



# Cap-and-Trade Programs and Climate-Friendly Innovation

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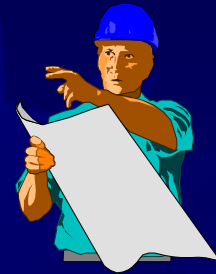
Air Resources Board  
Environmental Justice Committee

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# Today's Road Map



1. Framing:
  - a) Technological innovation key to answering climate change problem
  - b) Policy key to the key
2. Are cap-and-trade programs (CTPs) more supportive of innovation than other policy instruments?
3. The carbon context complicates things
4. Some thoughts on making climate policy more innovation compatible...

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1. Framing:
    - (a) Technological innovation key to answering climate change problem

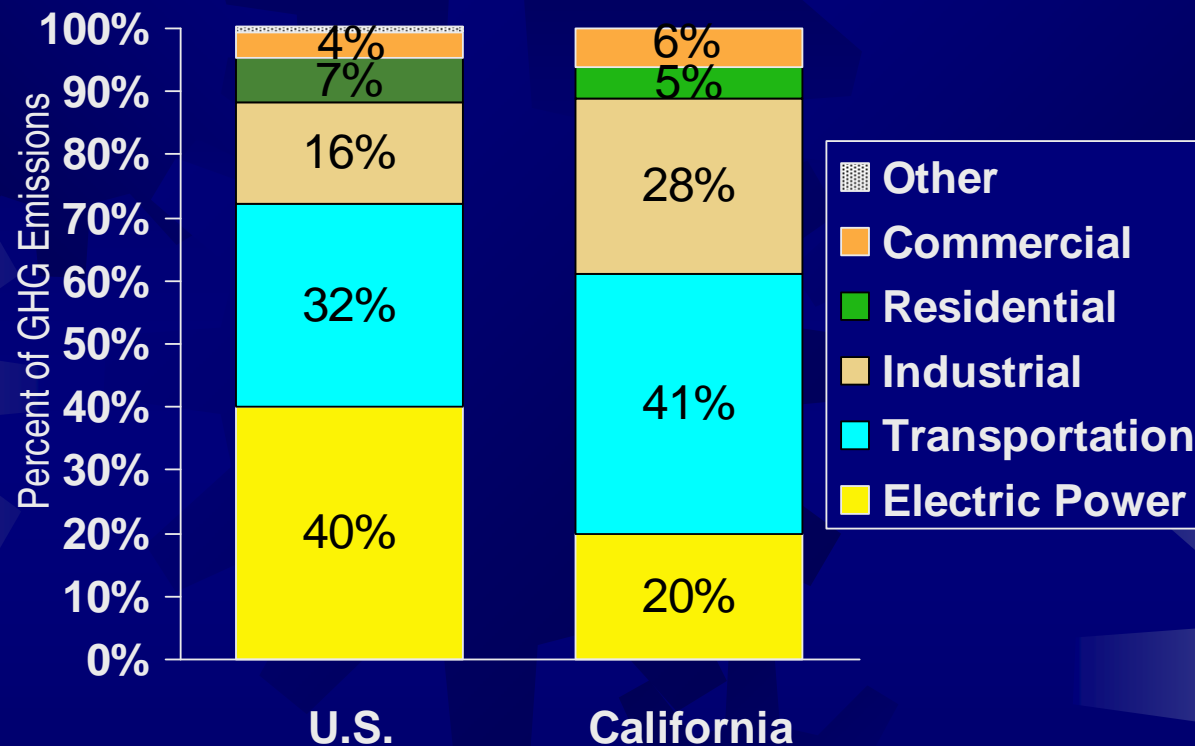


# Climate Change in California

Four main greenhouse gases (GHGs) account for almost all emissions

- Carbon dioxide (CO<sub>2</sub>) from fossil fuel combustion (83% of GHGs, even w/o imported electricity)
- Nitrous oxide primarily from agriculture and transportation
- Methane primarily from agriculture and landfills
- “High global warming potential” gases used in industry

# Diverse Emission Sources

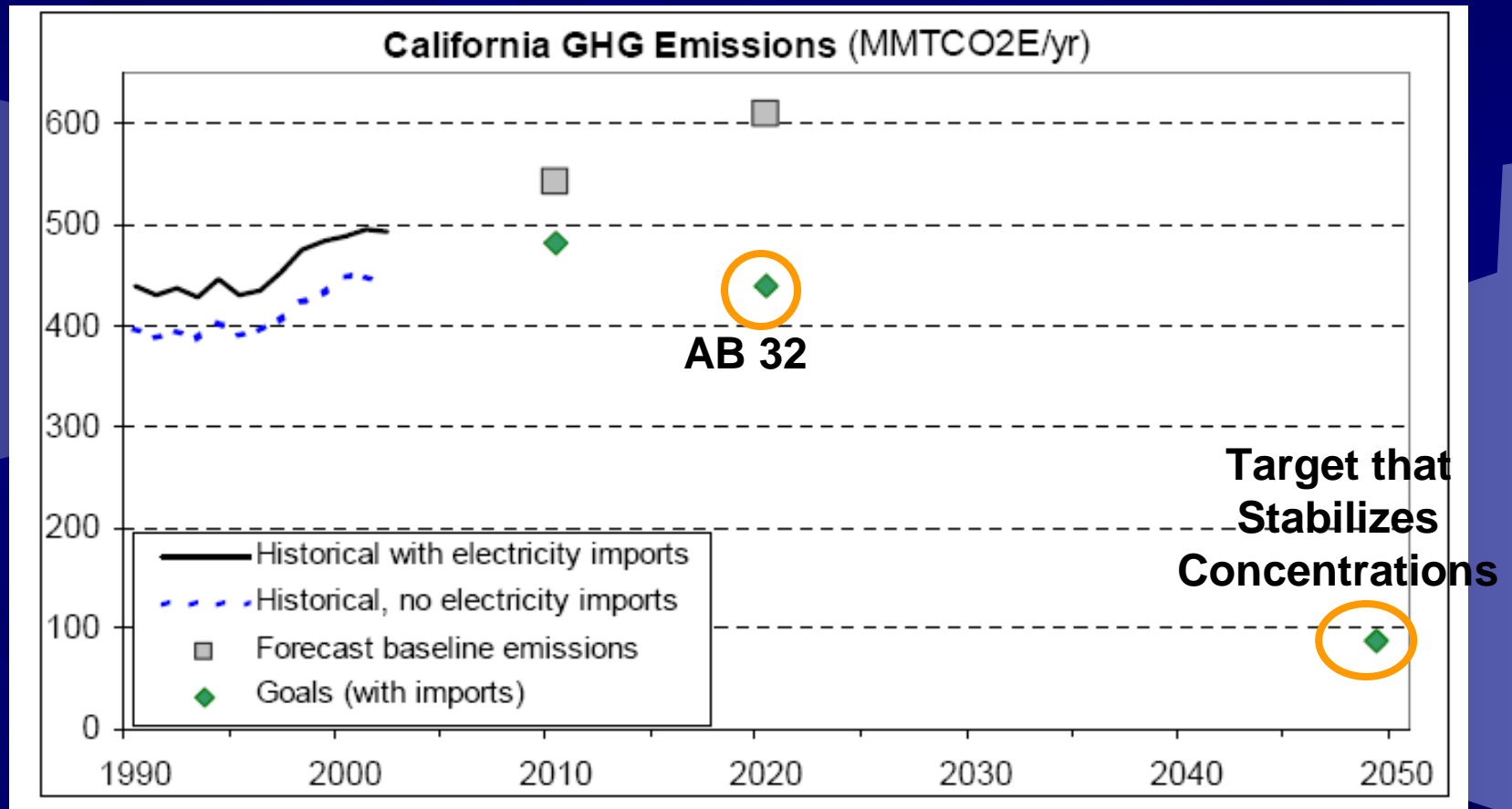


**Greenhouse Gas Emissions by Sector, 2002**

Source: Managing Greenhouse Gas Emissions in California, fig. 3-2

Note: Technology has helped make California's GHG emissions profile different than the U.S.

# California Acts: Exec. Order, AB 32 Targets



Source: Managing Greenhouse Gas Emissions in California, fig. 3-1

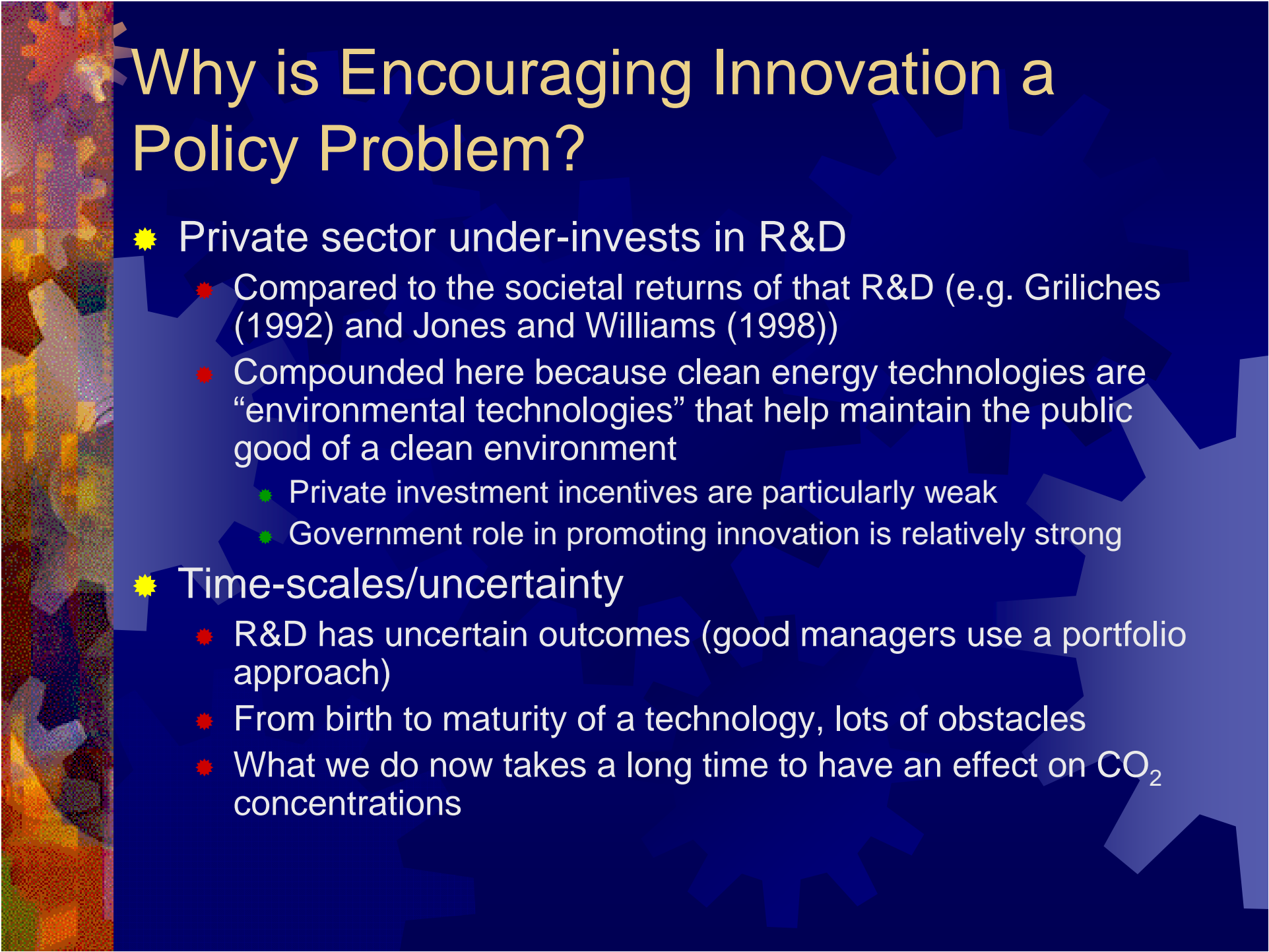


# The Need for Innovation

- ✱ The technologies aren't all there for CO<sub>2</sub> stabilization in 2050
- ✱ There is a need for innovation, probably in multiple technology strategies
  - ✱ Innovation is a process that includes invention, adoption/diffusion, and post-adoption learning from experience
  - ✱ Technology strategies include:
    - Traditional Power Generation
      - Control Emissions (pre, during, post-combustion)
      - Reduce Power Demand
    - Alternative Power Generation
      - Centralized
      - Distributed

- 
1. Framing:  
(b) Policy key to the key





# Why is Encouraging Innovation a Policy Problem?

## ☀ Private sector under-invests in R&D

- Compared to the societal returns of that R&D (e.g. Griliches (1992) and Jones and Williams (1998))
- Compounded here because clean energy technologies are “environmental technologies” that help maintain the public good of a clean environment
  - Private investment incentives are particularly weak
  - Government role in promoting innovation is relatively strong

## ☀ Time-scales/uncertainty

- R&D has uncertain outcomes (good managers use a portfolio approach)
- From birth to maturity of a technology, lots of obstacles
- What we do now takes a long time to have an effect on CO<sub>2</sub> concentrations



# Government Actions that Affect Clean Energy Innovation

## ☀ Direct support of R&D

- Funding R&D (government conducts, partners, or contracts out)
- Issuing tax credits for conducting R&D

## ☀ Indirect support of innovation – affect the market


- Altering the business environment/competitive playing field to create a niche market for a technology
  - E.g., environmental/energy efficiency standards, cap-and-trade programs, PURPA, RPS...
- Making innovative technology less expensive
  - E.g., tax credits, PUC direction of regulated utilities (rebates, other), low-interest loans, depreciation rates on taxes...
- Other
  - Procurement, information dissemination, voluntary programs, building codes, quality assurance programs, job training, solar access rights, municipal solar utilities, mortgage programs...



# What's the Best Climate Policy re: Innovation?

How to answer:

- ★ Study cases so past experience with policy details and firm behavior can guide the answer
  - Control emissions: SO<sub>2</sub> and NO<sub>x</sub> control
  - Reduce power demand: SWH
  - Alternative generation: PV, Wind, STE
- ★ Systematically apply multiple methods to cases
  - Compensates for data/methodological weaknesses
  - Facilitates cross-case comparisons
  - Addresses different stages of the innovation process
- ★ Insights for policy re:
  - Operating experience
  - Niche markets
  - Public R&D vs. policies promoting technology deployment
  - Policy stringency and certainty



2. Are cap-and-trade programs (CTPs) more supportive of innovation than other policy instruments?



# The What and Why of Cap-and-Trade Programs (CTPs)

## ★ The Basics:

- ★ Policy-makers set cap on emissions
- ★ Sources of emissions receive tradable allowances that are equivalent, in sum, to the cap

## ★ The Goal:

- ★ Incentivize sources to reduce emissions in the most cost-effective ways



# Results from Economic Theory

- ✱ Original expectation and general consensus until ~2000:
  - ✱ CTPs would encourage “innovation” more than other policy instruments
- ✱ Studies in recent years have mixed results:
  - ✱ Assumptions about the world matter (i.e., perfect competition, information, strategic effects)
  - ✱ CTP design matters (i.e., initial allocation of allowances)
- ✱ Criticisms of literature
  - ✱ Model of the comparison instrument design matters



# Results from Empirical Studies

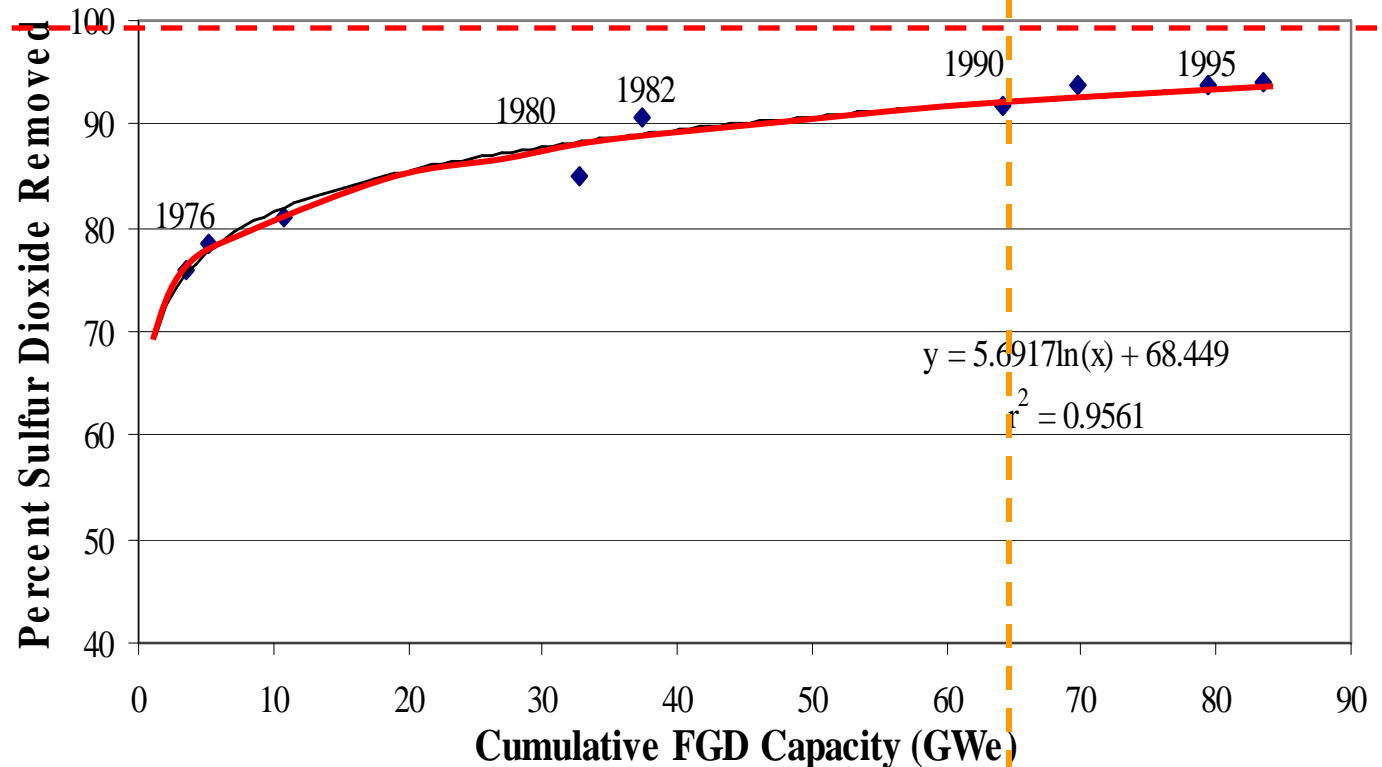
- ✦ Although evidence of adoption in response to stringency (e.g., leaded gasoline CTP)...
- ✦ Evidence of pre-CTP innovation is significant, and post-CTP innovation not necessarily superior

# Environmental Performance of the Most Effective, Highest Cost SO<sub>2</sub> Control Technology

Pre-CTP | Post-CTP

Limit

Average %  
SO<sub>2</sub> Removal  
Rating of Units  
Brought Online



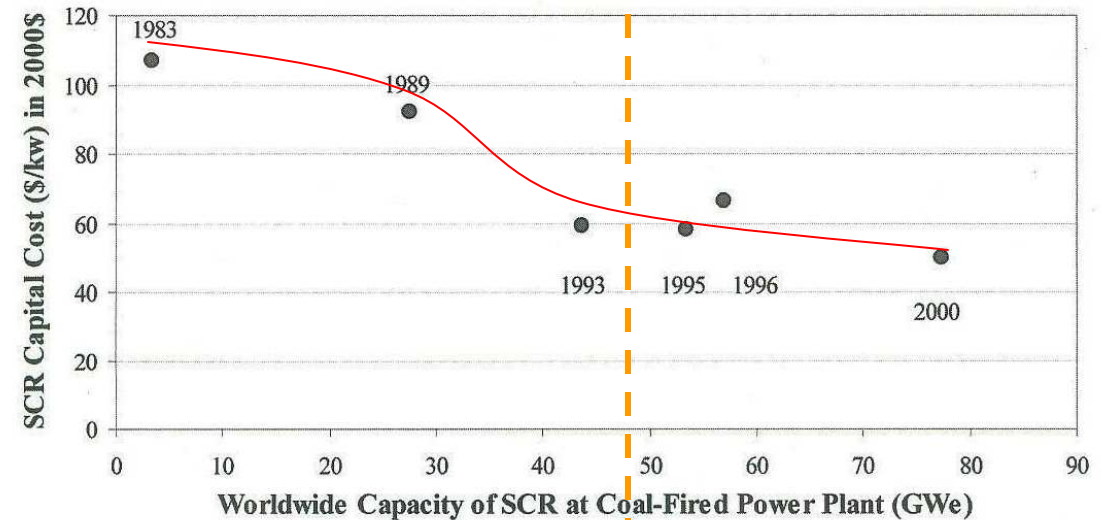


# Costs

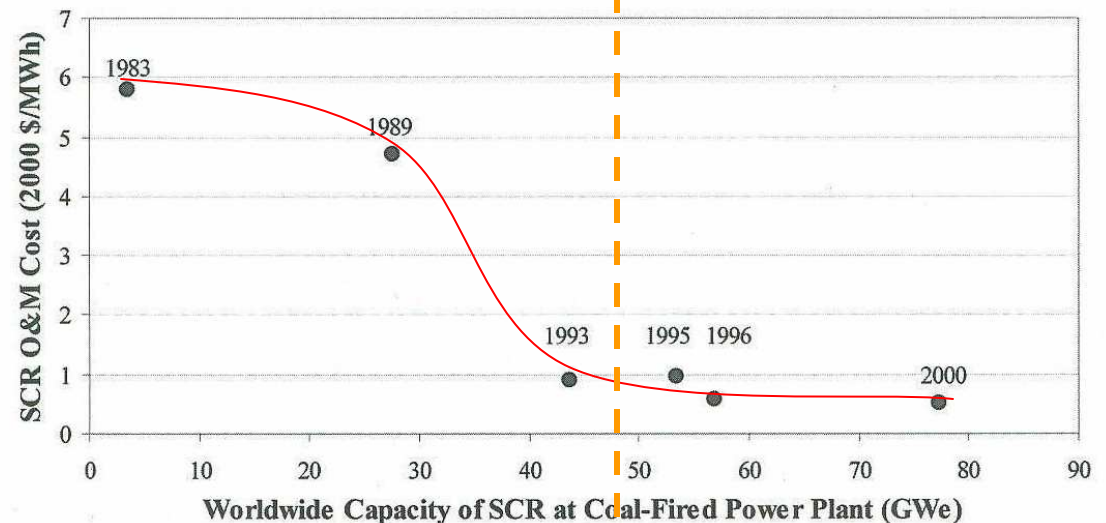
of the Most Effective, Highest Cost NO<sub>x</sub> Control Technology

Pre-CTP | Post-CTP

Capital Costs  
(Normalized  
System)



Operating and  
Maintenance  
Costs  
(Normalized  
System)



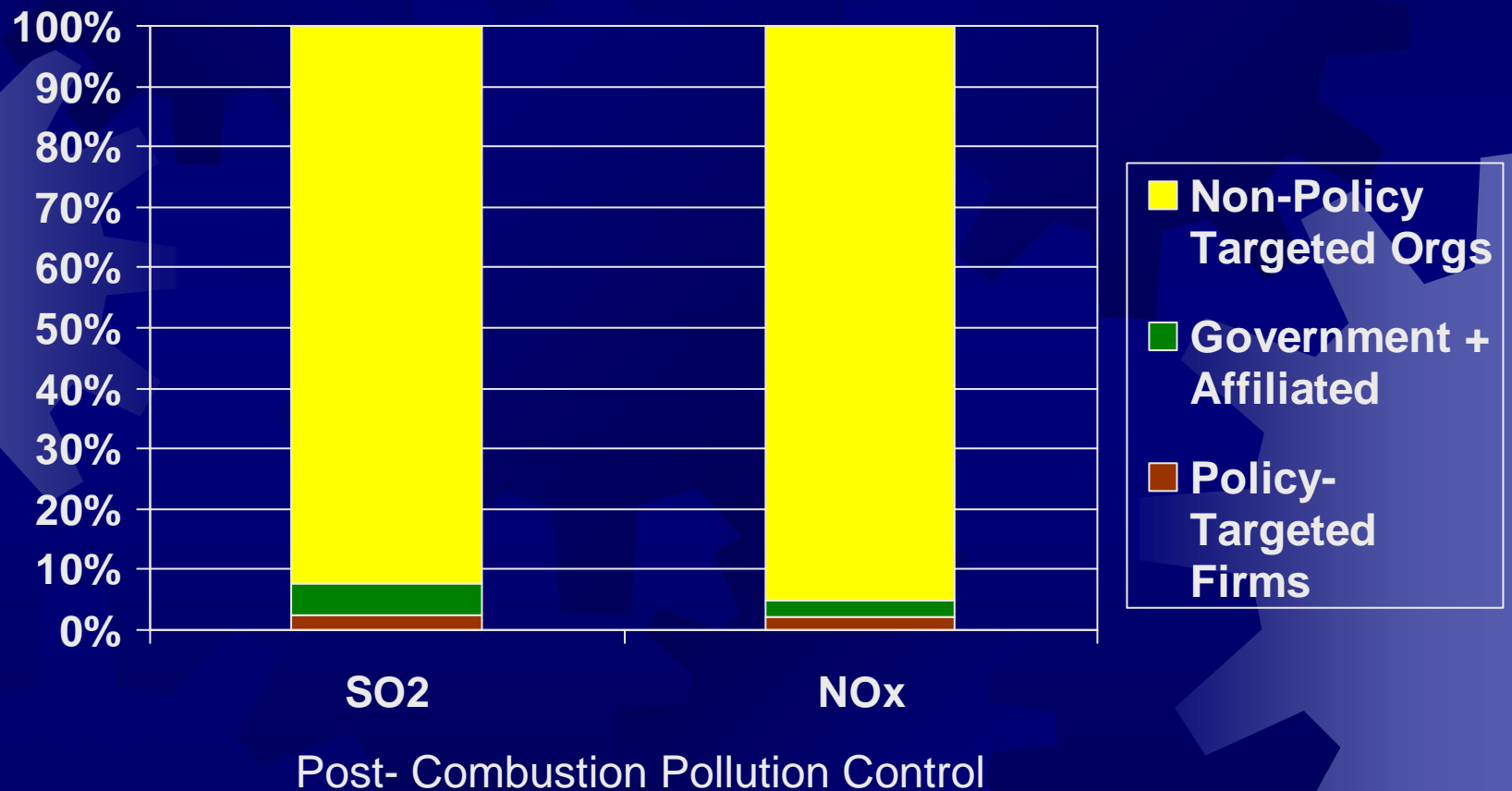


# Who does innovation?

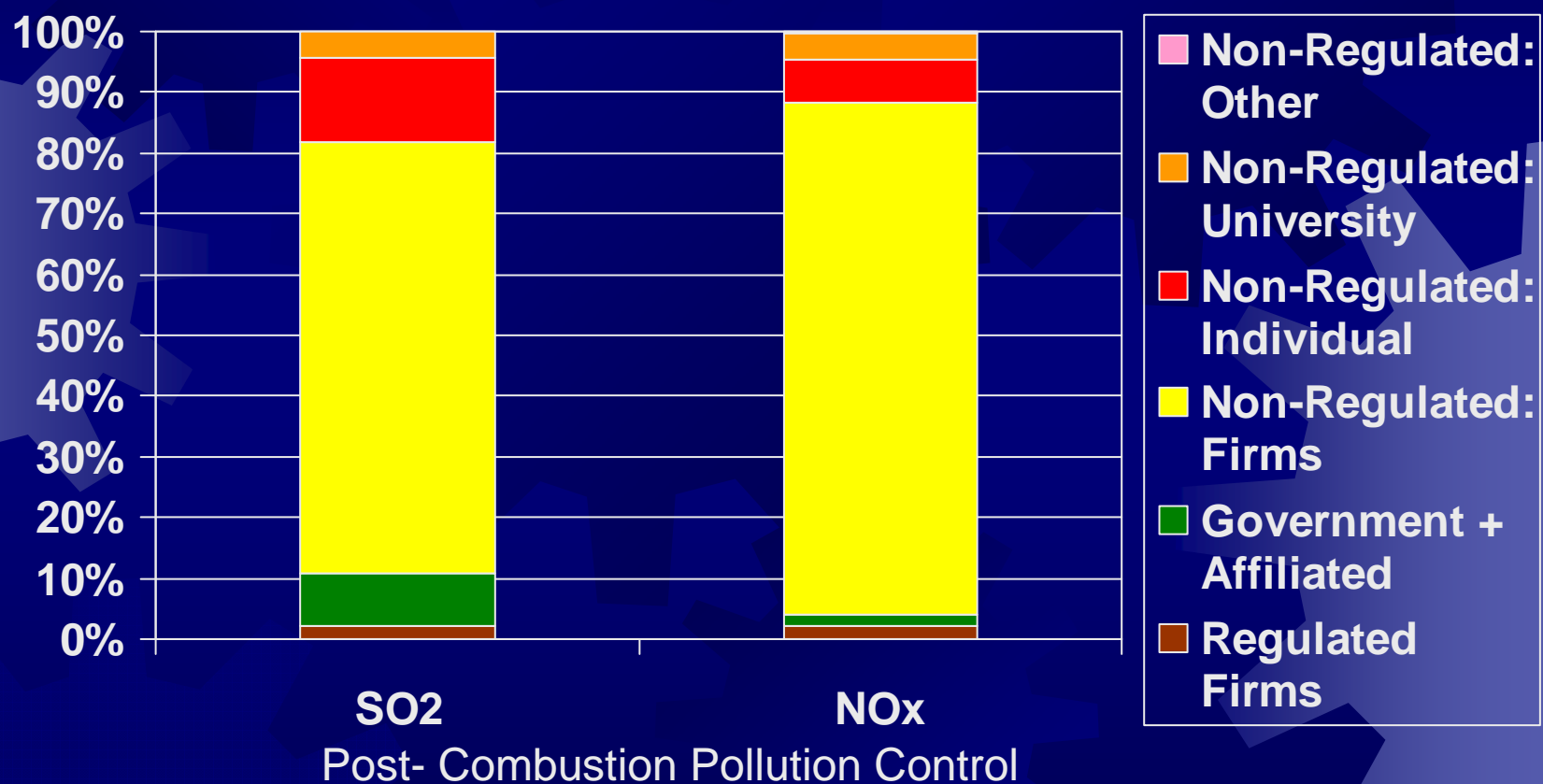
Most studies of cap-and-trade and innovation focus on emissions sources

But do emissions sources perform significant R&D, esp. in environmental performance?

# Most Patents by Non-Policy Targeted Organizations - 1



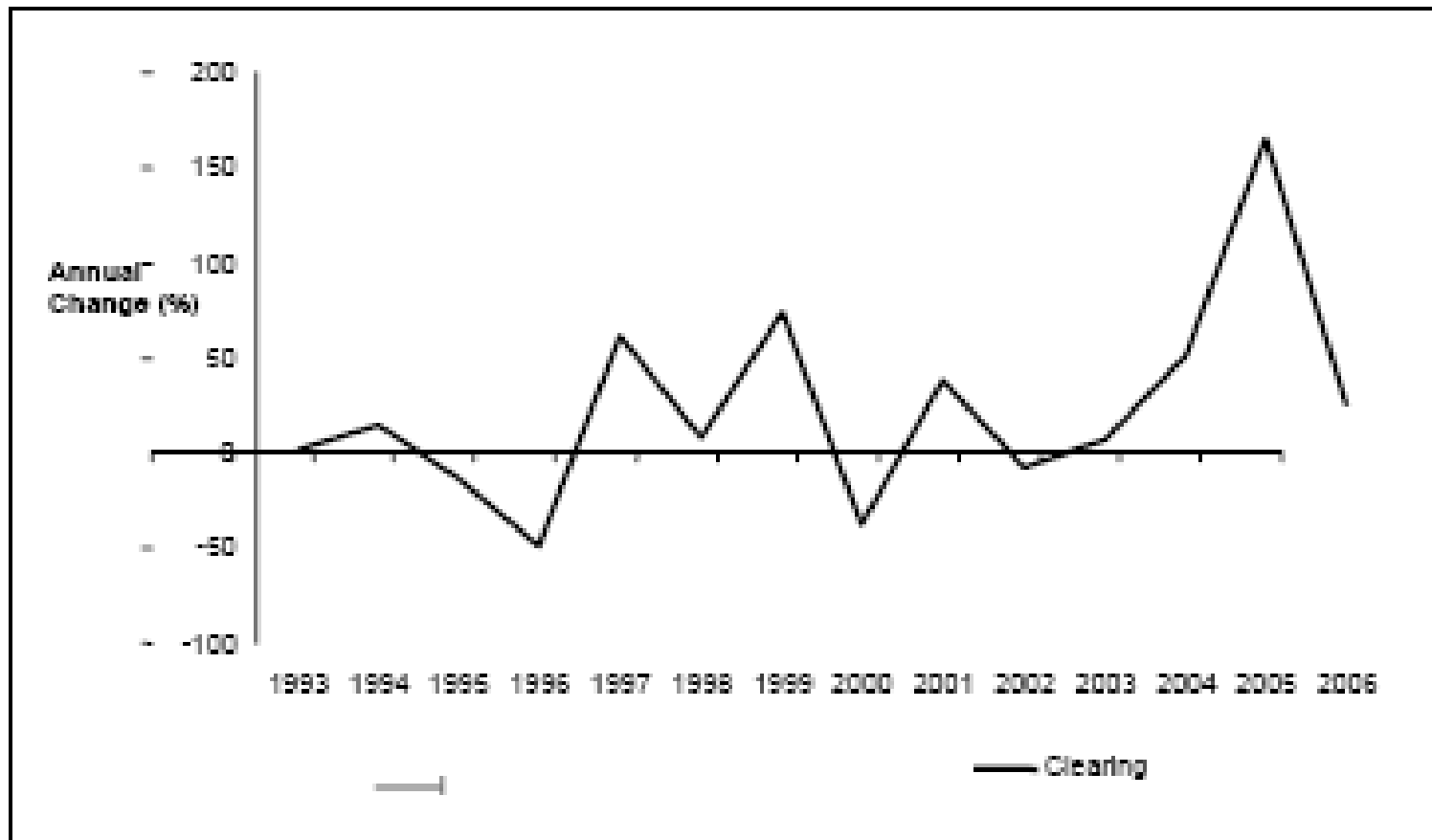
## Most Patents by Non-Policy Targeted Organizations - 2



# Emissions Sources = “Adopters”

- ✱ Previous CTPs on limited set of sources, concentrated industries
  - ✱ Most of experience with electric power plants
- ✱ Technology there to adopt (e.g. scrub vs. fuel switch for SO<sub>2</sub> control)
- ✱ Unpredictable allowance prices have been a problem for adoption decisions (e.g., SO<sub>2</sub> market, California NO<sub>x</sub> market)

# Price Volatility in CTPs (SO<sub>2</sub> Example)



U.S. Acid Rain Program (Title IV 1990 Clean Air Act)

Annual % Change in Clearing Prices for SO<sub>2</sub> Permits, 1993-2006

Price shifts average 43%/year

Source: Shapiro (2/07)



### 3. The carbon context complicates things



# The Carbon Context Complicates Things

- a) Diverse set of emissions sources (“adopters”)
- b) No mature technology to adopt
- c) Diverse set of “creators”

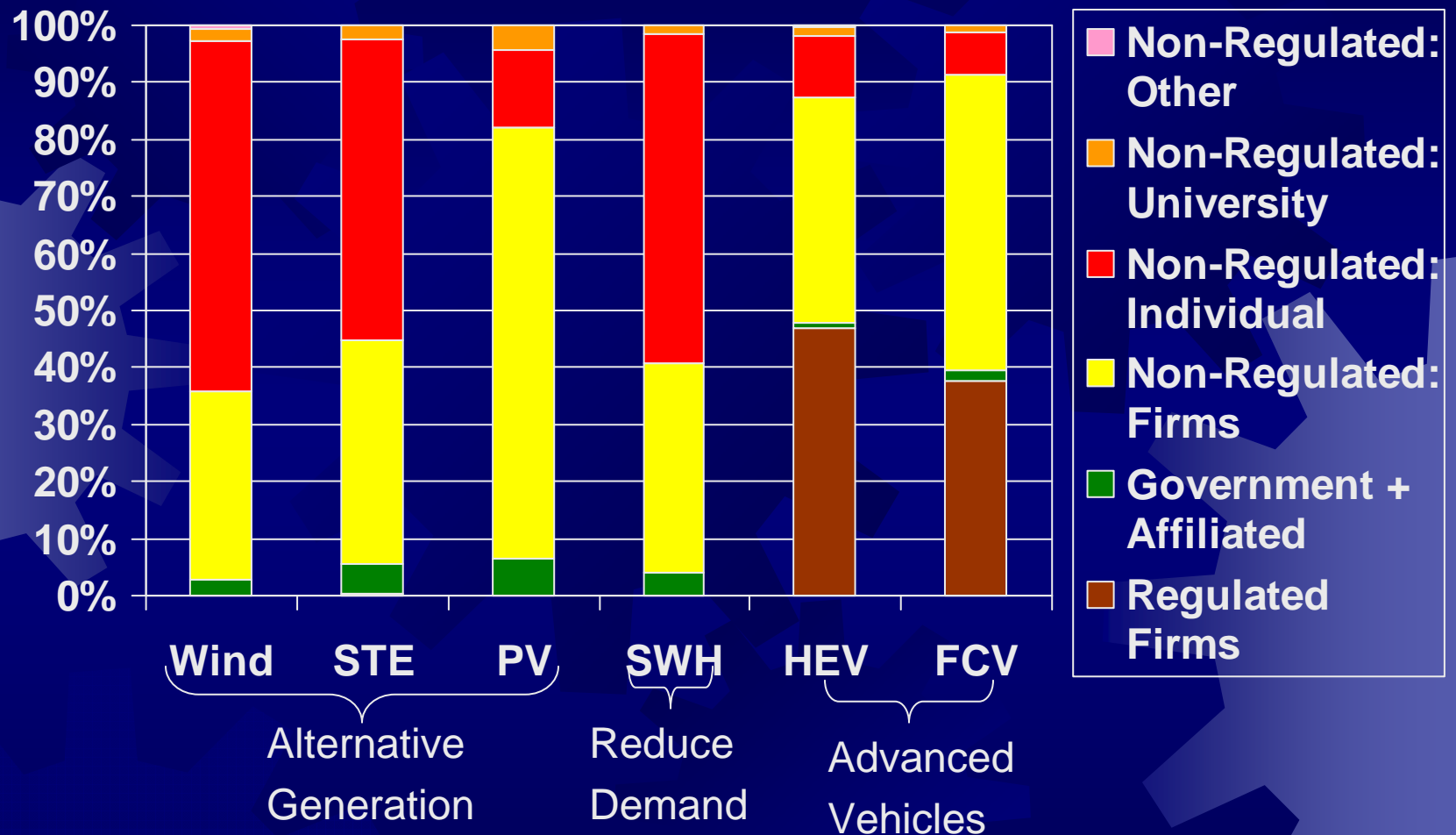




# The Carbon Context Complicates Things

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# Climate Technology “Creators”

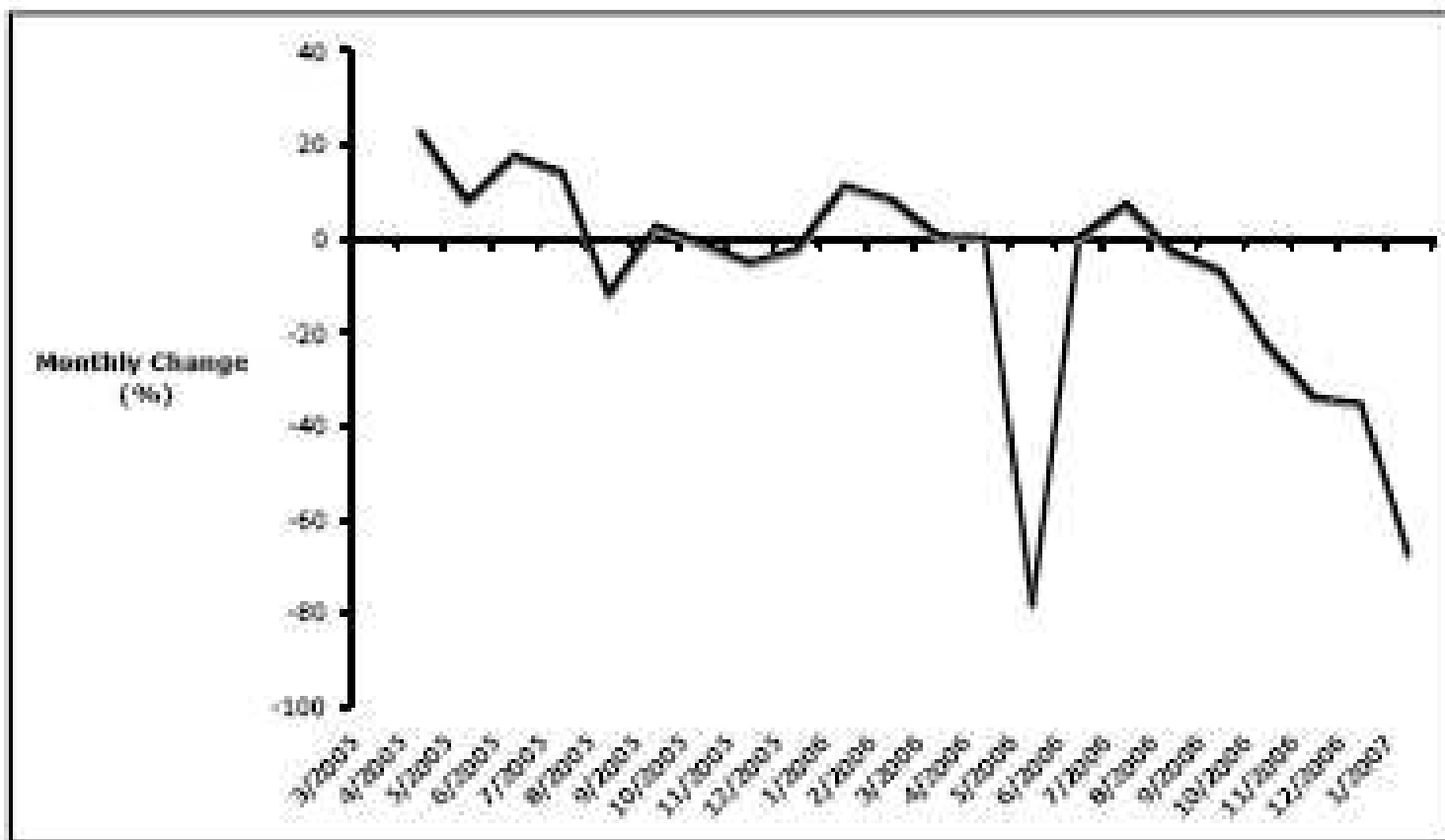


- ✳ Most Patents by Non-Policy Targeted Organizations
- ✳ Varying, but sometimes large role for individual inventors

# What Do Creators Want?

- ✱ Certainty about market
  - ✱ Price volatility of markets a problem
- ✱ Expanding market
  - ✱ Market for innovative product x is in competition with other technology strategies, allowances, etc.

# Price Volatility in CTPs (CO<sub>2</sub> Example)



## European Emissions Trading Scheme (EU-ETS)

Monthly % Change in Avg. Prices for CO<sub>2</sub> Permits, 3/05-1/07

Price shifts average 17.5 %/month

Source: Shapiro (2/07)



# Implications for Creators of Ways Proposed to Address Price Volatility

## ★ Banking

- ★ Dilutes the demand for innovative product x temporally

## ★ Safety valves

- ★ Limits the comparative potential value of x vs. alternative technologies, allowances



## Implications for Creators of Other Proposed Design Features of CO<sub>2</sub> CTPs

### ☀ Offsets

- ☀ Dilutes the demand for x through inter-sectoral competition

### ☀ Initial Allocation of Permits

- ☀ Grandfathered initial allocations problematic – if emission sources get allowances for free, less incentive to do something about emissions



## What about Linkages to other CTPs?

- ✱ Unclear: potentially increases market, but also increases costs of doing business to creators by spreading market for x spatially
- ✱ Potentially compounds demand for x problem of offsets
- ✱ (What if California has already picked the low-hanging fruit, compared to other states? California seems a likely candidate for becoming a net buyer of allowances)



#### 4. Some thoughts on making climate policy more innovation compatible...





## It should think about the creators

How do they answer “Will there be a market for innovative product X?” In the short or long-term? How certain is that market?

- More stable government policies and signals of stringency help. X-Prizes, subsidies, and R&D support OK, but don't provide long-term signal to investors
- Strategies of targeted actors will also be directly important to this



## It should think about the adopters

What incentives are there for adopting a new technology?

- Focus on source mitigation not offsets
- Predictability of allowance price helps long-term planning
  - Transparency in the market can help
- How to make emissions more a part of bottom-line competitive strategy?
  - Interesting example of Japanese energy efficiency standard, which rewards best actors with standard set to their level, forces competitors to catch up (provides continuous innovation incentive)