Modeling of Energy Efficiency in Climate Policy Analysis

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December 8, 2010

ACEEE 30th Anniversary Policy & Analysis Conference
Washington, DC

Agenda

- Summary
- History of EPA Analysis of Climate Legislation
- Addressing Energy Efficiency Provisions in Waxman-Markey (HR 2454)
  - Approach
  - Results
- Challenges in Modeling Energy Efficiency Policies
- Looking Ahead

EPA Modeling of Energy Efficiency in Context

- From 2005 through 2010, at the request of Congress, EPA conducted comprehensive economic analyses of the leading federal climate bills
  - Climate policy involves economy-wide price changes and investment impacts
  - For economy-wide modeling, EPA has used computable general equilibrium (CGE) Models, which track changes in prices throughout the economy for decades in the future, combined with bottom-up estimates of EE impacts
  - Although CGE models offer a comprehensive view, they have less geographic and technological detail than bottom-up energy sector models
    - Include a "price response" where energy demand falls in response to higher energy prices
    - Generally do not contain the technology detail necessary to represent EE policies

- Over this period, EPA's analyses represented increasing numbers of energy efficiency provisions (e.g., building codes, energy efficiency resource standard, and allocation of allowance value to support energy efficiency programs)

- Increased attention to modeling in this critical policy area is paying dividends, but more work is needed

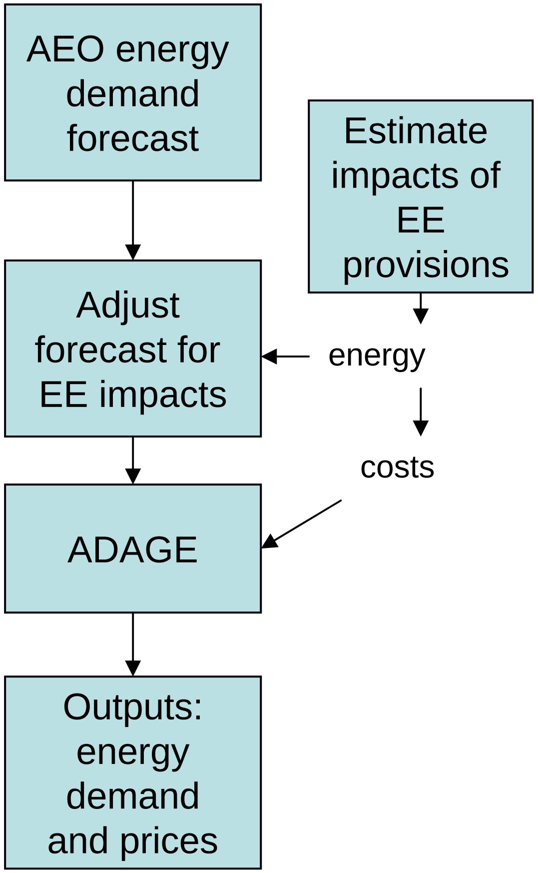
EPA Analysis of Climate Legislation

Increasing Inclusion of EE Provisions

- Lieberman-Warner (S 2191), March 2008
- Waxman-Markey Discussion Draft, April 2009
- Waxman-Markey Final (HR 2454), June 2009
- Waxman-Markey Voinovich (HR 2454), January 2010

General Approach for Modeling of EE Provisions in Climate Legislation

- Estimate energy and cost impacts of key EE provisions using "bottom-up" techniques
  - Typical provisions addressed include
    - Allowances allocated to support EE programs
    - Federal building codes
    - Energy Efficiency Resource Standard (EERS) or EE component of a Renewable Electricity Standard (RES)
- Use EE energy impacts to adjust energy demand forecast (recent Annual Energy Outlook from EIA/DOE) fed into ADAGE
- Represent cost impacts within ADAGE as appropriate
- Isolate/highlight impacts with "side scenario" where EE provisions have been removed from the core policy case
- Present EE results/impacts within presentation of full EPA analysis



Estimating Impacts of EE in HR 2454
Provisions Addressed

- Provisions analyzed
  - Funding of EE programs through allowance allocations to States and gas distribution companies (Title I, sub D)
  - EE component of the Combined Efficiency and Renewable Electricity Standard (CERES) (Title I, sub A)
  - Mandatory building codes (Title II, sub A)
- EE provisions not analyzed include*
  - Lighting and appliance standards** (Title II, sub B)
  - Industrial EE programs (Title II, sub D)
  - Energy savings performance contracting (Title II, sub E)
  - Public institutions (Title II, sub F)

* Except for lighting standards, provisions not analyzed are expected to have minor impacts and are particularly difficult to quantify. Provisions account for ~4/5's of ACEEE's estimated impacts.

** Lighting and appliance standards are only omitted provision with significant quantifiable impacts

Estimating Impacts of EE in HR 2454
Approach by Provision

- Allowance allocations to EE
  - Use allowance price to estimate value by year
  - Apply average "cost of saved energy" (CSE) ($35/MWh) and "measure life" (10 yrs) to estimate energy savings by year
  - Allocations for electricity and home heating oil go to States; allocations for natural gas go to local distribution companies
- EE component of CERES
  - Assume 25% of RES met with EE (25% to 40% is allowable)
  - Net out assumed BAU utility program EE savings in AEO forecast
  - Net out new nuclear and CCS generation from baseline
  - Apply CSE and measure life to estimate costs by year
- Mandatory building codes
  - Evaluate timeline for implementation steps and impacts
  - Apply mandated % savings to "regulated" end uses for forecast residential and commercial new construction to estimate energy savings by year
  - Estimate costs assuming 10 year simple payback

Estimating Impacts of EE in HR 2454

Summary Results*

- "Bottom-up" estimate of demand impacts from EE provisions
  - Electricity demand is reduced by 5% of reference case in 2020 and 6% in 2050
    - See next slide for detail by provision
  - Natural gas demand is reduced by 4.4% of reference case in 2030 and 4.3% in 2050

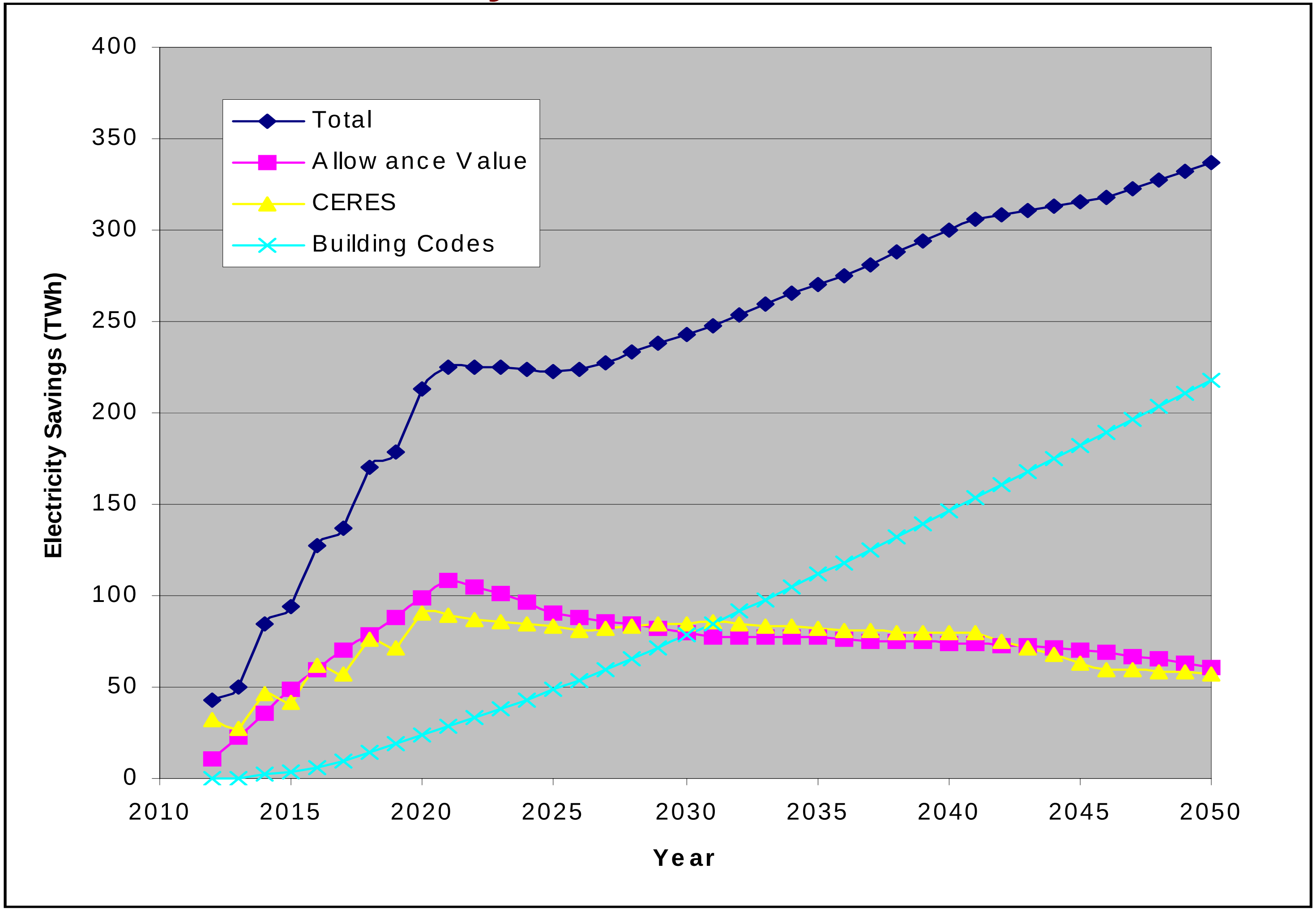
- Modeled economic impacts of EE provisions (from ADAGE)**
  - Allowance prices slightly lower: ~1.5% lower (2015-2050)
  - Fossil fuel prices slightly lower: coal and natural gas ~1% lower (2015-2050)
  - Electricity prices slightly lower: <1% lower (2015-2050)

* These results are taken from EPA's posted analysis of HR 2454. See Appendix for a complete set of slides from that analysis that reflects impacts of EE provisions.

** Modeled economic impacts of EE provisions are substantially muted in HR 2454 due to the offset provisions that allow significant use of relatively low cost offsets.

HR 2454 “Bottom-Up” Results

by EE Provision



- Allowance Value: impact decreases as % of allowances to EE drops (9.5% to 4.5%)
- CERES: impact decreases as nukes and CCS generation grows (alters baseline that is regulated)
- Building Codes: impacts rise steadily with new construction and increasingly stringent codes (~1%/yr)

HR 2454 ADAGE Results

Interaction of EE Impacts and Price Response

- "Price response" effect
- EE "rebound" effect
- Over the full term of analysis (2010 – 2050) the "rebound" effect negates ~1/3 of EE-driven reductions in electricity demand
- By 2050, price response becomes more dominant relative to EE impacts

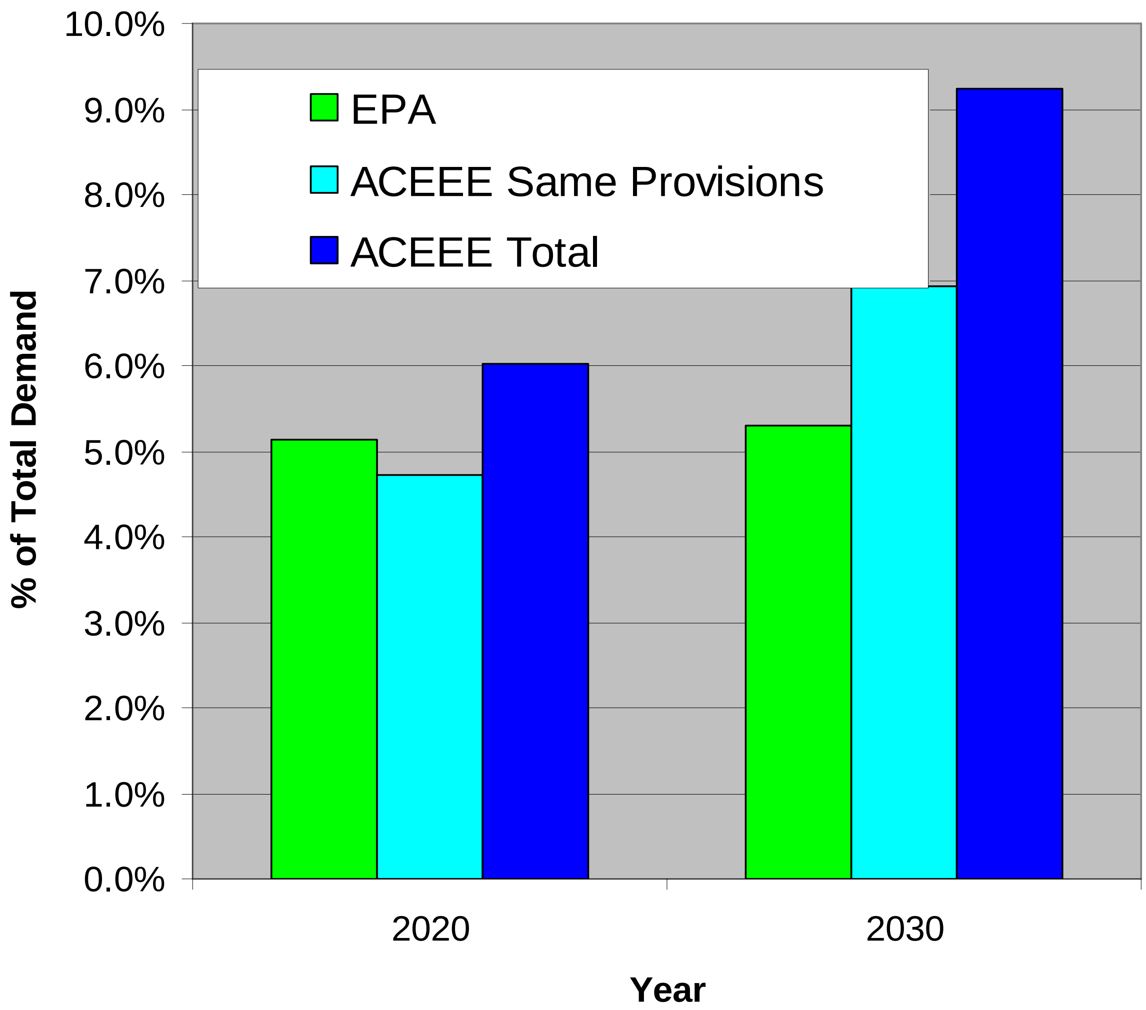
HR 2454 EE Results in Context
Comparison with Other Analyses

- H.R. 2454 EE provisions explicitly analyzed ("bottom up")
  - American Council for an Energy Efficient Economy (ACEEE)
- H.R. 2454 economy-wide modeling
  - Energy Information Administration (NEMS)
  - Massachusetts Institute of Technology (EPPA)
  - Charles River Associates (MRN-NEEM)
- EE "economic potential" studies (unrelated to H.R. 2454)
  - McKinsey & Co., "Unlocking EE in U.S. Economy" (July 2009)
  - Electric Power Research Institute (EPRI), "Assessment of Achievable Potential of EE/DR in the U.S." (January 2009)

HR 2454 EE Results in Context

"Bottom Up" Estimates of Electricity Impacts

Comparison with ACEEE Analysis



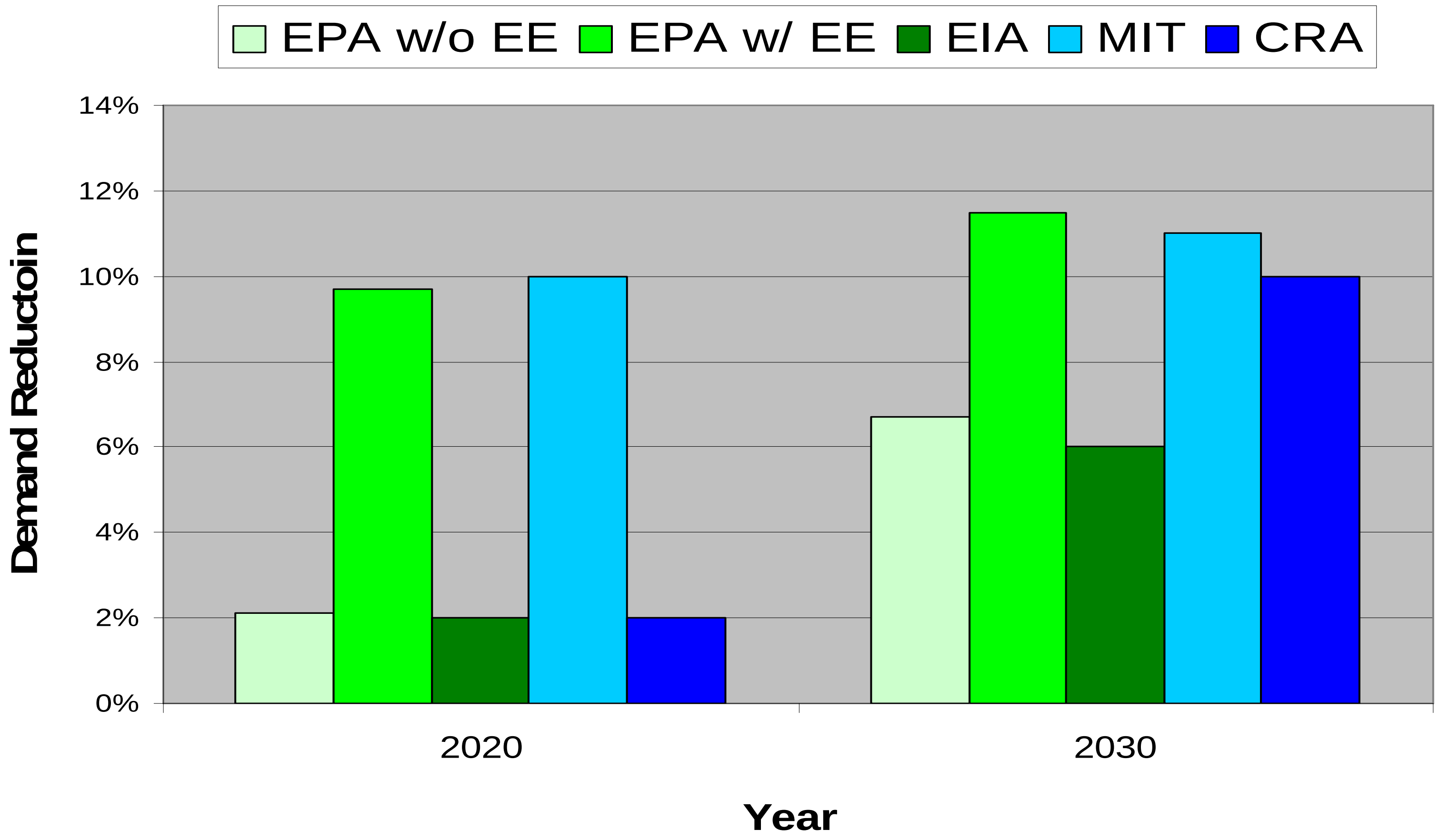
"ACEEE Same Provisions" refers to their analysis of the **same key provisions** as EPA.

"ACEEE Total" refers to their analysis of **all** EE provisions in the bill.

EPA's analysis addresses the provisions that account for 75-85% of ACEEE's total impacts.

HR 2454 EE Results in Context

Economy-wide Modeling

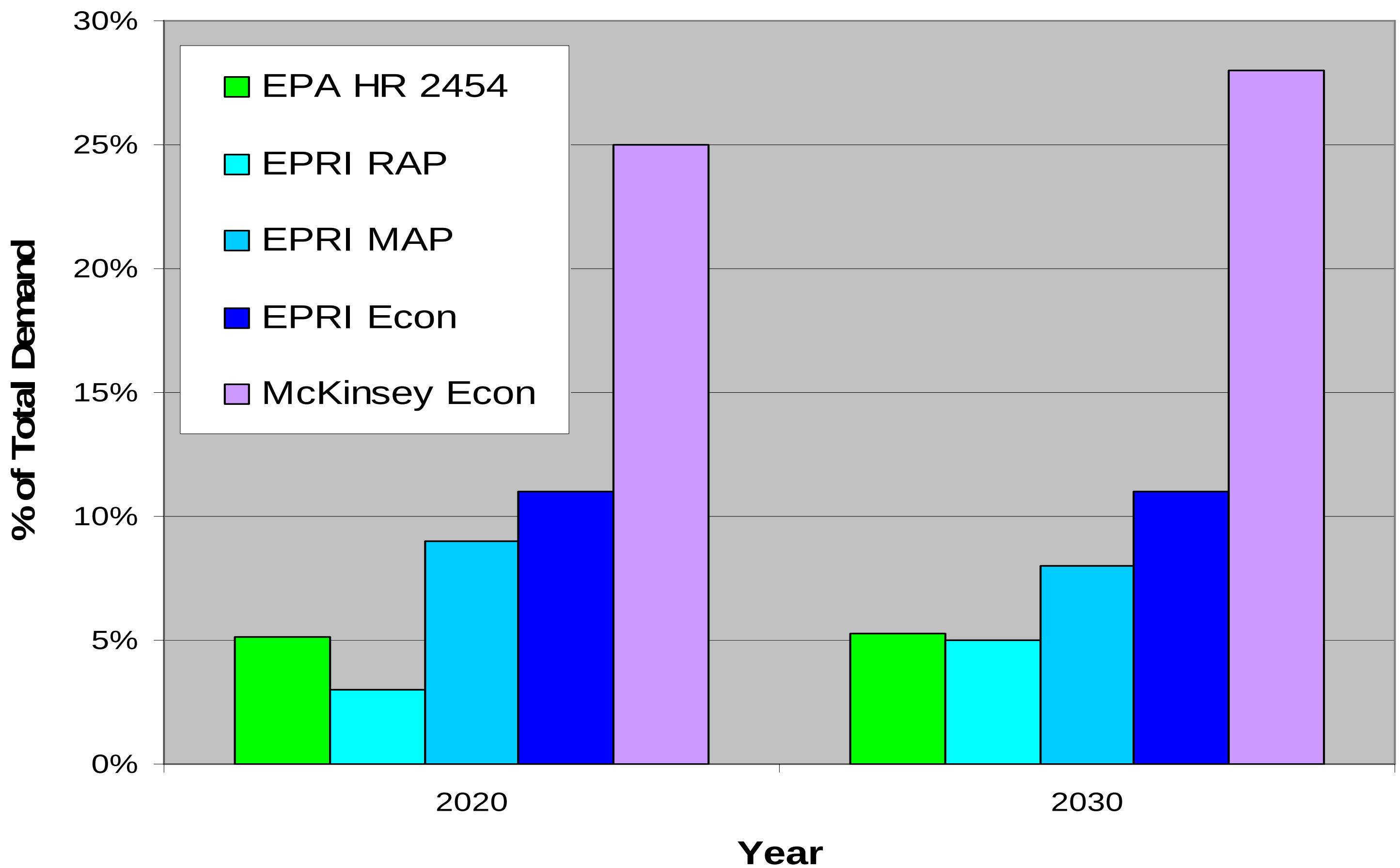


EPA w/o EE = without EE provisions (price response effects only)
EPA w/ EE = with EE provisions (effects of price response + EE provisions)
EIA = Energy Information Administration (effects of price response + EE provisions)
MIT = MIT's EPPA Model (price response effects only, no EE provisions)
CRA = Charles River Associates MRN-NEEM Model (price response effects only, no EE provisions)

HR 2454 EE Results in Context

Comparison w/ EE Potential Studies

HR 2454 EE impact (bottom-up analysis) similar to EPRI achievable values and a significant portion (25% - 40% in 2020) of McKinsey and EPRI economic potentials



EPRI RAP = Realistic Achievable Potential
EPRI MAP = Maximum Achievable Potential
EPRI Econ = Economic Potential
McKinsey Econ = Economic Potential

Issues in Modeling EE

- Economy-wide economic models are limited in their ability to represent EE policies
  - Include a "price response" where energy demand falls in response to higher energy prices
  - Usually do not contain the technology detail necessary to represent EE policies
  - EPA's hybrid approach is practical solution but not perfect
- Specific issues with current method
  - Reconciling efficiency embedded in EIA/AEO baseline forecast
  - Appropriate values for "cost of saved energy" and "measure life"
  - Incorporating associated costs within ADAGE
  - Specific "bottom-up" techniques used
  - Ability to estimate impacts of appliance standards
  - Interpreting/presenting ADAGE outputs and interaction between EE provision effects, price response, banking, etc.

Looking Ahead

- Energy efficiency provisions are likely to be important to any new energy or climate proposals
- EPA and others continue to develop modeling methodologies to better account for energy efficiency policies
  - In addition to EPA, there is EMF-25 as well as new focus by EPRI and EIA
- ACEEE and other energy efficiency stakeholders (e.g., BECC Conference participants) continue to play a valuable role in advancing methodologies for improving recognition

Appendix

EE-related Slides from EPA HR 2454 Analysis

U.S. Environmental Protection Agency
Office of Atmospheric Programs

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

6/23/09

Major Findings

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

- The analysis focuses on the economy wide cap & trade program, the energy efficiency provisions, and the competitiveness provisions.
  - Sensitivity analysis conducted for:
    - H.R. 2454 without Energy Efficiency Provisions
    - H.R. 2454 without Output Based Rebates
    - H.R. 2454 with Reference Level Nuclear
    - H.R. 2454 with No International Offsets
  - Several provisions outside of the cap & trade program are not modeled in this analysis (e.g. lighting standards are not in the analysis, and the renewable electricity standard is not included in economy-wide modeling but is modeled as a sensitivity in power sector analysis).
  - See Appendix 1 for a full description of the bill and which provisions are modeled in this analysis.

Major Findings

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

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

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

Analytical Scenarios

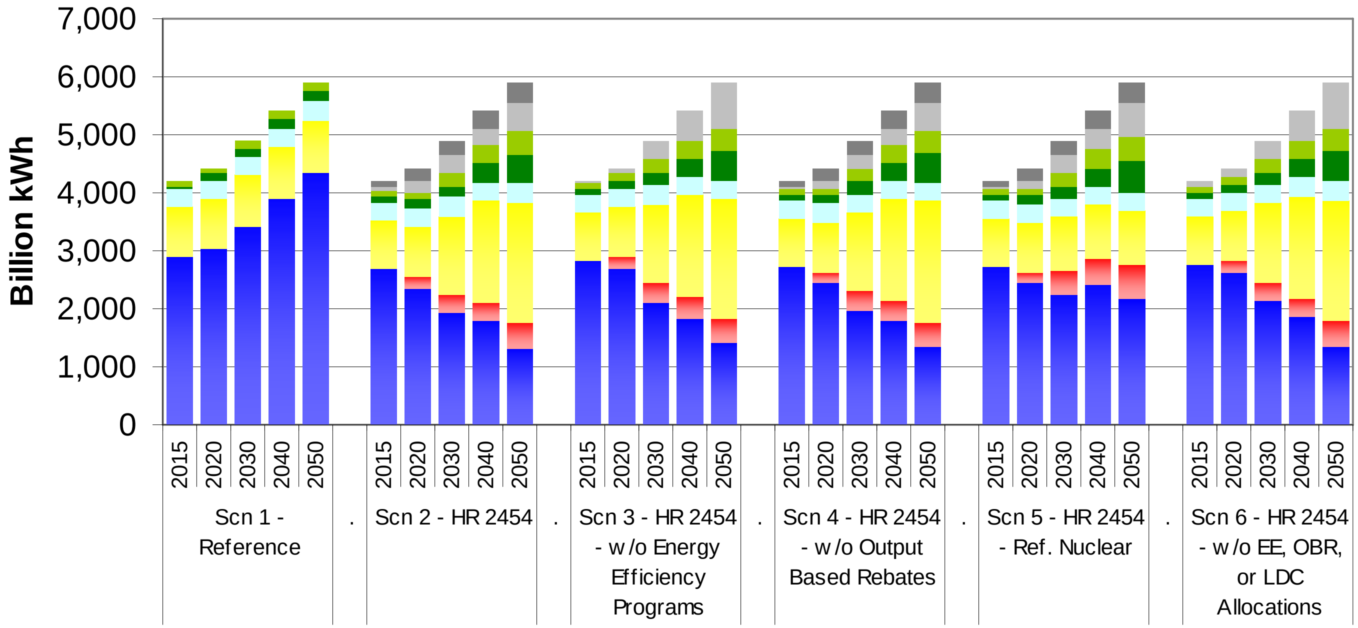
EPA analyzed 7 different scenarios in this preliminary report. A full description of all scenarios is available in Appendix 1. The assumptions about other domestic and international policies that affect the results of this analysis do not necessarily reflect EPA's views on likely future actions. These scenarios do not account for the American Recovery and Reinvestment Act, which could further advance the deployment of clean energy technologies.

1) **EPA 2009 Reference Scenario**
   - This reference scenario is benchmarked to the AEO 2009 forecast (March release) and includes EISA but not ARRA.
     - Does not include any additional domestic or international climate policies or measures to reduce international GHG emissions
     - For domestic projections, benchmarked to AEO 2009 (March release) without the American Recovery and Reinvestment Act of 2009 (ARRA).
     - Does not include the recently announced federal greenhouse gas and fuel economy program for passenger cars, light-duty trucks, and medium-duty passenger vehicles.
     - For international projections, used CCSP Synthesis and Assessment Report 2.1 A MiniCAM Reference.
2) **H.R. 2454 Scenario**
   - This core policy scenario models the cap-and-trade program established in Title III of H.R. 2454.
     - The strategic allowance reserve is not modeled (i.e., these allowances are assumed to be available for use and not held in reserve).
   - Provisions explicitly modeled in this scenario:
     - CCS bonus allowances
     - EE provisions (allowance allocations, building energy efficiency codes, and energy efficiency standard component of CERES).
     - Output-based rebates (Inslee-Doyle)
     - Allocations to electricity local distribution companies (LDCs) (used to lower electricity prices)
   - Widespread international actions by developed and developing countries over the modeled time period. International policy assumptions are based on those used in the 2007 MIT report, "Assessment of U.S. Cap-and-Trade Proposals."
     - Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling gradually from the simulated Kyoto emissions levels in 2012 to 50% below 1990 in 2050.
     - Group 2 countries (rest of world) adopt a policy beginning in 2025 that returns and holds them at year 2015 emissions levels through 2034, and then returns and maintains them at 2000 emissions levels from 2035 to 2050.
3) **H.R. 2454 Scenario without Energy Efficiency Provisions**
4) **H.R. 2454 Scenario without Output-Based Rebates**
5) **H.R. 2454 Scenario with Reference Nuclear**
6) **H.R. 2454 Scenario without Energy Efficiency, Output-Based Rebates, or LDC Allocations***
7) **H.R. 2454 Scenario with No International Offsets**

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

U.S. Electricity Generation

H.R. 2454 Scenario Comparison (ADAGE)



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

** *Energy Efficiency Programs* represents the energy savings achieved by the energy efficiency programs funded by allowance allocations or auction revenues, the energy efficiency portion of the RES, and the impact of revised building codes.

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