Looking at Technological Innovation in Energy

ITIF Talk

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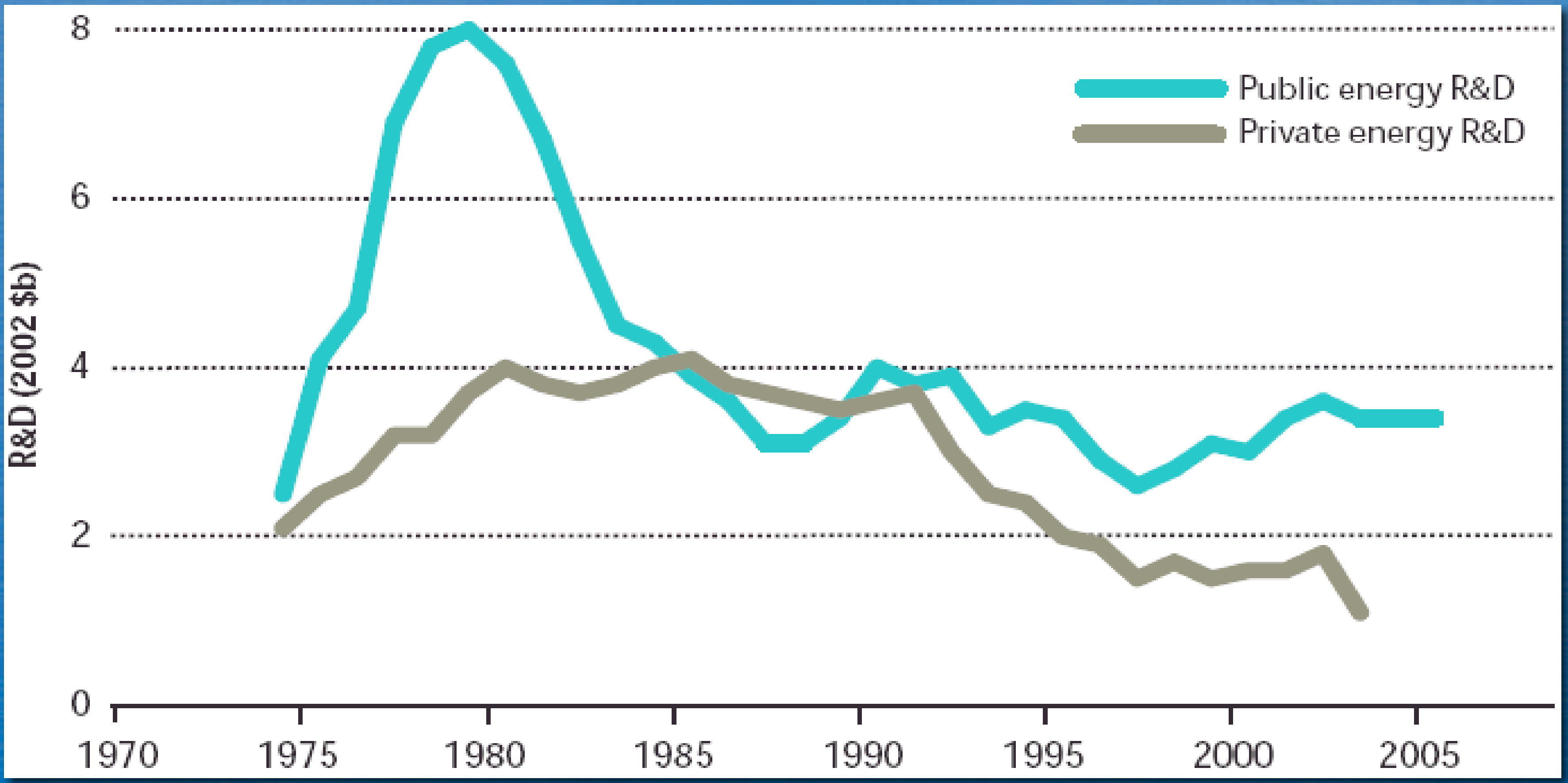
To Recap the data: Decline in Energy R&D

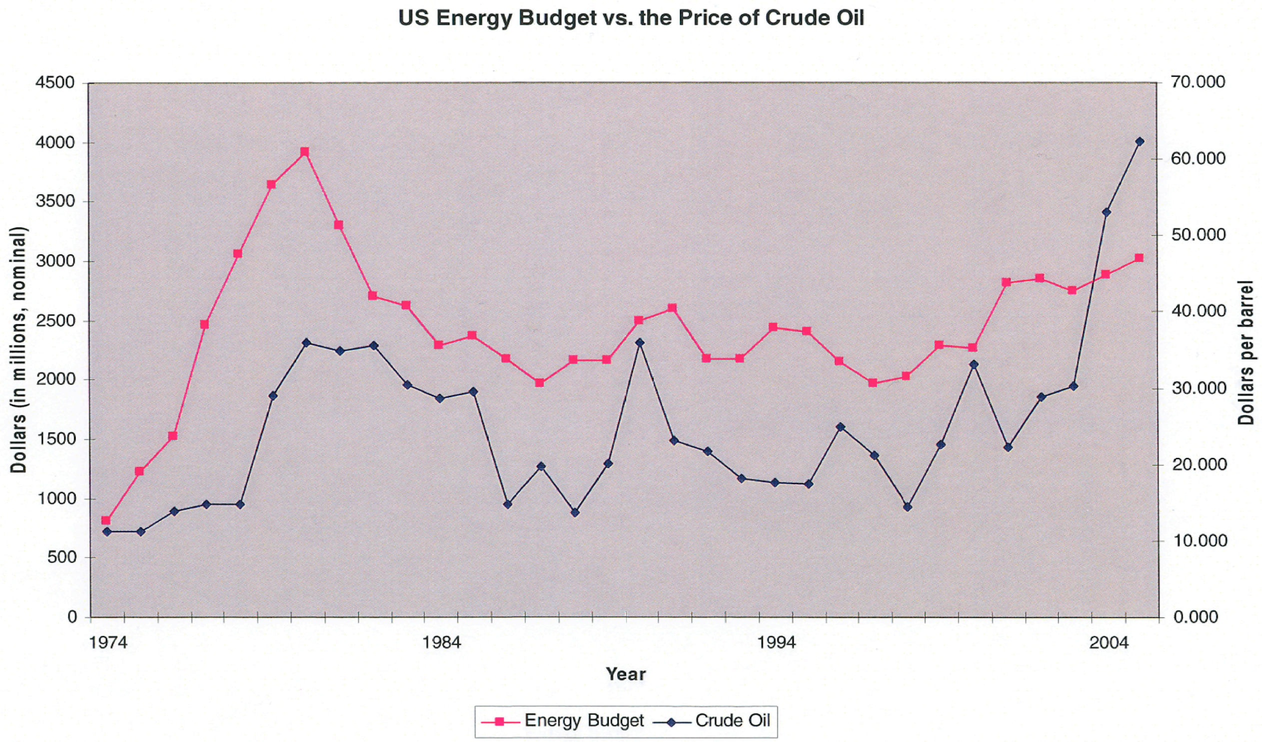
- Today, <u>US federal spending on R&D for new energy tech is about half what it was in 1980</u>
  - Energy declined from 10% of all US R&D in 1980 to just 2% in 2005. (in ‘02 dollars)
  - Between 1980 and 2005, the US decreased its energy R&D investment by 58%.
  - Federal Energy R&D spending level in ’07 is <u>less than half the R&D spending of the largest US pharmaceutical company</u>.
- <u>Private sector R&D story is similar.</u>

US Public and Private Trends in Energy R&D

Source: in Nemet and Kammen (2007)

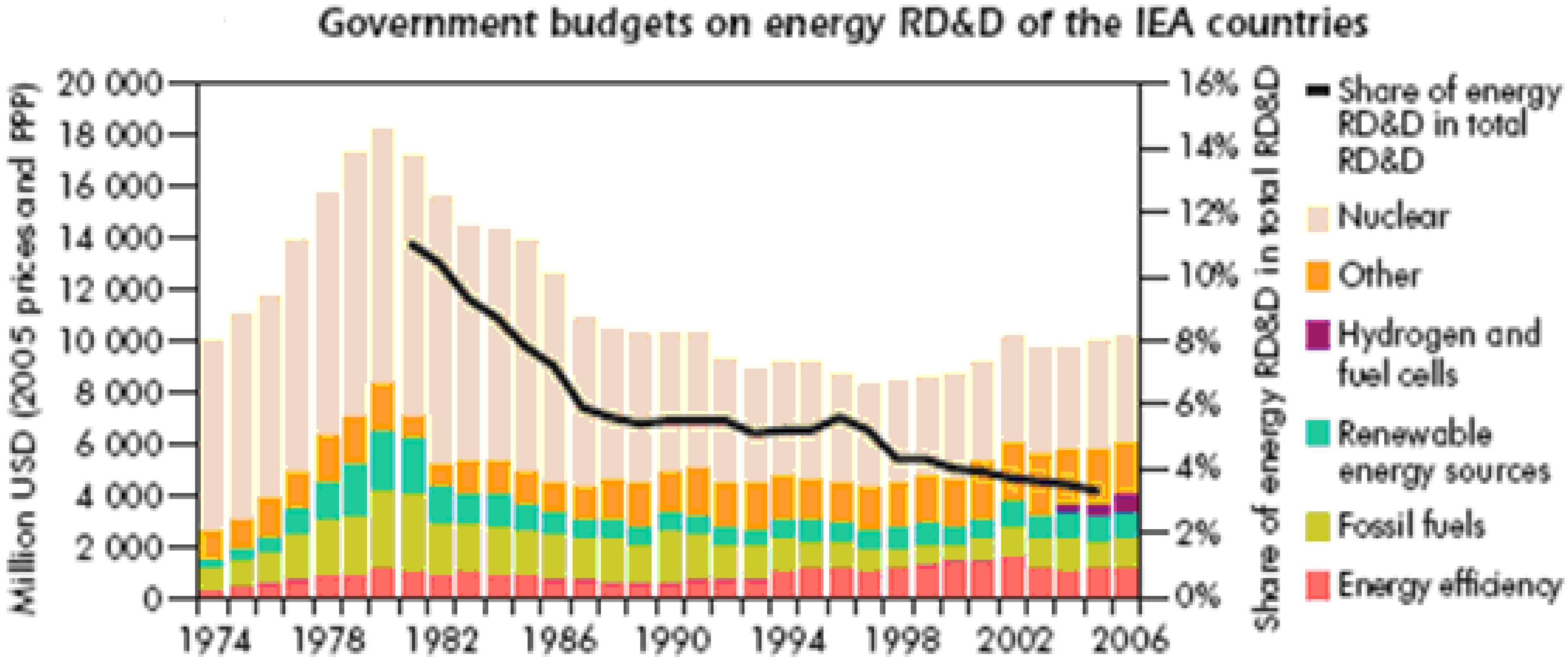


U.S. Energy R&D Spending vs. Price of Crude Oil



-- Neal, Smith, McCormick, *Beyond* Sputnik*: National Science Policy in the 21st Century,* University of Michigan Press, 2008. Original Sources: Oil prices based upon the yearly average prices per barrel from the Federal Reserve Bank of St. Louis, taken from the Dow Jones and Company data, http://research.stlouisfed.org/fred2/data/oilprice.txt; Energy R&D spending is from the International Energy Agency, http://www.iea.org/Textbase/stats/rd.asp.

IEA: OECD Countries – Similar R&D Decline



Note: RD&D budgets for the Czech Republic not included due to lack of available data.

Source: IEA 2007a, OECD 2007a.

US Private Energy Sector R&D Investment Compared to that into Sectors with Significant Innovation:

Innovating industries -

- The biotech industry invests 39% of annual revenue,
- pharmaceuticals invest 18%,
- semiconductors invest 16%.

Established industries:

- electronics industry invests 8% of sales
- auto industry invests 3.3%.

Overall US Industry Average R&D Investment is 2.6% of Sales...

-->The private energy sector invested on-average less than 1% of annual revenue in new energy tech R&D from 1988-2003

Experts: Multiply Energy R&D

Recommendation	*Multiplier*	*US Private R&D*	*US Public R&D*	*Total US R&D*
Current Level	X1	$1.2B	$3.6B	$4.8B
PCAST (2007), NCEP (2004) ACI (2006), Stern Review (2006)	X2	$2.4B	$7.2B	$9.6B
Council on Competitiveness	X3	$3.6B	$10.8B	$15.4B
Davis and Owen, Schock, CEPR	X4	$4.8B	$14.4B	$19.2B
Nemet and Kammen, high estimate	X10	$12B	$36B	$48.B

Is an R&D Increase Justified?

- <u>Precedents</u> for increased government spending on similar scale (in 2002 dollars)
  - Apollo Program ($185 billion over 9 years),
  - Carter/Reagan defense buildup ($445 billion over 8 years),
  - Doubling NIH ($138 billion over 5 years)
  - Ballistic Missile Defense ($145 billion over the first 6 years - actual dollars).

These are examples of the <u>needed size and scope</u> of a technology development program (including implementation), <u>*not* the way such a program should be organized</u>

Would an increase in R&D Produce Results?

- Social cost/benefit return on federal R&D overall typically: 5 to 1 over a decade (Tassey 2007)
- Social rates of return on fed R&D range from 40-100%
- Studies of cost/benefit ratio and rate of return show energy R&D may have a considerably higher return -
  - DOE in 2001
  - 1997 PCAST
  - Combines: energy efficiency, energy savings, plus new technology
- Such high rates of return/benefit-cost in energy R&D imply substantial underinvestment

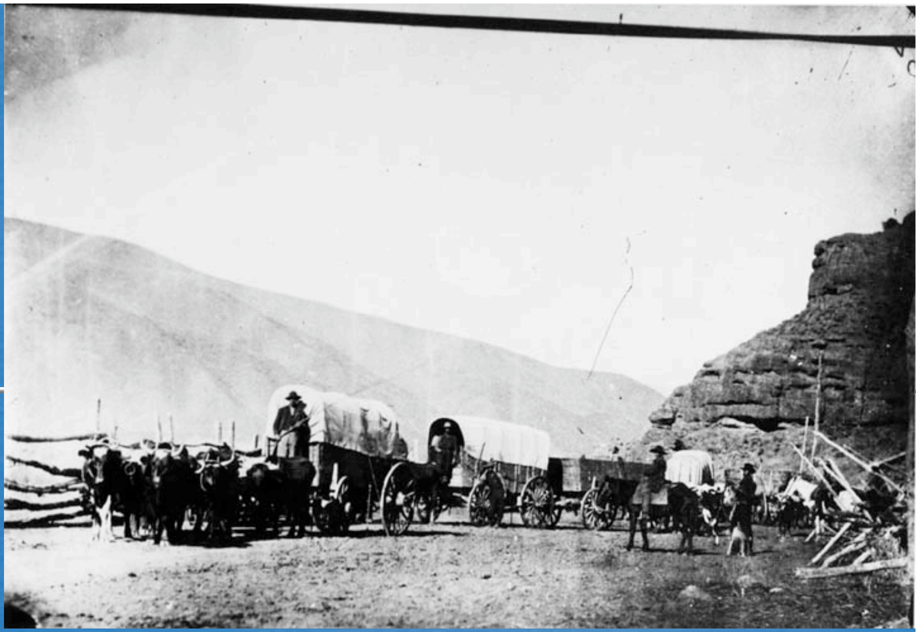
IEA: Investments Required for CO_2 Reductions are Large:

- The International Energy Agency (IEA) 2008 report estimates
  - Stabilizing CO_2 emissions at current levels in 2050 will require a total worldwide investment of $17 trillion ($400 billion per year) in R&D and implementation.
  - Reducing emissions to 50% below 2005 levels, the goal that the G-8 leaders committed to in July 2008, will require a total worldwide investment of $45 trillion ($1.1 trillion per year) in R&D and implementation

So….

- Let's just throw R&D money at it, right?
- But: innovation in established, complex sectors like energy is a <u>much</u> more complicated proposition

Because the US is a Covered Wagon Culture



- We're good at completely new things
- Don't like your neighborhood?
- Take a covered wagon over the mountain to new territory
- This is also true in technology --
  - We're good at standing up completely new things - creating new functionality.
  - We're used to standing up technology in open fields - like computing.
  - We pack our metaphorical Tech Covered Wagons and Go West, leaving Legacy problems behind

U.S. Innovations Like to Land in Unoccupied Territory. Energy is Occupied Territory

- With energy, we'll be <u>parachuting new</u>
- <u>technology into occupied territory</u> -
  - and will be <u>shot at</u>
- We're <u>not good at going back over the mountain</u> in the other direction - at rediscovering established territory and bringing innovation to it - <u>we don't do West to East</u>
  - We do biotechnology, we don't go back and fix the health care delivery system.
- <u>Yet huge gains</u> not just from the new but fixing the old
- <u>The bad news</u>: Established sectors are complex and hard and often have established, cost-efficient incumbents

A Complex, Established Sector is a 'Non-Level Playing Field'

- Existing technologies are heavily subsidized and politically powerful
- New entrants are up against an established *Techno-Economic-Political Paradigm*
- Alternative technologies are evolving
- But they must be <u>price competitive immediately</u> upon market introduction against legacy competitors that don't pay for environmental or geopolitical costs

A Carbon Charge
(Carbon Tax or Cap-and-Trade)
Market- based Incentive is Necessary

- The price of CO_2 emissions becomes a cost of doing business - captures externalities
- It sends an unmistakable price signal to energy users that the market is changing - enables new entrants to enter and start to drive down the cost curve
- Only works if it is sustained and high enough

But even a Strong Carbon Charge Alone will be Insufficient – Public Investment is also Needed.

- The need for new technologies is urgent.
- Well-known imperfections in the market for technology support the need for public investment: doctrine of “non-appropriability,” etc.
- We have two innovation models:
  - Induced - market signals - industry led - incremental
  - Pipeline - gov’t R&D - tech supply - radical/ breakthrough innovation
  - Need both in a complex est. sector to meet 2050 target
- Recent venture capital is for Commercialization, not for R&D
  - Tends to back technologies with specific subsidies

What would a new energy technology program actually look like?

How would it be organized?

A Public Strategy for Energy Technology Should be…

- Very Large in Scale and Scope
  - The problem of energy is scale
  - Comparable to Manhattan Project in Size and Scope
  - But NOT in Form or Organization
- Private Sector Led
  - Public-Private Partnerships
- Technology Neutral
  - Avoid technology lock-in
  - The opposite of the present pattern of subsidies to specific subsidies with powerful lobbies
    - ‘No Lobbyist Left Behind’
- Organized around Obstacles to Market Launch

New Four-Step Analysis:

- 1. *Launch Pathways:* Group technologies to be implemented into <u>categories based on launch characteristics</u>
- 2. *Tie to Policy Packages:* Use these launch pathways to <u>guide federal innovation policy roles</u>:
  - Bundle policies, available across technologies, so as to be as technology neutral as possible.
- 3. *Gap Analysis:* to identify <u>gaps between existing institutions</u> in the innovation system
- 4. *<u>Recommendations for Institutional Innovations</u>* to fill these gaps

Step One: Identify Market Launch Categories

1. Experimental technologies requiring long-term research
   - Examples: Fusion, Hydrogen Fuel Cells
2. Potentially Disruptive innovations that can be launched in niche markets where they are competitive, and achieve gradual scale-up building from this base.
   - Examples: Solar PV’s and wind for off-grid power, LED’s
3. Secondary innovations - uncontested launch: components in larger systems that face immediate market competition based on price, but are acceptable to the system manufacturer.
   - Examples: Batteries for Plug-in Hybrids, Enhanced Geothermal

Energy Technology Launch Categories – Con't

4. <u>Secondary innovations - contested launch:</u>

   component innovations having inherent cost disadvantages and facing political and non-market economic efforts to block their introduction.

   - Examples: Carbon Capture and Sequestration, Biofuels, Nuclear Power

<u>Crossover Categories:</u>

5. <u>Conservation and end-use efficiency</u> -- incremental improvements for all technologies

   Examples: Improved IC engines, BuildingTechnologies, Appliance Standards

6. Advances in <u>manufacturing technology and scale-up</u> of manufacturing for all types of energy technology so as to drive down production costs.

   - Examples: Wind energy, Carbon Capture and Sequestration

Step Two: Policy Packages Matched to Launch Categories

- (1) ***Front End Support:***
  - Needed for all technologies
  - Examples - research and development (R&D), technology prototyping and demonstrations (P&D), public-private R&D partnerships, monetary prizes to individual inventors and innovative companies, and support for technical education and training
- (2) ***Back End Incentives*** (carrots) to encourage technology deployment:
  - Needed for secondary (component) technologies
  - Examples - tax credits for new energy technology products, loan guarantees, price guarantees, government procurement programs, new product buy-down programs

Step Two, cont'd - Policy Packages for Promoting Energy Innovation

- (3) ***Back End Regulatory and Related Mandates*** **(sticks):**
  - **For secondary technologies - contested launch**
  - **Prospect of political battles since launch will be contested**
  - **Examples: standards for particular energy technologies in building, construction, and comparable sectors, renewable portfolio standards, fuel economy standards, emissions taxes, general and technology-specific intellectual property policies.**
- Need work on best tools for tech categories

Step Three: Identify the Gaps in Existing Energy Innovation System

- “Front-End” - RD&D -
  - Translating Research into Innovation
  - Carefully monitored demonstrations of engineering-intensive technologies (Carbon Sequestration, Biofuel Processing)
  - Improved manufacturing processes
- “Back-End” - deployment
  - Manufacturing scale-up
  - Launching into the economy
  - Installation of conservation technology
  - Financing infrastructure standup
- “Roadmapping”

Step Four: Filling the Gaps with the Establishment and Funding of:

- 1) *ARPA-E*: A translational R&D entity
- 2) A *wholly-owned gov't corporation* for "back end" elements:
  - Sharing the financing of carefully monitored demonstrations of large engineering projects
  - Encouraging and incentivizing industry consortia to cut costs of manufacturing technologies and processes
  - Speed the scale-up of manufacturing production capacity
  - Financing installation of conservation, efficiency and related new technologies in residential and commercial markets
- 3) *A Think-Tank* to develop a detailed "roadmap" for the requirements for the development and launch of particular energy-related innovations, and to recommend policies to facilitate them

A Program Commensurate with the Scope of the Energy Problem Requires Leadership

- This is the toughest Technology Implementation task we have faced - nothing else is close

Where is the Obama Administration on this kind of program?

THE NEXT THING: Energy as a Solution?

- This is a structural recession - have to grow our way out
- Economies grow through innovation
- Can’t do short term solution, but key to the longer term solution
- Energy - <u>Next technology revolution?</u>
    - **<u>Could it be new tech *innovation wave*, drive efficiency throughout the economy?</u>**

The Institutional Problems with Energy Innovation System

- DOE Sec Chu standing up ARPA-E
  - Will the labs/DOE agencies allow it?
  - Has $400m in funding already appropriated
  - Sec. Chu personally backs the model
  - 2 ex-DARPA staffers designing it
- Other key institutions:
  - Need **Financing Bank**
  - House & Senate Energy proposed; Chu: loan guarantee
  - Need **Tech Strategy** leading to Energy Roadmap
    - We have tech list not a strategy and long way from Roadmap
- Bills written backward
  - Each technology has a title, each own deal
  - No lobbyist left behind
  - Reverse: set up tech neutral incentives
  - Let best technologies compete for support based on energy merits
  - Administration not yet focused on organizing a tech revolution
  - Its Clean Tech Fund ($150B/10 years) is not defined

Tech Revolutions cost money - Where will the $ come from?

- Energy R&D Approp's stagnant in 2008-09, but Stimulus provided major new R&D input
  - $5.5 R&D and infrastructure; $34b late stage implementation
  - But: US deficit/fiscal posture an ongoing problem
- Cap and Trade only significant new revenue source
  - Funding will fall off a funding cliff in two years and lose momentum unless a follow-on funding source is found
- The Administration understood this and proposed:
  - FY2010 President's Budget proposes $150B "Clean Energy Tech Fund" from cap and trade revenues
- ***June 2009: House Energy Committee cap and trade bill passed - only $1.5B in R&D funding***, $8B go to coal, utility, oil refinery, auto sectors, states: tech deployment only

Pres. Obama: “We can cede the race for the 21st Century, or we can embrace the reality that our competitors already have: The nation that leads the world in creating a new clean energy economy will be the nation that leads the 21st century global economy.”
6/29/09

What are others up to?

- China
  - $400B/10 year clean energy tech program- ACORE
  - $3/watt subsidy for solar - largest in world
  - Wind: 150GigaWatts (GW) by 2020
  - World's largest solar panel mfg. industry - 95% exported to US
  - World's largest wind market (passed US)
  - Mercantilism: barring imports of wind/solar technology into China via standards, etc policy
- Korea
  - 2% of GDP in clean tech: $84B over 5/years
  - Wants 8% global market share
  - LED's, plug in hybrids
- India
  - 2020 target for solar: 20GW's (sources: NYT, Wash Post)

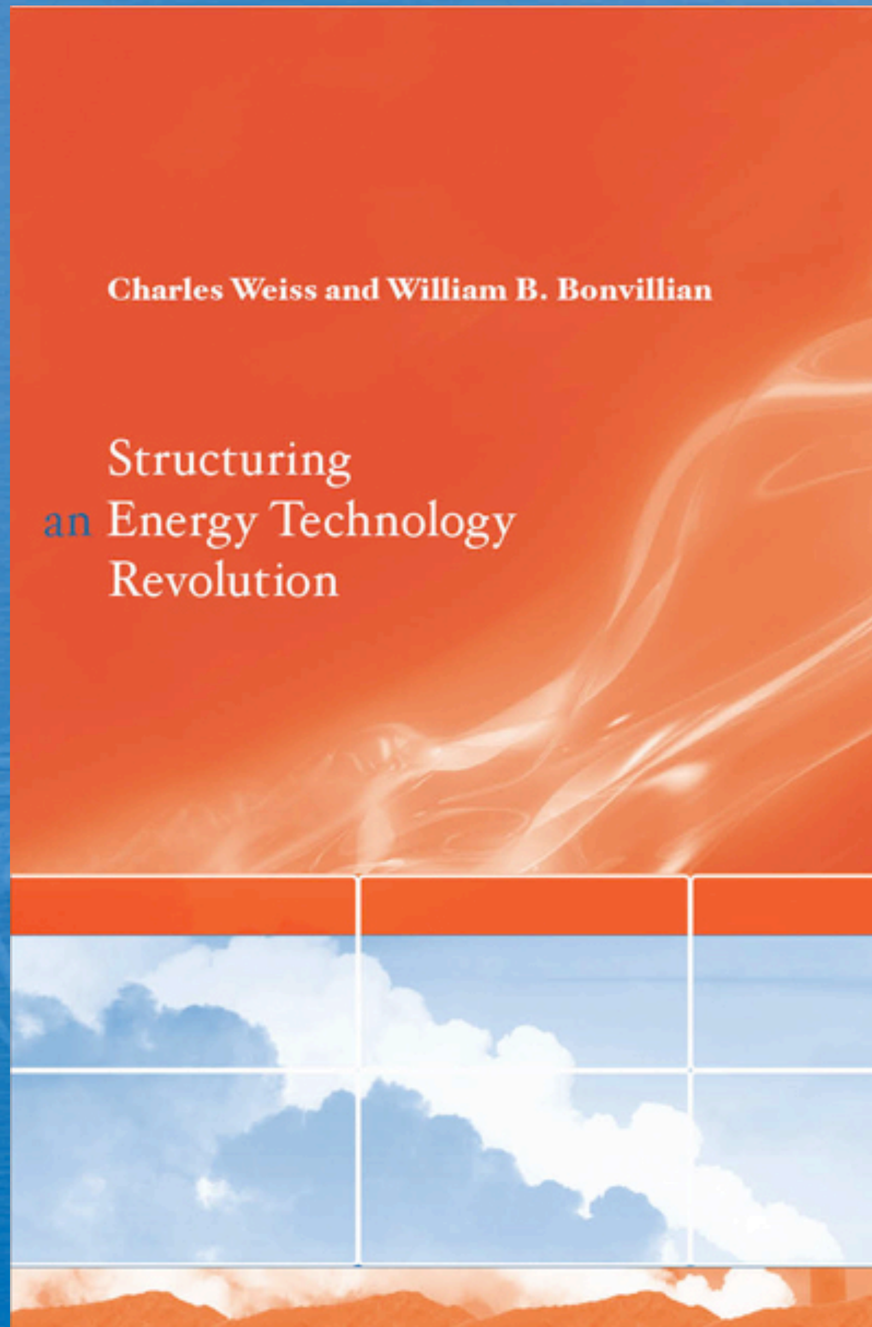
US Response?

- There is no US Energy Technology Strategy
- The Administration’s energy technology funding is falling apart on the Hill

Admin Needs The Four Strategies…

- Need an energy innovation strategy
  - That brings in the private sector
  - Treats innovation as a system
  - Ties in energy science/engineering education
- Need a roadmap for energy
  - If energy is to be an innovation wave a roadmapping process between public-private-academic sectors needed
- Need an energy tech manufacturing strategy
  - required to reverse the covered wagon
  - Need productivity leapfrog - AI, robotics, processes, materials
- And Key: Need a long term energy innovation funding strategy
  - -headed off a cliff after Stimulus FY10 funding

Read all about it:



One more slide: