# Integrating Common Themes: Some Observations for the Workshop on Technologies and Policies for a Low-Carbon Future

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# **A "budget" for these remarks** (12 minutes)

(Can deficit spending be avoided??)

- What problems are we trying to solve? The challenges to energy technology & policy (2 min)
- What is hard about this? What are the hardest parts? (2 min)
- What do we need from improved energy technologies to address these adequately? (2 min)
- Is our energy-technology-innovation system up to it? How & by how much does it fall short? (4 min)
- What are the key issues in moving to fix it? (2 min)

# The challenges to energy technology & policy

ECONOMIC

- reliably meet fuel & electricity needs of a growing economy
- limit consumer costs of energy
- limit cost & vulnerability from imported oil
- help provide energy basis for economic growth elsewhere

ENVIRONMENTAL

- improve urban and regional air quality
- avoid nuclear-reactor accidents & waste-mgmt mishaps
- limit greenhouse-gas contribution to climate-change risks
- limit impacts of energy development on fragile ecosystems

NATIONAL SECURITY

- minimize dangers of conflict over oil & gas resources
- avoid spread of nuclear weapons from nuclear energy
- reduce vulnerability of energy systems to terrorist attack
- avoid energy blunders that perpetuate or create deprivation

## What’s so hard about this?

- Often the objectives are in conflict, e.g.,
  - cost reduction versus environment
  - domestic oil production versus environment
  - nuclear energy production vs nuclear risk reduction
- All energy options have limitations
  - oil & gas… not enough resources
  - coal, tar sands, oil shale… not enough atmosphere
  - biomass… not enough land
  - wind & hydro… not enough sites
  - nuclear fission… too unforgiving?
  - nuclear fusion… too difficult?
  - hydrogen… needs energy input & infrastructure
  - end-use efficiency… needs purchasers who are paying attention

# Implications of the lack of a “silver bullet”.

- That everything has limitations and liabilities doesn’t mean that nothing is usable.  It means that…
- We need to work to see how the liabilities might be reduced and the constraints relieved.
- We need to accept that, even after all plausible improvements and more, there will probably come a point in the expansion of any energy option where rising marginal costs and/or risks make further expansion unattractive.   (Getting 10 TW from anything is hard!)
- It follows that we’re going to need significant contributions from many options -- a portfolio.

(A portfolio doesn’t mean that everything gets deployed.  The market, tweaked to reflect important externalities & public goods, should be allowed to pick the least-cost mix from the menu served up by RD&D.)

# The hardest pieces

- Providing the affordable energy needed to sustain prosperity where it now exists, and to create and sustain it where it now doesn't, without entraining intolerable disruption of global climate by the emissions from fossil-fuel use.

    This is hard enough for the industrialized countries, harder still for the developing ones; and it doesn't work unless we all get it right together.

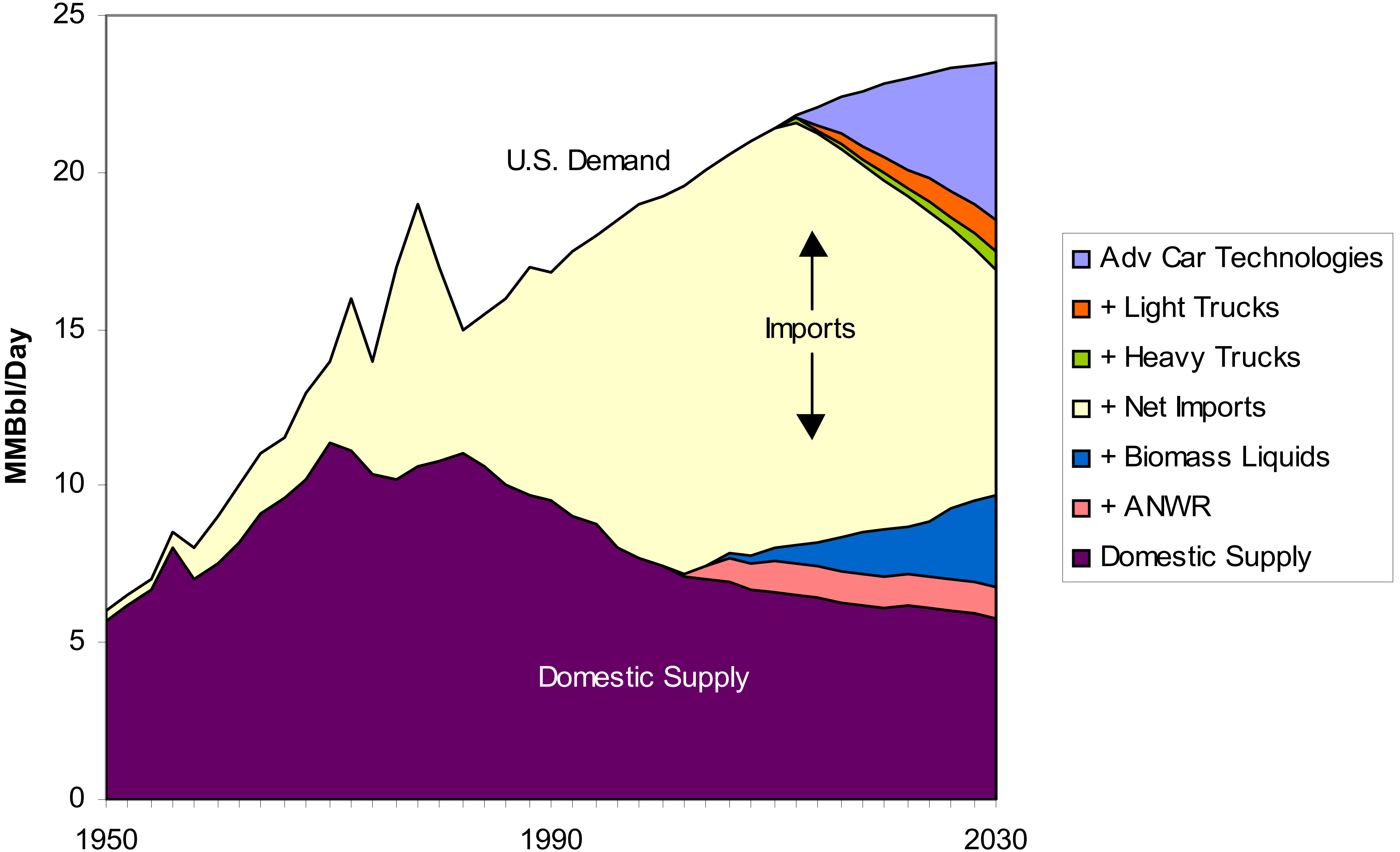
- Reducing the macroeconomic vulnerability arising from our oil dependence overall, and the balance-of-payments & national-security indignities associated with the part that is imported, despite huge & growing liquid fuel demands from the transport sector.

## What do we need? Increase in C-free energy to stabilize atmospheric $CO_2$ below 550 $ppm_v$

To avoid a doubling of preindustrial $CO_2$, conventional fossil primary energy must not exceed 500 EJ in 2050 and 350 EJ in 2100. Starting from 350 EJ of conventional fossil fuel in 2000 and BAU rates of change in world GDP and energy intensity, it follows that EJ/yr of C-free energy needed in 2050 and 2100, compared to 100 EJ/yr actual in 2000, are…

| | 2000 | 2050 | 2100 |
|---|---|---|---|
| | ------- | ------ | ------ |
| C-free energy under BAU | 100 | 600 | 1500 |
| ...if E/GDP falls 1.5%/yr | 100 | 350 | 800 |
| ...if E/GCP falls 2.0%/yr | 100 | 180 | 350 |

# U.S. Oil Futures



# Where do improved technologies come from and how do we make sure it happens?

- R&D entail relatively modest investments in finding out what improvements are possible.
- Demonstrations entail somewhat larger investments in finding out how the most promising possibilities work out at near-commercial to commercial scale.
- Initially subsidized and niche deployment can help "buy down" the unit costs of demonstrated technologies, speeding up their trajectory to commercial competitiveness.
- Widespread deployment appropriately is determined in the marketplace, based on characteristics & information arising from R&D, demonstration, & initially subsidized & niche deployment, and on cost & price signals tweaked to account for important externalities and public goods.

This is not a simple pipeline – there are lots of feedbacks.

The extent of private-sector engagement increases from a little at the top to the dominant role at the bottom.

# How much is enough? Thinking about the energy-technology-innovation portfolio

Should be judged by "internal" and "external" criteria.

The "internal" criteria have to do with…

- whether the goal of the program is reasonable;
- whether the program elements likely to be necessary to achieve the goal are all present, including redundancy appropriate to the level of uncertainty about the outcomes of particular elements and to the urgency of the goal;
- whether the individual elements are suitably designed for their purposes;
- with whether they are suitably linked and phased; and
- with whether they are being funded at levels commen-surate with the tasks involved, the opportunities available, the other (competing or cooperating) entities pursuing or likely to pursue the same goal, and the timing desired.

## **Thinking about the portfolio** (continued)

The “external” criteria have to do with whether the funding allocated to the program can be justified in relation to the total resources available in the agency, or in the society, for similar activities, e.g., for all energy R&D or for all R&D in general.

Judgments in this category entail reaching conclusions about the importance and prospects of attainment of a program's goals in relation to its cost and in relation to the importance/ prospects/cost combinations of other R&D programs.

# Recommendations of the 1997 PCAST study

- Ramp up DOE's applied energy-technology R&D spending from $1.3 B in FY1997 and FY1998 to $2.4 B in FY2003 (as-spent dollars), with circa 80% of the increases in efficiency & renewables. Cut funding for short-term coal R&D better done by industry.
- Expand research in "basic energy sciences" & improve DOE internal communication among technology "stovepipes" and between stovepipes & BES. Undertake "portfolio" analysis.
- Develop a commercialization strategy complementing public investments in R&D, emphasizing public-private partnerships
- Increase US participation in international cooperation on ER&D & commercialization, esp with developing countries.

# Recommendations of the 1999 PCAST study

*Increase US federal funding for international cooperation on ERD$^3$ from $250M (1997) to $500M in FY2001, $750M in FY2005, to be spent on…*

*FOUNDATIONS OF INNOVATION & COOPERATION*

capacity building, energy-sector reform, energy-technology demonstration and cost buy-down, financing for accelerated deployment

*COOPERATION ON ERD$^3$ IN ENERGY END-USE EFFICIENCY*

<u>building-sector</u> standards, design software, grant & lending programs; <u>transport-sector</u> emissions standards, vehicle testing, R&D on buses and 2-3 wheelers; <u>industrial-sector</u> roadmaps, training, joint ventures; <u>combined heat and power</u> education, training, barrier reduction

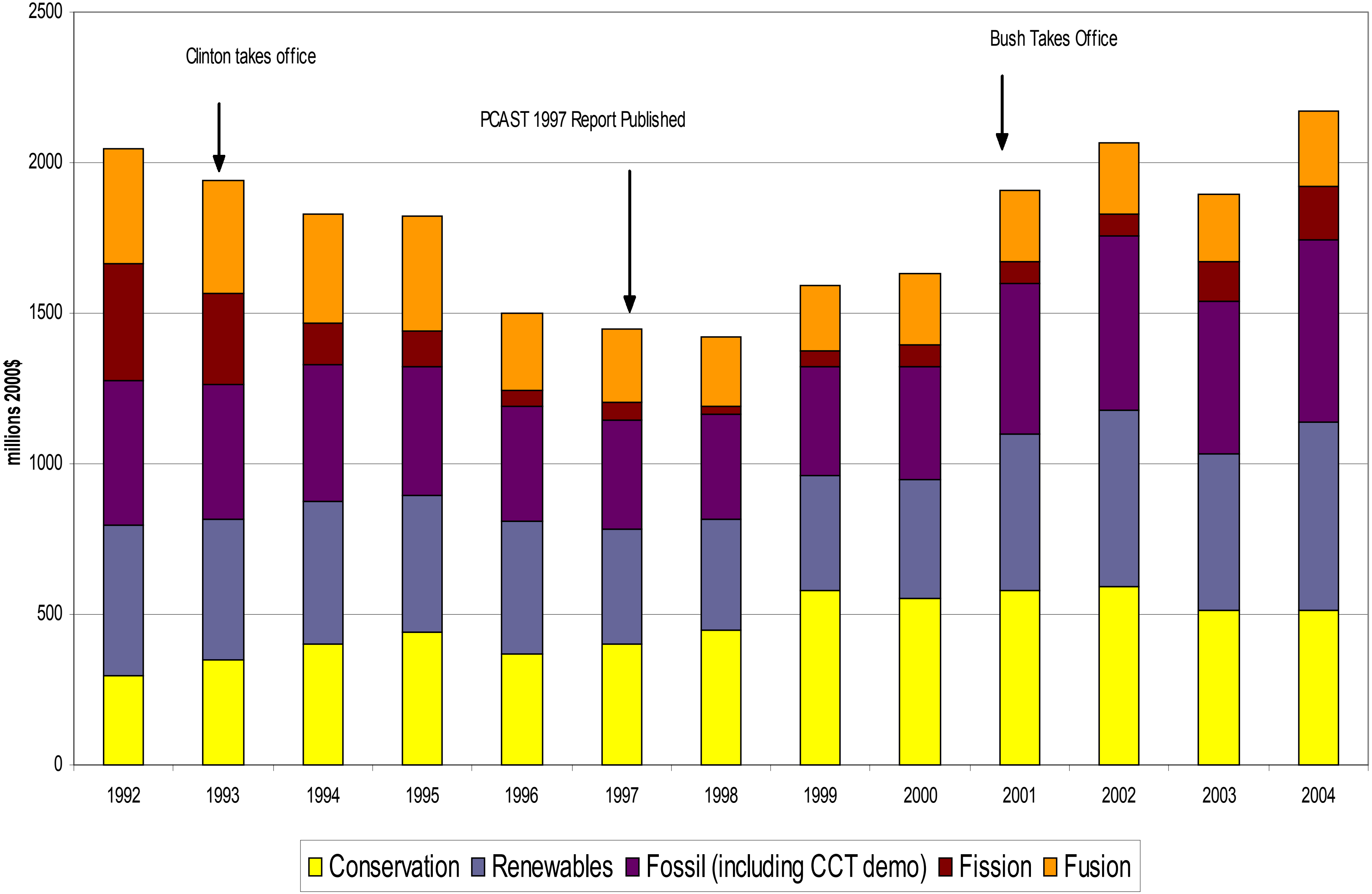
*COOPERATION ON ERD$^3$ ON ADVANCED ENERGY SUPPLY*

renewables, C capture & sequestration, nuclear fission & fusion

*IMPROVEMENTS IN MANAGEMENT OF ERD$^3$ COOPERATION*

interagency task force, improved accountability, multi-year funding

# U.S. DOE Energy RD&D Before and After PCAST 1997 Report (millions 2000$)



# Recommendations of the 2001 WEC Study Group

- Energy RD&D spending and technology transfer need to be increased in almost every country, and internationally.
- Priorities within this effort should go to technologies that…
  - – increase efficiency of conversion & end use
  - – promote deployment of locally appropriate renewables
  - – respond to public concerns about nuclear energy
  - – allow carbon sequestration
- Regional collaboration on ERD&D should be encouraged.
- Governments should…
  - – produce more detailed ERD&D data;
  - – review balance of long-term E research vs short-term development;
  - – require better ERD&D data from the private sector;
  - – promote increased private-sector ERD&D;
  - – use market-like mechanisms to encourage renewables (e.g., RPS).

**Some key issues as we think about narrowing the gap between what we have and what we need.**

- role of interactions among fundamental research, applied research, development, demonstration, and deployment
- importance of mechanisms for demonstrating advanced energy technologies & driving costs down to competitive levels
- appropriate roles of the public and the private sector in innovation processes…and the value of public-private partnerships
- how to develop a broad-based portfolio of energy RD3 balanced across technologies, sectors, time frames, risks
- leverage from technologies that address multiple goals (e.g., oil-import reduction, air-quality improvement, greenhouse gas abatement)
- necessity of addressing many of these issues in a global context.

# Some references beyond the papers for this meeting


J. Dooley & P. Runci, "Adopting a long view to energy R&D…", Battelle PNNL-122115, February 1999, http://www.globalchange.umd.edu/publications/PNNL-12115.pdf

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A. Sagar and J. Holdren, "Assessing the Global Energy Innovation System", Energy Policy, vol. 30, 2002, http://bcsia.ksg.harvard.edu/BCSIA_content/documents/AssessingEnergy.pdf