EPA Preliminary Analysis of the Waxman-Markey Discussion Draft

The American Clean Energy and Security Act of 2009 in the *111th Congress*

4/20/09

Request for Analysis

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February 27, 2009

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

Dear Administrator Jackson:

One of the top priorities of the Committee on Energy and Commerce is to pass comprehensive climate change legislation. To facilitate this effort, we are requesting technical assistance from the Environmental Protection Agency (EPA). In particular, we request that EPA estimate the economic impacts of our draft legislation as it is developed. EPA's analysis of the draft legislation would prove useful to us and other members of the House as we craft measures to combat global climate change.

We ask that EPA begin this process by meeting with our staff to discuss the parameters, methods, and duration of the analysis. 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 February 27, 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 comprehensive climate legislation being developed by the committee.
- The committee released the Waxman-Markey Discussion Draft of the American Clean Energy and Security Act of 2009 on March 31, 2009.
- This document represents EPA's preliminary analysis of the Waxman-Markey Discussion Draft.

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 Waxman-Markey Discussion Draft (WM-Draft):
  - Establishes an economy wide cap & trade program.
  - Creates incentives and standards for clean energy and energy efficiency.
  - Establishes GHG standards for vehicles, stationary sources, and fuels.

- Due to time limitations, this preliminary analysis does not encompass all of the major provisions of the bill.
  - The analysis focuses on the economy wide cap & trade program.
  - Sensitivity analysis conducted for:
    - WM-Draft Scenario with Energy Efficiency Allowance Allocations
    - WM-Draft Scenario with Output Based Rebates
    - WM-Draft Scenario with No International Offsets
  - Several provisions outside of the cap & trade program, such as the renewable electricity standard, the low carbon fuel standard and the vehicle and engine emission standards, are not modeled in this analysis.
  - See Appendix 1 for a full description of the bill and which provisions are modeled in this analysis.

Major Findings

- The Waxman-Markey Discussion Draft transforms the structure of energy production and consumption, moving the U.S. to a clean energy economy.
  - 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 the middle of the century 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 46% 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 6% in 2020, 9% in 2030, and 13% in 2050.
  - Electric power supply and use represents the largest source of emissions abatement.

- Allowance prices are less than previous EPA analyses of Senate cap and trade bills, ranging from $13 to $17 per metric ton CO_2 equivalents (tCO_2e) in 2015 and from $17 to $22/$tCO_2e$ in 2020 in the core scenario.
  - This is partially driven by updating to the AEO 2009 baseline, which includes a lower rate of annual GDP growth relative to AEO 2006 (2.5 v. 3.0%) and the 2007 Energy Independence and Security Act (EISA).
  - Across all scenarios modeled, the allowance price ranges from $13 to $26 per ton CO_2 equivalents (tCO2e) in 2015 and from $17 to $33 / tCO_2e in 2020.

- Offsets have a strong impact on cost containment.
  - The capped sector uses all of international offsets allowed in all years of the policy (1.25 billion tCO_2e offsetting 1 billion tCO_2e of capped sector emissions annually).
  - The 1 billion tCO_2e annual limit on domestic offsets is never reached due to limited mitigation potential.
  - Without international offsets, the allowance price would increase 96 percent.

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 household.
  - Household consumption is reduced by 0.02-0.11% in 2015 and 0.17-0.19% in 2020 and 0.37-0.39% in 2030, relative to the no policy case.
  - Household consumption under the WM Draft scenario still increases by 9-10% percent between 2010 and 2015 and 18-19% between 2010 and 2020.
  - In comparison to the baseline, the 5 and 10 year consumption growth under the policy is only 0.1 and 0.2 percentage points lower for 2015 and 2020, respectively.
  - A policy that failed to return revenues from the program to consumers would lead to substantially larger losses in consumption.

- For the duration of the policy, average annual household consumption is estimated to decline in a range of $98 to $140 dollars per year* relative to reference scenario.
  - 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 emissions allowances returned lump sum to households which offsets much of the cap & trade program's effect on household 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

Contents

Major Changes for this Analysis, Bill Summary & Analytical Scenarios

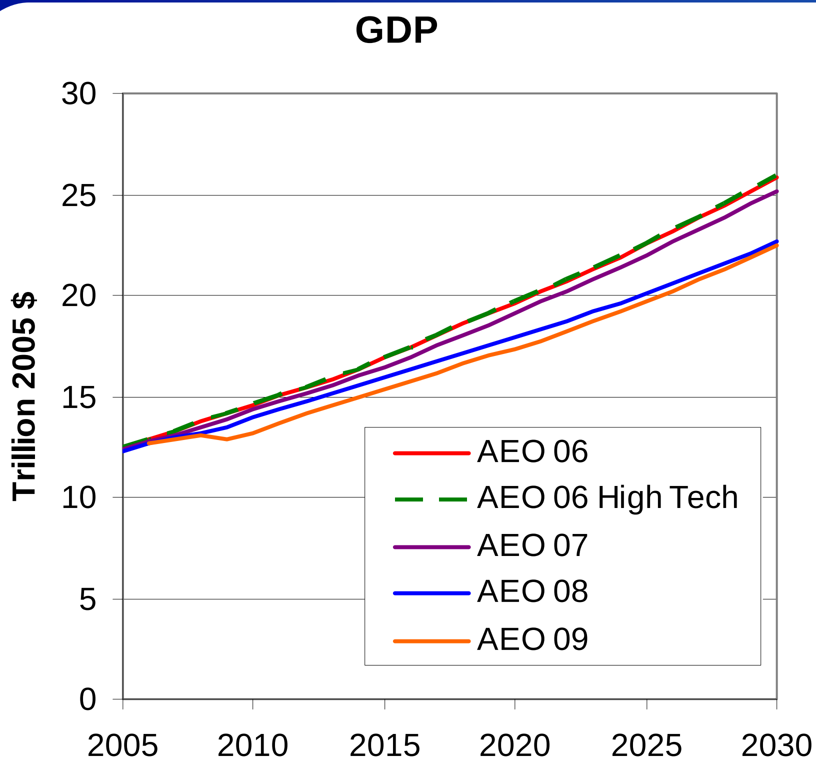
Major Changes for this Analysis

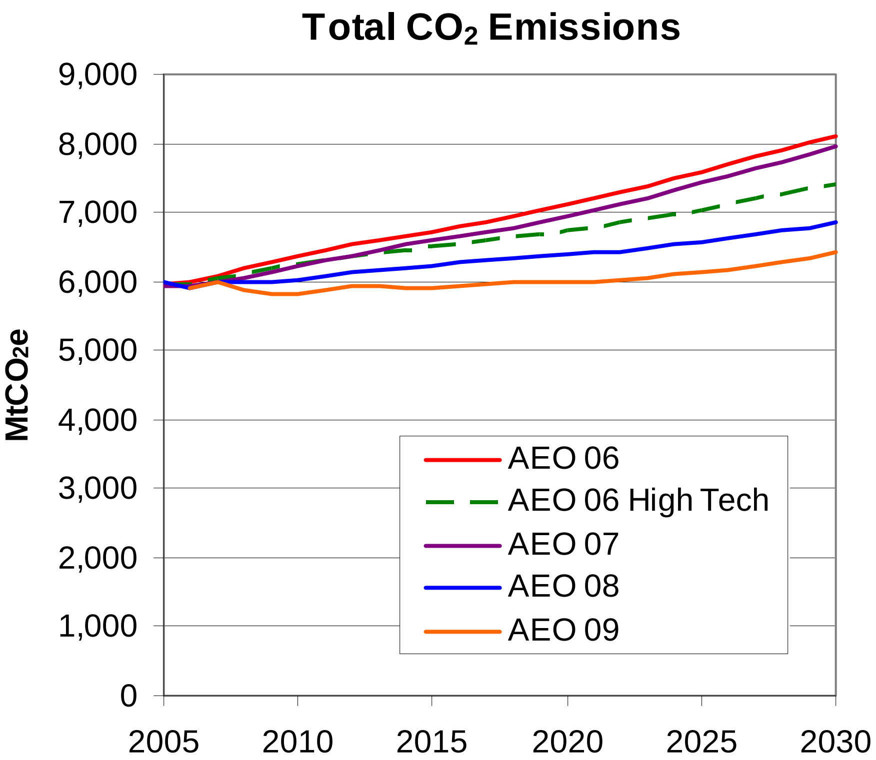
- Several changes have been made in this analysis compared to EPA's previous analyses of Senate cap and trade bills (S. 2191, S. 1766, and S. 280).

- Updated reference scenario (Annual Energy Outlook (AEO) 2009 which includes the Energy Independence and Security Act (EISA) provisions)
  - This has the largest impact on results. The inclusion of EISA as well as actions of the states, such as renewable electricity standards in AEO 2009, as well as a lower GDP growth rate in AEO 2009 compared to the old AEO 2006 reference case used in the previous analysis leads to considerably lower emissions in baseline. Lower reference case emissions lead to lower allowance prices as less abatement is required.
- ADAGE model updates
  - Model updates include a new less flexible putty-clay approach to capital movements, and higher capital costs for new electricity generation capacity based on AEO 2009. Both of these changes tend to increase allowance costs.
- IGEM model updates
  - IGEM now includes a representation of CCS abatement potential, which will tend to lower allowance prices. The baseline calibration procedure for IGEM now also results in GHG emissions that are closer to ADAGE. Since IGEM GHG emissions were higher than ADAGE GHG emissions in the old reference case, the updated reference case has a bigger impact on allowance prices in IGEM than in ADAGE.
- IPM model updates
  - Model updates include an enhanced approach for modeling natural gas supply; updated capital costs; representation of state RPS and climate programs; CCS retrofits; and updated constraints on new renewable, nuclear, and coal with CCS capacity.
- New FASOM marginal abatement cost curves (MACs)
  - The updated FASOM MACs tend to show mixed potential for agriculture and forestry offsets compared to the old FASOM MACs depending on the year and practice.

Updated Reference Scenario

Comparison of AEO 2006, 2007, 2008, and 2009





- AEO 2009 indicates lower near term GDP, but a faster GDP growth rate; and lower total GHG emissions than AEO 2008.
- The average annual GDP growth rate varies by 60 basis points across these scenarios (a high of 3.0% in AEO 2006 and a low of 2.4% in AEO 2008).
- In 2010, the difference between the AEO 2006 and AEO 2009 GDP forecasts compared above is $1.4 trillion, in 2020 the difference is $2.3 trillion, and in 2030 the difference is $3.4 trillion.
- The difference in CO_2 emissions across forecasts is even larger, showing that significant down payments on our energy and climate objectives have been made through EISA as well as actions of the states, such as renewable electricity standards.

Waxman-Markey Discussion Draft

Bill Summary

- Title III of the Waxman-Markey Discussion Draft (WM-Draft) establishes a cap & trade system for greenhouse gas emissions.
  - The cap gradually reduces covered greenhouse gas emissions to 20 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.
  - Offsets are limited to 2,000 million metric tons CO_2 equivalent ($MtCO_2e$) per year split evenly between domestic and international.
  - Offsets discounting requires entities using offsets to submit 1.25 tons of offsets credits for each ton of emissions being offset.
  - Supplemental emissions reductions from reduced deforestation through allowance set-asides.
- Titles I & II of WM-Draft deal with clean energy and energy efficiency, and among other things establish a renewable electricity standard, a low carbon fuel standard, and energy efficiency programs and standards for buildings, lighting, appliances, and vehicles and engines.
  - Titles I & II are not explicitly modeled within the cap & trade 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, additional assumptions provided by House Energy and Commerce Committee staff, and which provisions are modeled here.

Analytical Scenarios*

EPA analyzed 5 different scenarios in this preliminary report. A full report will include a larger list of scenarios to evaluate a range of assumptions and key parameters. 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 revised AEO 2009 forcast and includes EISA.
     - Does not include any additional domestic or international climate policies or measures to reduce international GHG emissions
     - For domestic projections, benchmarked to AEO 2009
     - For international projections, used CCSP Synthesis and Assessment Report 2.1 A MiniCAM Reference.
2) **WM-Draft Scenario**
   - This core policy scenario models the cap-and-trade program established in Title III of the Waxman-Markey Discussion Draft.
     - The strategic allowance reserve is not modeled (i.e., these allowances are assumed to be available for use and not held in reserve).
   - This scenario does not include provisions from Titles I, II, or IV.
   - Additional assumptions provided by committee staff on the use of allowances in this scenario are as follows:
     - CCS Bonus Allowances: 2% 2012-2016; 5% 2017-2050
     - International Forest Carbon: 5% through 2025, 3% through 2030, 2% through 2050.
     - The necessary allowances for the policy to be deficit neutral.
     - All remaining allowances are returned to households in a lump sum fashion.
   - 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) **WM-Draft Scenario with Energy Efficiency Allowance Allocations**
4) **WM-Draft Scenario with Output-Based Rebates**
5) **WM-Draft Scenario with No International Offsets**

*** 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.**

Key Uncertainties

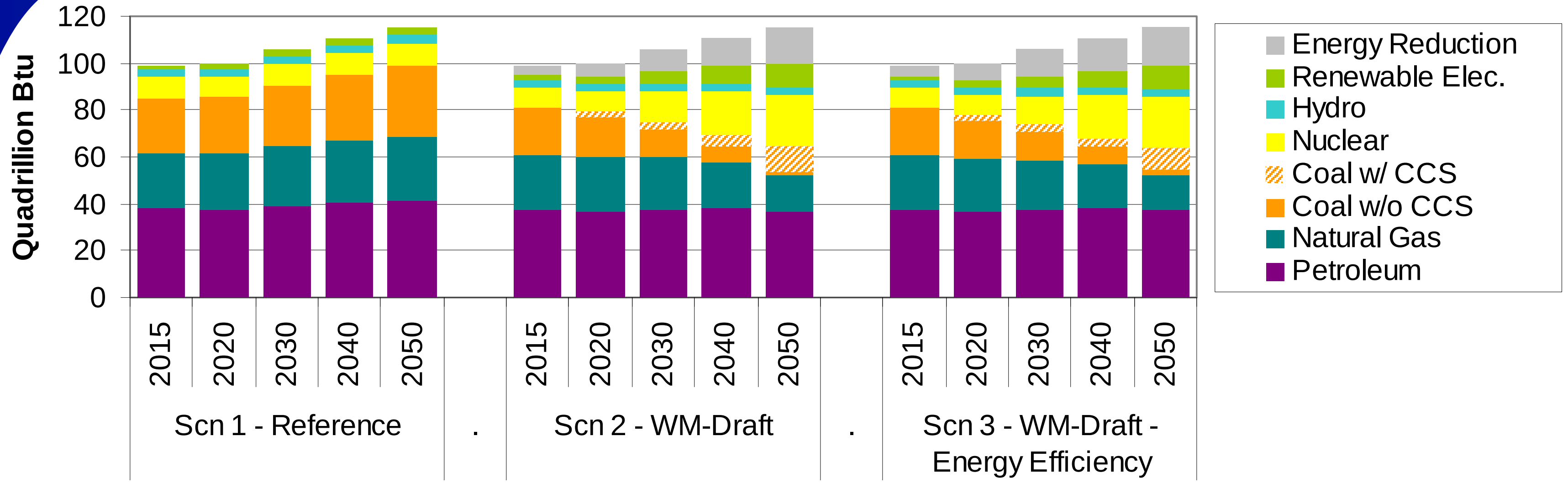
- There are many uncertainties that affect the economic impacts of WM-Draft.
- This analysis contains a set of scenarios that cover some of the important uncertainties.*
  - The extent and stringency of international actions to reduce GHG emissions by developed and developing countries.
  - The availability of foreign credits and international offset projects.
  - The amount of GHG emissions reductions achieved by the energy efficiency provisions of WM-Draft.
- Additional uncertainties include but are not limited to:
  - The degree to which new nuclear power is technically, politically, and socially feasible.
  - The availability and cost of domestic offset projects.
  - Whether or not carbon capture and storage technology will be available at a cost that allows for its employment of on a large scale.
  - 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 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 preliminary analysis does not contain a full set of scenarios that would cover some of the additional uncertainties described above.

Economy Wide Impacts:
GHG Emissions & Economic Costs

Primary Energy

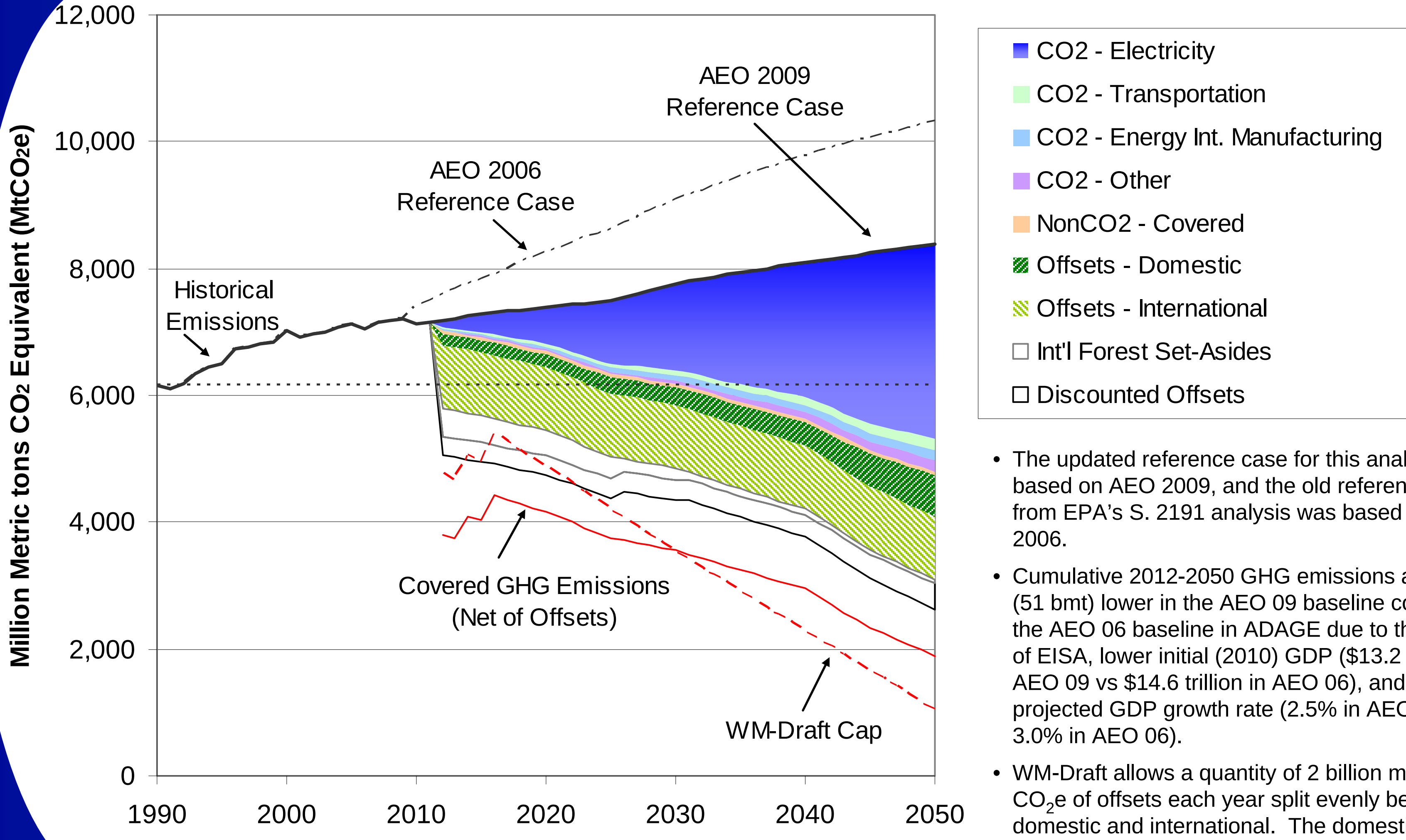
WM-Draft Scenario Comparison (ADAGE)



- 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 quadrillion Btu in 2015 and 94 quadrillion Btu in 2020, before rebounding back to 2015 reference levels by 2040.
  - In scenario 3 with additional energy efficiency measures, primary energy use falls to 95 quadrillion Btu in 2015 and to 93 quadrillion Btu in 2020, and slowly rebounds to 2015 reference levels by 2050.
- In the reference case low- or zero- carbon energy makes up a steady 14% of total primary energy.
  - In scenario 2, low- or zero- carbon energy (including nuclear, renewables, and CCS plus increased energy efficiency and energy reductions makes up 23% of primary energy by 2020, 32% by 2030, and 53% by 2050.
  - In scenario 3 with additional energy efficiency measures, low- or zero- carbon energy (including nuclear, renewables, and CCS plus increased energy efficiency and energy reductions makes up 24% of primary energy by 2020, 34% by 2030, and 53% by 2050.
  - See Appendix 3 for a discussion of the limitations and caveats associated with the methodology used in scenario 3.

Total US GHG Emissions & Sources of Abatement

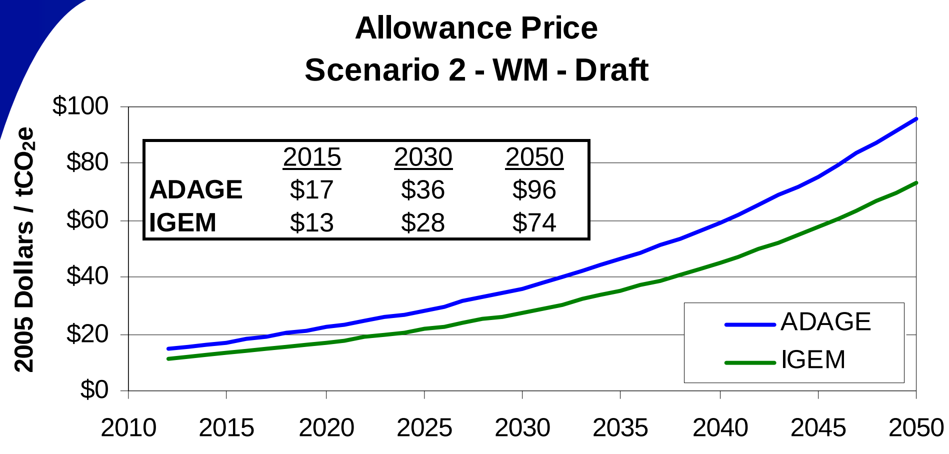
Scenario 1 - Reference & Scenario 2 – WM-Draft (ADAGE)

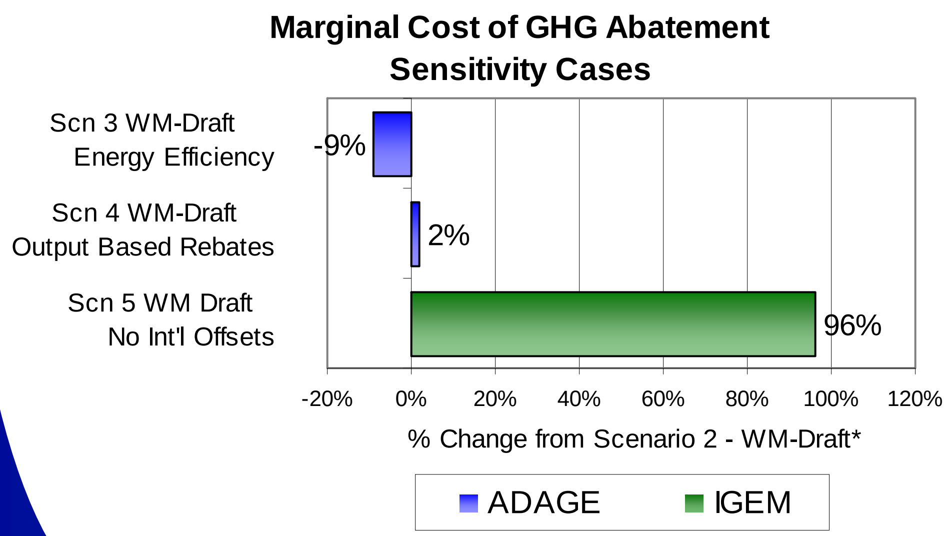


- The updated reference case for this analysis is based on AEO 2009, and the old reference case from EPA's S. 2191 analysis was based on AEO 2006.
- Cumulative 2012-2050 GHG emissions are 14% (51 bmt) lower in the AEO 09 baseline compared to the AEO 06 baseline in ADAGE due to the inclusion of EISA, 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).
- WM-Draft allows a quantity of 2 billion metric tons CO_2e of offsets each year split evenly between domestic and international. The domestic limit is non-binding in this analysis.

GHG Allowance Prices & Sensitivities

WM-Draft Scenario Comparison



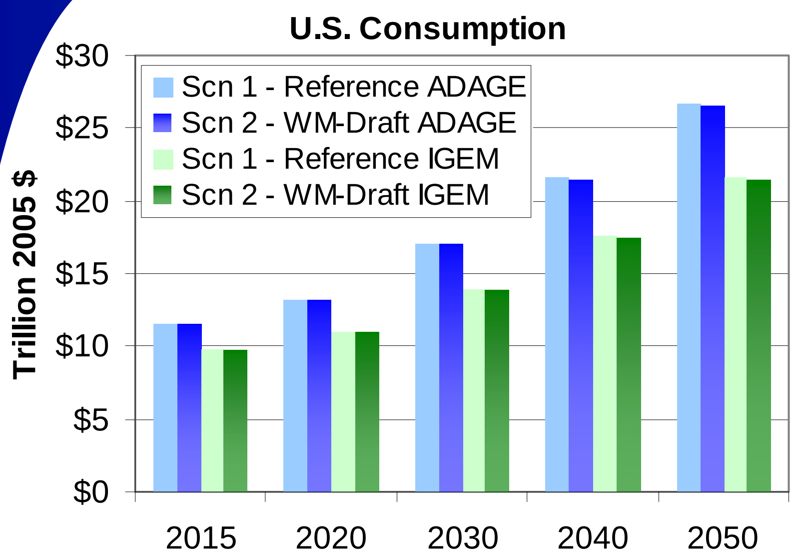


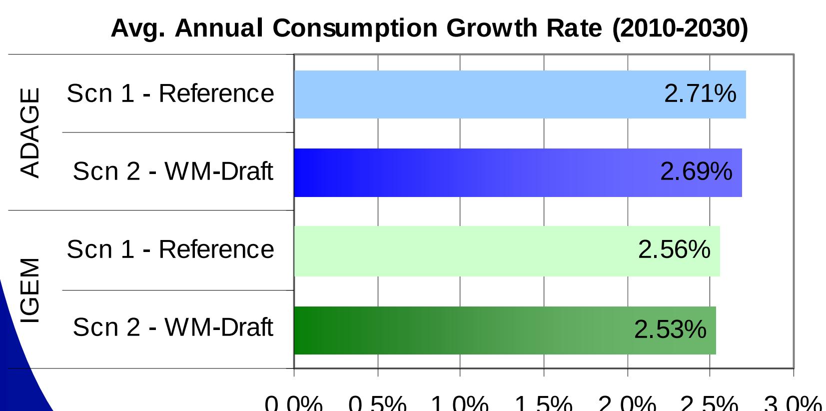
* Note that these percentage changes apply in all years.

- The marginal cost of GHG abatement is equal to the allowance price.
- Range of 2030 allowance price in *"scenario 2 – WM-Draft"* across models is: $28 - $36. This range only reflects differences in the models and does not reflect other scenarios or additional uncertainties discussed elsewhere.
- Range of 2030 allowance prices across all scenarios is: $28 - $54.
- The EE scenario results in lower allowance prices because of significant projected energy demand reductions. See Appendix 3 for a discussion of the limitations and caveats associated with the methodology used in this scenario.
- The availability of offsets under WM-Draft significantly influences the allowance price.
- While limited technology runs are not included in this analysis, previous EPA analyses have shown that the availability of nuclear and carbon capture and sequestration (CCS) technologies have a significant impact on allowance prices.
- In EPA's S. 2191 analysis, restricting nuclear and biomass electricity to reference case levels increased allowance prices by ~30% and additionally not allowing CCS until after 2030 increased allowance prices by ~80%.

Consumption

Scenario 1 – Reference & Scenario 2 – WM-Draft





ADAGE	2015	2020	2030	2040	2050
Ref. Consumption per Household	$92,202	$99,888	$117,973	$140,233	$164,348
% Change (Scn. 2)	-0.11%	-0.19%	-0.37%	-0.67%	-0.78%
Consumption Loss per Household	-$100	-$192	-$441	-$936	-$1,288
NPV Cost per HH ($)	-$75	-$112	-$158	-$206	-$174

Average Annual NPV cost per Household **-$140**

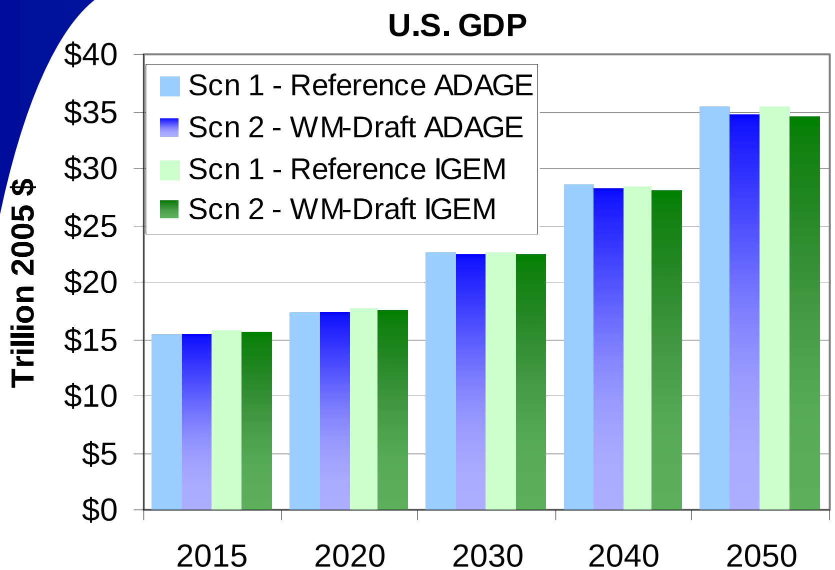
IGEM	2015	2020	2030	2040	2050
Ref. Consumption per Household	$77,310	$83,367	$96,443	$113,760	$132,956
% Change (Scn. 2)	-0.02%	-0.17%	-0.39%	-0.62%	-0.85%
Consumption Loss per Household	-$19	-$137	-$358	-$647	-$1,018
NPV Cost per HH	-$14	-$80	-$128	-$143	-$138

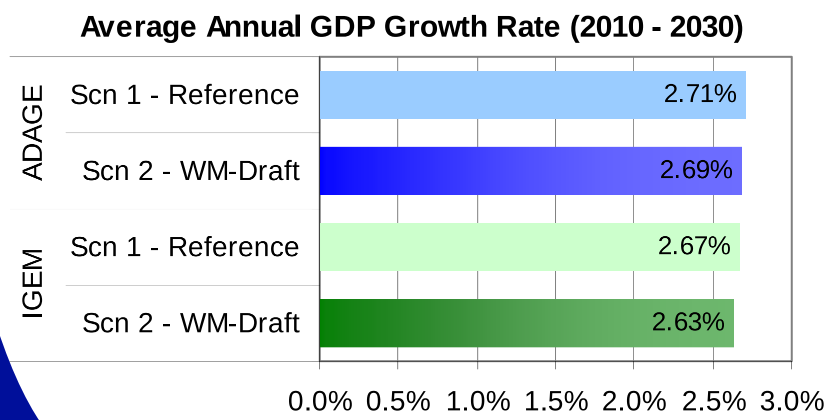
Average Annual NPV cost per Household **-$98**

- 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 – WM-Draft*."
- 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 $98 - $140 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.

GDP

Scenario 1 – Reference & Scenario 2 – WM-Draft





ADAGE

	2015	2020	2030	2040	2050
Reference	$15.4	$17.4	$22.6	$28.6	$35.4
Scn 2 - WM-Draft	$15.4	$17.4	$22.5	$28.3	$34.8
Absolute Change	-$0.041	-$0.045	-$0.112	-$0.268	-$0.567
% Change	-0.27%	-0.26%	-0.50%	-0.94%	-1.60%

IGEM

	2015	2020	2030	2040	2050
Reference	$15.7	$17.7	$22.7	$28.5	$35.4
Scn 2 - WM-Draft	$15.6	$17.5	$22.4	$28.0	$34.6
Absolute Change	-$0.095	-$0.132	-$0.268	-$0.466	-$0.790
% Change	-0.60%	-0.75%	-1.18%	-1.64%	-2.23%

- Other ways to frame these GDP reductions are as follows:
  - In the reference case, GDP in ADAGE is $22.6 trillion in 2030. In "*scenario 2 – WM-Draft*" GDP reaches $22.6 trillion approximately three months later than in the reference case.
  - In IGEM the reference case GDP is $22.7 trillion in 2030. In "*scenario 2 – WM-Draft*" GDP reaches $22.7 trillion six months later than in the reference case.
  - Under "*scenario 2 - WM-Draft*", average annual GDP growth between 2010 and 2030 is approximately 2 basis points lower in ADAGE and 4 basis points lower in IGEM than in the reference scenario.
- Compared to EPA's S. 2191 analysis, GDP impacts in ADAGE and IGEM are much closer due to a calibration procedure giving more consistent reference case GDP and GHG projections.

Total Abatement Cost

Scenario 2 – WM-Draft

Table: Total Abatement Cost Calculations
Scenario 2 - WM-Draft

	2015	2020	2030	2040	2050
Total Allowance Value (Billion 2005 Dollars)					
ADAGE	$85	$108	$128	$135	$99
IGEM	$66	$83	$98	$103	$76
Domestic Covered Abatement (MtCO2e)					
ADAGE	408	744	1,629	2,520	3,631
IGEM	761	1,068	1,598	2,168	3,210
Domestic Offset Abatement (MtCO2e before discounting)					
ADAGE	237	252	355	468	817
IGEM	144	147	261	332	584
International Offsets & Set-Asides (MtCO2e before discounting)					
ADAGE	1,677	1,640	1,433	1,338	1,305
IGEM	1,580	1,548	1,390	1,318	1,292
Allowance Price ($/tCO2e)					
ADAGE	$17	$22	$36	$59	$96
IGEM	$13	$17	$28	$45	$74
Offset Price ($/tCO2e before discounting)					
ADAGE	$14	$18	$29	$47	$77
IGEM	$11	$14	$22	$36	$59
International Offset/Credit Price ($/tCO2e before discounting)					
ADAGE	$10	$13	$21	$34	$55
IGEM	$10	$13	$21	$34	$55
Domestic Covered Abatement Cost (Billion 2005 Dollars)					
ADAGE	$4	$8	$29	$74	$174
IGEM	$5	$9	$22	$49	$118
Domestic Offset Abatement Cost (Billion 2005 Dollars)					
ADAGE	$2	$2	$5	$11	$31
IGEM	$1	$1	$3	$6	$17
International Credit Payments (Billion 2005 Dollars)					
ADAGE	$17	$21	$30	$45	$71
IGEM	$16	$20	$29	$44	$71
Total Abatement Cost (Billion 2005 Dollars)					
ADAGE	$22	$31	$64	$130	$277
IGEM	$22	$30	$54	$99	$206

- 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 before discounting is equal to 80% of 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 credits 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.

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 Waxman-Markey on the electricity sector.

Power Sector Modeling (EPA Base Case 2009 using IPM):

- This version of IPM builds on the version used previously to analyze 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 Energy Information Administration's Annual Energy Outlook 2009.

Modeling Approach:

- For this analysis, EPA's Base Case 2009 using IPM 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.

Key Model Updates and Major Power Sector Provisions Modeled in IPM

Updates to EPA's Base Case 2009 using IPM:

- **Electricity Demand Growth:** Calibrated to AEO 2009.
- **Cost of New Power Technologies:** Consistent with AEO 2009 and includes added costs for GHG-intensive projects.
- **Cost of Carbon:** An increase to the capital charge rate for new coal plants (consistent with AEO 2009).
- **Natural Gas:** Updated supply projection from ICF.
- **State RPS and Climate Programs:** Calibrated to AEO 2009 with finalized regulations like RGGI.
- **CCS Retrofit Option for Existing Coal Fleet:** New option for existing coal-fired units.
- **Limits for New Power:** Limits on new renewables, nuclear, and coal with CCS have been updated.

Major Bill Provisions:

CCS Demonstration and Early Deployment (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 5-7 projects (3 GW) are established by 2015. These projects are "hard-wired" into IPM and are not chosen based upon economics. CCS projects built after 2015 are chosen by the model based upon economics.

CCS Bonus: Designed to provide additional economic incentive for coal with CCS through allocation of "bonus" allowances and based upon the provision found in the Dingell-Boucher Discussion Draft of 2008, as directed by Committee staff.

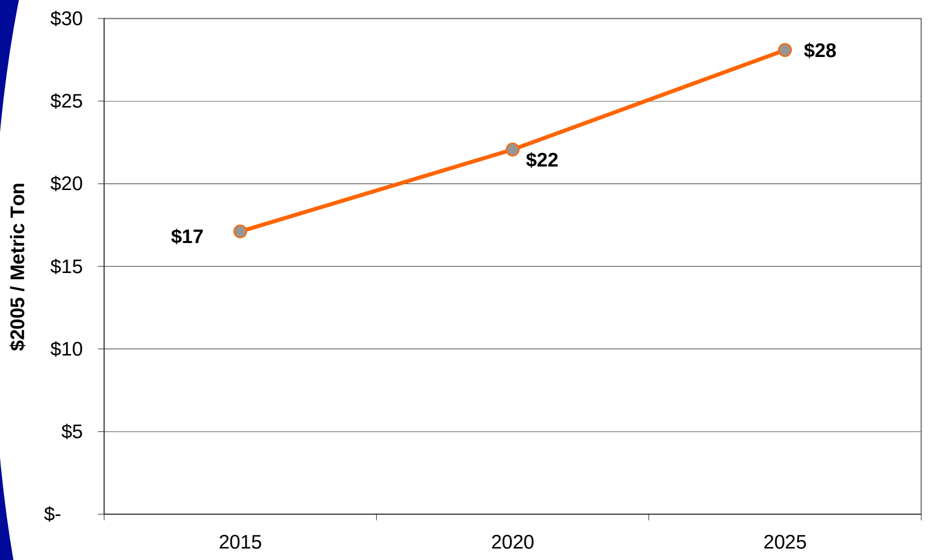
- The incentive is designed as a fixed monetary value for every ton of CO_2 sequestered, rather than a certain number of allowances. The value is specified as $90/ton for the first 3 GW, $70/ton for the next 3 GW, and $50/ton thereafter (up until a maximum of 60 GW of coal with CCS has been incentivized). A stream of specified bonus allowances are made into "current" allowances and made available to qualifying projects.
- IPM implementation: Similar to past IPM applications, CCS projects essentially receive a subsidy equal to the bonus amount. The allowances are distributed on a first-come, first-serve basis and can be carried forward if they go unused.

EPA has not modeled the Energy Efficiency Resource Standard (EERS), the Renewable Energy Standard (RES), or any specific allocation methodology (since none is specified) contained in the proposal.

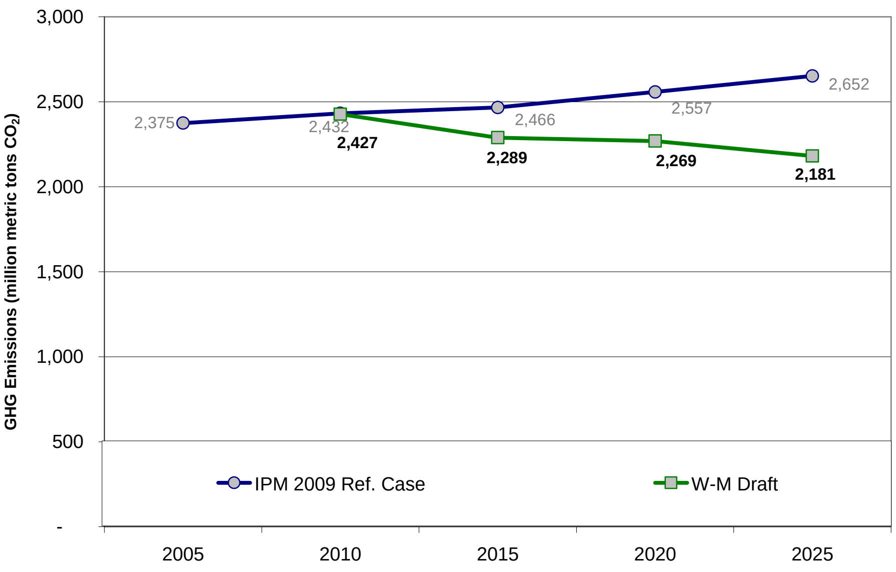
Note: See Appendix for more detail on updates to IPM. For more detail on the all of the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html.

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

GHG Allowance Price (inputs to IPM)*

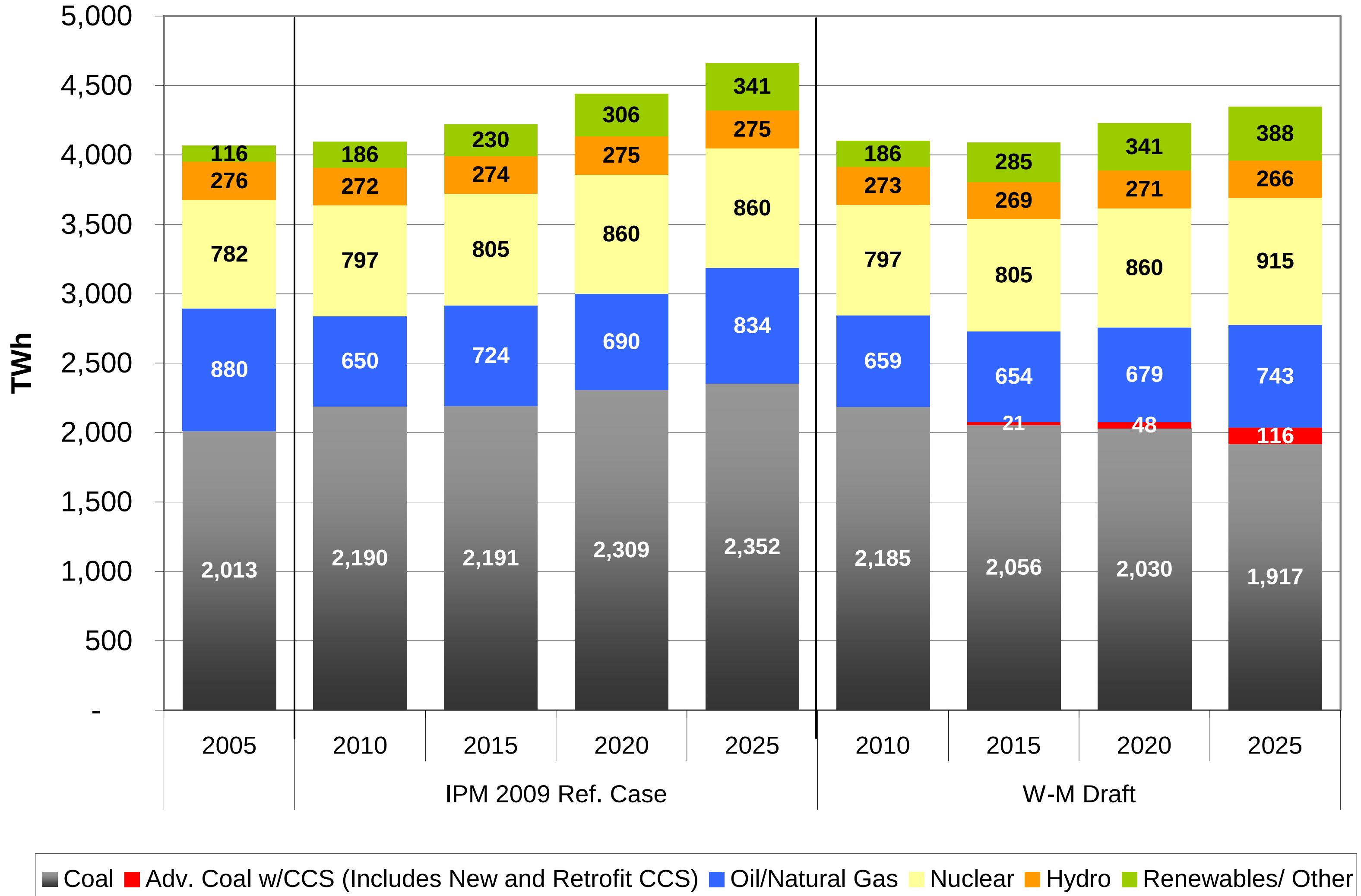


Power Sector CO_2 Emissions

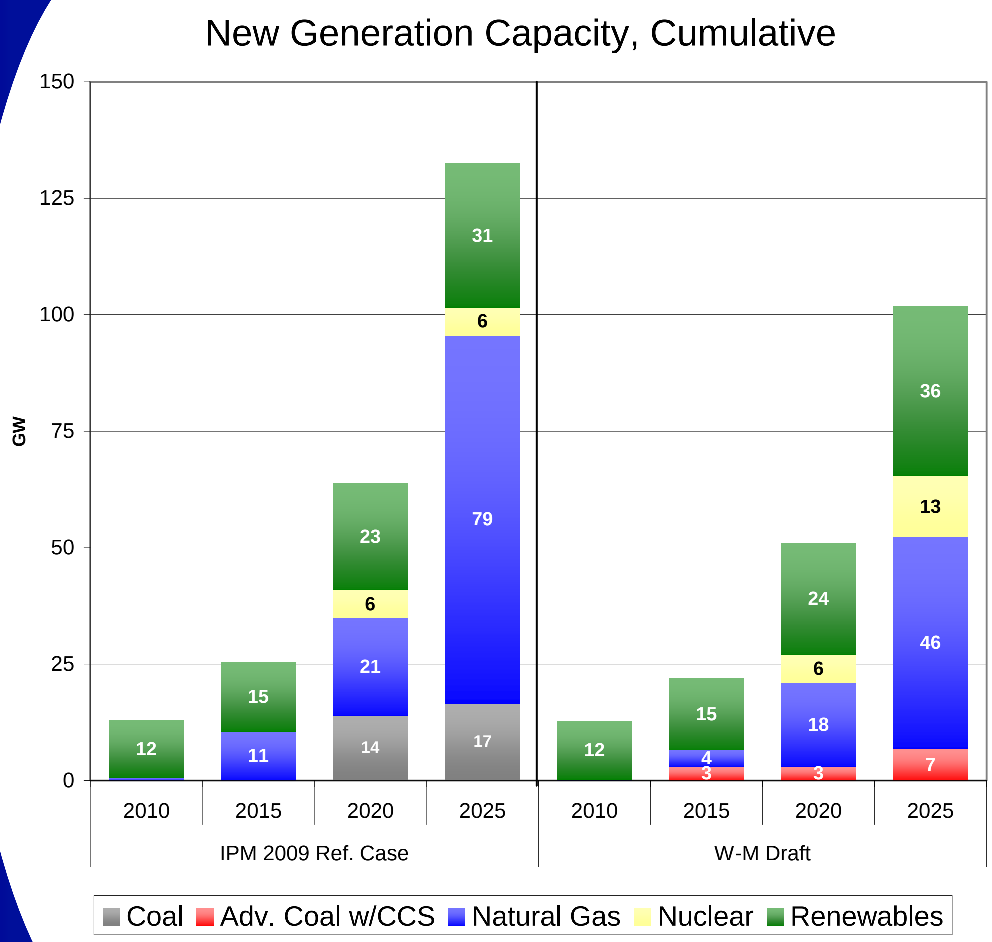


* Allowance prices are taken from ADAGE.

Electricity Generation Mix (IPM)



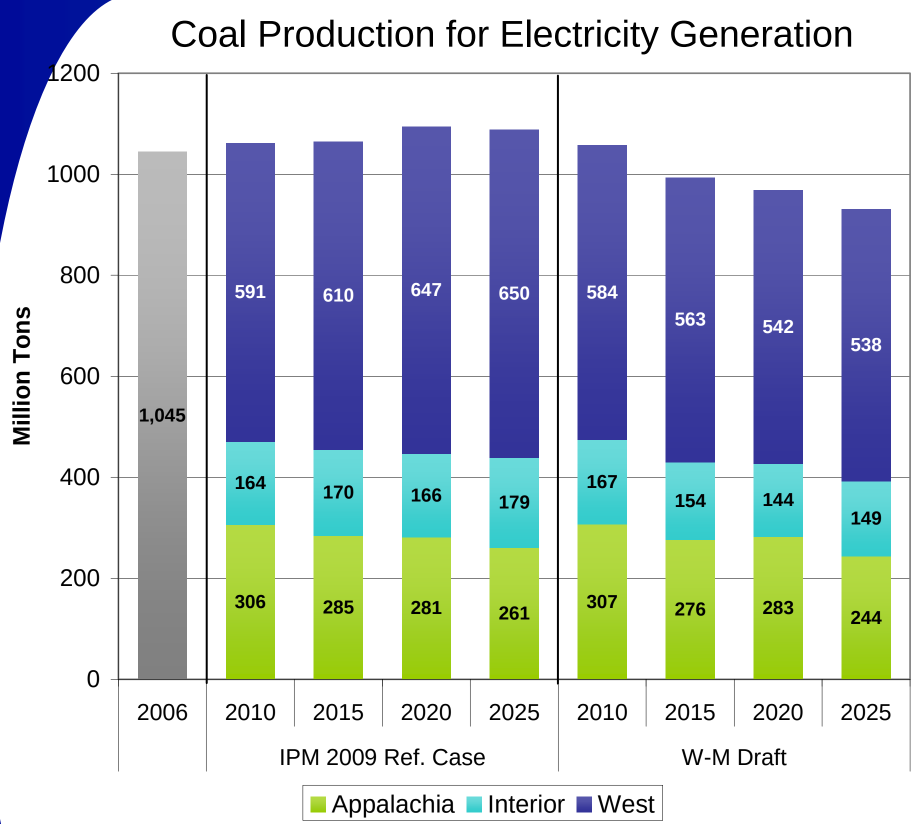
New Generation Capacity (IPM)

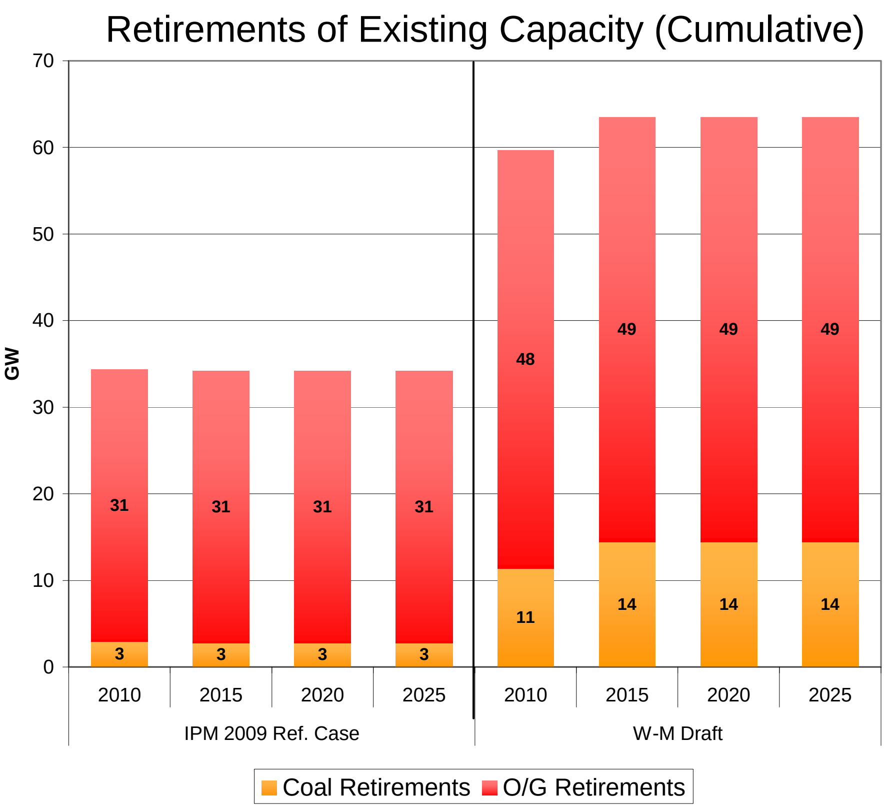


Note: New capacity additions less that 1 GW of capacity are not indicated.
* See appendix for more detail on EPA's technology penetration limits applied in IPM.

- Lower electricity demand, along with lower allowance prices and higher costs for new technologies, results in fewer new power plants needing to be built.
- Waxman-Markey contains a bonus allowance provision for CO_2 emissions that are captured and sequestered, but the bonus does not result in significant penetration of *new* coal capacity with CCS technology
  - 3 GW if new coal with CCS is forced in IPM in 2015 to reflect the early deployment provisions of the Bill. An additional 4 GW of new coal with CCS is built by 2025 due to the CCS bonus.
  - CCS retrofits to the *existing* coal fleet are economic, facilitated by the bonus (retrofits to existing facilities are not reflected in the graphic).
    - There are roughly 4 GW in 2020 and 9 GW (cumulative) in 2025 of post-retrofit capacity. The *retrofit capacity limitations* are reached in IPM.
- The technology penetration limits placed on *new capacity* are not reached in this analysis.*

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





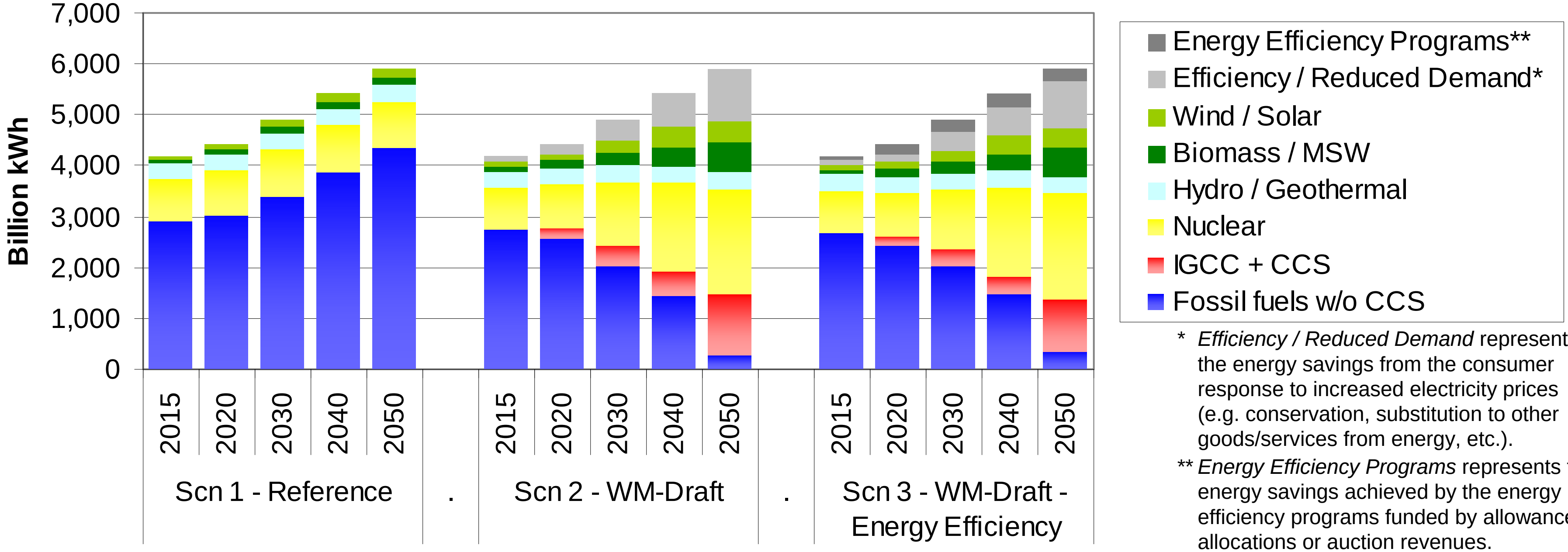
- There are fewer coal retirements under Waxman-Markey than in past IPM modeling because of lower allowance prices and higher costs to build new technology, making existing coal more cost competitive than before.
- In reality, uneconomic units may be "mothballed," retired, or kept running to ensure generation reliability. The model is unable to distinguish among these potential outcomes.
- Most 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.

Energy Sector Modeling Results from Economy-Wide Modeling

U.S. Electricity Generation

WM-Draft 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.

- 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 1,982 bill. kWh in 2050).
- Renewable electricity (including incremental hydro) is responsible in the reference scenario for 3% of generation in 2010, 4% in 2020, and 5% in 2030. In "*scenario 2 – WM-Draft*" the renewable generation share increases to 7% in 2020 and 12% in 2030, and in "*scenario 3 – WM-Draft EE*" the renewable generation shares are 8% in 2020 and 11% in 2030.
- CCS deployment on fossil-fuel generation begins in 2020. By 2030 in "*scenario 2 – WM-Draft*", 55 GW of new CCS capacity is projected to be built, which is the equivalent of 100 CCS units of 550 MW each. By 2050, 162 GW of new CCS capacity is projected to be built, which is the equivalent of 295 CCS units 550 MW each. Through 2025, ADAGE projects a greater amount of CCS generation than IPM (418 billion kWh in ADAGE vs. 116 billion kWh in IPM in 2025).
- Without a subsidy for CCS, the technology would not deploy until 2040, and allowance prices would be 13% higher (see Appendix 5).
- By 2050, over 80 percent of fossil electricity generation is capturing and storing CO_2 emissions.
- See the following slide for a discussion of "*scenario 3 – WM-Draft EE"*, including limitations of the methodology used for this scenario.

Scenario 3 – WM-Draft Energy Efficiency
Discussion

Calculated demand impacts

- The energy efficiency programs are estimated to reduce electricity demand from reference case values by 4% in 2020, 5% in 2030, and 4% in 2050.
- The energy efficiency programs are estimated to reduce natural gas demand from reference case values by 3% in 2020, 7% in 2030, and 6% in 2050.

Modeled economic impacts

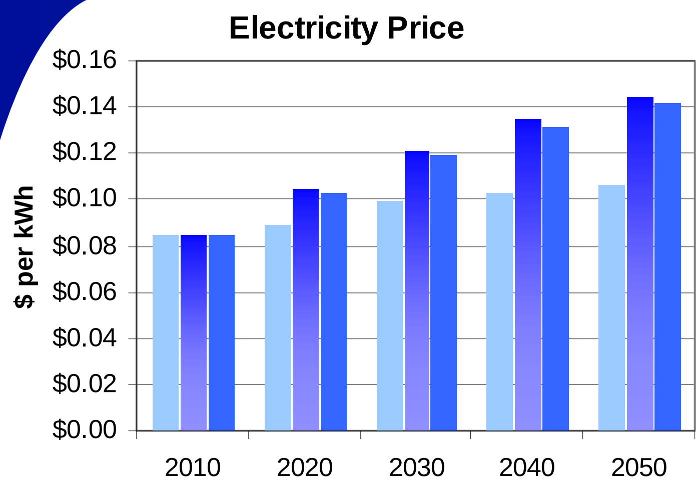
- This section compares results from energy efficiency scenario (#3) with base policy scenario (#2)
- Significantly lower forecasted allowance prices
  - ~10% lower allowance prices estimated each year for 2015-2050
- Reductions in non-electricity energy prices each year for 2015-2050
  - Coal (5% in 2030, 7% in 2050)
  - Natural gas (3% in 2030, 3% in 2050)
  - Petroleum (1% in 2030, 2% in 2050)
- ~ 2% reductions in electricity prices from 2025-2045 and ~1% before and after that period
- Economy-wide energy intensity in 2050 is reduced from 2.88 1000 BTU per $ GDP (Scn. 2) to 2.83 1000 BTU per $ GDP (2% reduction)
- Demand savings has largest impact on electricity generation from IGCC + CCS, decreasing IGCC + CCS by 15% in 2050

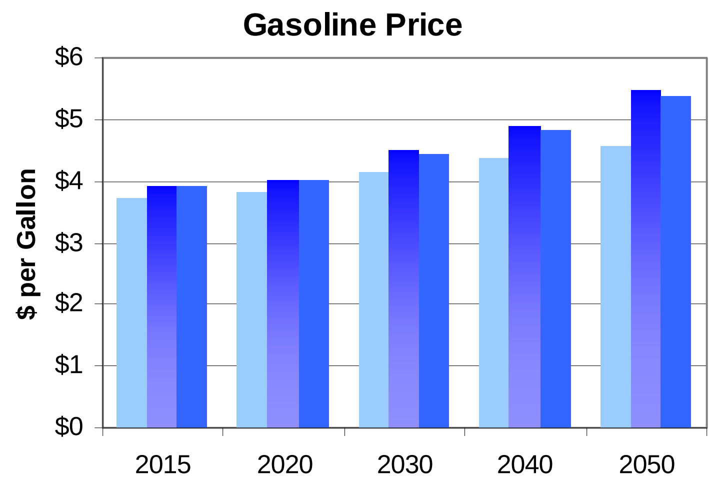
Caveats

- A significant electricity 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 electricity demand reduction from the energy efficiency subsidy (assumed allowance allocation) 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.
- The ADAGE model does not represent the capital cost associated with the electricity demand reduction from the energy efficiency subsidy (assumed allowance allocation), and the cost of reduced energy consumption from energy efficiency programs is not endogenous to the model.

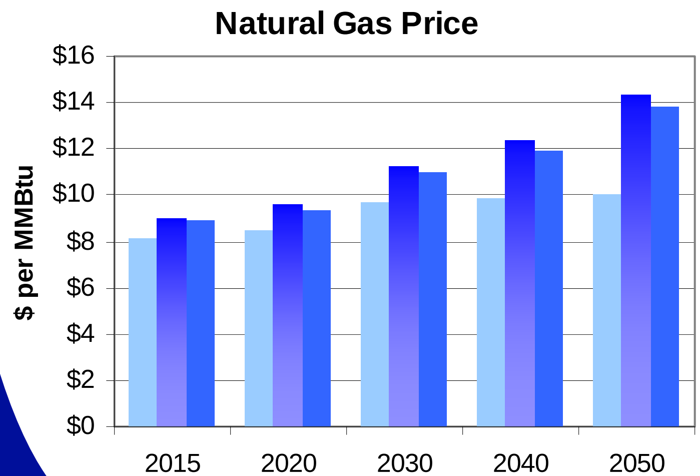
Energy Prices

WM-Draft Scenario Comparison (ADAGE)





- The gasoline price is obtained by multiplying the petroleum price index in ADAGE by the 2010 price of gasoline from the AEO 2009 projection.

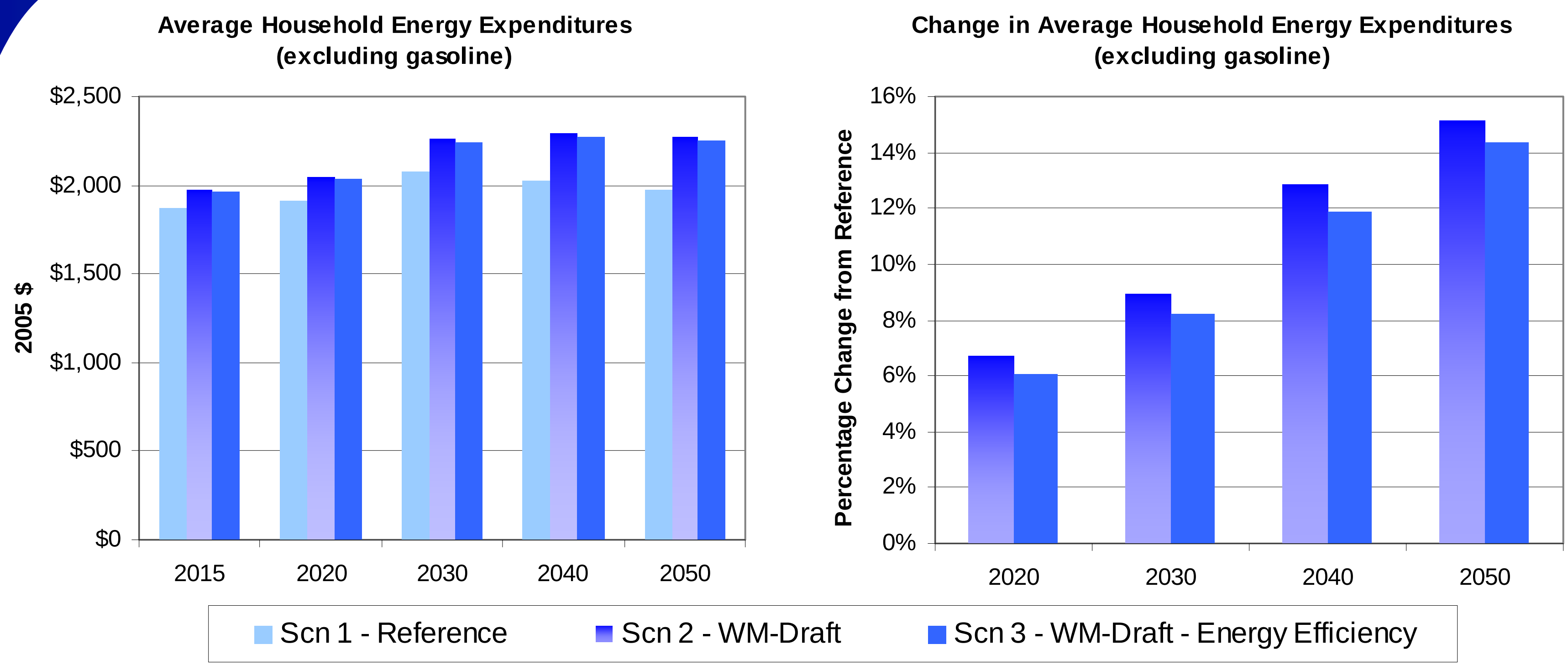


- Scn 1 - Reference
- Scn 2 - WM-Draft
- Scn 3 - WM-Draft - Energy Efficiency

- See Appendix 3 for a discussion of the limitations and caveats associated with the methodology used in *Scenario 3 – WM-Draft Energy Efficiency*.

Household Energy Expenditures

WM-Draft Scenario Comparison (ADAGE)

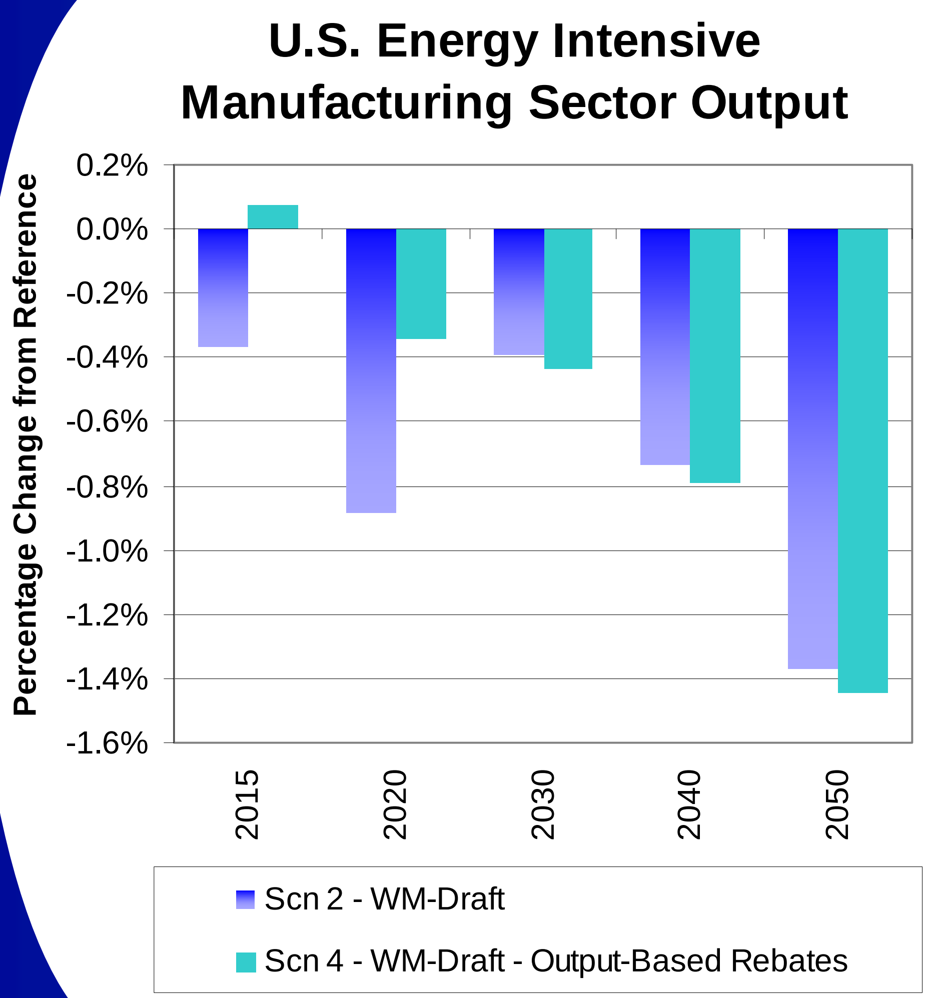


- In 2030 electricity prices increase by 22% in "*scenario 2 – WM-Draft*" and natural gas prices increase by 17%. In "*scenario 3 – WM-Draft Energy Efficiency*" electricity prices increase by 20% and natural gas prices (including allowance costs) increase by 13%.
- Actual household energy expenditures increase by a lesser amount due to reduced demand for energy. In 2030 the average household's energy expenditures (excluding motor gasoline) increase by 9% in *scenario 2 – WM-Draft*" and by 8% in "*scenario 3 – WM-Draft Energy Efficiency.*"
- 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.

Global Results:
Trade Impacts, Emissions Leakage, and Output-Based Rebate Scenario

Summary of Trade Impacts, Emissions Leakage, and Output-Based Rebate Scenario

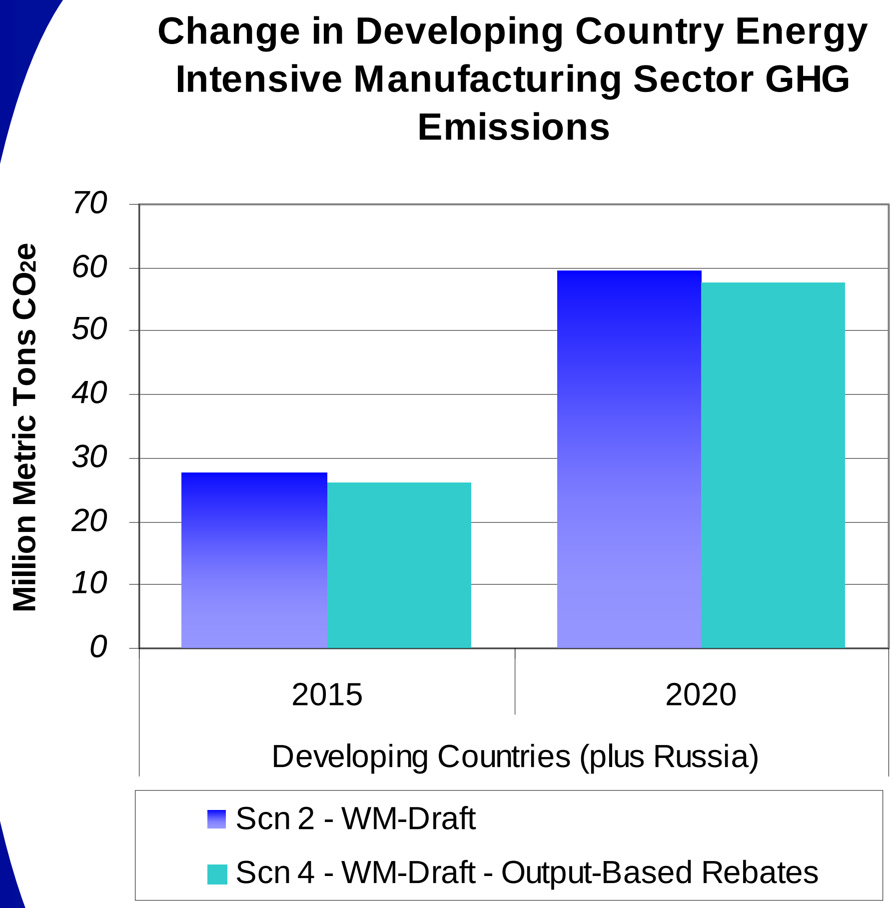
(ADAGE)



- The output-based rebate provision specified in Title IV of WM-Draft is similar to H.R. 7146 (Inslee - Doyle).
  - Applies to energy- or GHG-intensive industries that are also trade-intensive.
  - Rebates on average 85 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 2021 and 2030, or when other countries take comparable action on climate change.
- Without output-based rebate provision, energy intensive manufacturing output decreases by 0.4% in 2015 and by 0.9% in 2020. With the output-based rebates, energy intensive manufacturing output *increases* by 0.1% in 2015 and only falls by 0.3% in 2020.
- The output-based rebate provisions increase allowance prices by 2%, and thus, in later years after the rebates are phased out, the energy intensive manufacturing sector output losses are slightly higher than in scenarios without the rebates.
- More detailed results are presented in Appendix 5.

Summary of Trade Impacts, Emissions Leakage, and Output-Based Rebate Scenario

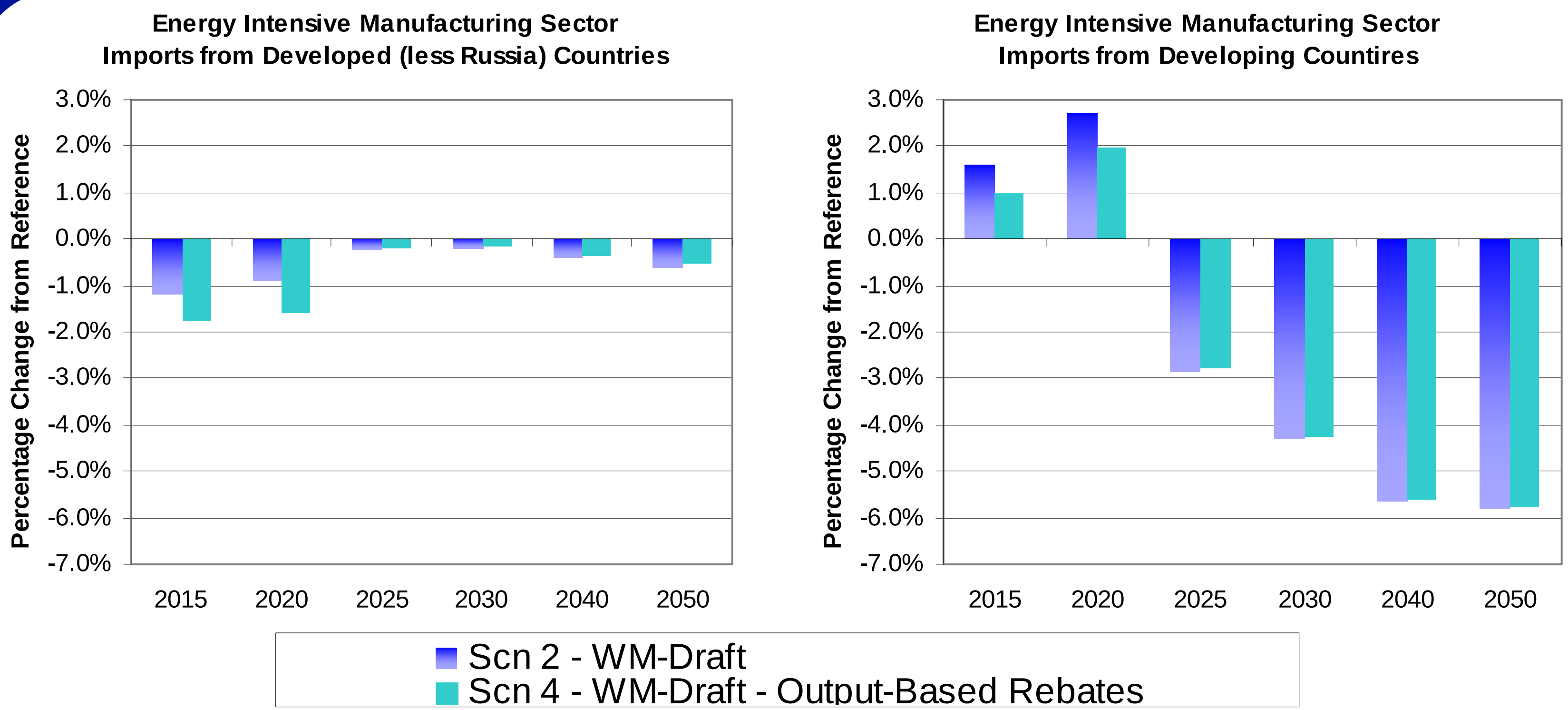
(ADAGE)



- GHG emissions leakage may occur when a domestic GHG policy causes a relative price differential between domestically produced and imported goods. This can cause domestic production, which embodies the GHG allowance price, to shift abroad, which would thus result in an increase in GHG emissions in countries without commensurate GHG regulation. Additionally, emissions leakage not associated with trade effects may occur when a GHG policy reduces domestic consumption of oil; lower demand for oil lowers the world oil price, which increases oil consumption in countries without a GHG policy and thus increases emissions.
- The figure shows developing country energy-intensive manufacturing sector emissions leakage. In scenarios 2 and 4, developing countries adopt climate policies in 2025, so their emissions fall in later years.
- In scenario 2, energy-intensive manufacturing sector emissions in Group 2 increase slightly before 2025 (28 and 60 million metric tons CO_2e in 2015 and 2020 respectively), and fall after policy is adopted. In scenario 4, the increase in EIS emissions from Group 2 in is lessened by 6% in 2015 and by 3% in 2020.
- More detailed results are presented in Appendix 5.

Summary of Trade Impacts, Emissions Leakage, and Output-Based Rebate Scenario

(ADAGE)



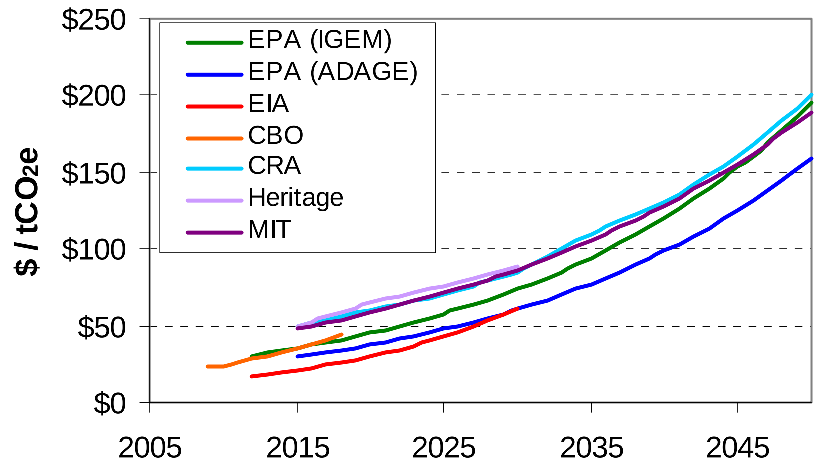
- Imports of energy intensive manufacturing goods from developing countries increase in 2015 and 2020, then decrease in 2025 and after as the developing countries are assumed to adopt climate policies.
- In 2015 and 2020, the output-based rebate provisions decrease imports from both developed and developing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

Literature Review

Comparing EPA and Other Analyses of Lieberman-Warner (S.2191)

- Comparing the results of EPA's analyses of previously proposed climate legislation (S.2191) to a variety of other modeling approaches and assumptions shows that they produce similar estimates of allowance prices and GDP impacts.

Comparison of Allowance Price Estimates for Lieberman-Warner S. 2191 in the 110th Congress



Comparison of Estimates for the Change in GDP for Lieberman-Warner S. 2191 in the 110th Congress (% Change from Reference)

	2020	2030	2040	2050
EPA (IGEM)	-2.6%	-3.8%	-5.2%	-6.9%
EPA (ADAGE)	-0.7%	-0.9%	-1.4%	-2.4%
EIA	-0.3%	-0.3%		
CRA	-1.1%	-1.0%	-1.6%	-3.5%
Heritage	-1.4%	-2.2%		

- EPA and other models produce a similar rise in allowance prices. The cost of allowances rises from $20-$50 per ton in 2015 to $160-$200 in 2050.
- The drop in GDP compared to the baseline is similar across models and rises over time from 0.3%-2.6% in 2020 to 2.4%-6.9% in 2050.
- The two EPA models produce different results because of different approaches to modeling the compensated elasticity of labor supply.

Please note that EPA has not included the MIT analysis in its comparison of GDP impacts. While the cost estimates and allowance prices from MIT's analysis are valid, the authors are re-estimating forecasted GDP impacts due to a recently discovered anomaly in the calculations. The National Association of Manufacturers also conducted an analysis of this bill, but EIA's review of the analysis indicated that they did not use a consistent set of assumptions between the baseline and the policy scenario, so the impacts could not be appropriately compared.

Comparing EPA and Other Analyses of Lieberman-Warner (S.2191)

The decrease in the cumulative 10-year GDP *growth rate* compared to the baseline is also similar across models but does not consistently rise over time.

Comparison of Average Ten Year Growth Rate

	2010-2020			2020-2030			2030-2040			2040-2050		
	% GDP Growth in Reference	% GDP Growth in Forecast	Cumulative 10 Year Difference	% GDP Growth in Reference	% GDP Growth in Forecast	Cumulative 10 Year Difference	% GDP Growth in Reference	% GDP Growth in Forecast	Cumulative 10 Year Difference	% GDP Growth in Reference	% GDP Growth in Forecast	Cumulative 10 Year Difference
EPA (IGEM)	3.47%	3.25%	-2.20%	3.18%	3.02%	-1.63%	2.88%	2.69%	-1.93%	2.27%	2.05%	-2.21%
EPA (ADAGE)	3.56%	3.49%	-0.68%	3.34%	3.31%	-0.29%	2.84%	2.77%	-0.69%	2.57%	2.45%	-1.19%
EIA	2.84%	2.81%	-0.24%	2.65%	2.65%	-0.03%						
CRA	2.89%	2.74%	-1.42%	2.88%	2.89%	0.13%	2.93%	2.85%	-0.78%	2.93%	2.68%	-2.50%
Heritage	2.80%	2.63%	-1.71%	2.67%	2.57%	-1.03%						

- The change in cumulative growth rates reflects the compounding of GDP growth over time (Annual average growth rates do not capture this compounding effect.).
- The models predict that the policy will reduce cumulative 10-year GDP growth rates by 0.68%-2.2% over 2010-2020 and 1.19%-2.5% over 2040-2050.
- CRA projects a small reversal in GDP growth reductions over 2020-2030 due to specific assumptions.
  - It forecasts steep GDP growth losses over 2010-2020 due to the low-carbon fuel standard, so GDP growth rebounds somewhat in the following decade when it is no longer binding (LCFS not modeled in other analyses).
  - The policy still has negative impacts on GDP relative to the baseline in every time period even if GDP growth is temporarily higher.

Key Drivers of the Differences between Analyses of Lieberman-Warner (S.2191)

- **Different models and different baselines**

	EPA	EIA	CBO	CRA	Heritage	MIT
Model	ADAGE, IGEM, IPM	NEMS	Synthesis	MRN-NEEN	Global Insight	EPPA
Timeframe	2005-2050	2005-2030	2009-2018	2015-2030	2010-2030	2012-2050
Baseline	AEO 2006	AEO 2008	AEO 2007-2008	AEO 2008		AEO 2005 (used 1% annual growth rate to get to 2008)

- **CBO lists four main reasons for the difference in the allowance price**
  - Projections of emissions and energy prices – Higher projections raise allowance prices
  - Responsiveness to price changes – More responsiveness lowers allowance prices
  - Discount rate – A lower discount rate raises the allowance price in early years
  - Offsets – Increased availability of offsets reduces allowance prices
- **Greater expansion in nuclear power reduces the costs**

	EPA	EIA	CBO	CRA	Heritage	MIT
Assumptions on Nuclear Power	Nuclear capacity grows 150% from 2005 levels	Nuclear power is unconstrained, growing by 268 GW		Nuclear power grows from 21% currently to 35% of the electricity mix	Nuclear power growth is limited to 0.5% per year	Nuclear capacity is not permitted to expand

- **Common messages from the models**
  - The majority of the cost-effective reductions come from the electricity sector.
  - CCS is an important enabling technology.
  - Increased availability of international offsets reduces the costs and impacts.
  - Increased international action raises allowance prices and economic welfare and reduces ultimate GHG concentrations

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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