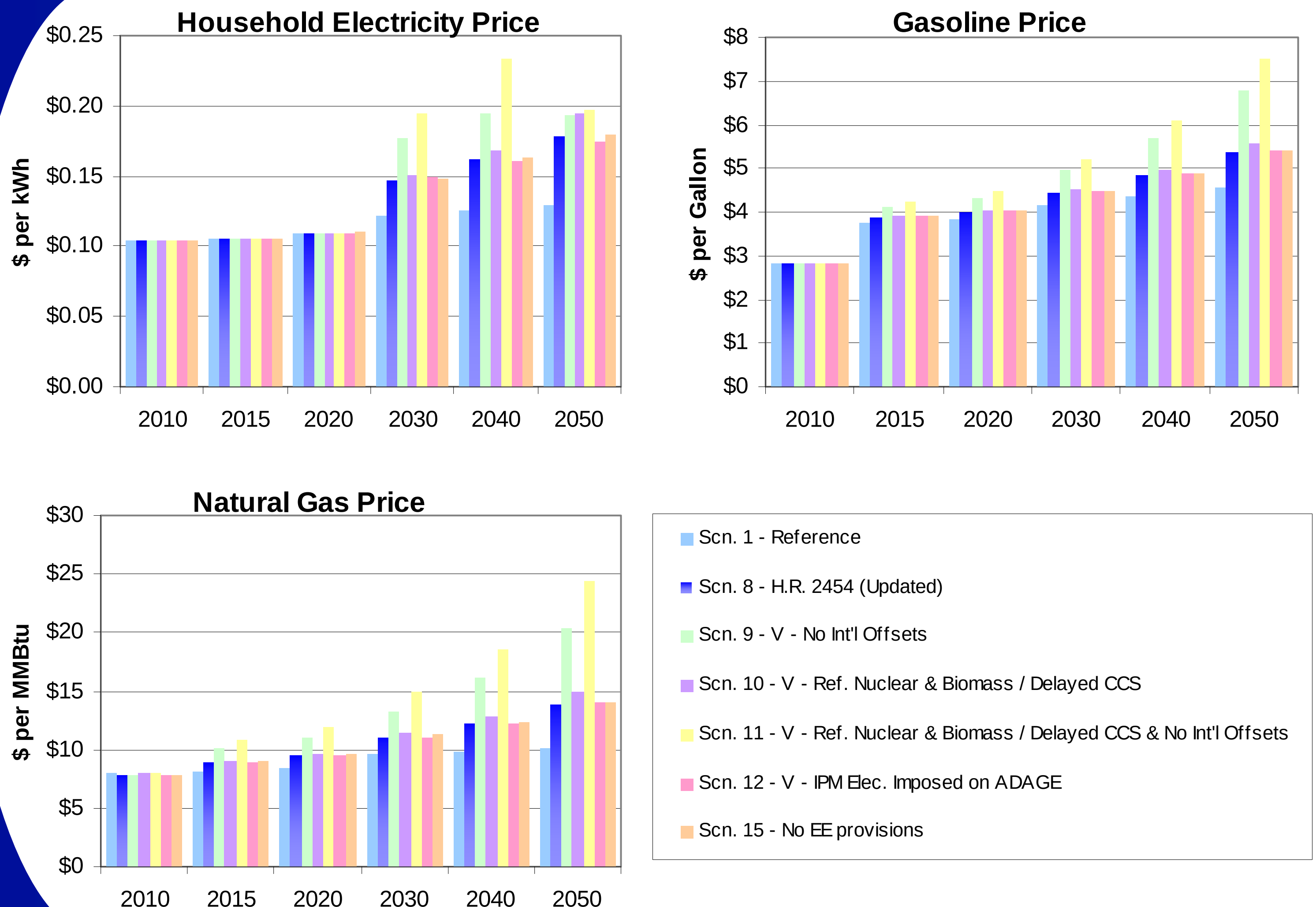
- Allowance prices are forecast to be slightly higher without energy efficiency provisions ('*scenario 15 – H.R. 2454 w/o Energy Efficiency Provisions'* relative to '*scenario 8 – H.R. 2454.')*
  - ~2% higher allowance prices estimated each year for 2015-2050
- Fossil fuel prices are forecast to be slightly higher for 2015-2050 without energy efficiency provisions (*scenario 15* relative to *scenario 8).*
  - Coal and Natural Gas ~2% higher
- Electricity prices are forecast to be slightly higher (<1%) for 2015-2050 without energy efficiency provisions (*scenario 15* relative to *scenario 8).*

Caveats on modeling of energy efficiency provisions

- A significant energy demand price response is forecast by ADAGE. This response is driven by a number of factors including substitution away from energy consumption to other products/services, conservation behavior (e.g., turning off lights), as well as increased investments in energy efficiency.
- A portion of estimated energy demand reduction from energy efficiency provisions may be a-priori incorporated into the baseline responsiveness of demand to a price increase in ADAGE. Further analyses are needed to quantify the extent to which demand reduction may be double-counted in this scenario.
- While the costs of the energy efficiency programs are applied to the manufacturing and services sectors of ADAGE, the cost of saved energy for energy efficiency programs is not calculated by the model.

Energy Prices

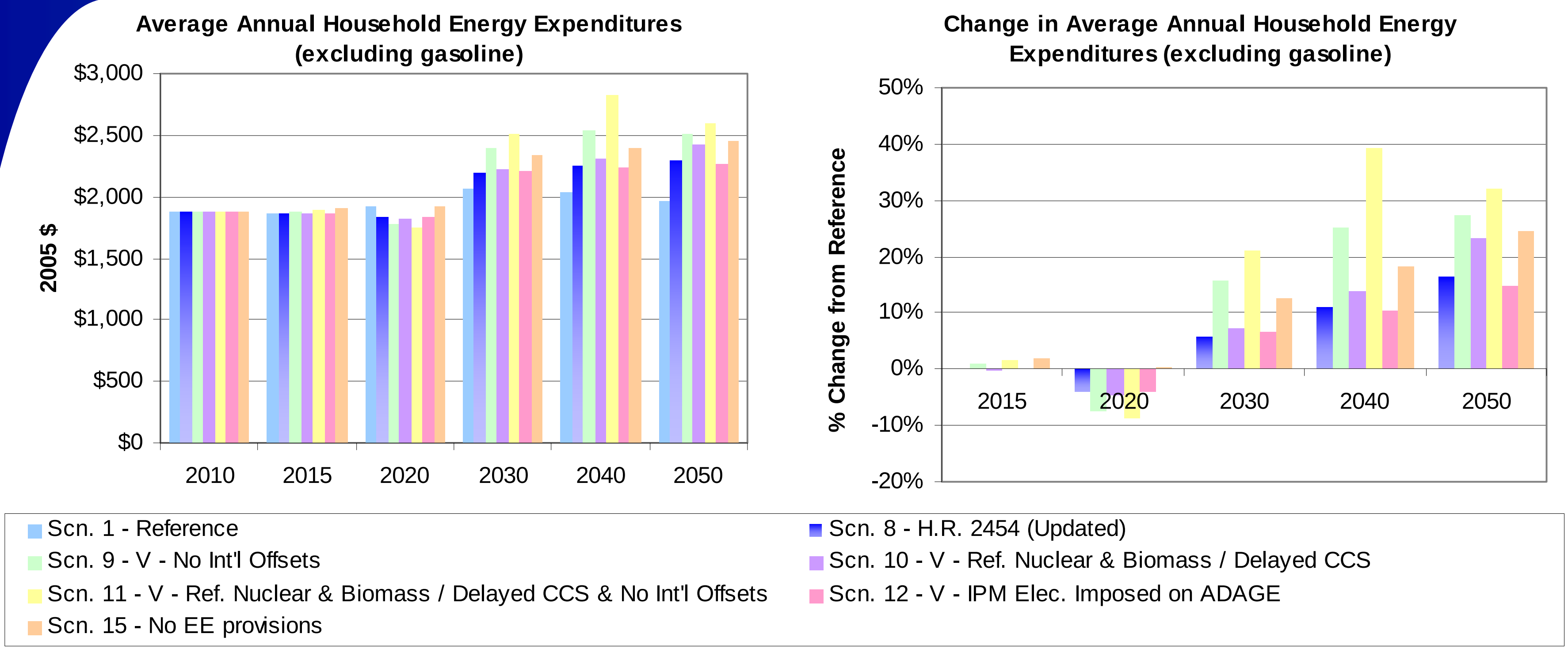
H.R. 2454 Scenario Comparison (ADAGE)



- Gasoline and natural gas prices are inclusive of the allowance price (i.e. they represent the price faced by consumers, not the price received by producers which would be exclusive of the allowance price).
- The gasoline price is obtained by multiplying the petroleum price index in ADAGE by the 2010 price of gasoline from the AEO 2009 projection.
- The allocations to electric local distribution companies (LDC's) prevent the household electricity price from increasing until the allocations phase out beginning in 2025.

Household Energy Expenditures

H.R. 2454 Scenario Comparison (ADAGE)



- In 2020, electricity prices are equal to reference levels in "*scenario 8 – Updated H.R. 2454.*" In 2030 they increase by 21% over reference levels, and in 2050 the increase is 36%.
- Actual household energy expenditures increase by a lesser amount due to reduced demand for energy.
    - In 2020, the average household's energy expenditures (excluding motor gasoline) falls by 5% in *scenario 8 – updated H.R. 2454.*" In 2030, the increase is 6% over reference levels, and in 2050 the increase is 17%.
- In ADAGE, energy expenditures represent approximately 2% of total consumption in 2020, falling to 1% by 2050 in all scenarios.
- The energy expenditures presented here do not include any potential increase in capital or maintenance cost associated with more energy efficient technologies.
- While energy expenditures begin to rise by significant amounts in 2030 to 2050, these increases are largely offset by the per-capita rebate, protection for low-income households, and other ways of returning allowance value to households. (Slide 20 shows the net impact on households accounting for both increased costs and return of allowance value.)

Detailed Near-Term Electricity Sector Modeling Results

Detailed Electricity Sector Modeling with IPM

Motivation for Using the Integrated Planning Model (IPM):

- The CGE models used for this analysis do not have detailed technology representations; they are better suited for capturing long-run equilibrium responses than near-term responses.
- Since the electricity sector plays a key role in GHG mitigation, EPA has employed the Integrated Planning Model (IPM) to project the near-term impact of this policy scenario on the electricity sector.

Power Sector Modeling (IPM 2009 ARRA Ref. Case):

- This version of IPM is the same one used for the H.R. 2454 analysis released in June, 2009. It is built on the versions used previously to analyze the Waxman-Markey discussion draft, S. 280, S. 1766, and S. 2191.
- This version of the model incorporates key carbon-related options and assumptions, such as carbon capture and storage technology for new and existing coal plants, biomass co-firing options, and technology penetration constraints on new nuclear, renewable, and coal with CCS capacity.
- The model includes assumptions from the revised Energy Information Administration's Annual Energy Outlook 2009, taking into account the impacts of the American Recovery and Reinvestment Act (ARRA) of 2009. This update changed the reference case forecast for renewable energy considerably.

Modeling Approach:

For this analysis, IPM 2009 ARRA Ref. Case incorporated two sets of data from the ADAGE model:

- CO_2 allowance price projections*
- Percent change in electricity demand*

Note: For more detail on the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html.

* Allowance prices for the core IPM scenario are taken from the updated ADAGE core scenario (Scenario 8).

IPM Scenarios and Major Power Sector Provisions Modeled in IPM

The following IPM scenarios were modeled for the power sector:

1. Core ADAGE H.R. 2454 Scenario (Scenario 8)
2. Effects of the Combined Efficiency and Renewable Electricity Standard Scenario (CERES) (ADAGE Scenario 8)

<u>Major Bill Provisions:</u>

CCS Demonstration and Early Deployment (Title I, Subtitle B, Sec. 114): Designed to "accelerate the commercial availability of carbon dioxide capture and storage technologies and methods."

- A Carbon Storage Research Corporation is created and administers funds generated through fees on electricity production by fuel type. The Corporation, organized through EPRI, will administer and distribute roughly $1 billion in annual funding for 10 years from date of enactment.
- IPM implementation: Assumed that this funding spurs 1 additional GW of CCS capacity by 2015 (beyond the baseline amount) and an additional 4 GW by 2020. These projects are "hard-wired" into IPM and are not a result of the model's economic analysis. The model may independently add CCS capacity after 2015 on an economic basis, subject to an upper-bound capacity development constraint. The funding amounts to about $2,000/kW for 5 GW of CCS.

CCS Bonus (Title I, Subtitle B, Sec. 115): Designed to provide additional economic incentive for coal with CCS through allocation of "bonus" allowances.

- A portion of allowances are reserved for incentivizing carbon capture and storage technology (starting at 1.75% of allowances and rising to 5% through 2050). The specific incentive is designed as a fixed monetary value for every ton of CO_2 sequestered, rather than a certain number of allowances. The value is specified as up to $100/ton for the first 6 GW and is unspecified (at no greater than $90/ton) for additional support until a maximum of 72 GW of CCS receives the bonus. A stream of specified bonus allowances are made into "current" allowances and made available to qualifying projects dependent upon allowance prices and the total quantity allocated. The bonus is administered as a reverse auction.
- IPM implementation: Similar to past IPM applications, CCS projects receive a subsidy equal to the bonus amount. The allowances are distributed on a first-come, first-serve basis and can be banked. Analysis was performed for a range of potential dollar-per-ton values after the initial $90/ton for the first 6 GW. In this analysis of H.R2454, $40/ton was used as the bonus amount for generation beyond the first 6 GW.

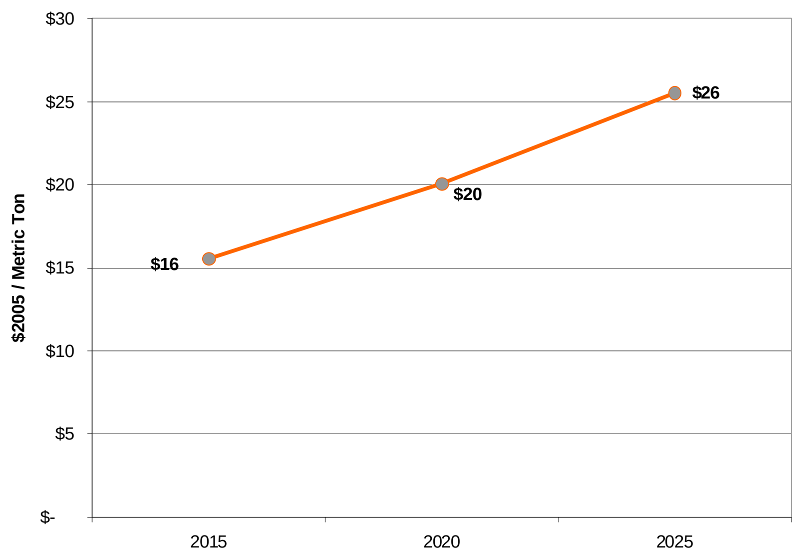
Combined Efficiency and Renewable Electricity Standard (Title I, Subtitle A, Sec. 101): Requires retail electricity providers to meet a minimum share of sales with electricity savings and qualifying renewable generation by holding tradable credits.

- Nominal targets begin at 6% in 2012 and rise to 20% by 2020. Up to 1/4 of the target may be met with electricity savings (Governors may petition to raise this amount to 2/5). Qualifying renewable resources include solar, wind, biomass, landfill gas, and geothermal. Sales of generation from new nuclear, new CCS[†], and existing hydropower capacity are deducted from a retail provider's total sales for assessing the CERES requirement. The bill allows sources to bank federal Renewable Electricity Credits (RECs) for 3 years following generation. Retailers selling less than 4 million MWh a year are exempted from CERES.
- IPM implementation: Reductions in electricity consumption are assumed to meet 1/4 of the standard's targets, which are reduced accordingly.* Estimated sales from hydro generation, new CCS[†] generation, and new nuclear generation (as projected by IPM in the main H.R. 2454 policy case) are deducted from total sales to establish the qualifying sales levels for meeting CERES. Banking is not explicitly modeled but is implicitly included because the model runs roughly every 5 years. The share of sales from exempted retailers is assumed to remain constant at about 23% (its 2007 level) and is removed from CERES assessment.

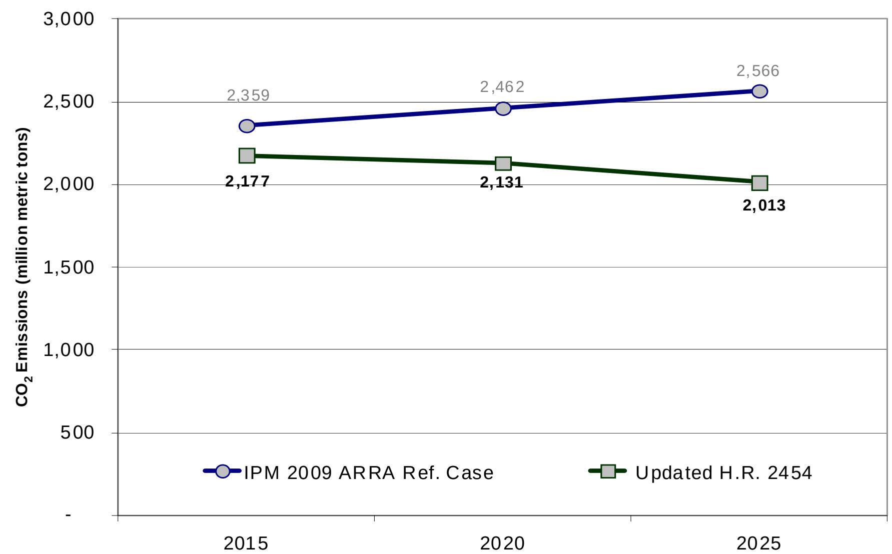
Note: See Appendix for more detail on updates to IPM. For more detail on the all of the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html.

GHG Allowance Prices and Power Sector CO_2 Emissions (IPM)*

Core Scenario GHG Allowance Price
(from ADAGE Core H.R. 2454 - Scenario 8)*

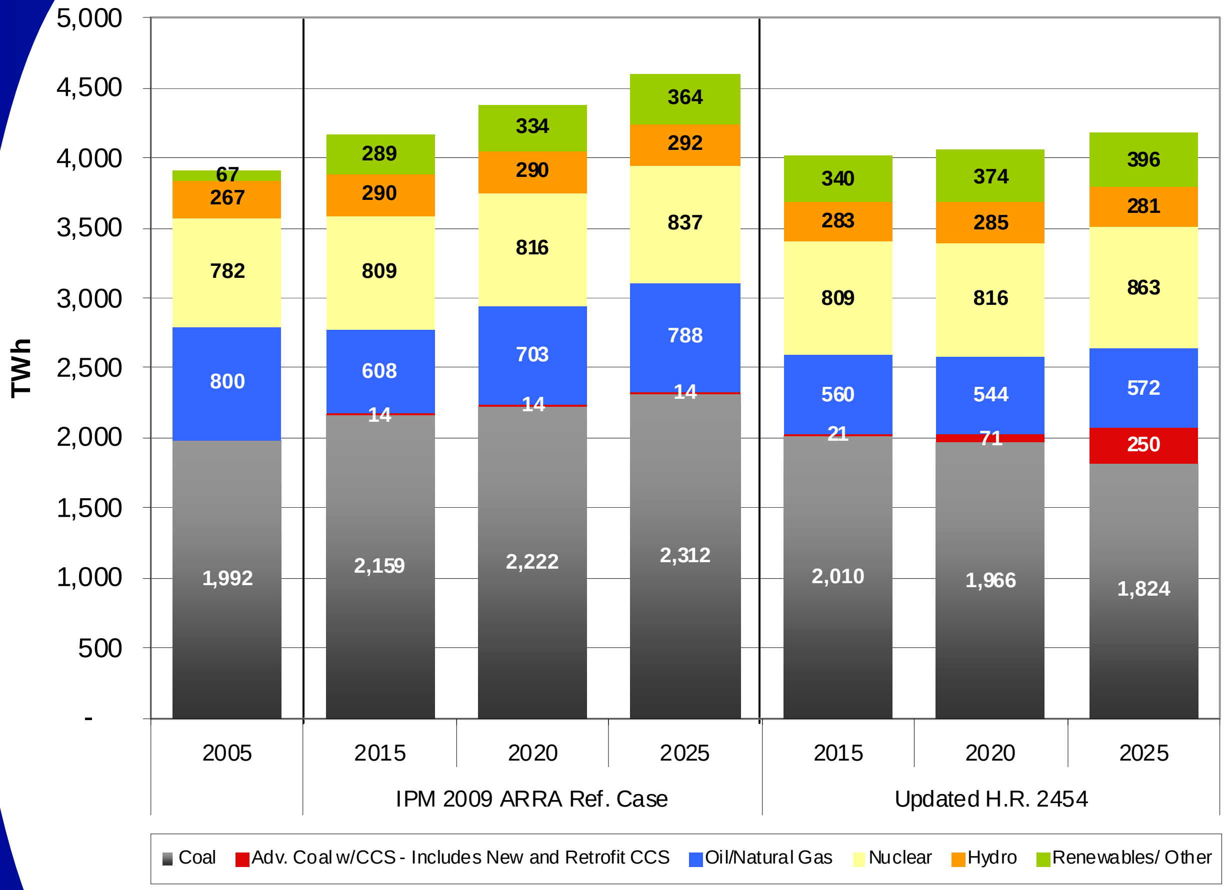


Power Sector CO_2 Emissions



* Allowance prices for the core IPM scenario are taken from the ADAGE H.R. 2454 core scenario (Scenario 8). IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has slightly different treatment of key assumptions and variables.

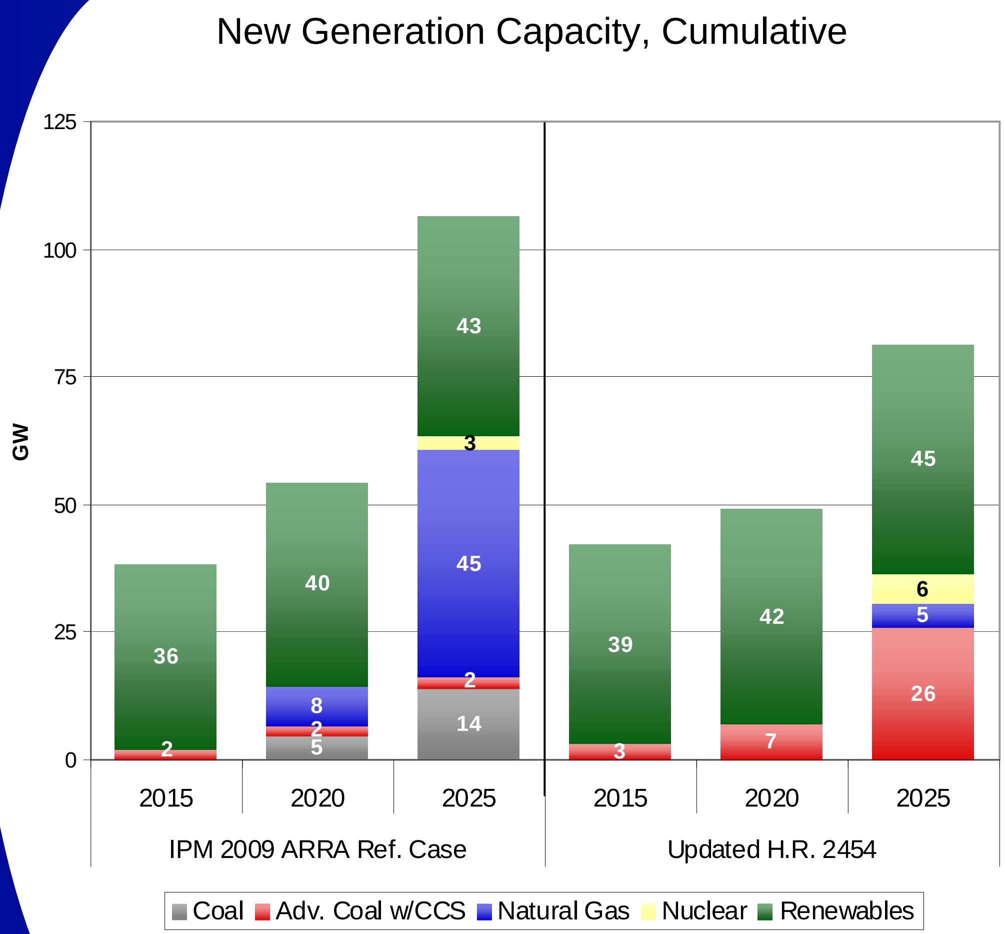
Electricity Generation Mix (IPM)



- The reference case electricity demand forecast is lower than in EPA analyses of legislative proposals prior to H.R. 2454, reflecting revised economic growth and recently enacted laws supporting energy efficiency.
- Due to a large increase in renewable energy largely driven by ARRA provisions, there is excess electricity generating capacity projected through 2015 in the reference case and the policy scenario.
  - This tends to drive generation away from existing natural gas.
- The difference in electricity generation between the reference case and policy case is around 420 TWh in 2025. This difference is equivalent to the amount of electricity used by more than 30 million (40% of the total) single family homes in the US annually*
- Increased renewable generation in the policy scenario is due both to additional renewable capacity and increased co-firing of biomass at existing coal plants.

2005 data from EIA's Electric Power Annual (for electric utilities, independent power producers, and CHP electric power). IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables.
*EIA. 2005 Residential Energy Consumption Survey. Table 3. http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html.

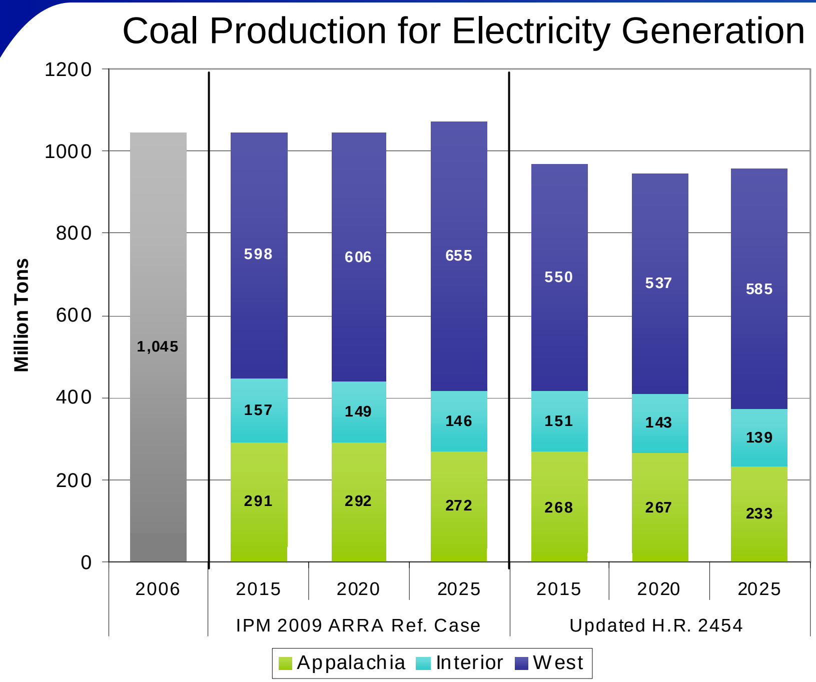
New Generation Capacity (IPM)

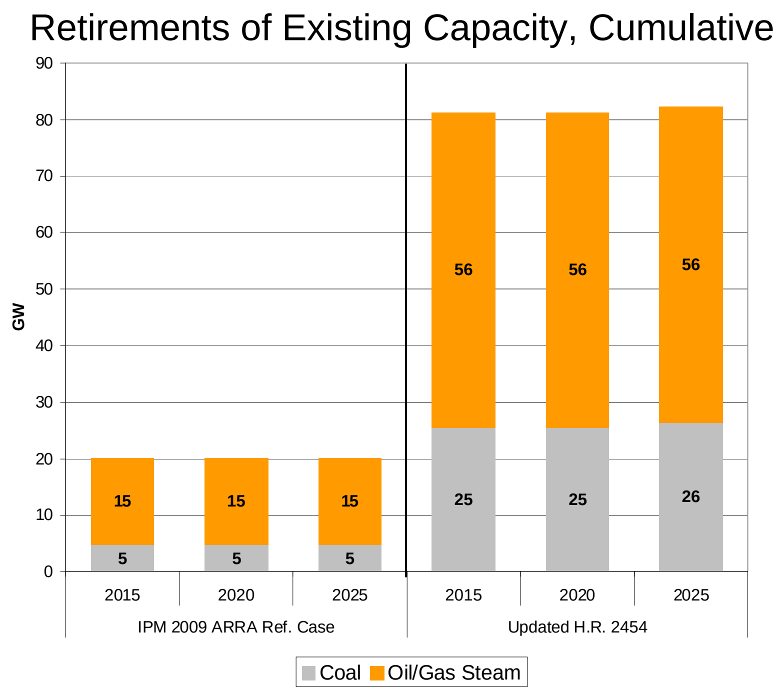


- The IPM 2009 ARRA reference case (used also in EPA's previous H.R. 2454 analysis) greatly increased the amount of new renewables expected to be built in the short-term in response to additional ARRA incentives. Overall electricity demand is also lower, necessitating fewer new power plants than past EPA modeling with IPM.
- Allowance prices support deployment of some additional low- or zero- carbon energy (including nuclear and renewables) by 2025, although the CCS bonus allowances drive the largest additions of new capacity.
- Early deployment funding and a bonus allowance provision for captured and sequestered CO_2 emissions result in some penetration of new coal capacity with CCS technology.
  - The policy results in a total of 24 GW of additional new capacity with CCS by 2025. Of that amount, 5 GW are forced in IPM beyond the reference case by 2020 to reflect early deployment funding. The other 19 GW become economic due to the bonus allowance allocation.
  - CCS retrofits to the existing coal fleet are also economic, facilitated by the bonus (retrofits to existing facilities are not reflected in the graphic).
    - There are about 9 GW in 2025 of post-retrofit capacity, which meets IPM's CCS retrofit penetration limit (while the limit on new CCS capacity penetration is not reached).*
- The amount of new nuclear capacity is well below the combined nuclear/CCS penetration limit throughout the entire modeling period.

Note: New capacity additions less that 1 GW of capacity are not indicated. IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables. IPM projects less new nuclear and slightly less new renewable capacity compared to AEO 2009 ARRA. * See appendix for more detail on EPA's technology penetration limits applied in IPM, post-retrofit capacity of CCS includes associated de-rating and/or energy use of CCS system.

Coal Production for Electricity Generation & Retirements of Existing Capacity (IPM)

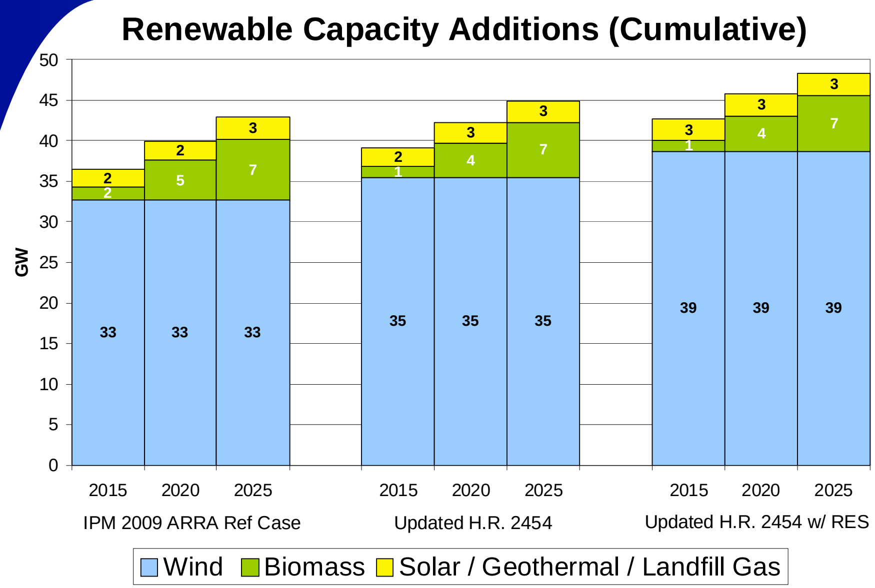


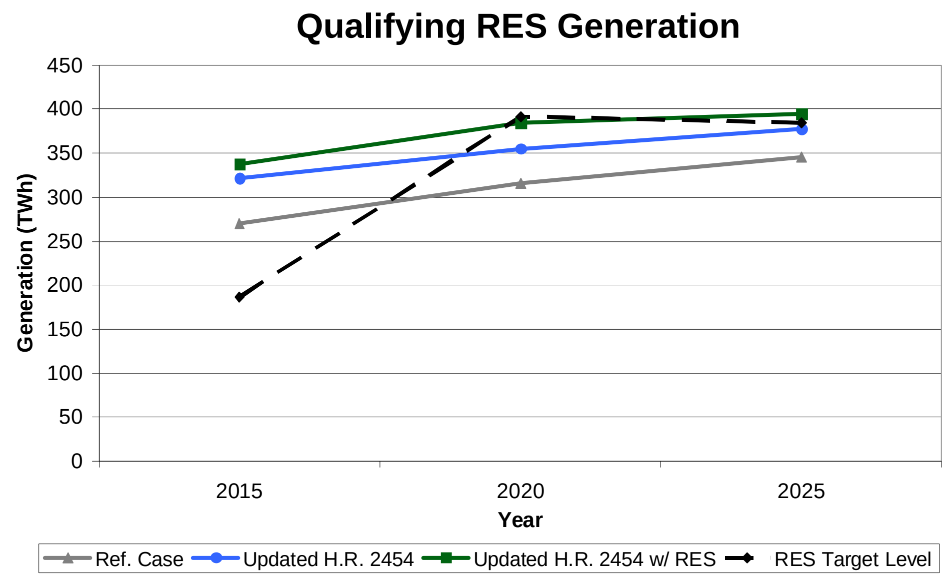


- Roughly 20 GW of additional existing coal capacity and 41 GW of additional oil/gas capacity are projected to retire under the updated policy scenario. Relatively low allowance prices and relatively high costs to build new technology make existing coal cost-competitive in the shorter-term.
- These results show greater amounts of coal and oil/gas steam retirements in the updated policy scenario. Electricity demand reductions achieved by the energy efficiency provisions in H.R. 2454 and incentives for CCS decrease the need for the less efficient existing stock of coal-fired power.
- In reality, uneconomic units may be “mothballed,” retired, or kept running to ensure generation reliability. The model is unable to distinguish among these potential outcomes. Most of these are marginal units with low capacity factors.
- Most uneconomic units are part of larger plants that are expected to continue generating. Currently, there are roughly 120 GW of oil/gas steam capacity and 320 GW of coal capacity.

Note: Regional coal production data includes coal production for power generation only. Historical data is from EIA’s AEO 2008. Coal production (in terms of tons) does not correlate to generation perfectly because different grades of coal have greater heat content (e.g. bituminous coal has greater heat content than sub-bituminous coal). In addition, coal production data shown here does not include coal imports, which increase over time in IPM. IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables.

Effects of the Combined Efficiency and Renewable Electricity Standard (CERES)

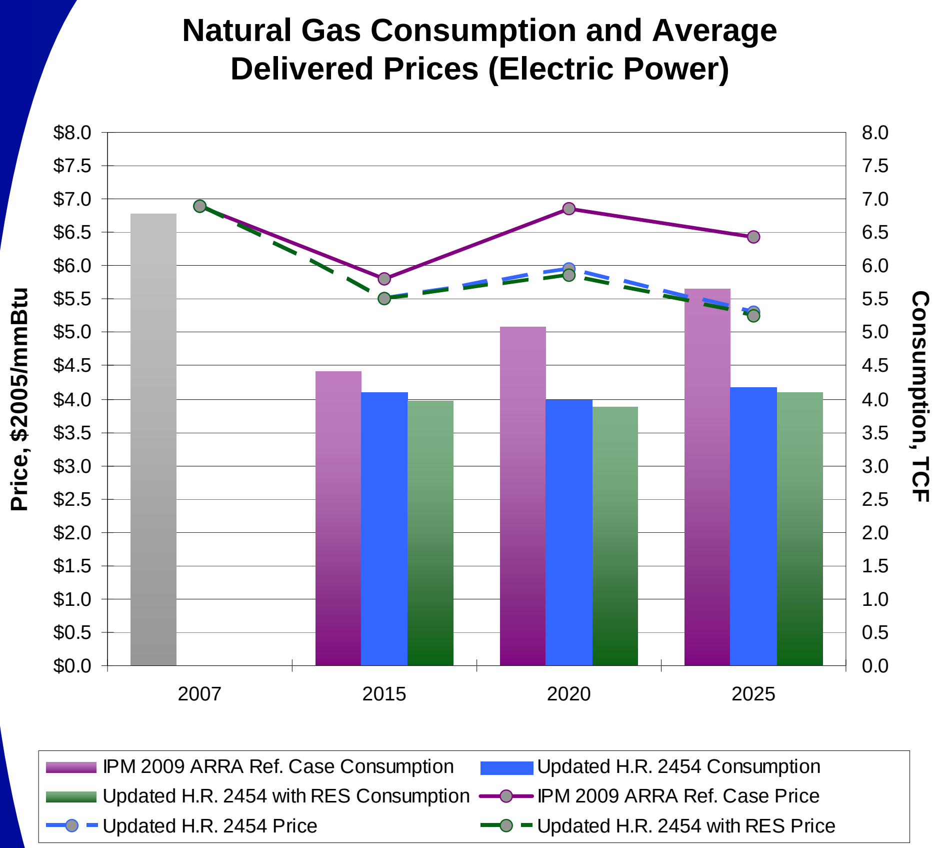




- The power sector is projected to reach the bill's RES targets through 2015 in the reference case (with 25% compliance from electricity savings assumed).
- The RES portion of CERES increases deployment of renewable capacity and drives a more substantial increase in renewable generation than the cap-and-trade program yields on its own.
  - Non-hydro renewables approach 10% of electricity supply in 2025 with the RES in place, as compared with only 7% in the reference case.
- H.R. 2454 includes an alternative compliance payment (ACP) of $25 per MWh, which the model triggers in 2020 to bridge a small shortfall in qualifying renewable generation in that period. The ACP is used only for 3.4% of total CERES compliance.
- By increasing the share of renewable generation, the RES would likely lower power sector GHG emissions and could lower the economy-wide allowance price, although this effect was not modeled in the analysis.
  - To the degree that the RES requires generation or capacity deployment that is not most cost effective otherwise, total system costs increase. A binding RES will not result in any emission reductions beyond what is need to achieve the caps under HR2454.

Note: Please see appendix for additional information on the Updated H.R. 2454 w/ RES scenario.

Power Sector Natural Gas Consumption and Prices (IPM)



Lower producer natural gas prices are the result of decreases in natural gas demand. This is due, in part, to the power sector's response to the emissions cap and CERES in H.R. 2454. Gas prices reflected here do not include the cost of CO_2 allowances.

		N. Gas Consumption and Prices			
		2007	2015	2020	2025
Nat. Gas Consumption (TCF)	Ref. Case	6.8	4.4	5.1	5.6
	Updated H.R. 2454		4.1	4.0	4.2
	Updated H.R. 2454 w/ RES		4.0	3.9	4.1
Nat. Gas Price, Delivered ($2005/mmBtu)	Ref. Case	$6.90	$5.79	$6.85	$6.42
	Updated H.R. 2454		$5.50	$5.95	$5.31
	Updated H.R. 2454 w/ RES		$5.50	$5.85	$5.25

Note: Natural gas prices and consumption presented here are determined endogenously in IPM and do not reflect changes in supply/demand (and thus prices) outside the power sector as a result of the policy (the ADAGE model is the economy-wide model that EPA uses to reflect this dynamic). To the extent that natural gas demand increases outside the power sector, the price impacts reflected here may be a bit lower than if the total demand for natural gas were reflected in IPM. However, demand for natural gas in ADAGE outside the power sector is not projected to increase significantly, so the price projections presented here would not be greatly impacted by demand from other sectors.

Technology Deployment: Carbon Capture and Storage

EPA analyses of cap-and-trade legislation clearly show the importance of technology in achieving climate goals and the Agency included an alternate scenario on technology deployment, as requested by Sen. Voinovich. Today, there is already considerable interest and activity in low- and non-emitting technologies like CCS, nuclear, and biomass. A cap-and-trade system would serve to make these technologies more cost-competitive for widespread commercialization.

CCS:

- CCS technology has been demonstrated for decades in industrial applications and is used widely by the oil and gas industry. Although challenges remain for larger scale applications, the basic engineering has been applied at numerous facilities for long periods of time.
- There are nearly 3 GW of CCS power plant projects in planning, design, and/or construction phases, some of which are already capitalizing on existing funding opportunities available. Several projects have obtained funding and commenced or scheduled operation.
  - We Energies' Pleasant Prairie Plant (Pleasant Prairie, WI): Technology currently operational in test phase (Source: We Energies Press Release, 10/08/2009).
  - AEP's Mountaineer Plant (New Haven, WV): Technology currently operational in test phase with plans to transition from the current 20 MW CCS pilot demonstration to a 235 MW full module demonstration in 2013-2014 (Source: AEP Press Release, 10/30/2009).
  - Southern Company's Plant Barry (Bucks, AL): Has been awarded $265 million from DOE to "retrofit a CO2 capture plant on a 160 megawatt flue gas stream at an existing coal-fired power plant. The capture plant is scheduled to begin operating by the first quarter of 2011 (Source: DOE, Mitsubishi Heavy Industries Press Release, 05/22/09).
  - Tenaska's Taylorville Energy Center (Taylorville, IL): Plans to operate a 750 MW IGCC with CCS in 2014. Taylorville was selected by DOE for a loan guarantee of up to $2.579 billon which is currently under negotiation (Source: DOE, Tenaska Press Release, 07/13/2009).
  - Tenaska's Trailblazer Energy Center (Sweetwater, TX): Requested permitting in 2008 for a 600 MW supercritical pulverized coal plant with CCS, which Tenaska plans to operate in 2015 (Source: Tenaska Press Release, 06/04/2009).
  - Hydrogen Energy California (Kern County, CA): Requested permitting in 2008 for a 250 MW IGCC with CCS and was awarded with $308 million from DOE in July 2009. Hydrogen Energy International, a joint venture between BP and Rio Tinto, projects the plant to start operation in September 2015 (Source: Hydrogen Energy International interview with California Energy Markets, 10/02/2009).

Sources: Worley-Parsons (http://www.globalccsinstitute.com/downloads/Status-of-CCS-WorleyParsons-Report-Synthesis.pdf), Department of Energy, Company statements. List of projects is not intended to be a comprehensive list.

Technology Deployment: Nuclear

Nuclear License Applications at the Nuclear Regulatory Commission

Combined License Applications Received

Proposed New Reactor(s)	Applicant	Design
Bell Bend Nuclear Power Plant	PPL Bell Bend, LLC	U.S. EPR
Bellefonte Nuclear Station, Units 3 and 4	Tennessee Valley Authority (TVA)	AP1000
Callaway Plant, Unit 2	AmerenUE	U.S. EPR
Calvert Cliffs, Unit 3	Calvert Cliffs 3 Nuclear Project, LLC and UniStar Nuclear Operating Services, LLC	U.S. EPR
Comanche Peak, Units 3 and 4	Luminant Generation Company, LLC (Luminant)	US-APWR
Fermi, Unit 3	Detroit Edison Company	ESBWR
Grand Gulf, Unit 3	Entergy Operations, Inc. (EOI)	ESBWR
Levy County, Units 1 and 2	Progress Energy Florida, Inc. (PEF)	AP1000
Nine Mile Point, Unit 3	Nine Mile Point 3 Nuclear Project, LLC and UniStar Nuclear Operating Services, LLC (UniStar)	U.S. EPR
North Anna, Unit 3	Dominion Virginia Power (Dominion)	ESBWR
River Bend Station, Unit 3	Entergy Operations, Inc. (EOI)	ESBWR
Shearon Harris, Units 2 and 3	Progress Energy Carolinas, Inc. (PEC)	AP1000
South Texas Project, Units 3 and 4	South Texas Project Nuclear Operating Company (STPNOC)	ABWR
Turkey Point, Units 6 and 7	Florida Power and Light Company (FPL)	AP1000
Victoria County Station, Units 1 and 2	Exelon Nuclear Texas Holdings, LLC (Exelon)	ESBWR
Virgil C. Summer, Units 2 and 3	South Carolina Electric & Gas (SCE&G)	AP1000
Vogtle, Units 3 and 4	Southern Nuclear Operating Company (SNC)	AP1000
William States Lee III, Units 1 and 2	Duke Energy	AP1000

Issued Design Certifications

Design	Applicant
Advanced Boiling Water Reactor (ABWR)	General Electric (GE) Nuclear Energy
System 80+	Westinghouse Electric Company
Advanced Passive 600 (AP600)	Westinghouse Electric Company
Advanced Passive 1000 (AP1000)	Westinghouse Electric Company

Design Certification Applications Currently Under Review

Design	Applicant
AP1000 Amendment	Westinghouse Electric Company
ABWR Design Certification Rule (DCR) Amendment	South Texas Project Nuclear Operating Company
Economic Simplified Boiling-Water Reactor (ESBWR)	GE-Hitachi Nuclear Energy
U.S. Evolutionary Power Reactor (U.S. EPR)	AREVA Nuclear Power
U.S. Advanced Pressurized-Water Reactor (US-APWR)	Mitsubishi Heavy Industries, Ltd.

Issued Early Site Permits

Site	Applicant
Clinton ESP Site	Exelon Generation Company, LLC
Grand Gulf ESP Site	System Energy Resources Inc.
North Anna ESP Site	Dominion Nuclear North Anna, LLC
Vogtle ESP Site	Southern Nuclear Operating Company

http://www.nrc.gov/reactors/new-reactors/new-licensing-files/expected-new-rx-applications.pdf

- The U.S. has extensive experience with nuclear power and has rapidly expanded deployment of nuclear power in the past.
- The U.S. Nuclear Regulatory Commission expects to have a total of 21 applications for 31 units through 2011.*
  - Typical units are usually 1 - 1.3 GW in size (30-40 GW under review).
- The NRC has established a streamlined process for licensing new nuclear power plants.
- The NRC has certified several reactor designs as meeting all safety requirements, and the agency expects to certify two more designs in the near term.

Technology Deployment: Biomass

The U.S. has used biomass for electricity production for decades.

- There are over 190 facilities that currently use biomass as the primary fuel (7.5 GW), and many other that co-fire biomass with coal.

Some utilities have recently completed or are planning to convert coal facilities to biomass.

- R.E. Burger Station (OH): 2 x 156 MW units - 20% coal / 80% biomass (FirstEnergy)
- E.J. Stoneman Power Plant (WI): 53 MW (DTE Energy Services)
- Buena Vista Biomass Power Facility (CA): 18 MW (Buena Vista Biomass Power)
- Schiller Station (NH): Completed 50 MW (Public Service of New Hampshire)
- Bayfront (WI): 30 MW (Xcel Energy)
- Mt. Poso Cogen (CA): 44 MW (Millennium Energy)
- Montville Generating Station (CT): 30 MW (NRG)

Sample new projects under development:

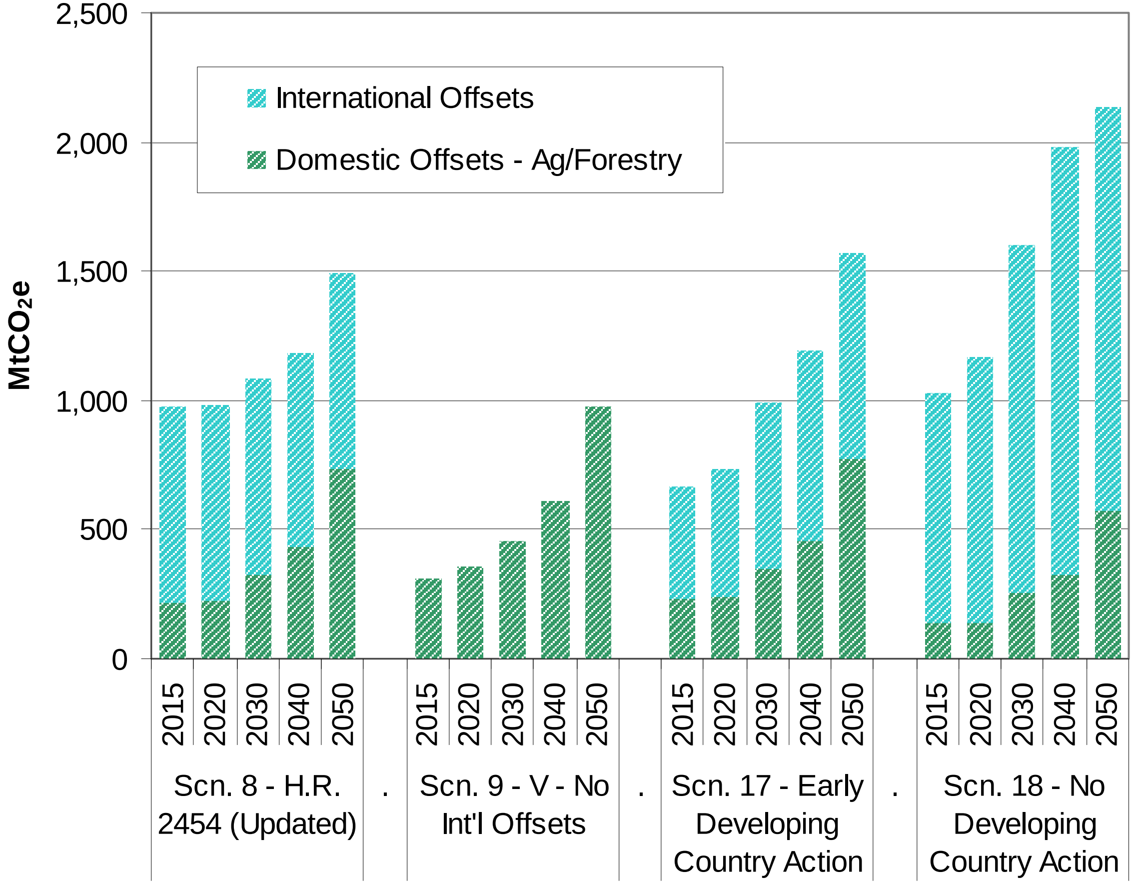
- Sacul Biomass Plant (TX): 100 MW (Georgia Power)
- Deerhaven Generating Station (FL): 100 MW (Gainesville Regional Utilities)
- Savannah River Cogeneration Plant (WV): 15 MW (Washington Savannah River Company)

Note: List of projects is not intended to be a comprehensive list.
Sources: Department of Energy, Energy Information Administration, EPA, company statements.

Offsets Usage & Limits

Offsets Usage

H.R. 2454 Scenario Comparison (IGEM)



- The annual limit on the usage of domestic offsets is non-binding.
  - H.R. 2454 Sec 722 (d) (1) (A) allows covered entities to collectively use offset credits to demonstrate compliance for up to a maximum of 2 billion tons of GHG emissions annually.
  - This section also attempts to share the 2 billion tons of offsets allowed pro rata among covered entities. However, the formula specified for pro rata sharing among covered entities does not result in 2 billion tons of offsets in total, unless total emissions are two billion tons more than the cap.
  - H.R. 2454 Sec 722 (d) (1) (C) modifies the pro rata sharing to allow more international offsets if fewer than 0.9 GtCO2e are expected to be used.
  - See appendix 3 for a detailed discussion of the offsets provisions in H.R. 2454.
- See Appendix 4 for a detailed discussion of the agriculture and forestry sectors including sources of ag/forestry offsets.
- Restricting the use of international offsets, as in "*scenario 9 – No Int'l Offsets*" has a large impact on allowance prices (54% increase relative to '*scenario 8 – Updated H.R. 2454'* in IGEM).

International Offsets Sensitivities

Side Scenarios (IGEM)

Because of the importance of international offsets, several side scenarios are included here to further explore the relationship between the availability of international offsets and the price of domestic allowances. A reduced form version of the IGEM model was used for these side scenarios. These scenarios can be compared to scenario 8, which places no restrictions on offsets beyond those in the bill.

Side Scenarios

Scenario 9a – H.R. 2454 with International Offsets Delayed 10 Years

- U.S. covered entities are not allowed to purchase international offsets for the first 10 years.

Scenario 9b – H.R. 2454 with International Offsets Delayed 20 Years

- U.S. covered entities are not allowed to purchase international offsets for the first 20 years.

Scenario 9c – H.R. 2454 with No International REDD Offsets

- No reduced emissions from deforestation and degradation (REDD) offsets for the U.S. or for any other country.

Scenario 9d – H.R. 2454 with No Domestic Offsets

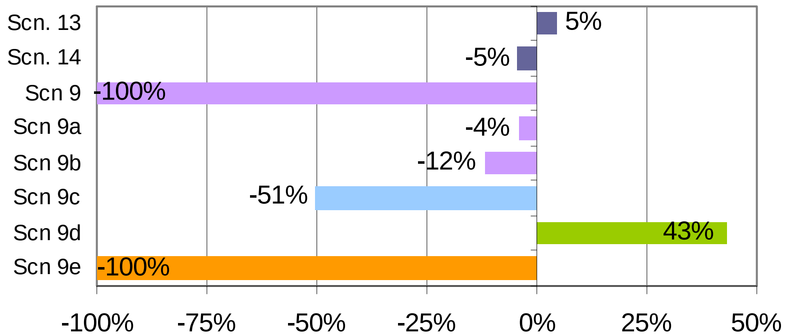
- U.S. covered entities are not allowed to use domestic offsets.

Scenario 9e – H.R. 2454 with No Offsets

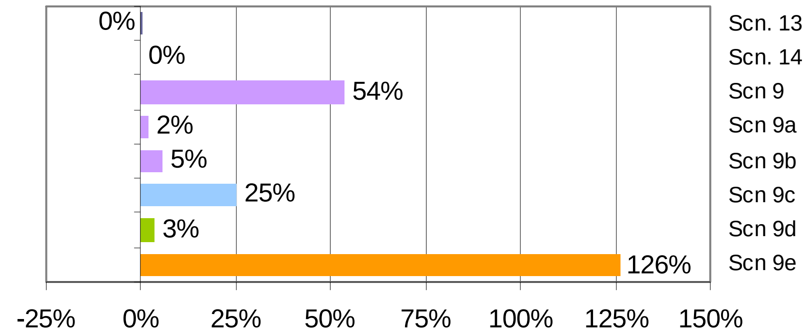
- U.S. covered entities are not allowed to use domestic or international offsets.

International Offsets Usage & Allowance Prices (IGEM)

2012 - 2050 Cumulative Int'l Offsets Usage
% Change from *Scn. 8 - Updated H.R. 2454*



Allowance Price
% Change from *Scn. 8 - Updated H.R. 2454*



Note: percentage changes in allowance prices apply in all years.

	International Offsets Usage		% Change from Scn. 8	
	Cumultive (GtCO2e)	Avg. Annual (MtCO2e)	Intl Offsets Usage	Allowance Price
Scn. 8 - H.R. 2454 (Updated)	30	757	n/a	n/a
Scn. 9 - V - No Int'l Offsets	0	0	-100%	54%
Scn. 9a – Int'l offsets delayed 10 years	28	725	-4%	2%
Scn. 9b – Int'l offsets delayed 20 years	26	668	-12%	5%
Scn. 9c – No REDD offsets	15	375	-51%	25%
Scn. 9d – No domestic offsets	42	1,085	43%	3%
Scn. 9e – No int'l or domestic offsets	0	0	-100%	126%
Scn. 13 - 20% 2020 Cap	31	793	5%	0.4%
Scn. 14 - 14% 2020 Cap	28	721	-5%	-0.4%

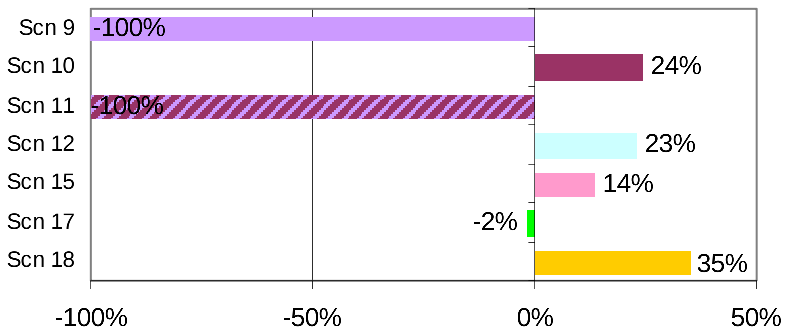
- Since the annual limit on the usage of international offsets is non-binding in most scenarios, sensitivities that would be expected to impact allowance prices (e.g. changes in cap levels) have a smaller impact than expected, because international offsets usage, and thus the amount of abatement within covered sectors, can change.
- Because of the possibility of banking, the cumulative number of offsets available over the entire time horizon drives how the availability of offsets influences allowance prices, not the particular time path of when that cumulative amount of offsets is available.

- **While eliminating all international offsets has a large impact on allowance prices, simply delaying international offsets has a much more modest impact. Delaying international offsets 10 years decreases cumulative international offset usage by 4% and increases allowance prices only 2%. A 20 year delay reduces usage 12% and increases allowance prices 5%.**
- If REDD offsets are not allowed in the US, or in any other country, the entire global market for GHG abatement is impacted. This increases the global carbon price, decreases U.S. usage of international offsets by 51%, and thus increases the domestic allowance price by 25%.

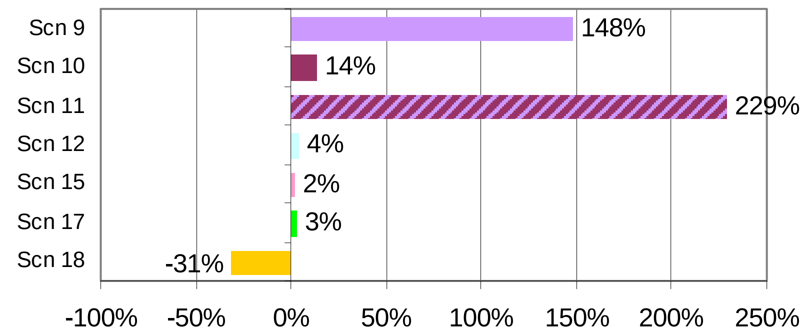
International Offsets

International Offsets Usage & Allowance Prices (ADAGE)

2012 - 2050 Cumulative Int'l Offsets Usage
% Change from *Scn. 8 - Updated H.R. 2454*



Allowance Price
% Change from *Scn. 8 - Updated H.R. 2454*



Note: percentage changes in allowance prices apply in all years.

	International Offsets Usage		% Change from Scn. 8	
	Cumultive (GtCO2e)	Avg. Annual (MtCO2e)	Intl Offsets Usage	Allowance Price
Scn. 8 - H.R. 2454 (Updated)	41	1,040	n/a	n/a
Scn. 9 - V - No Int'l Offsets	0	0	-100%	148%
Scn. 10 - V - Ref. Nuclear & Biomass / Delayed CCS	50	1,291	24%	14%
Scn. 11 - V - Ref. Nuclear & Biomass / Delayed CCS & No Int'l Offse	0	0	-100%	229%
Scn. 12 - V - IPM Elec. Imposed on ADAGE	50	1,279	23%	4%
Scn. 15 - No EE provisions	46	1,182	14%	2%
Scn. 17 - Early Developing Country Action	40	1,019	-2%	3%
Scn. 18 - No Developing Country Action	55	1,404	35%	-31%

- Since the annual limit on the usage of international offsets is non-binding in most scenarios, sensitivities that would be expected to impact allowance prices (e.g. changes in EE provisions) have a smaller impact than expected, because international offsets usage, and thus the amount of abatement within covered sectors, can change.

- ADAGE shows significantly more usage of international offsets than IGEM in scenario 8, therefore, removing international offsets in scenario 9 has a much larger impact on the ADAGE allowance price than the IGEM allowance price.
- The reason ADAGE shows more international offsets usage is that domestic covered GHG abatement is more costly in ADAGE. This is partially due to the putty-clay capital representation in ADAGE compared to IGEM's perfectly mobile capital stock.

Global Results:

Market for International GHG Abatement

International Climate Policy Assumptions

Assumptions from Current & Previous Analyses

- At the July 9, 2009 Major Economies Forum, "the G8 leaders agreed to reduce their emissions 80% or more by 2050 as its share of a global goal to lower emissions 50% by 2050." For this analysis (scenarios 8-16), EPA is using a revised set of assumptions about international action consistent with the G8 agreement:
  - Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling linearly from the simulated Kyoto emissions levels in 2012 to 83% below 2005 in 2050.
  - Group 2 countries (rest of world) adopt a policy beginning in 2025 that caps emissions at 2015 levels, and linearly reduces emissions to 26% below 2005 levels by 2050.
  - The combination of U.S., Group 1, and Group 2 actions cap 2050 emissions at 50% below 2005 levels.

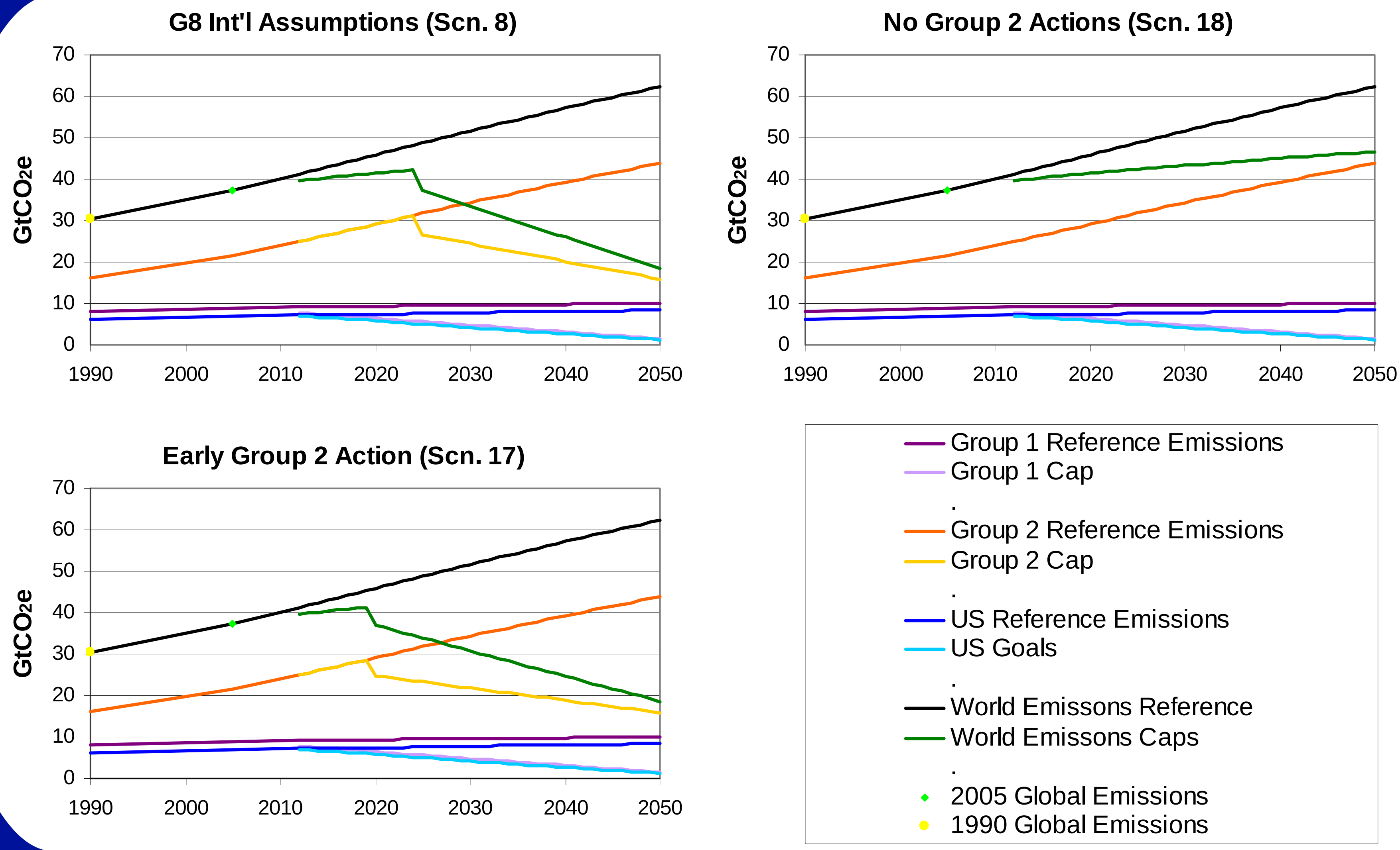
- In previous analyses (and in scenario 8d of this analysis), EPA had assumed widespread international actions by developed and developing countries over the modeled time period based on the 2007 MIT report, "Assessment of U.S. Cap-and-Trade Proposals."
  - Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling gradually from the simulated Kyoto emissions levels in 2012 to 50% below 1990 in 2050.
  - Group 2 countries (rest of world) adopt a policy beginning in 2025 that returns and holds them at year 2015 emissions levels through 2034, and then returns and maintains them at 2000 emissions levels (8% below 2005 levels) from 2035 to 2050.
  - The combination of U.S., Group 1, and Group 2 actions cap 2050 emissions at 32% below 2005 levels.

International Climate Policy Assumptions

Assumptions from Sensitivity Scenarios

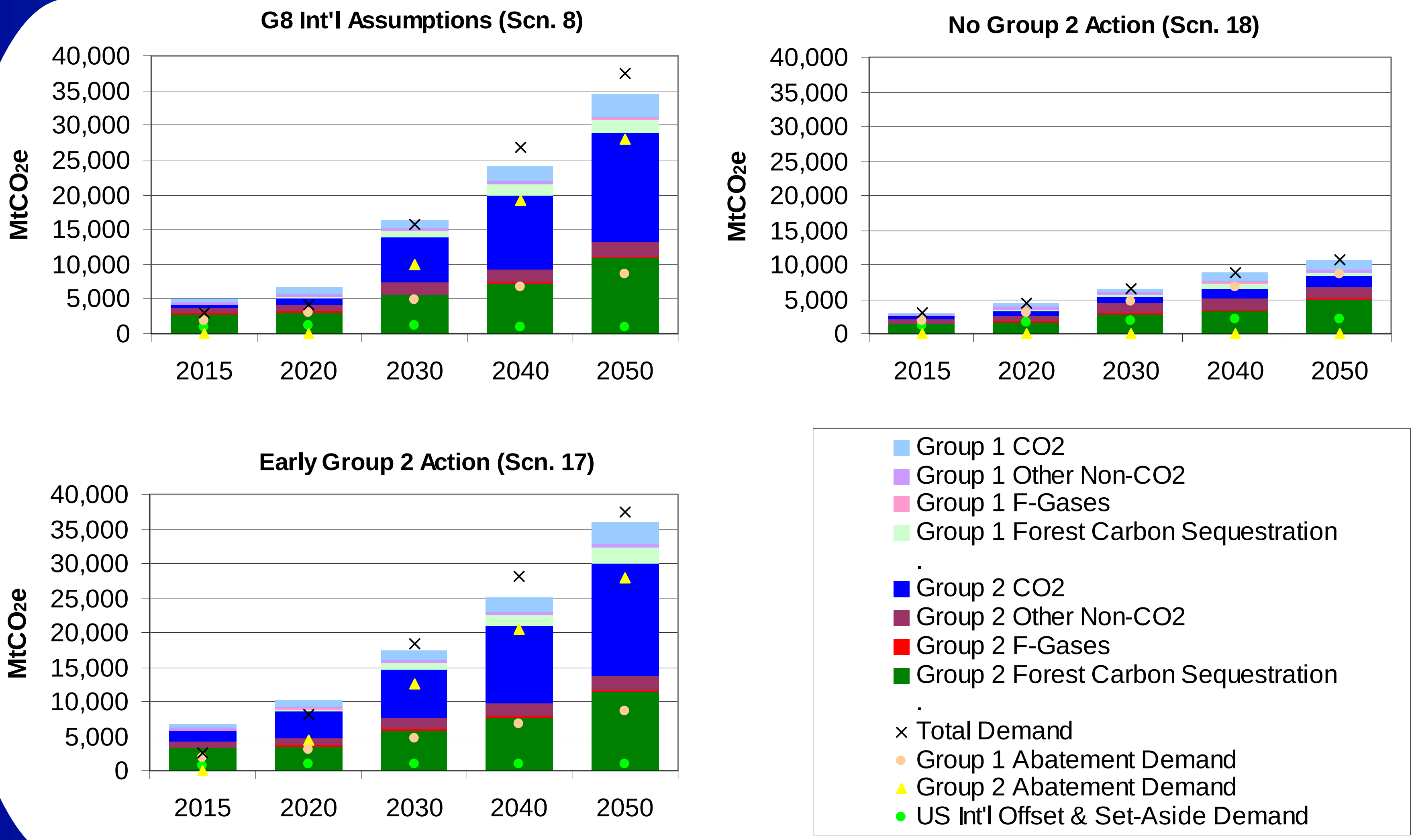
- Scenario 17 explores the impact of earlier action by developing countries, with a 2050 target that is consistent with the G8 agreement:
  - Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling linearly from the simulated Kyoto emissions levels in 2012 to 83% below 2005 in 2050.
  - Group 2 countries (rest of world) adopt a policy beginning in 2020 that caps emissions 15% below BAU levels, and linearly reduces emissions to 26% below 2005 levels by 2050.
  - The combination of U.S., Group 1, and Group 2 actions cap 2050 emissions at 50% below 2005 levels.
- Scenario 18 explores the impact of developing countries not taking any action, resulting in a failure to achieve the G8 2050 goals:
  - Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling linearly from the simulated Kyoto emissions levels in 2012 to 83% below 2005 in 2050.
  - Group 2 countries (rest of world) do not cap GHG emissions.

International GHG Reference Emissions & Cap Assumption



International GHG Abatement Supply & Demand

Impacts of International Action Assumptions



International GHG Abatement Supply & Demand

Impacts of International Action Assumptions

- The previous slide shows international GHG abatement supply by region and source across time for three different scenarios. Reference emissions for non-U.S. countries are based on the MiniCAM model, abatement supply is based on the MiniCAM model for CO2, the GTM model for forestry, and the "Global Mitigation of Non-CO2 GHG" marginal abatement cost curves for F-Gases and other non-CO_2 GHG abatement.
- The slide also shows the demand for GHG abatement from developed (group 1) countries, developing (group 2) countries, as well as U.S. demand for international offsets.
  - Note that the abatement demand shown here for groups 1 & 2 are simply the difference between reference emissions and the caps. The actual total demand accounting for banking will be exactly equal to the supply clearing the market. The difference between the total demand and total supply depicted is the amount of banking occurring in a particular year.
- The supply and demand of GHG abatement represents a global market for GHG abatement that encompasses the cap-and-trade systems in developed and developing countries as well as the U.S. participation in the international offsets market.
- The price of international offsets purchased by the U.S. is determined by this market.
  - Because the international offsets limits are non-binding, the price of international GHG abatement acts as a floor on the price of U.S. domestic allowances.
  - With the 4 to 5 turn in ratio for international offsets and a non-binding limit, the price of U.S. allowances will be equal to 125% of the international GHG abatement price.
- It is not possible to determine the exact mix of abatement sources contributing to the international offsets purchased by the U.S.
  - For example, if the U.S. chose to buy only forest carbon sequestration offsets from group 2, the other players in the market would meet their demand for abatement from the remaining sources. Alternatively the U.S. could purchase equal shares of international offsets from all types of abatement, and again the groups 1 & 2 would simply adjust where they purchase abatement from to again meet their demand.
- The GHG marginal abatement cost (MAC) curves are adjusted based on whether or not a country is assumed to have adopted a climate policy in order to represent the more limited amount of abatement that can be supplied through an offsets market compared to the abatement that can be supplied from a country with a cap on GHG emissions.
  - For example the MAC curve for CO_2 from group 2 allows only 10% of the full potential in 2015, and 25% of the full potential in 2020. This is a proxy for the limited ability to employ sectoral offseting or other energy-related CO_2 offset projects. After group 2 is assumed to have adopted it's own cap, the MAC curve for CO2 is no longer adjusted reflecting the of ability of a cap-and-trade system to utilize the full abatement potential.
  - After Group 2 has adopted a climate policy (2025 under the G8 assumptions in scenario 8, 2020 under the early action assumptions in scenario 17, after 2050 in the no group 2 action assumptions in scenario 18), the CO2 MAC is not adjusted and full potential of the CO_2 MAC is available. This reflects the availability of allowances from a cap-and-trade system covering all energy-related CO_2 once a policy is in place.

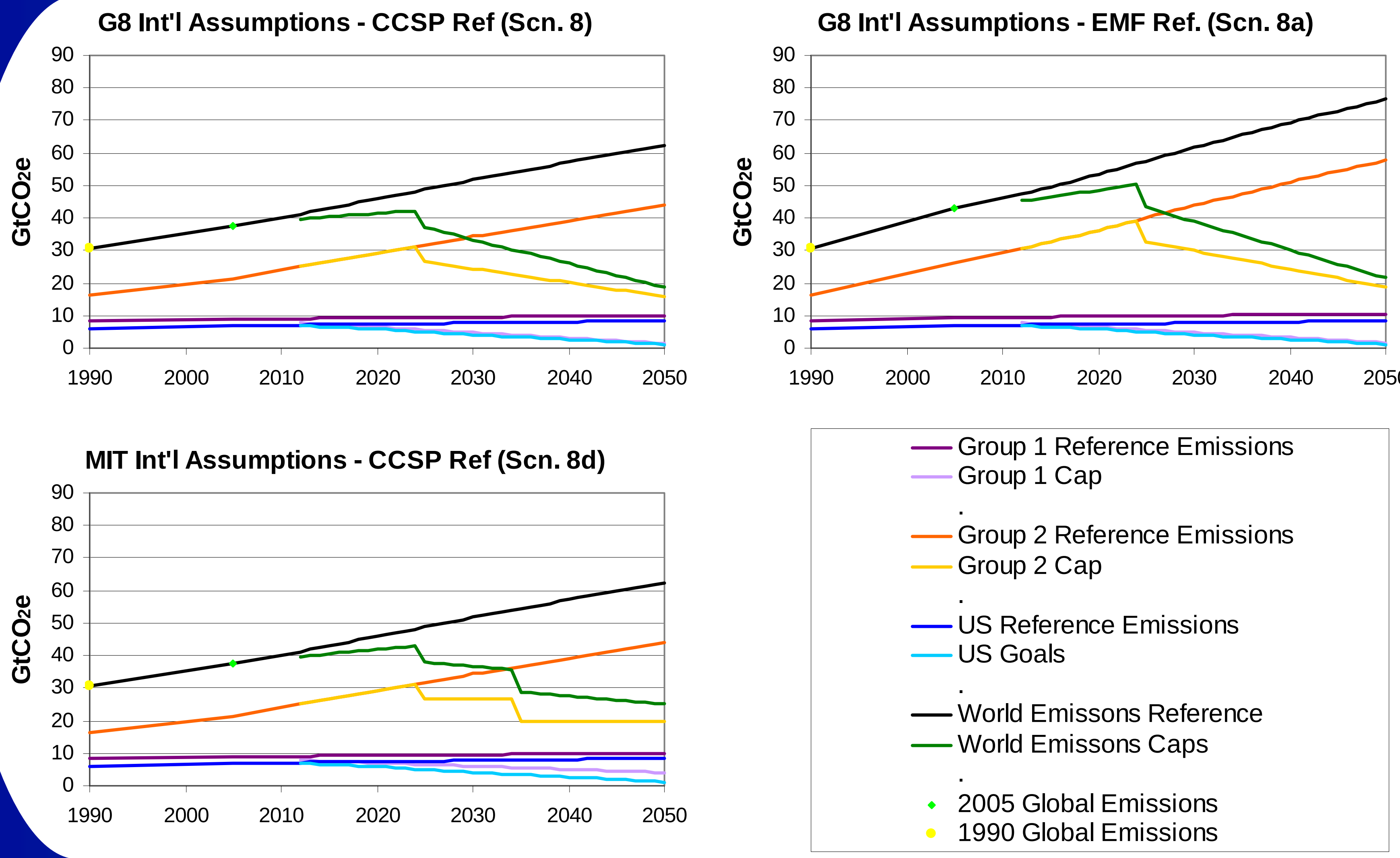
International GHG Abatement Supply & Demand

Impacts of Reference Emissions Assumptions

- The international market for greenhouse gas emissions abatement determines the price of international offsets.
- This market is sensitive to the assumptions about policies adopted by other countries, as shown in scenarios 8, 17, and 18 which depict varying degrees of developing country action.
- This market is also sensitive to assumptions about the growth of GHG emissions in the reference case. For any given policy, higher reference case emissions imply a greater amount of abatement that would be required to meet the cap.
- The reference case GHG emissions for non-U.S. countries in this analysis are based on the MiniCAM Climate Change Science Program (CCSP) Synthesis and Assessment Product (SAP) 2.1a.
- Scenario 8a, discussed below, demonstrates the impact of using an alternative assumption about the non-U.S. GHG emissions in the reference case.
  - This scenario uses the MiniCAM reference case GHG emissions from the Energy Modeling Forum (EMF) 22 study on transition scenarios.
  - Cumulative global GHG emissions from 2012 – 2050 are 24% higher in the EMF-22 MiniCAM reference case compared to the CCSP MiniCAM reference case. This difference is primarily due to revised projections of non-CO_2 GHG emissions from developed and developing countries.
    - Developed country (group 1) cumulative GHG emissions are 8% higher.
    - Developing country (group 2) cumulative GHG emissions are 39% higher.
  - All other assumptions in scenario 8a are identical to scenario 8.

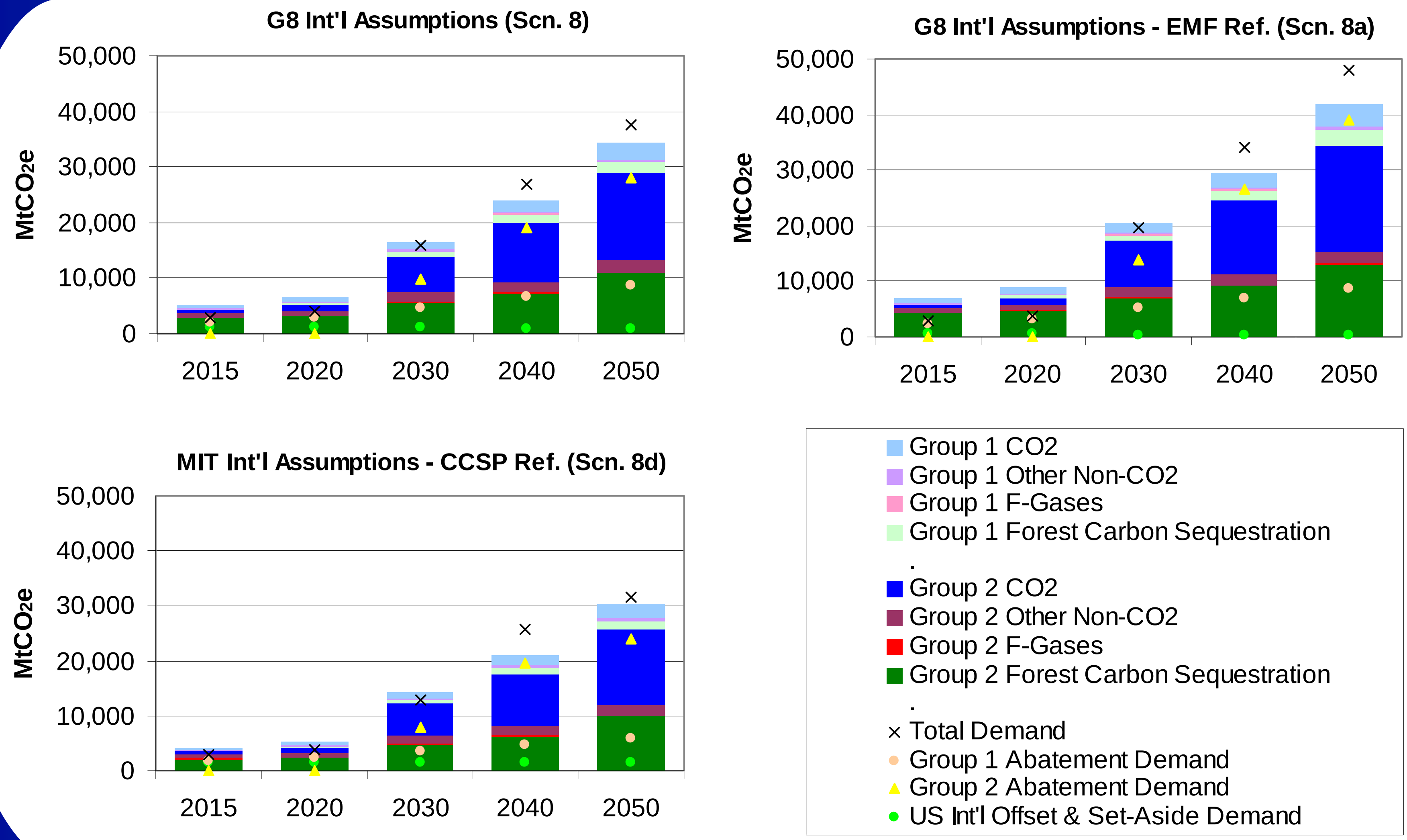
International GHG Abatement Supply & Demand

International Reference GHG Emissions and Cap Assumptions



International GHG Abatement Supply & Demand

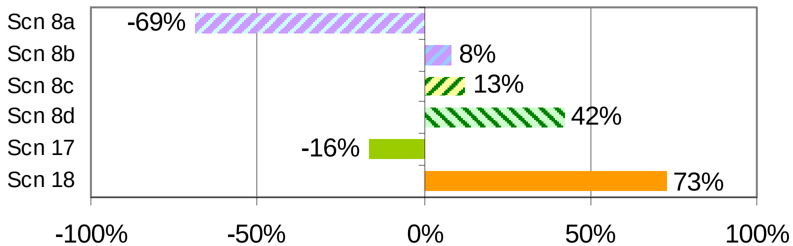
Impacts of International Action Assumptions



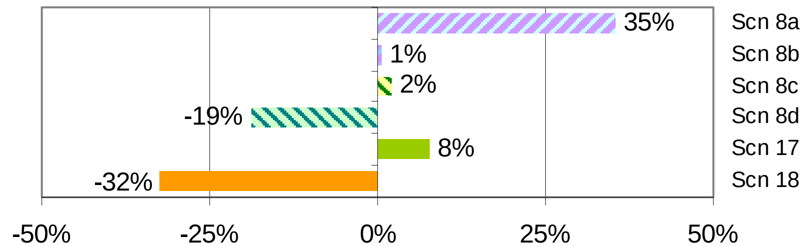
International Offsets Sensitivities

International Offsets Usage & Allowance Prices (IGEM)

2012 - 2050 Cumulative Int'l Offsets Usage
% Change from *8 - Updated H.R. 2454*



Allowance Price
% Change from *Scn. 8 - Updated H.R. 2454*



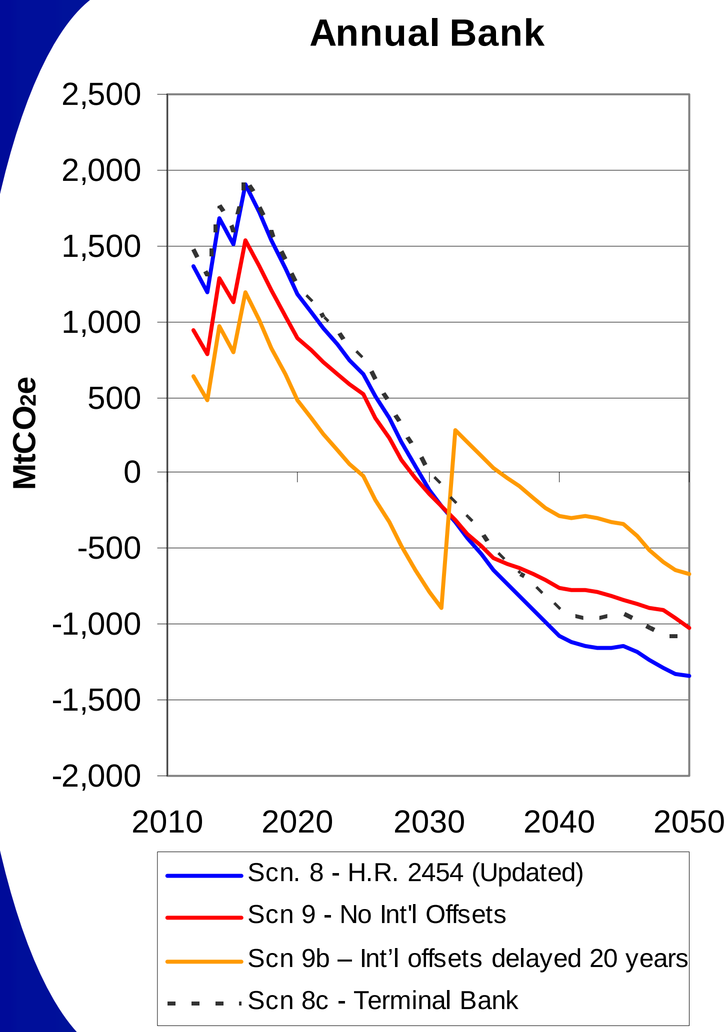
Note: percentage changes in allowance prices apply in all years.

	International Offsets Usage			Domestic Offsets Usage		
	Cumultive (GtCO2e)	Avg. Annual (MtCO2e)	% Change from Scn 2	Cumultive (GtCO2e)	Avg. Annual (MtCO2e)	% Change from Scn 2
Scn. 8 - H.R. 2454 (Updated)	30	757	n/a	15	373	n/a
Scn. 8a – Alternative (EMF) int'l ref. emissions	9	234	-69%	19	477	28%
Scn. 8b – Strategic reserve carve out	32	817	8%	15	375	0%
Scn. 8c – Terminal bank	33	852	13%	15	379	2%
Scn. 8d – MIT int'l assumptions	42	1,075	42%	12	319	-15%
Scn. 17 - Early Developing Country Action	25	632	-16%	15	396	6%
Scn. 18 - No Developing Country Action	51	1,309	73%	11	279	-25%

- Because reference GHG emissions for developing countries are growing faster in scenario 8a, those countries must abate more to reach their caps.
- This greater demand for GHG abatement internationally increases the price of international offsets.
- The higher price of international offsets increases allowance prices in the U.S., decreases the usage of international offsets, and increases the usage of domestic offsets.
- As shown in the scenarios above, the price of international offsets (and in turn the U.S. allowance price) is highly dependent on the competing demand for international GHG abatement, which is determined by the reference case growth in GHG emissions, and the stringency of the caps adopted by other countries.
- Although not addressed here in an explicit sensitivity case, the supply curve for GHG abatement (or marginal abatement cost curve) also will impact this market contributing to the uncertainty in the cost and availability of international offsets.
- Scenario 8c, discussed on slide 62, forces all countries to hold positive bank of allowances in 2050. Scenario 8d tightens the cap in H.R. 2454 by removing allowances associated with the strategic reserve and not releasing them back into the system.

GHG Allowance Banking

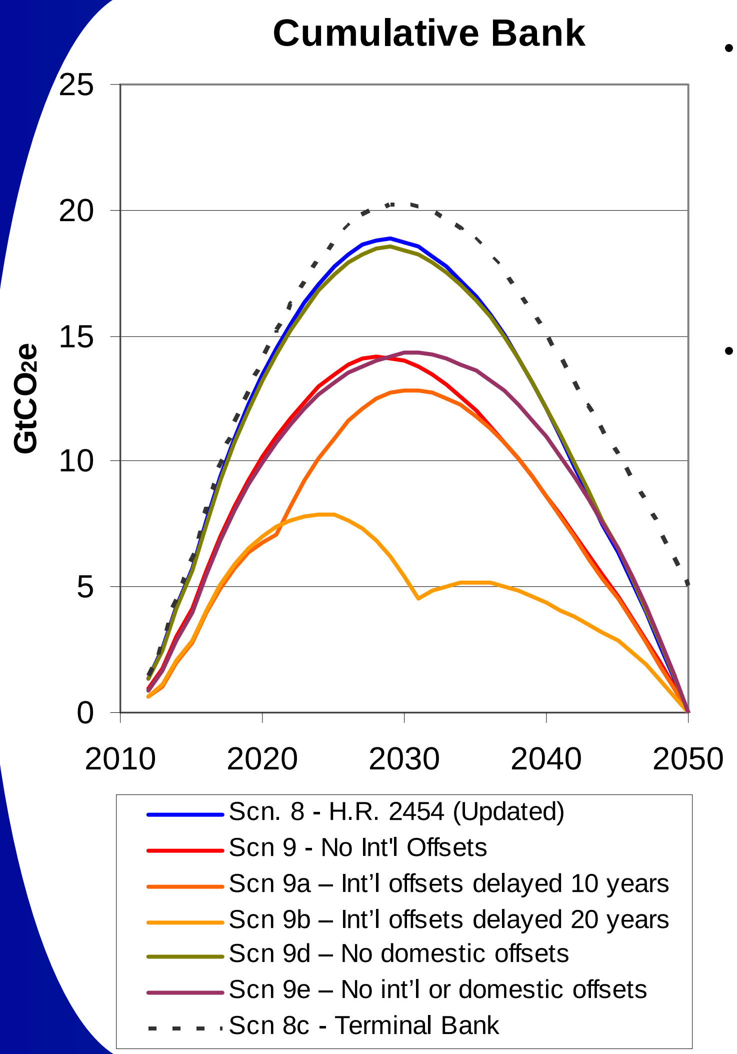
Scenario Comparison (IGEM)



- H.R. 2454 allows for unlimited banking of allowances. As a result the allowance prices in both models grow at the exogenously set 5% interest rate.
  - If instead the allowance price were rising faster than the interest rate, firms would have an incentive to increase abatement in order to hold onto their allowances, which would be earning a return better than the market interest rate. This would have the effect of increasing allowance prices in the present, and decreasing allowance prices in the future. Conversely, if the allowance price were rising slower than the interest rate, firms would have an incentive to draw down their bank of allowances, and use the money that would have been spent on abatement for alternative investments that earn the market rate of return. This behavior would decrease prices in the present and increase prices in the future. Because of these arbitrage opportunities, the allowance price is expected to rise at the interest rate.
- In all modeled scenarios, a bank of allowances is built up in early years, and drawn down in later years so that the cumulative covered emissions (net of offsets) over the 2012 – 2050 period is equal to cumulative emissions allowed under the cap.
- The IGEM model builds up a larger bank of allowances than the ADAGE model. The reason for this is mobility of capital in the two models. ADAGE has a putty-clay capital structure with quadratic capital adjustment costs, while IGEM has perfectly mobile capital. The capital adjustment costs in ADAGE slow down the movement of capital, and make it harder to build up a large bank of allowances in early years.

GHG Allowance Banking

Scenario Comparison (IGEM)

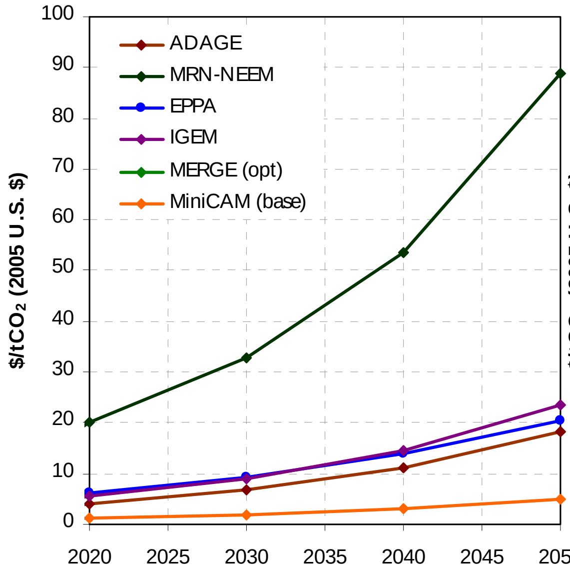


- As modeled, the allowance bank goes to zero in 2050. However, unlike other bills previously analyzed by EPA, H.R. 2454 specifies a cap past 2050. The banking behavior predicted by the models is dependent on the complete credibility of the caps. Firms bank allowances beginning in 2012 in anticipation of rising allowance prices that are driven in part by the out-year caps. If firms believe that Congress may revise the caps upward, then the incentive for banking is diminished, as an upwardly revised cap would reduce the value of banked allowances. If the caps past 2050 are credible, then a positive bank would still be held in 2050 at the end of the model run, and allowance prices would accordingly be higher than forecast here.
- As a proxy for constant post 2050 caps, domestically and internationally, we run a scenario in the reduced form version of IGEM that requires a positive terminal bank in 2050.
  - In order to determine the size of the terminal bank needed, we extrapolate US and international policy case emissions past 2050, and calculate the cumulative amount by which the post 2050 cap is exceeded before emissions fall to the cap level. We then iteratively solve the reduced form IGEM model to converge on a new allowance price path and required 2050 bank. This process results in the following terminal banks:
    - In the U.S. the required 2050 bank is 5.1 $GtCO_2e$. The bank is exhausted and the post-2050 cap is met exactly by 2061.
    - In the international market the required 2050 bank is 5.3 $GtCO_2e$. The bank is exhausted and the post 2050 cap is met exactly in 2055.
  - Requiring the U.S. and the international market to hold these banks in 2050 increases the allowance price by 2% over IGEM scenario 8 results; and international offsets usage in the U.S. increases by 13%.
  - After the bank is exhausted, the allowance price would be expected to grow at a rate less than 5% per year as the caps are met exactly in each year and there is no longer any incentive to bank allowances.

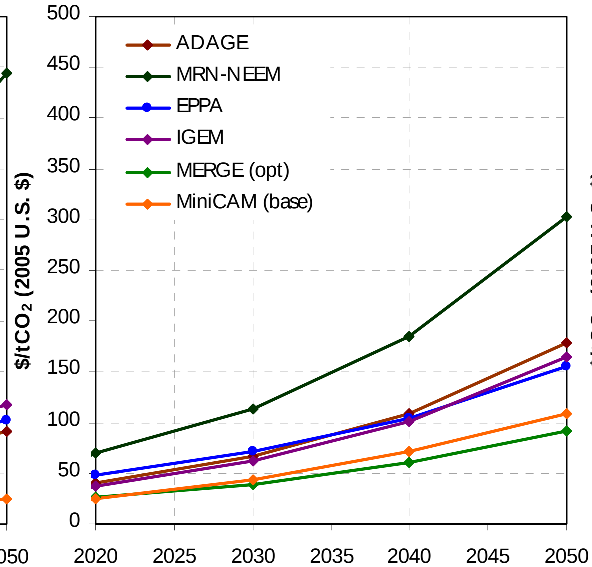
Literature Review
& Near Term Incidence Analysis

Comparing Costs of Three Possible U.S. Emissions Targets through 2050

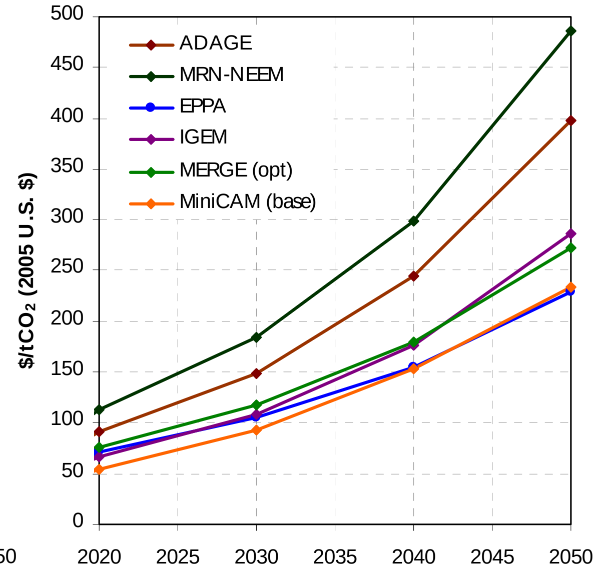
To put the EPA models (ADAGE and IGEM) in context, we compare the results of EMF's analysis (Fawcett, et al. 2009) of three emission goals that span a wide range of possible U.S. 2050 targets. Caps are based on CO_2-equivalents (CO_2-e), covering all Kyoto gases. These scenarios were not intended to represent any specific bill, and no domestic or international offsets are allowed. Domestic emissions (before subtracting abatement from offsets) under H.R. 2454 would fall between the 203 and 287 $GtCO_2e$ cases.



287 $GtCO_2$-e



203 $GtCO_2$-e



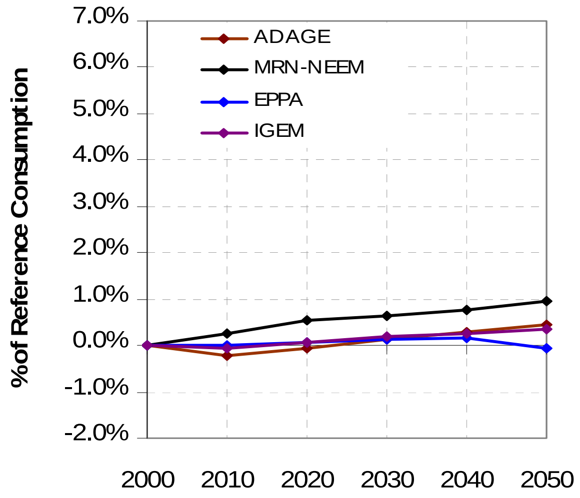
167 $GtCO_2$-e

- 287 bmt CO_2-e: ADAGE, IGEM and EPPA predict a similar rise in allowance prices. The cost of allowances rises from approximately $4 to $6 per ton in 2020 to $20 to $25 in 2050, however MiniCAM predicts only a small increase in allowance prices ($1 to $5), while NEEM predicts allowance prices will rise from $20 in 2020 to nearly $90 in 2050.
- 203 bmt CO_2-e: The models predict allowances prices in 2020 that range from $25 to $70, and that allowance prices grow to a range of $90 to $300 in 2050.
- 167 bmt CO_2-e: The models predict allowances prices in 2020 that range from $55 to $115, and that allowance prices grow to a range of $230 to $485 in 2050

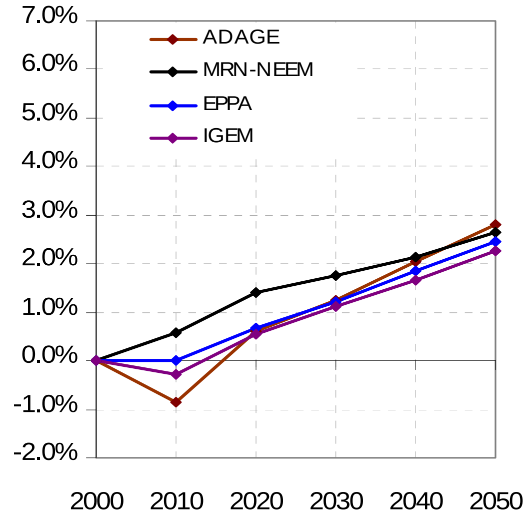
Comparing Costs of Three Possible U.S. Emissions Targets through 2050

Changes in consumption approximate changes in consumer welfare

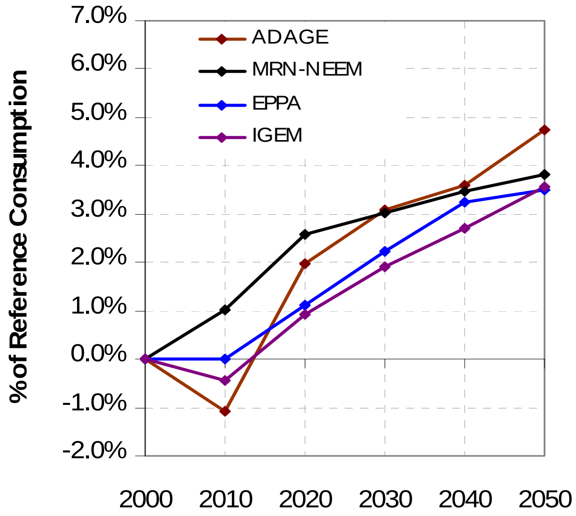
Annual Consumption Losses across Scenarios



287 bmt CO_2-e



203 bmt CO_2-e



167 bmt CO_2-e

- 287 bmt CO_2-e: Annual consumption losses remain below 1% for all models through 2050.
- 203 bmt CO_2-e: Annual consumption losses are all 1.4% or below in 2020 and rise to between 2.25% to 2.8% in 2050.
- 167 bmt CO_2-e: Annual consumption losses are between 1% and 2.6% in 2020 and rise to between 3.5% to 4.75% in 2050.

Comparing Costs of Three Possible U.S. Emissions Targets through 2050

- **Different Models, Different Baselines and Assumptions**

	EPA	MIT	CRA	EPRI	PNNL
Model	ADAGE,IGEM	EPPA	MRN-NEEM	MERGE	MiniCAM
Baseline	AEO 2008 Early Release*	AEO 2009 Early Release	AEO 2008 Early Release	Own baseline	Own baseline
Nuclear Assumptions	Capacity grows at 150% 2005 levels	Not permitted to expand in the base case (Advanced Nuclear available in 2020)	Capacity limited but growing over time (3 GW in 2015; 100 GW in 2050)	New capacity in 2020: capacity limited but growing over time subject to uranium supply constraints	Soft constraints in 2020; after 2020 allowed to grow unconstrained (Advanced nuclear case)
CCS Assumptions	Available in 2020	Available in 2020	Available in 2015 but with capacity limits	Available in 2020; allowed to triple each decade	Available in 2020

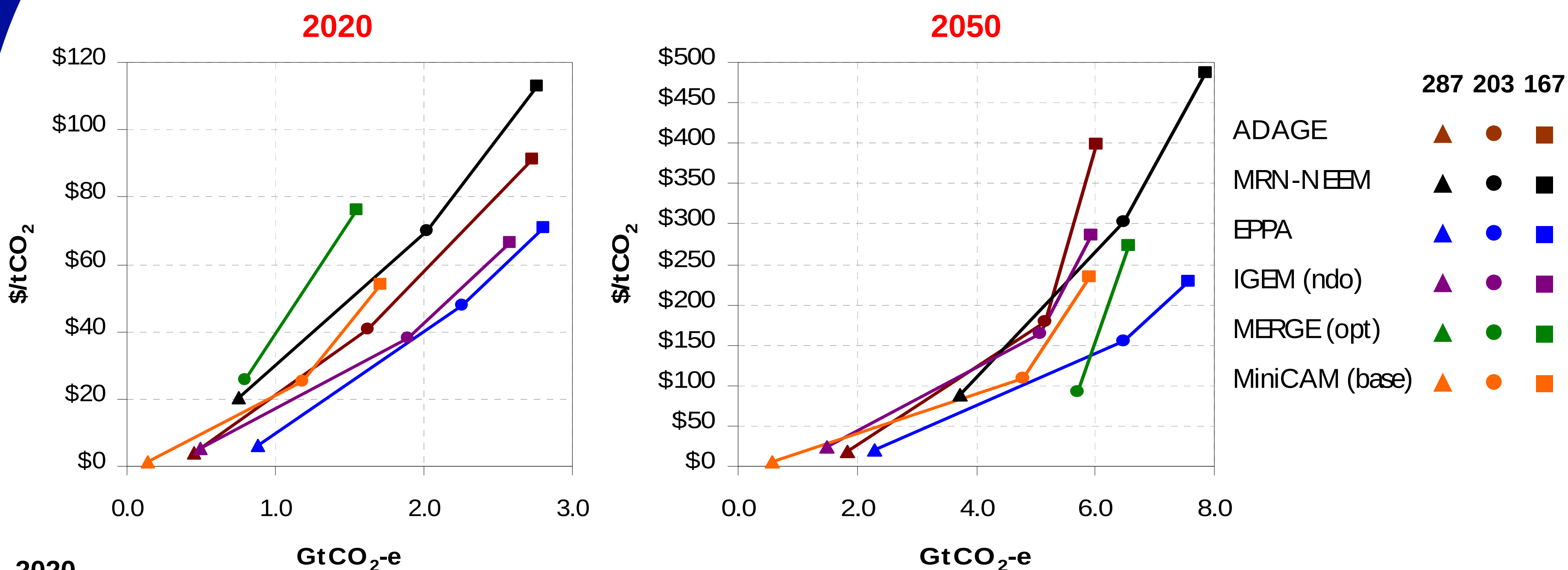
*** AEO 2008 Early release was used by the EPA models for EMF-22. The baseline in EPA's H.R. 2454 analysis is AEO 2009 (March release).**

Common messages from the models

- The majority of the cost-effective reductions come from the electricity sector.
- Greater expansion in nuclear power reduces the costs
- CCS is an important enabling technology

Comparing Costs of Three Possible U.S. Emissions Targets through 2050

Marginal Abatement Cost Functions (MACs) in 2020 and 2050



2020

- All models, except MERGE, require abatement of less than 1 $GtCO_2$-e to reach 287 bmt – MACs range from $1-$6, except for NEEM, which reaches $20
- All models require abatement between 0.8-2.25 GtCO2-e to reach the 203 bmt – MACs range from $25-$70
- All models, except MERGE and MiniCAM, require abatement between 1.55-2.8 GtCO2-e to reach 167 bmt – MACs range from $55-$113

2050

- All models, except MERGE, require abatement between 0.6-3.75 GtCO2-e to reach 287 bmt – MACs range from $5-$25, except NEEM which reaches $90
- All models require abatement between 4.8-6.5 GtCO2-e to reach 203 bmt – MACs range from $90-$180, except NEEM, which reaches $300
- All models require 6-8 GtCO2-e to reach 167 bmt – MACs range from $230-$485.

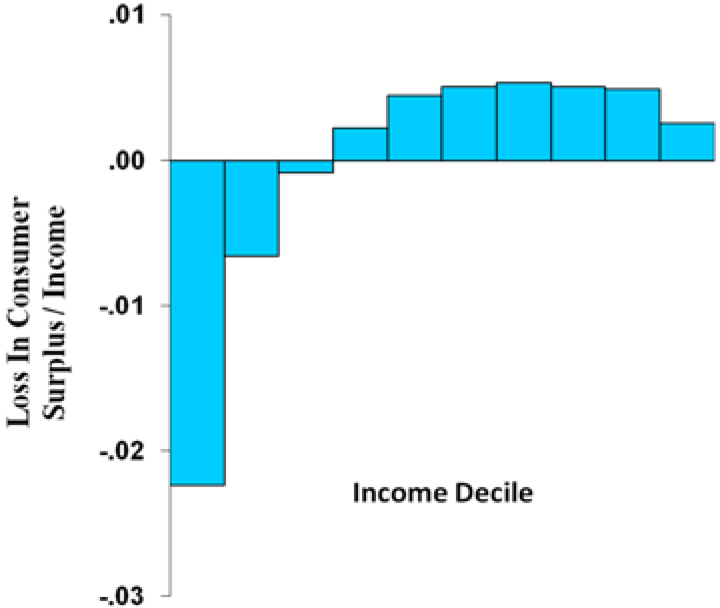
Household Distributional Issues

- There is relatively little analysis in the economics literature on how benefits from a domestic GHG or carbon cap-and-trade policy are distributed across U.S. households. There are more analyses of the distribution of the costs associated with a cap-and-trade policy.
  - These studies' findings are briefly summarized here (Fullerton, forthcoming; Parry 2004; Dinan and Lim Rogers 2002; Rose and Oladosu 2002, Metcalf 2009).
- A cap-and-trade policy increases the price of energy-intensive goods. The majority of this price increase is ultimately passed onto consumers.
- Before accounting for the way in which allowances are allocated or auction revenues are distributed, lower income households are disproportionally affected by a GHG cap-and-trade policy because they spend a higher fraction of their incomes on energy-intensive goods.
- The way in which allowances are allocated (auctioned or given away) and how any revenues collected are utilized affects the distribution of costs across households.
- Grandfathered free distribution of allowances to firms in competitive economic markets tends to be very regressive.
  - Higher income households may actually gain at the expense of lower income households under this policy. This is because the asset value of the allowances flow to households in the form of increased stock values or capital gains, which are concentrated in higher-income households.
  - The government would collect some additional revenue via a tax on profits; the stringency of the profit tax and the use of this revenue may have distributional effects.
- If allowances are auctioned, revenues can be used to influence the regressivity of the policy.
  - Revenues can be redistributed in the form of lower payroll or corporate taxes. These options tend to look less regressive when paired with auctioned allowances then when combined with free allocation but more regressive than equal lump-sum rebates to households.
  - Auctioned allowances with lump-sum distribution of revenues to households is often the least regressive cap-and-trade policy analyzed and is usually shown to be progressive.
- Returning the allowance value to consumers of electricity via local distribution companies in a non-lump sum fashion prevents electricity prices from rising but makes the cap-and-trade policy 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.

Household Distributional Issues

- Recent studies have explored regional differences in the distributional effects of many allowance allocation and revenue distribution options for a carbon cap-and-trade policy (Burtraw et al. 2009, Hassett et al. 2009).
  - Regional differences result from differences in pre-existing policies, consumption levels, pricing of electricity, and the inputs used to produce energy goods (e.g. coal, natural gas).
  - For instance, a cap-and- (taxable) dividend policy that results in a ~$21/metric ton CO_2 price is estimated to result in an average welfare gain of 2.7% for the households with incomes in the lowest 20% nationally. However, regionally, this varies from 1.1% to 3.8%.
- Most studies of climate policy incidence use annual household expenditures as a proxy for income. When a wealth measure is used instead, the distributional difference between low and high income households is less pronounced (Dinan and Lim Rogers 2002; CBO 2003).
  - However, lower income households are still disproportionately impacted relative to higher income households.
- These analyses do not consider how expenditure patterns and demand for energy goods may change over time as a result of the policy. Furthermore, they do not always consider the effect of the policy on the prices of non-energy goods.
- Providing lump-sum compensation to households – or other economic entities – has an opportunity cost in the form of foregone efficiency gains.
  - By providing lump-sum compensation, the value of allowances (i.e., allowance auction revenue) cannot instead be used to reduce distortionary taxes, which would reduce the overall cost of the cap-and-trade policy (Fullerton forthcoming; CBO 2003).

Near Term Incidence Analysis
Scenario 8



Income Decile	Average Income (2006$)	Loss Per Household (2006$)
1 (lowest)	$7,200	-$160
2	$15,500	-$102
3	$23,200	-$19
4	$31,200	$69
5	$39,700	$177
6	$49,800	$254
7	$61,700	$329
8	$77,200	$394
9	$100,600	$492
10 (highest)	$179,400	$465
Average	$58,500	$190

- This analysis looks at the incidence of the cost of this policy per household across income classes in 2016 using an incidence model and methodology adapted from the one described in Burtraw et al. (2009). The allowance and electricity price changes used in the incidence model come from Scenario 8 results (ADAGE). The price change for energy goods and inputs (natural gas, home heating oil, etc.) are estimated using the carbon content of the fuel and allowance price. The indirect price increases of other final goods are estimated based on the share of energy inputs used to produce them.
- The height of each blue bar shows the welfare cost (loss in consumer surplus) in 2016 of imposing the cap as a percentage of household income (average household income increases along the horizontal axis), accounting for the distribution of the entire value of allowances to households. The table provides the value of these losses in 2006$.
- The policy is fully phased in in 2016, which is why this year is used as the time period of analysis.
- The next slide reports the way the allowance value is assumed to be allocated in this analysis.

Near Term Incidence Analysis

Treatment of Allowance Value

Use of Allowance Value	Share of Allowance Value in 2015	Treatment in Incidence Model*	Treatment in ADAGE
Electricity Consumers	31.5%	Effect on electricity prices drawn from ADAGE results.	Subsidy to electricity consumption
Electricity Consumers (Merchant Coal)	3.5%	Provided as shareholder dividend	Lump-sum rebate to representative household
Natural Gas Consumers	6%	Lump-sum non-taxable per-capita rebate	Lump-sum rebate to representative household
Natural Gas Consumers (Energy Efficiency)	3%	Effect of lower demand for fuel prices drawn from ADAGE results.	Effect of lowering demand for natural gas.
Home Heating Oil & Propane Consumers	0.8%	Lump-sum non-taxable per-capita rebate	Lump-sum rebate to representative household
Home Heating Oil & Propane Consumers (Energy Efficiency)	0.8%	Indirect effect from lower demand for fuel.	Effect of lowering demand for heating oil and propane.
Low-Income Consumers	15%	Per-capita rebate to those below 150% of poverty line.	Lump-sum rebate to representative household
Trade-Vulnerable Industries	13.5%	Reflected in equilibrium abatement behavior from ADAGE	Remove direct cost of holding allowances and indirect electricity price signal through rebate for allowances held and electricity price increases.
CCS Bonus Allowances	1.8%	Effect on electricity prices drawn from ADAGE results.	Encouragement to CCS
Energy Efficiency & Renewable Energy Investments	6.5%	Reflected in equilibrium abatement behavior from ADAGE	Effect of lower demand for fuels and greater renewable generation.
Building Codes	0.5%	Reflected in equilibrium abatement behavior from ADAGE	Effect of lower demand for fuels.
Clean Energy Innovation Centers	1.5%	Lump-sum non-taxable per-capita rebate.	Lump-sum rebate to representative household
Investment in Clean Vehicle Technologies	3%	Lump-sum non-taxable per-capita rebate.	Lump-sum rebate to representative household
Domestic Fuel Production	2%	Provided as shareholder dividend	Lump-sum rebate to representative household
Investment in Workers /Domestic Adaptation / Wildlife and Natural Resource Adaptation	2.5%	Lump-sum non-taxable per-capita rebate.	Lump-sum rebate to representative household
International Adaptation	1%	Not allocated.	Not allocated domestically.
International Clean Energy Technology Deployment	1%	Not allocated.	Not allocated domestically.
Deficit Reduction & Climate Change Consumer Refund	1.3%	Lump-sum non-taxable per-capita rebate	Lump-sum rebate to representative household

*** Lump sum distributions to households are given as non-taxable dividends in order to be as consistent with ADAGE as possible.**

Near Term Incidence Analysis

Additional Discussion

- The allocation strategy in Scenario 8, as modeled, improves the welfare of households in the bottom three income deciles by more than offsetting the increased cost of goods and services resulting from the policy. The majority of costs as a portion of household income are born by households in the fifth to ninth income deciles.
- Regressivity and progressivity are normative concepts that do not have commonly agreed upon definitions. In this discussion we refer to a progressive policy as one where the net cost of the policy as a percentage of income is lower for poorer households than it is for wealthier households. A regressive policy would have higher cost as a percentage of income for low income households. This is a common approach to evaluating incidence of climate policy in the economics literature (e.g. Metcalf 2009 and Hassett et al. 2009).
- A method of distributing the allowance value that is different than what is assumed in this analysis will yield different distributional results than those reported here. For example,
  - Assumptions are made about the ultimate implementation of the legislation that remains uncertain. For example, it assumed that the full 15 percent of allowance value allocated in section 782(d) is directed at low income households when, upon implementation of the policy, this might not be the case.
  - If the lump sum rebates were taxable the policy would be more progressive (see Burtraw et al., 2009). This is because, assuming budget neutrality, the pre-tax lump sum rebate would be increased by the average income tax rate for all households. Poorer households would then hold a larger after-tax rebate than wealthier households.
  - Some of the allocations are treated as lump-sum to households even though they may have an effect on the prices of goods and inputs. For example, Clean Energy Innovation Centers may generate research that lowers the cost of cleaner technologies. To the extent that the intensity of use of these cleaner technologies varies across income deciles, the distributional results will change.
- Appendix 2 shows how the incidence of the policy changes under the conditions assumed in Scenarios 10 and 11. Those results show that the higher the cost of reducing emissions the greater the magnitude of the welfare changes by decile, but the shape of the distribution does not change significantly. Those in the bottom three deciles gain, while the welfare declines for the other deciles. This is because the effect of the higher allowance price on the prices of all goods outweighs the effect of any differences in the amount of each good consumed by each decile.
  - However, the limitations of the incidence model may affect the results more the greater is the allowance price. That is because at higher prices, the composition of the fuels and technologies used to produce goods may change significantly from what they are today.
- Scenario 16 considers a different use of allowance value, which influence both the cost of the policy and its distribution across households. This scenario could not be modeled for this analysis. However, qualitatively the average household cost would be lower than under Scenario 8 because of the reduced welfare cost that comes from lowering labor taxes (see the discussion on Allowance Allocation Issues in Appendix 2). The change in the distribution of the cost of Scenario 16 relative to Scenario 8 is less clear because the incidence of Scenario 16 depends on how one distributes the labor tax reduction across tax brackets (see slide 24).

Near Term Incidence Analysis

Caveats to Incidence Modeling

- The incidence model is a partial equilibrium structure that captures the direct effect of energy good price increases on households and the indirect effects of increased energy prices on other final goods, assuming full pass through of the allowance price onto consumers. That is, the incidence model does not draw the price changes of goods directly from ADAGE (with the exception of the change in electricity price).
- Generally, the budget shares assumed in the incidence model for 2016 absent HR 2454 are assumed to be the same as actual household budget shares in 2006.
  - The 2004 through 2006 Consumer Expenditure Survey is used to estimate representative household budget shares for each income decile.
    - The boundaries of the income deciles provided in the chart on slide 75 are based on the incomes of the respondents to the survey.
  - Another reason why 2016 was chosen as the time period of analysis is that the assumption that 2006 consumption levels are a reasonable approximation of baseline consumption without HR 2454 is less appropriate for later years.
- Because price changes differ somewhat between the two models certain conditions, such as final good demands and the share of energy inputs in production, also differ between the two models. ADAGE is a general equilibrium model that captures competition amongst markets for production inputs and capital and labor markets, which the incidence model (generally speaking) does not. Had the general equilibrium price changes been used in the incidence model, the budget shares of goods consumed would differ as a result of HR 2454.
  - However, the relative effects of HR 2454 across the income deciles would likely not change significantly if all price changes were drawn from ADAGE because in the near term the changes in the bundles of goods consumed are not dramatic.
  - The sectoral-level forecast price changes from ADAGE could not be used in the incidence model could in time for this analysis.
- While goods price and quantity changes may differ somewhat between the two models, the abatement costs in each sector in the incidence model are calibrated to the sectoral abatement costs implied by marginal abatement cost curves results from ADAGE Scenario 8. This implies that the average abatement cost per household is similar between the two models.
  - See slide 21 for discussion about the calculation of abatement costs in ADAGE.
- The environmental benefits of avoiding global climate change are not accounted for in this analysis.
- The adapted incidence model used in this analysis differs from the one described in Burtraw et al. (2009) in a limited number of ways. The incidence model used here…
  - … uses ADAGE to represent changes in the electricity market. The model used in Burtraw et al. (2009) has competition amongst markets for inputs and capital in the electricity sector using the Haiku electricity market model.
  - …is calibrated to welfare loses forecast by ADAGE. The Burtraw et al. (2009) model is calibrated to an EIA forecast.
  - …does not withhold allowance value for the energy price increases faced by government, unlike the Burtraw et al. (2009) model.
  - …captures the earning of profits by sellers of domestic offsets and the payment by demanders of domestic offsets differently than the Burtraw et al. (2009) model. We proxy the suppliers of offsets with shareholders and give the profits to shareholders.
    - Compared to an assumption where the profits are assumed to be distributed per-capita, this assumption does not have a noticeable effect on the general shape of the distribution across incomes for the three scenarios analyzed. However, in scenario 11 where a large number of domestic offsets are purchased, households in top decile lose a $360 rather than $1,332 per household with HR 2454. However, our assumption is more likely than assuming a per-capita distribution of domestic profits as the owners of land are concentrated in higher income households.

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www.epa.gov/climatechange/economics/economicanalyses.html