Embracing Complexity: Climate Policy with Imperfect Economies and Federal Governments

Dallas Burtraw
Resources for the Future

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Blair Beasley, David Evans, Arthur Fraas, Josh Linn, Erin Mastrangelo, Karen Palmer, Anthony Paul, Matt Woerman

My intent: Rethink how to direct the power of incentive-based regulation in the current climate policy context.

My anxiety:
Priscillian of Avila

Roadmap

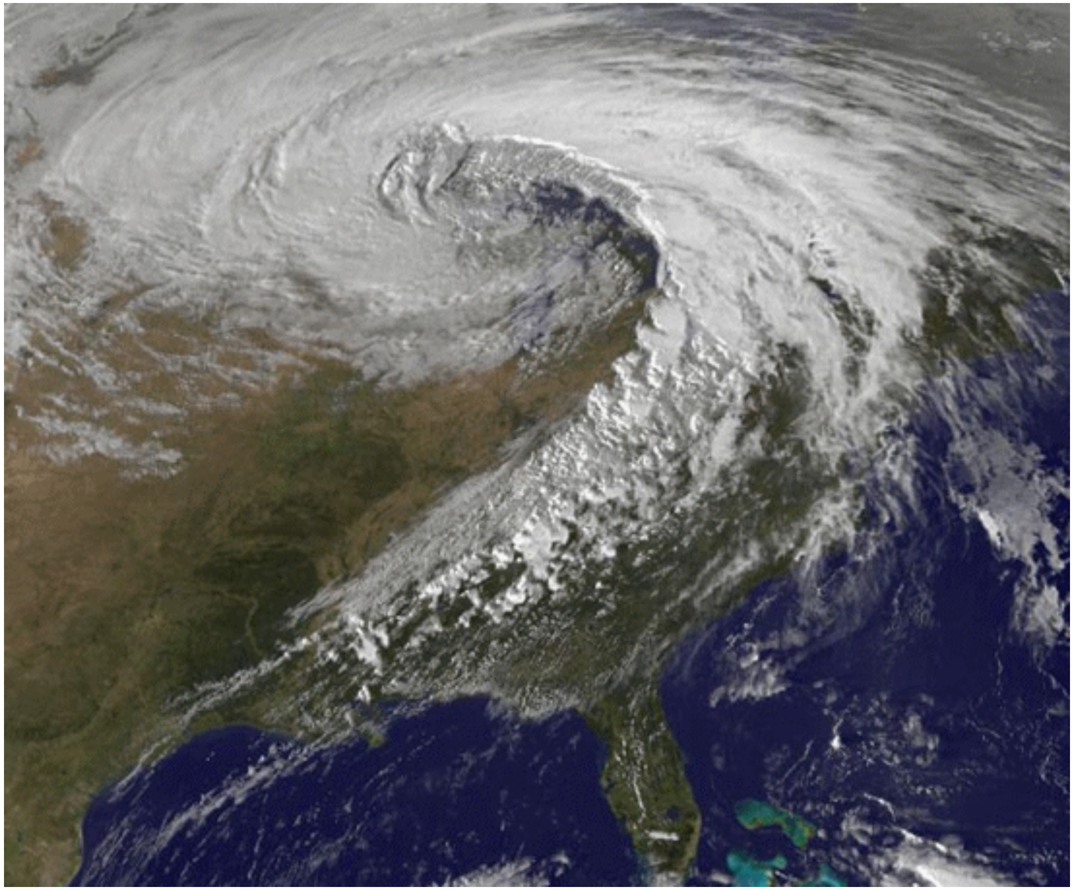
- Environmental federalism (in U.S., with international analogues)
- Prices *versus* regulation
- California, the U.S. Clean Air Act and additionality
- Performance standards
- Institutional context for climate policy implementation and economic research

First let's always remember why we are having this conversation…

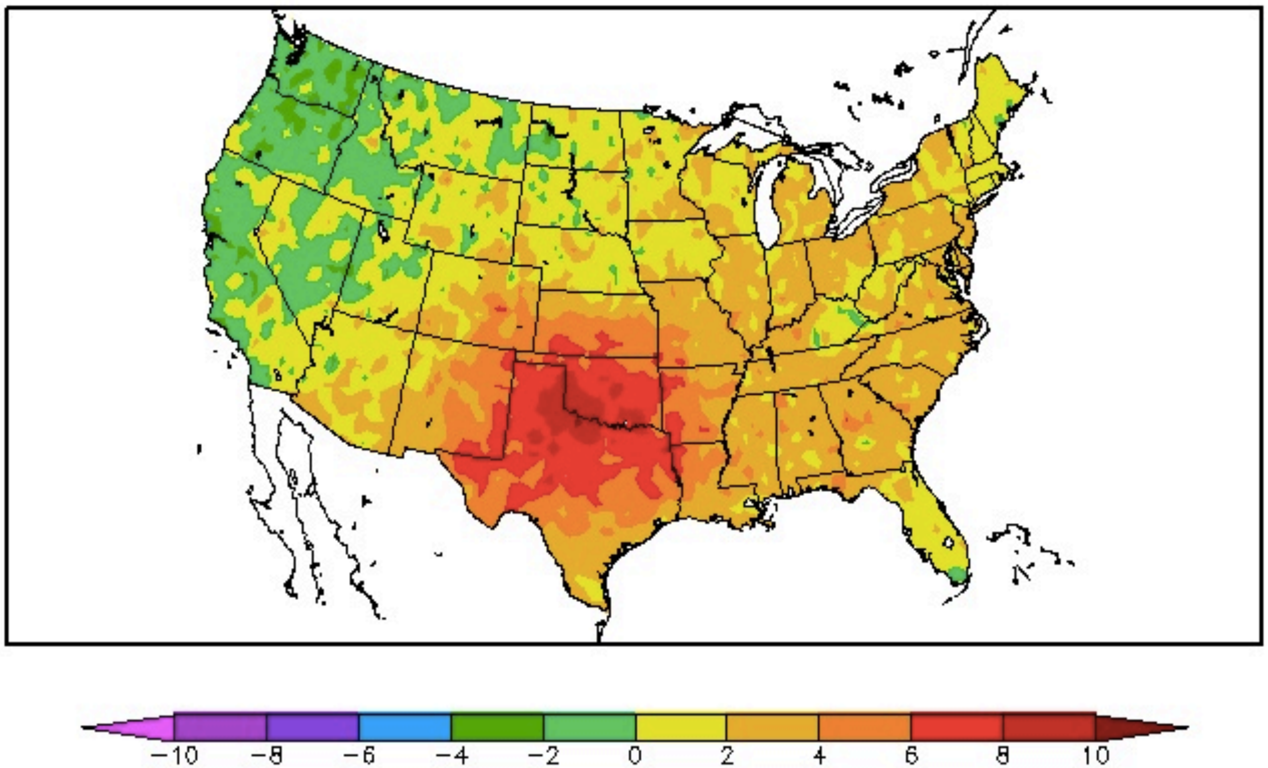
2008 Mississippi River Floods

Eight of the top 10 years for extreme one-day precipitation events have occurred since 1990

The "Chiclone" – 26 October 2010 *Superstorm*



Departure from Normal Temperature (F)
6/1/2011 – 8/31/2011



Source: *Climate Central*

State & Local Roles in U.S. Environmental Policy

- Relevant state & local activities are extensive (land use, transportation planning, permitting, standards, etc.).
- But these functions are excluded from virtually all economic models.
- The term "environmental federalism" is a misnomer – it actually describes a <u>shared</u> role for national and state governments.

❖ Analogy (in a loose sense) to nationally appropriate mitigation actions.

Climate Change Economics, forthcoming

Federalism issues for economic and policy research

- Assumption of harmonization *as if* in a unitary model of government is unhelpful.
- Under federalism, cost effective federal policy requires support and cooperation from the states. How to elicit that?
- Three ways national government affects state policy:
  1. Command
  2. Bribe and subsidize
  3. Markets
- Meanwhile, states have their own ideas.

  Two conflicting views frame the debate:
  - "Meet or exceed"
  - "Preemption"

Should we expect a price signal to be sufficient?

- Is the potent price signal politically achievable?
- Is the price signal salient, especially for subnational government?
- Are decision makers (firms, households) omniscient?
  - Is attention not a scarce resource?

If perhaps not, then…

- What is the role for subnational policies?
  - How can national policy encourage those policies to be cost effective?
- What is the role for regulation?
- Which, prices or regulation, is likely to be more successful in establishing international cooperation?

Doremus and Hanemann, 2008

Additionality under an Emissions Cap?

We have understanding of prices as a cost effective policy tool

- But, incidentally 100% leakage of subnational or individual efforts
  - An " emissions cap is an emissions floor"

For example, under Waxman-Markey cap and trade:

- Effective preemption of subnational efforts
- Explicit preemption of Clean Air Act for stationary sources
- Crowding out of emissions reductions due to fuel market or technology changes

In this case,… we must rely on the price signal to be passed through to various functions of government, and to do all of the work. Will it?...

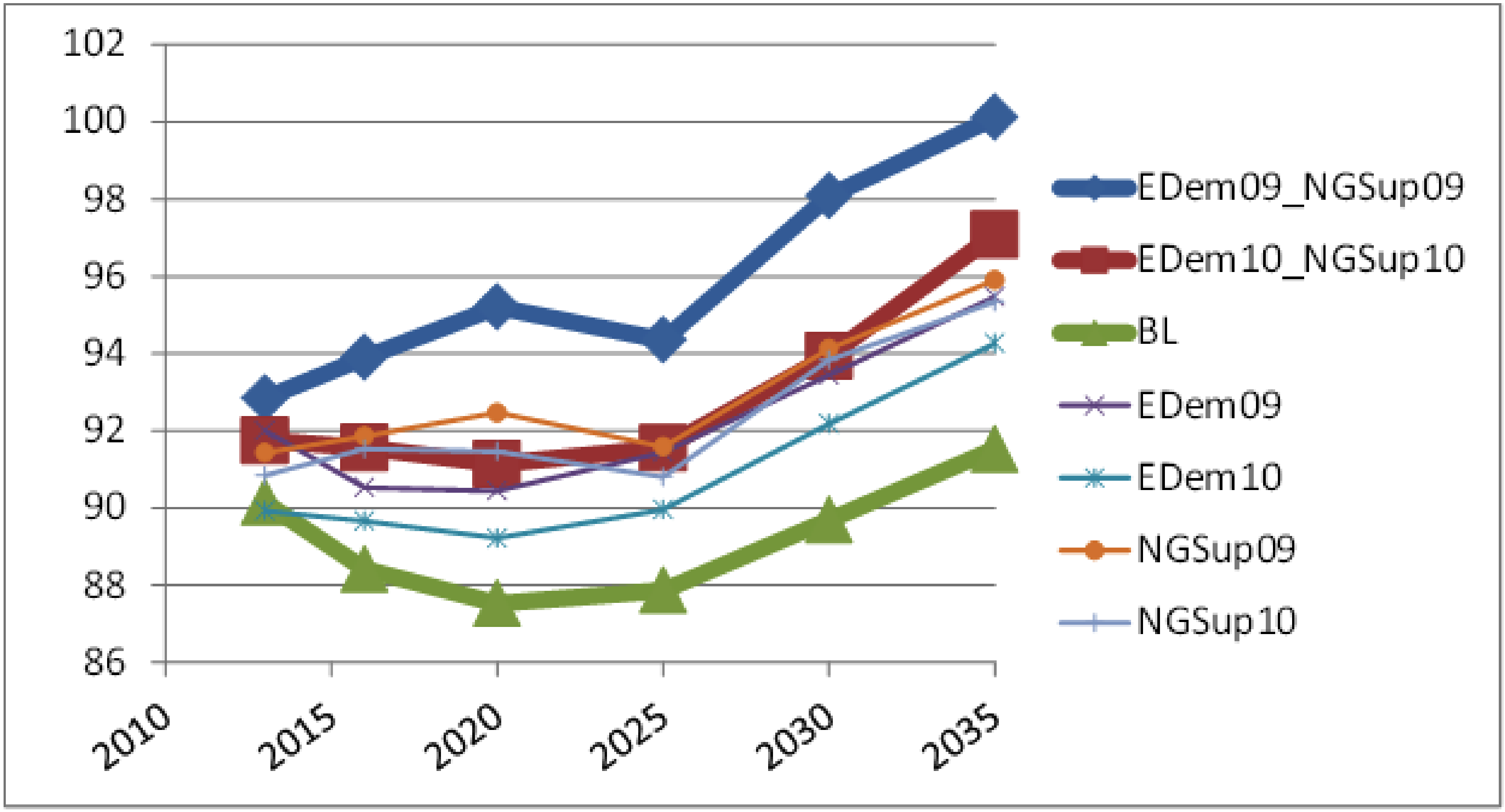
Goulder and Stavins 2011, Burtraw and Shobe 2009

Secular Trends, EPA's Regulatory Agenda… and CO_2

- ✓ Important Change in Natural Gas Supply & Electricity Demand
  - – Increased supply of natural gas from shale gas extraction
    - 2020 price of natural gas has fallen by 35% between EIA's 2009 and 2011 forecasts
    - 2020 consumption of natural gas has increased by 18% between same forecasts
  - – Decreased demand for electricity due to efficiency measures
    - 2020 electricity consumption has decreased by 151 TWh (4%) between same forecasts

Secular Trends in the Electricity Sector

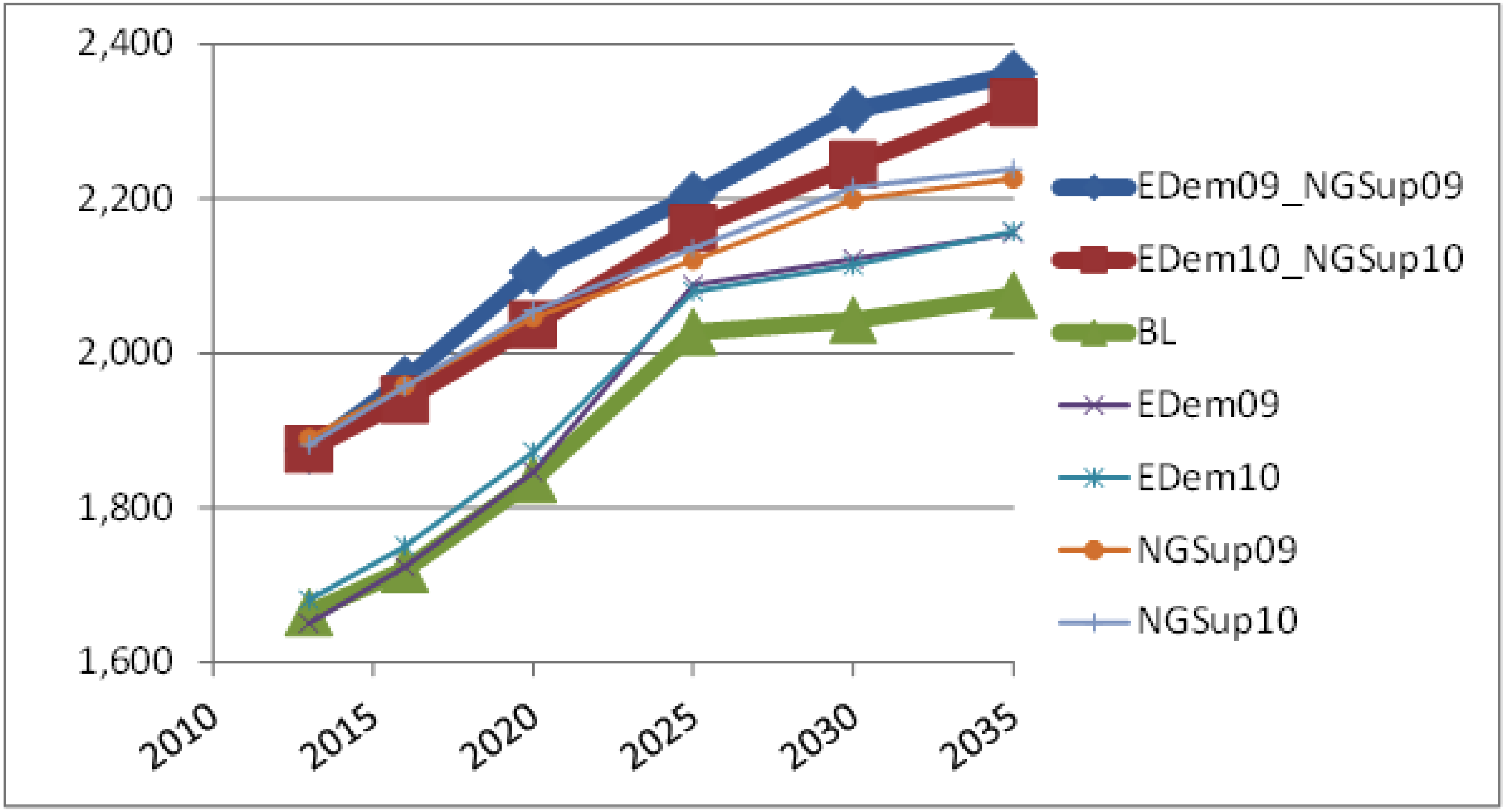
National Average Electricity Price (2009$/MWh)



The Electricity Journal, forthcoming

Effects on Coal (Prior to CSAPR / MATS)

Coal Generation (TWh)

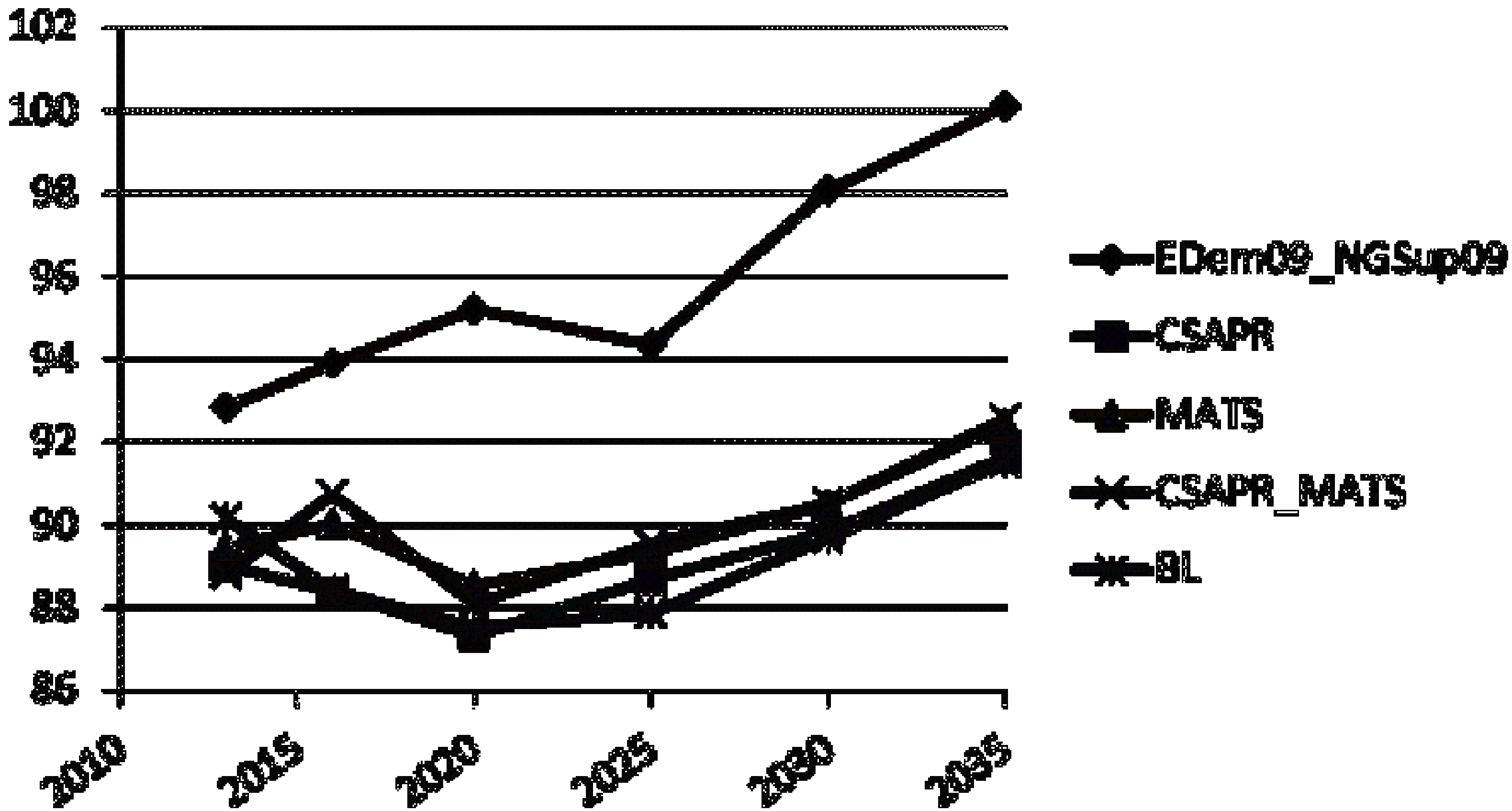


Secular Trends, EPA's Regulatory Agenda and Reductions in CO_2

- ✓ Important Change in Natural Gas Supply & Electricity Demand
- ✓ Cross State Air Pollution Rule (CSAPR)
  - Finalized in June 2011, replacing CAIR; stayed by court in December; decision imminent.
  - EGUs in 27 states subject to new constraints on SO_2 and NO_x. Limited trading.
- ✓ Mercury and Air Toxics Standard (MATS)
  - Under court order. Final rule issued in December 2011.
  - Regulates heavy metals including mercury and acid gases.
  - Compliance at most units will also reduce SO_2. No trading.
- ❑ Coal Combustion Residuals Rule - ash
- ❑ Clean Water Act (316(b)) - cooling water
- ❑ Greenhouse Gas Performance Standards

Small Changes in Price, Especially Relative to Secular Trends

Electricity Price Changes under CSAPR and MATS (2009$/MWh)



However, Costs are Substantial

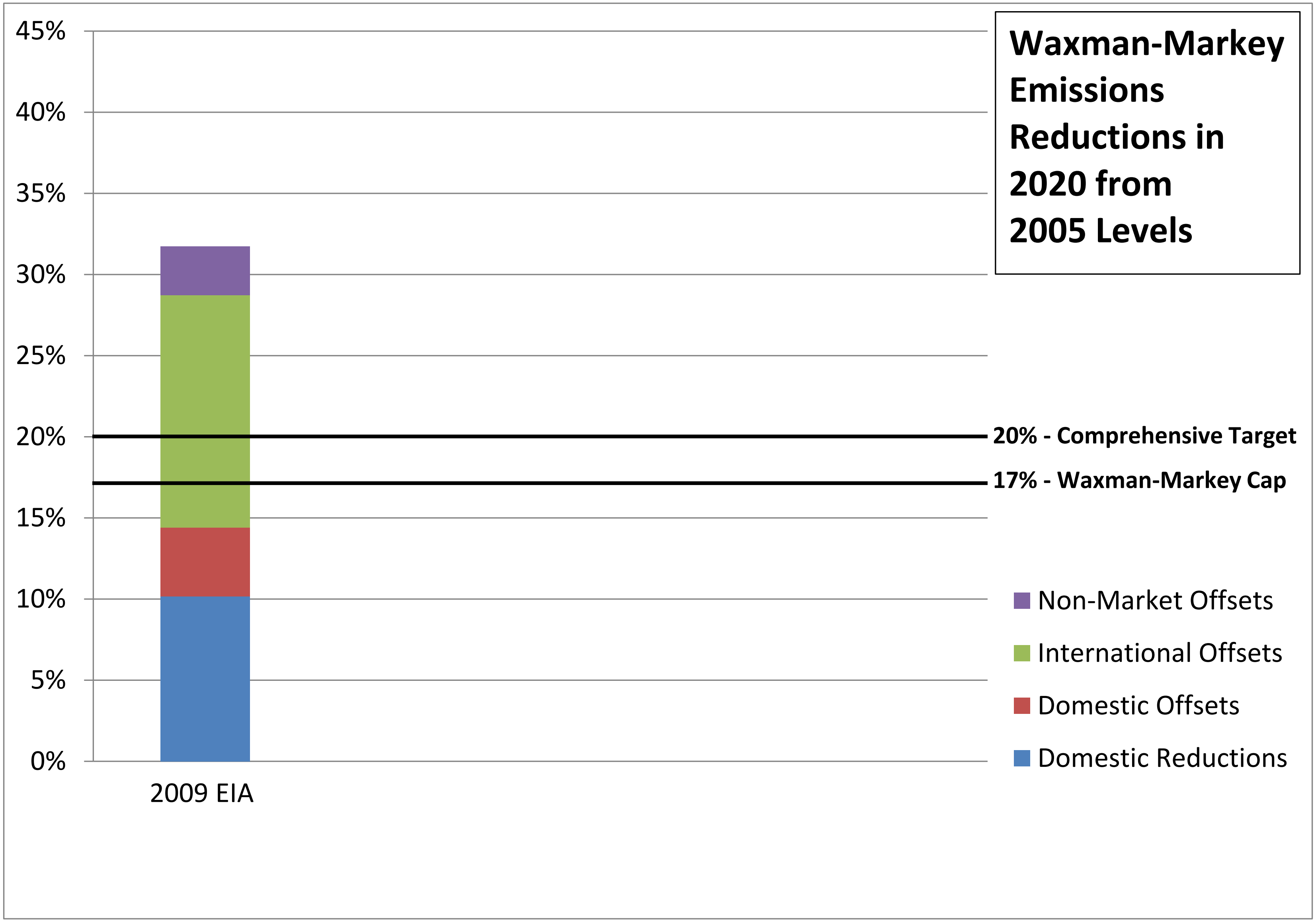
- In 2020, for example, total annual costs are about $7 billion.
- Retail price increase is partially offset by a decrease in the allowance burden associated with tradable allowances under prior rule (CAIR).
    - CAIR allowances were given away for free but reflected in variable costs, and hence in electricity price.
    - Lower "opportunity cost" of CAIR allowances leads to lower marginal generation costs and a downward effect on electricity prices, and less revenue.
    - Effectively, reduction in allowance burden removes a subsidy to emitting generation.
- The combined effect of investment costs and change in allowance burden lead to decrease in producer profits of $3 to $5 billion in 2020.
- Over modeling horizon, consumers pay 70 percent of the costs of the regulations. This is a lower share than typically would occur because of:
    - Expanded natural gas generation more often setting marginal price.
    - Loss of effective subsidy through reduced value of free allowances.

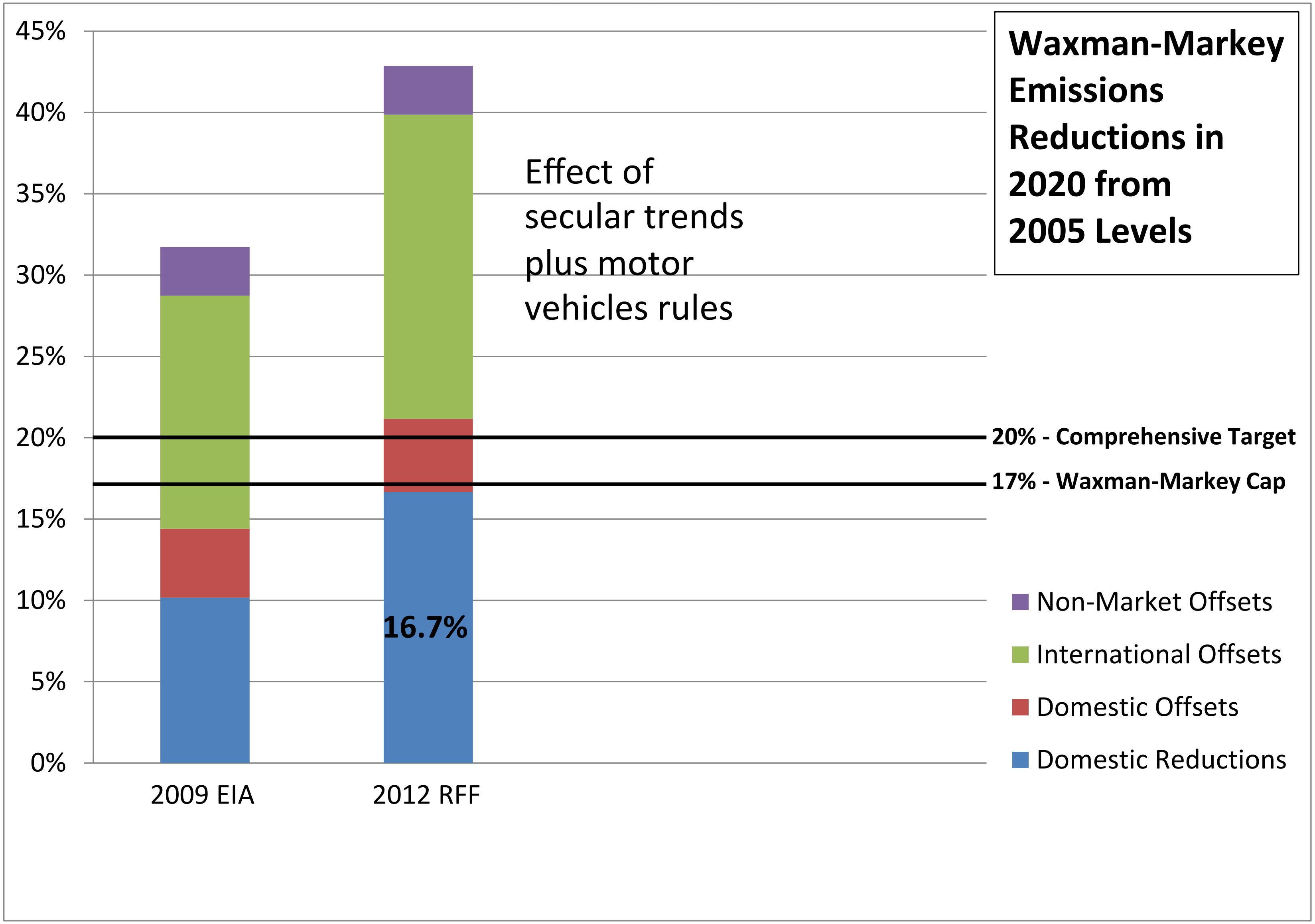
In review:

- Secular trends in fuel prices, electricity demand
- Important changes in regulatory context
- Together provide a punishing blow to coal-fired power

So, what will be the effects on CO_2?

1. Consider effects under cap and trade
2. Consider effects under *Clean Air Act* regime


Waxman-Markey Emissions Reductions in 2020 from 2005 Levels
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
2009 EIA
20% - Comprehensive Target
17% - Waxman-Markey Cap
Non-Market Offsets
International Offsets
Domestic Offsets
Domestic Reductions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Effect of secular trends plus motor vehicles rules
20% - Comprehensive Target
17% - Waxman-Markey Cap
16.7%
2009 EIA
2012 RFF
Non-Market Offsets
International Offsets
Domestic Offsets
Domestic Reductions

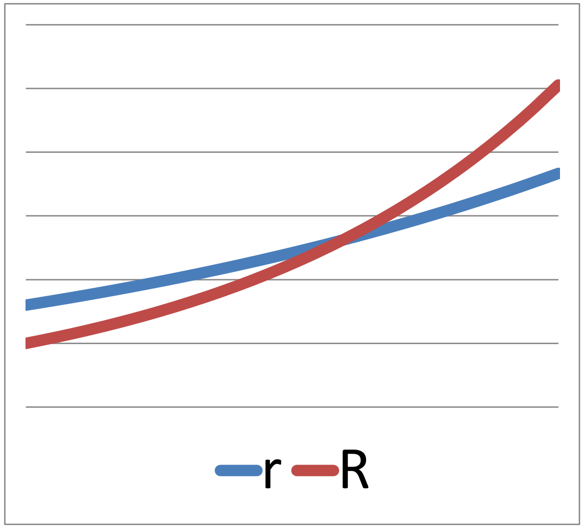
Risk premium for banking allowances

- Regulators or policymakers may institute a policy change in the future that would decrease the value of a banked allowance (Fraas and Richardson, 2012)
  - Investors may not want to bank allowances long-term
  - Holders of banked allowances must receive a premium to assume this risk of a policy change, so the allowance price must rise at a rate greater than the real rate of interest

Risk premium for banking allowances

$$P_t(1+r) = \alpha f_{t+1} + (1-\alpha)P_{t+1} < P_{t+1}$$

$$R_t \equiv \frac{P_{t+1} - P_t}{P_t} = r + \frac{\alpha}{1-\alpha}\left[(1+r) - \frac{f_{t+1}}{P_t}\right] > r$$



where

P is allowance price

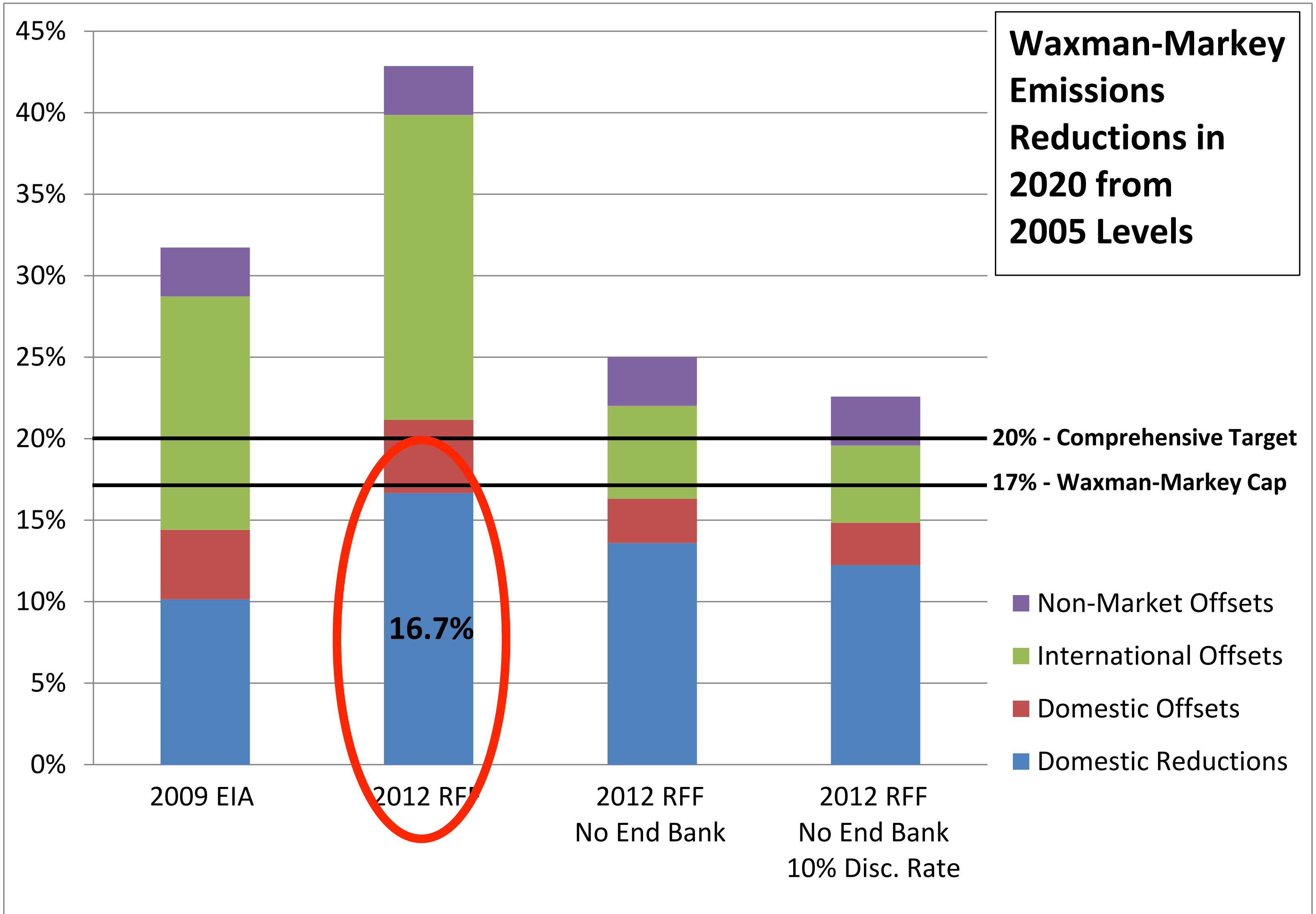
r is real rate of interest

α is the probability of a policy reversal in the next period

f is the value of an allowance if there is a policy reversal

R is the rate at which allowance prices rise

Salant and Henderson, 1978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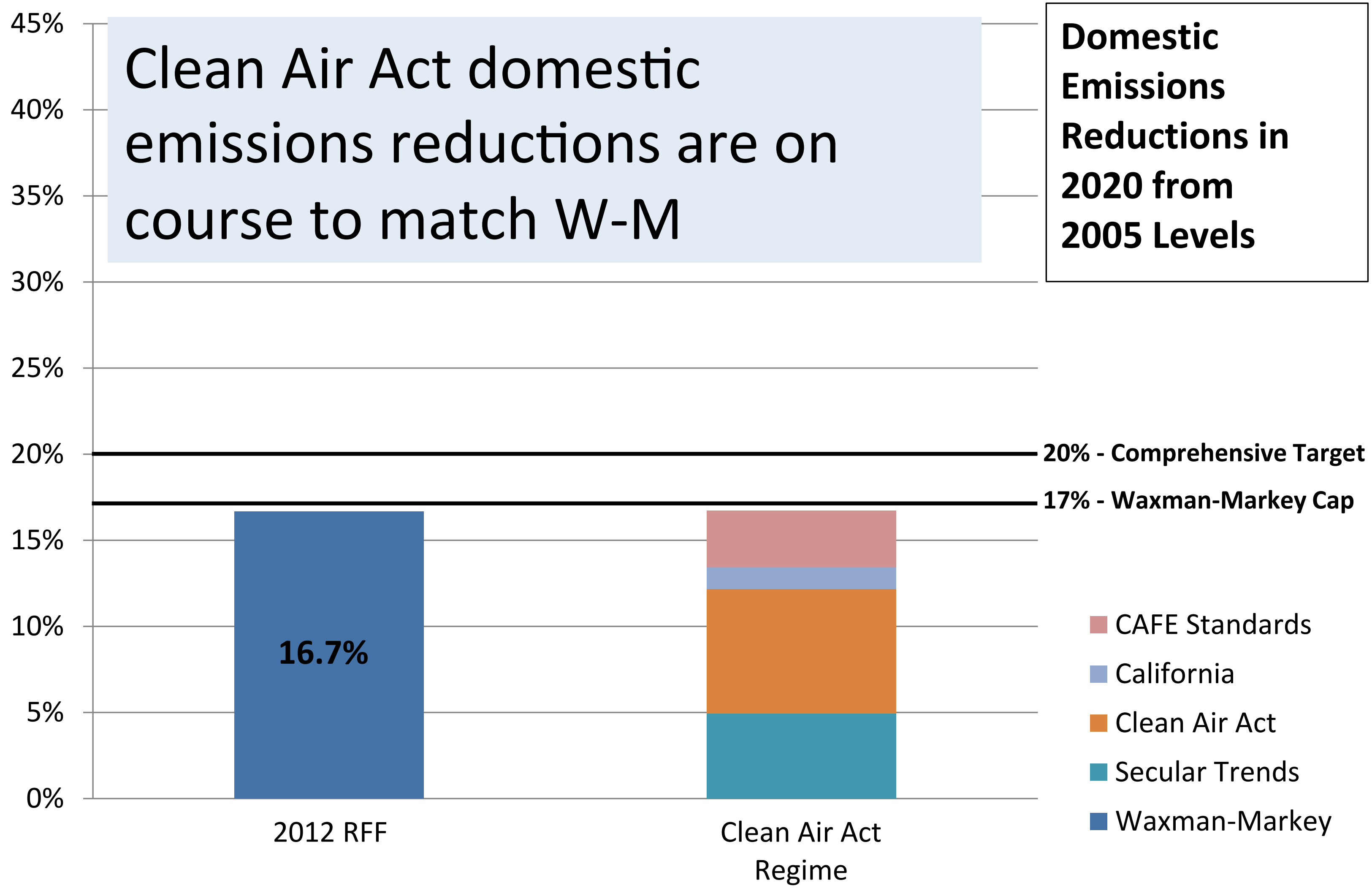
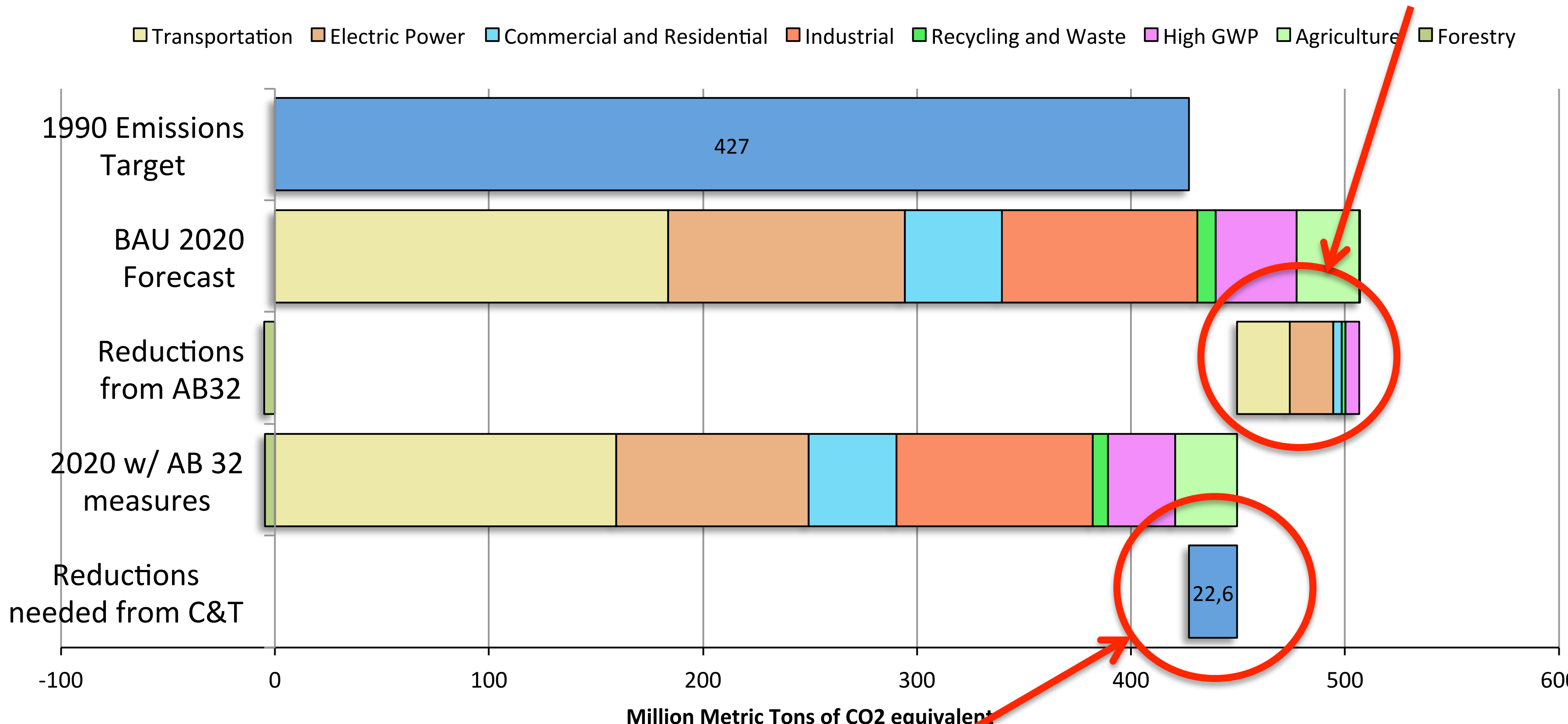
2009 EIA
2012 RFF
2012 RFF No End Bank
2012 RFF No End Bank 10% Disc. Rate
Non-Market Offsets
International Offsets
Domestic Offsets
Domestic Reductions

Clean Air Act domestic emissions reductions are on course to match W-M



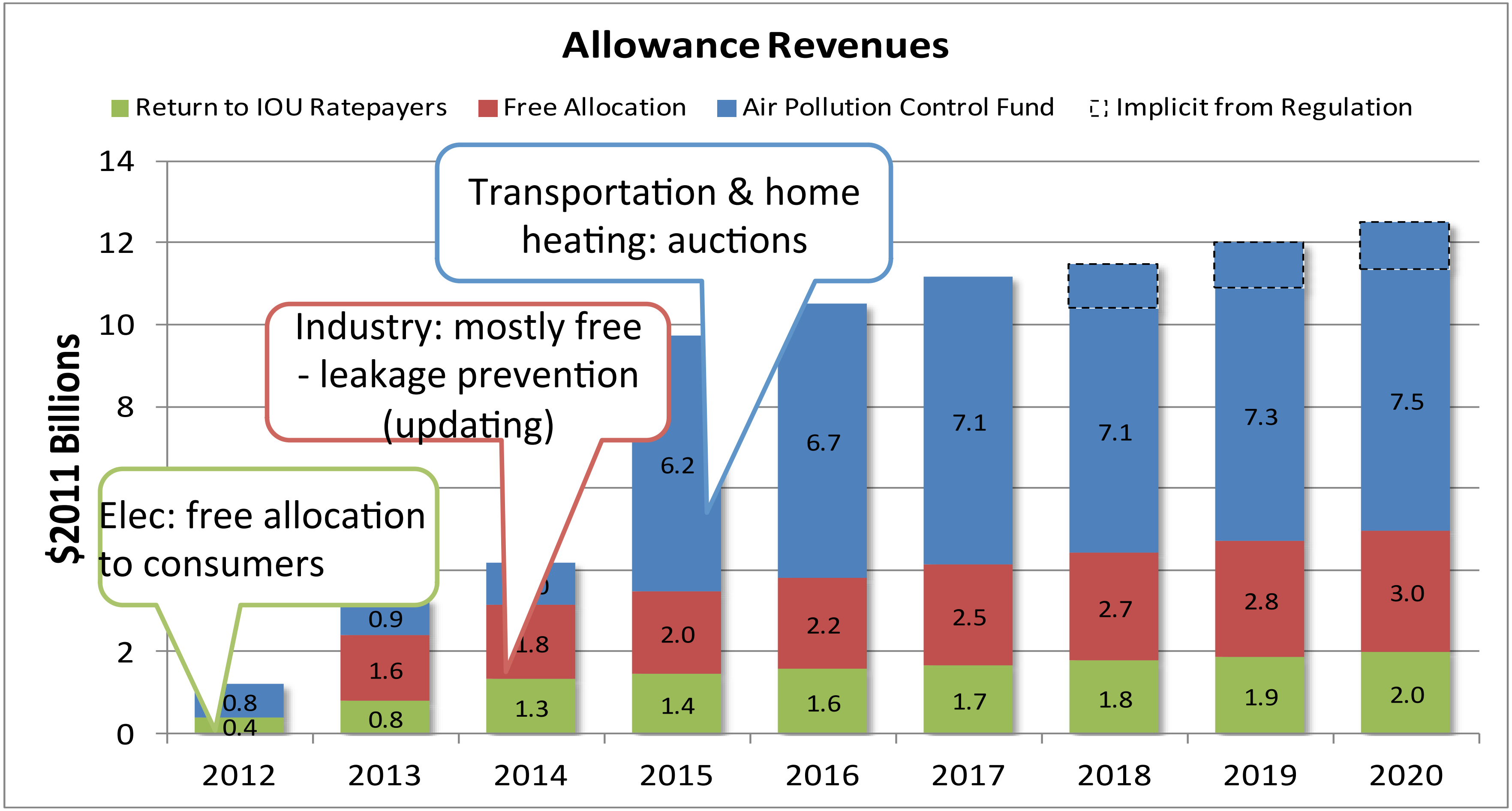
No RPS, No RGGI

California: most reductions come from regulatory measures



Cap and Trade contributes a small amount to overall reductions but ensures that *"no low-cost reductions get left behind."*

California - Representing the policy over time



U.S. -- National Level

Act

2000

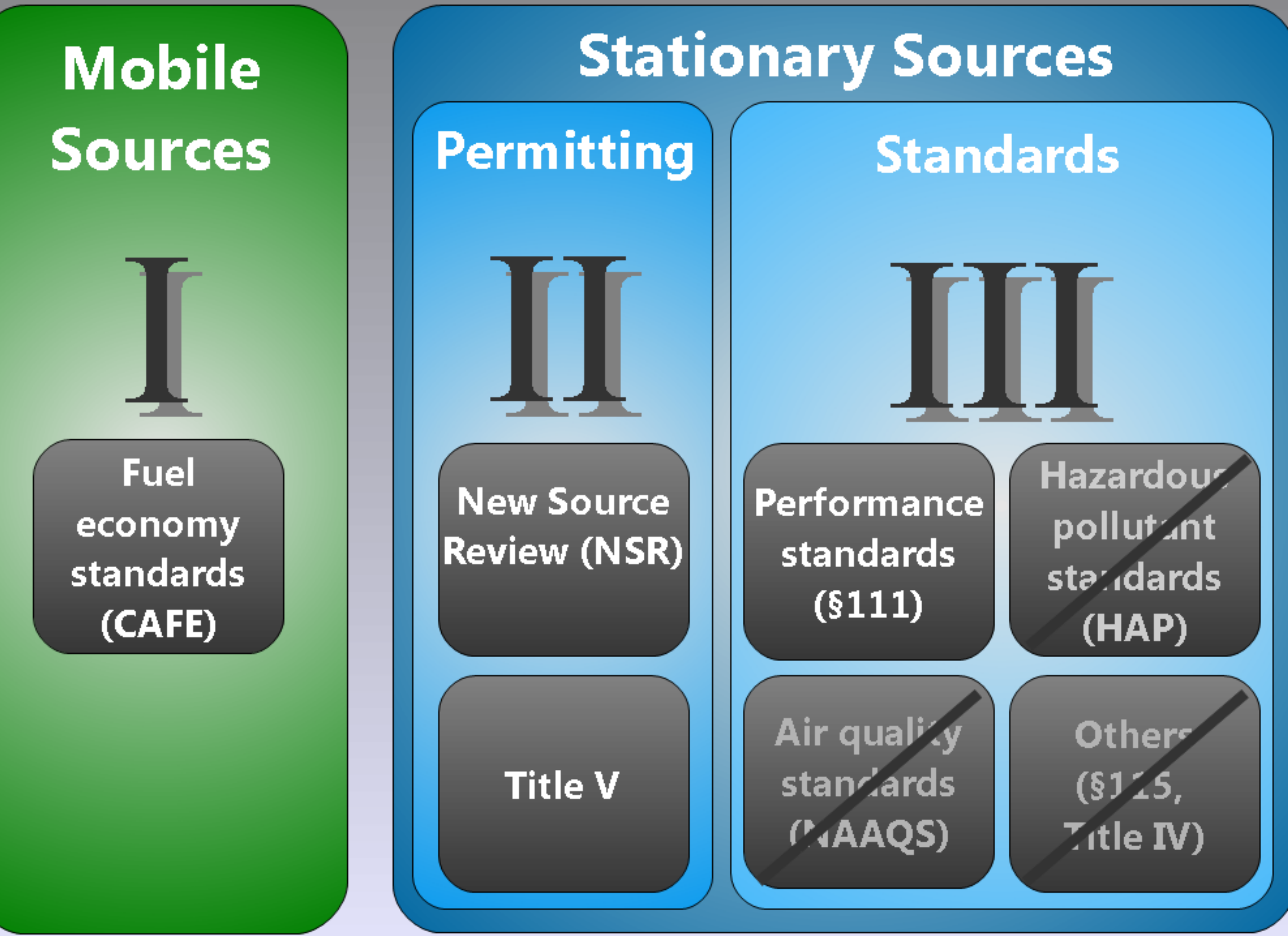
2010

Massachusetts v. EPA

Advance Notice of Proposed Rulemaking

2008 Electio

Clean Air Act Tools for GHGs



US “federal” policy is taking shape under the Clean Air Act

Indeed, the only national-level emission mitigation regulations we have currently are due to the initiative of states

- *Mass. V. EPA*, 2007
- *Settlement Agreement Between State Petitioners, Environmental Petitioners, and EPA*, Dec. 10, 2010

1. Vehicles: 5%/yr improvement to 35.5 mpg fleet avg. in 2016; 54.5 mpg by 2025.
2. Construction permitting (implementation by the states).
3. Performance standards for stationary sources (implementation by the states).
   - Can include flexible mechanisms like cap and trade (RGGI, California).
   - New source rules proposed for steam electricity boilers in April

Performance Standards Remain Uncertain

Dec. 2010: Settlement agreement

~~July 2011: Initial deadline for power plant proposal~~

~~Sep. 2011: New deadline for power plants~~

~~Dec. 2011: Initial deadline for refineries~~

April 2012: New source proposal

Late 2012: Final GHG new source rule ?

2013: GHG existing source rule ?

Proposed GHG standard for <u>new fossil steam boilers</u>

- Price-based policy not available under CAA
- 1,000 pounds CO_2 per MWh (equivalent to natural gas combined cycle)
- New flexibility:
  30-year averaging with obligation for year 10 CCS retrofit
  - Dynamic inconsistency (like nuclear phase outs)
- *Fix?:* Alternative compliance payment to secure unfunded obligation for retrofit by year 10

Patino Echeverri et al. 2012

Modeling GHG New Source Standard

- Traditional (inflexible) standard delays investment and often increases cumulative emissions
  - Familiar "anti-new source bias"
- Uncertainty is as important as "anti-new source bias"
- Under uncertainty, traditional standard can accelerate investment. Traditional standard has two effects:
  - Raises costs of new investment (familiar "anti-new source bias")
  - Reduces value of waiting
- Nonetheless, ACP with escrow recovers investment, decreases emissions, increases profits

<u>Existing Source</u> Performance Standards

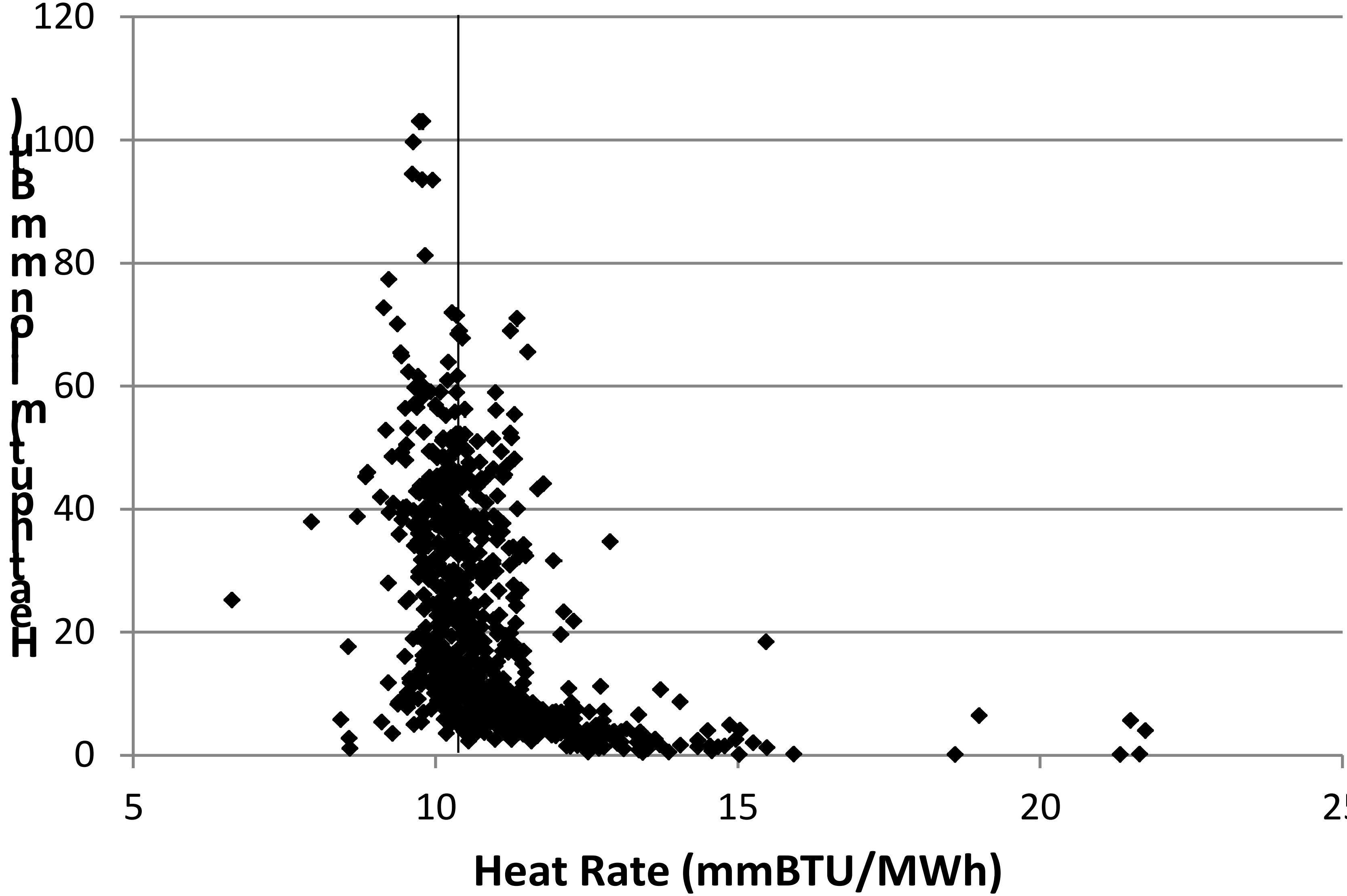
- EPA has to regulate after new source rule is final
- State implementation plan process
- EPA can issue model rule, but states can deviate
- Compliance flexibility? Probably
- Other sectors will follow electricity

Efficiency at Existing Coal Plants

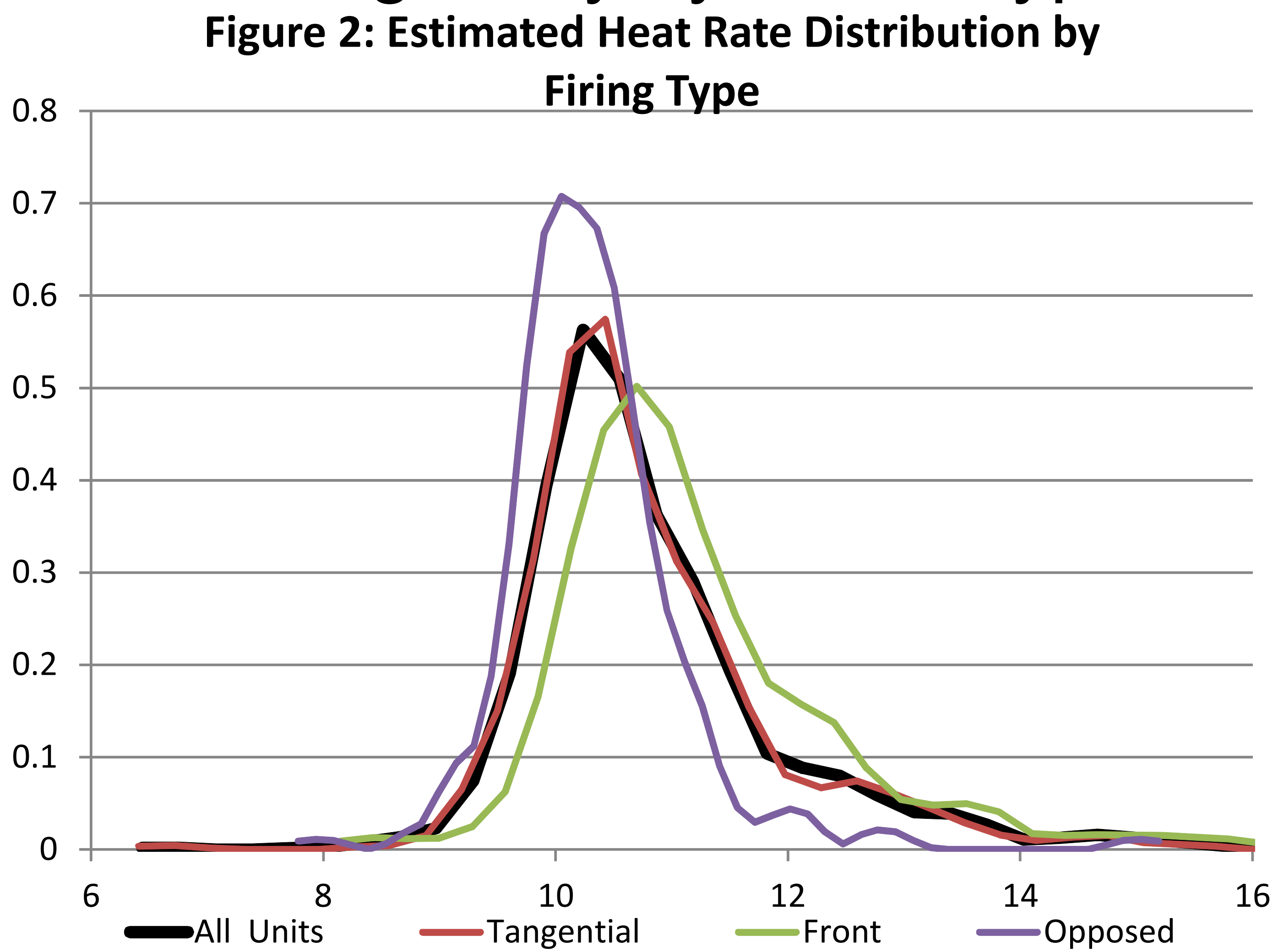
- Coal accounts for about 1/3 of U.S. CO_2 emissions
- 2/3 to ¾ of expected emissions reductions over first two decades of price-based policy
- Based on engineering estimates, EPA expects 2-5 percent efficiency improvements are possible (without changing utilization)
- Corresponds to 1.6 percent total GHG emissions, or 10 percent of the U.S.' 2020 target
- Equal additional changes from biomass cofiring possible
- These reductions could happen very quickly and at large scale

Linn et al. 2012

Figure 1: Heat Input vs. Heat Rate (2008)



Heterogeneity by Boiler Type



Empirical Objectives: Estimate Abatement Opportunities, Costs, and Rebound Effect

- Construct panel data set of coal unit operation and characteristics, 1985-2009
  - Operational data include monthly heat input and net generation
  - Characteristics include size, vintage, firing type, etc.
  - Merge in coal prices by plant/month

- Approach: Use historic variation in fuel prices as proxy for impact of future regulatory costs and measure effect on heat rates

Estimating Equation

- Derivation
  - Assume CES function for technology cost, c(h)
  - Rearranging:

$$\ln HR_{it} = \alpha \ln P_{it} + X_{it}\beta + \epsilon_{it}$$

- Interpretation:
  - α is the elasticity of heat rate to coal price
  - Expect α to be negative because high coal prices raise the benefit of improving efficiency
  - Large α (in magnitude) implies low cost of improving heat rate
  - Controls (X_{it}) include utilization and error term includes unobserved unit characteristic (θ)

Effect of Coal Prices on Heat Rates

	Dependent Variable: Log Heat Rate			
	(1)	(2)	(3)	(4)
Log Coal Price (α)	-0.053 (0.008)	-0.046 (0.008)	-0.016 (0.009)	-0.015 (0.009)
Number of Observations	4,927	3,908	4,927	3,908
R-Squared	0.75	0.77	0.93	0.94
Specification	Baseline	Add state economic controls to (1)	Add unit fixed effects to (1)	Add firm X year fixed effects to (3)

Other control variables: age, size, firing type, fuel type, cogenerator, scrubber, SCR, utilization, state, time period, ownership type

Main Empirical Results

- Heterogeneity suggests significant abatement opportunities exist, up to 5 percent emissions reduction
  - ~1.5% of total U.S. CO2 emissions
- Costs appear to be as low as engineering estimates
  - \$10 CO_2 tax would yield 1-3 percent efficiency improvements.
- Evidence of small “rebound” effect
- Another 1.5% possible from biomass cofiring
- Analysis suggests <u>significant benefits from flexibility</u>

Design for Existing Source Performance Standard

- Performance standard measured as either:
  - heat input per electricity output (Btu/ MWh)
  - CO_2 per electricity output (lbs CO_2 /MWh)
- Set by EPA based on technological assessment
  - Then adjusted to account for benefits of trading
- Definition of allocation group for earning credits is central issue (<u>subcategorization</u>)
  - Source category, individual unit crediting, commonly owned units, etc.?

Environmental Law Reporter 2012

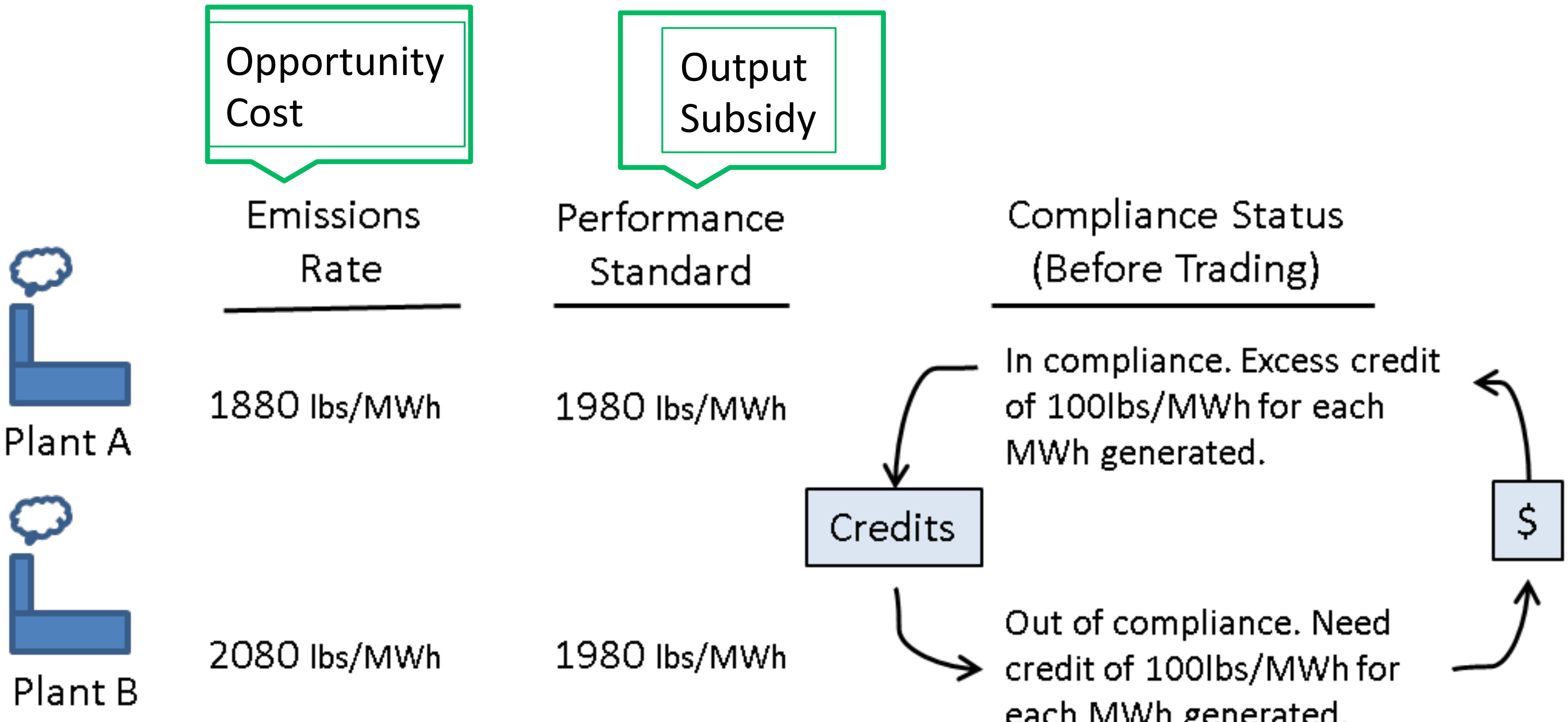
Efficiency of Tradable Performance Standard

A tradable performance standard is <u>two instruments in one</u>:

1. Opportunity cost of surrendering a performance credit
2. Output subsidy associated with earning a credit

Fischer 2003

Credit Trading to Achieve Compliance with a Performance Standard



Environmental Law Reporter 2012

Categories of performance? (benchmarking)

- Perceived equity issues
- What are the potential efficiency effects?

Modeling Flexibility for EGUs with Subcategorization

- Opportunities for efficiency improvements from Sargent & Lundy
- Assignment of opportunities to specific plants based on heat rate and other factors. (It is *not* econometric as in Linn et al.).
- 4% reduction in emissions rate from BL by 2020 modeled.
- Subcategorization scenarios calibrated to achieve same emissions reductions among coal plants as a companion uniform national standard. Three policies examined:

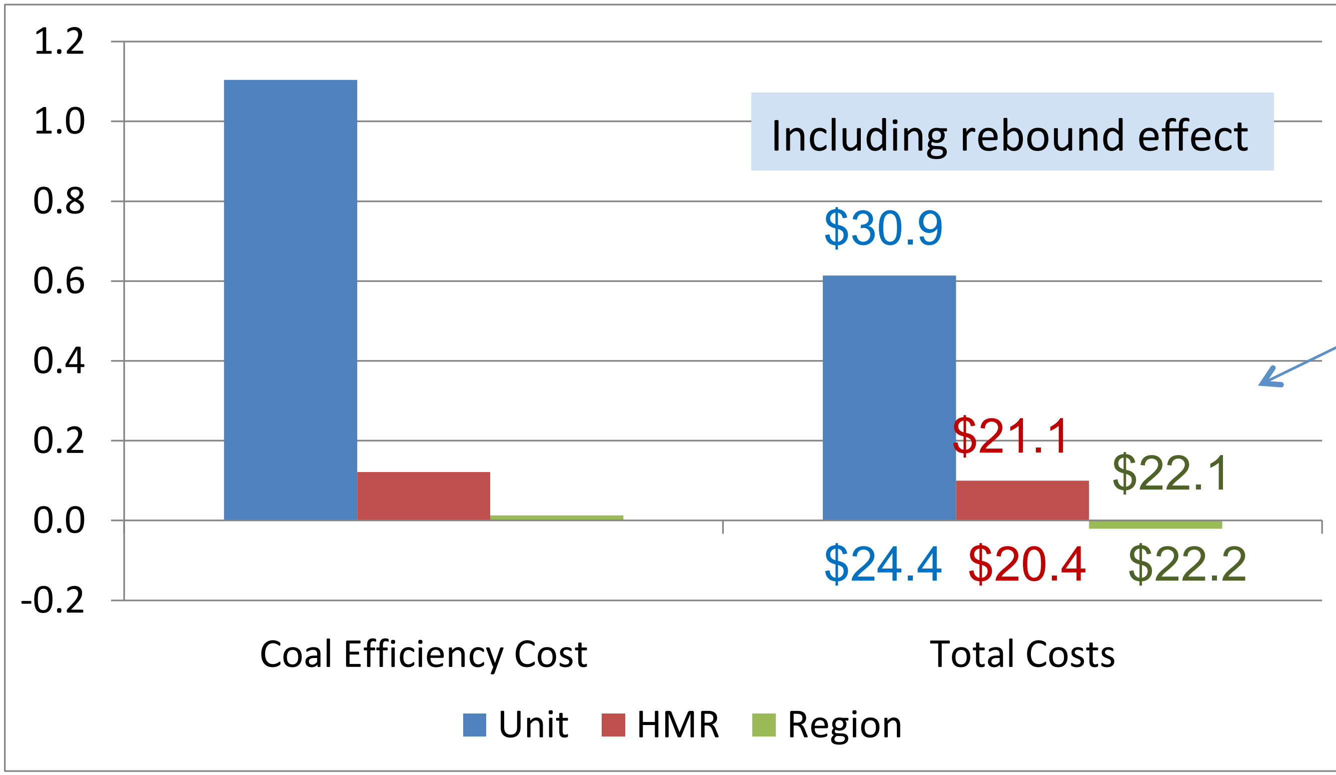
  1. Five region subcategorization
  2. Twenty-two region subcategorization
  3. Unit-specific subcategorization

Key Simulation Results

- Retail electricity prices do not vary across scenarios
  - No change in consumer welfare across policies
- Generating capacity changes negligibly
  - No change in the cost of new capacity investments
- Subcategorization
  - leads to greater investment in efficiency
  - results in a smaller change in generation mix
  - imposes a cost of up to $600 million annually

Cost of Subcategorization in 2025 (B$)

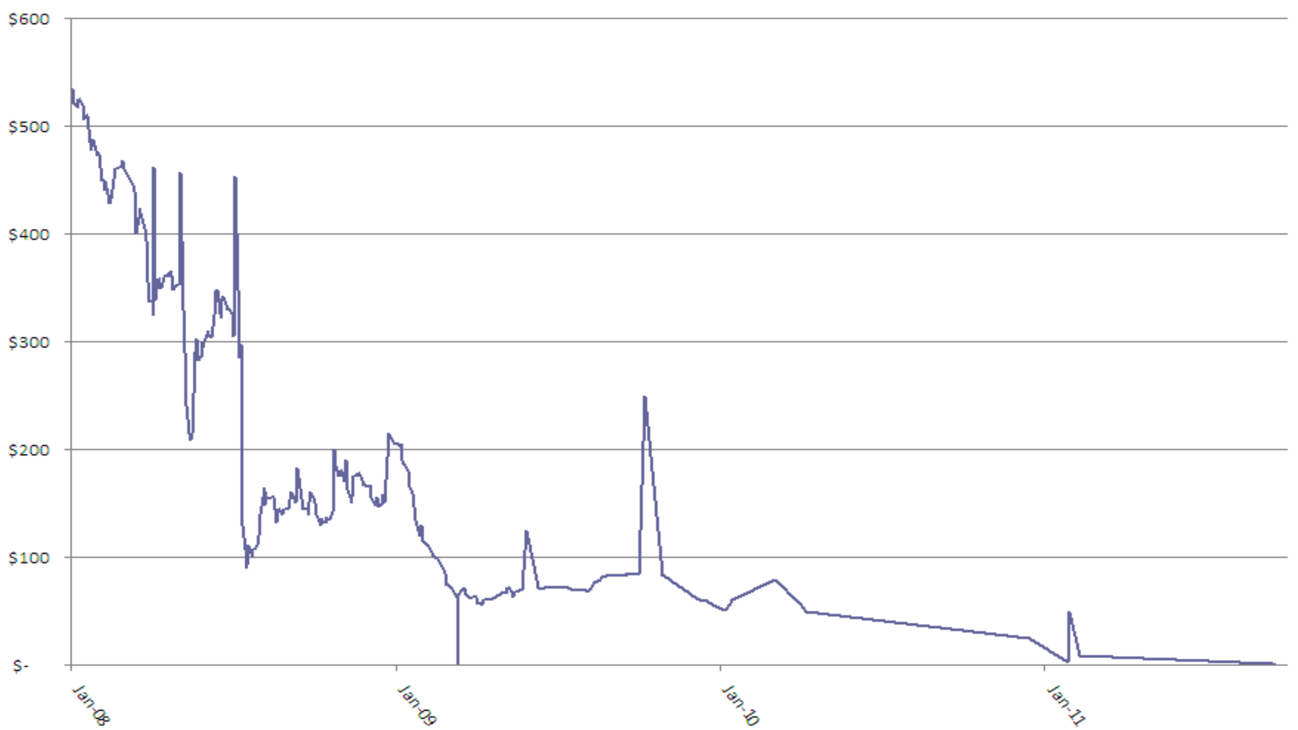
Difference between subcategorization and uniform benchmark policies



Cost per ton

- Additional costs of up to $600 million annually

The Flagship US Program: SO_2 Trading

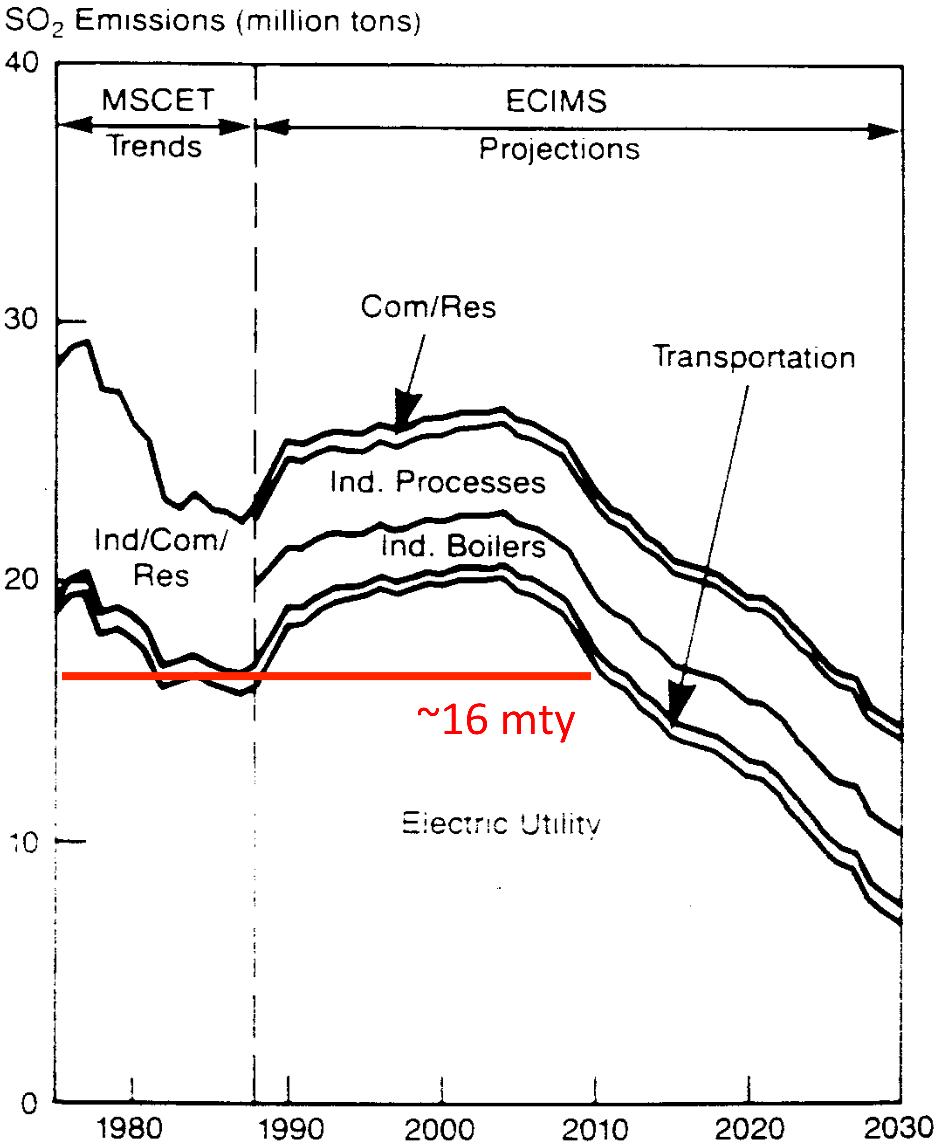


Source: Prices or 2000-2009 prices are end of day prices from ICAP provided by Thaddeus J. Huetteman, Power & Energy Analytic Resources,

- EPA 2012 SO2 Allowance Auction: 2012 vintage: $0.56/ton
- Legal requirements of Title IV still in place.

Optimal Sulfur Dioxide Levels

- Recall that Title IV Phase II allocation is 8.95 million tons per year.
- Studies analyzing efficient cap (million tons):
  - Banzhaf et al, 2004: 1.1 mty (0.9-3.1)
  - Muller and Mendelsohn, 2009: ~1 mty
- Studies differ in assumed VSL, market response/ prices/behavior, etc., but key result is that optimal level below Title IV cap.



1990 NAPAP forecast of SO_2 emissions by sector was about 16 million tons in 2010

Cap was pegged at 8.95 million tons

Emission Reductions from most recent EPA rule

Table ES-2: Projected Electricity Generating Unit (EGU) Emissions of SO_2, NO_X, Mercury, Hydrogen Chloride, PM, and CO_2 with the Base Case and with MATS, 2015 [a,b]

		Million Tons			Thousand Tons		CO_2
		SO_2	NO_X	Mercury (Tons)	HCl	$PM_{2.5}$	(Million Metric Tonnes)
Base	All EGUs	3.4	1.9	28.7	48.7	277	2,230
	Covered EGUs	3.3	1.7	26.6	45.3	270	1,906
MATS	All EGUs	2.1	1.9	8.8	9.0	227	2,215
	Covered EGUs	1.9	1.7	6.6	5.5	218	1,883

[a] Source: Integrated Planning Model run by EPA, 2011

[b] The year 2016 is the compliance year for MATS, though as we explain in later chapters, we use 2015 as a proxy for compliance in 2016 for IPM emissions and costs due to availability of modeling impacts in that year.

Emissions by 2015 will be 2.1 million tons

Regulation *after* Trading

- Congress tried repeatedly, was unable to adjust cap
- Clean Air Act forced progress
  - Clean Air Interstate Rule (2005)
  - Cross State Air Pollution Rule (2011)
  - Mercury and Air Toxics Standard (2012)

Since adoption of cap and trade in 1990, as many emissions reductions are attributable to prescriptive regulation as to the cap

Lessons?

- Question **teaching** of dichotomy of price-based (flexible) policies *versus* regulation.
- Avoid **policy** advice that annihilates one approach or the other.
- For **research**, look at intensive margin ->
  i.e. expanded introduction of flexibility (including prices) into regulatory frameworks.

In Conclusion

Price-based instruments are good theory and good policy but not good orthodoxy

- Their expanded application requires attention to institutions
- Additionality of non-price policies is apparently important
- Climate policy is a social decision

Climate policies are advancing in the US

- Clean Air Act is like a freight train: *slow but hard to stop*

Embrace complexity