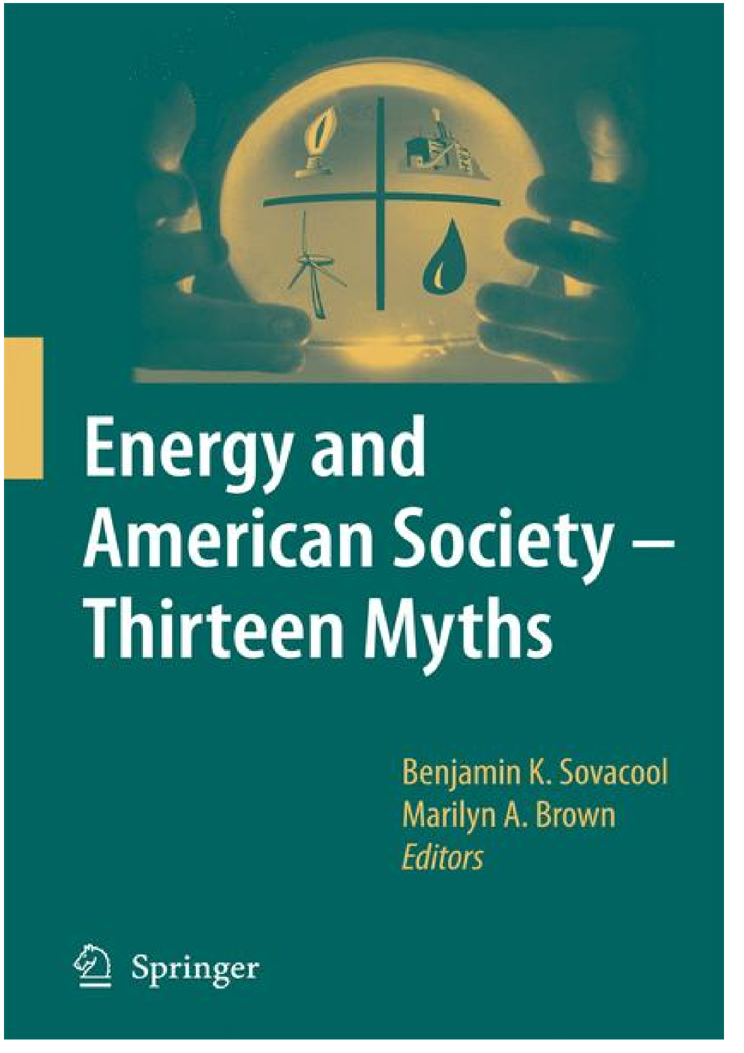
Carbon Lock-In: Barriers and Enablers of a Climate-Friendly Future

Marilyn A. Brown
Professor of Energy Policy
Georgia Institute of Technology
(Marilyn.Brown@pubpolicy.gatech.edu)

Sixth Annual James Anderson Distinguished Lecture in Applied Geography

Association of American Geographers

April 18, 2008



www.ornl.gov/sci/eere/publications.shtml

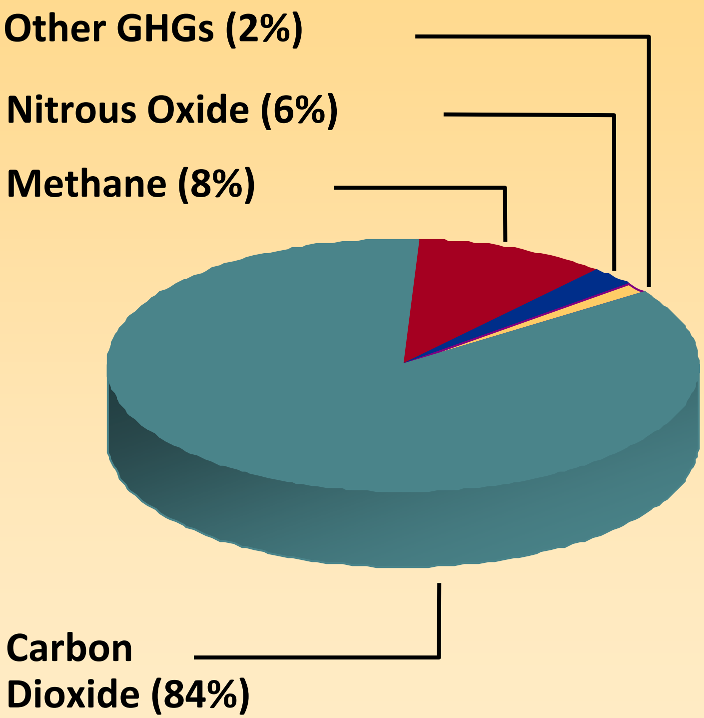
Tackling climate change promises to be one of the biggest challenges of the 21st century

- It will require considerable scientific and engineering ingenuity to produce entirely new energy systems that curb GHG emissions while simultaneously powering global economic growth.

- Success will also necessitate economic, social and policy innovations to foster the widespread and rapid deployment of technology solutions.

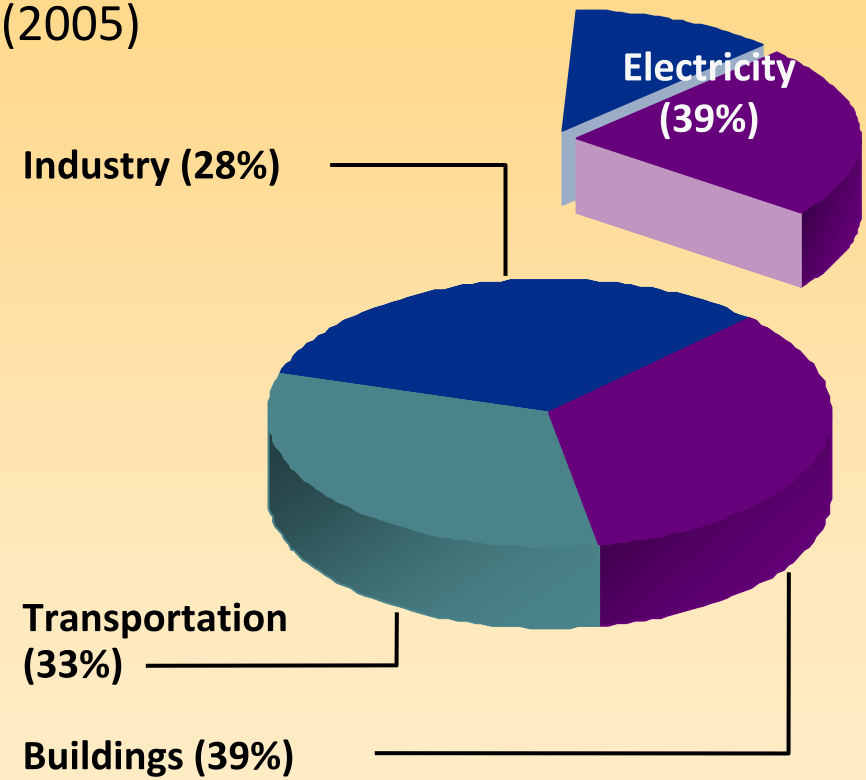
Global climate change is all about energy

U.S. GHG Emissions 88% are energy related



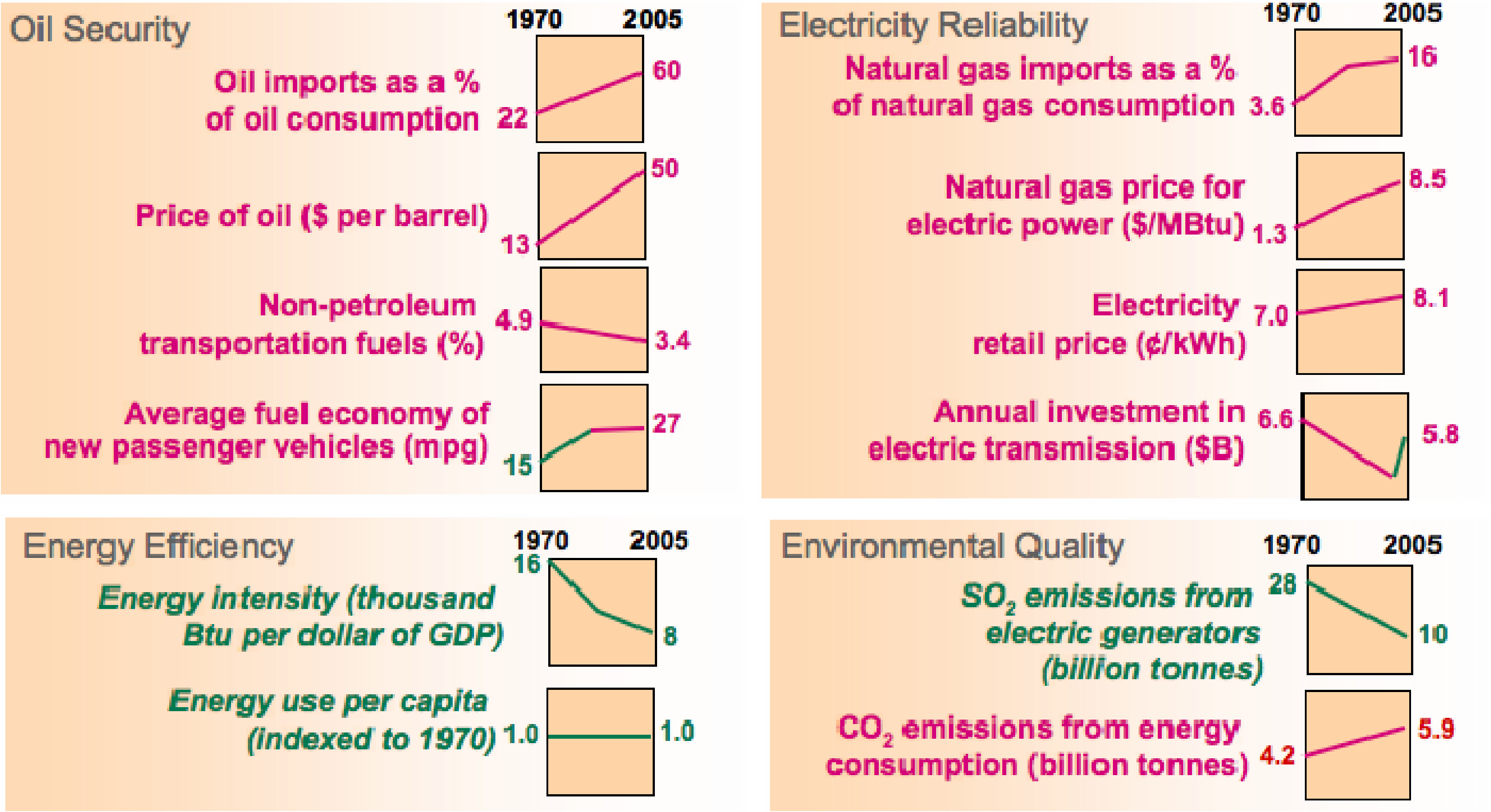
Source: EPA. 2007. *Inventory of U.S. GHG Emissions and Sinks: 1990-1995*, 2007.

U.S. CO_2 Emissions by Energy Sector (2005)



Source: EIA. 2007. *Annual Energy Outlook 2007*, Table A18.

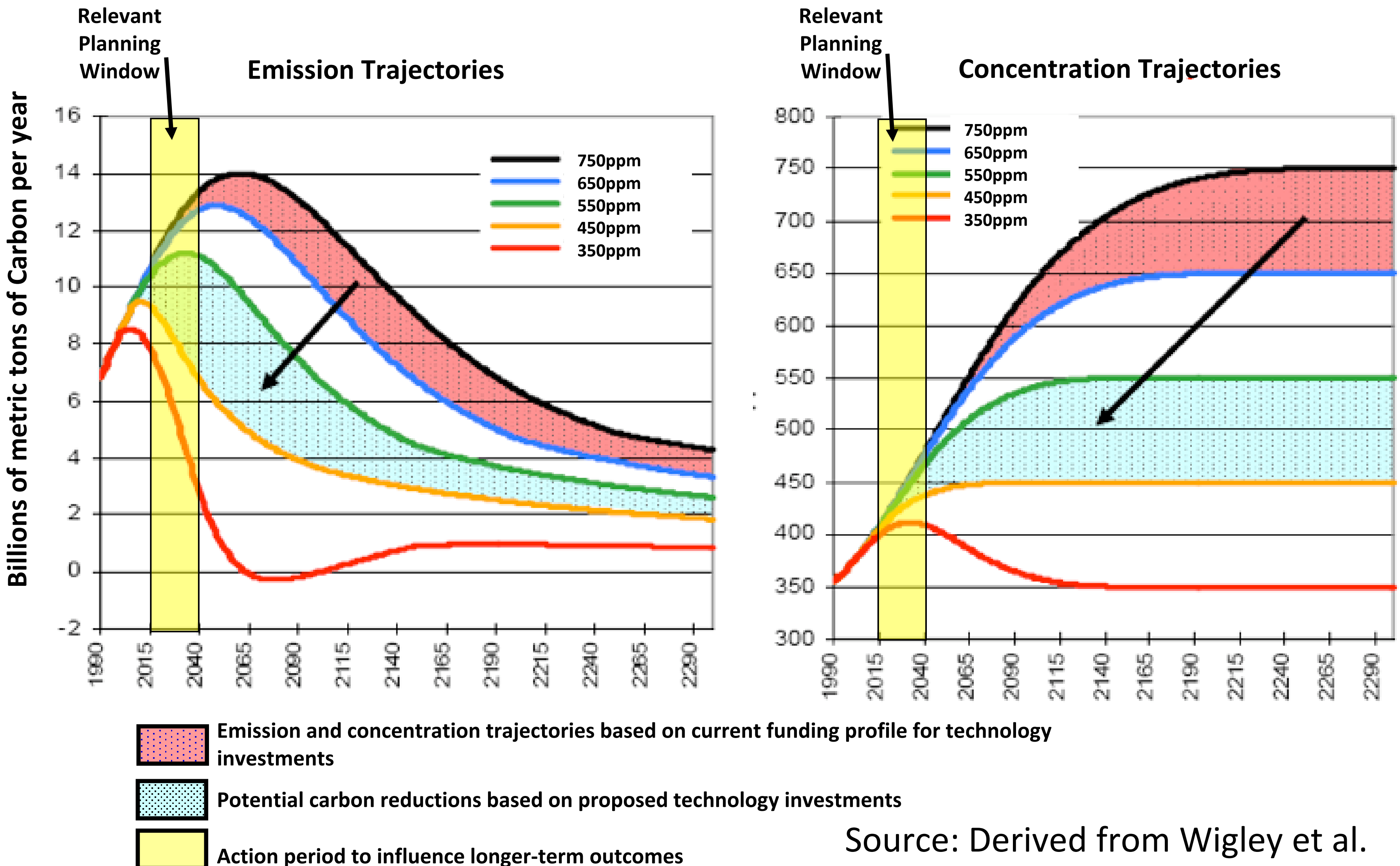
Indicators of “Energy Sustainability” show few positive trends



Source :MA Brown and BK Sovacool (2007). “*Developing an ‘Energy Sustainability Index’ to Evaluate U.S. Energy Policy,”* *Interdisciplinary Science Review,* 32 (4): 335-349.

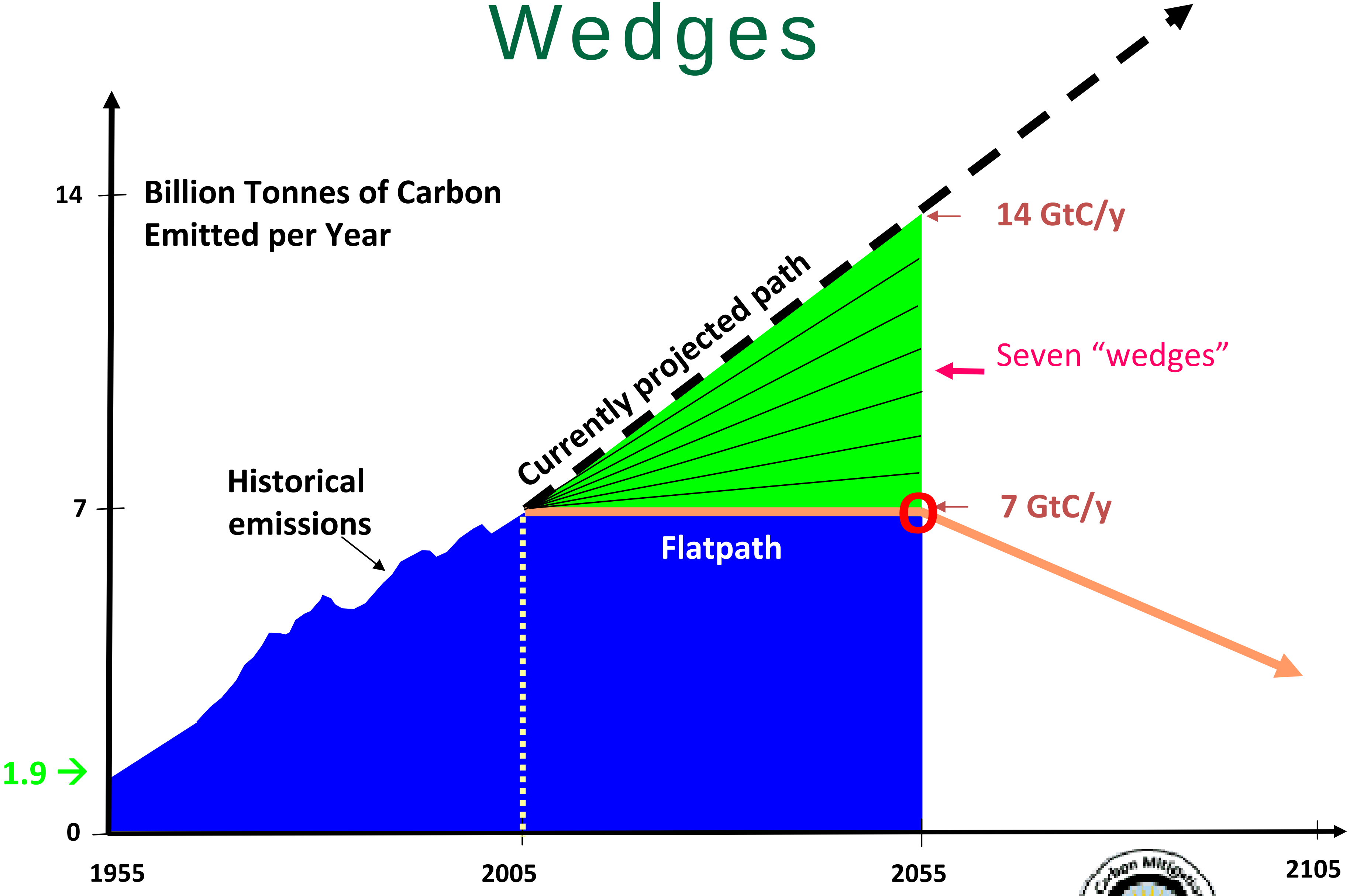
*Metrics are in $2005.

Near-term actions are needed to avoid long-term (potentially cataclysmic) costs



Source: Derived from Wigley et al. (1996)

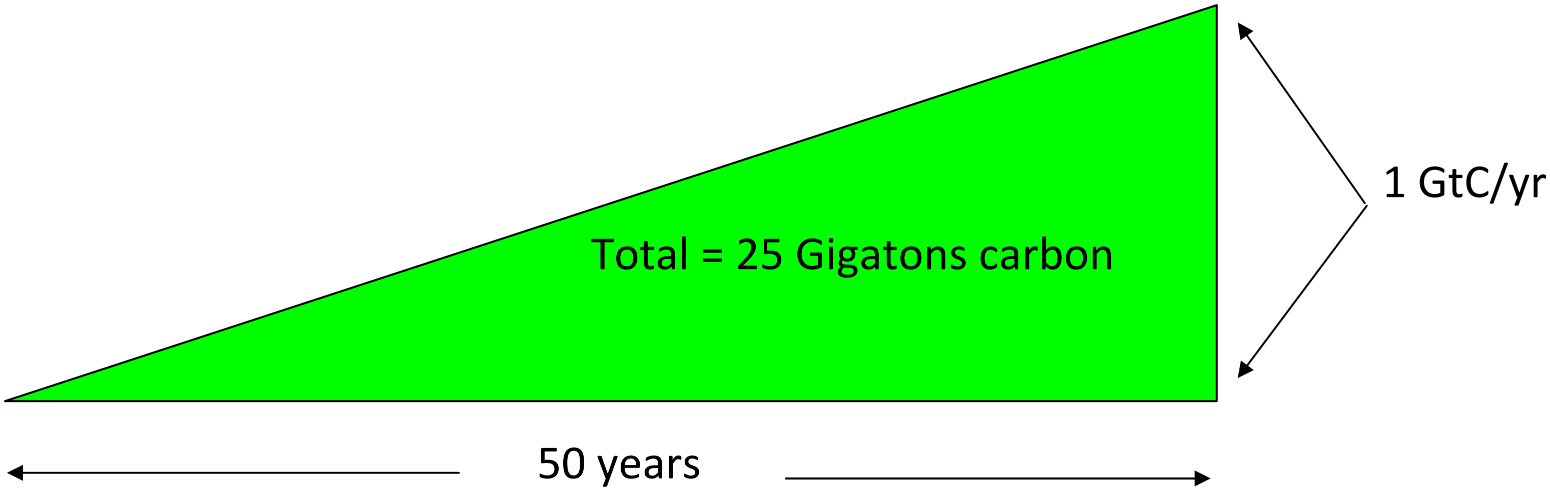
Wedges



Billion Tonnes of Carbon Emitted per Year
14
7
0
1.9 →
Historical emissions
Currently projected path
14 GtC/y
Seven "wedges"
O
7 GtC/y
Flatpath
1955
2005
2055
2105

What is a "Wedge"?

A "wedge" is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr. The strategy has already been commercialized at scale somewhere.



Cumulatively, a wedge redirects the flow of 25 GtC in its first 50 years. This would cost $1.25 trillion at $50/tC. A $50/tC tax or carbon trading value would raise electricity prices by almost 1 cent per kWh.

How Big is a Gigaton?

Today's Technology	Actions that Provide 1 Gigaton / Year of Mitigation
Coal-Fired Power Plants	Build 1,000 "zero-emission" 500-MW coal-fired power plants (in lieu of coal-fired plants without CO_2 capture and storage)
Geologic Sequestration	Install 3,700 sequestration sites like Norway's Sliepner project (0.27 MtC/year)
Nuclear	Build 500 new nuclear power plants, each 1 GW in size (in lieu of new coal-fired power plants without CO_2 capture and storage)
Efficiency	Deploy 1 billion new cars at 40 miles per gallon (mpg) instead of 20 mpg
Wind Energy	Install capacity to produce 50 times the current global wind generation (in lieu of coal-fired power plants without CO_2 capture and storage)
Solar Photovoltaics	Install capacity to produce 1,000 times the current global solar PV generation (in lieu of coal-fired power plants without CO_2 capture and storage)
Biomass fuels from plantations	Convert a barren area about 15 times the size of Iowa's farmland (about 30 million acres) to biomass crop production
CO_2Storage in New Forest.	Convert a barren area about 30 times the size of Iowa's farmland to new forest

Giga-Tonnes = 10^9 Metric-Tonnes (1000 Kilograms)

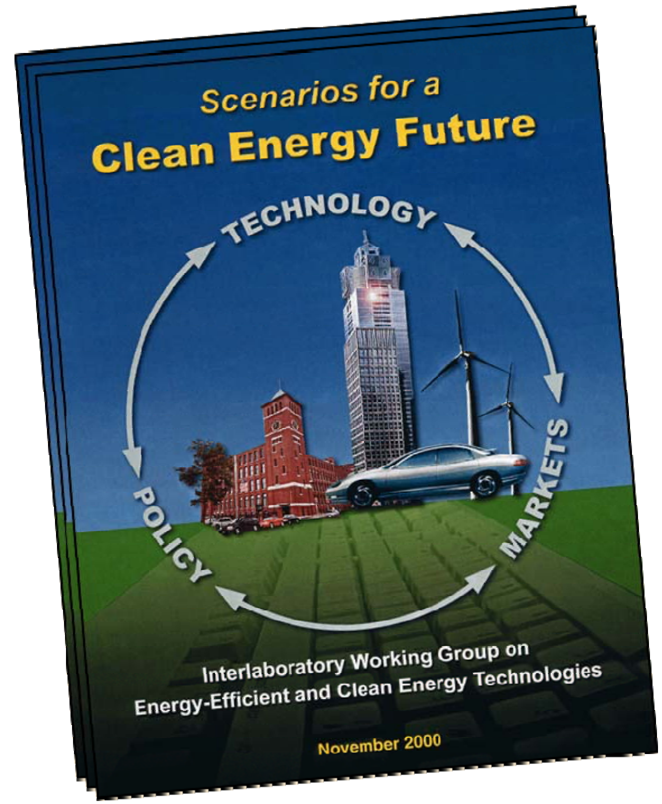
The "matching principle" justifies national action on climate change

Criteria	Local/Metropolitan	Federal/Global
Innovation	Encourages innovation and experimentation	Stifles innovation and experimentation
Flexibility	Less rigid, and able to adapt to local conditions	More uniform and consistent, but less flexible
Transaction costs	More agile and adaptive administration, but also more expensive	Standardization minimizes transaction costs
Spillovers	Vulnerable to free ridership and emissions leakage	Minimizes free ridership and emissions leakage

Source: BK Sovacool and MA Brown. 2008. "Is Bigger Always Better? The Importance of Scale in Addressing Climate Change." In Sioshansi, ed. *Carbon Constrained: Future of Electricity.* Elsevier, forthcoming.

Scenarios for a Clean Energy Future – Numerous Low-Cost Opportunities Exist

- **Advanced policies implemented in 2000 could cut U.S. electricity consumption in 2020 by 24%, with no net cost to the economy.**
  - Funded by DOE and EPA
  - Undertaken by researchers at 5 DOE national laboratories with input from experts groups
  - Published in November 2000



http://www.ornl.gov/ORNL/Energy_Eff/CEF.htm

"Special Issue" of ***Energy Policy***, Vol. 29, No. 14, Nov. 2001

Taxonomy of Climate Change Technologies (CCTs)

Number of Technologies Suitable for Deployment by Climate Change Goal

End-Use and Infrastructure	Energy Supply	Carbon Capture and Sequestration	Non-CO_2 GHGs

The U.S. Climate Change Technology Program's R&D portfolio is strong but has gaps

ORNL-6976

Results of a Technical Review of the U.S. Climate Change Technology Program's R&D Portfolio

Marilyn A. Brown[1]
Matt Antes[2]
Charlotte Franchuk[3]
Burton H. Koske[4]
Gordon Michaels[1]
Joan Pellegrino[2]

Sponsored by:

U.S. CLIMATE CHANGE TECHNOLOGY PROGRAM
www.climatetechnology.gov

May 2006

Prepared by:
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, Tennessee 37831

Managed by:
UT-Battelle, LLC
for the
U.S. Department of Energy
under contract DE-AC05-00OR22725

[1] Oak Ridge National Laboratory
[2] Energetics, Inc.
[3] Data Support Services
[4] Idaho National Laboratory

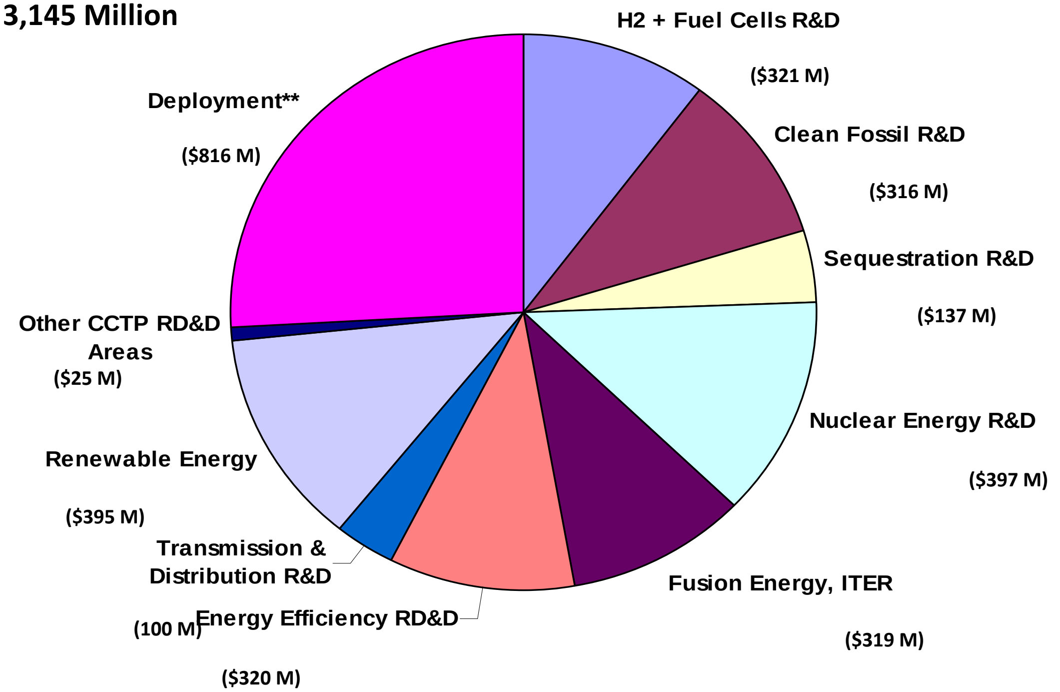
OAK RIDGE National Laboratory

www.ornl.gov/sci/eere/communications.htm

Also: www.climatetechnology.gov

The Current (FY 2007) CCTP Portfolio

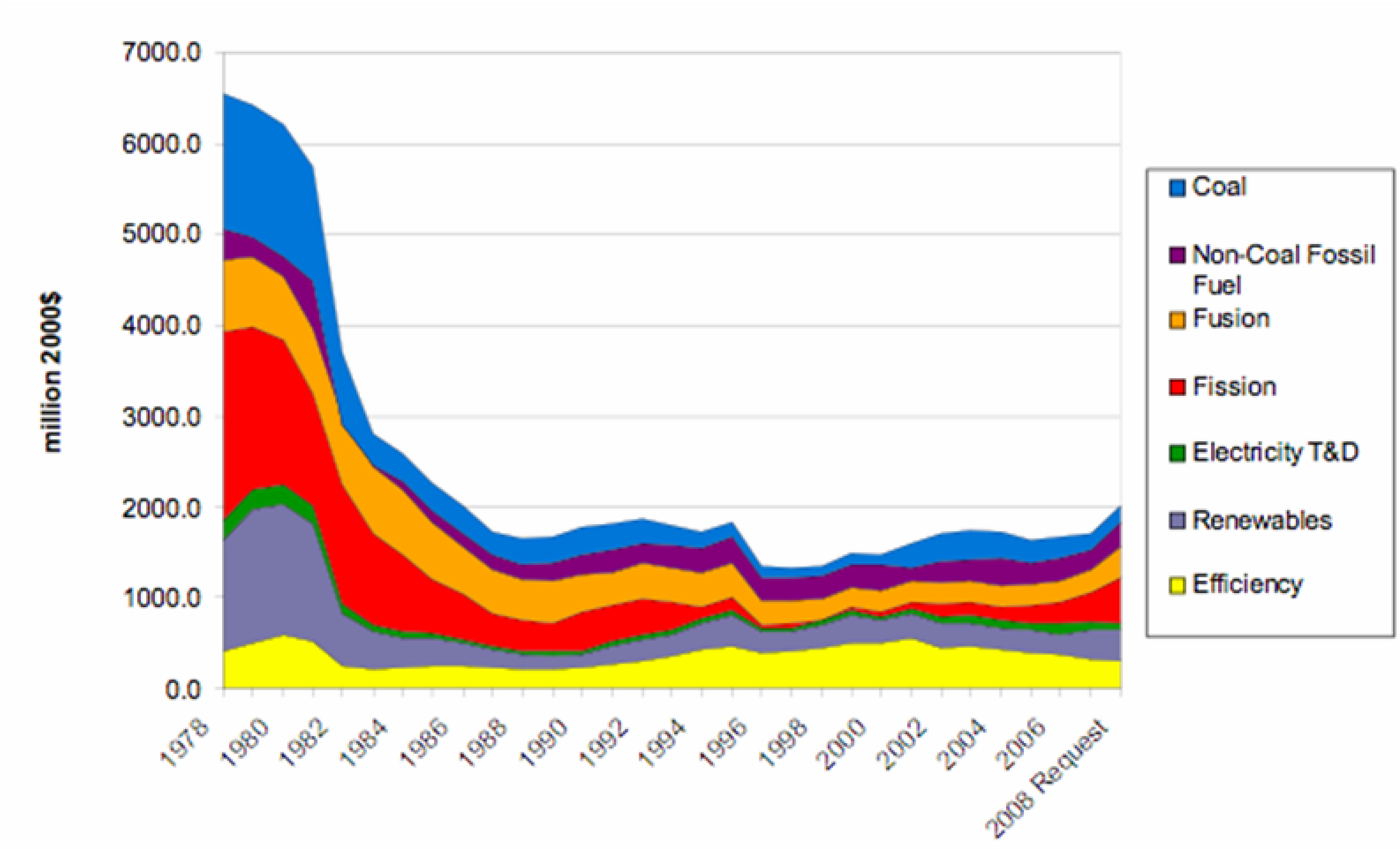
Total Multi-Agency FY07 Budget Request: $ 3,145 Million



*** All CCTP Federal Agencies FY07 Budget Request (inc: USAID & STATE)**

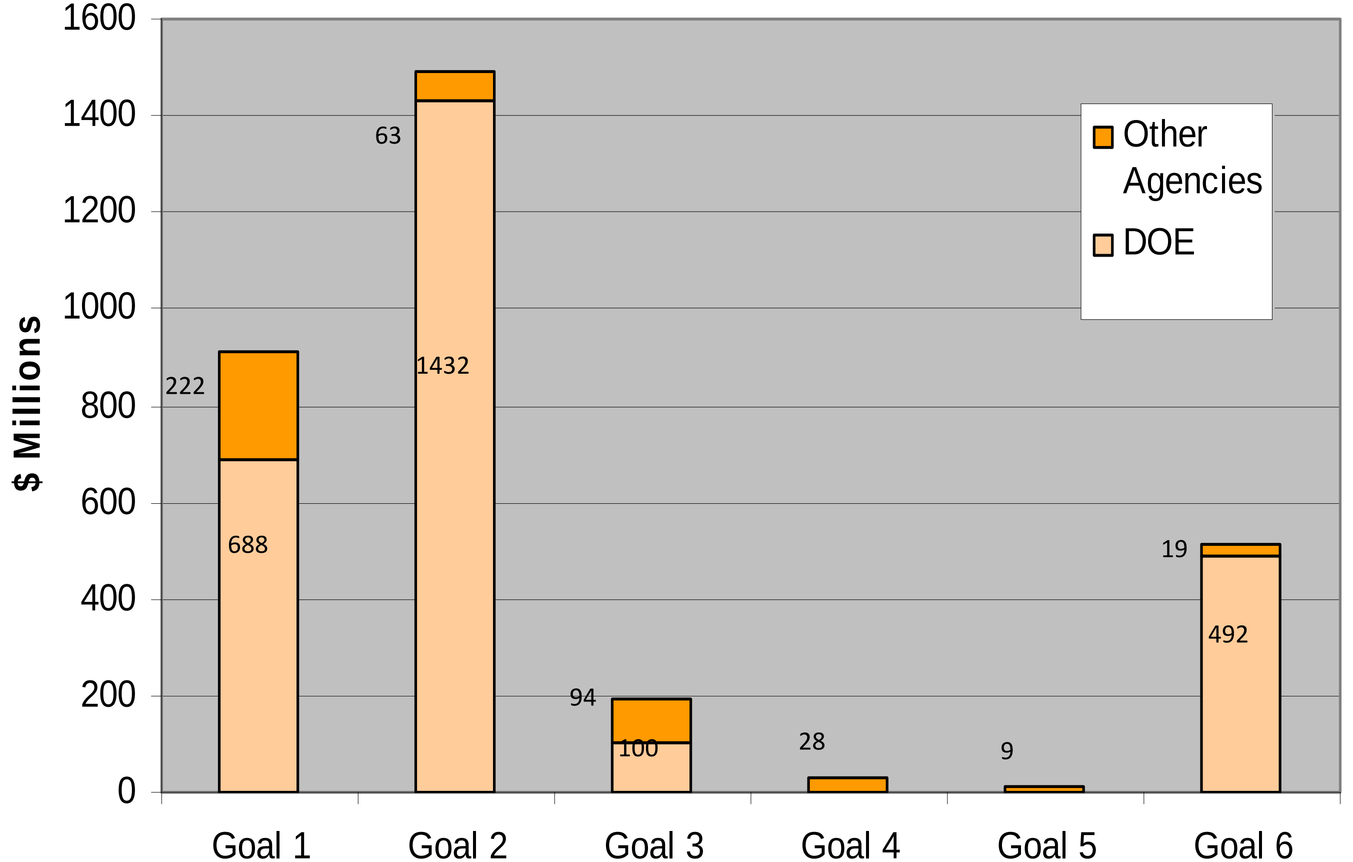
**** Deployment is 68% Energy Efficiency**

DOE's energy R&D budget has been declining



Based on data from Gallagher, et al, "DOE Budget Authority for Energy Research, Development, and Demonstration Database," Energy Technology Innovation Project, John F. Kennedy School of Government, Harvard University, 2007.

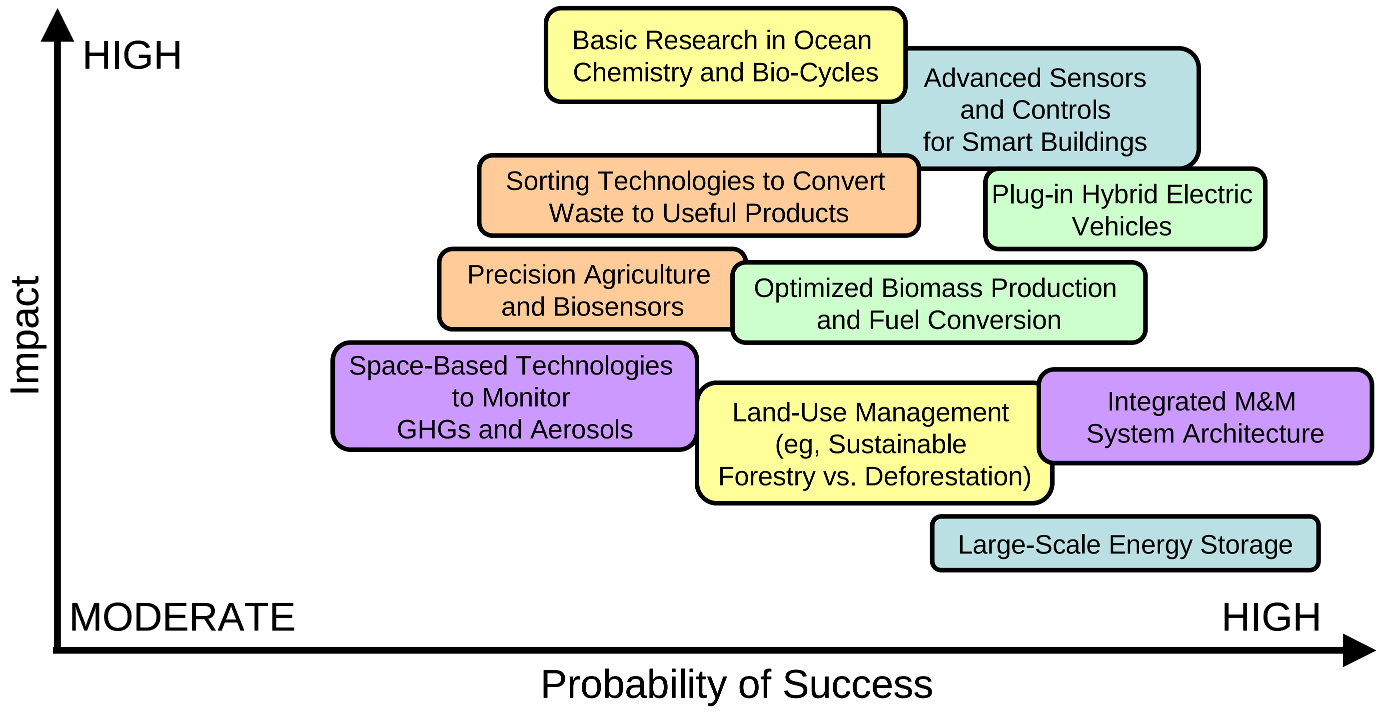
Allocation of CCTP FY07 Budget by Goal Highlights Gaps



Total CCTP	$ 910 M End Use	$ 1494 M Supply	$ 194 M CCS	$ 28 M Other Gases	$ 9 M M&M	$ 510 M Science

Structured Methodology to Assess the R&D Portfolio

1 = Identify portfolio gaps & opportunities; 2 = Evaluate results (probability of success vs. impact, by time-frame); 3= Prioritize; 4 = Add substance to key ideas



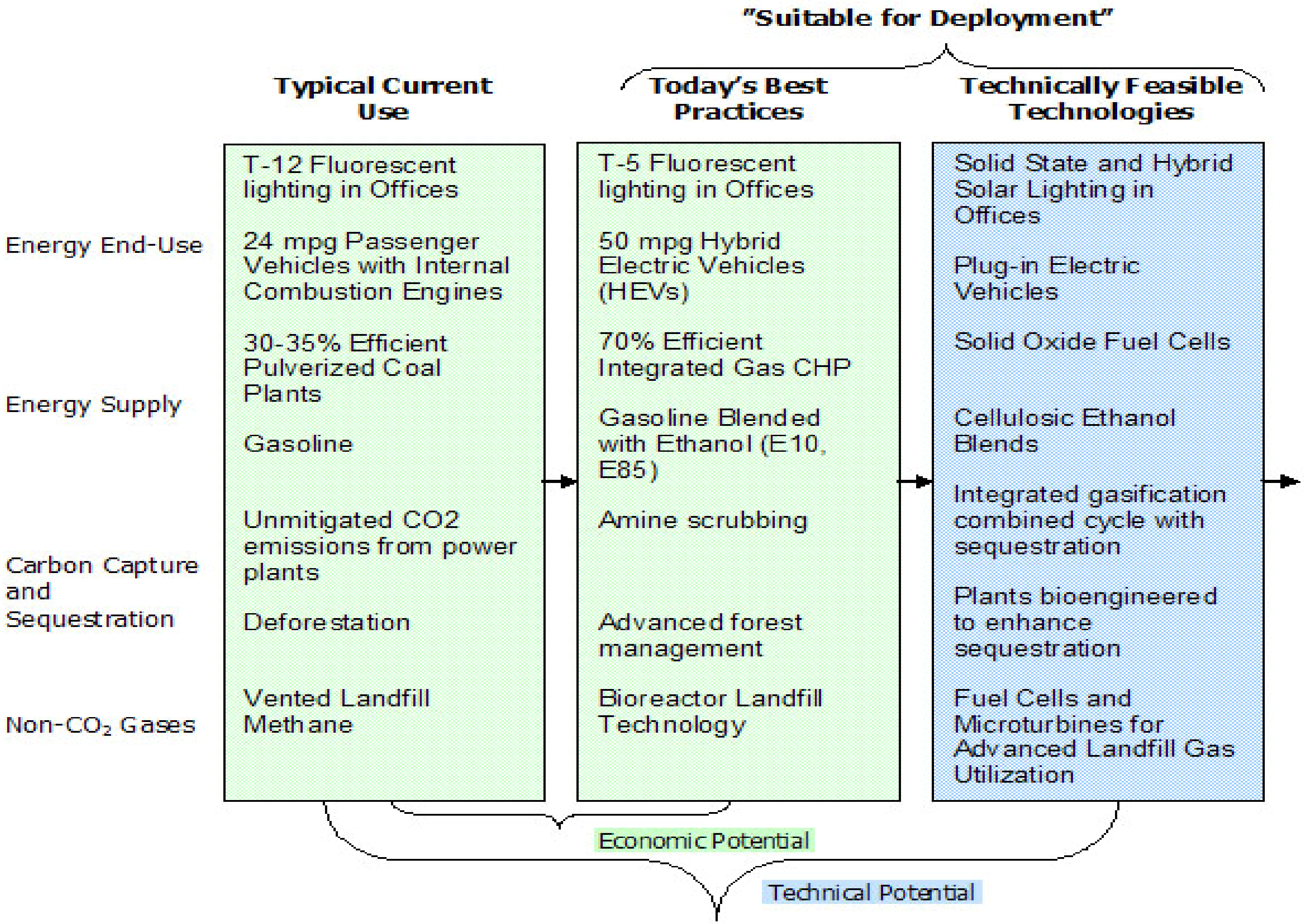
Results Highlight Technology-Specific Gaps – e.g., in Goal #1 Energy End-Use

Goal Sub-Area	Gaps & Opportunities
Transportation (SP- 4.1)	• *Enabling Technologies for Low-GHG Plug-in Hybrid Electric Vehicles* • *Advanced Thermoelectric Conceptsto Convert Temperature Differentials* • Studies of Advanced Urban-Engineering Concepts to Reduce VMT • Advanced Freight and Low-Emission Aviation Systems • New Combustion Regimes with Fuel Flexibility, Near-Zero Regulated Emissions
Buildings (SP- 4.2)	• *Advanced Sensors, Communications and Controls for Smart Buildings* • Smart Roofs, Walls and Insulation • Integration of Distributed Energy/Renewables • Ultra-Efficient HVACR
Industry (SP- 4.3)	• *Advanced Applications of Biotechnology* • Substitutes for Steel, Cement, Limestone, and Other High-GHG Products • Greater Waste Heat Utilization • Computational Modeling and Process Simulation for System Optimization • Water and Energy System Optimization • Life-Cycle Analysis for GHG Emissions
Infrastructure (SP- 4.4)	• *Large-Scale Energy Storage* • Materials Science for Efficient AC/DC Conversion • Nanotechnology for Efficient Transmission of Energy • Real-Time Observability, Monitoring and Control of Electric System Conditions

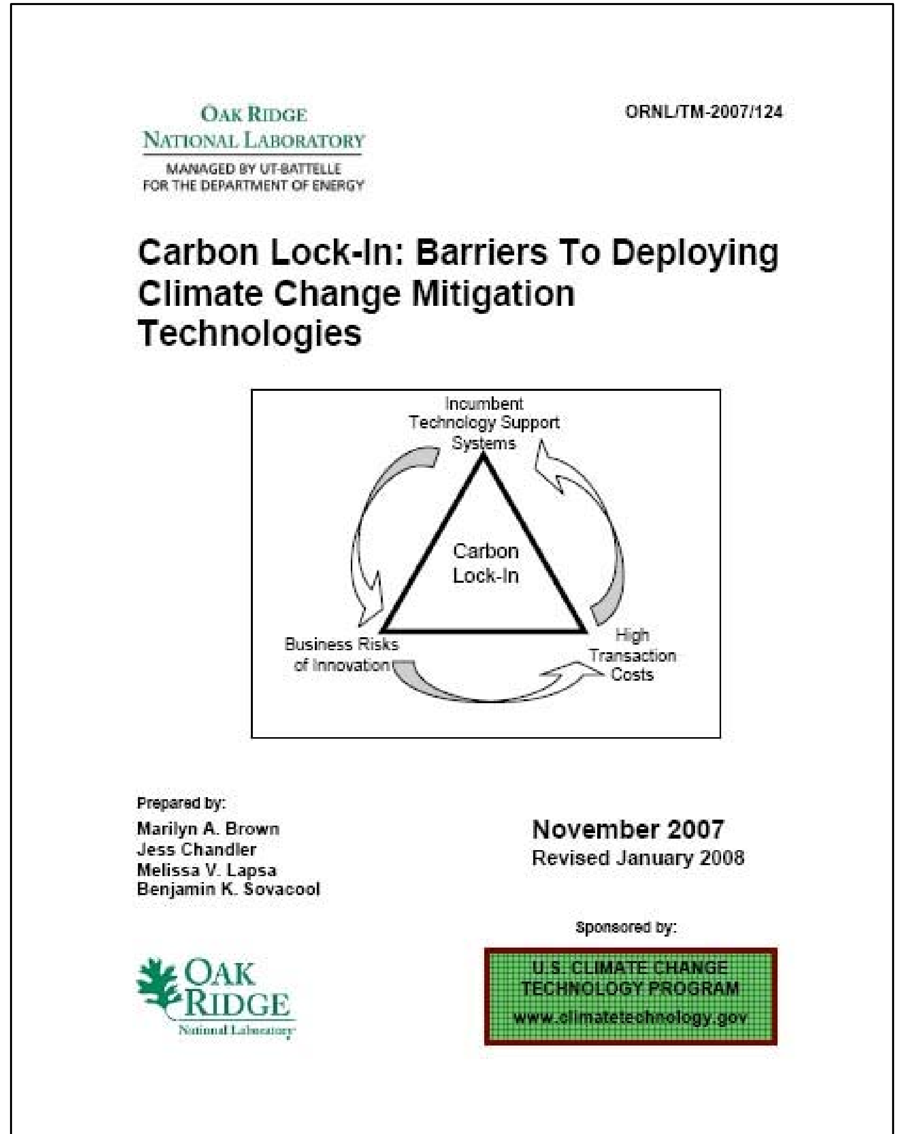
Moving “Best Practices” Into Greater Use is Also Important

- GHG emission reductions come from:
  - Improving the technology frontier
  - Shifting current best practices closer to the technology frontier
  - Moving typical technology use closer to current best practices

The Deployment Challenge: Rapid & large-scale absorption of low-carbon technologies



Deployment is Inhibited by Inherited Infrastructures and Policies – Resulting in Carbon Lock-In



OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

ORNL/TM-2007/124

Carbon Lock-In: Barriers To Deploying Climate Change Mitigation Technologies

Prepared by:
Marilyn A. Brown
Jess Chandler
Melissa V. Lapsa
Benjamin K. Sovacool

November 2007
Revised January 2008

Sponsored by:
U.S. CLIMATE CHANGE TECHNOLOGY PROGRAM
www.climatetechnology.gov

OAK RIDGE National Laboratory

www.ornl.gov/sci/eere/publications.shtml

and www.climatetechnology.gov

Numerous barriers hinder deployment of climate change technologies

Cost Effectiveness	Fiscal Barriers	Regulatory Barriers	Statutory Barriers	Intellectual Property Barriers	Other Barriers
High Costs	Unfavorable Fiscal	Unfavorable Regulations	Unfavorable Statutes	IP Transaction Costs	Incomplete and Imperfect Information
Technical Risks	Fiscal Uncertainty	Regulatory Uncertainty	Statutory Uncertainty	Anti-competitive Patent Practices	Infrastructure limitations
Market Risks				Weak International Patent Protection	Industry Structure
External Benefits and Costs				University, Industry, Government Perceptions	Misplaced Incentives
Lack of Specialized Knowledge					Policy Uncertainty

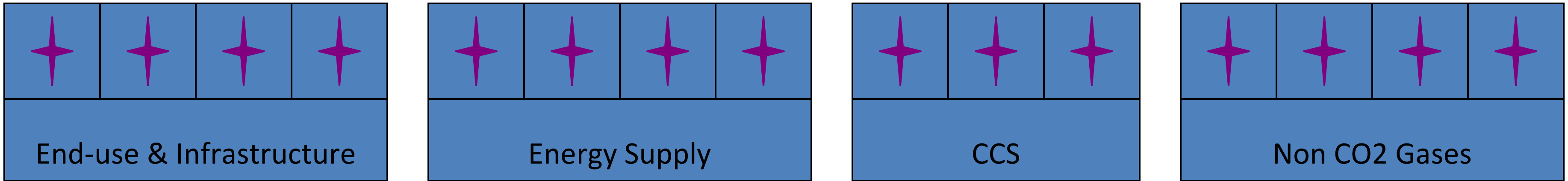
6 Barrier Categories

20 Types of Barriers

Each Climate Change Technology Sector Faces a Distinct Set of Barriers

External Benefits and Costs: Lack of a market price for carbon is a universal obstacle

- **External environmental benefits**
  - Lack of a market signal (price on carbon) is the most critical barrier
- **Incomplete and uneven policies to internalize externalities**

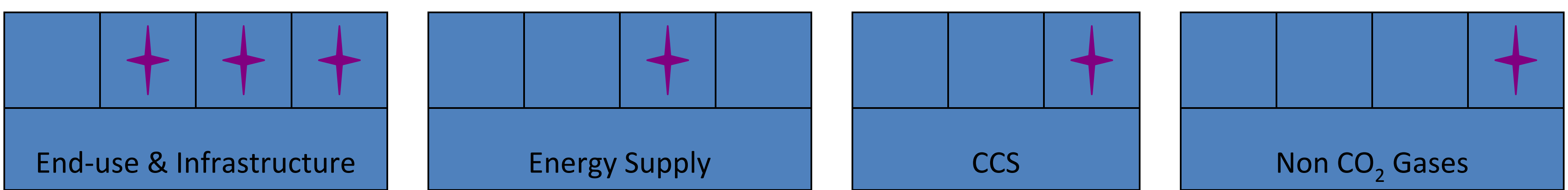


But: numerous fiscal policies, regulations and statutes also impede climate change technologies*

***See "Governing Confusion: How Statutes, Fiscal Policies, and Regulations Impede Clean Energy Technologies" forthcoming in *Stanford Law and Policy Review*, May 2008. http://www.spp.gatech.edu/faculty/workingpapers.php**

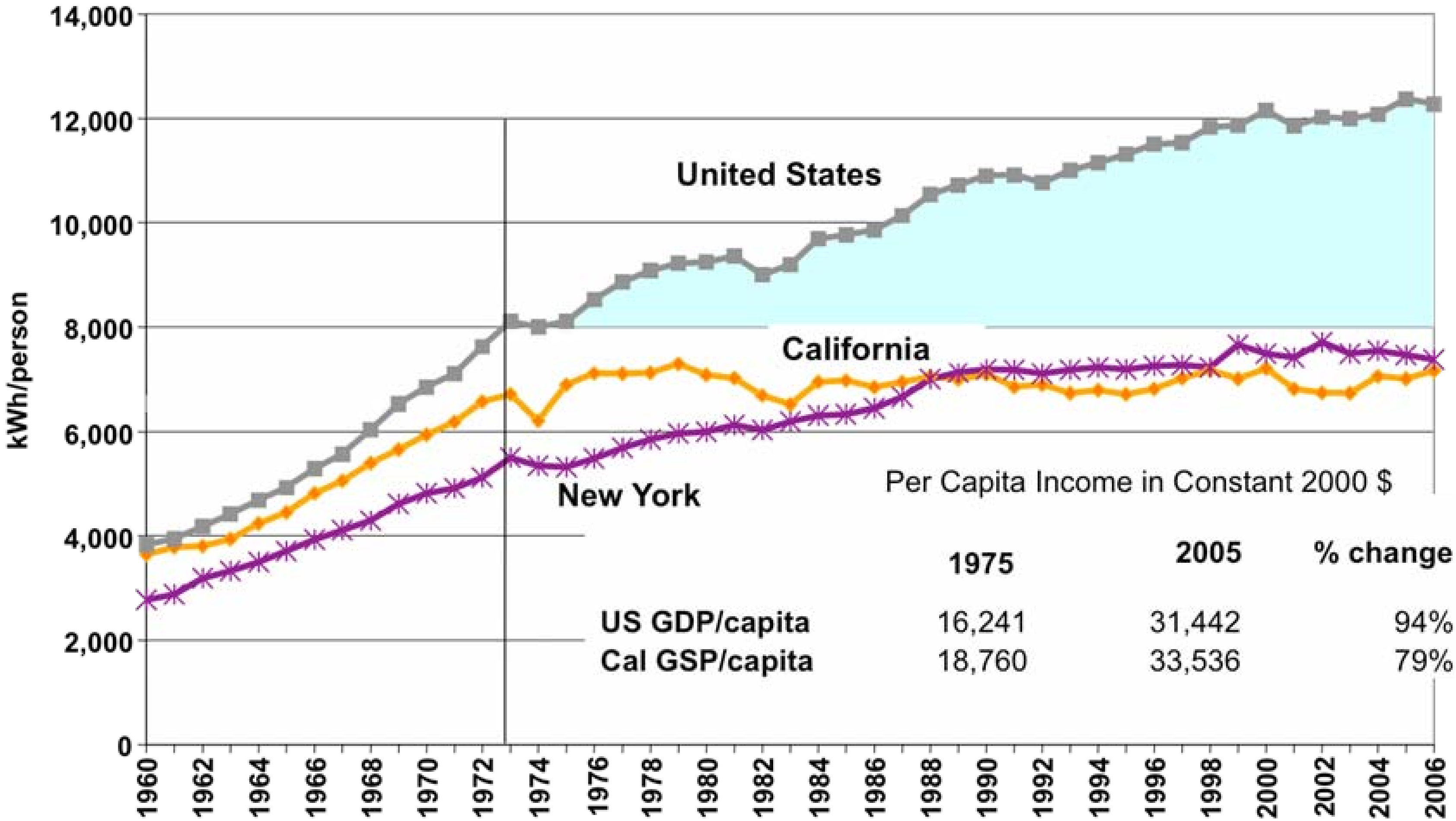
Unfavorable Fiscal Policies

- **Distortionary fiscal subsidies**
  - Favor high levels of energy consumption--e.g., business deduction for large light trucks, gas guzzler tax on cars (not SUVs)
  - Transportation funding linked to VMT
- **Unequal taxation of capital and operating expenses**
  - Outdated tax depreciation rules penalize energy-efficiency investments
  - Capital-intensive technologies (wind, nuclear) have higher tax burdens than expense-intensive fossil fuel plants



Unfavorable Fiscal Policies (cont.)

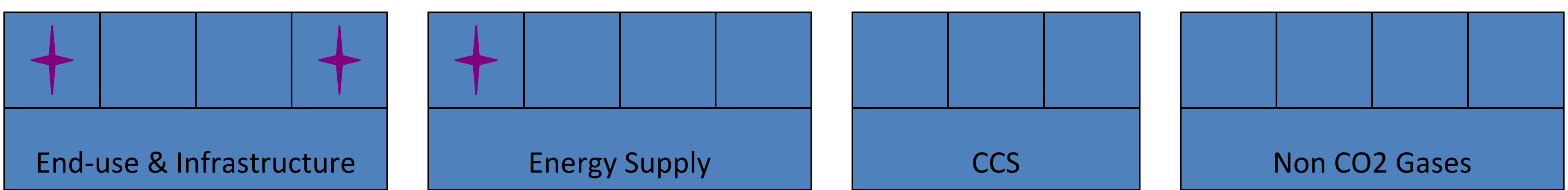
- **Utility pricing policies**
  - Coupling of electricity company profits to sales



Source: Art Rosenfeld (Commissioner, California Energy Commission), March 11, 2008

Unfavorable Regulations

- **Performance standards**
  - Exempting existing facilities from Clean Air Act regulations
  - Clean Air Act disincentivizes investing in plant upgrades
  - Input-based emissions standards discourage improvements
- **Connection standards**
  - Ban on private electric wires crossing public streets standards discourage improvements

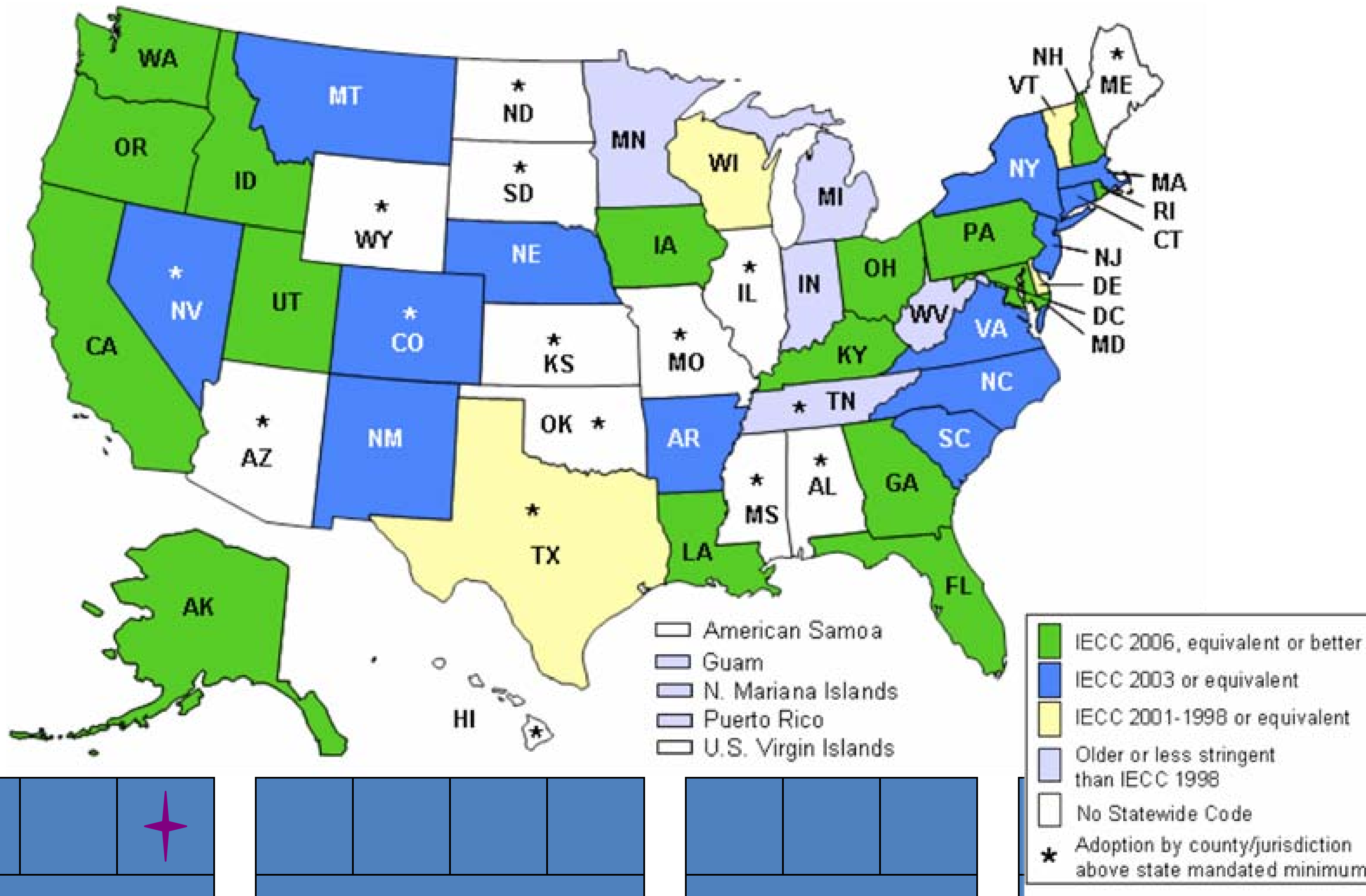


Unfavorable Regulations (cont.)

- **Poor land use planning**
  - "Fiscal zoning" for low-density urban development
- **Burdensome permitting**
  - Lack of permitting procedures for off-shore wind, and maze of regulatory oversight of land-based wind projects development
- **Regulatory loopholes**
  - CAFE exemption of vehicles over 8500 pounds
  - CAFE credits for E-85 vehicles regardless of fuel used

Unfavorable Statutes

- **Lack of modern and enforceable building codes**



End-use & Infrastructure | Energy Supply | CCS | Non CO2 Gases

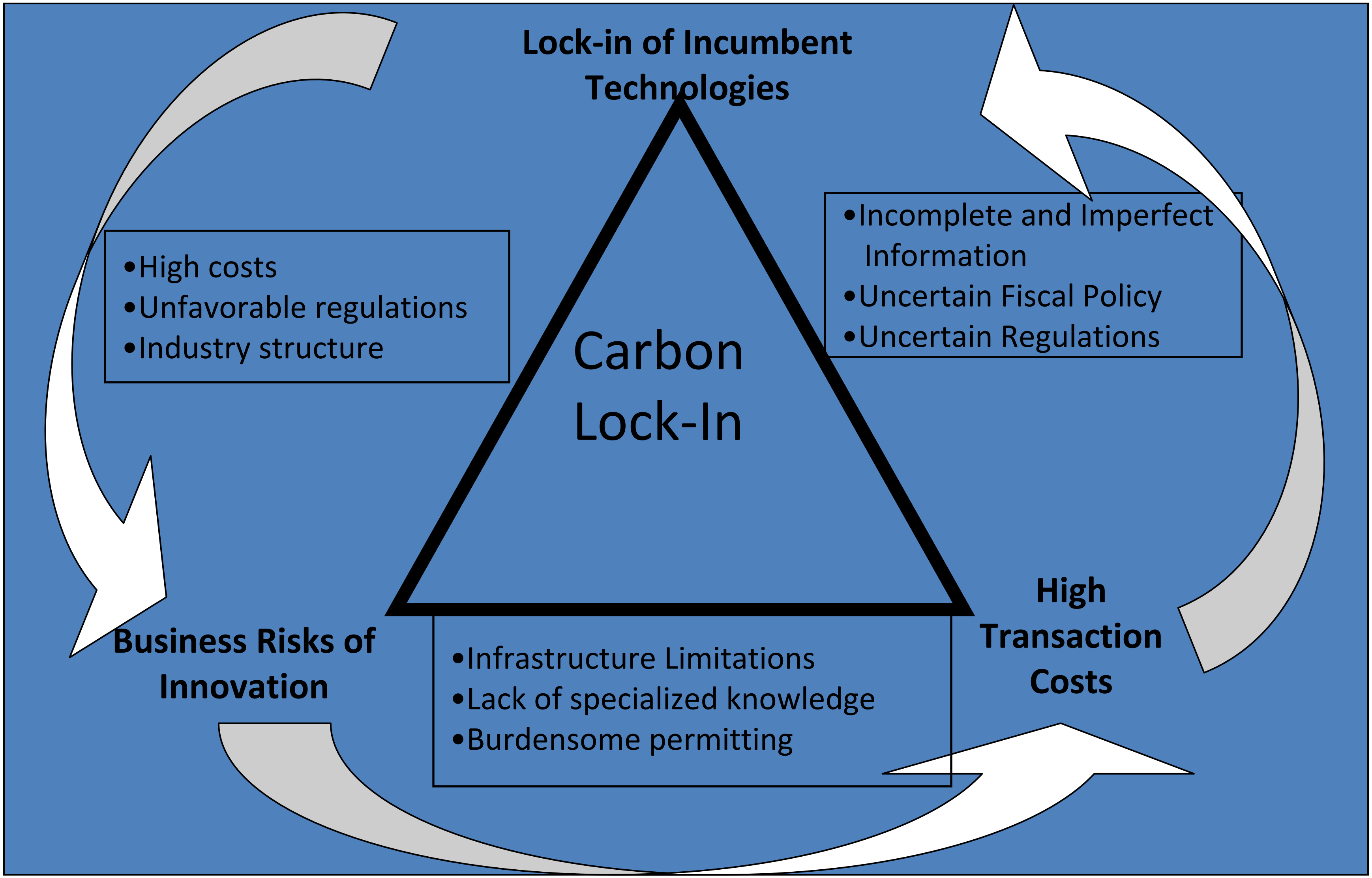
Interrelated, overlapping & reinforcing barriers necessitate a broad program of policy reform

- **Lock-in of incumbent technologies**:
  positive feedback between government, financial institutions, suppliers, and existing infrastructure systems contribute to technology "lock-in" and maintain status-quo technologies even in the face of superior substitutes.

- **Business risks of innovation**:
  inventions and innovations face an array of obstacles in the marketplace, and since many GHG-reducing technologies are relatively new, these obstacles can strongly impact them.

- **High transaction costs**:
  costs associated with gathering and processing information, developing patent portfolios, obtaining permits, and designing and enforcing contracts can all be prohibitive during the early stages of a technology's deployment.

The "Iron Triangle" of Carbon Lock-In



Establishing a market price for carbon is necessary but not sufficient

- There are numerous critical policy needs
- Interventions to fix “market failures” have produced an array of “public policy failures.”
- Many existing policies place climate change technologies at a comparative disadvantage.
- Other policies have design flaws that undermine their effectiveness.
- Tackling this legacy of inherited broken policies is critical