A New Architecture for Domestic Climate Policy: Trading, Tax or Technologies?

Michael Hanemann

University of California, Berkeley

hanemann@are.berkeley.edu

Topics

- What California is doing
- How it differs from straight emission trading
- Why California is doing this
- How emission trading works
  - In theory
  - In practice
- Why I don’t believe emission trading alone (let alone a carbon tax) will work for GHGs

Climate Change as an Issue in California

- 2002: AB1493 passed to reduce GHG emissions from motor vehicles in California.
- January 2004: Governor Schwarzenegger takes office. Committed to support AB 1493 and act on climate change.
- September 2004: California Air Resources Board approves regulations to implement AB 1493.
- June 2005: Governor Schwarzenegger announces GHG emissions reduction targets for California:
  - By 2020, to reduce emissions back to the level of 1990
  - By 2050, to reduce emissions 80% below 1990

California's 2006 GHG law

- AB 32, places a cap on all GHG emissions in California; requires that, by 2020, these be reduced to their 1990 level. A reduction of ~29% compared to BAU in 2020, and 15% compared to 2005 emissions.

- AB 1493 Imposes emissions cap on fleet of new model vehicles sold in California.
  - Enacted 2002; regulations issued 2004
  - Near term (2009-2012): 22% reduction in GHG emissions (grams of CO2e/mile)
  - Mid-term (2013-2016): 30% reduction in GHG emissions
- Low Carbon Fuel Standard: ≥ 10% emission reduction by 2020
- CPUC Carbon adder $8/ton
- Million solar roof Initiative. $3.2B subsidies for solar, especially photovoltaic.
- Renewable Portfolio Standard 20% by 2010, 33% by 2020
- SB 1368 Prohibits any load-serving entity from entering into long-term financial commitment for baseload generation unless GHG emissions are less than from new, combined-cycle natural gas.

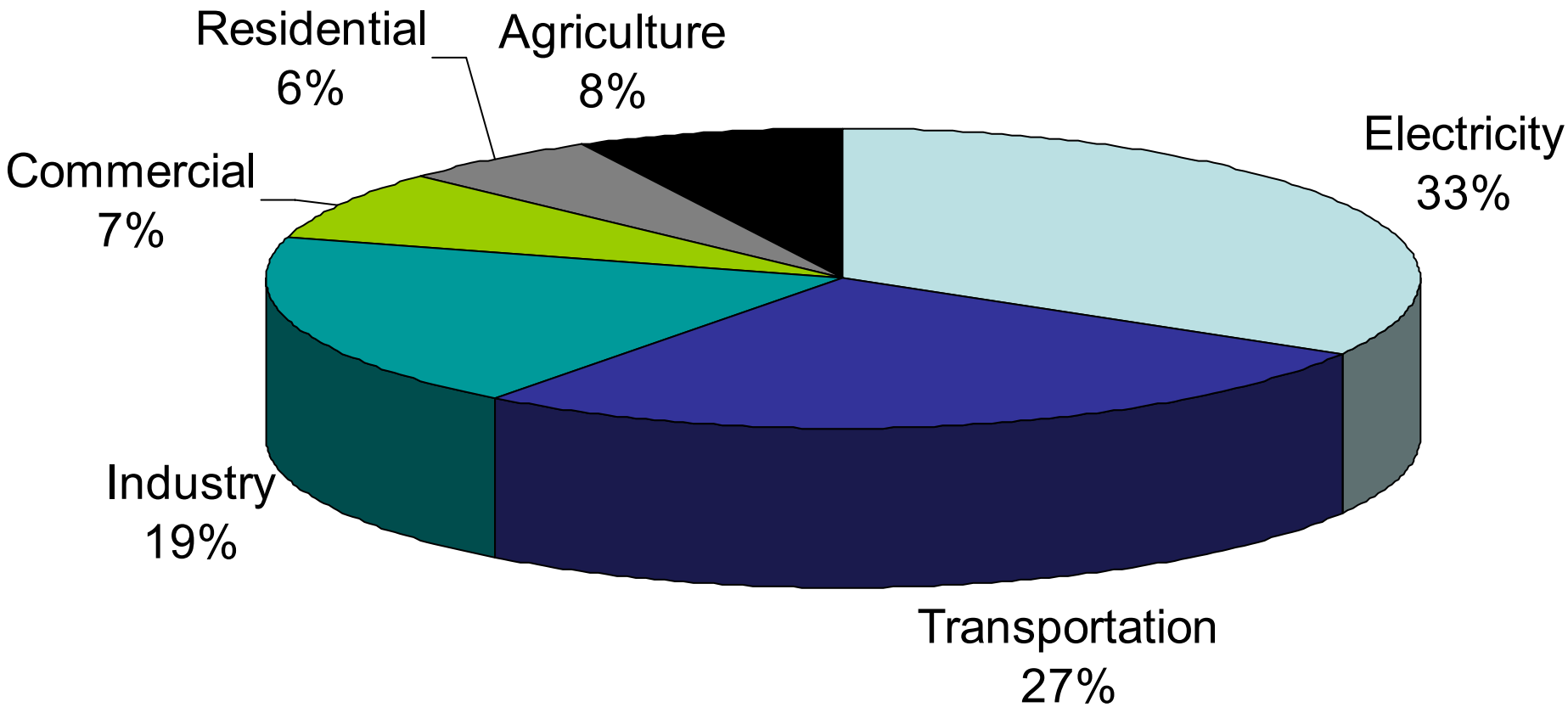
- Taken together, these are the most ambitious and comprehensive effort to control GHG emissions in force in the US.
- They apply:
  - To all GHGs, not just CO2 (CO2 from fossil fuel combustion is 81% of all GHGs in CA)
  - To all sources, not just electric power plants (= 22% of all GHG emissions in CA).

- The only other binding cap on emissions is Regional GHG Initiative in 9 northeastern states (RGGI).
  - RGGI applies only to GHG from electricity; target is to reduce emissions 10% below 2005 level by 2019.

The contrast with RGGI

- A different inspiration
  - RGGI: SO2 emission trading under 1990 CAA
  - CA: 1988 California regulation of automotive air pollution emissions
- A different approach
  - RGGI: emission trading
  - CA: Performance standards, efficiency standards, and also some emission trading

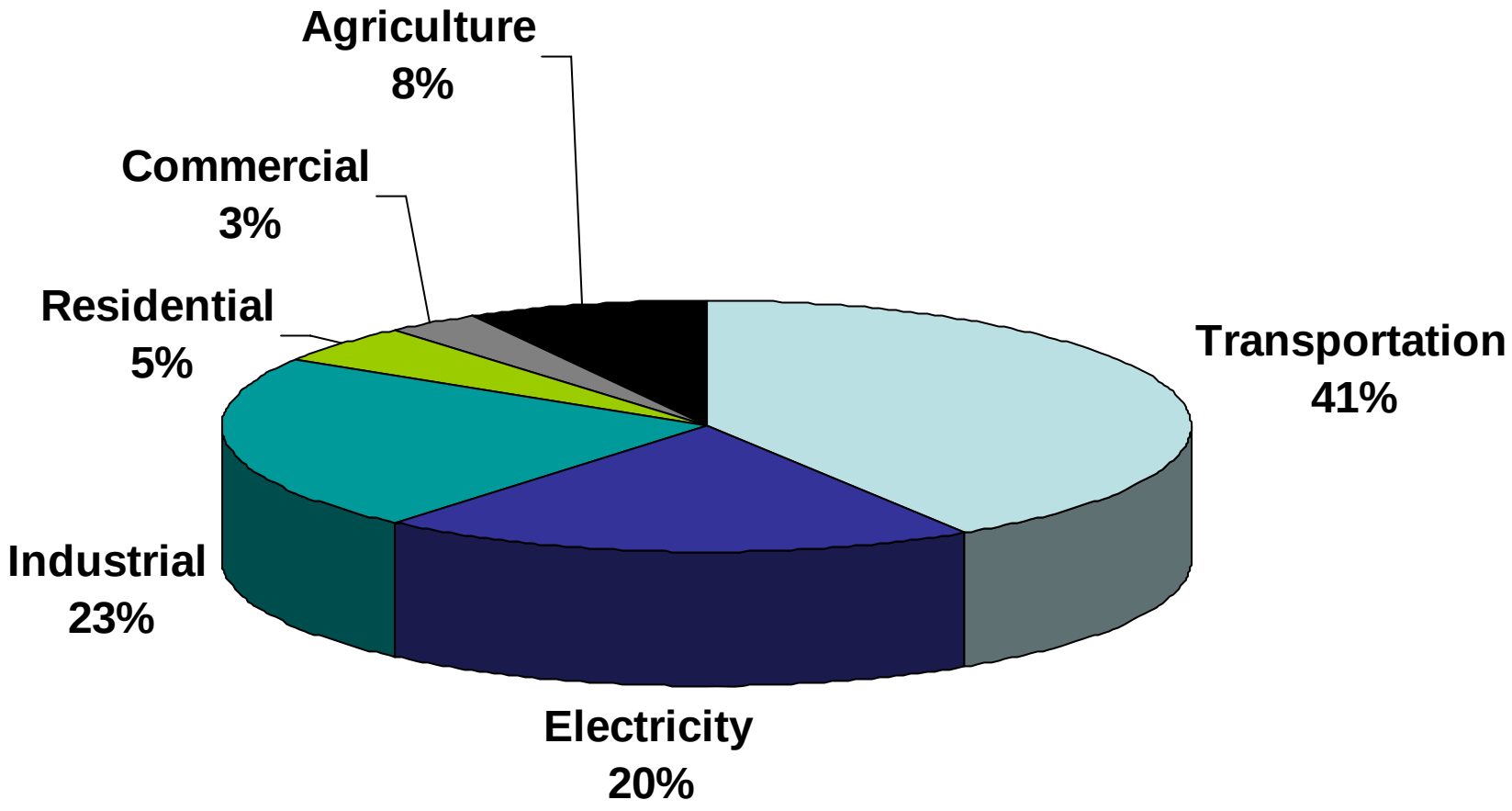
US Greenhouse Gas Emissions



Source: EPA. 2002 Emissions, including CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6.

California GHG Emissions (2002)

6.2% of US GHG emissions; 1.2% of world's emissions



Source: CEC. Gross emissions only.

California's unique history

- California has a unique history, unlike that of any other state in the US, with regard to:
  - controlling air pollution from automobiles
  - regulating energy efficiency
- In both cases, California pioneered regulatory approaches that were later copied by the federal government and applied to other states.
- This experience provided the foundation for California's new GHG initiative.

Air pollution

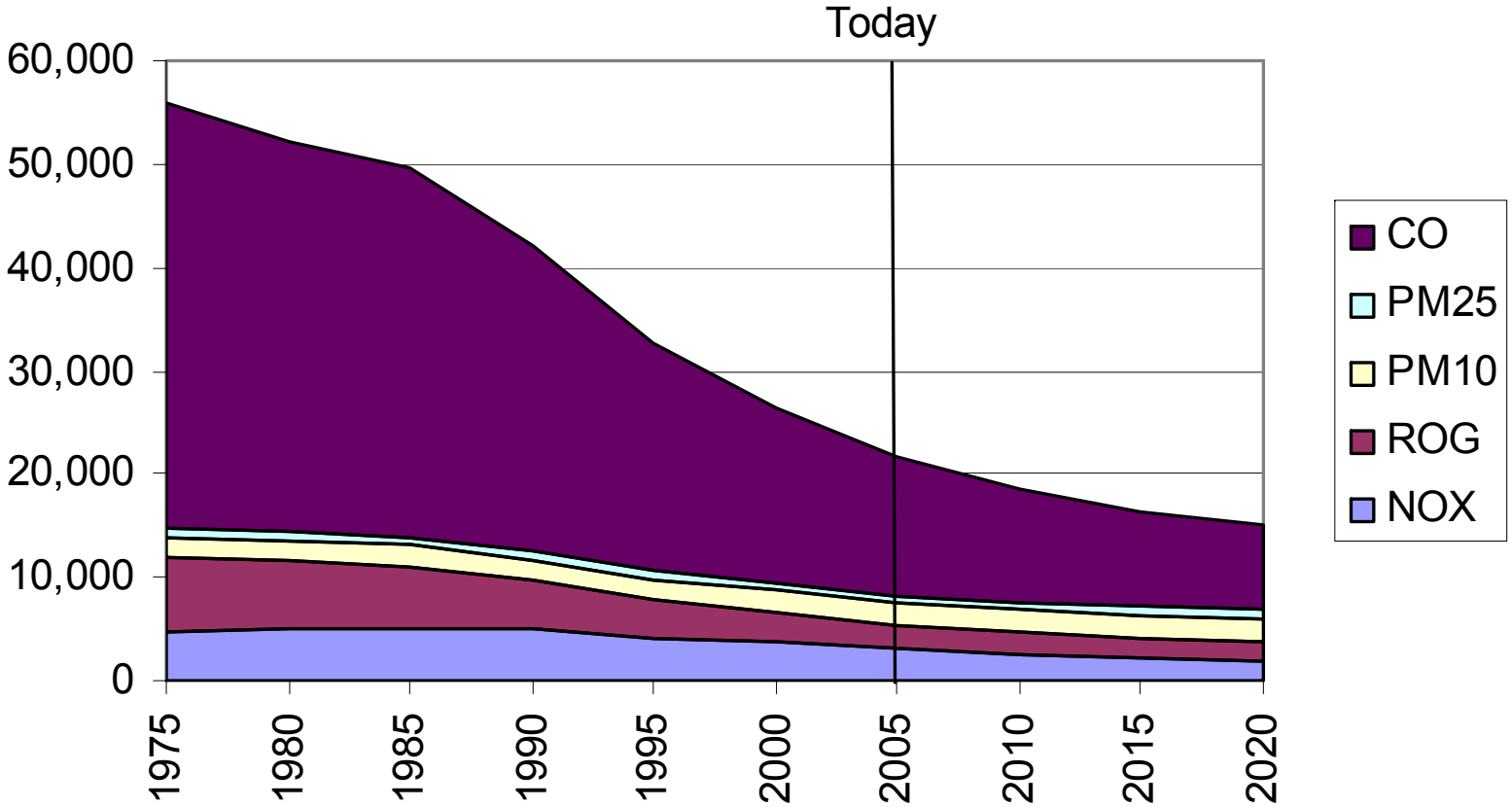
- 1943 First smog episodes in Los Angeles.
- 1947 Los Angeles County Air Pollution Control District (APCD) is established, the first in the nation.
- 1959 State Department of Public Health to establish air quality standards and necessary controls for motor vehicle emissions.
- 1960 Motor Vehicle Pollution Control Board is established to test and certify devices for installation on cars for sale in California
- 1961 PVC emissions controls required for new cars in 1963.
- 1966 Auto tailpipe emission standards for hydrocarbons and carbon monoxide, the first in the nation. California Highway Patrol begins random inspections of smog control devices.
- 1967 California Air Resources Board (ARB) is created.
- Federal Air Quality Act of 1967 enacted. Allows California a waiver to set its own emissions standards based on California's unique need for controls. Other states may copy California standard if they wish.

- Since 1967 a waiver has been requested and granted, in whole or in part, 53 times – until now. These include
  - the first introduction of NOx standards for cars and light trucks (1971)
  - heavy-duty diesel truck standards (1973)
  - Two-way catalytic converters (1975)
  - unleaded gasoline (1976)
  - the low-emissions vehicles (LEV) program (1994 and 1998)
  - zero-emissions vehicles (1990)
  - evaporative emissions standards and test procedures (1999).

Air pollution control

- The population of California grew from 21.5 million in 1975 to almost 35.5 million in 2005, and the vehicle miles traveled grew from about 389 million miles per day in 1980 to 873 million miles per day in 2005.
- Yet, over this period, there has been a major reduction in the statewide emission of criteria air pollutants.

CARB Impact on Air Pollution Emissions in California (tons/day, annual average)



Source: California Air Resources Board 2005 Almanac (web)

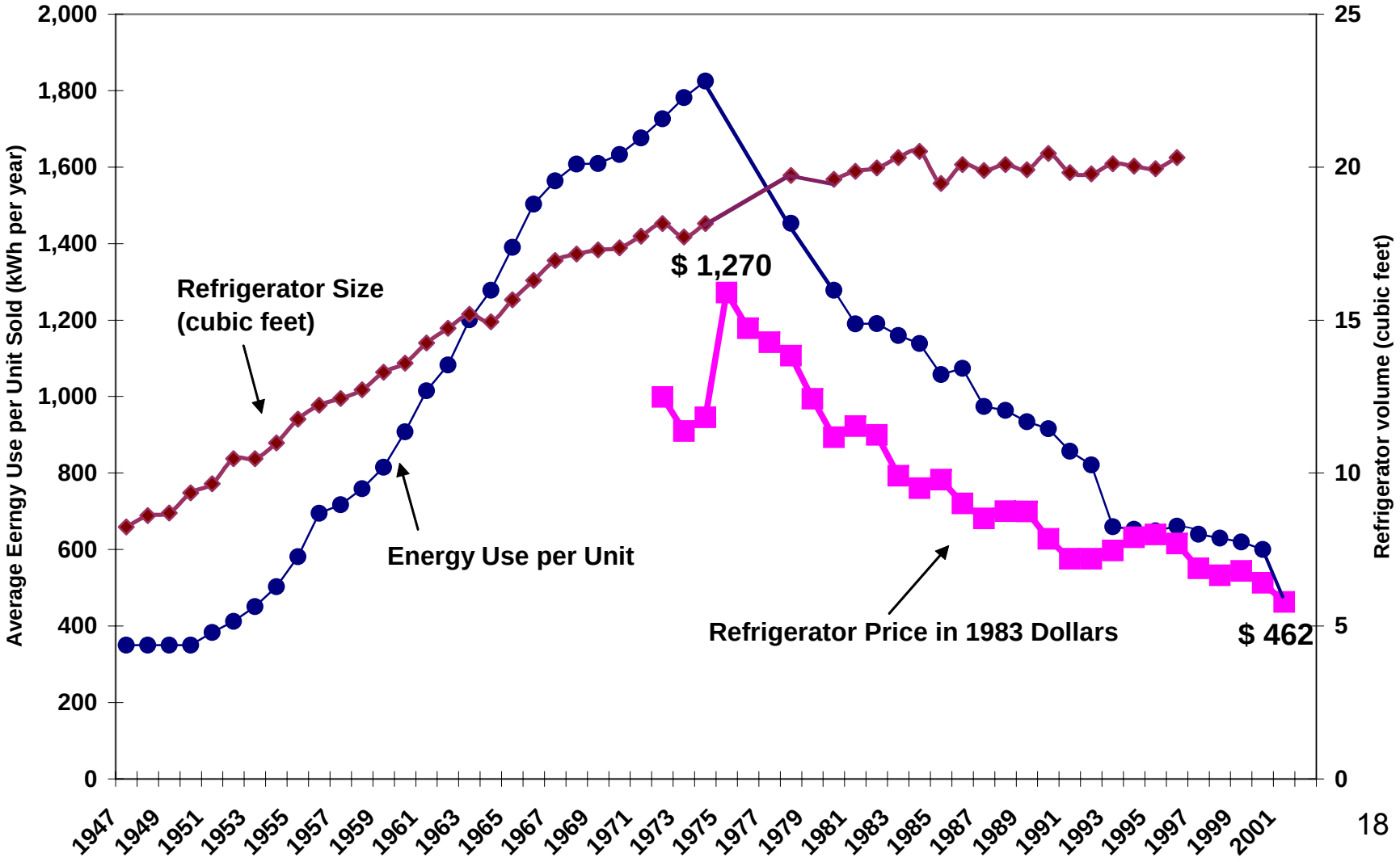
Energy efficiency

- A distinctive feature of California over the last 30 years has been its regulatory approach to promoting energy efficiency through the California Energy Commission and the California Public Utility Commission. CPUC authority applies to investor-owned utilities; CEC to municipals as well.
- The result has been a wave of regulation-induced technical change.

Energy Efficiency in California

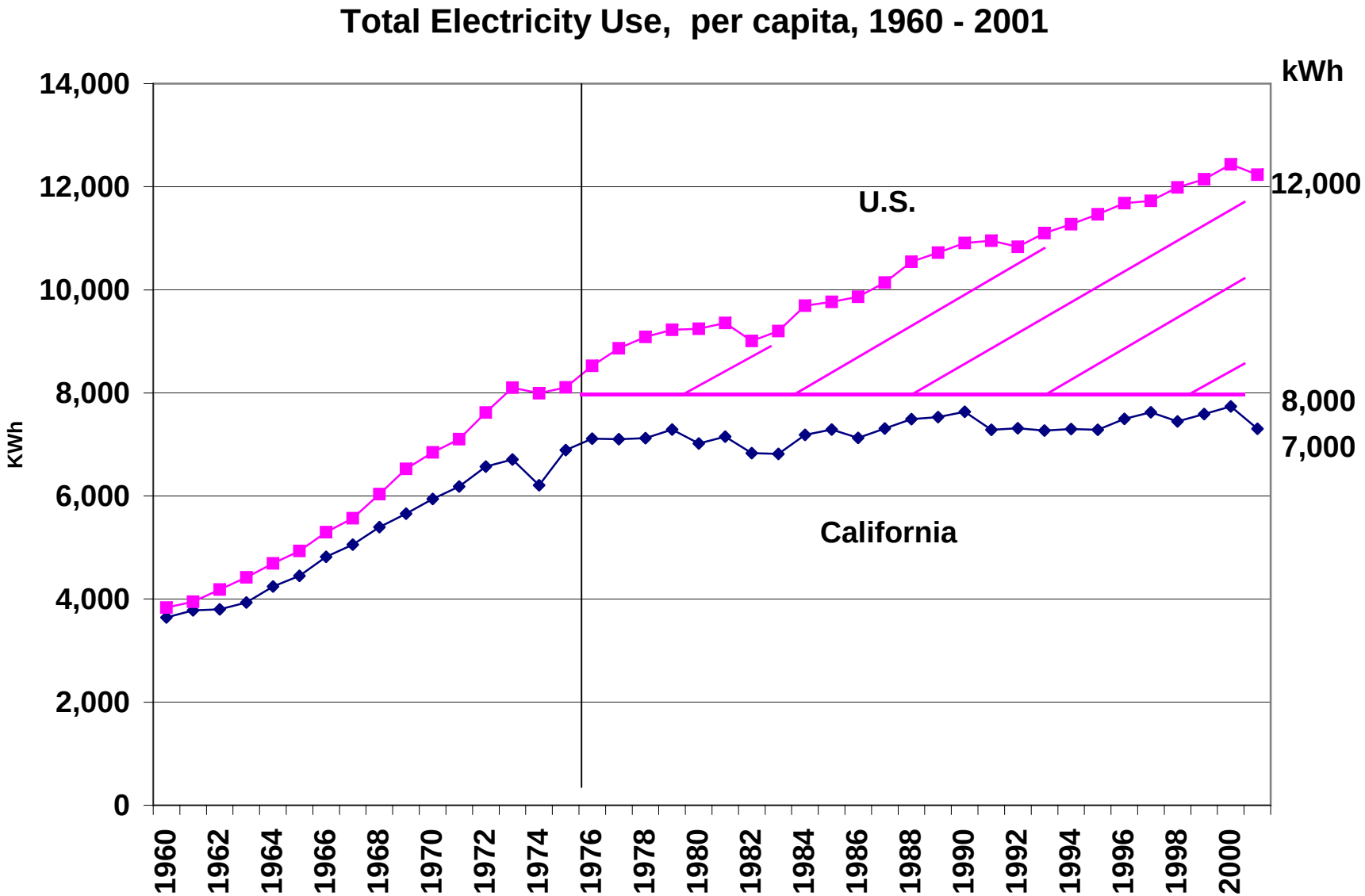
- In 1974, the California Energy Commission was created with five major responsibilities:
  - Forecasting future energy needs and keeping historical energy data
  - Licensing thermal power plants 50 megawatts or larger
  - Promoting energy efficiency through appliance and building standards
  - Developing energy technologies and supporting renewable energy
  - Planning for and directing state response to energy emergency
- Since 1975, CEC has promulgated energy efficiency standards for buildings and energy-using appliances and equipment.

Inflation-adjusted price of refrigerators dropped from $1270 (1974) to $462 (2001)



California Public Utility Commission

- Regulates investor-owned electric and gas utilities.
- Has energetically pushed them to promote energy conservation.
- Adopted rate decoupling for natural gas in 1978 and electricity in 1982. Ensures that utilities receive their expected revenue even if energy efficiency programs reduce their sales.
- 2003 Energy Action plan establishes a “loading order” of preferred options for electricity : efficiency, renewables, natural gas.


Total Electricity Use, per capita, 1960 - 2001
kWh
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
KWh
U.S.
California
12,000
8,000
7,000
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000

What California is proposing

- The Draft Scoping Plan, issued at the end of June, calls for a mix including:
  - Regulatory measures
  - Performance standards
  - Best management practices
  - Hold local governments accountable in land use decisions ?
  - Emission trading
    - Downstream approach
    - Only a subset of sectors covered at first
    - Capped sectors also subject to regulatory measures
  - Technology development and promotion (for 2050 target)

Table 4: Sector Responsibilities Under Cap-and-Trade Program

(MMTCO$_2$E in 2020)

Sector	Projected 2020 Business-as-Usual Emissions		Projected 2020 Emissions After Implementation of Other Recommended Measures		Preliminary 2020 Emissions Limit under Cap-and-Trade Program
	By Sector	Total	By Sector	Total	
Transportation	225	512	163	400	365
Electricity	139		94		
Commercial and Residential	47		42		
Industry	101		101		

Table 2: Recommended Greenhouse Gas Reduction Measures

Recommended Reduction Strategies	Sector	2020 Reductions ($MMTCO_2E$)
The Role of State Government • Reduce carbon footprint • Set an example	Various	1-2[17]
California Cap-and-Trade Program Linked to WCI: Emissions cap of 365 $MMTCO_2E$ covering electricity, transportation, residential/commercial and industrial sources by 2020. Shaded reductions contribute to achieving the cap.		
California Light-Duty Vehicle GHG Standards • Implement Pavley standards • Develop Pavley II light-duty vehicle standards	Transportation	31.7

Energy Efficiency
• Building and appliance energy efficiency and conservation
  • 32,000 GWh reduced electricity demand
  • 800 million therms reduced gas use
• Increase Combined Heat and Power (CHP) electricity production by 30,000 GWh
• Solar Water Heating (AB 1470 goal)
	Electricity & Commercial and Residential	26.4

Renewables Portfolio Standard (33% by 2020)	Electricity	21.2
Low Carbon Fuel Standard	Transportation	16.5
High Global Warming Potential Gas Measures	High GWP	16.2
Sustainable Forests	Forests	5
Water Sector Measures	Water	4.8[18]
Vehicle Efficiency Measures	Transportation	4.8
Goods Movement • Ship Electrification at Ports • System-Wide Efficiency Improvements	Transportation	3.7
Heavy/Medium Duty Vehicles • Heavy-Duty Vehicle GHG Emission Reduction (Aerodynamic Efficiency) • Medium- and Heavy-Duty Vehicle Hybridization • Heavy-Duty Engine Efficiency	Transportation	2.5
Million Solar Roofs (Existing Program Target)	Electricity	2.1
Local Government Actions and Regional GHG Targets	Land Use and Local Government	2
High Speed Rail	Transportation	1
Landfill Methane Control	Recycling & Waste	1
Methane Capture at Large Dairies	Agriculture	1[19]
Energy Efficiency and Co-Benefits Audits for Large Industrial Sources	Industrial	TBD
Additional Emissions Reduction from Capped Sectors		35.2
	Total Reductions	**169**

- Cap-and-trade program is intended to cover 85 percent of the state's emissions.
- Propose capping electricity and industry beginning in 2012, and transportation and commercial and residential natural gas by 2020.
- Commits to "consideration" of a California Carbon Trust, funded through auction revenues, carbon fees, or public-goods charges on water.
- Key elements yet to be addressed:
  - The method of allowance distribution
  - How to apply cap for electricity -- “considering” first deliverer approach
  - Potential constraints on the system, including trading in communities with disparate environmental impacts
  - Safety valve
  - Offsets

Economic Cost

- Analysis performed by my colleague David Roland-Holst assumes a mix of:
  - 8 specific regulatory policies
    - Building efficiency
    - Reduced motor vehicle emissions
    - HFC reduction
    - Semiconductors
    - Cement manufacturing
    - Landfill management
    - Manure management
    - Afforestation
  - emission trading
  - recycling of revenues from distribution of permits to fund into innovation investment

Finding

- Meeting the 2020 goal is feasible
  - There are many possible strategies for lowering GHG emissions using existing or near-existing technologies.
- This can be done at a moderate or no cost
  - Goods produced in California have a lower carbon footprint than those produced out of state
  - Energy efficiency strategies promote economic growth and raise employment
  - Innovation investment also promotes economic growth and raises employment
- However, substantial technological innovation will be required to meet the 2050 goal. This will require a significant policy effort aimed at promoting technology development.

Emission trading

Emission trading in theory

- The theory is that emission trading with a cap on aggregate emissions generates price signals which radiate throughout the economy.
- Commodities which are carbon-intensive become more expensive.
- This triggers price-induced demand and supply responses: decrease in demand for carbon-intensive commodities, increase in supply of less intensive substitutes.
- The price signals trigger demand/supply responses upstream and downstream of the capped sector.

1990 Clean Air Act (CAA) emission trading programs

- SO2 trading program achieved ~50% reduction in emissions from electric power plants.
- NOx trading program achieved ~50% reduction in emissions from electric power plants.
- In both cases the cost of emission reduction was significantly less than had been predicted.

Other successes with emission trading

- Emission trading was used with great success in 1980s to phase out automobile lead emissions by limiting the quantity of lead that refineries could use in gasoline.
- Similarly, emissions of ozone-depleting substances were phased out through limits on their production through an emission trading scheme.

How emission trading worked

- In all these cases, the producer essentially reformulated the product in a manner that met the emissions cap without requiring the users of the product to (i) switch to a different type of product produced by a different manufacturer, or (ii) reduce their use of the product.
- Almost all of the action was by the party that was capped.
- There was minimal adjustment in other sectors in response to price signals radiating from the capped sector.

- With lead in gasoline, the automobile manufacturers had to produce cars that could run on unleaded gasoline, but this was a relatively minor modification. The consumers did not have to adjust their behavior at all (e.g., buy cars with a higher fuel–efficiency, or drive less).
- With SO2, the electricity generator reformulated his production process, leaving the product unchanged, and there no further adjustment downstream.

Strategies used for SO2

- Existing power plants
  - Change dispatch order to favor lower-emission plants
  - Modify combustion by switching from high- to low-sulfur coal.
  - Install scrubber to remove emissions post-combustion
- New power plants
  - Fired by natural gas rather than coal

- In all these cases:
  - Emission trading did not work by generating price signals that radiated throughout the economy motivating behavior changes in other sectors.
  - The entities that responded were primarily the firms that were capped.
  - To the extent that they responded by employing new inputs or new technologies that were not used previously, what occurred was a shift in the supply curve, rather than a move along a given supply curve.

- Does this mean that emission trading was an unnecessary innovation? NO
- Emission trading was superior to prior emission regulation in two ways:
  - It was a performance standard as opposed to a technology standard.
  - It gave regulated firms flexibility in compliance.
    - A firm could re-allocate abatement among its different plants. Instead of abating at plant A, it could abate more at plant B.
    - Instead of having to install abatement equipment immediately, a firm could buy permits for now and invest in abatement at a more opportune time in the future.

What *didn't* happen with SO2 trade

- While operational practices were refined, the strategies relied on known, mature technologies.

- Strategies *not* used:
  - Energy conservation, demand management
  - Switch to renewables
  - New combustion technologies

- Fundamental technological innovation played essentially no role.

Emission trading for GHGs

- How readily does past experience with SO2 carry over to CO2?
- If it does not, what does this mean for CO2 policy?

- This does not bode well for GHGs because there are some important physical and engineering differences between SO2 as versus GHGs as pollutants.

CO2 is different than SO2

- For CO2 there is no good analog for the strategies used to reduce SO2:
- Fuel switching is not such a major option
  - There is no low-CO2 coal
  - Co-firing with biomass can be done, but on a limited scale and the logistics are complicated.
- There is no post-combustion scrubber
  - Carbon capture and sequestration can't be retrofitted to an existing power plant; it requires a new plant.
  - It is a technology still in its infancy, 10+ years away from commercialization.

- The approach used with SO2 was to reduce emissions by modifying the functioning of the existing coal-fired fleet of power plants.
- But, it won't work for CO2 because the existing power plants can't do much to reduce their emissions.
- The only significant way to reduce CO2 emissions from existing coal-fired plants is to use them less.
- With CO2 from coal-fired generation, the key opportunity to reduce emissions lies with *new* power plants and how they are designed:
  - Higher thermal efficiency through technologies such as supercritical combustion or IGCC
  - Designed so they can accommodate CCS

Will emission trading be as satisfactory for GHGs?

- If you think that emission trading works by generating price signals that radiate throughout the economy, there is no reason why CO2 should be any different than SO2.
- If you think that it works by inducing regulated firms to fix the problem by themselves, there are grounds for worry.
  - Electricity generators per se may not be the key.
  - It is energy users who need to change

What is needed for GHGs

- Conservation, increased energy efficiency
  - Behavioral change
  - Technological innovation
- Deployment of new technologies to decarbonize the economy:
  - Renewables to generate electricity
  - Effective carbon capture and sequestration
  - New fuel technologies such as biofuels, hydrogen

GHGs are a much broader problem

- Even if one could control emissions effectively through emission trading by electric utilities, for GHGs this would *not* take care of the problem.
- This is because power plants account for a far smaller share of GHG emissions then they did for SO2 emissions.
  - Power plants account for 33% of US GHG emissions. In California, they account for 22% of GHG emissions (half of this is from out of state generation).
  - By contrast they account for 65% of SO2 emissions
  - Transportation accounts for 27% of emissions nationally, and 40% in California

The difference

- With SO2, we could work with existing capital assets and readily modify their operation.
- With CO2, we are stuck with the *wrong set of assets* – coal-fired power plants, coal-burning industrial boilers, SUVs, suburbs hostile to public transportation etc.
  - Changing the dispatch order is a short-run fix
- It will take time, resources, and new technologies to change the capital stock.
- We have to balance a short-run goal of emission reduction with a long-run goal of decarbonization

LIMITS TO PRICES

- Incentives are certainly crucial.
- But, an incentive has to be visible to the decision maker (car owner, car manufacturer, etc).
- It has to be salient and meaningful in order to prompt a shift in behavior.
  - Bounded rationality
  - Restricted consideration (choice) set.
- Not all prices are equally effective. “The carrot has to be in front of the donkey, not behind.”

Technological innovation

- Schumpeter identified three stages: **invention** (first development of a new product or process); **innovation** (the product or process is commercialized); **diffusion** (when it is widely adopted).
- SO2 emission control involved diffusion. But, success with diffusion is *not* the same as success with innovation or invention.
- For climate change, invention and innovation are crucial – development & commercialization of technologies that do not exist yet or, at best, are still highly experimental (e.g., CCS).

Taxes

- In theory, a tax works through the price mechanism just like cap and trade.
- The difference is that the price signal is fixed with a tax; it is uncertain with a cap and trade.
- This hinges on the question of how emission trades induce emission reduction. Is it the *cap* or the trading price that induces the response?
- I think that the cap is a key factor in shifting behavior, not just the price alone

- The other difference between a tax and emission trading has to with the cap involved in cap-and-trade.
- This relates to the issue of prices vs quantity

Price versus quantities

- Weitzman (1974) famously addressed this issue. In the face of uncertainty, the two instruments perform differently.
  - Price leads to uncertainty about amount of emission reduction. But, whatever emission does occur, will be achieved efficiently (at least total cost).
  - Quantity regulation generates certainty about reduction in emissions; but the amount of reduction may turn out ex post to have been non-optimal.

- Which instrument is preferred depends on which is the more serious error.

- It turns out that which is instrument is preferred depends on whether the marginal damage curve (from more emissions) is steeper or flatter than the marginal cost curve (of reducing emissions).
- If the marginal damage is steeper, a cap is preferred; if it is flatter, a price signal is preferred.

- What is the answer in the case of climate change?

- In the case of climate change, the conventional wisdom among economists has been that the marginal damage curve is much flatter than the marginal cost of abatement curve.

- Therefore a price signal is called for, not a cap.

[Pizer, J. Pub. Econ. 2002]

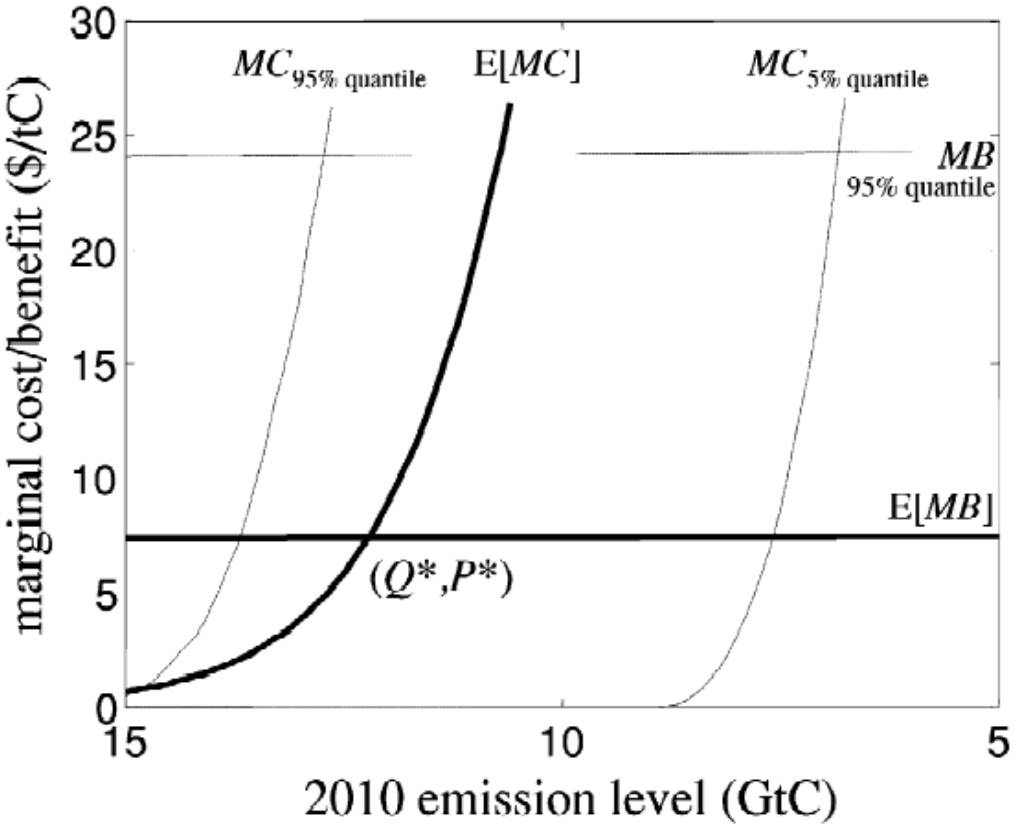


Fig. 2. Distribution of marginal costs and benefits in 2010. (The 5% quantile of marginal benefits overlaps the x-axis.).

How might the ranking of slopes be reversed?

- There are some factors that are not well considered in the existing analysis:
  - Annual versus multi-year framing of the abatement decision
  - Risk aversion
  - Also, some recent work suggests that the damages associated with, say, a 2.5^{o} C warming may be larger than previously estimated.
  - Which GHGs are considered – methane has faster impact than CO2
  - It also depends on the discount rate
- These have the potential to reverse the conclusion

POLICY CHOICE

- My recommendation is neither a tax nor emission trading *alone*; for the reasons outlined, I believe a portfolio of measures is needed including regulatory approaches.
- I believe the cap associated with cap and trade – especially a downstream cap – is essential.
- There also needs to be reliance on complementary regulatory measures. At first, these are likely to be the most important component of the portfolio. However, they can ultimately be scaled back or eliminated.