An Outlook for

Electric Power Generation in a Lower Carbon Economy

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Overview

- Electric power generation:
  - In context of the climate change issue
  - EPA's air emissions agenda
  - Carbon dioxide emissions
- Results of EPA analyses of major legislative proposals to address greenhouse gas emissions
  - Waxman-Markey bill
  - Senate legislative proposals
- Looking ahead into uncertainty and opportunity

We Are at a Crossroads of Energy and Environmental Policy for Electric Power

The landscape for electric generation has changed in many ways over the past 15 to 20 years:

- Models have reasonably predicted some things, missed others
- Resurgence of the nuclear fleet (up-rates, increased availability, life-extensions)
- Growth of renewables (state requirements, federal incentives)
- Boom, and bust, and boom of natural gas
- Hybrid electricity markets (quasi-competitive in some areas for generation)
- Recently seeing a much lower demand outlook
- Remaining throughout the last 20 years heavily reliant on fossil fuels

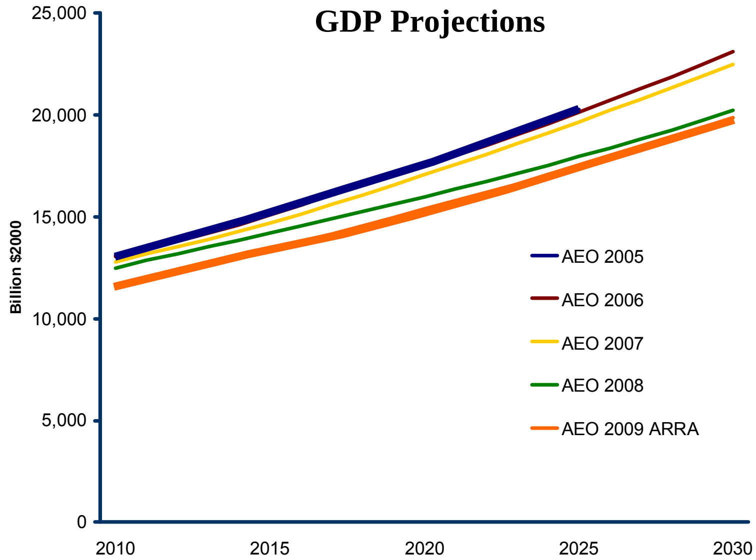
Electric generation and the environment:

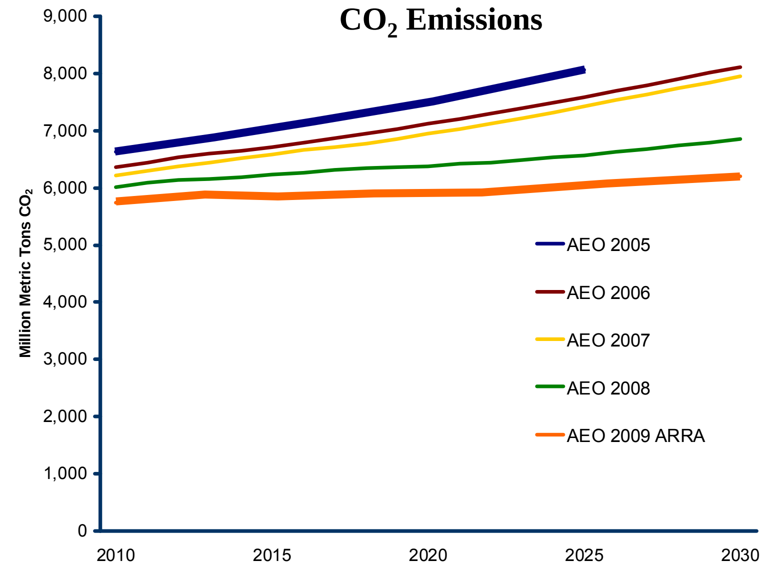
- There is a wide range of environmental issues arising from power generation, especially regarding air emissions from generation produced by fossil fuels
- As the country becomes more focused on climate change issues, two things have become increasingly clear. Electric generation sector is:
  - Largest emitter of greenhouse gases
  - Widely recognized as a source for large-scale and cost-effective reductions

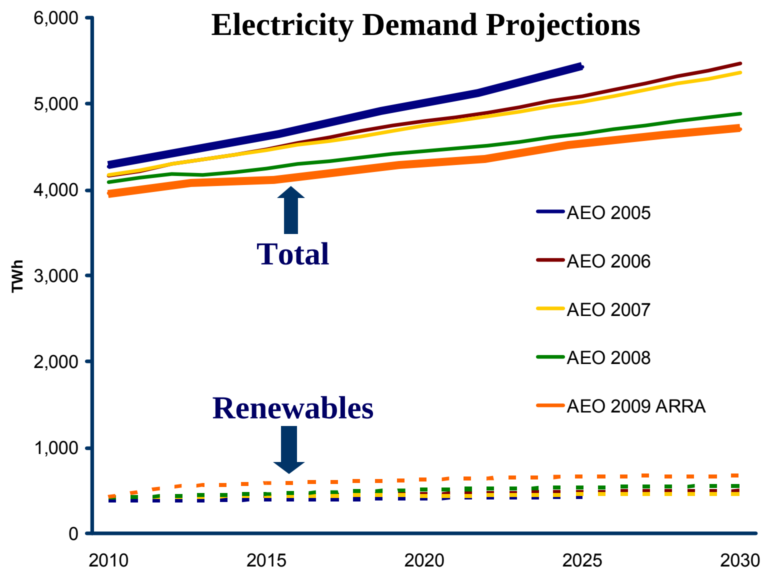
Climate debate appears to be centered around policy, not emerging science

United States Environmental Protection Agency

Our Outlook in the U.S. Is Changing….







Current Picture:

- The economy is in transition and economic forecasts continue to be revised downward.
- As a result, CO_2 emissions growth will be lower than previously expected.

Source: Energy Information Administration's Annual Energy Outlook, 2005-2009.

EPA Is Working to Lower Power Sector Air Emissions in Many Ways

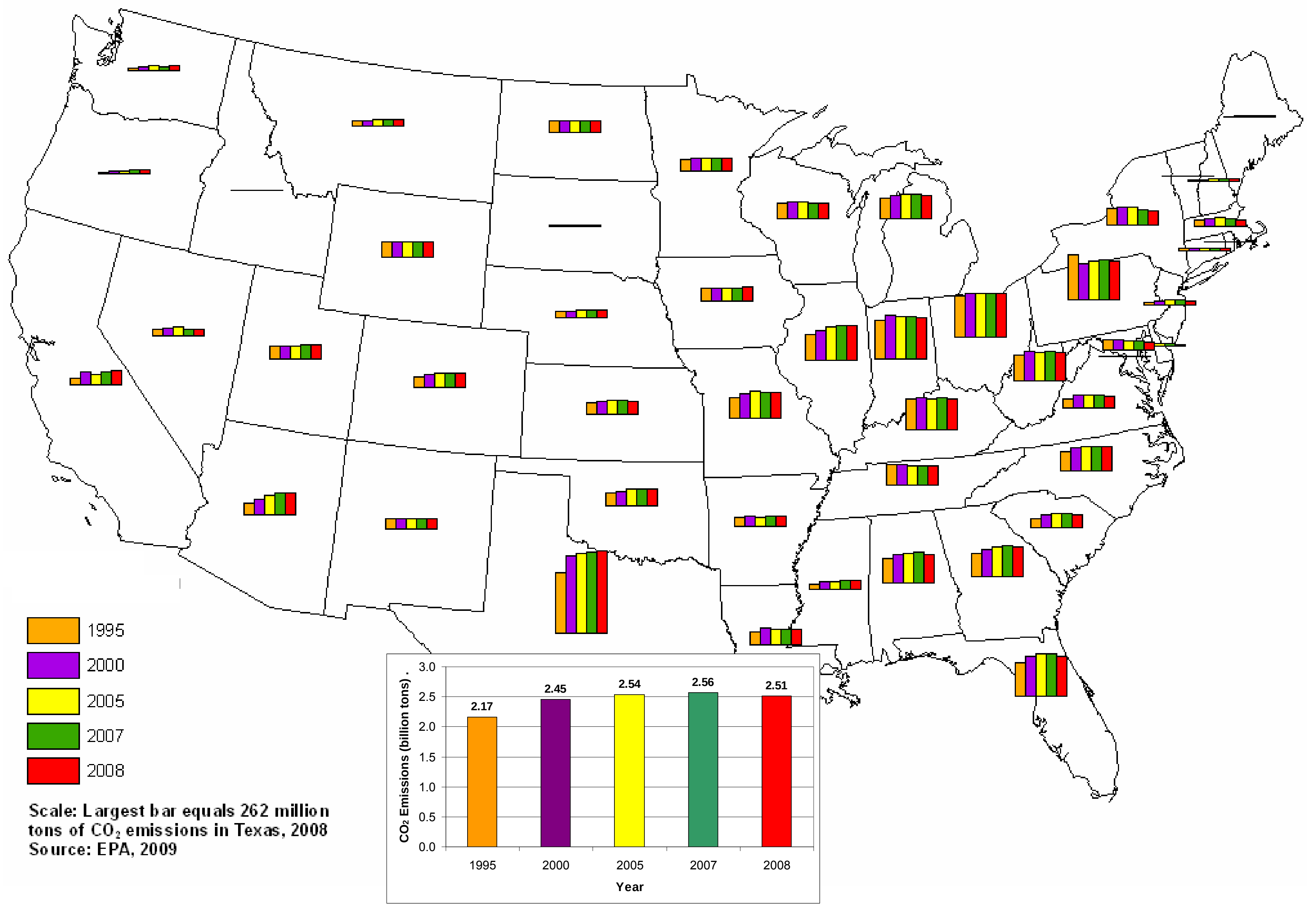
Clean Air Act Actions:

- Developing regulations
  - CAIR replacement rule
  - Utility MACT
  - NSPS
  - Mandatory GHG reporting rule
- Permitting
  - NSR/PSD
  - Title V
  - Case by case MACT (e.g.,112(g))
- State Implementation Plans
  - NAAQS Attainment
  - RACT
  - Visibility

Other Activities:

- Voluntary programs promoting:
  - Energy Efficiency
  - Renewables
- Providing assistance to Congress as they consider legislative options
  - Waxman/Markey Climate Bill and Proposed Senate Climate Bills
  - Carper/Alexander multi-pollutant roundtables and technical support

State-by-State Annual CO_2 Emission Levels for Acid Rain Program Sources, 1995-2008



EPA Analysis of Climate Proposals

- Over the past several years, EPA has been asked to estimate the economic impacts of various economy-wide climate proposals.

  Senate:
  - The Climate Stewardship and Innovation Act of 2007 (S. 280, McCain and Lieberman)
  - The Low Carbon Economy Act of 2007 (S. 1766, Bingaman and Specter)
  - The Climate Security Act of 2007 (S. 2191, Lieberman and Warner)

  House:
  - The American Clean Energy and Security Act of 2009 (Waxman-Markey Discussion Draft)
  - The American Clean Energy and Security Act of 2009 (H.R. 2454, Waxman-Markey Bill)

- These proposals include a cap and trade program covering most GHGs, an auction, offsets, technology incentives, and some complementary policies.

- For these analyses, EPA uses a suite of modeling tools:
  - Near-term (out to 2025): EPA uses the Integrated Planning Model (IPM) to provide a more detailed picture of the electricity sector in the short-run (through 2025), which complements the long-run (through 2050) equilibrium response represented in the CGE models.
  - Long-term (out to 2050): Computable general equilibrium (CGE) models (ADAGE and IGEM) are used to simulate a market economy, where prices and quantities adjust so that all markets clear in response to a new policy. These models are best suited for capturing long-run equilibrium responses, and unique characteristics of specific sectors of the economy.

Summary of Key Elements of

Waxman-Markey Bill

- 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 billion metric tons CO_2 equivalent ($MtCO_2e$) per year.
  - Supplemental emissions reductions from reduced deforestation through allowance set-asides.

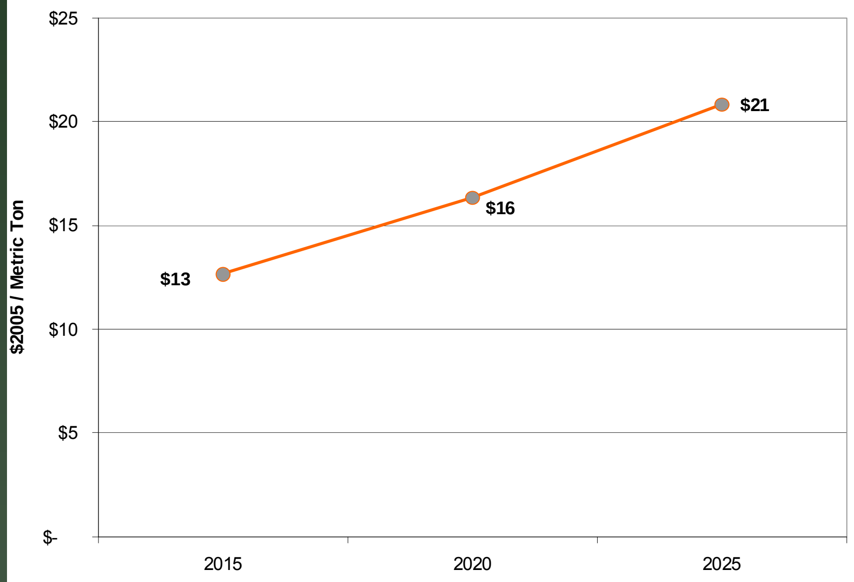
- Titles I & II of H.R. 2454 deal with clean energy and energy efficiency, and among other things establish a renewable electricity standard, and energy efficiency programs and standards for buildings, lighting, appliances.
  - Not all provisions in Titles I & II are explicitly modeled in this analysis.

- 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.

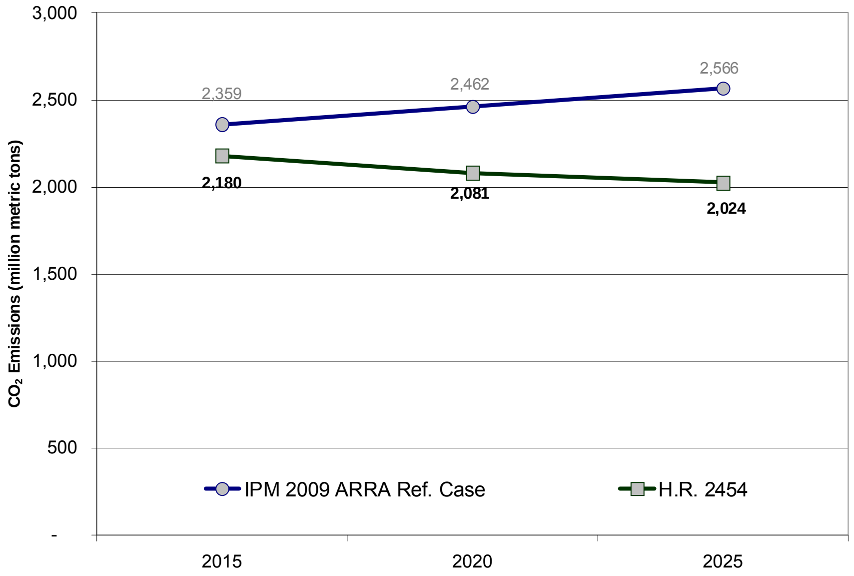
Near-Term Outlook (2015-2025): Waxman-Markey (H.R.2454)

Allowance Prices and Power Sector CO_2 Emissions

GHG Allowance Price (inputs to IPM)*

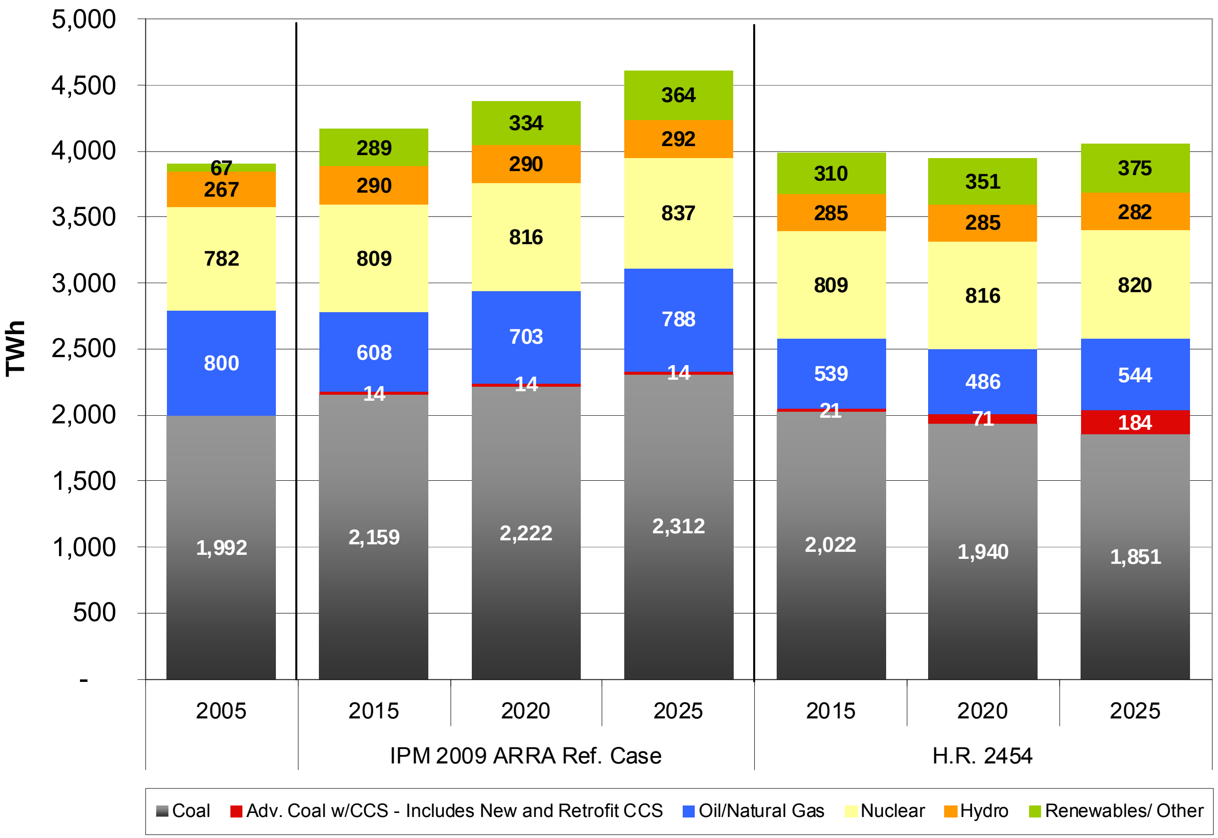


Power Sector CO_2 Emissions



* 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.

Near-Term Outlook (2015-2025): Waxman-Markey
Electricity Generation Mix



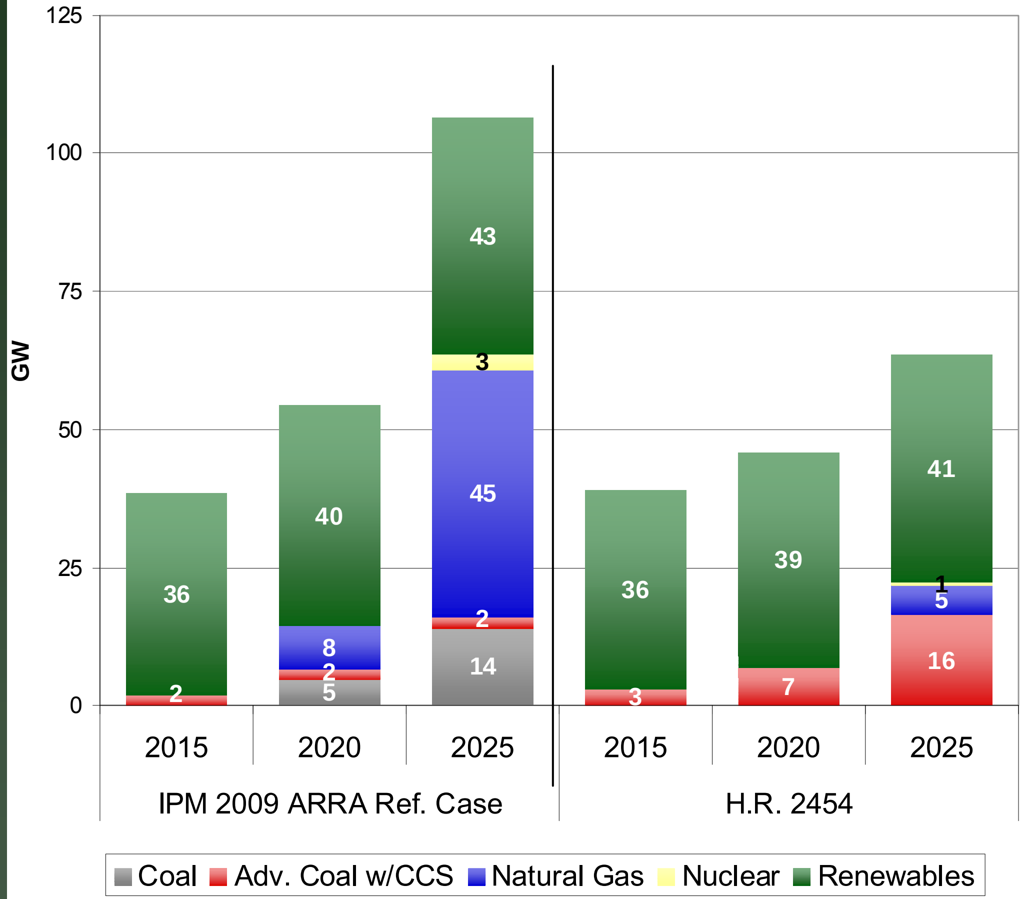
- The electricity demand forecast is lower than past EPA analyses, reflecting economic and policy-related adjustments.
- Due to a large increase in renewable energy largely driven by ARRA provisions, there is excess electricity generating capacity projected through 2015 in the reference case and H.R. 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.

Near-Term (2015-2025): Waxman-Markey

New Generation Capacity

New Generation Capacity, Cumulative

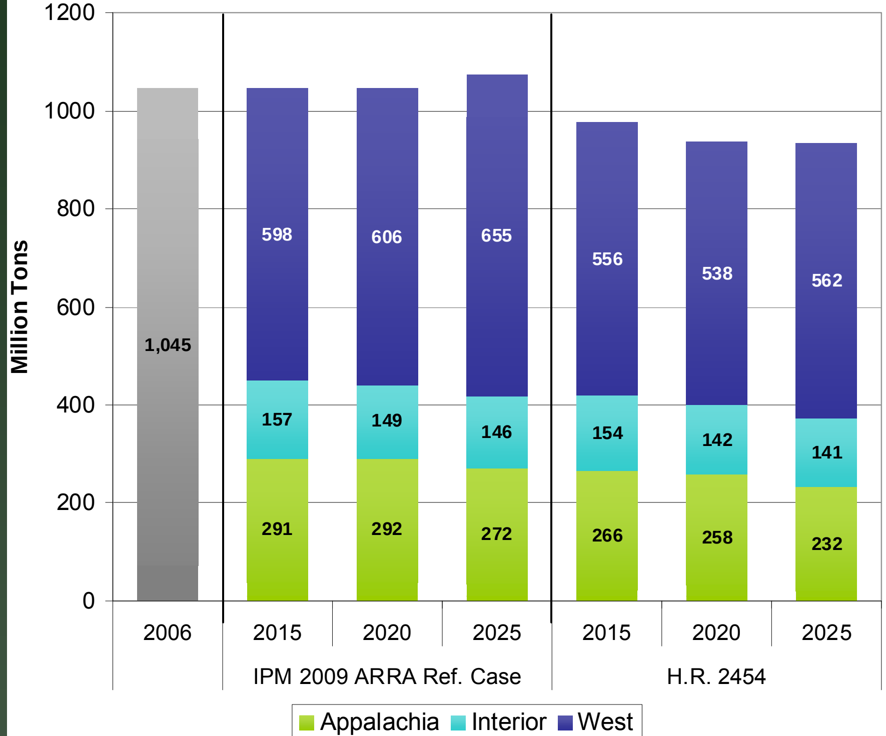


- A major change to the IPM 2009 ARRA reference case is the amount of new renewables expected to be built in the short-term in response to additional ARRA incentives. Overall electricity demand is also lower, necessitating fewer new power plants than past EPA modeling with IPM.
- Under H.R. 2454, electricity 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 and renewables) 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.

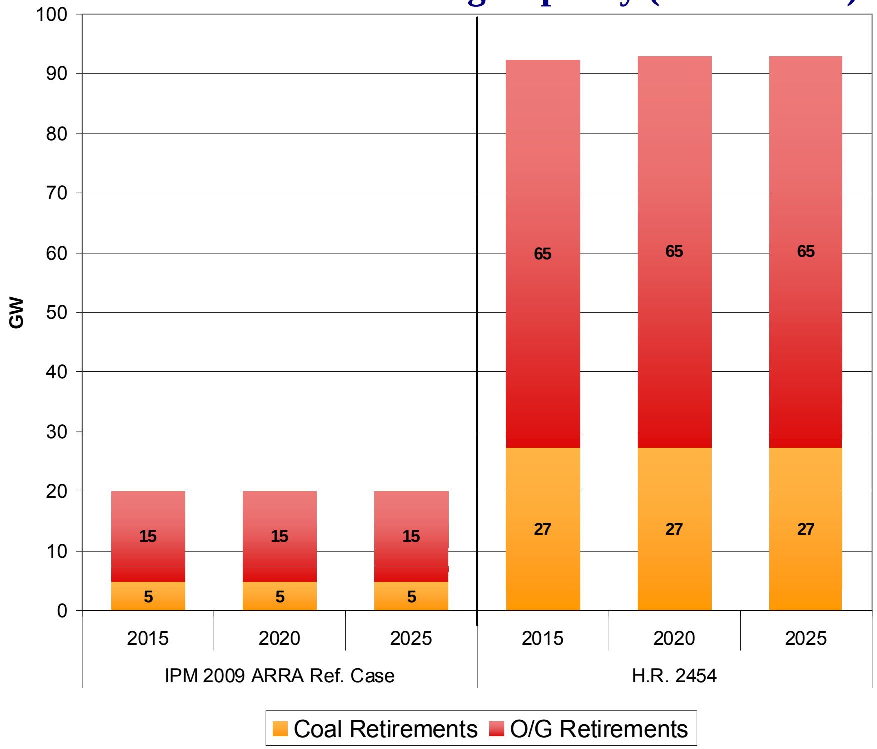
Note: New capacity additions less that 1 GW of capacity are not indicated. IPM 2009 ARRA Reference Case is generally consistent with AEO 2009 (ARRA update), although projections are not identical because IPM is a power sector model and has different treatment of key assumptions and variables. IPM projects 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.

Near-Term (2015-2025): Waxman-Markey
Coal Production and Generation Unit Retirements

Coal Production for Electricity Generation



Retirements of Existing Capacity (Cumulative)



- 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.

Waxman-Markey 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.

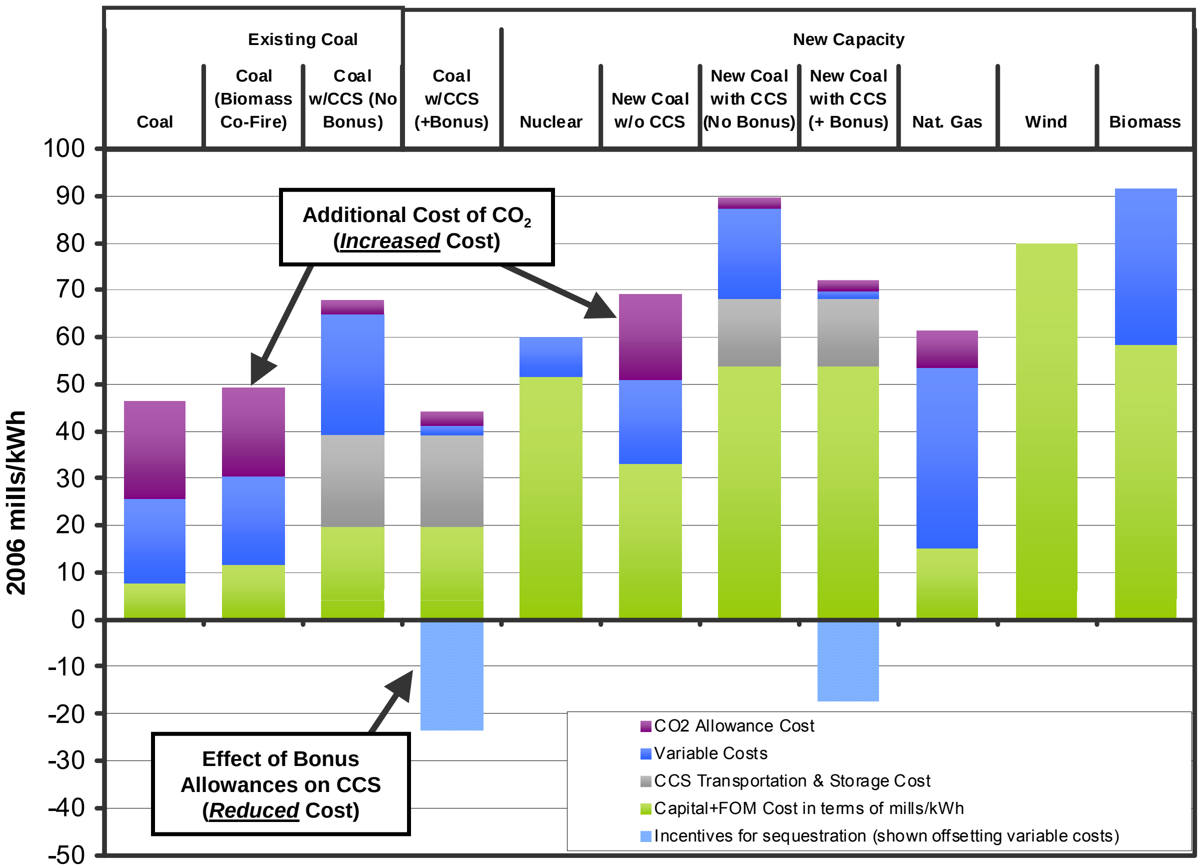
- Where allowance value is rebated to consumers on the basis of quantity consumed, electricity prices will be lower and consumption will be higher than would have occurred otherwise. Higher consumption yields higher GHG emissions from the power sector, which means other reductions will be needed that 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.

Power Plant Economics with CO_2 Allowance Costs Waxman-Markey Bill

Estimated Power Plant Electricity Costs in 2025 for Various Technologies

(includes the cost of CO_2 of ~$20/metric ton)

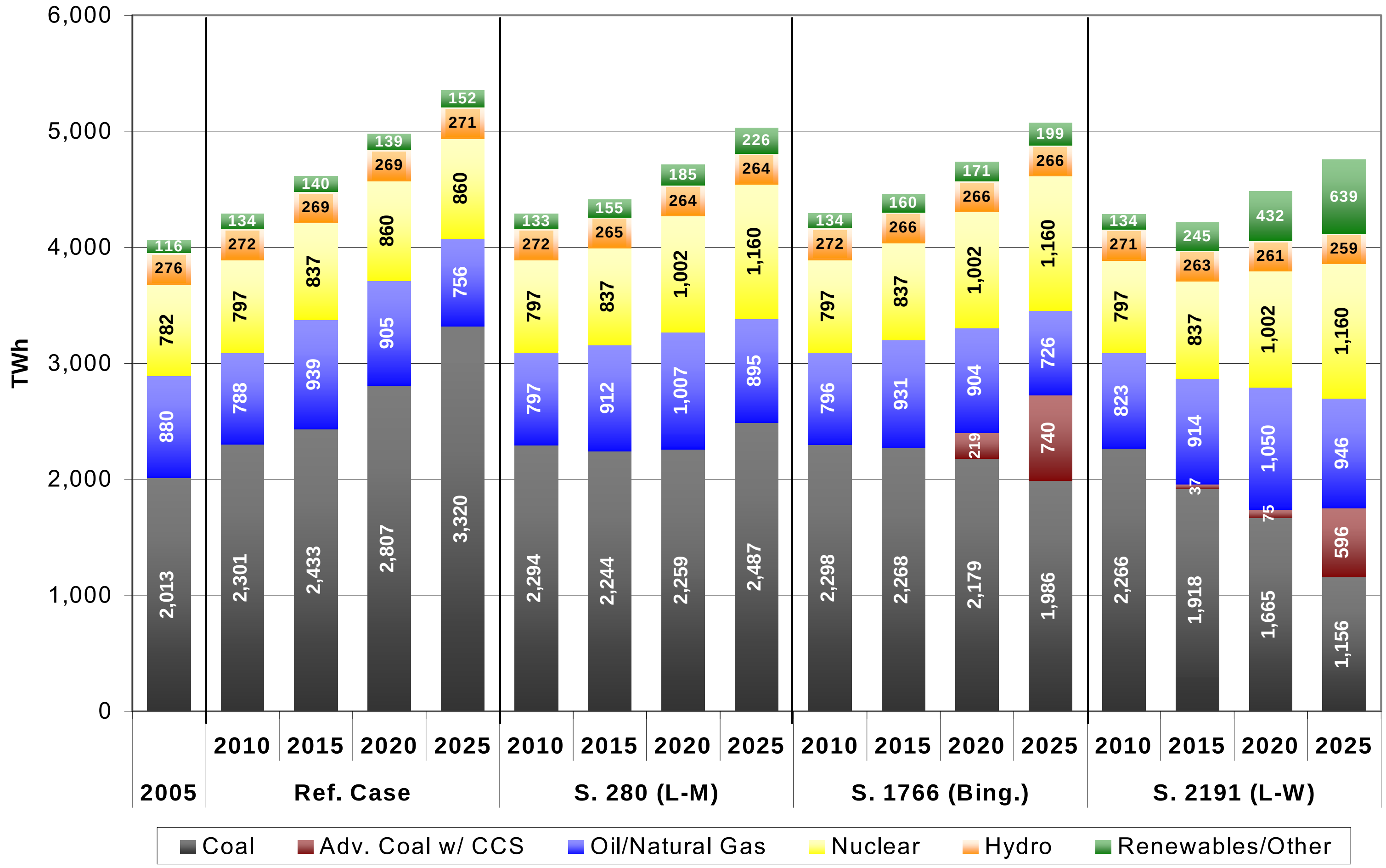


- To illustrate the economics of operating existing and new power technologies, the chart shows the cost of various technologies when the projected CO_2 allowance prices are included.
- Projected CO_2 allowance prices of roughly $20/ton in 2025 increase variable costs of existing plants powered by fossil fuels to the point where some are likely to shut down.
- However, H.R. 2454 provides significant incentives for CCS technology for coal plants in the form of bonus allowances, resulting in earlier penetration of advanced coal with CCS.

Notes: For the case with bonus allowances, the variable, capital, and fixed O&M costs are actually an aggregate of the solid part and the hashed part but the net cost is only the solid part. For this illustrative calculation, EPA used a conservative efficiency metric for existing coal plants (10,500 Btu/kWh), which most plants currently meet or exceed. The capital costs used here are from IPM 2009 ARRA, which relies upon EIA capital cost data from AEO 2009 ARRA. More recently, capital costs have increased with increasing international demand for raw materials. It is not clear how the market will respond to these price increases and whether these increased costs will be sustained over the period of the analysis. In reality, there would be greater regional differences in all but allowance costs due to differences in construction, operating, labor, and fuel costs. However, the overall relative costs are generally reflected.

Near Term (2010-2025): Earlier Senate Bill Analyses

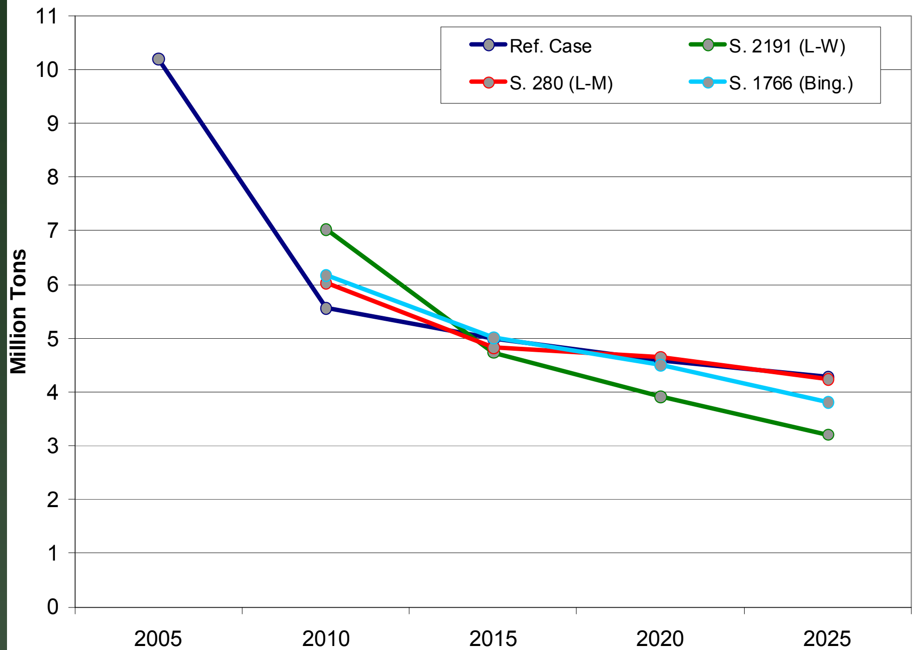
Look at Electricity Generation



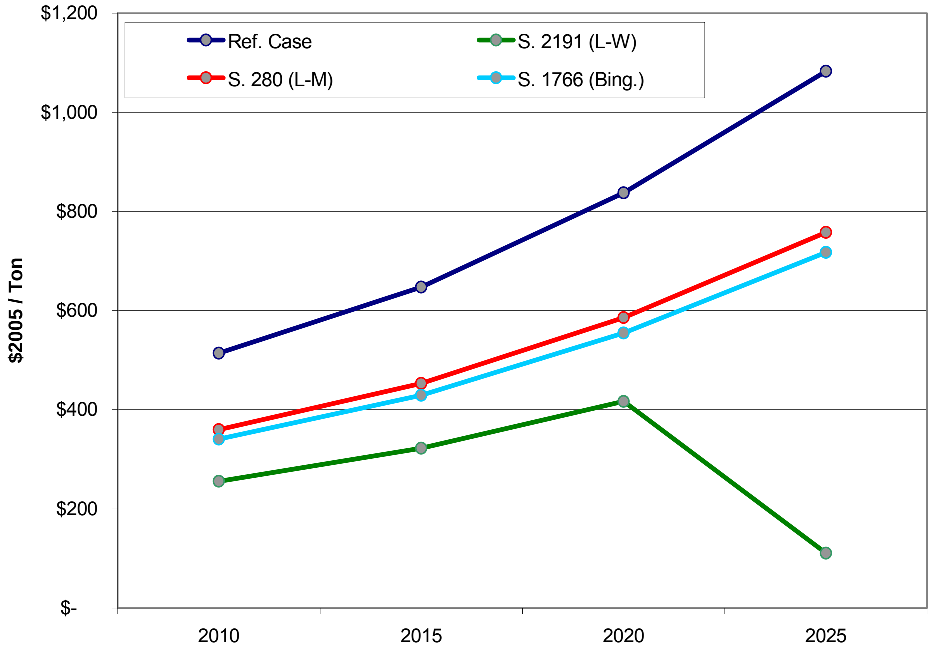
Scenario	Year	Coal	Adv. Coal w/ CCS	Oil/Natural Gas	Nuclear	Hydro	Renewables/Other
2005	2005	2,013		880	782	276	116
Ref. Case	2010	2,301		788	797	272	134
Ref. Case	2015	2,433		939	837	269	140
Ref. Case	2020	2,807		905	860	269	139
Ref. Case	2025	3,320		756	860	271	152
S. 280 (L-M)	2010	2,294		797	797	272	133
S. 280 (L-M)	2015	2,244		912	837	265	155
S. 280 (L-M)	2020	2,259		1,007	1,002	264	185
S. 280 (L-M)	2025	2,487		895	1,160	264	226
S. 1766 (Bing.)	2010	2,298		796	797	272	134
S. 1766 (Bing.)	2015	2,268		931	837	266	160
S. 1766 (Bing.)	2020	2,179	219	904	1,002	266	171
S. 1766 (Bing.)	2025	1,986	740	726	1,160	266	199
S. 2191 (L-W)	2010	2,266		823	797	271	134
S. 2191 (L-W)	2015	1,918	37	914	837	263	245
S. 2191 (L-W)	2020	1,665	75	1,050	1,002	261	432
S. 2191 (L-W)	2025	1,156	596	946	1,160	259	639

Prior Near-Term (2010-2025) Senate Bill Analyses:
Interesting Changes in SO_2 Levels and Allowance Price

Nationwide SO_2 Emissions



Projected Allowance Prices to Cover a Ton of SO_2 under CAIR



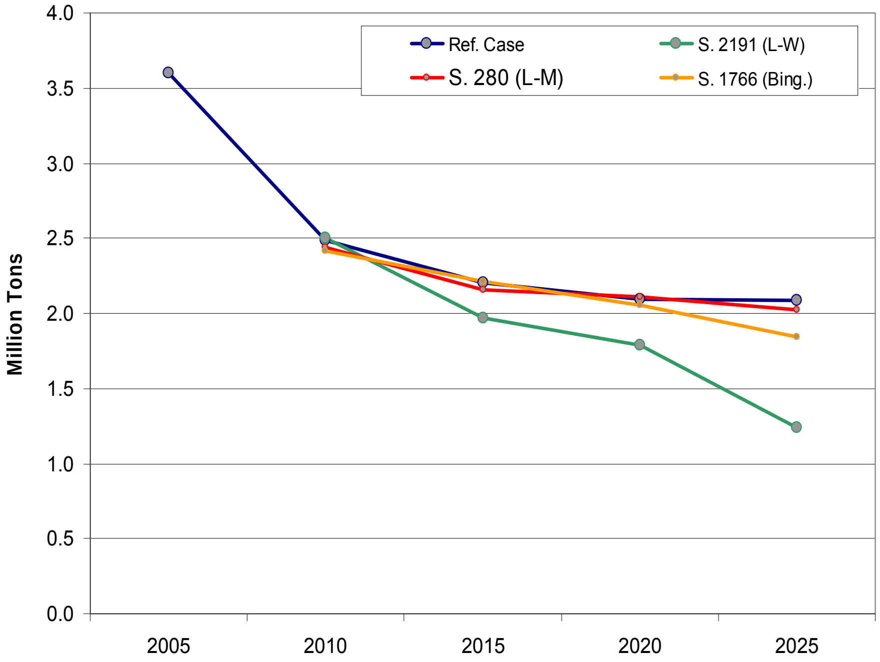
- SO_2 emissions are initially somewhat higher and then drop below levels seen with CAIR alone in the reference case, indicating that a GHG program inevitably drives both CO_2, SO_2, and NO_x reductions.
- CO_2 allowance prices projected in S. 2191 influence the timing of SO_2 emissions because of existing cap and trade programs and emission banking provisions of the CAIR program.
- SO_2 allowance prices are for CAIR affected sources on a $/ton of emissions basis; Title IV allowance prices are not shown separately, but would be a fraction of this amount.
- Under S. 2191, there is a large amount of incremental coal retirements in 2025 as the CO_2 allowance price hits $50/ton. In response, a considerable amount of new nuclear and renewables capacity is built along with new coal with CCS (although not nearly as much coal capacity as is retired) and thus, demand for SO_2 allowances goes down, leading to a kink in 2025.

Note: Emissions generally reflect emissions from affected sources (Acid Rain Program and CAIR), which includes emissions from sources greater than 25 MW in capacity.

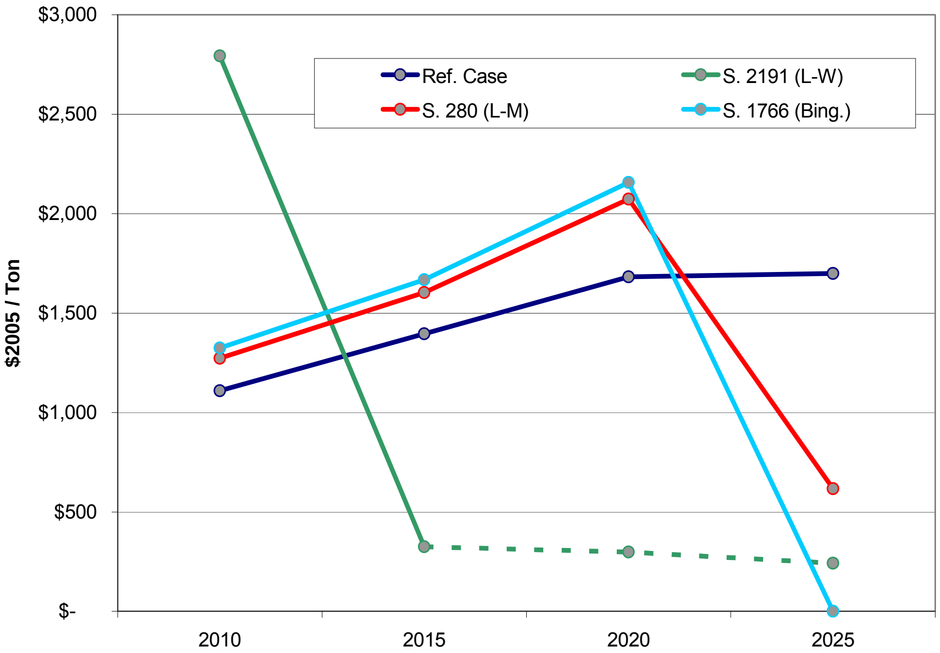
From Prior Near-Term Senate Bill Analyses:

NO_x Emissions and Allowance Price Comparisons

Nationwide NO_x Emissions under CAIR



Projected Allowance Price of NO_x under CAIR



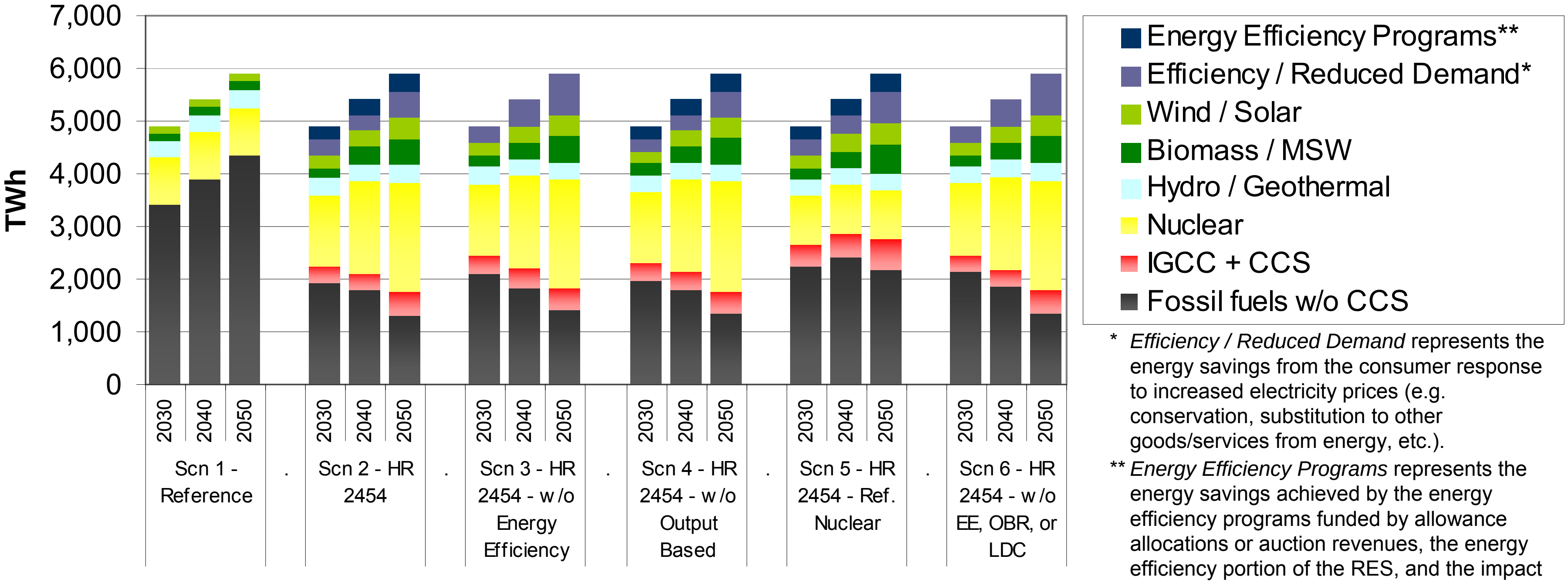
- S. 2191 has an influence on the allowance prices under existing and future cap and trade programs.
- NO_x allowance prices in the S. 2191 policy case above were calculated exogenously, rather than modeled in IPM (dotted line). The adjustment was made to reflect that actual emissions are likely to be closer to the cap as some EGUs stop running controls to reduce operating costs. The allowance price reflects the VOM costs for controls.
- Under S. 2191, there is a large amount of incremental coal retirements in 2025 as the allowance price hits $50/ton. In response, a considerable amount of new nuclear and renewables capacity is built along with new coal with CCS (although not nearly as much coal capacity as is retired).

Limits to Near-Term Modeling (IPM)

- The EPA version of the IPM model focuses on the near-term impacts and only produces reportable results through 2025.
  - Model does not see longer-term changes in electricity demand and CO_2 allowance prices (due to lowering of the cap over the entire timeframe of the bill).
  - This will affect projections for new capacity additions and retrofit decisions in later years.
- EPA's application of IPM does not incorporate several technological innovations that can become available over time (e.g., ultra-supercritical coal, advanced renewables) or enhanced energy efficiency that could lead to demand reductions.
  - The model provides a good sense over the next 15 to 20 years of how the power sector could operate with expected demand, fuel prices, technologies, and other factors, based on EPA's best information available.
- Geographic deployment, cost, and performance of CCS is highly uncertain and still being developed in EPA's modeling applications.
- Allowance allocation and auctioning are not accounted for in the modeling.
- While IPM endogenously builds new capacity, the model places an exogenous constraint on the total amount of most new capacity builds.
- There are non-economic considerations for significant expansion of new coal with CCS, nuclear power, and renewables which are not reflected in IPM, such as the need for new transmission, siting concerns, and permitting.
- IPM assumes a 60 year life for nuclear power plants.
  - There is an option in IPM for nuclear plants to extend their operating life beyond 60 years at an added cost.

Long-Term Outlook (2030 -2050) Using ADAGE:

Electric Generation H.R. 2454 Scenario Comparison



* *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.

Long-Term Outlook (2015-2050): Total Abatement and Cost for 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.

Long-Term Outlook (2015-2050): Consumption and GDP Impacts of H.R. 2454

Consumption

ADAGE	2015	2020	2030	2040	2050
Ref. Total C (Billion 2005 $)	$11,575	$13,168	$17,079	$21,655	$26,752
Change in Total C (Billion 2005 $)	-$9	-$14	-$53	-$119	-$209
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**
Total NPV Cost per Household (2010-2050)	**-$4,564**

IGEM	2015	2020	2030	2040	2050
Ref. Total C (Billion 2005 $)	$9,705	$10,990	$13,962	$17,567	$21,642
Change in Total C (Billion 2005 $)	-$3	-$11	-$42	-$97	-$166
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**
Total NPV Cost per Household (2010-2050)	**-$3,270**

- The costs described here include the effects of higher energy prices, price changes for other goods and services, impacts on wages and returns to capital, and the value of auction revenues returned lump sum to households. The cost does not include the impacts on leisure.
- In the model the loss in consumption is calculated in each year and divided by the household size (~2.5) to find the cost per household.
- The economic discount rate (5%) is applied to find the net present value (NPV) of the cost in each year in the future.
- Average annual NPV cost per household is found by summing over all years and dividing by the number of years, which results in the $80 - $111 figure.

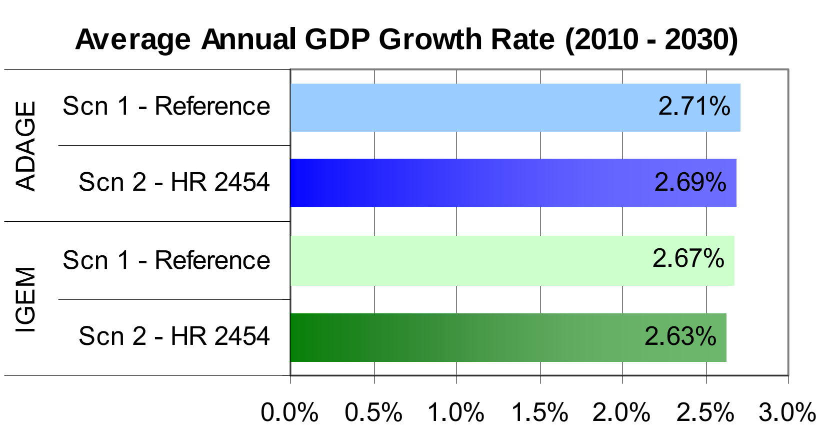
GDP

ADAGE

	2015	2020	2030	2040	2050
Reference	$15.4	$17.4	$22.6	$28.6	$35.4
Scn 2 - H.R. 2454	$15.4	$17.5	$22.5	$28.4	$34.9
Absolute Change	$0.013	$0.023	-$0.083	-$0.208	-$0.459
% Change	0.08%	0.13%	-0.37%	-0.73%	-1.30%

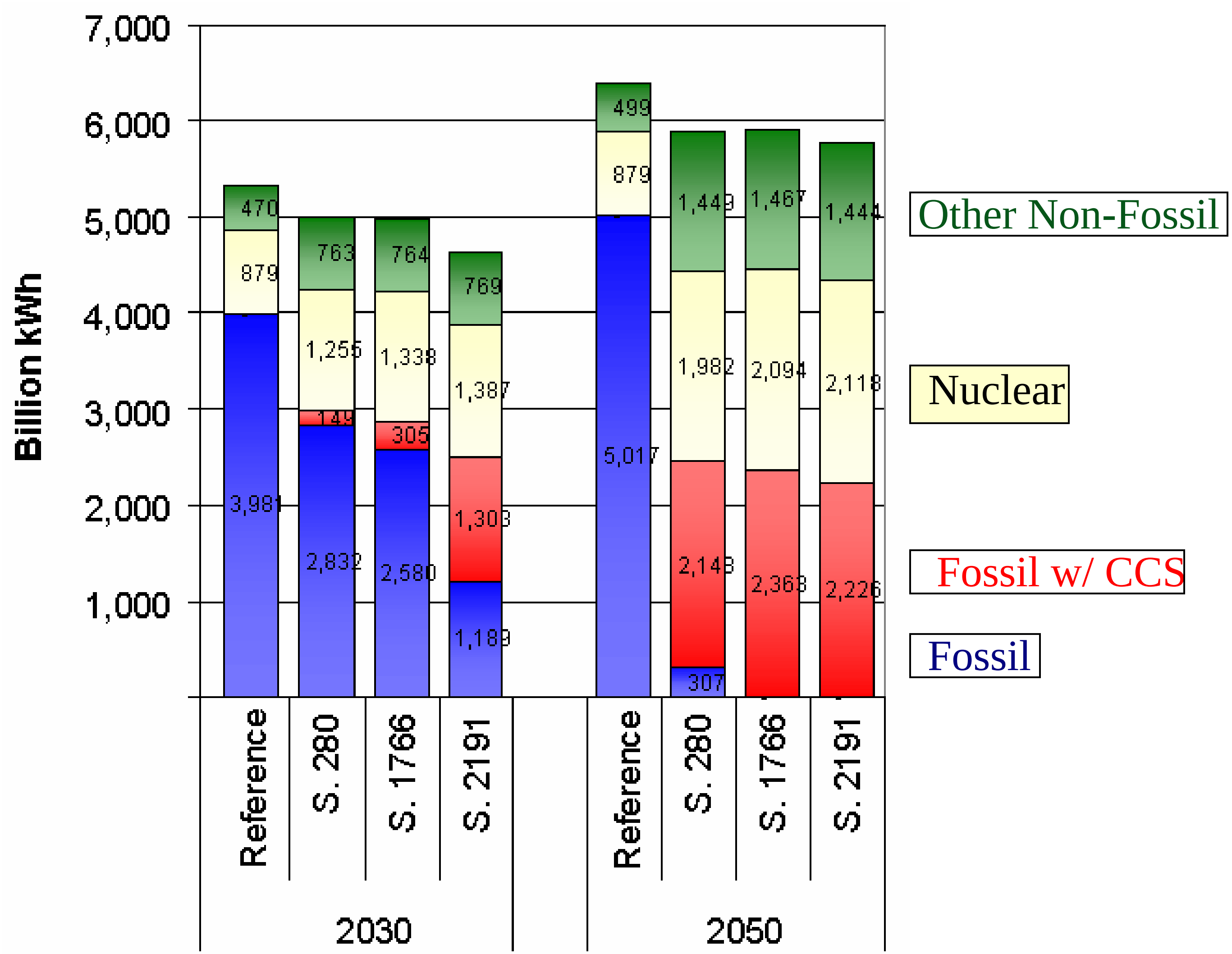
IGEM

	2015	2020	2030	2040	2050
Reference	$15.7	$17.7	$22.7	$28.5	$35.4
Scn 2 - H.R. 2454	$15.7	$17.6	$22.5	$28.0	$34.7
Absolute Change	-$0.067	-$0.101	-$0.241	-$0.425	-$0.727
% Change	-0.43%	-0.57%	-1.06%	-1.49%	-2.05%



Long-Term Outlook 2030-2050 Using ADAGE:

Electric Generation Comparison from Senate Bill Analyses



Key Factors and Uncertainties Emerging from EPA Analyses

The long-term analyses contain alternate scenarios that cover some of the important uncertainties

- The degree to which important technologies are technically and politically feasible (e.g., nuclear, CCS).
- The importance of technology incentives (i.e., CCS).
- The availability of international offset projects.
- The effect of international action on offset/allowance prices and GHG concentrations.
- The amount of GHG emissions reductions achieved by energy efficiency provisions.
- The impact of output based rebates to energy intensive and trade exposed industries.

United States Environmental Protection Agency

Key Insights from Alternative Scenarios

Generally, abatement is similar across scenarios because of emissions cap, but magnitude of economic impacts varies

Assumption	Analysis	Impacts
No New Nuclear	All	Higher CO_2 prices, wide range depending upon proposal
No New Nuclear/CCS	S. 2191, S. 1766	Higher CO_2 prices, wide range depending upon proposal
No CCS, Low Nuclear	S. 1766	Higher CO_2 prices, wide range depending upon proposal
No Offsets	All	CO_2 prices as much as double
Unlimited Offsets	All	CO_2 prices lower by half
High Technology	S. 2191	CCS does not need incentives, 50% more renewables
Low International Action	S. 2191, S. 1766	Lower CO_2 prices, greater GHG concentrations
Low Technology and Gas Cartel	S. 2191	Delayed technology deployment, little effect on gas prices
No Safety Valve	S. 1766	Greater emissions reductions and slightly higher CO_2 prices
No CCS Subsidy	S. 1766	Delayed CCS penetration, slightly higher CO_2 prices

Other Analytical Efforts

	EPA	EIA	MIT	CRA	EPRI	PNNL
Model	ADAGE, IGEM	NEMS	EPPA	MRN-NEEM	MERGE	MiniCAM
Baseline	AEO 2008 Early Release* (AEO 2009 for IPM)	EIA publishes the AEO	AEO 2009 Early Release	AEO 2008 Early Release	Own baseline	Own baseline
Nuclear Assumptions	Capacity grows at 150% 2005 levels	Endogenous, no limits	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	Pilot projects in baseline by 2017, more widely available thereafter	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). EIA did not produce scenarios for EMF-22.

Common messages from the models

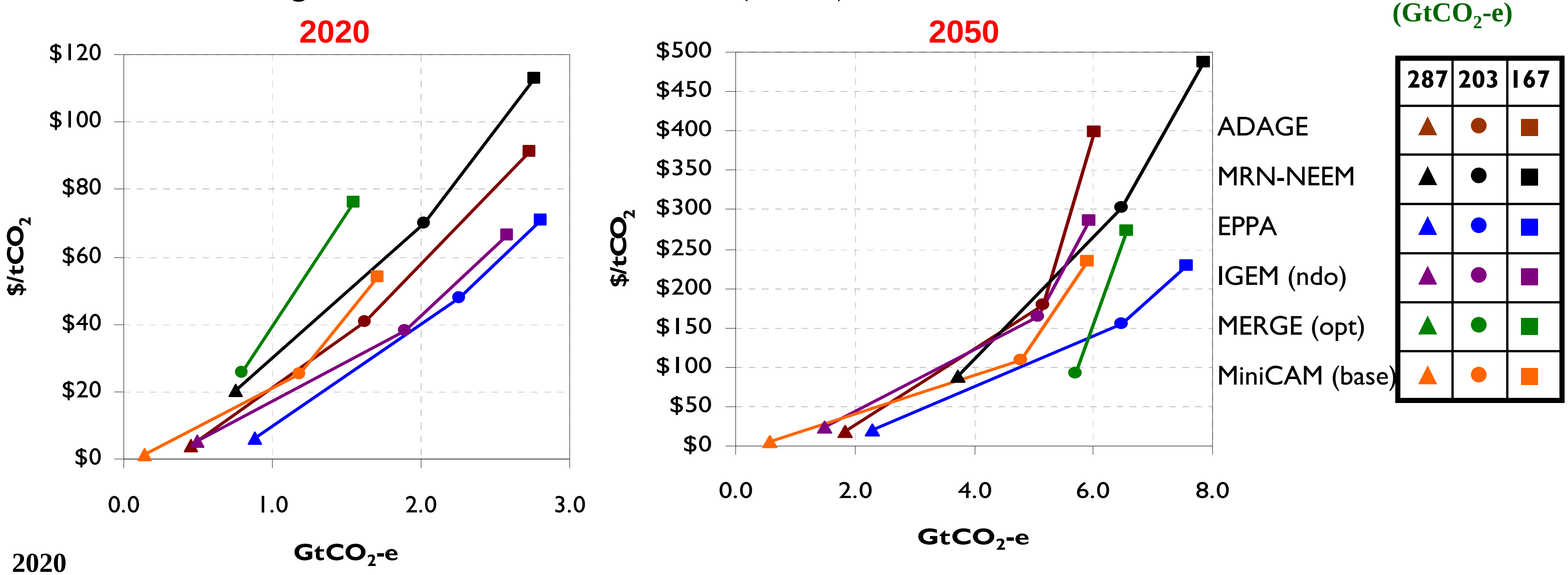
- The majority of the cost-effective reductions come from the electricity sector
- Greater expansion in nuclear power reduces the costs
- CCS is an important enabling technology

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

To put the EPA models (ADAGE and IGEM) in context, EPA compared 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.

Marginal Abatement Cost Functions (MACs) in 2020 and 2050

CO2-e Cumulative Emissions Goals ($GtCO_2$-e)



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.

Limits of Long-Term Modeling (ADAGE and IGEM)

- The models used in this analysis do not formally represent uncertainty.
  - Confidence intervals cannot be presented for any of the results in this analysis.
  - Alternate scenarios are presented to provide sensitivities on a few of the key determinants
- The CGE modeling approach generally does not allow for a detailed representation of technologies.
  - While ADAGE does represent different generation technologies within the electricity sector, it does not represent peak and base load generation requirements.
  - The CGE models do not explicitly model new developments in transportation technologies. These reductions occur as households alter their demand for motor gasoline and through broad representations of improvements in motor vehicle fuel efficiency.
  - The CGE models do not explicitly represent end-use efficiency technologies.
- None of the models used in this analysis currently represent the benefits of GHG abatement.
- Using sectoral models to construct offset curves limits ability to estimate all leakage effects.
- The federal government costs of administering H.R. 2454 (e.g. monitoring and enforcement) are not captured in this analysis.
- While ADAGE does include capital adjustment costs, capital in IGEM moves without cost.

Uncertainty….and Opportunity

- In wanting to look forward, often it's best to first look back to see how much things have changed – a lot of the last 15 to 20 years not clearly foreseen.

- We will certainly not predict all the key elements that will unfold in the next 20 years. However, energy modeling has had some successes at looking forward and has value.

- Analyses show promising notions:
  - Today's "known" technology can begin to deliver the U.S. to an affordable low carbon economy in the near term.
  - Incentives are likely to be there for better, cheaper ways to lower greenhouse gas emissions.

- It is clear that collective action is needed and the stakes are high from several vantage points.

Energy

Full Climate Bill Analysis:

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

Environment

Visit the Clean Air Markets web site to view:

Emissions data
Allowance transfers
Program rules and guidelines
Studies and reports
Clean Air Markets: www.epa.gov/airmarkets

New updated portion of web site on cap and trade:

http://www.epa.gov/captrade

CLEAN AIR MARKET PROGRAMS

Human Health