Policies to Promote Innovation and Investment in Clean Technology

Climate Change Policy Workshop
Margaret Taylor

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Today’s Road Map

Framing: the climate change problem
Technology, innovation, and policy
Clean energy technology cases
Some insights to date...
1. Framing: the climate change problem, technology, innovation, and policy
CO₂ Concentration: 381 ppm, concentration in the atmosphere, 100 ppm above the pre-industrial average. “That’s higher than we’ve been for over a million years, possibly 30 million years.” – Professor Sir David King, UK chief scientific adviser.

CO₂ Sources: CO₂, the most prominent (82%) greenhouse gas (GHG), is generated from the burning of fossil fuels, primarily for electric power (40%) and transportation (32%).
Climate Change and Technology

CO₂ emissions more than double in the next 50 years according to business as usual (BAU)

CO₂ emissions need to stay at today’s levels for CO₂ concentration to stabilize at 500 +/- 50 ppm by 2125 (WRE500)

Innovation is a process that includes invention, technology strategies, adoption/diffusion, and post-adoption learning from experience.

This will require innovation, probably in multiple stabilization in 2050.

The technologies aren’t all there for CO2.
The Need for Innovation

- The technologies aren’t all there for CO₂ stabilization in 2050
- This will require innovation, probably in multiple technology strategies
  - Innovation is a process that includes invention, adoption/diffusion, and post-adoption learning from experience
Clean Technology Strategies

- **Traditional** Power Generation
  - Control Emissions
    - Pre-Combustion: Fuel Switching/Cleaning
    - During Combustion: Modifications/additives
    - Post-Combustion: Pollution Control
  - Reduce Power Demand
    - More Efficient End-Use Technologies
    - More End-Use Technologies Ind. of Fossil Fuels

- **Alternative** Power Generation
  - Centralized
  - Distributed
Clean Technology Strategies

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The Need for Innovation

- The technologies aren’t all there for CO₂ stabilization in 2050
- This will require innovation, probably in multiple technology strategies
  - Innovation is a process that includes invention, adoption/diffusion, and post-adoption learning from experience
- The private sector will not provide this innovation without public involvement
Why is Encouraging Innovation a Policy Problem?

- Private sector under-invests in R&D
  - General finding in economics literature, with respect to "socially optimal" returns
  - Compounded here because interested in "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
  - What we do now takes a long time to have an effect
  - R&D has uncertain outcomes (good managers use a portfolio approach)
  - From birth to maturity of a technology, lots of obstacles
Government affects innovation, both directly and indirectly. Examples:
- **Demand-pull**
  - Regulation: performance-based standards, cap-and-trade programs
  - Renewable portfolio standards
  - Procurement
  - Investment subsidies: tax credits, rebates
  - Production subsidies: tax credits, rate guarantees
- **Technology-push**
  - Research funding (basic, applied, facilitating technology transfer…)
  - Prizes

Government success in supporting innovation relies on details of policy design, including:
- Stringency
- Flexibility/neutrality
- Implementation issues (timing, training, selection of R&D partners…)

Much innovation is conducted by **non-polluting firms**
- Their investments in innovation depend on their understanding of the strategic environment shaped by government
What’s the Best Climate Policy re: Innovation?

How to answer:

A. Study cases so past experience with policy details and firm behavior can guide the answer

B. Systematically apply multiple methods to cases
   1. Compensates for data/methodological weaknesses
   2. Facilitates cross-case comparisons

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<th>Data</th>
<th>Innovation Stage</th>
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<th>Adoption/ Diffusion</th>
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2. Clean energy technology cases and observations
Clean Technology Strategies: Cases

Traditional Power Generation

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Alternative Power Generation

- Centralized
  - Solar water heating
  - Large-scale wind power, solar thermal electricity

- Distributed
  - Photovoltaics

SO₂ & NOₓ control

* Pre-combustion not a factor in NOₓ control situation.
About the Cases...

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**Key Takeaways**

Nutshell
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### Key Takeaways

- **Nutshell**
- **“Winner”**
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Key Takeaways:

- Too Small
- Niche
- Boom/Bust
- Loser
- Winner

Nutshell:

- US$1/kWh
- 1-5
- 25-30
- 20-16

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Nutshell
3. Some insights to date...
Operating Experience is Important

- Initial commercial application - unforeseen problems. Solutions tend to be:
  - Incremental
  - Boundary spanning (draw from other industries/technologies)
  - Transferred knowledge (nations, organizations, facilities…)
    - Government has played a key role in this
    - EPRI and utilities as regulated monopolies fostered this; deregulation has been problematic
The Policy/Technology Interplay: Capacity Factor of CA Wind Turbines

- Build
- No Policy
- Run
- Build

Cumulative MW Capacity

Year Wind Power Online

- Fed. & CA Investment Tax Credits (p.'78) Expire
- Production Tax Credits Begin
- Texas RPS

Graph showing cumulative MW capacity from 1980 to 2002, with key events and policy changes.
Operating Experience is Important

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- Perception of unreliability difficult politically
  - “Tech-forcing” trickier when technology is distributed (SWH)
  - Government demonstration projects can be helpful for centralized techs

- Importance of niche markets (ex. CA):
  - CA leadership role has IP benefits in higher share of patents in STE (22.9%), Wind (18.1%), PV (14.5%), and SWH (14.2%) than overall patent system (8.7%)
  - Technology costs tend to fall while performance improves, once commercially implemented
Experience Curves

![Graph showing experience curves for different technologies: PV, STE, SWH, Wind, FGD, SCR. The graph plots capital cost per unit of cumulative capacity installed (MW) against cumulative capacity installed (MW).]

- **Capital Cost**: $200.48 W
- **Technology Types**: PV, STE, SWH, Wind, FGD, SCR
Experts say “Technology Push” (Public R&D) can be useful. In some cases, they point to specific technological improvements. Examples:

- PV benefits from “basic” research
- STE benefits from “applied” cost-cutting research (Luz-Sandia partnership)

R&D alone not as effective as in combination with “Demand Pull” instruments (market-creating policy).
Patents in SO₂ Control
1887–1997
Patents in SO$_2$ Control
1887–1997
Public R&D vs. Patents for Pollution Control

- FGD (SO₂)
- SCR (NOₓ)

Legend:
- Public R&D Funding
- Patents
Patents vs. R&D for Wind (Alt Energy)

Number of U.S. Patents

Public R&D Funding

Public R&D Funding (2002 MUS)
Patents vs. R&D for Wind (Alt Energy)

Number of U.S. Patents

Public R & D Funding

Public R & D Funding (2002 MUS)
More on Demand Pull

Policies (and politics) can create and destroy markets for – and incentives for innovation in – clean technologies

Stringency shapes technological pathways
FGD
U.S. Tech.
Winner
Early 1970s EPA says FGD is demonstrated enough to be basis of NSPS

SCR
U.S. Tech.
Loser
Late 1970s EPA says SCR not demonstrated enough to be basis of NSPS
More on Demand Pull

Policies (and politics) can create and destroy markets for – and incentives for innovation in – clean technologies

- Stringency shapes technological pathways
- Policy uncertainty is a disincentive to innovation
  - Subsidized industries are particularly prone to instability
  - “Rather have a lower rebate, say 15%, guaranteed for 5 years or more, than a large rebate, even more than 40%, that might last only a year or two”
- Implementation matters
- Unclear whether cap-and-trade beneficial to innovation
  - FGD mature before cap-and-trade
  - SCR for gas delayed by 10 years because of RECLAIM
Some thoughts on the best climate policy re: innovation…

Any policy effort should be innovation compatible.

- It should involve the private sector. Think about how firms answer: “Will there be a market for innovative product X?”
  - Demand pull policy instruments can help
    - Governmental due diligence a good (efficient) idea, however.
    - Policy certainty helps
- It should provide continuous incentives for innovation
  - Choose targets carefully.
    - The “just right” target moves with the technology.
      - Might require a periodic technology assessment or quasi X-prize
2. Clean energy technology cases and observations

California Greenhouse Gas Emissions by Sector, 2002

Clean Technology Strategies Work

Technology has helped make California’s GHG emissions profile different than the U.S.

Greenhouse Gas Emissions by Sector, 2002

Clean Technology Strategies Work

Technology has helped make California’s GHG emissions profile different than the U.S.

California Greenhouse Gas Emissions by Sector, 2002

How do we achieve this technical change?

Sources of CO₂ Emissions in U.S., 2001

- Electric Power 40%
- Transportation 32%
- Industrial 18%
- Residential 6%
- Commercial 4%

Innovation: a process of overlapping activities, including invention, adoption/diffusion, and post-adoption learning from experience