

Cap-and-Trade Programs and Climate-Friendly Innovation

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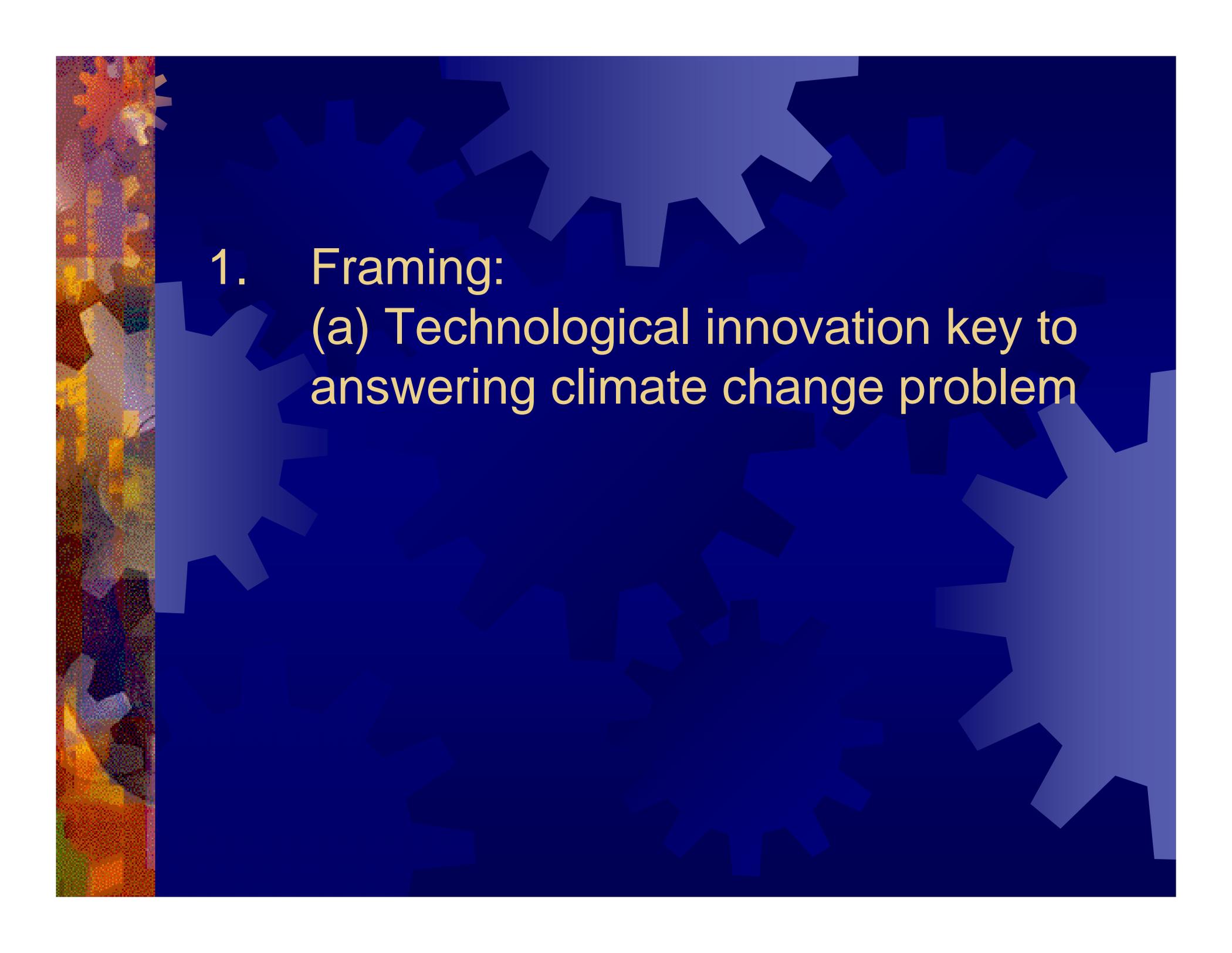
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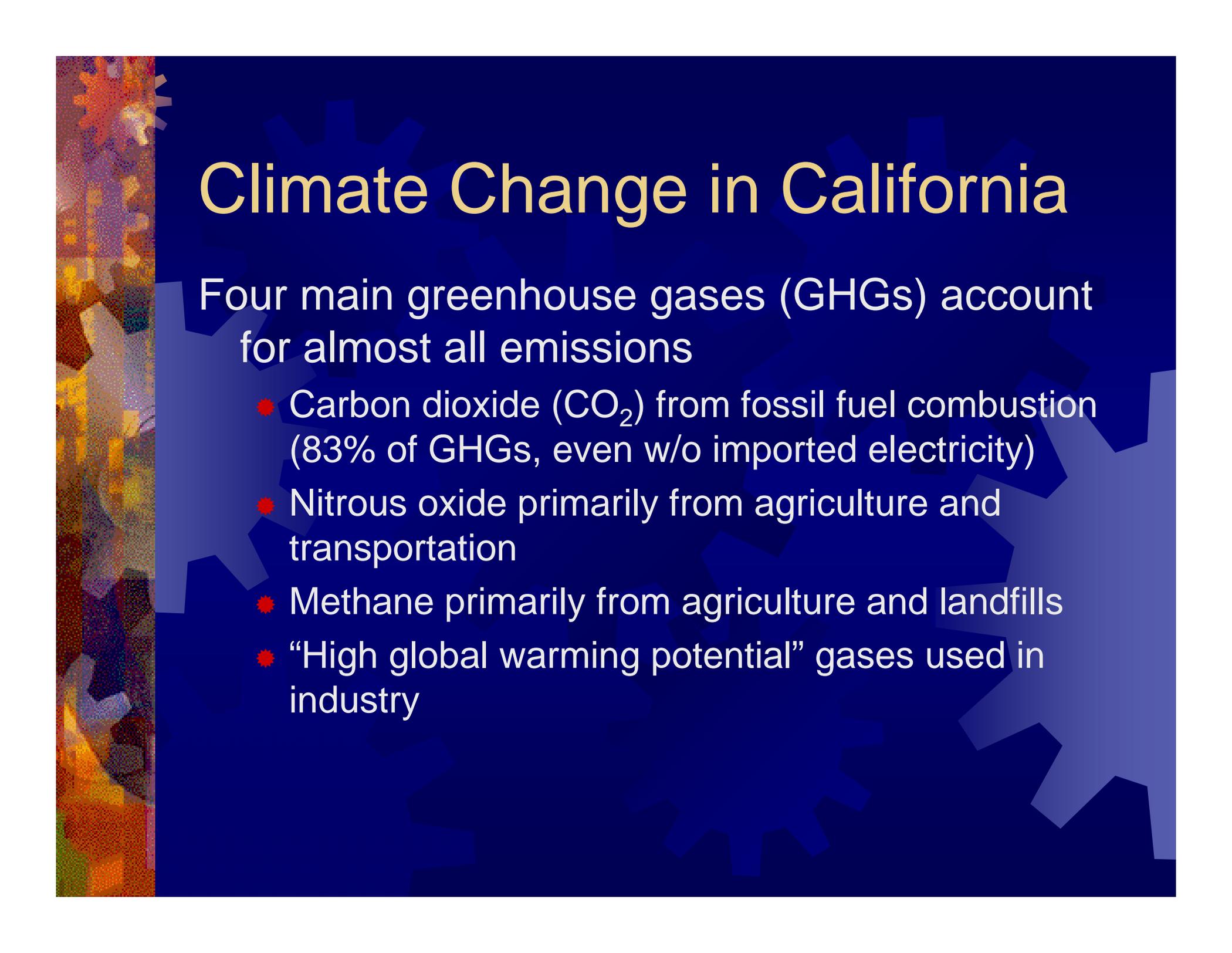
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Today's Road Map



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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- The background of the slide is a dark blue field filled with various shades of blue gears of different sizes, some overlapping. On the left side, there is a vertical strip with a colorful, abstract, and somewhat pixelated texture in shades of orange, yellow, and brown.
1. Framing:
 - (a) Technological innovation key to answering climate change problem

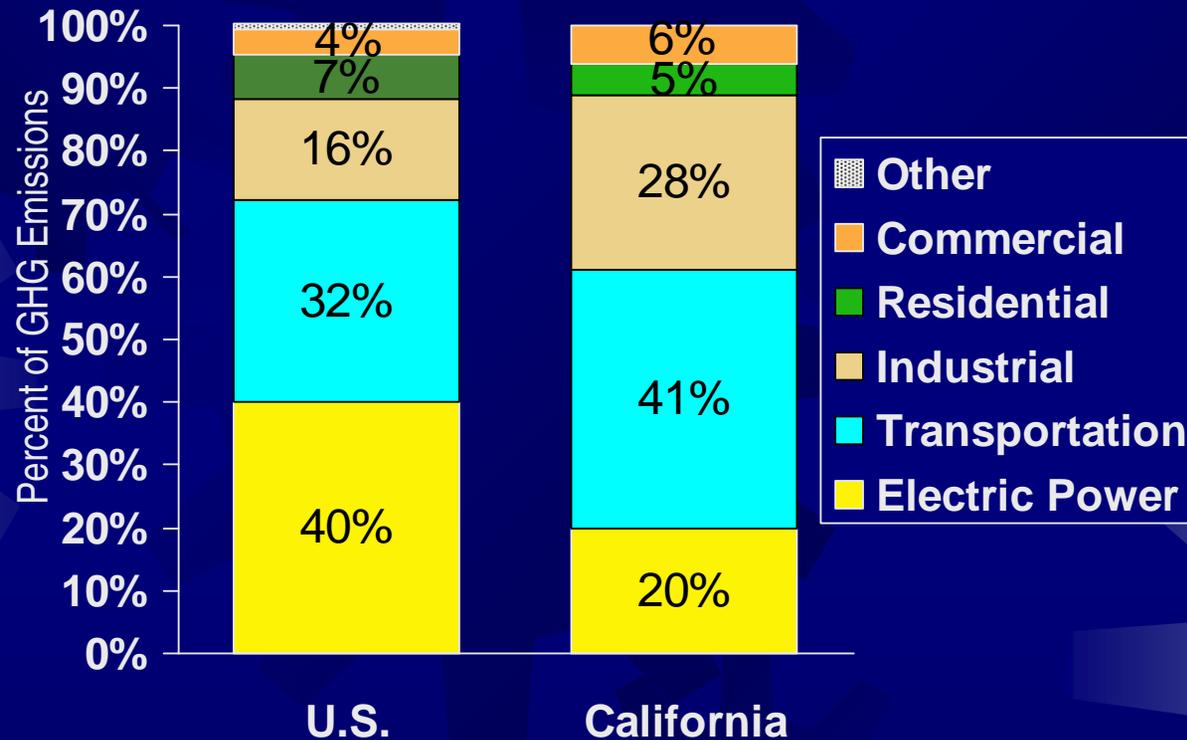


Climate Change in California

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

- Carbon dioxide (CO₂) 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

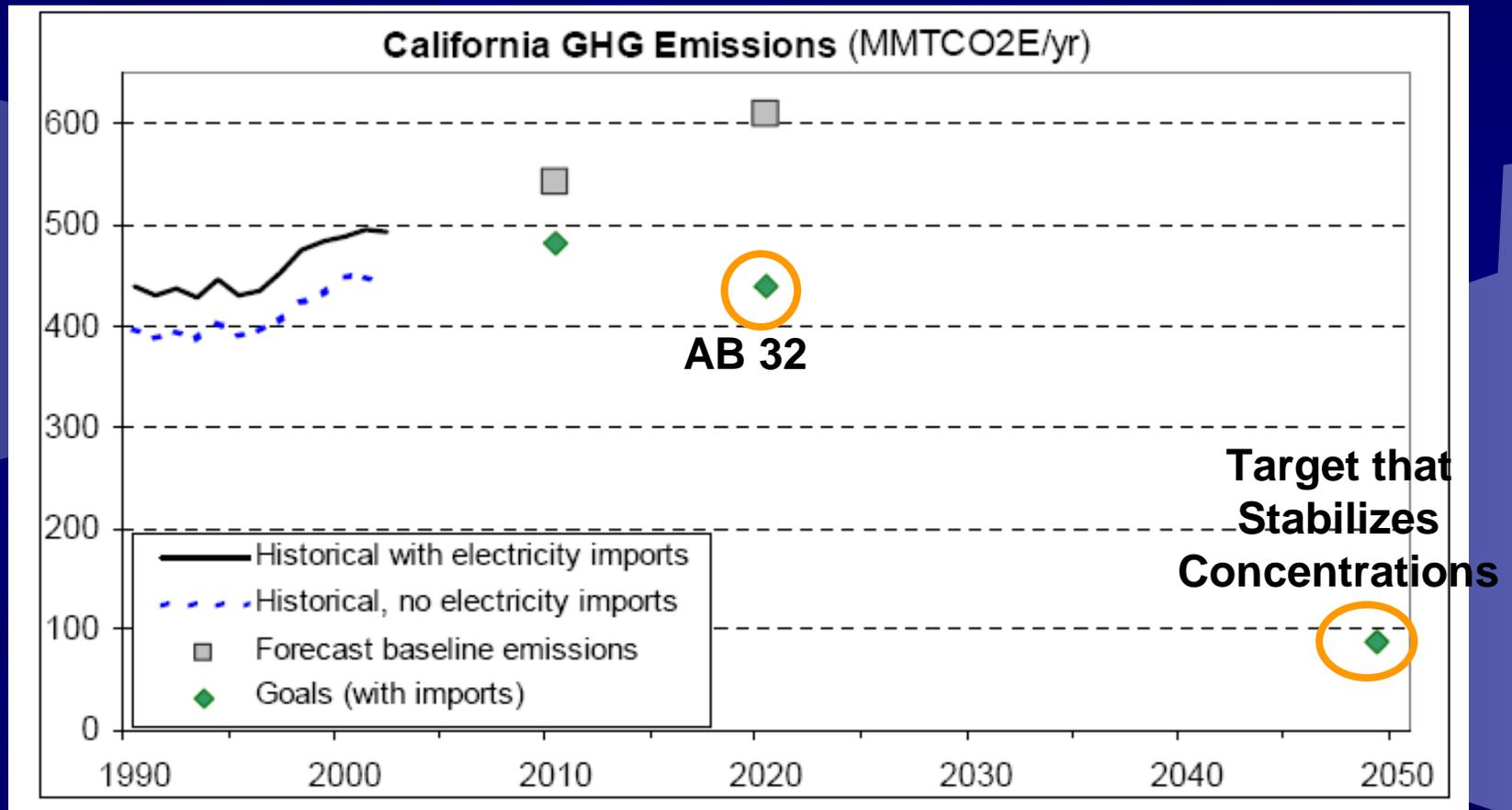


Greenhouse Gas Emissions by Sector, 2002

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

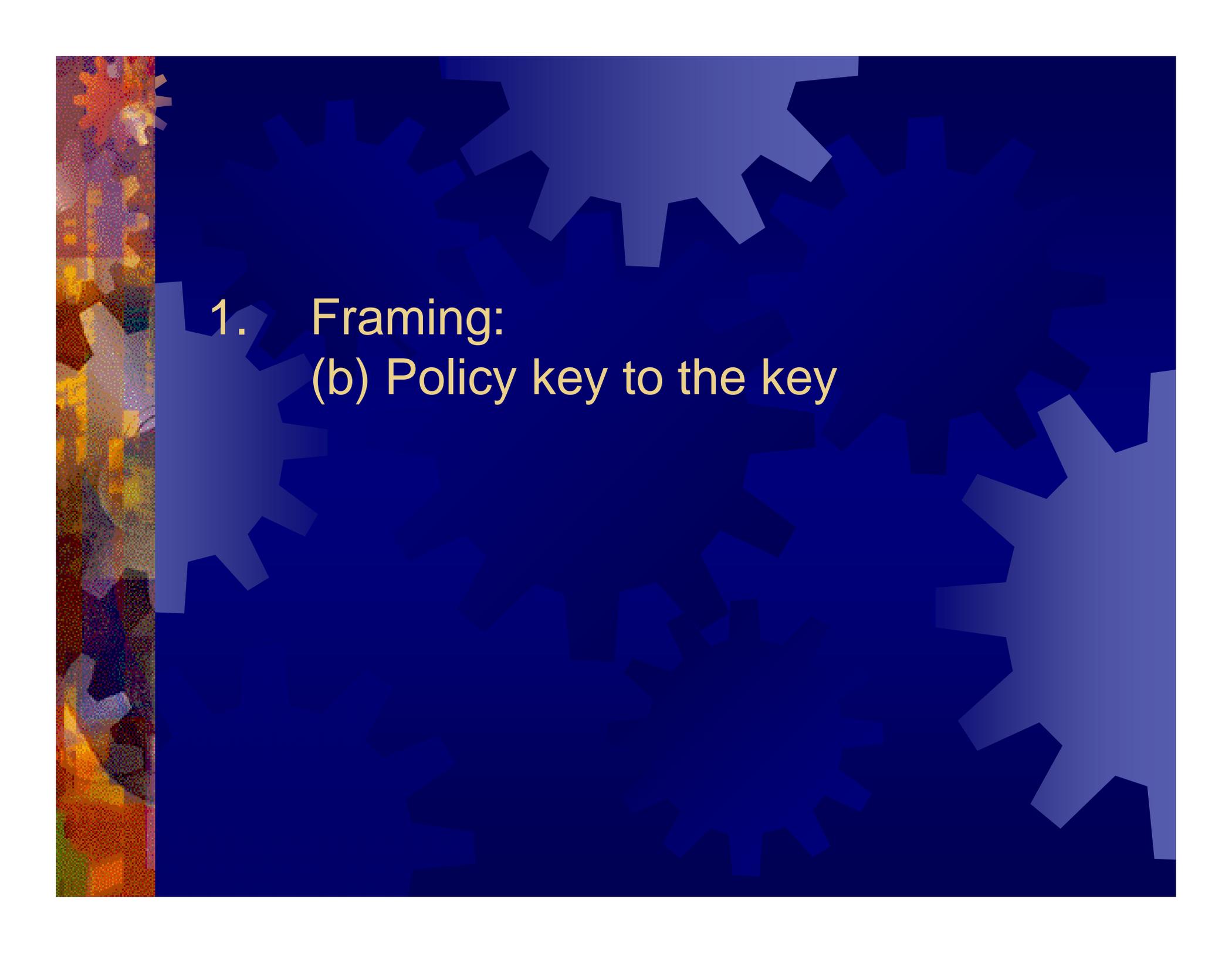


Source: Managing Greenhouse Gas Emissions in California, fig. 3-1



The Need for Innovation

- ✦ The technologies aren't all there for CO₂ 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

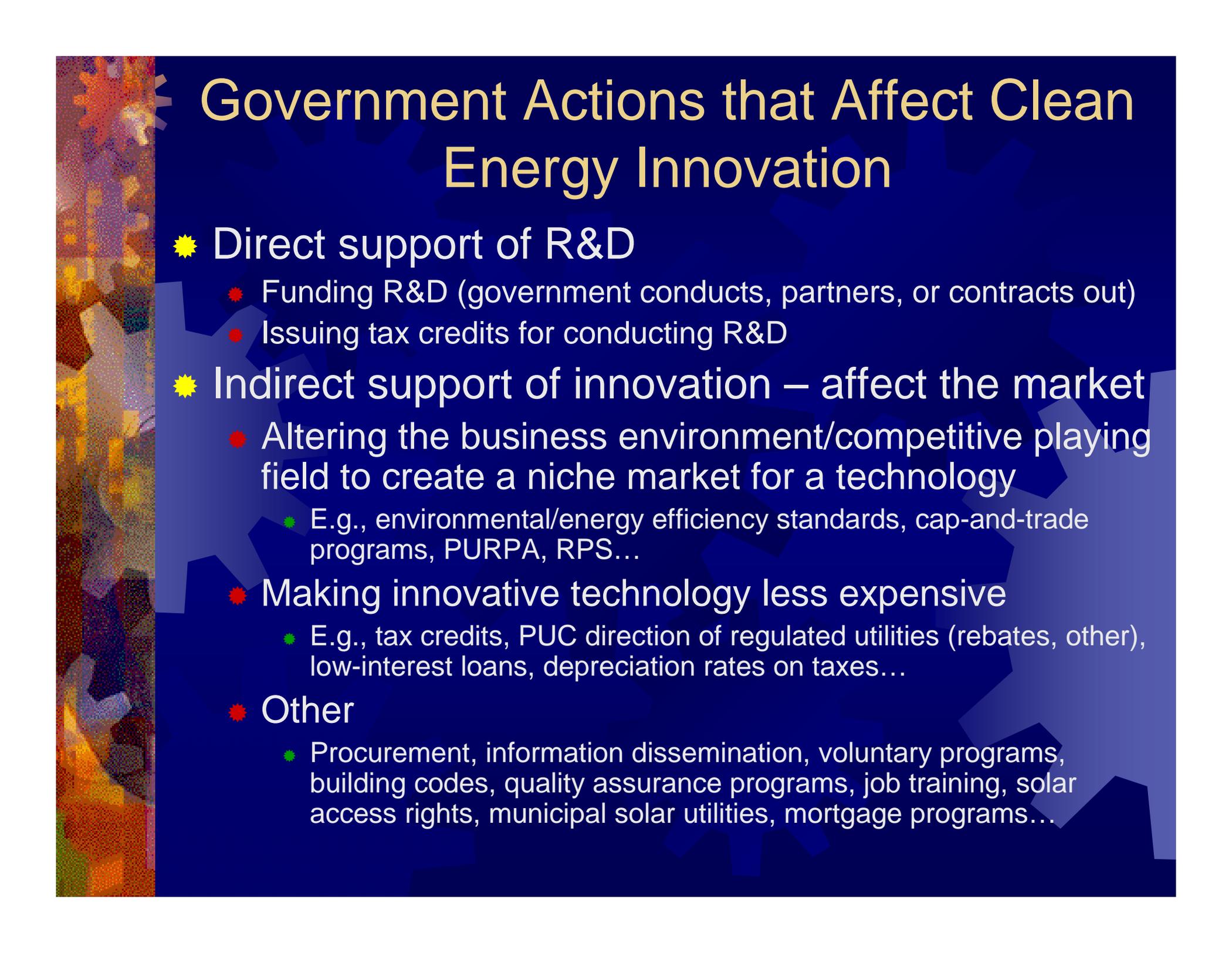
Why is Encouraging Innovation a Policy Problem?

☀ 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 CO₂ 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...

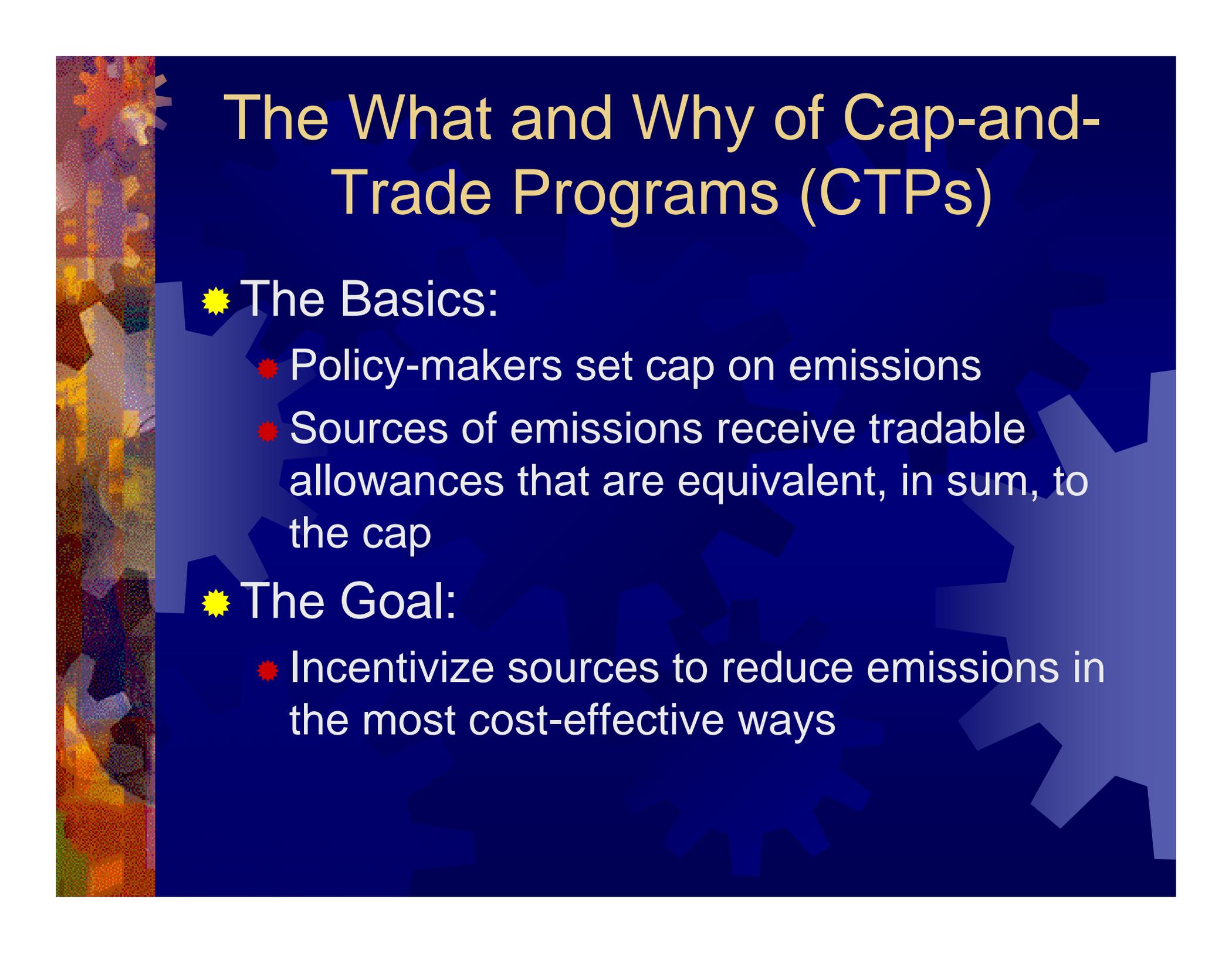
What's the Best Climate Policy re: Innovation?

How to answer:

- ★ Study cases so past experience with policy details and firm behavior can guide the answer
 - Control emissions: SO₂ and NO_x 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

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



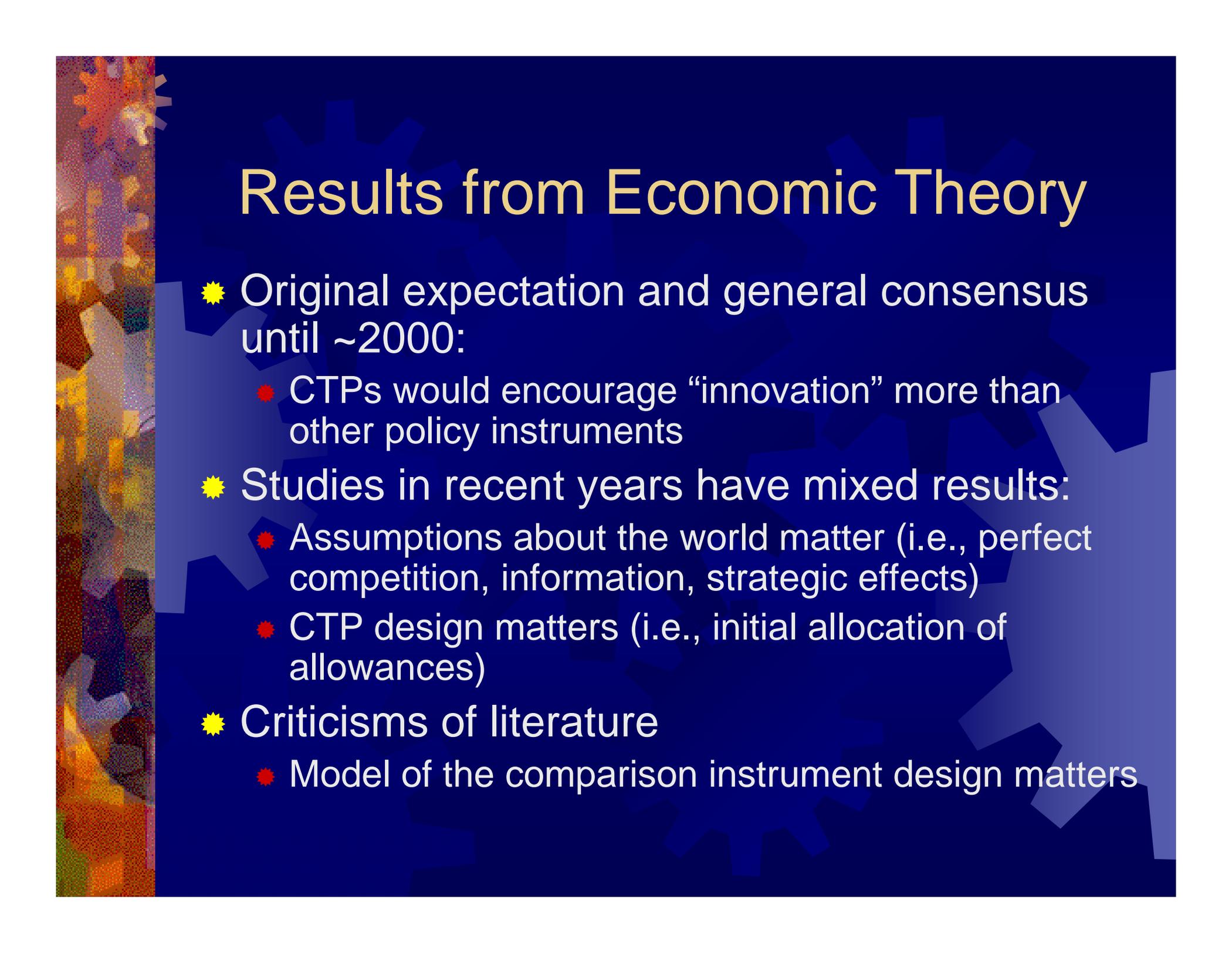
The What and Why of Cap-and-Trade Programs (CTPs)

☀ The Basics:

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

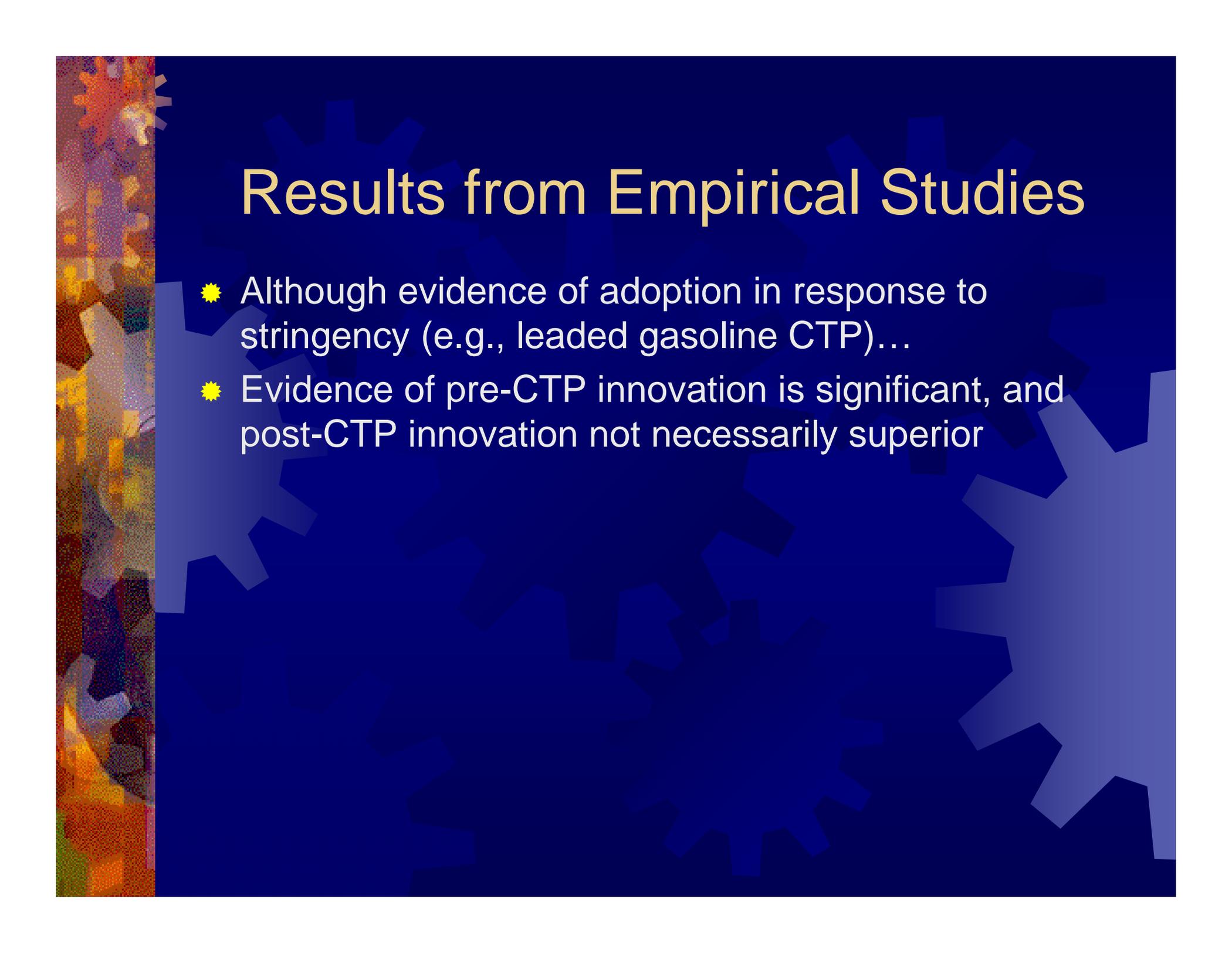
☀ The Goal:

- ☀ 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

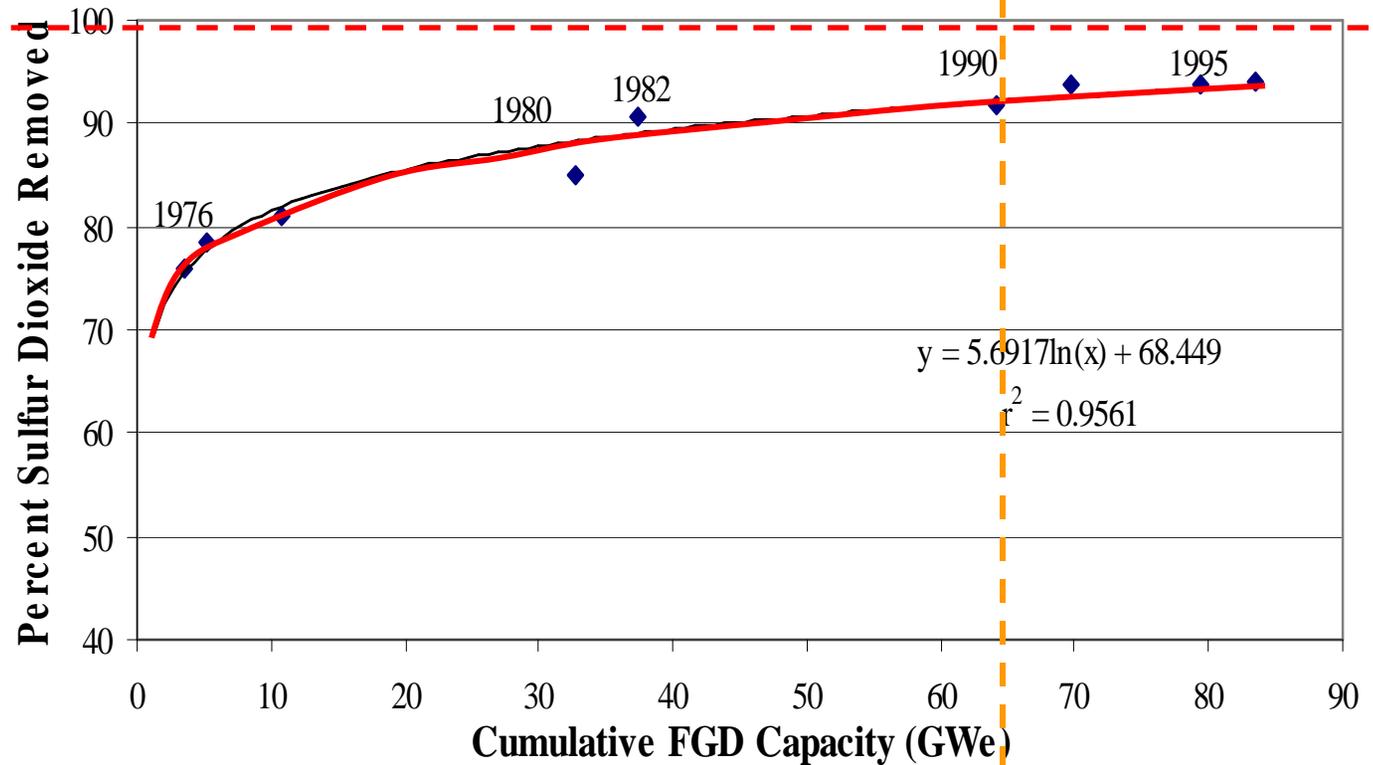
- ✦ Although evidence of adoption in response to stringency (e.g., leaded gasoline CTP)...
- ✦ Evidence of pre-CTP innovation is significant, and post-CTP innovation not necessarily superior

Environmental Performance of the Most Effective, Highest Cost SO₂ Control Technology

Pre-CTP | Post-CTP

Limit

Average %
SO₂ Removal
Rating of Units
Brought Online

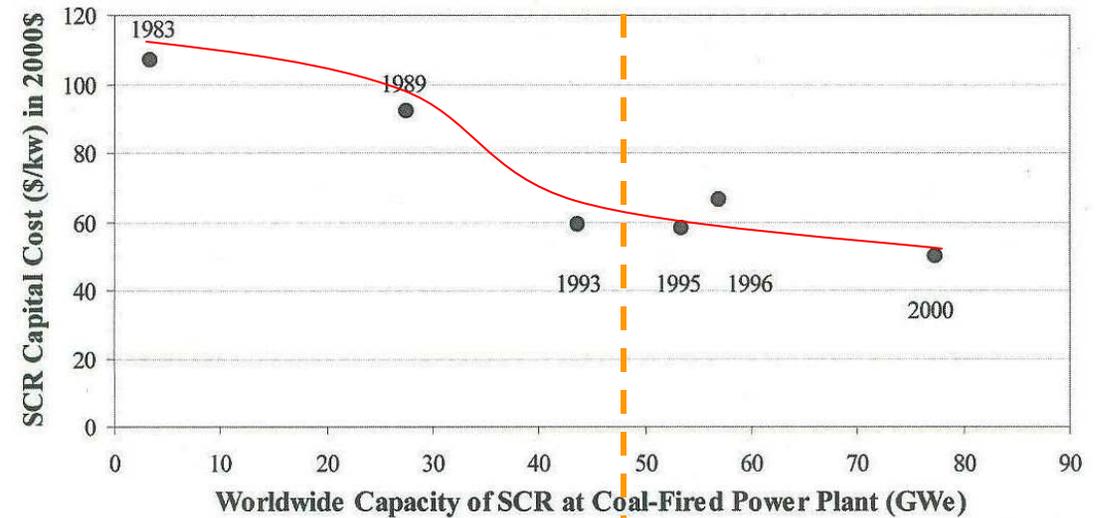


Costs

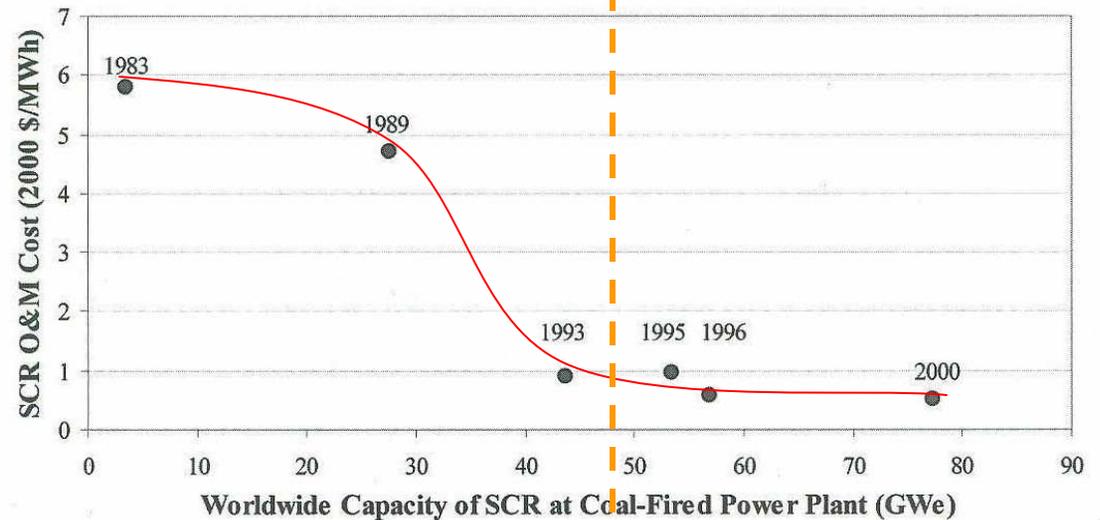
of the Most Effective, Highest Cost NO_x Control Technology

Pre-CTP | Post-CTP

Capital Costs
(Normalized
System)



Operating and
Maintenance
Costs
(Normalized
System)



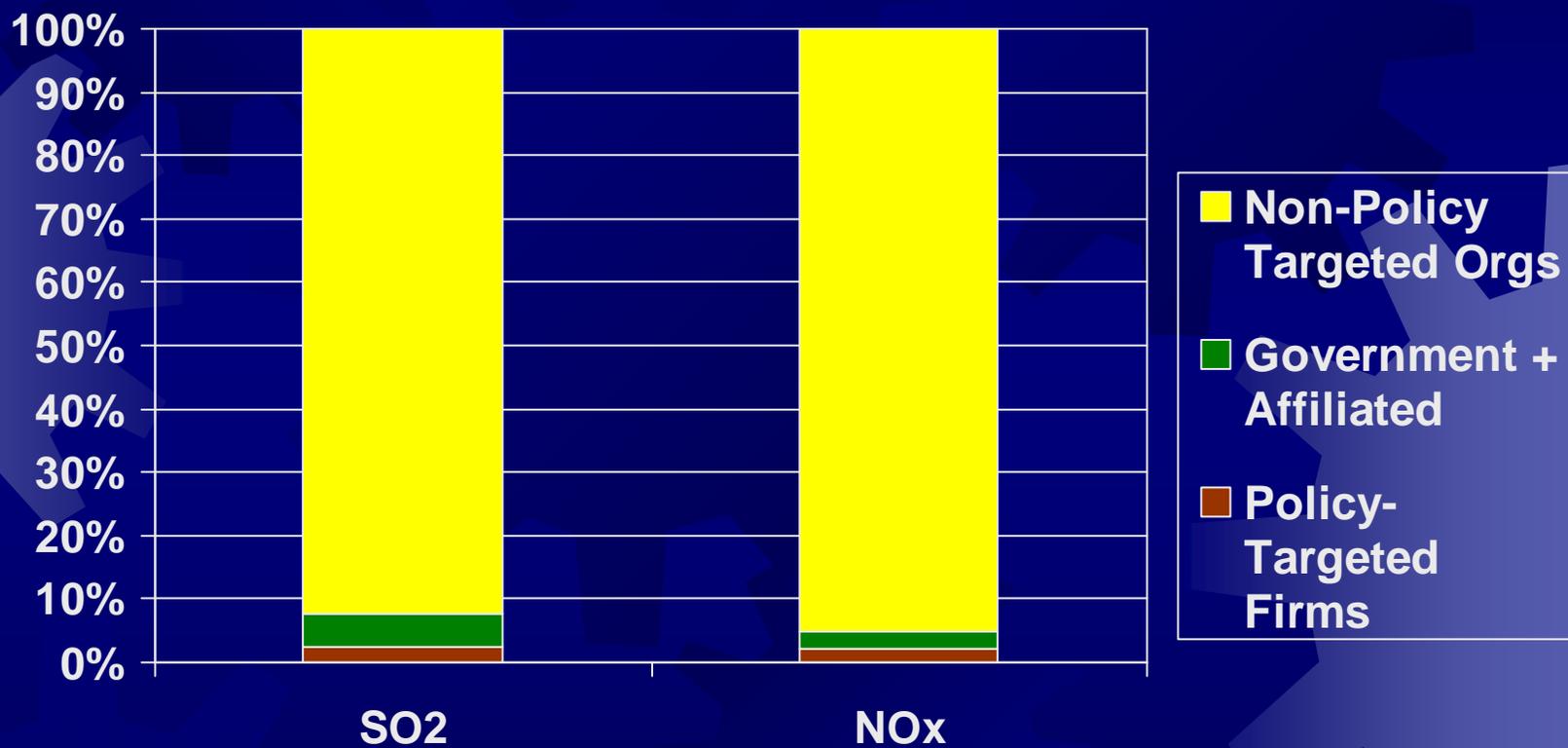


Who does innovation?

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

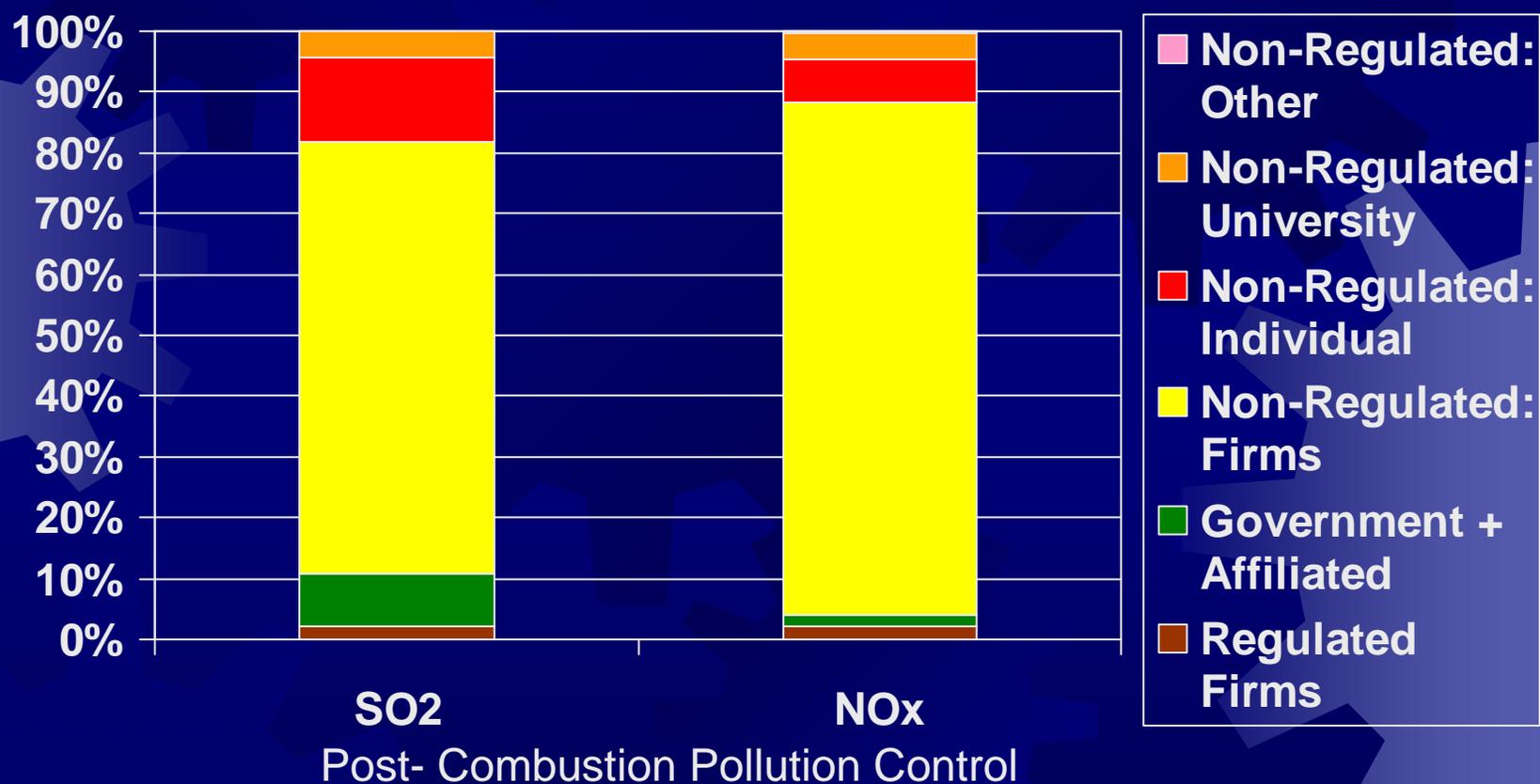
But do emissions sources perform significant R&D, esp. in environmental performance?

Most Patents by Non-Policy Targeted Organizations - 1



Post- Combustion Pollution Control

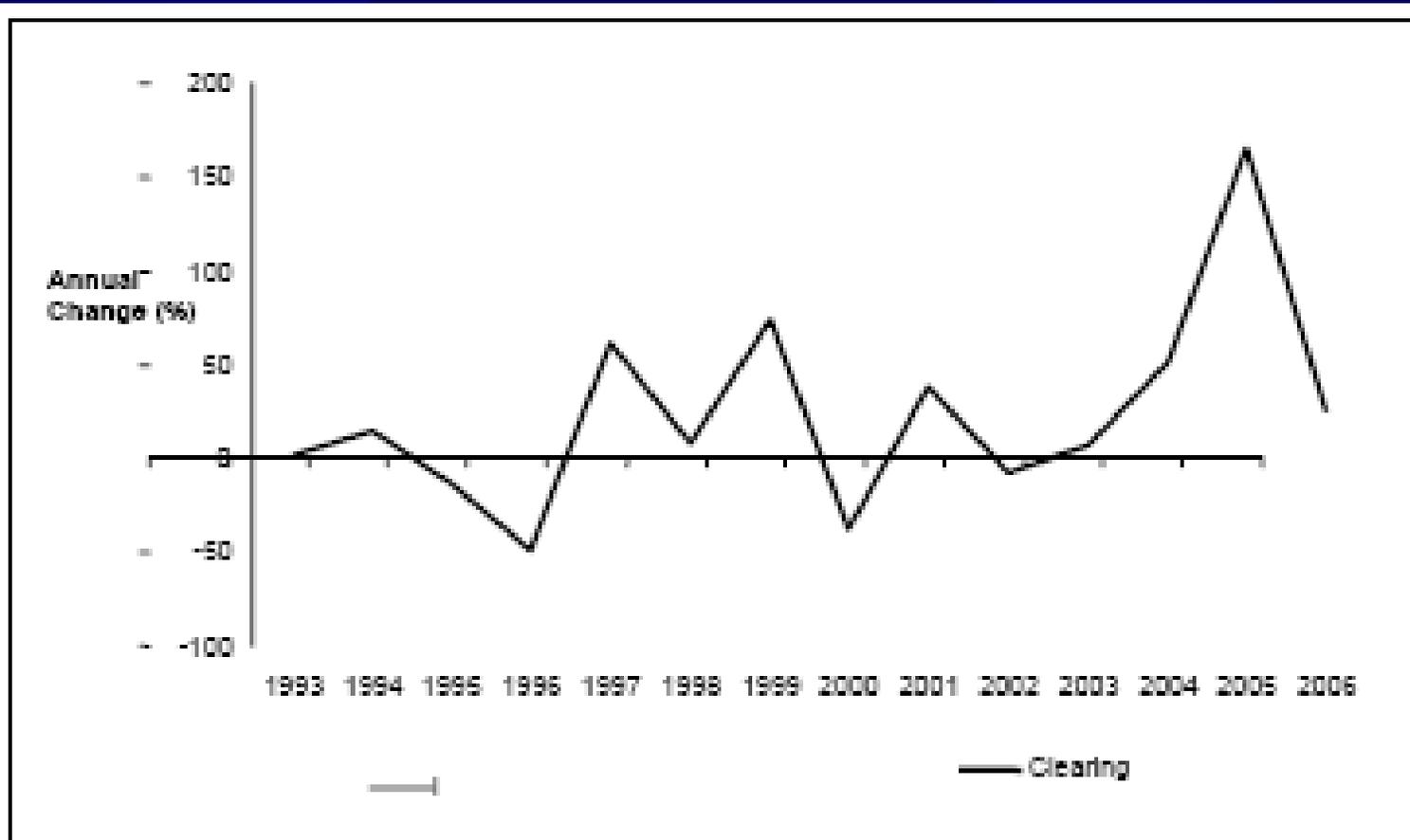
Most Patents by Non-Policy Targeted Organizations - 2



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 SO₂ control)
- ✦ Unpredictable allowance prices have been a problem for adoption decisions (e.g., SO₂ market, California NO_x market)

Price Volatility in CTPs (SO₂ Example)

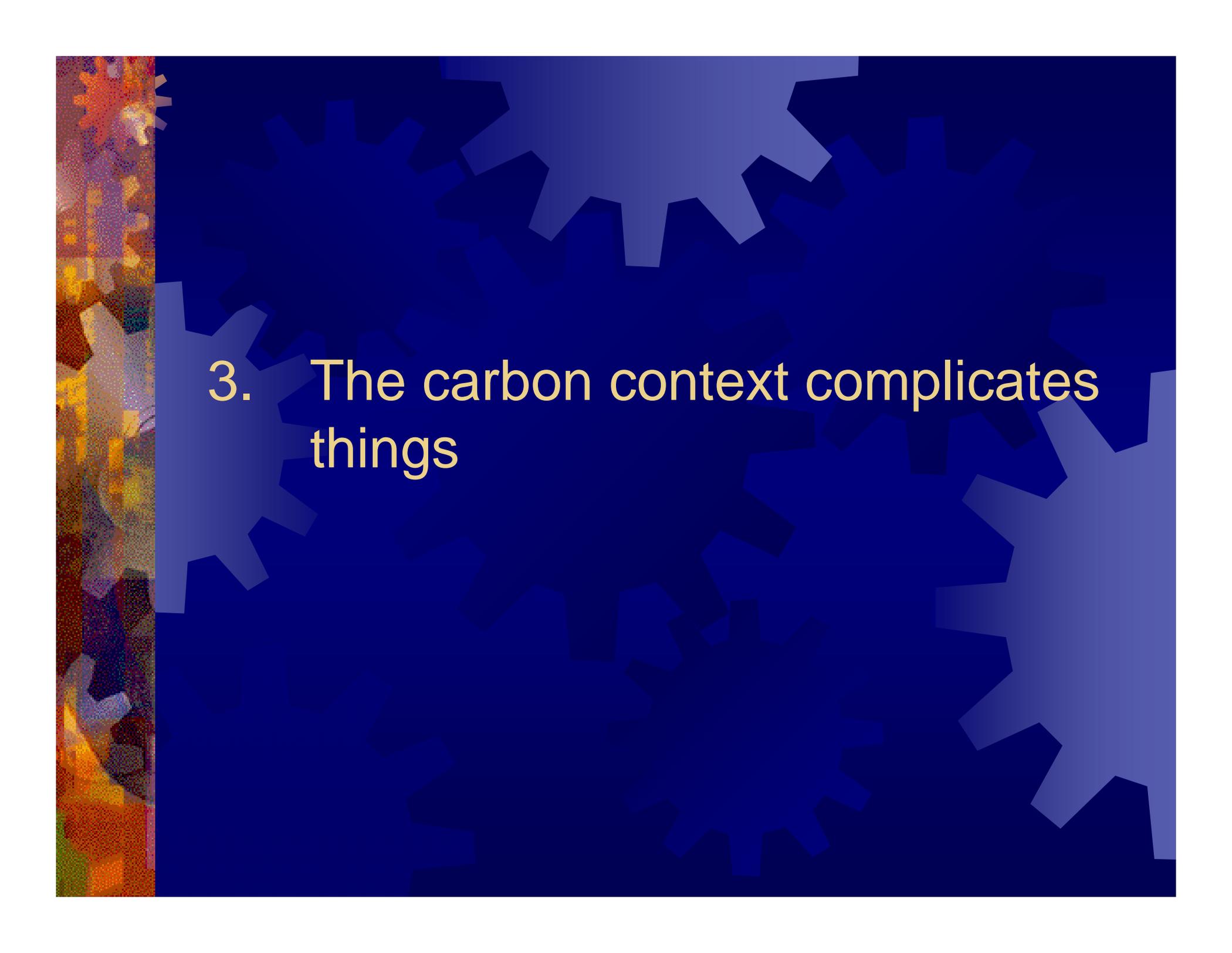


U.S. Acid Rain Program (Title IV 1990 Clean Air Act)

Annual % Change in Clearing Prices for SO₂ Permits, 1993-2006

Price shifts average 43%/year

Source: Shapiro (2/07)



3. The carbon context complicates things



The Carbon Context Complicates Things

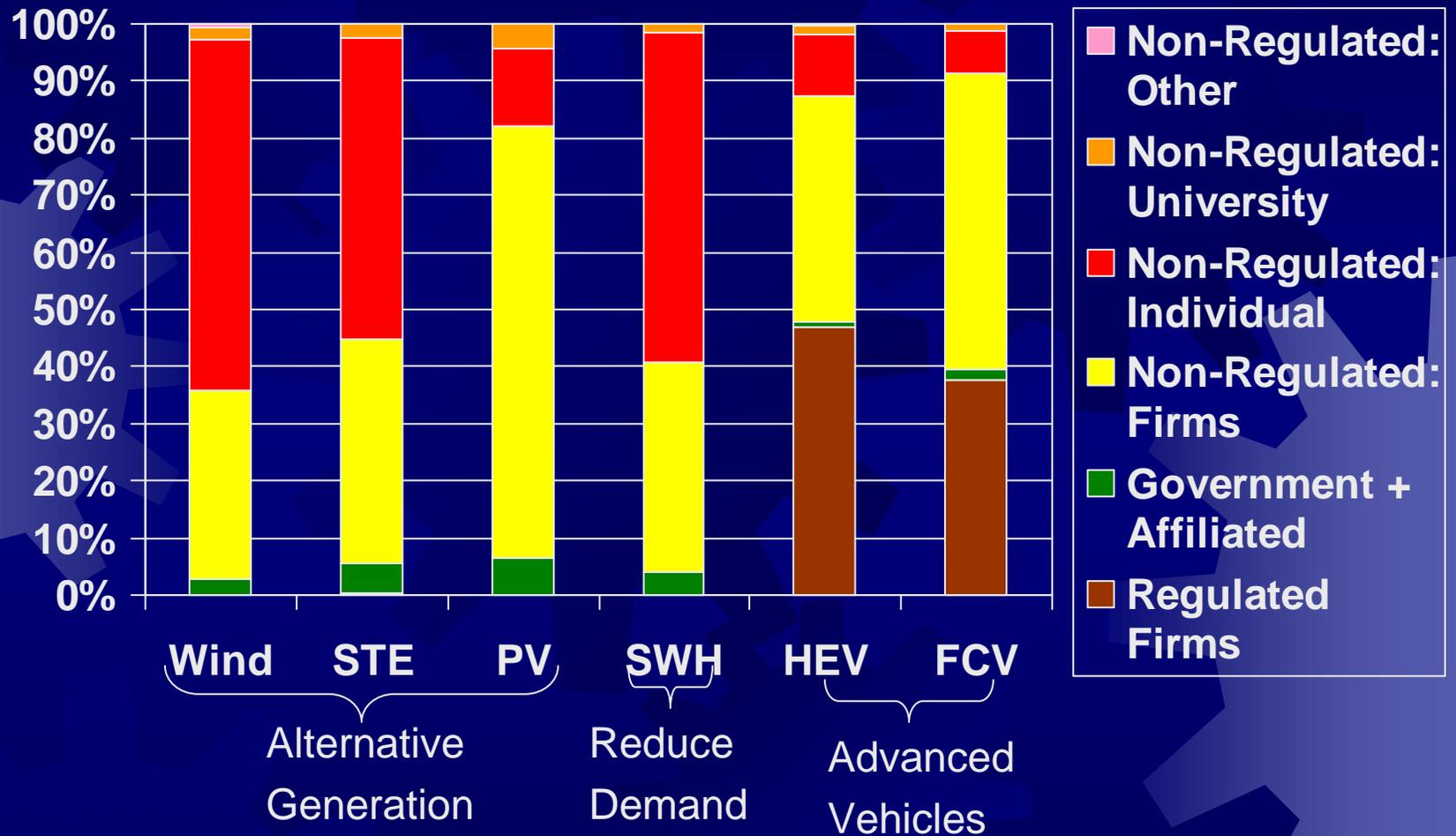
- a) Diverse set of emissions sources (“adopters”)
- b) No mature technology to adopt
- c) Diverse set of “creators”



The Carbon Context Complicates Things

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

Climate Technology “Creators”

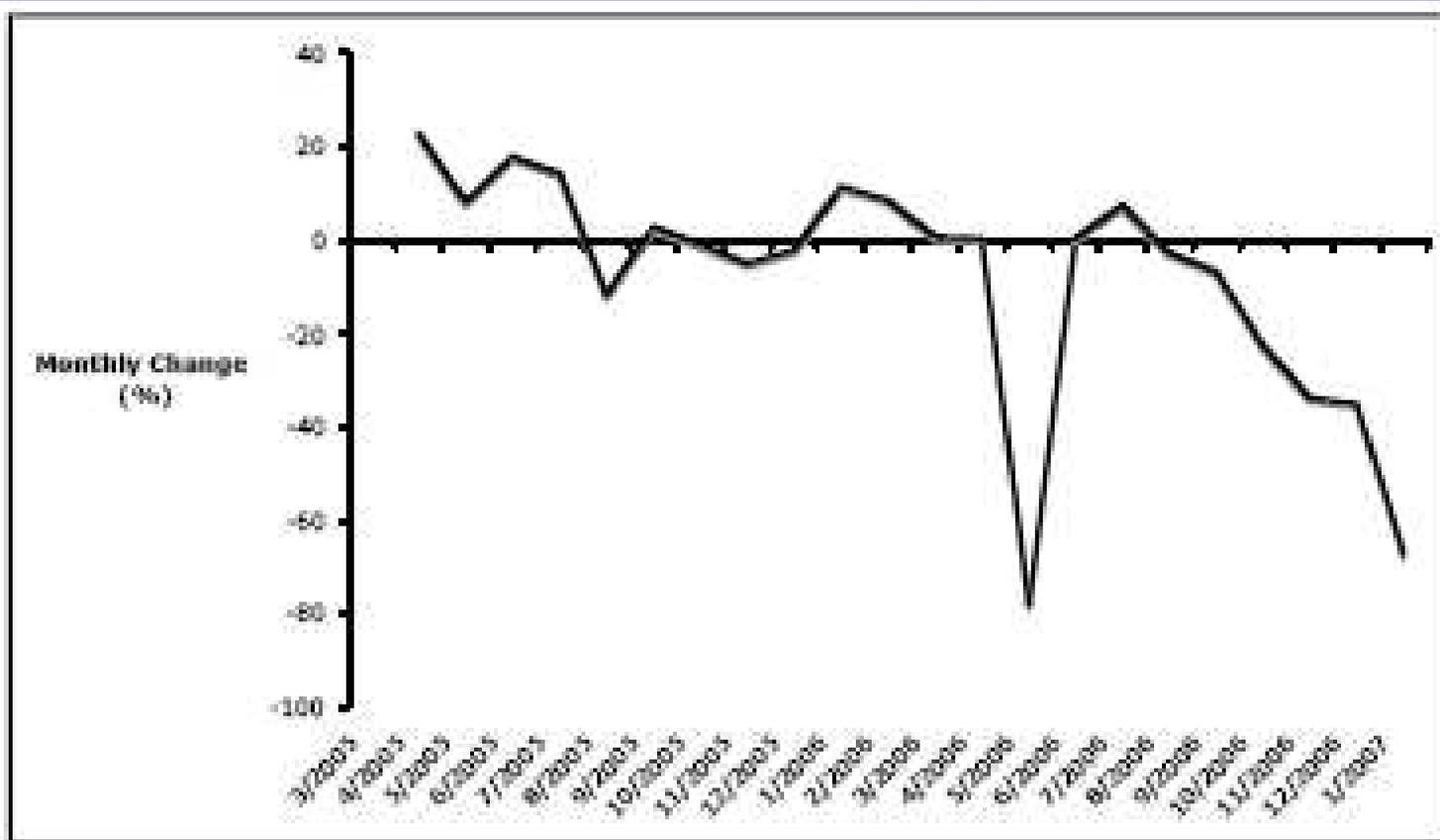


- ✦ Most Patents by Non-Policy Targeted Organizations
- ✦ Varying, but sometimes large role for individual inventors

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 (CO₂ Example)



European Emissions Trading Scheme (EU-ETS)

Monthly % Change in Avg. Prices for CO₂ Permits, 3/05-1/07

Price shifts average 17.5 %/month

Source: Shapiro (2/07)



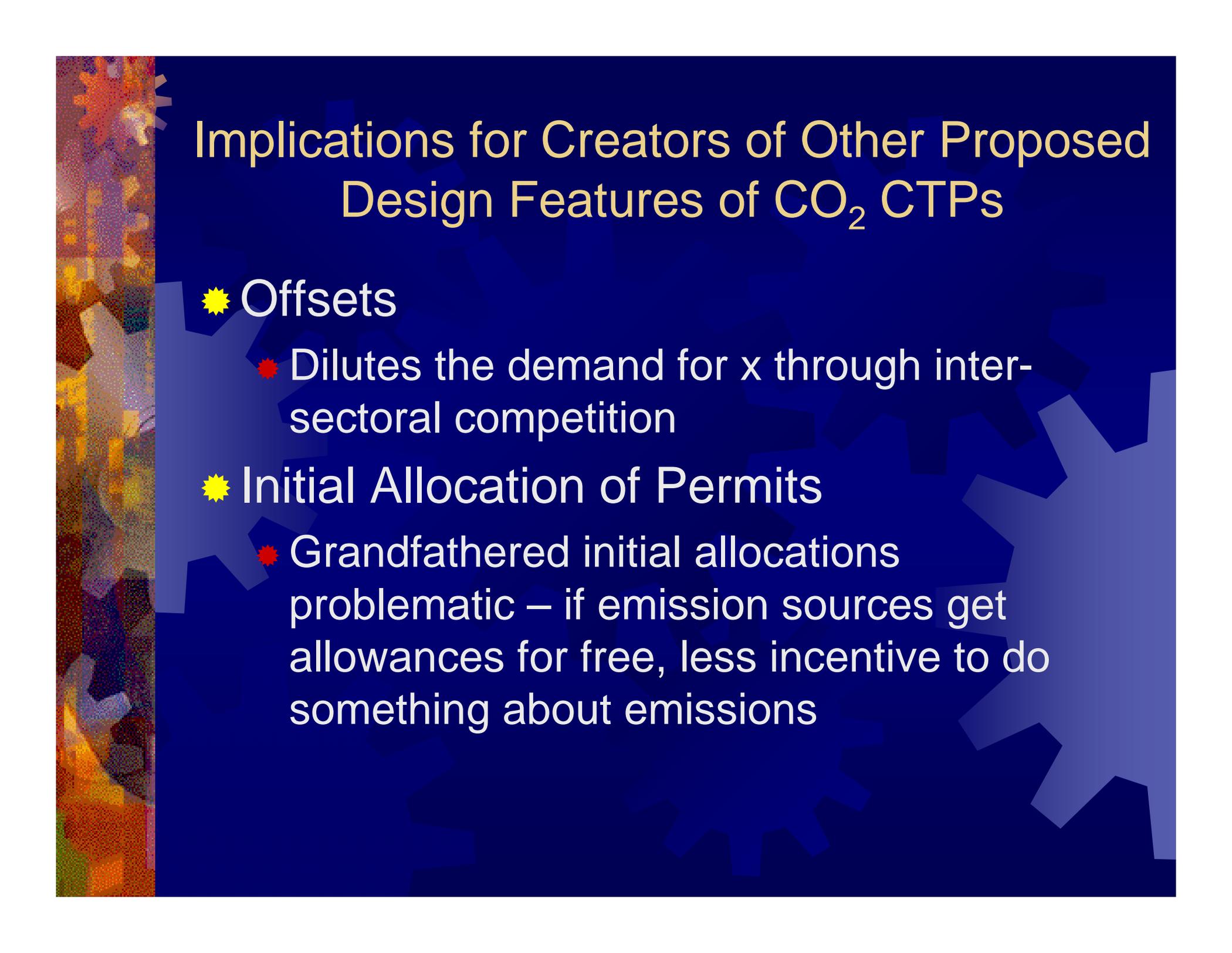
Implications for Creators of Ways Proposed to Address Price Volatility

★ Banking

- ★ Dilutes the demand for innovative product x temporally

★ Safety valves

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



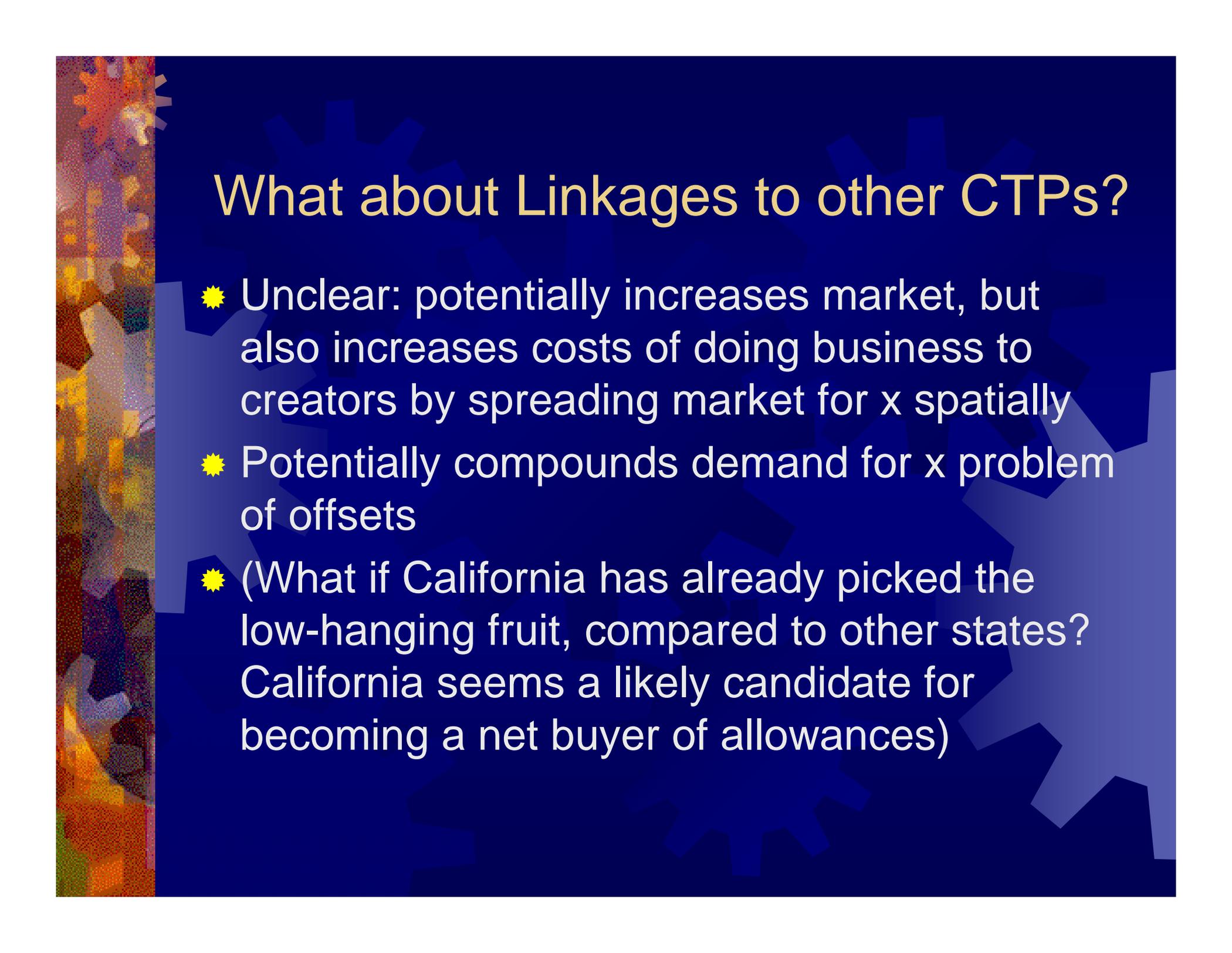
Implications for Creators of Other Proposed Design Features of CO₂ CTPs

☀ 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)