EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the *111th Congress*

6/23/09

Request for Analysis

HENRY A. WAXMAN, CALIFORNIA
CHAIRMAN

JOE BARTON, TEXAS
RANKING MEMBER

ONE HUNDRED ELEVENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE
2125 Rayburn House Office Building
Washington, DC 20515–6115

Majority (202) 225–2927
Minority (202) 225–3641

May 14, 2009

The Honorable Lisa Jackson
Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue NW
Washington DC, 20460

Dear Administrator Jackson:

Passage of comprehensive clean energy legislation is one of the top priorities of the Committee on Energy and Commerce. We plan to report a bill from committee prior to the Memorial Day recess. This legislation will reflect the Committee's work product and may differ significantly from the discussion draft circulated in March. To facilitate Congressional consideration of the legislation, we are requesting additional technical assistance and modeling results from the Environmental Protection Agency (EPA). EPA's analysis of the committee passed legislation will prove useful to us and other members of the House as we move forward.

We ask that EPA begin this process by meeting with our committee staff in advance of committee passage. Please call Alexandra Teitz, Lorie Schmidt or Joel Beauvais at (202) 225-4407.

Sincerely,

Henry A. Waxman
Chairman

Edward J. Markey
Chairman
Subcommittee on Energy and Environment

- On March 31, 2009, the House Energy and Commerce Committee released the Waxman-Markey Discussion Draft of the American Clean Energy and Security Act of 2009.
- On April 20, 2009, EPA released a preliminary analysis of the Waxman-Markey Discussion Draft.
- On May 14, 2009, the House Energy and Commerce Committee Chairman Waxman and Energy and Environment Subcommittee Chairman Markey requested that EPA estimate the economic impacts of the Committee-reported bill.
- On May 21, 2009, the American Clean Energy and Security Act of 2009 (H.R. 2454) was passed by the House Energy and Commerce Committee.
- This document represents EPA's analysis of the American Clean Energy and Security Act of 2009 (H.R. 2454).

The analysis was conducted by EPA's Office of Atmospheric Programs.

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This analysis is available online at:
www.epa.gov/climatechange/economics/economicanalyses.html

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 for:
    - H.R. 2454 without Energy Efficiency Provisions
    - H.R. 2454 without Output Based Rebates
    - H.R. 2454 with Reference Level Nuclear
    - H.R. 2454 with No International Offsets
  – 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

- H.R. 2454 transforms the structure of energy production and consumption.
  - Increased energy efficiency and reduced demand for energy resulting from the policy mean that energy consumption levels that would be reached in 2015 without the policy are not reached until 2040 with the policy.
  - The share of low- or zero-carbon primary energy (including nuclear, renewables, and CCS) rises substantially under the policy to 18% of primary energy by 2020, 26% by 2030, and to 38% by 2050, whereas without the policy the share would remain steady at 14%. Increased energy efficiency and reduced energy demand simultaneously reduces primary energy needs by 7% in 2020, 10% in 2030, and 12% in 2050.
  - Electric power supply and use, and offsets represent the largest sources of emissions abatement.

- Allowance prices are less than EPA's previous analysis of the Waxman-Markey discussion draft, \$13 per metric ton CO_2 equivalent (tCO_2e) in 2015 and \$16/tCO_2e in 2020 in the core scenario.
  - This is primarily driven by the looser 2020 cap and the expanded amount of international offsets allowed.
  - Across all scenarios modeled without constraints on international offsets, the allowance price ranges from \$13 to \$15 per ton CO_2 equivalents (tCO_2e) in 2015 and from \$16 to \$19 / tCO_2e in 2020.
  - Across all scenarios modeled that vary constraints on international offsets, the allowance price ranges from \$13 to \$24 per ton CO_2 equivalents (tCO_2e) in 2015 and from \$16 to \$30 / tCO_2e in 2020.

- Offsets have a strong impact on cost containment.
  - The annual limit on domestic offsets is never reached.
  - 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 over 1 billion tCO_2e each year.
  - Without international offsets, the allowance price would increase 89 percent relative to the core policy scenario. If international offsets were not available for only the first 10 years, the allowance price would increase by just 3%. If extra international offsets could not be used when the domestic offset usage was below one billion tCO_2e, then the allowance price would increase 11%.

Major Findings

- The cap & trade policy 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 0.03-0.08% in 2015 and 0.10-0.11% in 2020 and 0.31-0.30% 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 H.R. 2454 scenario.
  - In comparison to the baseline, the 5 and 10 year average household consumption growth under the policy is only 0.1 percentage points lower for 2015 and 2020.
  - Average annual household consumption is estimated to decline by $80 to $111 dollars per year* relative to the no policy case. This represents 0.1 to 0.2 percent of 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.

- 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, there are still remaining uncertainties that could significantly affect the results.

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

Contents

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.
  - 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

EPA analyzed 7 different scenarios in this preliminary report. 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.

1) **EPA 2009 Reference Scenario**
   - This reference scenario is benchmarked to the AEO 2009 forecast (March release) and includes EISA but not ARRA.
     - 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 recently announced 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.
2) **H.R. 2454 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 based on those used in 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 from 2035 to 2050.
3) **H.R. 2454 Scenario without Energy Efficiency Provisions**
4) **H.R. 2454 Scenario without Output-Based Rebates**
5) **H.R. 2454 Scenario with Reference Nuclear**
6) **H.R. 2454 Scenario without Energy Efficiency, Output-Based Rebates, or LDC Allocations***
7) **H.R. 2454 Scenario with No International Offsets**

* **Scenario 6 is most directly comparable to the core scenario of EPA's preliminary analysis of the Waxman-Markey discussion draft, which did not include energy efficiency provisions, output-based rebates, or LDC allocations.**

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 new nuclear power is technically and politically feasible.
  - The availability of international offset projects.
  - The amount of GHG emissions reductions achieved by the energy efficiency provisions of H.R. 2454.
  - The impact of output based rebates to energy intensive and trade exposed industries.

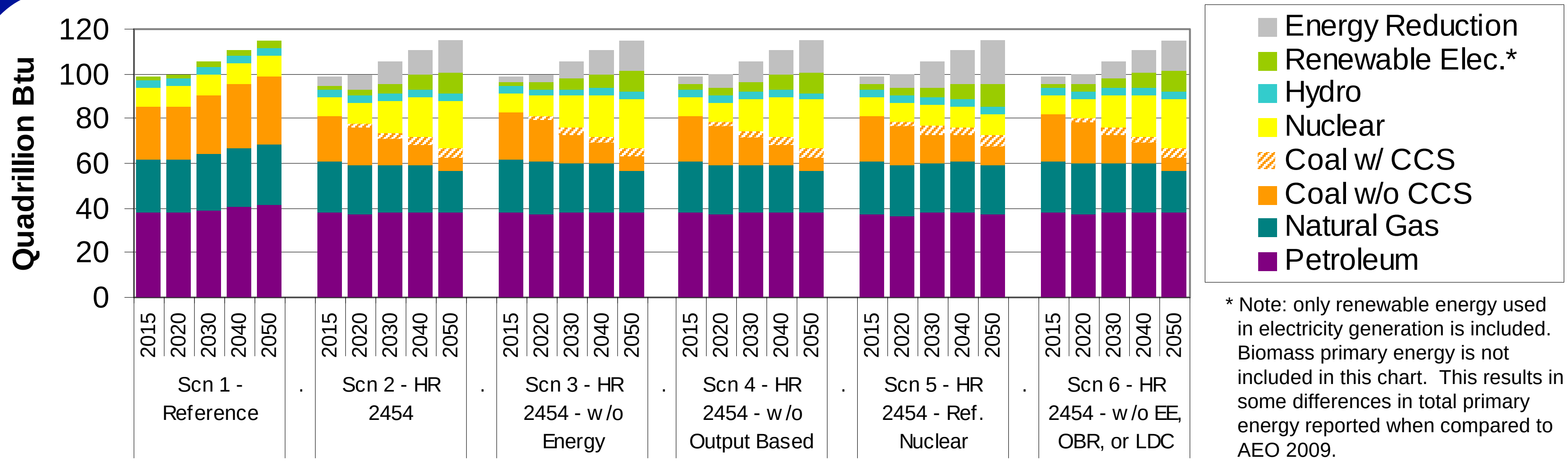
- Additional uncertainties include but are not limited to:
  - The impact of the Strategic Allowance Reserve (e.g., the extent to which it increases banking of allowances in the early years of the program).
  - The distributional consequences of H.R. 2454.
  - The extent and stringency of international actions to reduce GHG emissions by developed and developing countries.
  - The availability and cost of domestic offset projects.
  - The availability and cost of carbon capture and storage technology.
  - 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 price reducing versus lump sum allocations to 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.

Economy Wide Impacts:
GHG Emissions & Economic Costs

Primary Energy

H.R. 2454 Scenario Comparison (ADAGE)

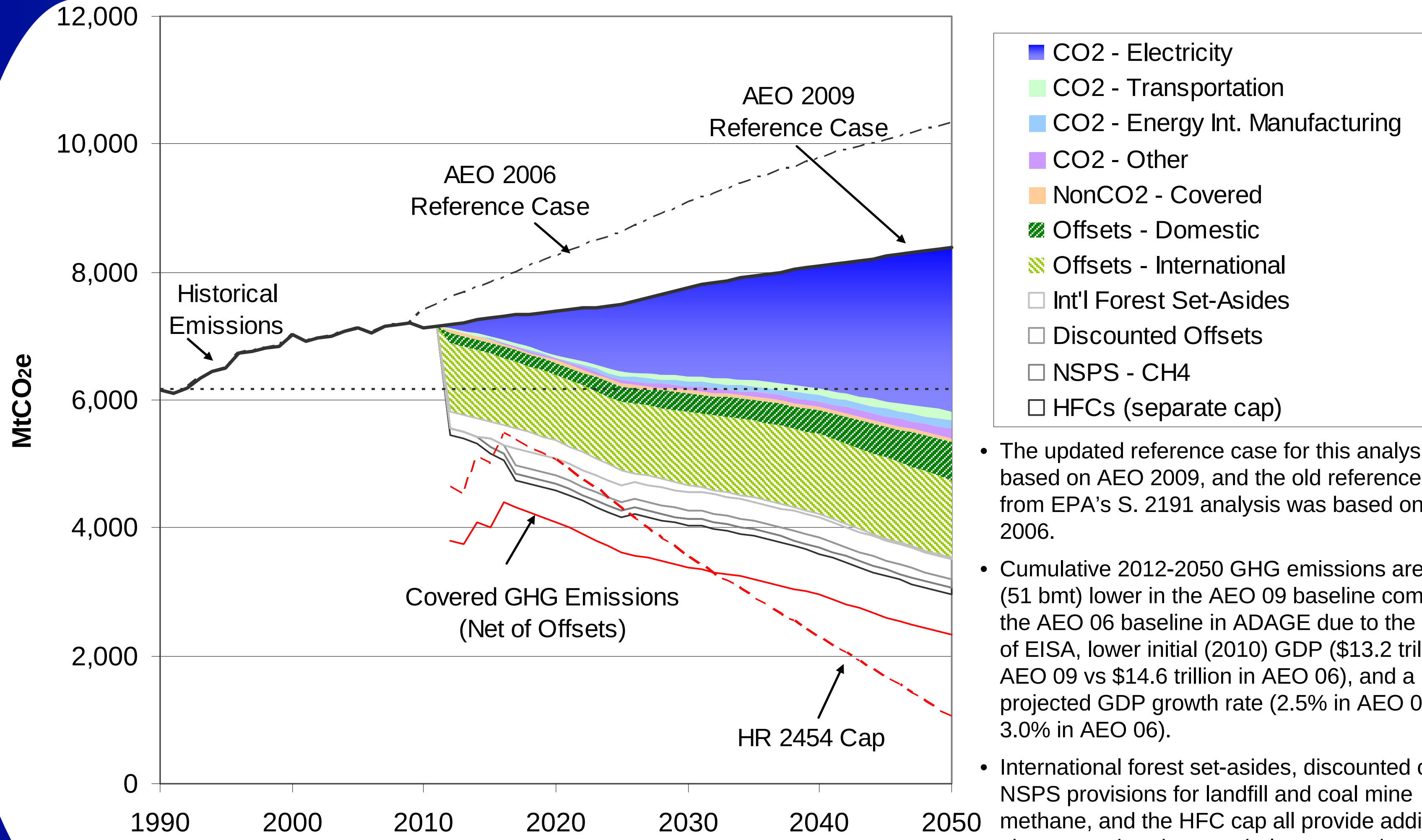


* Note: only renewable energy used in electricity generation is included. Biomass primary energy is not included in this chart. This results in some differences in total primary energy reported when compared to AEO 2009.

- The structure of energy consumption is transformed in the policy scenarios.
- In the reference scenario, primary energy use is 99 quadrillion Btu in 2015, and grows 7% by 2030 and 17% by 2050.
  - In scenario 2, primary energy use falls to 95 and 93 quadrillion Btu in 2015 and 2020 respectively, and rebounds to 2015 reference levels by 2040.
  - In scenario 5 with nuclear power constrained to reference case levels, primary energy use falls to 95 quadrillion Btu in 2015 and to 93 quadrillion Btu in 2020, and slowly rebounds to 95 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 2, low- or zero- carbon energy makes up 18% of primary energy by 2020, 26% by 2030, and 38% by 2050.
  - In scenario 5 with reference level nuclear, low- or zero- carbon energy makes up18% of primary energy by 2020, 22% by 2030, and 29% by 2050.
- See Appendix 3 for a discussion of the limitations and caveats associated with the methodology used to represent energy efficiency programs.
- Constraints on nuclear power growth are exogenous to the model (nuclear power generation is allowed to increase by ~150% from 782 bill. kWh in 2005 to 2,081 bill. kWh in 2050).
  - The reductions seen in primary energy from coal are somewhat driven by the model's representation of energy efficiency programs and the assumptions about nuclear power.
    - Compared to scenario 2, which includes energy efficiency programs, the reduction in primary energy from coal in scenario 3 without energy efficiency programs is 27% smaller in 2015 and 36% smaller in 2020. (In later years the two scenarios are more similar).
    - Compared to scenario 2, the reduction in primary energy from coal in scenario 5 with reference level nuclear is 18% smaller in 2030 and 17% smaller in 2050.

Total US GHG Emissions & Sources of Abatement

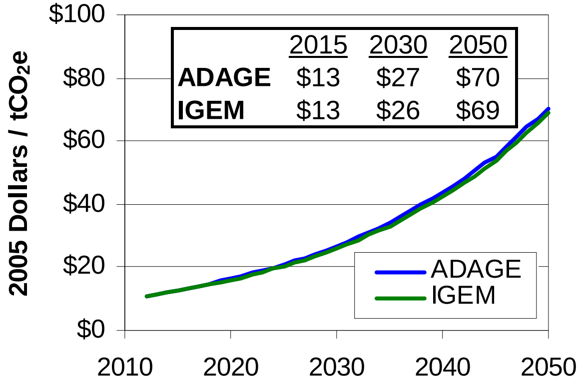
Scenario 1 - Reference & Scenario 2 – H.R. 2454 (ADAGE)

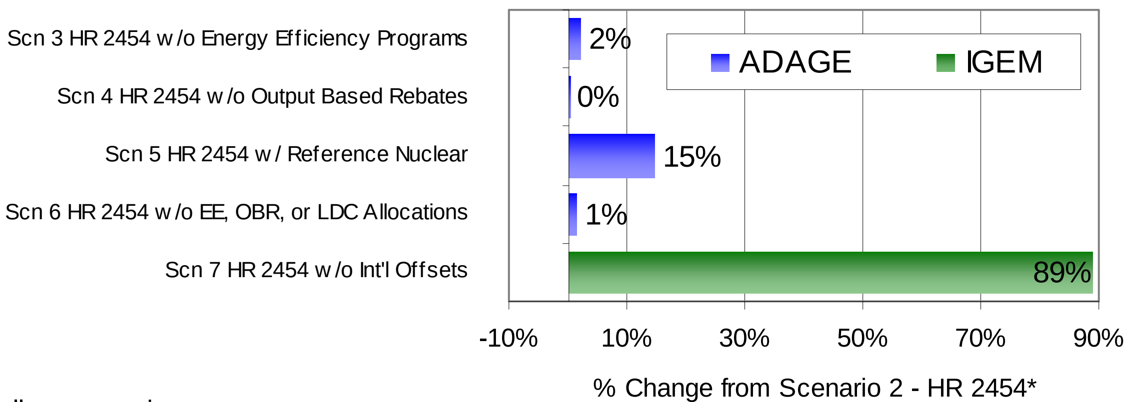


- The updated reference case for this analysis is based on AEO 2009, and the old reference case from EPA's S. 2191 analysis was based on AEO 2006.
- Cumulative 2012-2050 GHG emissions are 14% (51 bmt) lower in the AEO 09 baseline compared to the AEO 06 baseline in ADAGE due to the inclusion of EISA, 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).
- International forest set-asides, discounted offsets, NSPS provisions for landfill and coal mine methane, and the HFC cap all provide additional abatement that does not help to meet the main cap.

GHG Allowance Prices & Sensitivities

H.R. 2454 Scenario Comparison



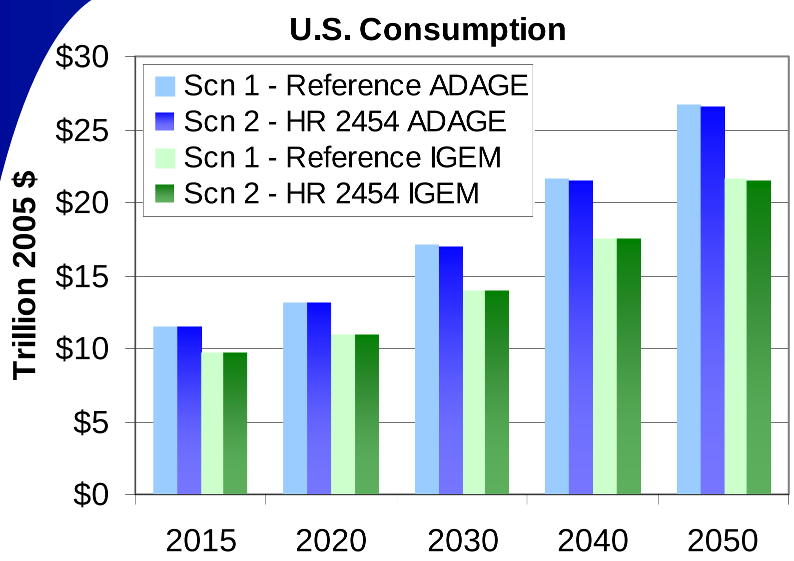


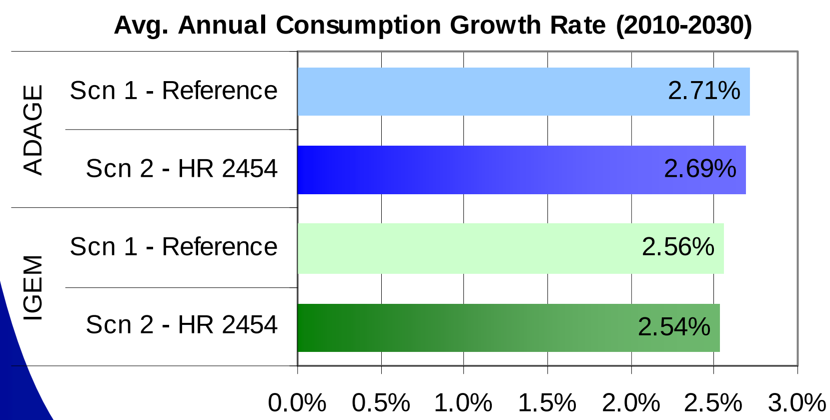
* Note that these percentage changes apply in all years.

- The marginal cost of GHG abatement is equal to the allowance price.
- Range of 2030 allowance price in *"scenario 2 – HR 2454"* across models is: \$26 - \$27. This range only reflects differences in the models and does not reflect other scenarios or additional uncertainties discussed elsewhere.
- The range of 2030 allowance prices across all scenarios that allow international offsets is: \$26 - \$31.
- In scenarios 2, 3, 4, and 6, 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 a floor on the allowance price.
  - 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 within covered sectors (e.g. a change that would ordinarily lead to lower allowance prices instead would lead to decreased usage of international offsets.)
  - See the 'Offsets Usage & Limits' section below for information on how international offsets usage changes across scenarios.
- Without any international allowances, the allowance price would increase by 89% relative to the core scenario. See 'Offsets Usage & Limits' section below for a discussion of how varying degrees of international offsets availability impacts allowance prices.
- The availability of nuclear and carbon capture and sequestration (CCS) technologies have a significant impact on allowance prices. In particular, restricting nuclear power to reference case levels increases international offsets usage to the limit and results in a 15% increase in allowance prices relative to the core scenario.

Consumption

Scenario 1 – Reference & Scenario 2 – H.R. 2454





ADAGE	2015	2020	2030	2040	2050
Ref. Consumption per Household	$92,202	$99,888	$117,973	$140,233	$164,348
% Change (Scn. 2)	-0.08%	-0.11%	-0.31%	-0.55%	-0.78%
Consumption Loss per Household	-$70	-$105	-$366	-$771	-$1,287
NPV Cost per HH ($)	-$53	-$61	-$132	-$170	-$174

Average Annual NPV cost per Household	**-$111**

IGEM	2015	2020	2030	2040	2050
Ref. Consumption per Household	$75,531	$80,507	$91,686	$105,202	$119,168
% Change (Scn. 2)	-0.03%	-0.10%	-0.30%	-0.55%	-0.76%
Consumption Loss per Household	-$21	-$84	-$277	-$582	-$912
NPV Cost per HH	-$16	-$49	-$99	-$128	-$123

Average Annual NPV cost per Household	**-$80**

- 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 2 – H.R. 2454*."
- 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 $80 - $111 average annual cost per household is the annual cost of achieving the climate benefits that would result from this bill.
- See Appendix 1 for a discussion of consumption accounting differences between ADAGE and IGEM and of composition of GDP.
- See Appendix 5 for a more detailed discussion of the average annual NPV cost per household calculation, and additional consumption cost metrics.

Total Abatement Cost

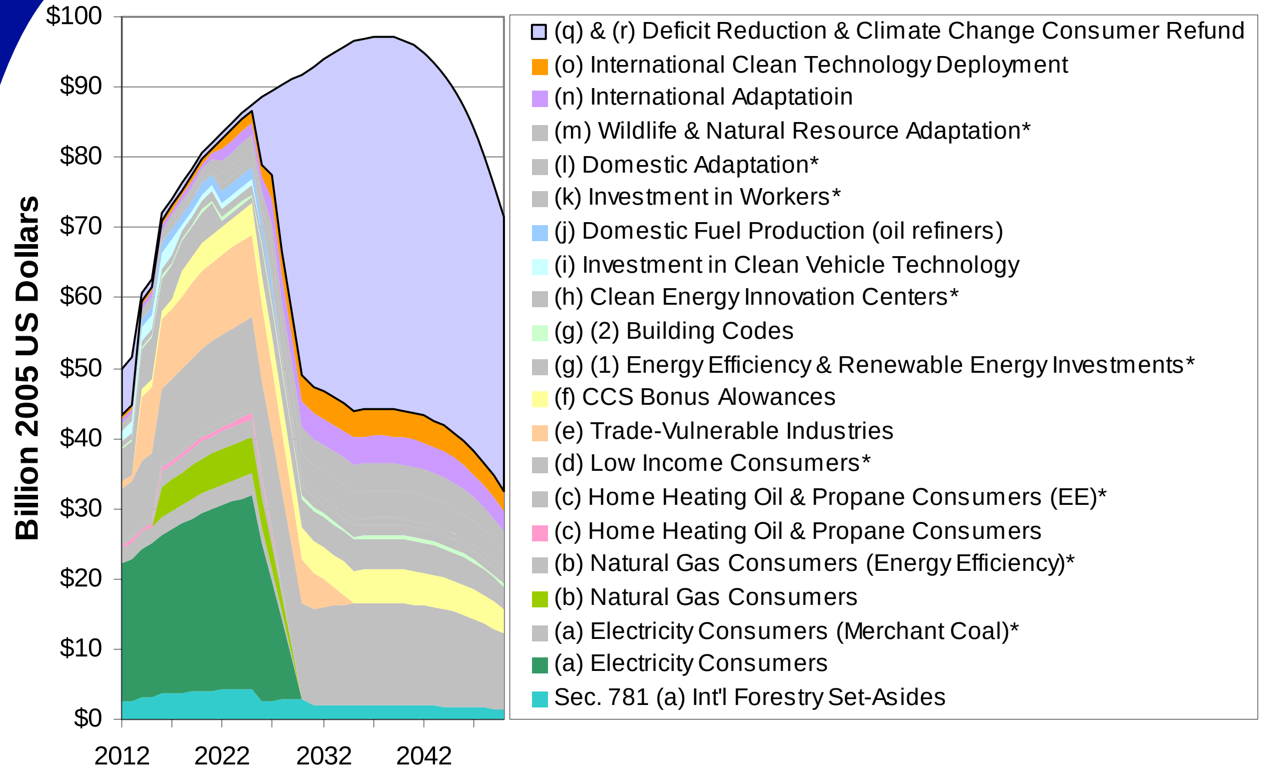
Scenario 2 – H.R. 2454

Table: Total Abatement Cost Calculations
Scenario 2 - HR 2454

	2015	2020	2030	2040	2050
Total Allowance Value (Billion 2005 Dollars)					
ADAGE	$62	$79	$94	$99	$73
IGEM	$63	$81	$92	$97	$71
Domestic Covered Abatement (MtCO2e)					
ADAGE	380	808	1,661	2,263	3,028
IGEM	728	1,028	1,421	1,912	2,628
Domestic Offset Abatement (MtCO2e)					
ADAGE	177	186	285	367	599
IGEM	172	176	287	370	643
International Offsets & Set-Asides (MtCO2e before discounting)					
ADAGE	1,340	1,571	1,552	1,632	1,550
IGEM	1,329	1,560	1,456	1,429	1,447
Allowance Price ($/tCO2e)					
ADAGE	$13	$16	$27	$43	$70
IGEM	$13	$16	$26	$42	$69
Offset Price ($/tCO2e)					
ADAGE	$13	$16	$27	$43	$70
IGEM	$13	$16	$26	$42	$69
International Offset/Credit Price ($/tCO2e before discounting)					
ADAGE	$10	$13	$21	$34	$55
IGEM	$10	$13	$21	$34	$55
Domestic Covered Abatement Cost (Billion 2005 Dollars)					
ADAGE	$2	$7	$22	$49	$107
IGEM	$5	$8	$18	$40	$91
Domestic Offset Abatement Cost (Billion 2005 Dollars)					
ADAGE	$1	$2	$4	$8	$21
IGEM	$1	$1	$4	$8	$22
International Offset Payments (Billion 2005 Dollars)					
ADAGE	$13	$20	$32	$55	$86
IGEM	$13	$20	$30	$48	$80
Total Abatement Cost (Billion 2005 Dollars)					
ADAGE	$17	$28	$58	$112	$213
IGEM	$19	$30	$52	$97	$193

- Total allowance value is the value of allowances issued in each year (i.e. allowance price multiplied by the cap level).
- The allowance price is equal to the marginal cost of abatement.
- The offset price is the marginal cost of abatement for uncovered sectors and entities in the U.S. When the limit on offset usage is non-binding, the offsets price is equal to the allowance price.
- The international offset price is the marginal cost of abatement outside of the U.S.
- Domestic covered abatement cost is approximated for each model as the product of domestic covered GHG emissions abatement and the allowance price divided by two.
  - Division by 2 is assumed to represent the fact that most reduction measures are not implemented at the marginal allowance price but at lower prices. In most cases, the relationship between emission reduction and the marginal price is a convex curve – which implies a value larger than 2. The value of 2, used here for simplicity leads to an overestimation of abatement costs.
- Domestic offset abatement cost is approximated for each model as the product of domestic offset abatement and the offset price divided by two.
- International offset payments are calculated for each model as the product of the amount of international offsets purchased and the international credit price.
  - Unlike the abatement costs associated with domestic covered abatement and domestic offsets, there is no need for dividing by two when calculating the costs of international offsets as they are all purchased at the full price of international allowances and those payments are sent abroad.
- Covered abatement occurs within the CGE models and thus the associated abatement cost is an ex-post general equilibrium cost.
- Offset abatement is generated by external MAC curves, and thus the associated abatement cost is an ex-ante partial equilibrium cost.
- Total abatement cost is simply the sum of domestic covered abatement cost, domestic offset abatement cost, and payments for international credits.

Value of Allocated & Auctioned Allowances (IGEM)



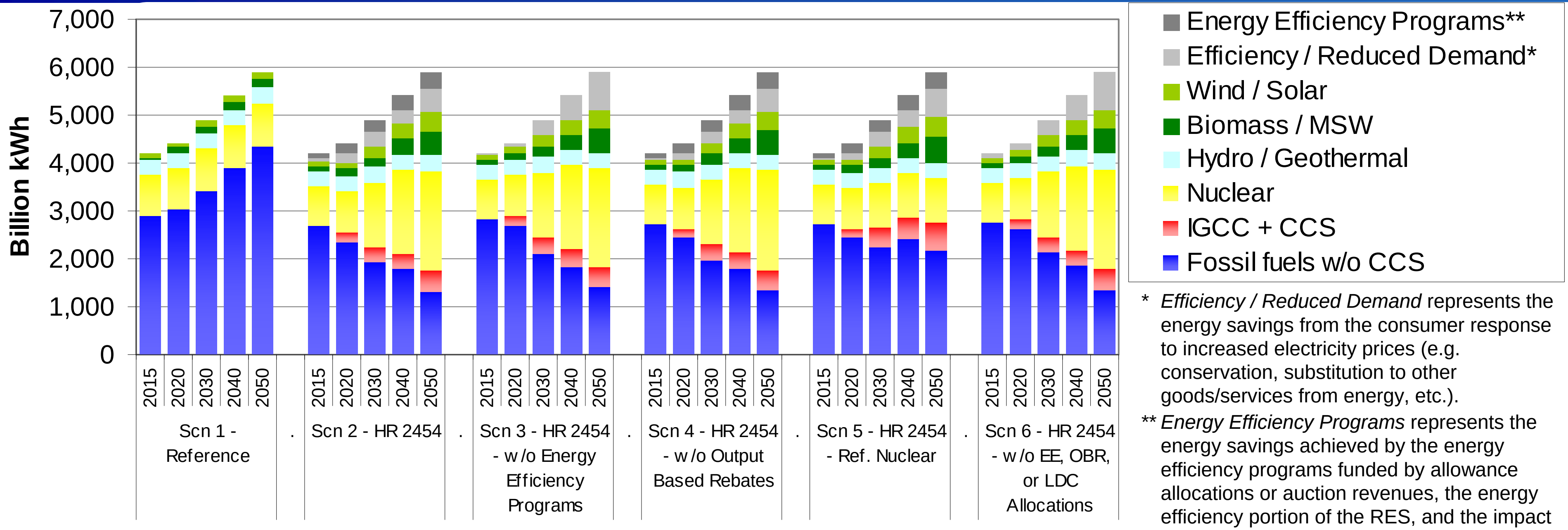
- H.R. 2454 Sec. 321 amends the Clean Air Act by inserting "Sec. 782. Allocation of Emissions Allowances." Parts (a) through (o) of this section allocate allowances for various purposes. Additionally, Sec. 781 (a) is added to allocate allowances for supplemental emissions reductions.
- The allowance price used in this figure is from the IGEM "*scenario 2 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 directed to special funds, the reduction in household annual consumption and GDP would likely be greater. If these auction revenues were instead used to lower distortionary taxes, the costs of the policy would be lower.

Energy Sector Modeling Results from Economy-Wide Modeling

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.

- Under the policy scenarios, both nuclear and renewable electricity generation expands above the reference levels.
  - Constraints on nuclear power growth are exogenous to the model (nuclear power generation is allowed to increase by ~150% from 782 bill. kWh in 2005 to 2,081 bill. kWh in 2050). EPA plans on revising these constraints for future analyses.
- The share of renewable electricity (as defined by the RES) in the reference scenario is 6% of generation in 2015, 8% in 2020, and 10% in 2030. In "*scenario 2 – HR 2454*" the renewable generation share increases to 8% in 2015, 12% in 2020, and 20% in 2030 (other policy scenarios have similar renewable shares).
- CCS deployment on fossil-fuel generation begins in 2020 with 25 GW of CCS capacity in "*scenario 2 – HR 2454*"; by 2030, 43 GW of new CCS capacity is projected to be built; and by 2050, 60 GW of new CCS capacity is projected to be built, which is the equivalent of 109 CCS units at 550 MW each. Through 2025, ADAGE projects a greater amount of CCS generation than IPM (328 billion kWh in ADAGE vs. 198 billion kWh in IPM in 2025).
- Previous modeling of the Waxman-Markey discussion draft showed that without a subsidy for CCS, the technology would not deploy until 2040.
- In scenario 5, nuclear power is held to reference levels, resulting in a 15% increase in allowance prices, and fossil generation in 2050 equal to 2010 levels.
- See the appendix 3 for a discussion of the limitations of the methodology used for representing energy efficiency programs.

Scenario 2 & 3

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 3 for further detail.
- In '*scenario 2 – H.R. 2454*' total electricity demand reductions are estimated to grow to 5% of reference case demand by 2020 and increase to 5.6% of AEO reference case demand in 2050.
- In '*scenario 2 – H.R. 2454*' total natural gas demand reductions are estimated to grow to 4.4% of reference case demand by 2030, and decrease to 4.3% of reference case demand in 2050.
- Cost impacts were calculated, and applied to the manufacturing and services sectors within ADAGE.

Modeled economic impacts

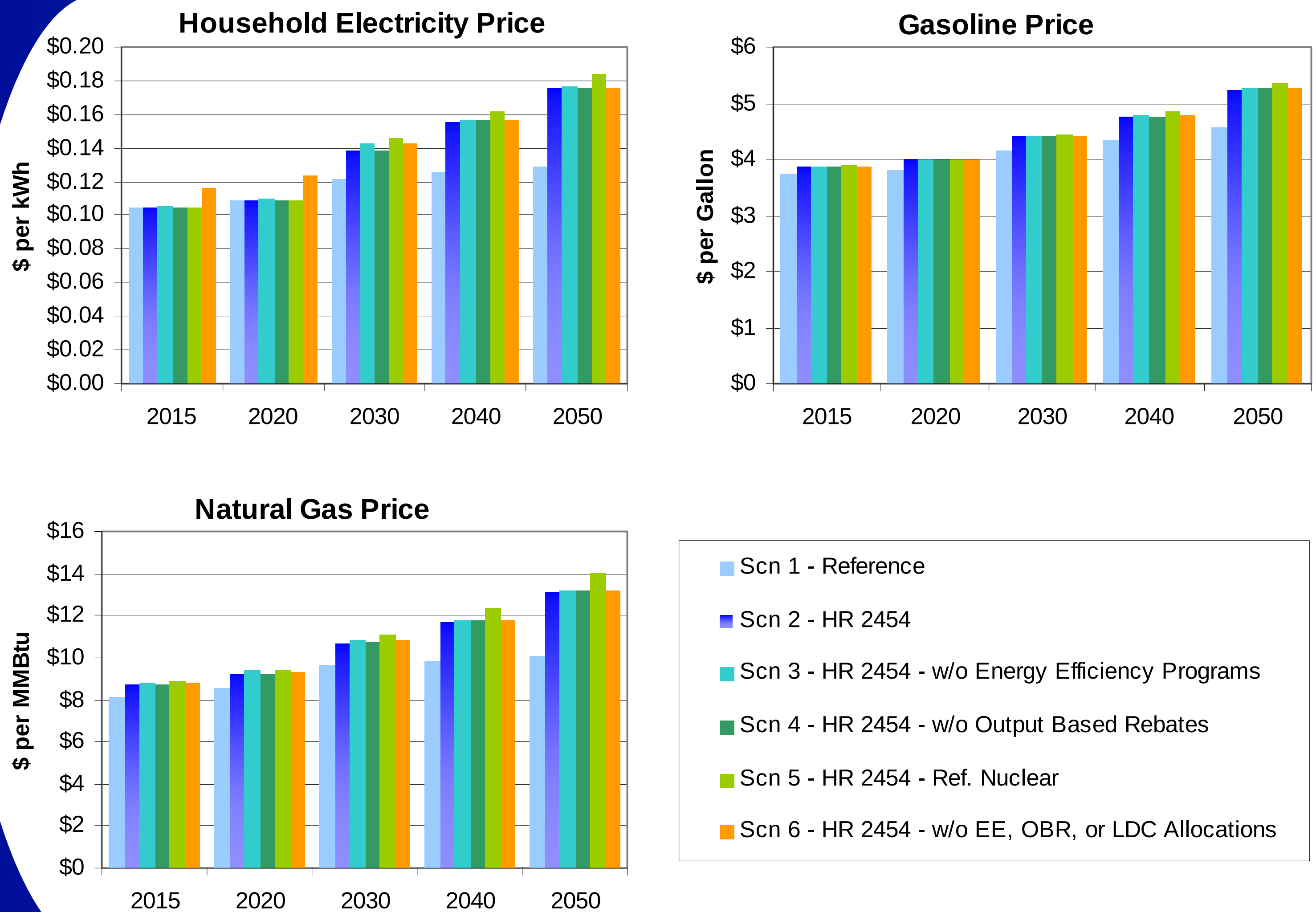
- Allowance prices are forecast to be slightly higher without energy efficiency provisions ('*scenario 3 – H.R. 2454 w/o Energy Efficiency Provisions'* relative to '*scenario 2 – H.R. 2454.')*
  - ~1.5% higher allowance prices estimated each year for 2015-2050
- Fossil fuel prices are forecast to be slightly higher for 2015-2050 without energy efficiency provisions (*scenario 3* relative to *scenario 2).*
  - Coal and Natural Gas ~1% higher
- Electricity prices are forecast to be slightly (<1%) higher for 2015-2050 without energy efficiency provisions (*scenario 3* relative to *scenario 2).*

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

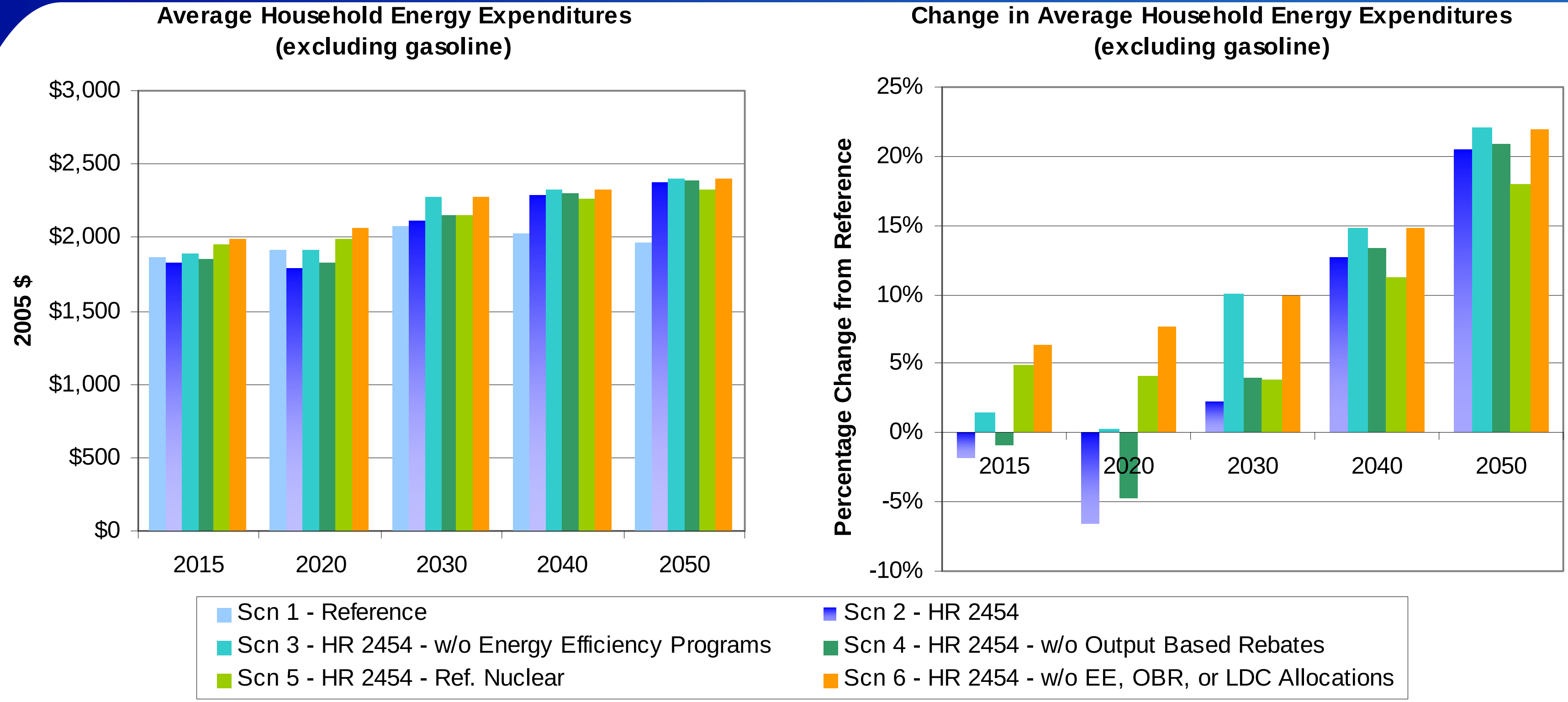
H.R. 2454 Scenario Comparison (ADAGE)



- Gasoline and natural gas prices are inclusive of the allowance price.
- The gasoline price is obtained by multiplying the petroleum price index in ADAGE by the 2010 price of gasoline from the AEO 2009 projection.
- See Appendix 3 for a discussion of the limitations and caveats associated with the methodology used for representing energy efficiency programs.

Household Energy Expenditures

H.R. 2454 Scenario Comparison (ADAGE)



- In 2020, electricity prices are unchanged in "*scenario 2 – H.R. 2454*" and increase by 13% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*". In 2030, electricity prices increase by 13% in "*scenario 2 – H.R. 2454*" and increase by 17% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*".
- 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) decrease by 7% in *scenario 2 – H.R. 2454*" and increase by 8% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*". In 2030, the increase is 2% in *scenario 2 – H.R. 2454*" and 10% in "*scenario 6 – H.R. 2454 w/o EE, OBR, or LDC Allocations*".
- 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.

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 H.R. 2454 on the electricity sector.

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

- This version of IPM builds 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 has been updated to include 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 changes 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 ADAGE core scenario (Scenario 2).

Key Model Updates and Major Power Sector Provisions Modeled in IPM

Updates to IPM 2009 ARRA Ref. Case:

- **Electricity Demand Growth:** Calibrated to AEO 2009 ARRA update (issued in April).
- **Cost of New Power Technologies:** Consistent with AEO 2009 ARRA update.
- **Biomass:** Supply curves and non-electricity demand for biomass are calibrated to AEO 2009 ARRA update.
- **Cost of Carbon:** An increase to the capital charge rate for new coal plants (consistent with AEO 2009).
- **State RPS and Climate Programs:** Calibrated to AEO 2009 with finalized regulations like RGGI.
- **CCS in Baseline:** Reflecting updated financial incentives including ARRA, 2 GW of CCS capacity are projected for 2015 in the baseline.

Major Bill Provisions:

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.

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.

Major Power Sector Provisions of H.R. 2454 Modeled in IPM

Major Bill Provisions (cont.):

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.

Allowance Allocation to Local Distribution Companies (Title III, Subtitle B, Sec. 783): Distributes allowances to electricity local distribution companies (LDCs) "for the benefit of retail ratepayers."

- LDCs collectively receive a declining share of allowances to 2030, beginning at about 39% in 2012 and ending with about 6% in 2029.‡ Half of those allowances are disbursed to LDCs based on historic GHG emissions. The remaining allowances are disbursed based on an updating measure of an LDC's population served (revised every 3 years). LDCs are required to direct allowance value toward "ratepayer benefit," which may range from energy efficiency improvements to consumer rebates. For the latter purpose, the bill encourages LDCs and their regulators to issue lump sum rebates.
- IPM implementation: Allowance prices and electricity demand response are taken from the core ADAGE H.R. 2454 Scenario (#2), which reflects the LDCs allocation as rebates based on electricity consumption.

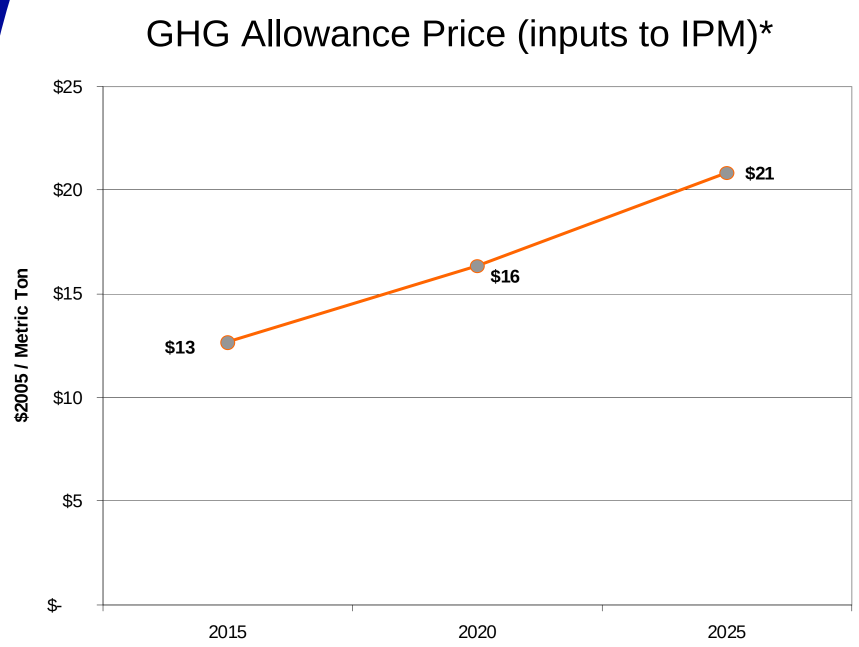
* Assumptions for energy efficiency are detailed earlier in this presentation and are taken from the ADAGE model.

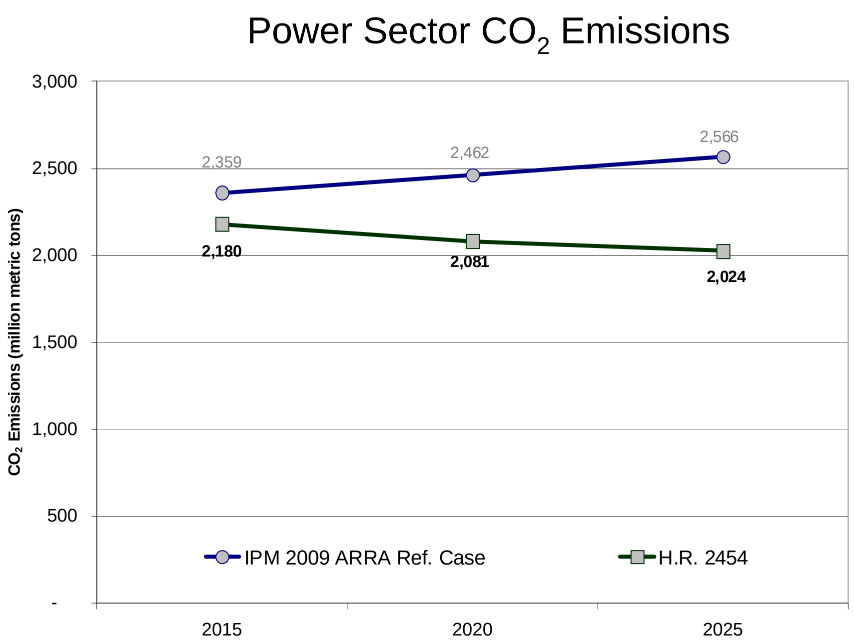
† Sales of generation from CCS is only deducted from the CERES baseline equivalent to the percentage of carbon capture achieved, which is assumed to be 90% in this analysis.

‡ The bill directs EPA to reserve up to 10% of the electricity consumer allocation for distribution to generators subject to long-term contracts and to merchant coal generators. The remaining amount is estimated here for LDCs.

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.

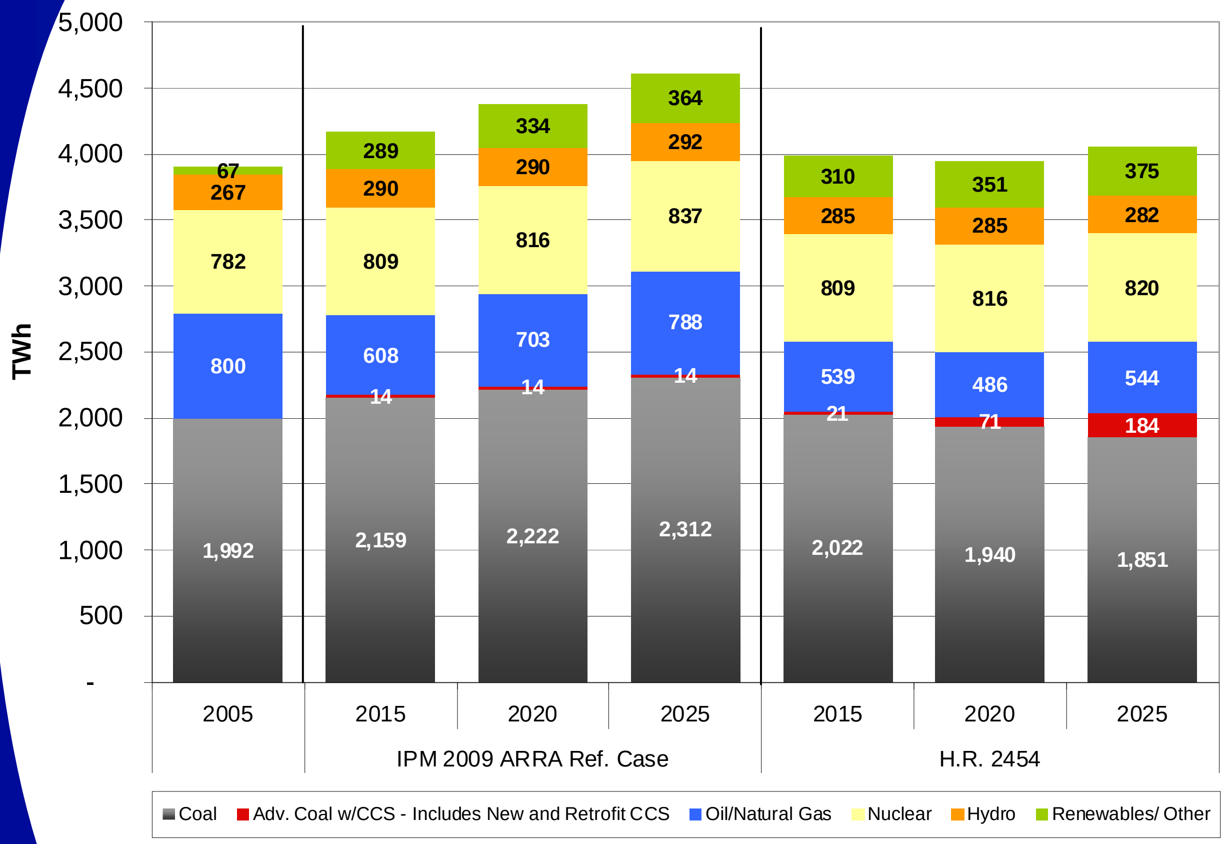
GHG Allowance Prices and Power Sector CO_2 Emissions (IPM)*





* Allowance prices for the core IPM scenario are taken from the ADAGE core scenario (Scenario 2). 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.

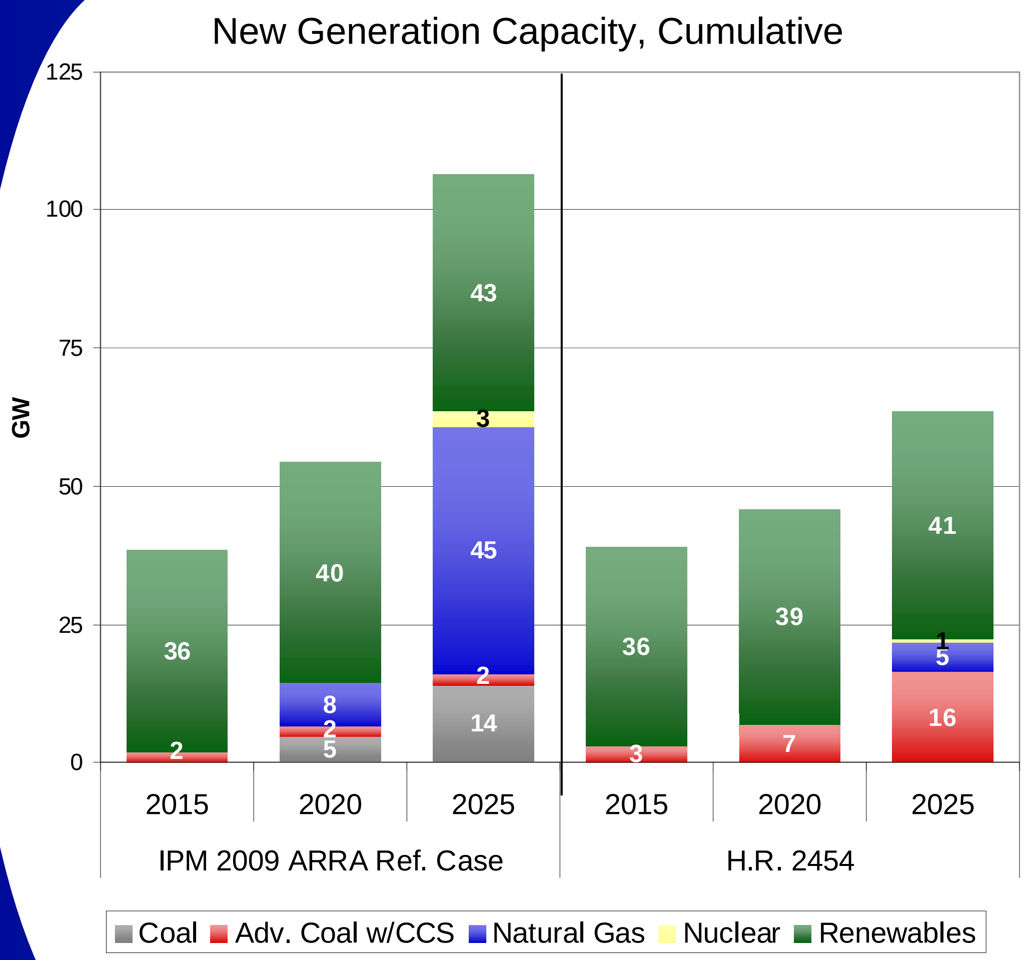
Electricity Generation Mix (IPM)



- The electricity demand forecast is lower than past EPA analyses, reflecting economic and policy-related adjustments.
- 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 H.R. 2454 scenario.
  - This tends to drive generation away from existing natural gas.
- The difference in electricity generation between the reference case and policy case due to energy efficiency and demand response is around 550 TWh in 2025. This difference is equivalent to the amount of electricity used by over 40 million (50% of the total) single family homes in the US annually.*
- There is greater renewable generation in the H.R.2454 scenario even though less new renewable generation is built because of greater reliance on bio-mass co-firing 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.

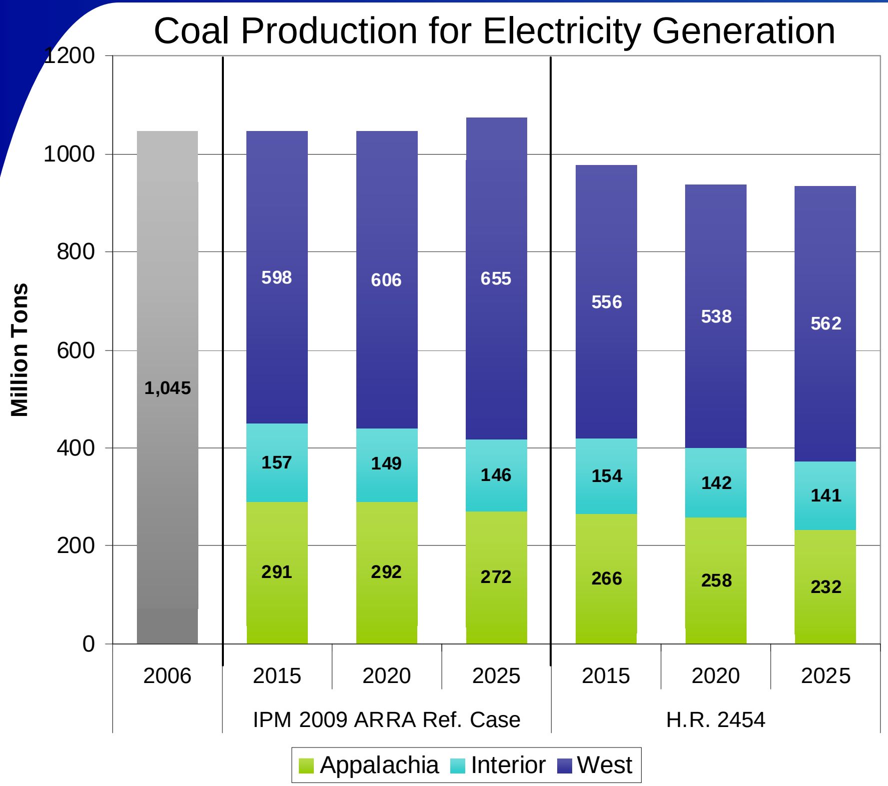
New Generation Capacity (IPM)

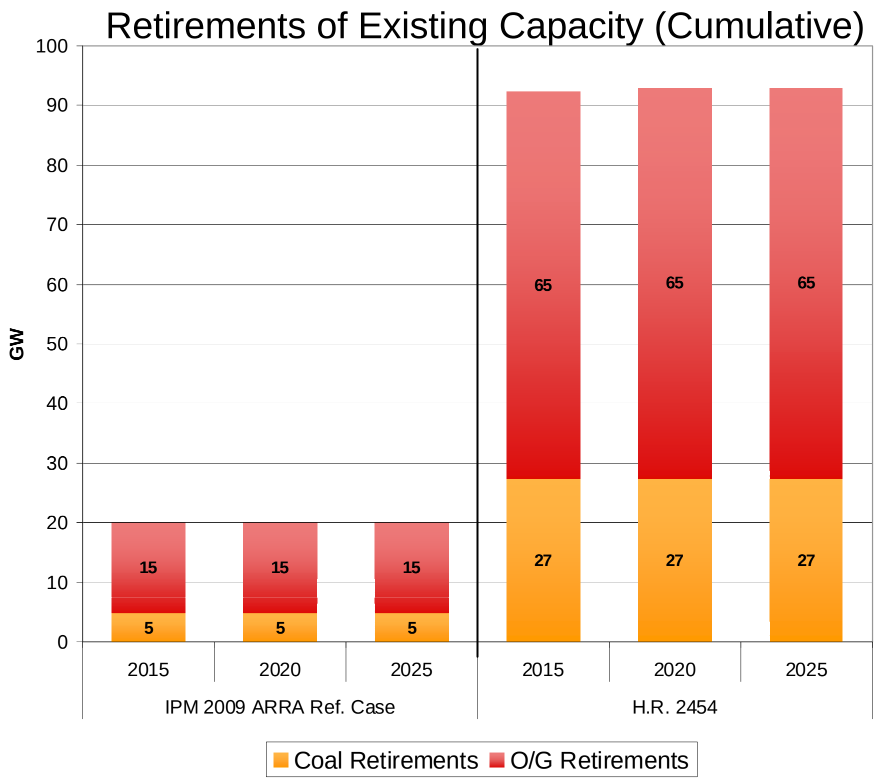


- A major change to the IPM 2009 ARRA reference case is the amount of new renewables expected to be built in the short-term in response to additional ARRA incentives. Overall electricity demand is also lower, necessitating fewer new power plants than past EPA modeling with IPM.
- Under H.R. 2454, electricity demand is reduced significantly and allowance prices are not high enough to drive a significant amount of additional low- or zero- carbon energy (including nuclear, renewables, and CCS) in the shorter-term, excluding the technologies with specific financial incentives (e.g., CCS).
- H.R. 2454 contains early deployment funding and a bonus allowance provision for CO_2 emissions that are captured and sequestered, resulting in some penetration of *new* coal capacity with CCS technology.
  - The policy results in a total of 14 GW of additional new capacity with CCS by 2025. Of that amount, 5 GW is forced in IPM beyond the reference case by 2020 to reflect early deployment funding. The other 9 GW becomes economic due to the bonus allowance allocation (see later slide).
  - 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 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.

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

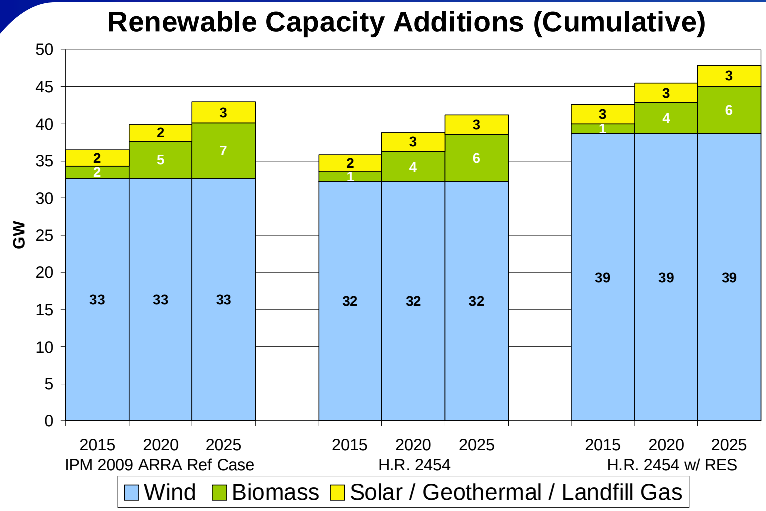


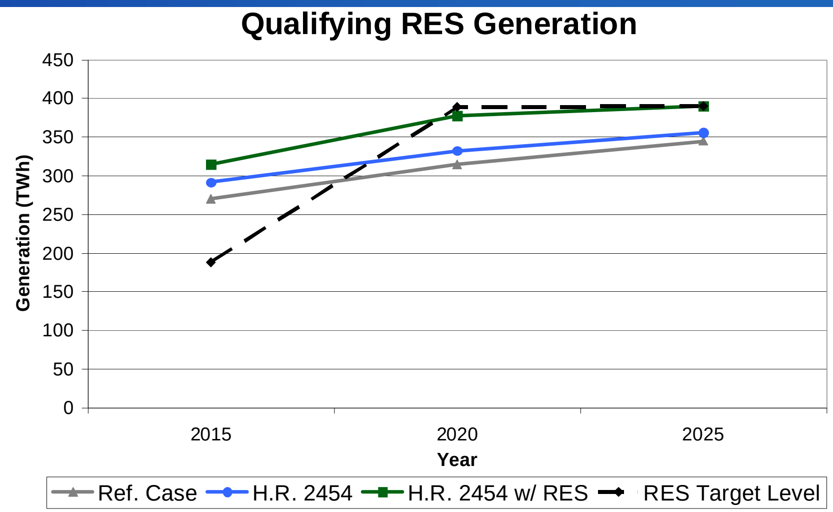


- Roughly 22 GW of additional existing coal capacity and 70 GW of additional oil/gas capacity is projected to retire under H.R. 2454. The lower allowance prices and higher costs to build new technology make existing coal cost-competitive in the shorter-term.
- In reality, uneconomic units may be “mothballed,” 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 is 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 core case for H.R. 2454 illustrates how the bill's provisions for increased energy efficiency reduce the need for new capacity additions (including renewables), even as renewable generation rises. The RES portion of CERES is shown here to increase deployment of renewable capacity, and it results in a more substantial increase in renewable generation than the cap-and-trade system yields on its own.
  - The RES also reduces average natural gas prices, gas consumption, and wholesale electricity prices by about 1-2% throughout the model's time horizon. Initial analysis indicates that retail electricity prices rise slightly relative to the core H.R. 2454 scenario in later years. The impact on a household's electricity bill, however, would be offset to the extent that efficiency gains would reduce overall power consumption.
  - The share of renewable electricity (as defined by the RES) in the IPM reference scenario is roughly 7% of generation in 2020 and 2025. In Scenario 2 (H.R. 2454), the renewable generation share increases to 8% in 2020 and 9% in 2025. And in Scenario 2 with the RES, renewable generation is 9% in 2020 and 10% in 2025.
- The power sector is projected to reach the bill's RES targets through 2015 in the reference case (with 25% from electricity savings assumed).
- H.R. 2454 includes an alternative compliance payment (ACP) of $25 per MWh. This analysis projects that the federal Renewable Electricity Credit (REC) price reaches that level in 2020 but falls back to about $11 per MWh in 2025.
  - Use of the ACP in 2020 is very limited (accounting for only 2% of total CERES compliance).
  - H.R. 2454 also allows States to petition for the right to meet up to 40% of the CERES with electricity savings. Additional use of efficiency to meet the standards would lower federal Renewable Electricity Credit (REC) prices, potentially reducing use of the ACP.
  - This analysis does not take into account the effect of ACP payments, which H.R. 2454 reserves for States to increase the deployment of renewables or increase electricity savings.
- 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. RES would not impact the achievement of the emission caps under H.R. 2454.

Note: 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. For more detail on natural gas impacts of the RES, see slide 93 of the Appendix.

Effects of Allocating Allowances to Electricity Local Distribution Companies

- Under lump sum rebate allocation, consumers pay higher electricity rates but receive payments irrespective of their consumption; therefore, the payments do not dampen the price incentive for more efficient use of electricity.

- Where allowance value is rebated to consumers on the basis of quantity consumed, electricity prices will be lower and thus consumption will be higher than would have occurred otherwise. Higher consumption yields higher GHG emissions from the power sector, which means other reductions will be needed that could lead to higher economy-wide allowance prices. EPA is doing additional analysis to examine the extent to which LDC allocation value impacts power prices, emissions, allowance prices, and developments in power sector generation and capacity.

- Note that any evaluation of the impact on consumers must examine electricity prices and total electric power consumption (e.g., monthly bills) together with other costs (e.g., efficiency investments) to get the full picture.

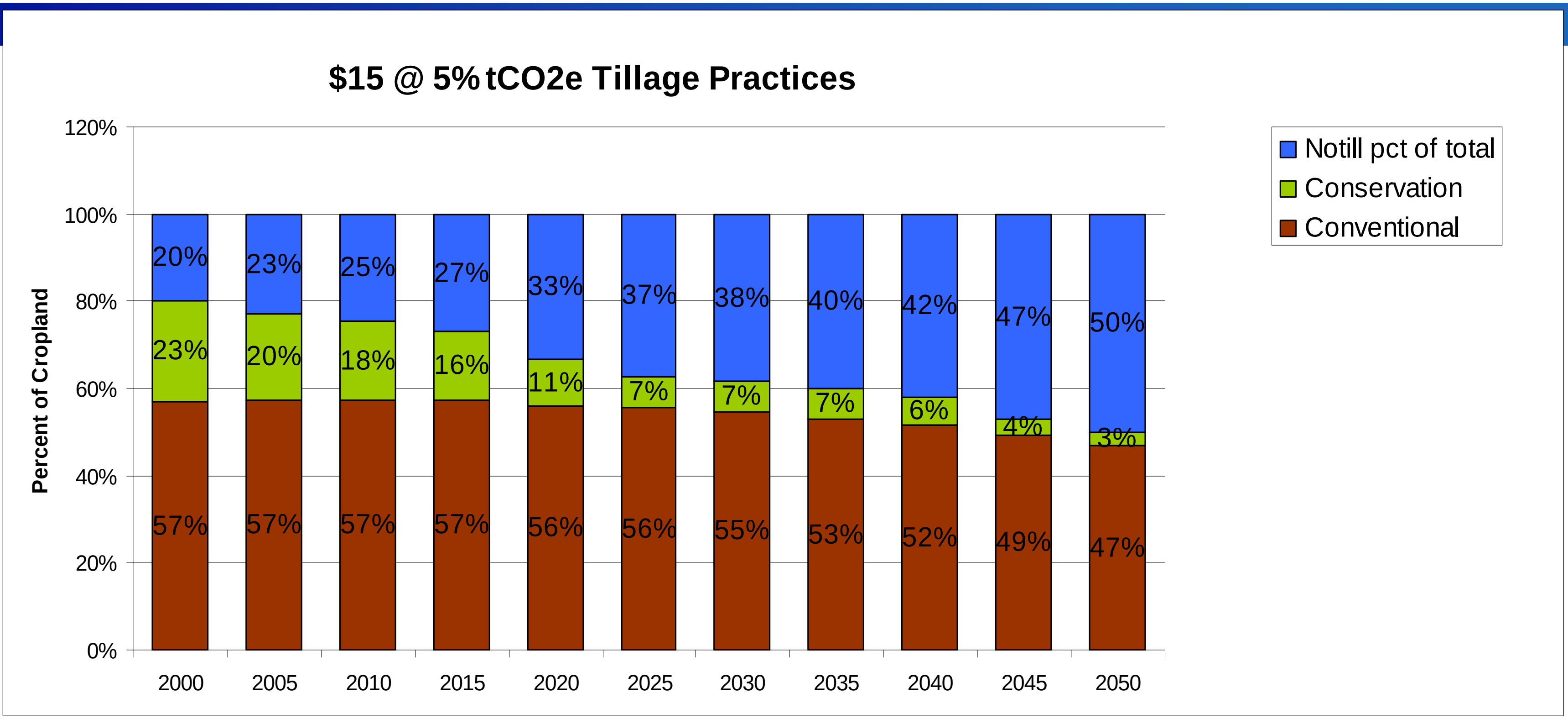
Offsets Usage & Limits

Factors Influencing Domestic Offset Supply

- The analysis of domestic forest and agriculture offsets is based on the FASOM marginal abatement cost curves used in the April 20th analysis of the Waxman-Markey Discussion Draft.
- The modeling of domestic offsets evaluates changes in greenhouse gases against a projected baseline. If offsets are evaluated against historic or current baselines, the overall volume of offsets would increase.
- The sources of domestic offsets modeled here represent sources that have significant supply in the FASOM model at the relevant allowance prices. The exclusion of other sources in the modeling results does not imply that those sources would not be eligible to receive offsets credits.
- The FASOM modeling did not account for several categories of potential agricultural GHG reductions, including:
  - Improvements in organic soil management;
  - Advances in feed management of ruminants;
  - Changes in the timing, form, and method of fertilizer application; and
  - Alternative manure management systems – other than anaerobic digesters
- Because of how it is handled in the model, agricultural soil sequestration does not show significant supply. However, detailed FASOM output indicates a 50% increase in the percent of cropland using conservation-tillage and no-till by 2020 in response to a $15/ton CO_2 incentive payment. Because overall land area in crops declines due to afforestation, the modeling indicates a net decrease in total agricultural soil carbon storage as carbon is transferred from the agricultural soils pool to the afforestation carbon pool.
- Within the model, reductions in fertilizer use result in declines in yields. To the extent fertilizer application can be improved without yield penalties, the potential for this category of emissions reductions will be higher.
- EPA is working with USDA to review the analysis of the forestry and agricultural sectors.

Increased Use of No-Till Under Increasing Carbon Prices

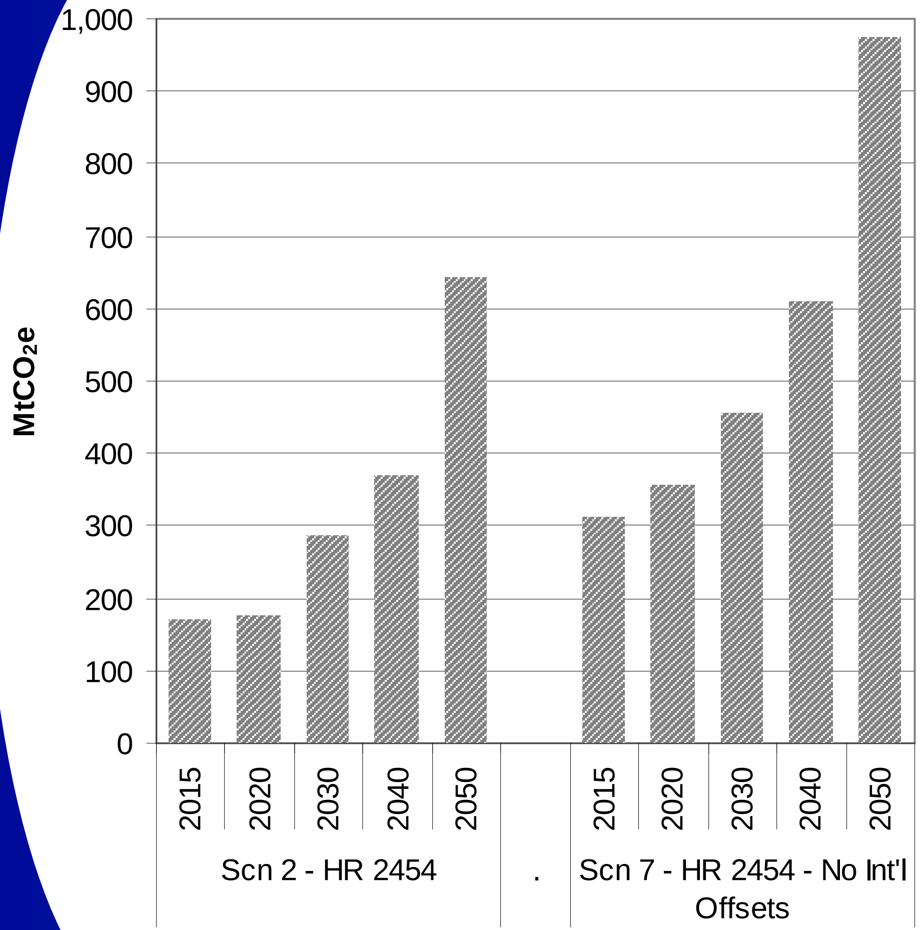
FASOM



- The above graphic represents the share of cropland under different tillage practices in one of the FASOM runs that contribute to the marginal abatement cost curves used for representing domestic offsets abatement potential. The specific run is based on an initial allowance price of $15/t$CO_2$e rising at five percent.
- Because of how it is handled in the model, agricultural soil sequestration does not show significant supply. However, detailed FASOM output indicates a 50% increase in the percent of cropland using conservation-tillage and no-till by 2020 in response to a $15/ton CO_2 incentive payment. Because overall land area in crops declines due to afforestation, the modeling indicates a net decrease in total agricultural soil carbon storage as carbon is transferred from the agricultural soils pool to the afforestation carbon pool.

Domestic Offsets Usage

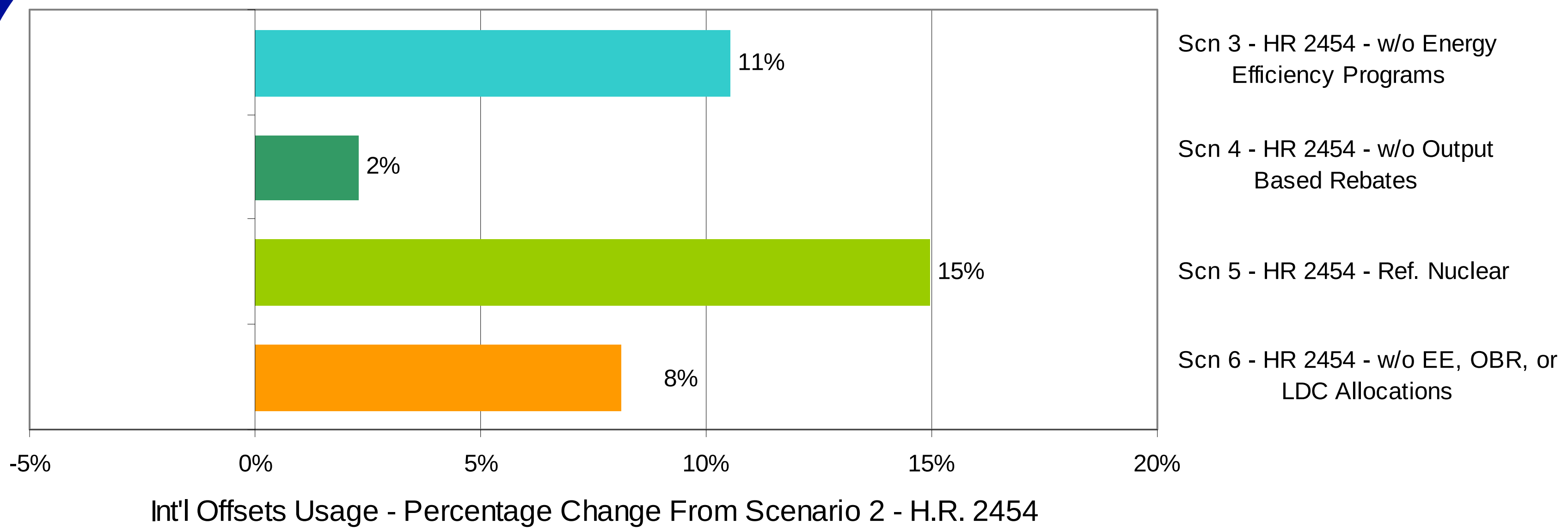
H.R. 2454 Scenario Comparison (IGEM)



- 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.
  - 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 2 for a detailed discussion of the offsets provisions in H.R. 2454.
- In our analysis, we assume that landfill and coal mine CH_4 are covered under new source performance standards (NSPS) and are thus not available for offsets.
  - EPA's previous analysis of the Waxman-Markey discussion draft showed that allowing landfill and coal mine methane as offset projects instead of covering them under NSPS would increase cumulative domestic offsets usage by 45%.
- Restricting the use of international offsets, as in "*scenario 7 – H.R. 2454 No Int'l Offsets*" has a large impact on allowance prices (89% increase relative to '*scenario 2 – H.R. 2454*').

International Offsets Usage Sensitivities

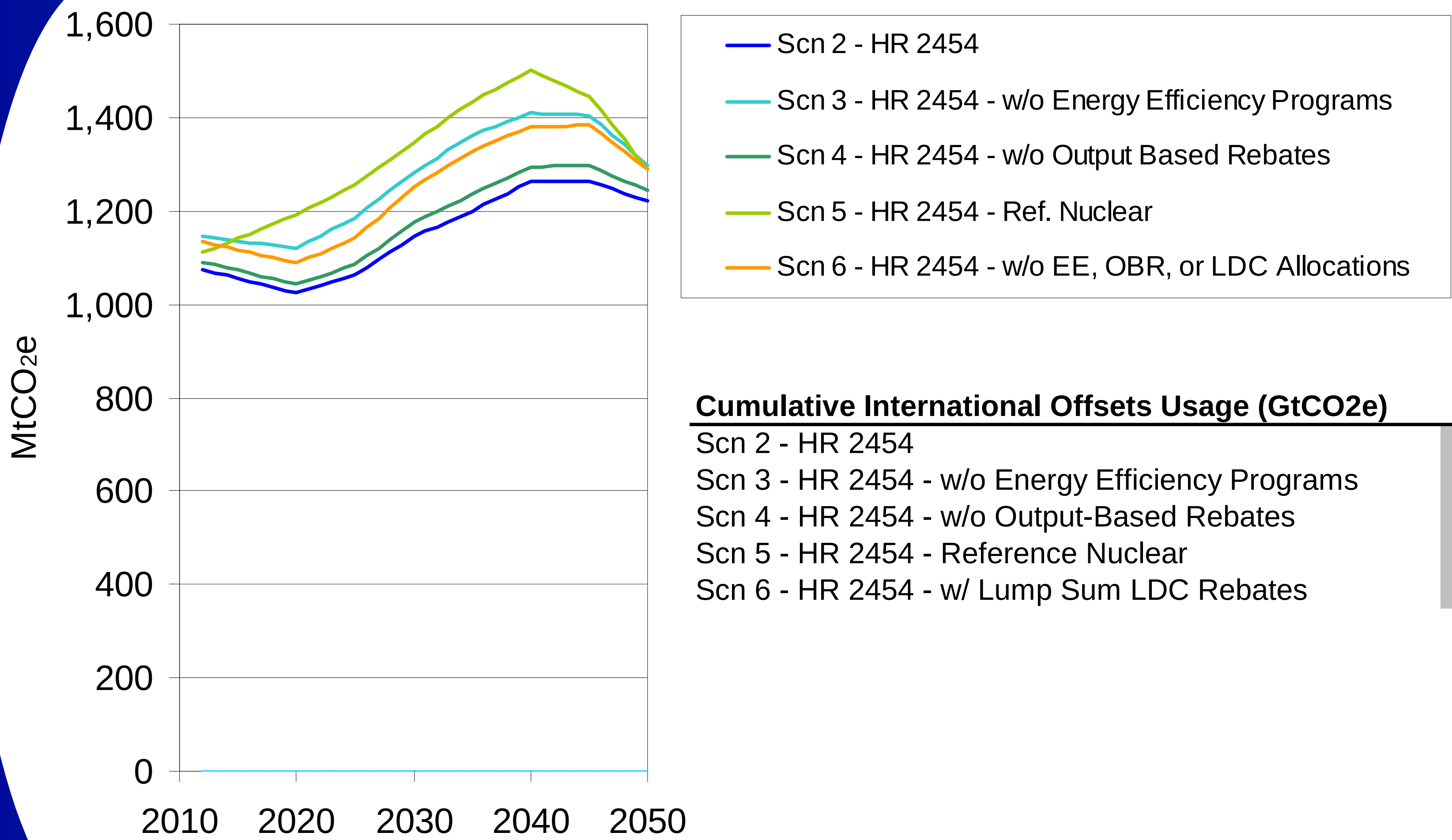
H.R. 2454 Scenario Comparison (ADAGE)



- 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, instead impact the usage of international offsets (and thus the amount of abatement within covered sectors).
- For example, in EPA's analysis of the Waxman-Markey discussion draft (WM-draft), the sensitivity case adding in the energy efficiency programs resulted in a 9% decrease in allowance prices. In this analysis of H.R. 2454, the sensitivity case removing the energy efficiency programs only increases allowance prices by 2%. The difference is that in the WM-draft analysis the cumulative U.S. covered emissions were the same in the two scenarios; whereas, in the H.R. 2454 analysis, removing the energy efficiency programs increases the marginal cost of abatement, but instead of allowance prices increasing to achieve the same level of abatement, the usage of international offsets increases and the amount of abatement decreases so cumulative U.S. covered emissions increase.

International Offsets Usage

H.R. 2454 Scenario Comparison (ADAGE)



Cumulative International Offsets Usage (GtCO2e)	
Scn 2 - HR 2454	45
Scn 3 - HR 2454 - w/o Energy Efficiency Programs	50
Scn 4 - HR 2454 - w/o Output-Based Rebates	46
Scn 5 - HR 2454 - Reference Nuclear	52
Scn 6 - HR 2454 - w/ Lump Sum LDC Rebates	48

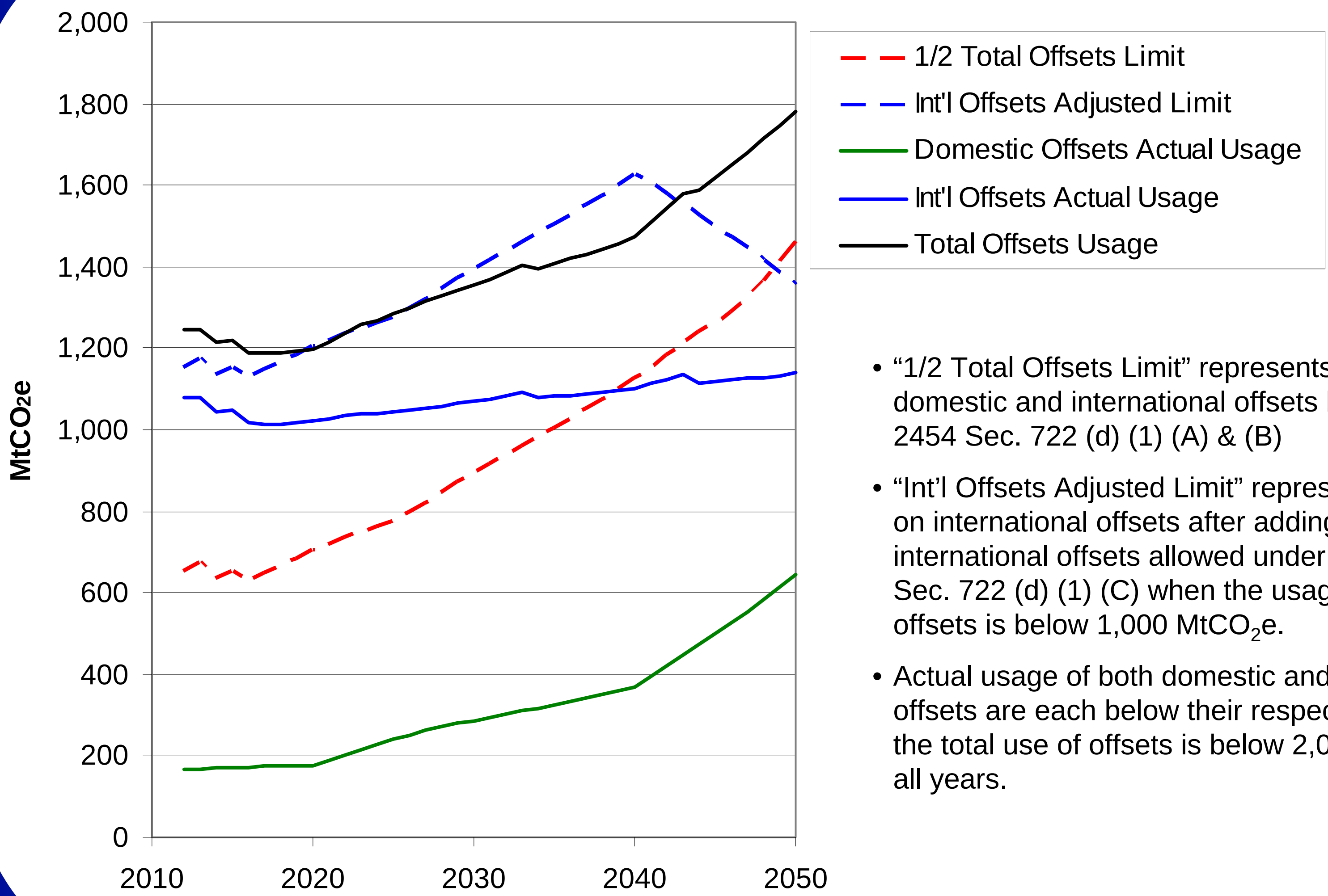
H.R. 2454 Offsets Provisions

Sec. 722 (d) (1)

- 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.
  - Covered entities are allowed to satisfy a specified percentage of the number of allowances required to be held for compliance with offsets credits.
  - H.R. 2454 Sec 722 (d) (1) (B) shows that for each year, the specified percentage is calculated by dividing two billion by the sum of two billion and the annual tonnage limit for that year. For example, in 2012, when the cap level is 4.627 GtCO2e, the percentage would be 30.20%; and in 2050, when the cap level is 1.035 GtCO2e the percentage would be 65.90%.
  - The number of allowances required to be held for compliance is equal to the amount of covered emissions, so for any given firm the amount of offsets they are allowed to use is equal to the product of their covered emissions and the percentage specified above.
  - The total amount of offsets allowed is equal to the product of the total amount of covered emissions and the specified percentage. In order for this to be equal to the 2 billion ton limit on offsets specified above, total covered GHG emissions would have to be equal to the cap level plus 2 billion tons. There are several reasons why this is unlikely to be the case.
    - First, even if covered emissions remain at reference levels, in the early years of the policy they will not be 2 billion tons over the cap level.
    - Second, if firms bank allowances, their covered GHG emissions will be reduced, which will reduce the amount of offsets they are allowed to use.
    - Third, in the later years when firms are drawing down their bank of allowances, it is possible for covered GHG emissions to be more than 2 billion tons above the cap, which means that the pro rata sharing formula can be in conflict with the overall 2 GtCO2e limit on offsets usage. However, if the domestic limit is non-binding, then the pro-rata sharing would allow for the international limit to exceed 1 GtCO2e, so long as the sum of domestic and international offsets were still below 2 GtCO2e.
- 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.
  - In years when this provision triggers, an additional amount of international offsets are allowed equal to the lesser of: 1 GtCO2e less the actual amount of domestic offsets used; or 0.5 GtCO2e.
  - This has the potential in later years to allow more than 2 GtCO2e of offsets into the system, so our interpretation is that the actual amount of extra international offsets allowed would be equal to the lesser of the amount calculated above, or 2 GtCO2e less the sum of the international offsets limit and the actual usage of domestic offsets.
  - Because the pro-rata sharing limits domestic offsets in the early years to well below 0.9 GtCO2e, this provision will automatically trigger, even if the actual limit on domestic offsets were binding.

Domestic & International Offsets Usage & Limits

Scenario 2 – H.R. 2454 (IGEM)



- "1/2 Total Offsets Limit" represents the limits on domestic and international offsets based on H.R. 2454 Sec. 722 (d) (1) (A) & (B)
- "Int'l Offsets Adjusted Limit" represents the limit on international offsets after adding in the extra international offsets allowed under H.R. 2454 Sec. 722 (d) (1) (C) when the usage of domestic offsets is below 1,000 $MtCO_2e$.
- Actual usage of both domestic and international offsets are each below their respective limits, and the total use of offsets is below 2,000 $MtCO_2e$ in all years.

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.

Scenario 2 – H.R. 2454

- One of the main scenarios.

Scenario 7 – H.R. 2454 with No International Offsets

- One of the main scenarios.

Scenario 7a – H.R. 2454 with Delayed International Offsets

- Side scenario.
- No international offsets are allowed in the first 10 years.

Scenario 7b – H.R. 2454 with No Extra International Offsets

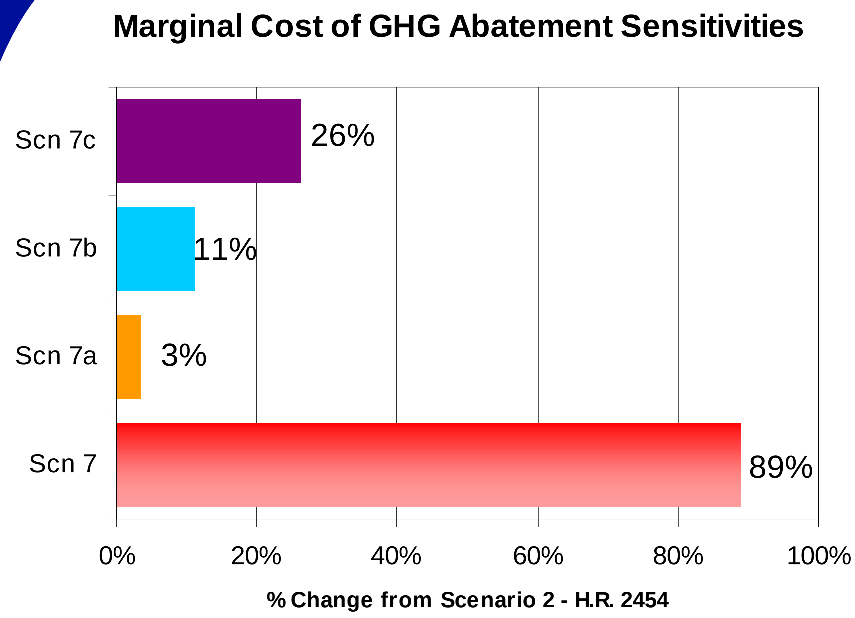
- Side scenario
- No extra international offsets from H.R. 2454 Sec 722 (d) (1) (C) when domestic offset usage is below 900 $MtCO_2e$.

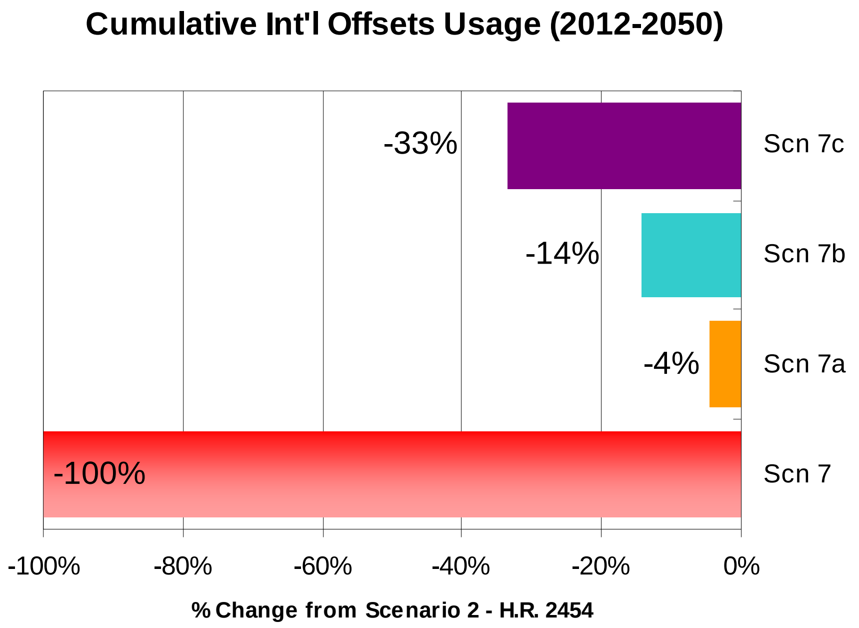
Scenario 7c – H.R. 2454 with Delayed International Offsets & No Extra International Offsets

- Side scenario
- No international offsets are allowed in the first 10 years.
- No extra international offsets from H.R. 2454 Sec 722 (d) (1) (C) when domestic offset usage is below 900 $MtCO_2e$.

International Offsets Sensitivities

Allowance Prices & Cumulative International Offsets (IGEM)



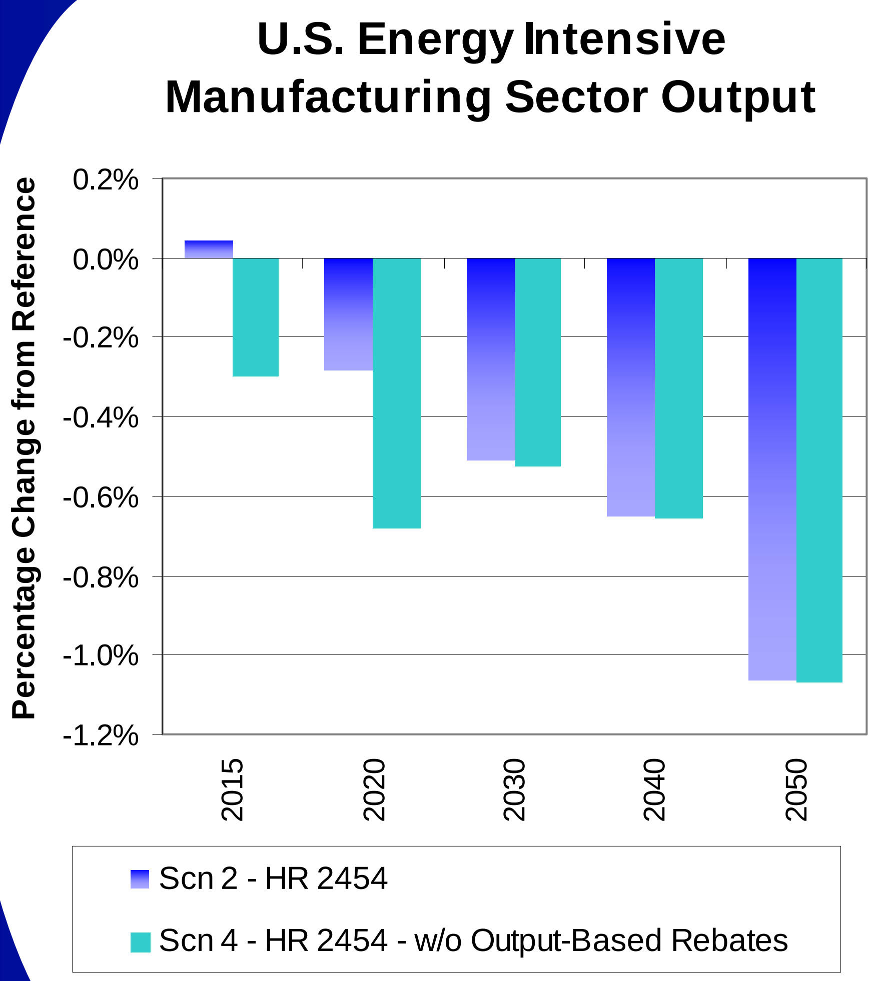


Cumulative International Offsets Usage (GtCO2e)	
Scn 2 - H.R. 2454	42
Scn 7 - H.R. 2454 - No Int'l Offsets	0
Scn 7a - H.R. 2454 - Delayed Int'l Offsets	40
Scn 7b - H.R. 2454 - No Extra Int'l Offsets	36
Scn 7c - H.R. 2454 - Delayed & No Extra Int'l Offsets	28

Global Results:
Trade Impacts and
Output-Based Rebate Provisions

Summary of Trade Impacts and Output-Based Rebate Provisions

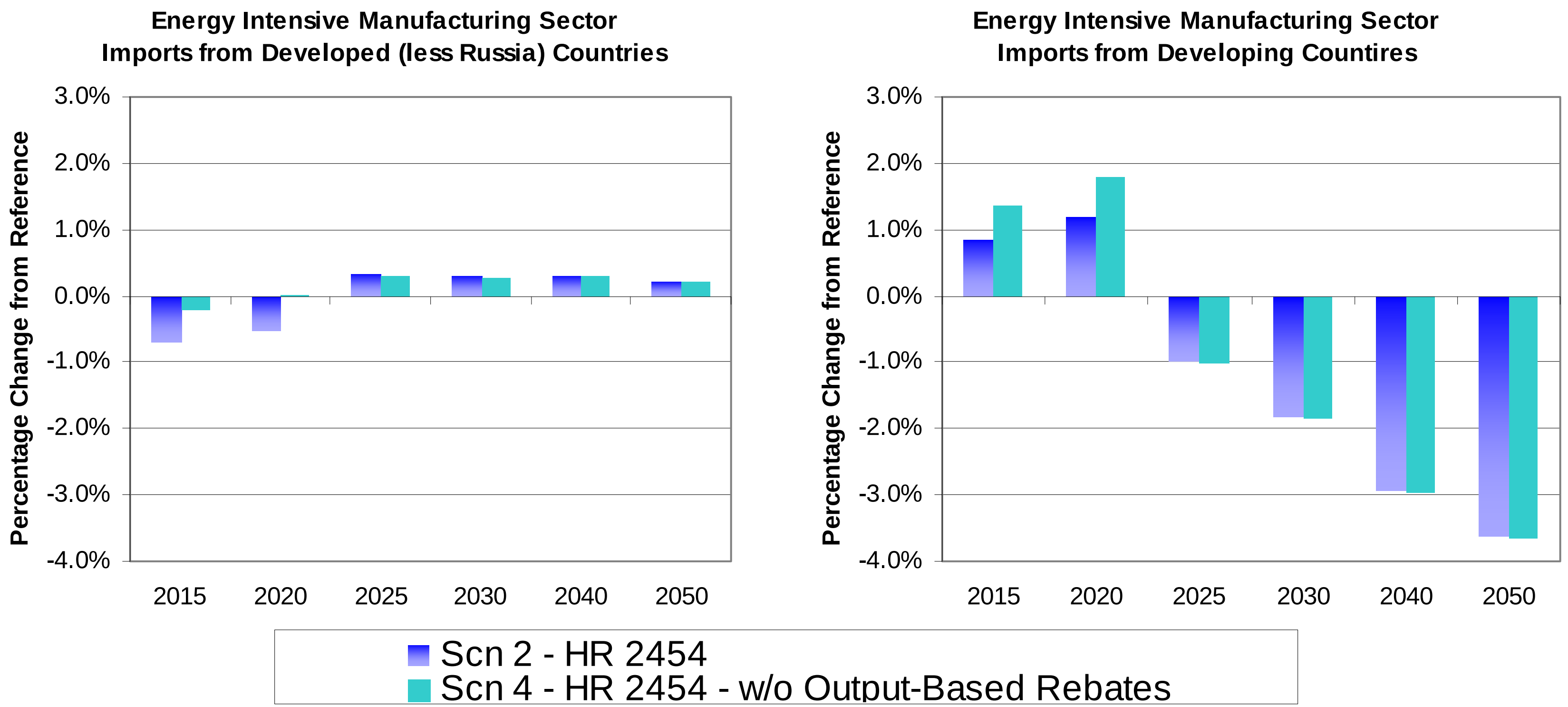
(ADAGE)



- The output-based rebate provision specified in Title IV of H.R 2454 is similar to H.R. 7146 (Inslee - Doyle).
  - Applies to energy- or GHG-intensive industries that are also trade-intensive.
  - Rebates on average 100 percent of the direct and indirect cost of allowances, based on an individual firm's output and the average GHG and energy intensity for the industry.
  - Gradually phases out between 2025 and 2035, or when other countries take comparable action on climate change.
- Without output-based rebate provision, energy intensive manufacturing output decreases by 0.3% in 2015 and by 0.7% in 2020. With the output-based rebates, energy intensive manufacturing output *increases* by 0.04% in 2015 and only falls by 0.3% in 2020.
- The output-based rebate provisions have little impact on allowance prices, and thus, in later years after the rebates are phased out, the energy intensive manufacturing sector output losses are similar in the two scenarios.
- More detailed results are presented in Appendix 5.

Summary of Trade Impacts and Output-Based Rebate Provisions

(ADAGE)

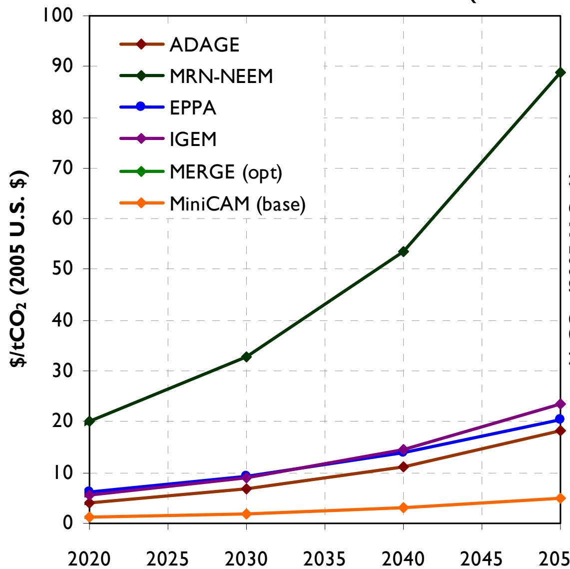


- Imports of energy intensive manufacturing goods from developing countries increase in 2015 and 2020, then decrease in 2025 and after as the developing countries are assumed to adopt climate policies.
- In 2015 and 2020, the output-based rebate provisions decrease imports from both developed and developing countries.
- More detailed results are presented in Appendix 5.

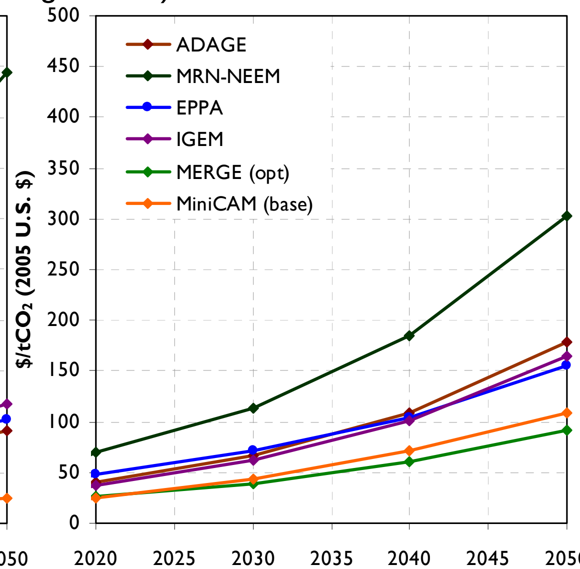
Literature Review

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

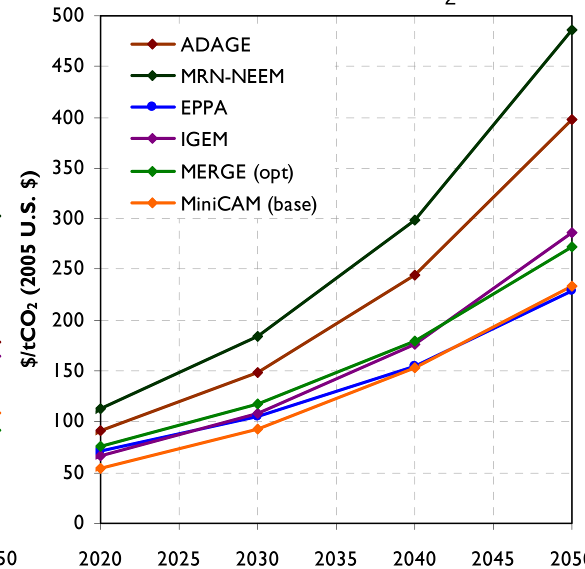
To put the EPA models (ADAGE and IGEM) in context, we compare the results of EMF's analysis of three emission goals that span a wide range of possible U.S. 2050 targets. Caps are based on CO_2-equivalents (CO_2-e), covering all Kyoto gases. These scenarios were not intended to represent any specific bill, and no domestic or international offsets are allowed. Domestic emissions (excluding offsets) under H.R. 2454 would fall between the 203 and 287 $GtCO_2$e cases.



287 $GtCO_2$-e



203 $GtCO_2$-e



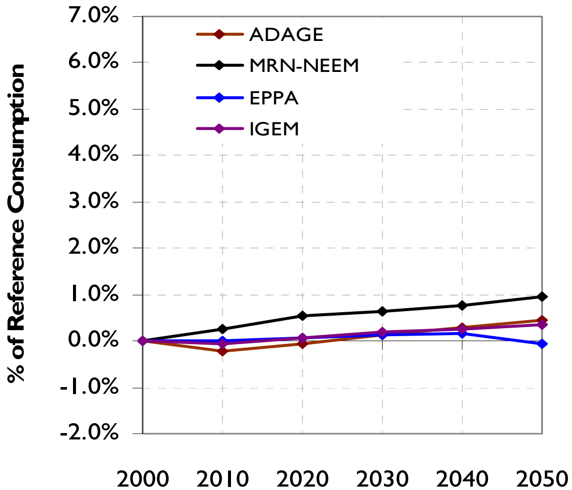
167 $GtCO_2$-e

- 287 bmt CO_2-e: ADAGE, IGEM and EPPA predict a similar rise in allowance prices. The cost of allowances rises from approximately $4-$6 per ton in 2020 to $20-$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: All models predict similar allowances prices in 2020 ($25-$70 per ton), but predict different growth rates resulting in a relatively wide range of allowance prices ($90 to $180; NEEM over $300) in 2050 .
- 167 bmt CO_2-e: All models predict relatively similar allowances prices in 2020 ($55-$115 per ton), but predict different growth rates resulting in a relatively wide range of allowance prices ($230 to $485) in 2050

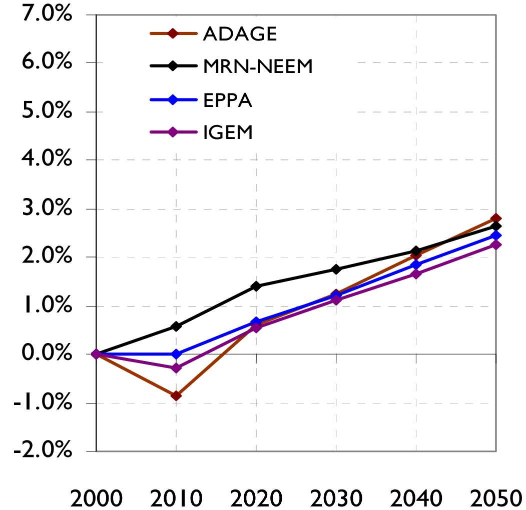
Comparing Costs of Three Possible U.S. Emissions Targets through 2050

Changes in consumption approximate changes in consumer welfare

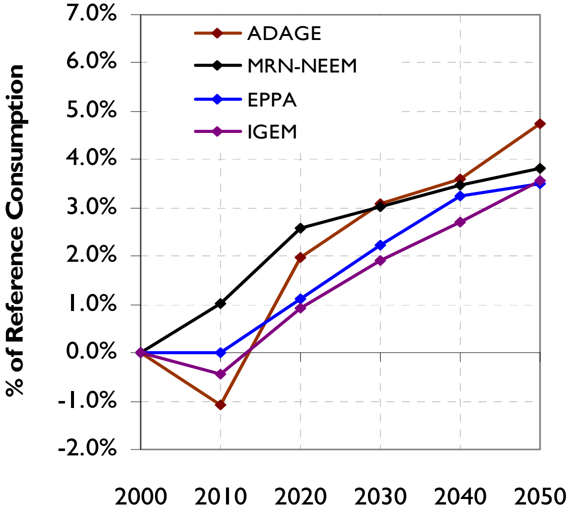
Annual Consumption Losses across Scenarios



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

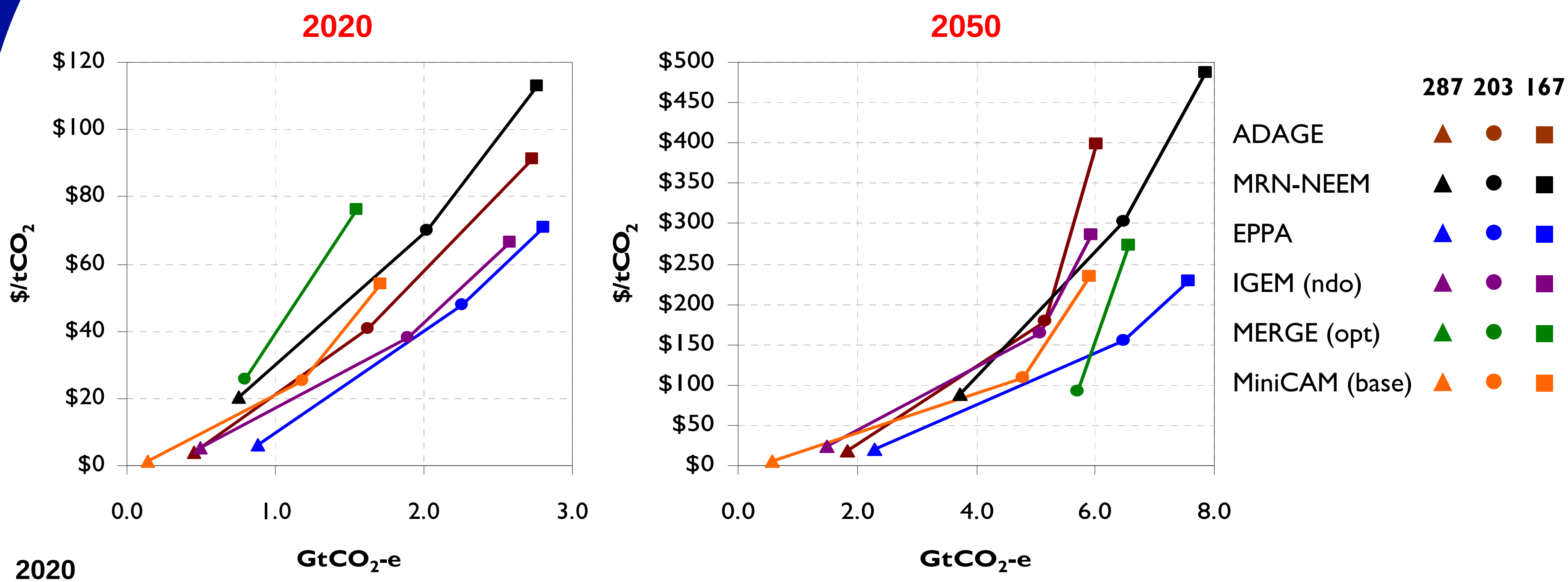
*** AEO 2008 Early release was used by the EPA models for EMF-22. The baseline in EPA's H.R. 2454 analysis is AEO 2009 (March release).**

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).
- 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 revenues are redistributed, 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.
- Freely distributed allowances to firms 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. For instance, lump sum distribution of revenues makes the policy look less regressive than lowering of payroll or corporate taxes.
- 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 the least regressive cap-and-trade policy analyzed and has been shown to be progressive in some cases.
- 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

- As way of illustration, Metcalf (2007) examines the distributional implications of a $15/ton CO_2 tax.
  - This is equivalent to a cap-and-trade policy with full auctioning.
  - This price is roughly equivalent to what is predicted to occur in this EPA analysis under Waxman-Markey in 2015.
- Metcalf's main case redistributes the revenue via an earned income tax credit
  - The tax credit is equal to total (employer and employee) payroll taxes paid in the current year, up to a maximum of $560.
  - This is equivalent to exempting the first $3,660 of wages per covered worker.
- Before the tax credit, the policy is regressive. After accounting for the tax credit, the policy is progressive.
- Metcalf also illustrates how the distributional impacts may change if the revenue is redistributed in others ways.
  - Including social security lowers the maximum tax credit available to $420 and makes the policy more progressive. A per capita lump sum rebate of $274 further increases progressivity relative to an earned income tax credit.

	$15/ton Tax		Earned Income		Earned Income and Social Security		Lump Sum	
Income group (decile)	Net ($)	Net (%)	Net ($)	Net (%)	Net ($)	Net (%)	Net ($)	Net (%)
1 (lowest)	-$276	-3.4	-$68	-0.7	$112	1.4	$166	2.1
2	-$404	-3.1	-$120	-1	$125	1.0	$128	1.0
3	-$485	-2.4	-$57	-0.2	$114	0.6	$120	0.6
4	-$551	-2	$6	0.1	$70	0.3	$103	0.4
5	-$642	-1.8	$26	0.1	$54	0.1	$108	0.3
6	-$691	-1.5	$115	0.3	$66	0.1	$26	0.1
7	-$781	-1.4	$135	0.2	$35	0.1	-$32	-0.1
8	-$883	-1.2	$99	0.2	-$61	-0.1	-$52	-0.1
9	-$965	-1.1	$70	0	-$95	-0.1	-$171	-0.2
10 (highest)	-$1,224	-0.8	-$130	0	-$332	-0.2	-$355	-0.2

* Metcalf uses 2003 Consumer Expenditure Survey data and assumes payroll tax rules from 2005.

Household Distributional Issues

- Recent, but still unpublished, 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. 2007).
  - 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 \$20.87/metric ton CO_2 price is estimated to result in an average welfare gain of 3.6% for the 20% poorest households. However, regionally, this varies from 1.9% to 5.4%.
- Most of these studies 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.
  - The government cannot use the revenue to reduce other distortions in the economy, which would reduce the overall cost of the cap-and-trade policy (Fullerton forthcoming; CBO 2003).

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