Energy Technology Innovation for Sustainable Development

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Outline of the presentation

- Character of the energy-environment-development nexus
- Where we are, where we've been, where we're headed
- The trouble with the business-as-usual future
- Goals and tensions in energy policy
- The roles of technological & institutional innovation
- Insights and recommendations from the past decade

THE ENERGY-ENVIRONMENT-DEVELOPMENT NEXUS

- Development should be thought of as the process of improving the human condition in all its aspects, not only economic but also environmental, political, social, cultural...

- Sustainable development should mean doing so by means and to end points that are consistent with maintaining the improved conditions indefinitely.

- Energy in convenient and affordable forms is an indispensable ingredient of economic progress. But energy is also a major cause of many of the world's most troublesome environmental problems.

ENERGY-ENVIRONMENT-DEVELOPMENT (continued)

Many of the most difficult and dangerous environmental problems at every level of economic development

- from the damage that the very poor do to their immediate environment and thus to themselves
- to the damage that the very rich do to global environmental systems and thus to everybody

arise from the harvesting, transport, processing, & conversion of energy.

Energy supply is the source of

- most indoor and outdoor air pollution
- most radioactive waste
- much of the hydrocarbon and trace-metal pollution of soil and ground water
- essentially all of the oil added by humans to the seas
- most of the anthropogenic emissions of greenhouse gases that are altering the global climate.

THE HEART OF THE MATTER

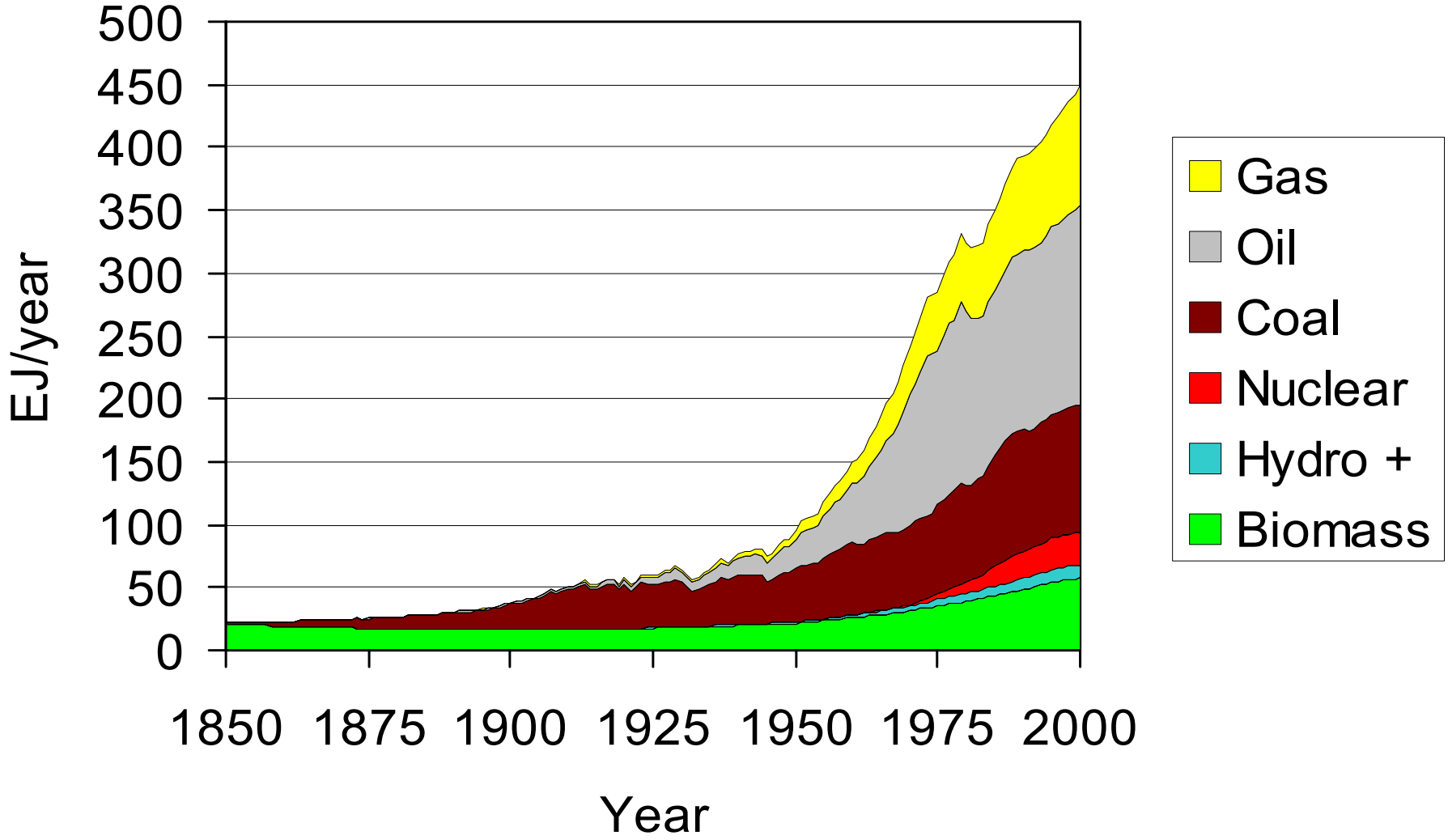
Because the environmental characteristics of the energy resources and technologies on which civilization depends today can generally be changed only slowly and at considerable cost, the dilemma of energy's dual roles in economic prosperity and environmental disruption is not easily resolved.

In light of all this, it becomes clear that

- Energy is the core of the environment problem.
- Environment is the core of the energy problem.
- The energy-environment-economy nexus is the core of the sustainable-prosperity problem, for industrialized & developing countries alike.

Where we are, where we've been, where we're headed

World Energy 1850-2000



ENERGY & ECONOMY BY INCOME CLASS, 2000

	POOR	TRANSI-TION	RICH
POPULATION, billions	4.1	1.2	0.8
GDP, trillion $ (ppp-corrected)	11	11	23
INDUSTRIAL ENERGY, terawatts	2.9	3.2	6.3
BIOMASS ENERGY, terawatts	1.4	0.2	0.2
FOSSIL CARBON, GtC/yr	1.6	1.7	3.1
per person			
GDP, thousand $	2.7	9.2	29
TOTAL ENERGY, kilowatts	1.0	2.8	8.1
FOSSIL CARBON, tC/yr	0.4	1.4	3.9

[poor = <$5k/pers-yr, transition = $5k-20k, rich = >$20k]

THE "BUSINESS AS USUAL" SCENARIO TO 2100

- World population increases from 6.1 billion in 2000 to 9.8 billion in 2050, stabilizing by 2100 at about 11 billion.
- Aggregate real economic growth averages 2.8%/year 2000-2020, 2.5%/year 2000-2100; ppp-corrected world economic product grows from ~$45 trillion in 2000 to $180 trillion in 2050, $500 trillion in 2100 (2000 US$). Industrial-developing country "gap" in ppp-GDP/person falls from 7x in 2000 to 3.5x in 2050, 2x in 2100.
- Energy intensity of economic activity falls at the long-term historical rate of 1%/yr. Energy use increases about 2.5 fold by 2050 and quadruples by 2100 (giving 1850 EJ/yr in 2100 compared to 450 EJ/yr in 2000).
- Carbon intensity of energy supply falls at 0.2%/yr. Carbon emissions from fossil-fuel burning go from a bit over 6 billion tonnes/yr in 2000 to some 20 billion tonnes/yr in 2100. LDCs = industrial countries ~2035.

What’s wrong with business as usual?

THE ESSENCE OF THE ENERGY PROBLEM

THE WORLD IS NOT RUNNING OUT OF ENERGY

BUT IT IS RUNNING OUT OF...

- CHEAP OIL
- ENVIRONMENT
- TOLERANCE FOR INEQUITY
- MONEY FOR BETTER OPTIONS
- TIME FOR A SMOOTH TRANSITION
- LEADERSHIP TO DO WHAT IS REQUIRED

The roles of technological and institutional innovation

ROLE OF TECHNOLOGICAL INNOVATION

ONLY WITH IMPROVED TECHNOLOGIES CAN WE

- efficiently, cleanly, & cost-effectively use local renewable energy resources to meet basic needs & fuel sustainable employment in the rural sectors of developing countries
- limit oil imports without incurring excessive economic or environmental costs
- improve urban air quality while meeting growing demand for automobiles
- use the world's abundant coal resources without intolerable impacts on regional air quality, acid rain, and global climate
- expand the use of nuclear energy while reducing accident and proliferation risks

ROLE OF INSTITUTIONAL INNOVATION

ONLY WITH IMPROVED INSTITUTIONS CAN WE

- provide the scale, continuity, and coordination of effort in energy research & development needed to realize in a timely way the required technological innovations
- gain the potential benefits of market competition in the electricity sector while protecting public goods (including provision of basic energy services to the poor, preservation of adequate system reliability, and protection of local and regional environmental quality)
- ensure the rapid diffusion of cleaner and more efficient energy technologies across the least developed countries and sectors
- devise and implement an equitable, adequate, and achievable cooperative framework for limiting global emissions of greenhouse gases

Insights and recommendations from the past decade

Insights of the 1990s about energy-technology innovation

- 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
- need 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.

The PCAST energy-technology innovation studies

(PCAST = President's Committee of Advisors on Science & Technology)

1997: Fed'l Energy R&D for the Challenges of the 21st Century

- 5 PCAST members & 16 other panelists from all energy sectors conclusions unanimous;
- focused on applied-energy-technology R&D in USDOE;
- led to Clinton's Climate-Change-Technologies Initiative.

1999: Powerful Partnerships

- 4 PCAST & 11 other panelists, similar composition to 1997 panel; conclusions again unanimous;
- focused on international ERD^3 cooperation – not just R&D but also demonstration & deployment – including efforts of EPA, USAID, Depts of Commerce and State, as well as DOE;
- led to Clinton's International Clean Energy Initiative.

http://www.ostp.gov/PCAST/pcastdocs93_2000.html

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.

The 1999 PCAST Study:

Powerful Partnerships –

The Federal Role in International Cooperation on Energy Innovation

The case for ERD^3 cooperation

BENEFITS FROM ENERGY-TECHNOLOGY IMPROVEMENTS IN ONE'S OWN COUNTRY

- lower cost & improved reliability of energy services
- reduced need for energy imports
- reduced local & regional environmental impacts of energy
- reduced risks from domestic nuclear-energy operations

BENEFITS FROM ENERGY-TECHNOLOGY IMPROVEMENTS IN ALL COUNTRIES

- reduced world oil prices and vulnerability
- reduced transboundary pollution & greenhouse gases
- reduced transboundary nuclear risks
- economic & security benefits of sustainable development

CORRESPONDING INCENTIVES FOR COOPERATION

- increase the pace & reduce the cost of energy-technology innovation for application in one's own country
- address the global dimensions of energy challenges by accelerated development & deployment of innovations worldwide

Area distribution of US ERD3 collaborations, 1997

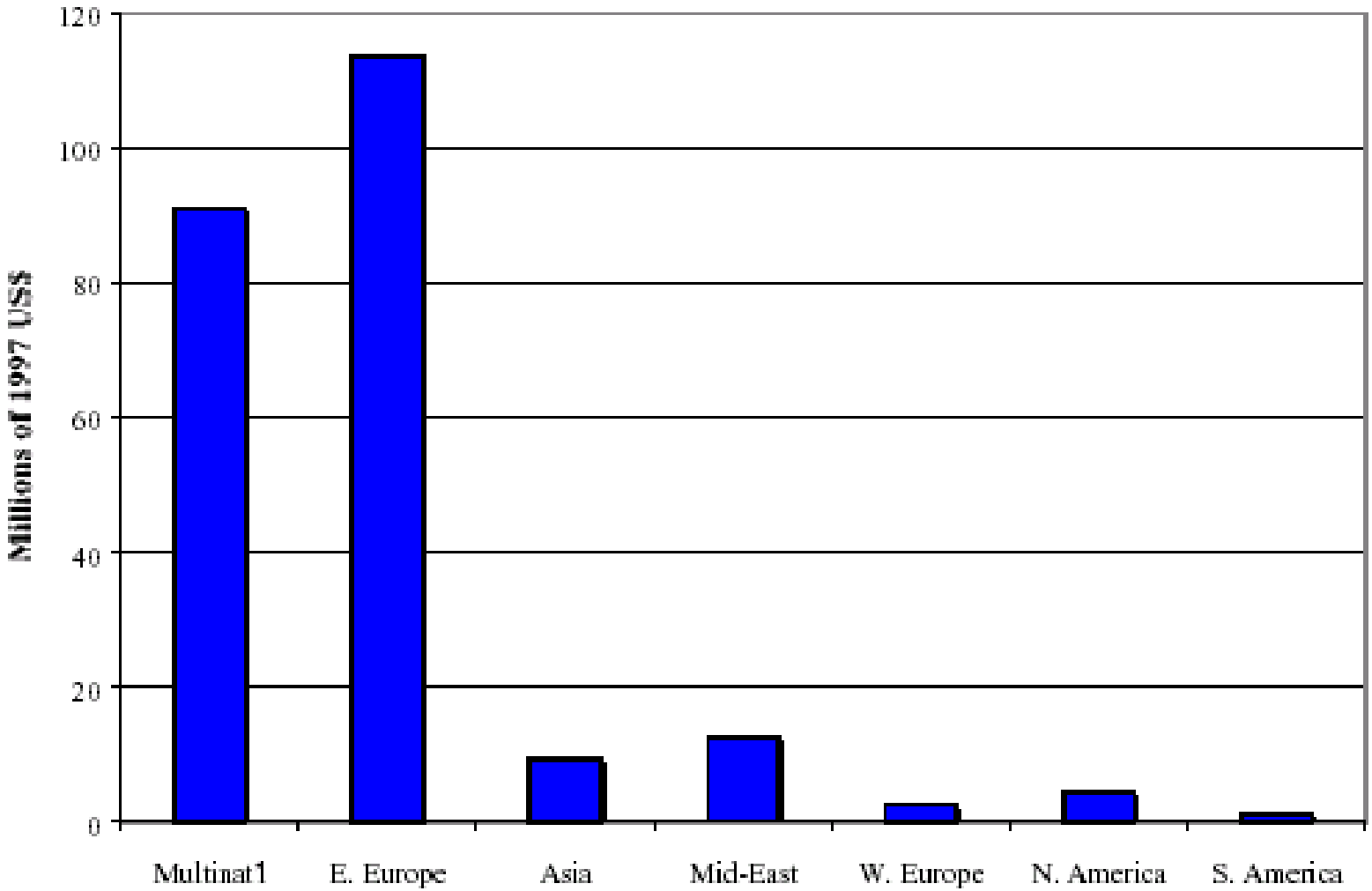


TABLE 12.2. THE ENERGY INNOVATION CHAIN FOR SUSTAINABLE ENERGY TECHNOLOGIES

	Research and development (laboratory)	Demonstration (pilot to market)	Early deployment (technology cost buy-down)	Widespread dissemination (overcoming institutional barriers and increasing investment)
Key barriers	• Governments consider R&D funding problematic • Private firms cannot appropriate full benefits of their R&D investments	• Governments consider allocating funds for demonstration projects difficult • Difficult for private sector to capture benefits • Technological risks • High capital costs	• Financing for incremental cost reduction (which can be substantial) • Uncertainties relating to potential for cost reduction • Environmental and other social costs not fully internalised	• Weaknesses in investment, savings, and legal institutions and processes • Subsidies to conventional technologies and lack of competition • Prices for competing technologies exclude externalities • Weaknesses in retail supply financing and service • Lack of information for consumers and inertia • Environmental and other social costs not fully internalised
Policy options to address barriers	• Direct public funding (national or international) • Tax incentives • Incentives for collaborative R&D partnerships	• Direct national or international support for demonstration projects • Tax incentives • Low-cost or guaranteed loans • Temporary price guarantees for energy products of demonstration projects	• Temporary subsidies through tax incentives, government procurement, or competitive market transformation initiatives	• Phasing out subsidies to established energy technologies • Measures to promote competition • Full costing of externalities in energy prices • 'Green' labelling and marketing • Concessions and other market-aggregating mechanisms • Innovative retail financing and consumer credit schemes • Clean Development Mechanism (see text)

Source: Adapted from PCAST, 1999.

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

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

The 2001 report of the

World Energy Council Study Group on

Energy Research, Development, and Demonstration

Energy Technologies for the 21st Century

Some conclusions of the 2001 WEC Study Group

- In half of 18 countries considered in detail, gov't ERD&D expenditures declined significantly between 1985 and 2000

  USA, w ~40% of world total, declined sharply; Japan increased by 45%.
- Private sector performance more difficult to assess.
- Cuts in ERD&D fell disproportionately on fossil and nuclear.
- Meeting demands of sustainability – E services for poor, reduced environmental impacts – will require big improvements in end-use efficiency, use of renewables, clean-fossil.
- The 1997 PCAST conclusion for USA has wider validity:

  "Energy RD&D programs are not commensurate in scope and scale with the energy challenges & opportunities the 21st century will present."
- The 1999 PCAST conclusion about scope of strengthened international cooperation on ERD&D is correct.

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).

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