Appliances:
Designs and Standards for Sustainability

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INSTITUTIONAL INTRODUCTION

- **LBNL is the first DOE national laboratory (1931)**
  - —Research in all scientific disciplines; team-based
  - —Current focus on solving the energy/carbon problem
  - —Ca 3600 persons, $400M/a

- **Environmental Energy Technologies Division (EETD) started in 1973**
  - —Energy, technologies and analysis of systems/policies
  - —End-use orientation, especially buildings, industry, and electricity sectors
  - —Ca 400 persons, $50M/a

- **Energy Analysis Department (EAD) since 1973**
  - —Ca 120 persons, $20M/a

OUTLINE

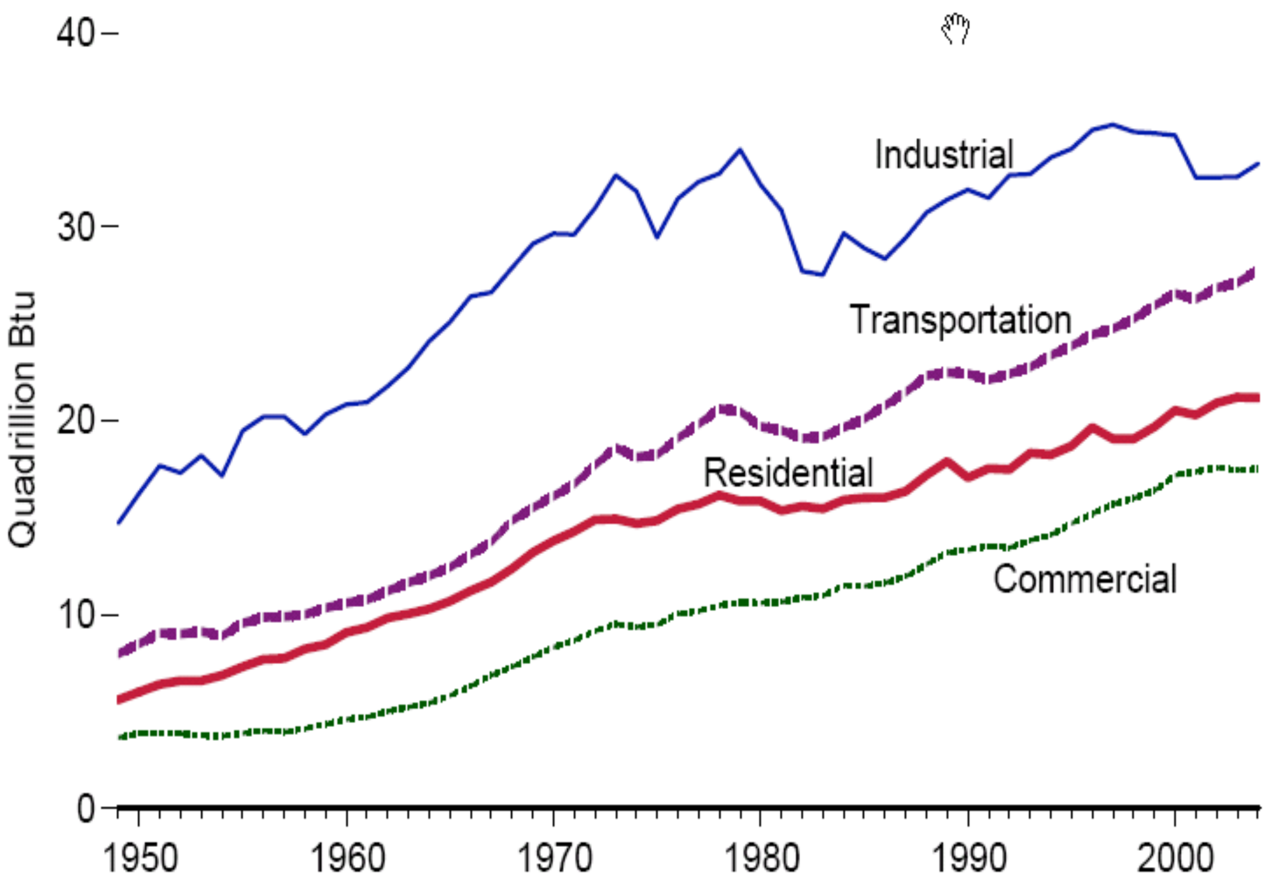
- **Overview of buildings sector**
  - Energy use, GHG emissions
  - Expenditures
  - End uses (appliances, equipment and lighting)
- **Time trends** (US buildings' energy, appliance efficiencies)
- **Potential for energy efficiency technology in buildings**
  - Energy savings
  - Costs of conserved energy
- **Market effects of policies**
  - Energy labels and standards
  - Public and private R&D
  - Private investment ("Clean Tech")
  - California AB32
  - National (and global) carbon policy

Buildings and expenditures

- Buildings include:
  - **Residential:** 116 million households in 2007
  - **Commercial:** 77 billion square feet
    - Office, retail, education, warehouse, lodging, service, public assembly, health care, food

- **Expenditures:** <u>70 % of construction, 40% of energy</u>
  - New construction: $780 B/yr (>7 million employees)
  - Renovation: $390 B/yr (>1 million contractors)
  - Energy: $370 B/yr

Total End-Use Energy Consumption 1949 – 2004



Combined Res/Com Buildings in 2007:

~ 40 Quads (of 100)

~ $370B/yr for energy

~ 630 MTC (of 1623) emitted

Energy Consumption by U.S. Buildings

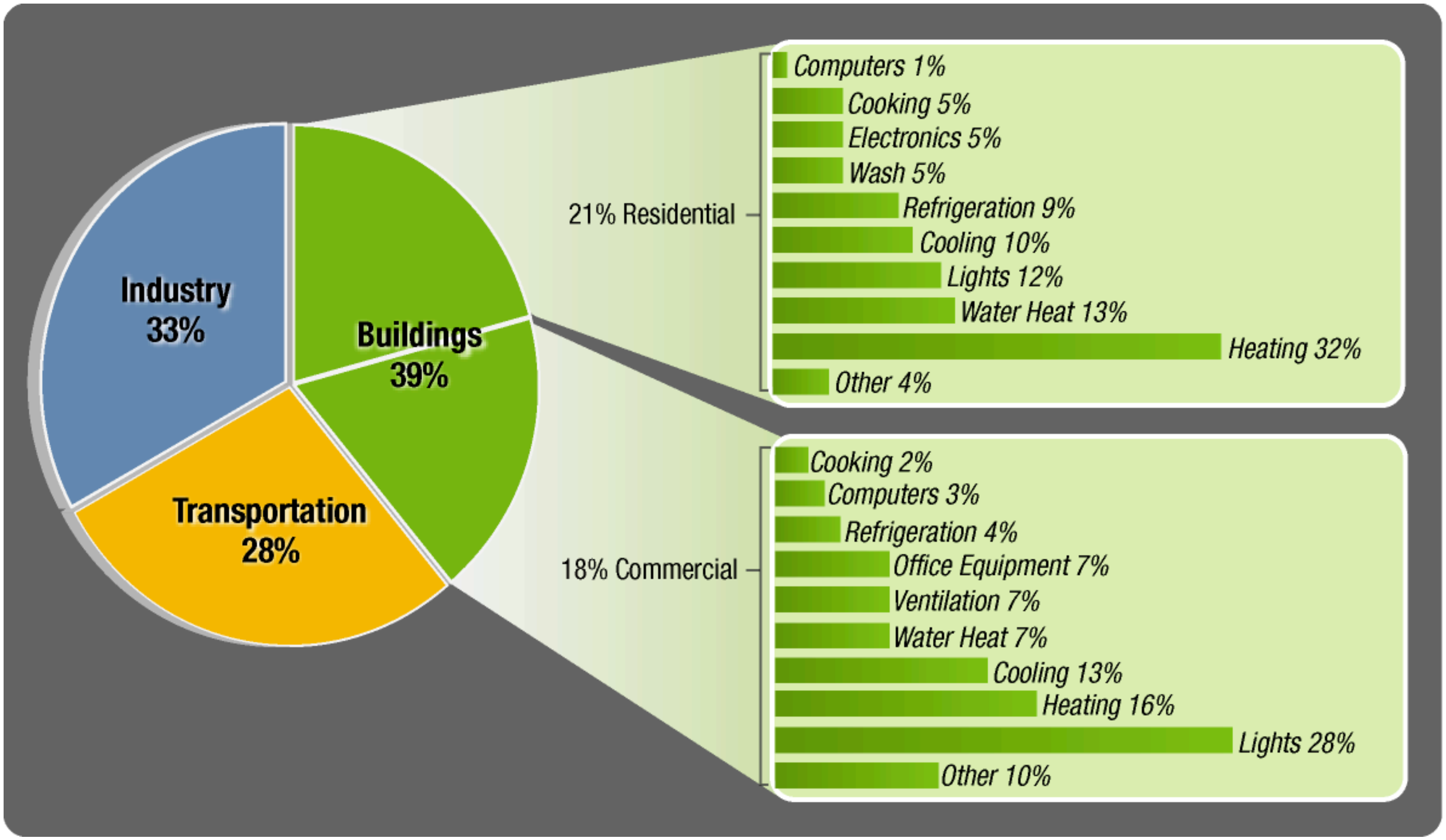
- 71% of U.S. electricity consumption
- 54% of U.S. natural gas consumption
- 39% of U.S. carbon dioxide emissions

.U.S. buildings are responsible for more CO_2 emissions than any country in the world except China & US

Buildings' Energy Consumption by End Use

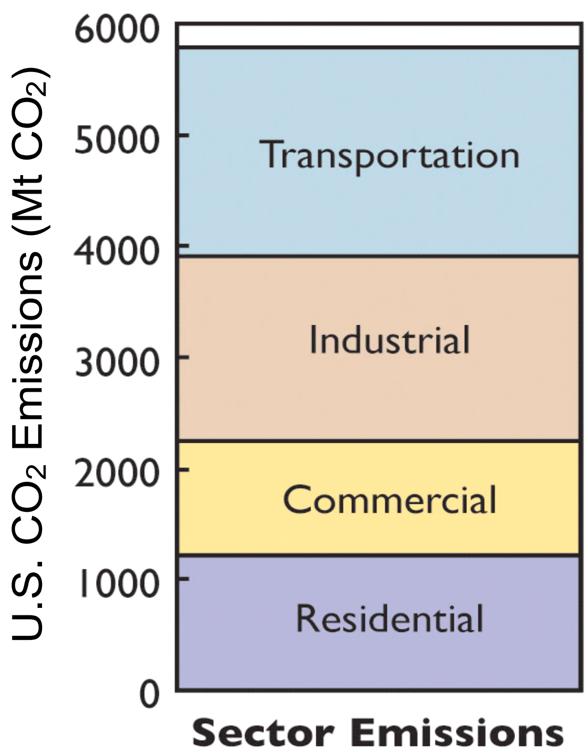
Buildings consume 39% of total U.S. primary energy

- ***71% of electricity and 54% of natural gas***

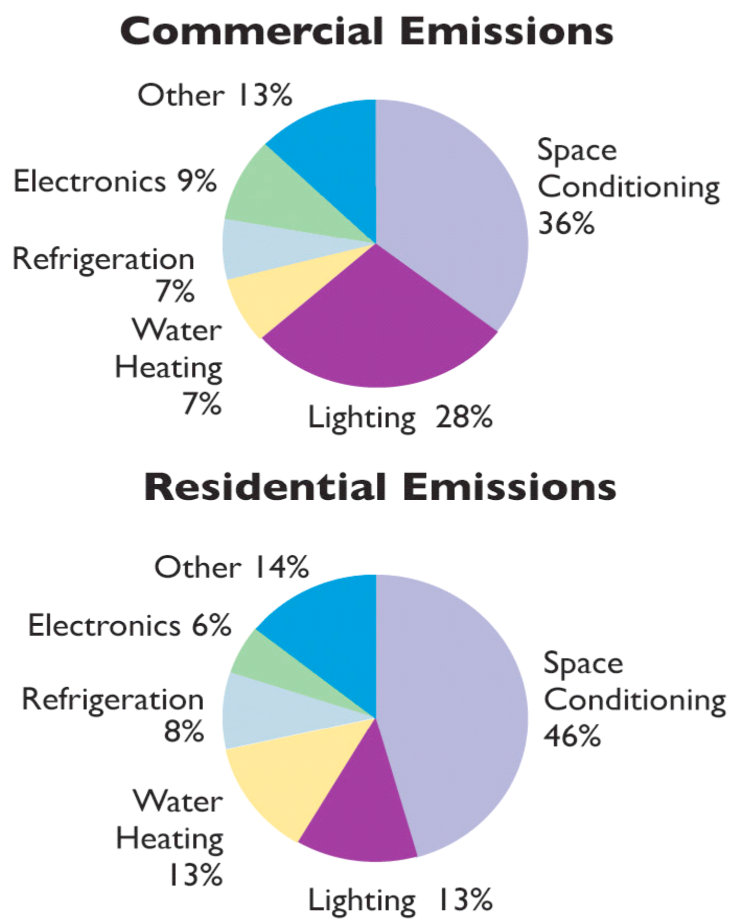


U.S. CO_2 Emissions

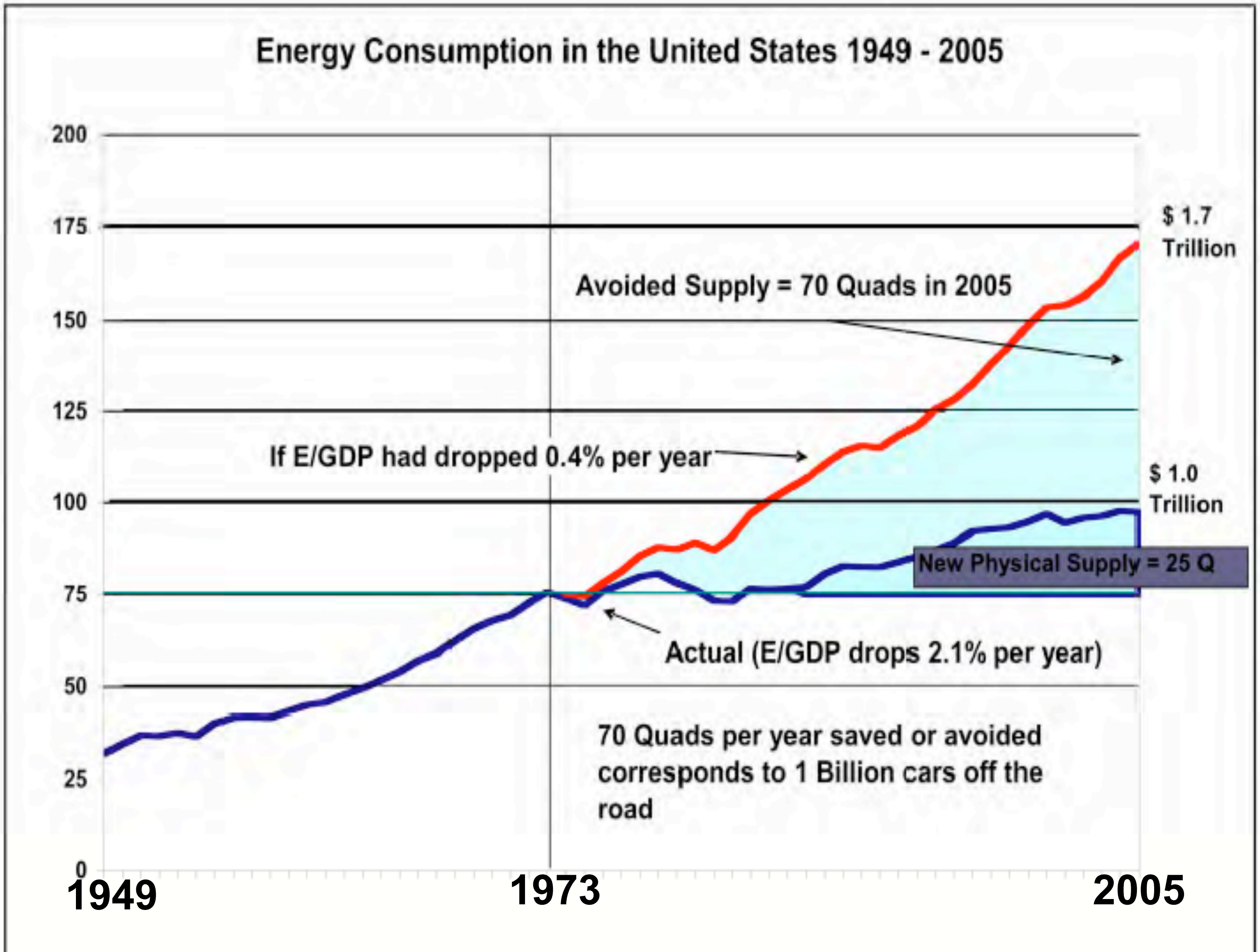
By Sector



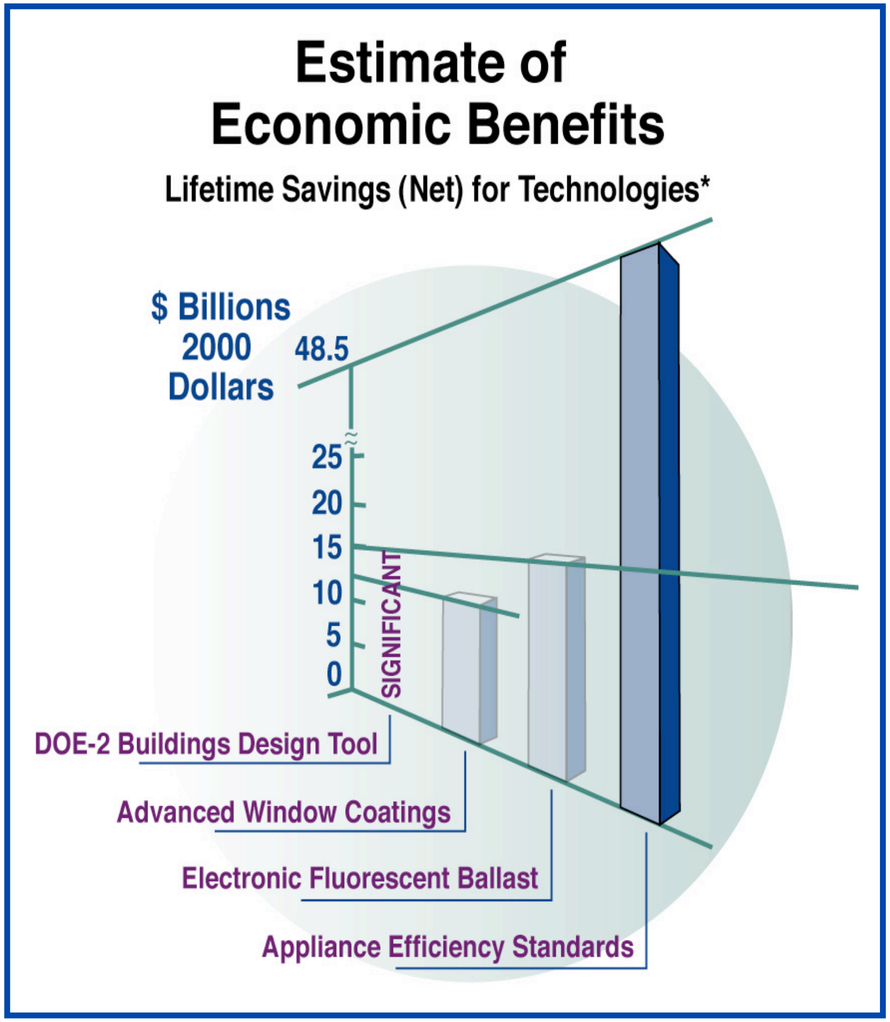
By End Use



Efficiency contributed to large decrease in energy intensity (E/GDP) after 1973 (70Q avoided vs 25Q new supply)



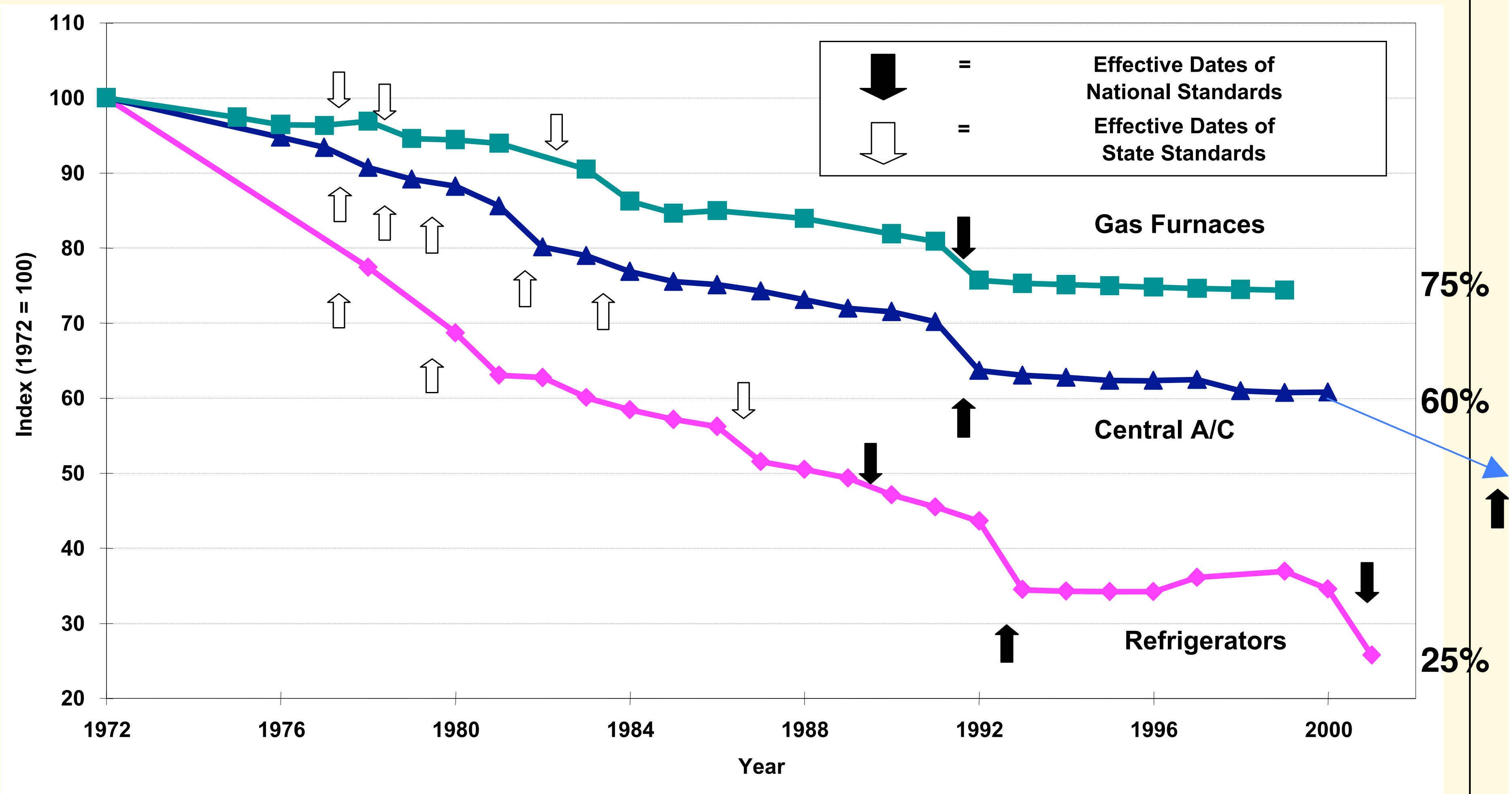
Economic Impacts of Energy R&D and Regulations



- Energy efficiency R&D has yielded a net benefit to the US economy
- Economic Benefits from energy efficiency standards were the largest from a sample of USDOE Energy Efficiency programs

Based on National Research Council, 2001. “Energy Research at DOE: Was It Worth It?”

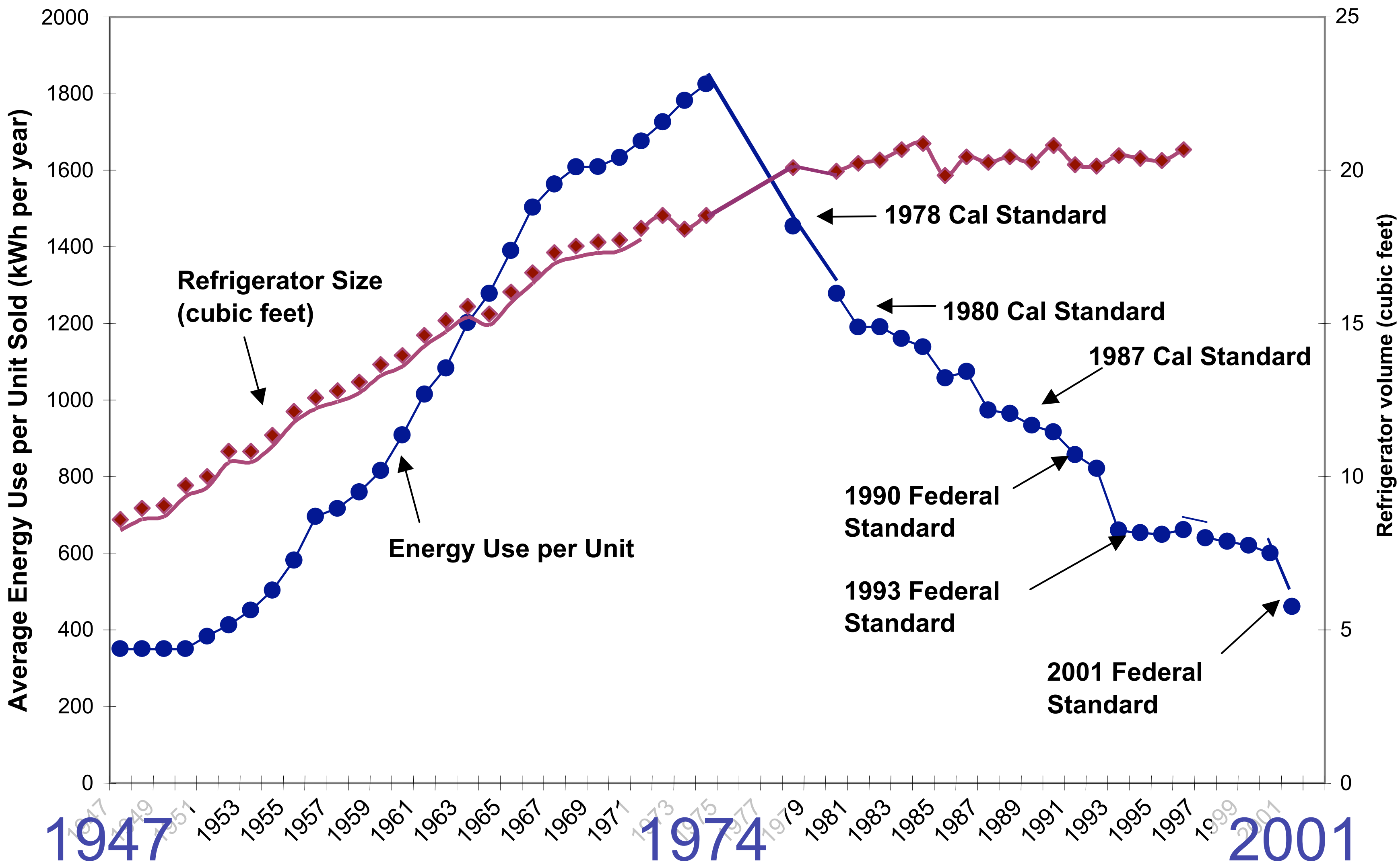
Impact of Standards on Efficiency of 3 Appliances



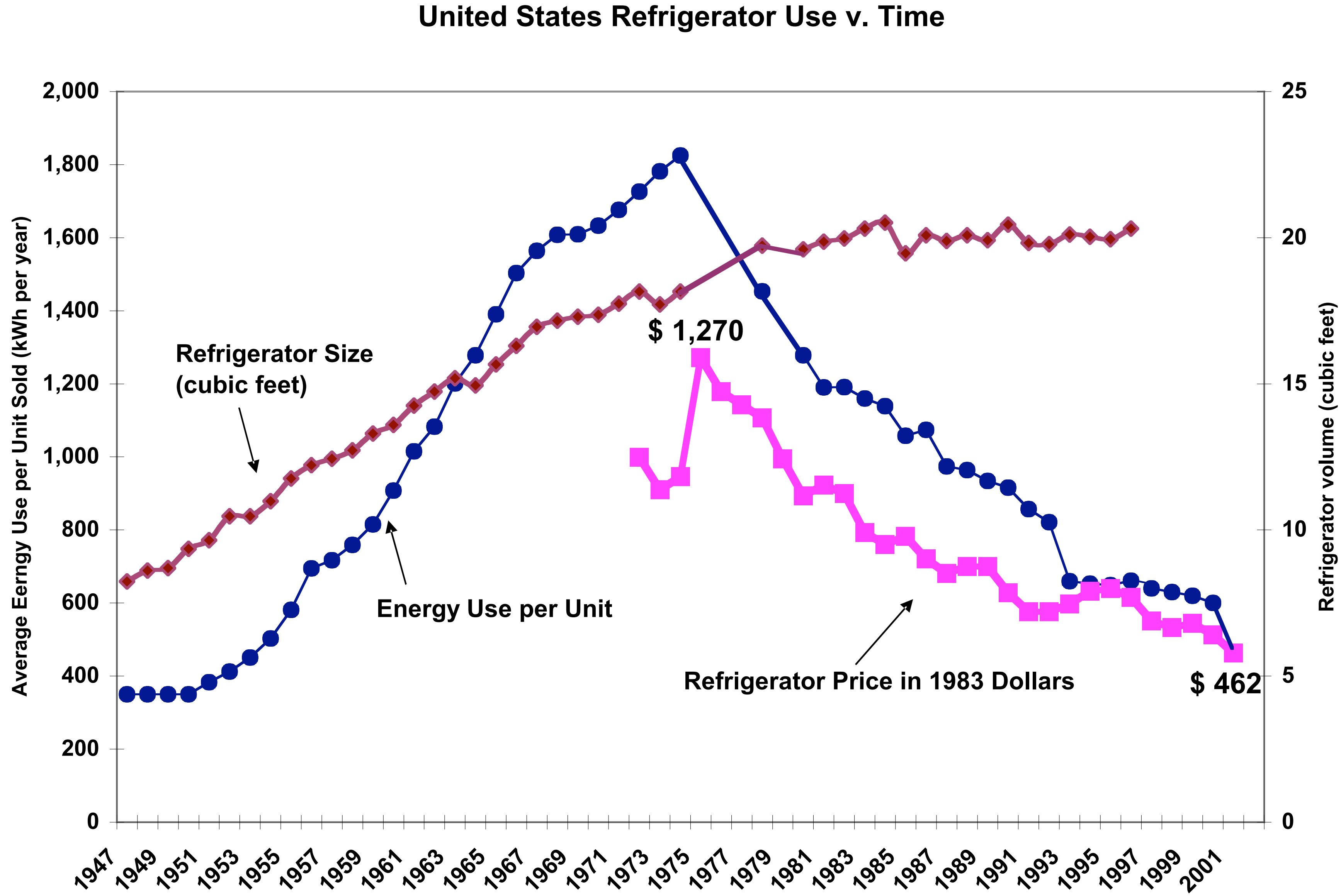
Source: S. Nadel, ACEEE, in ECEEE 2003
Summer Study, www.eceee.org

US New Refrigerator kWh/year Declined 74%

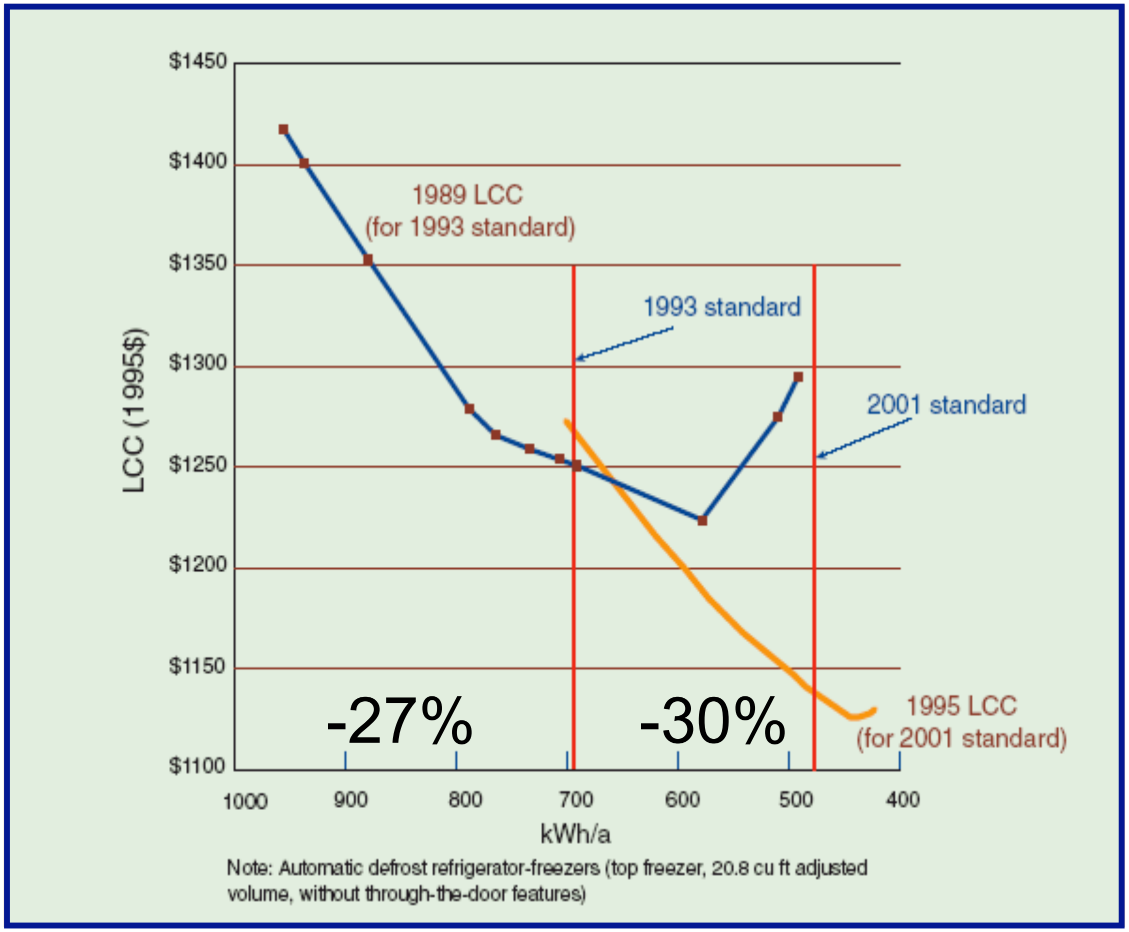
Annual Drop from 1974 to 2001 = 5% Per Year



Real Prices dropped while efficiency increased



Low-Hanging Energy-Efficiency is a Renewable Resource

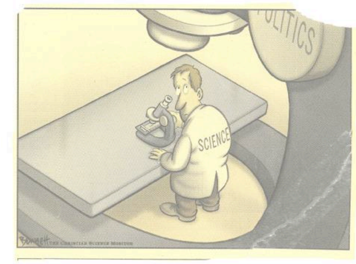


Updated 2001 standards exceeded the maximum technologically feasible level of a few years earlier.

The maximum technology kWh/a in refrigerators changed 14% in 6 years (2.5%/a) from 495 kWh/a (1989) to 425 kWh/a (1995)

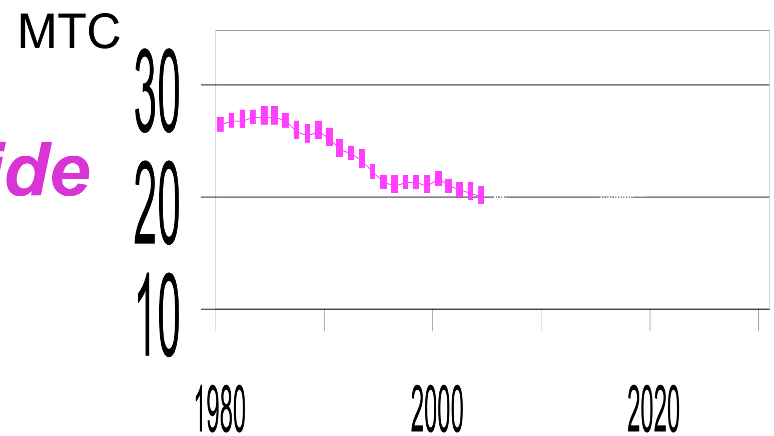
Average standards, % change, effective date:
690 kWh/a, -27%, 1993
475 kWh/a, -30%, 2001

Why Is this Example Important?



- Unit energy consumption per new refrigerator decreased at average rate of 5%/year for 27 years

•Absolute amount of energy consumption – ***and carbon dioxide emissions*** – for household refrigeration decreased



- Technology and policy together achieved this result

- Lessons learned can be applied to other energy technologies and services

National Estimates of Cost-Effective Energy Efficiency

Estimate	Source
20% Reduction by 2020-2025 compared to BAU	Five National Labs – Scenario for a Clean Energy Future – 2000
23% Reduction by 2025 compared to BAU	American Solar Energy Society - 2007

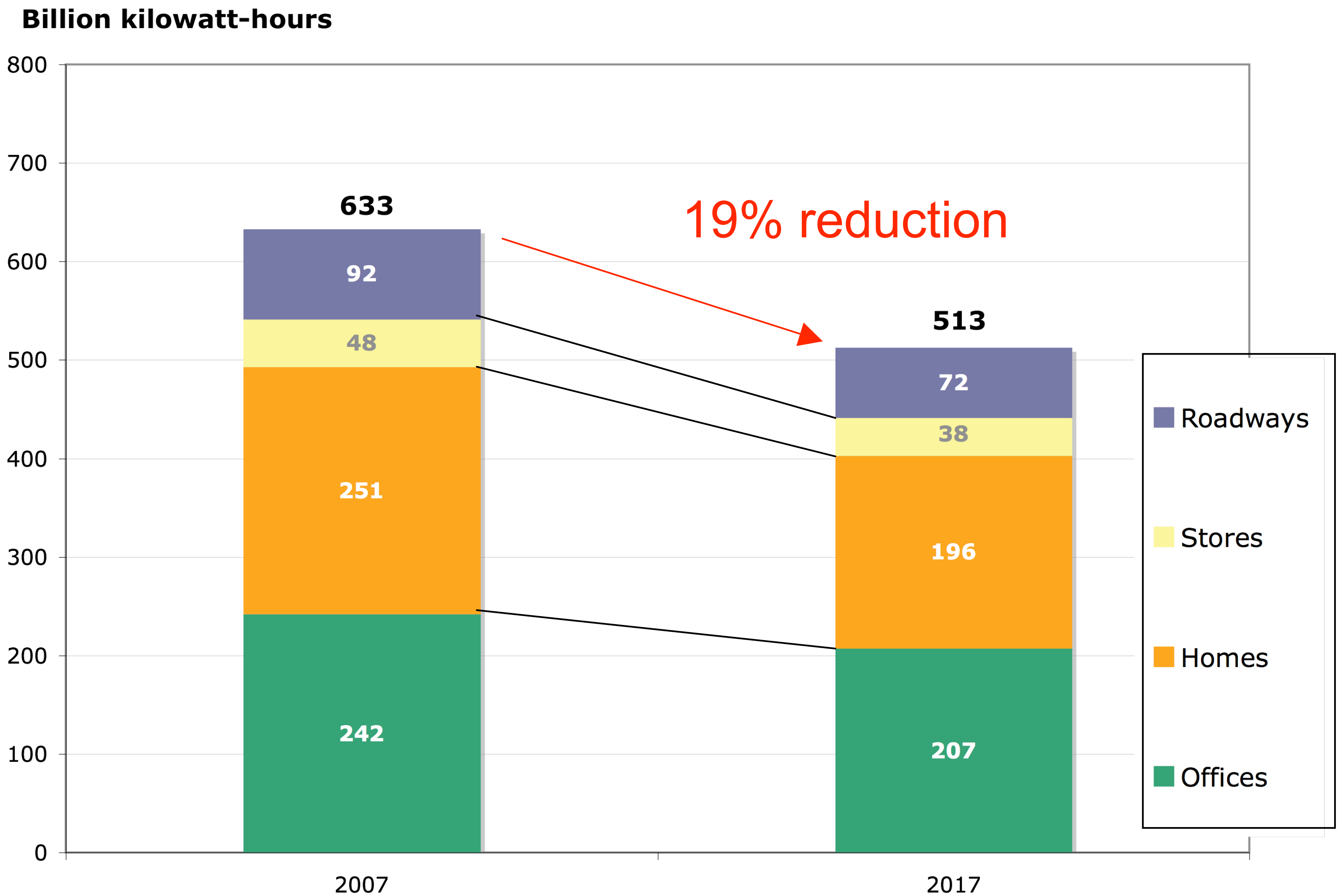
NEW OPPORTUNITY !

- **California's Water-Energy Relationship, 2005 found new potential electricity savings from water conservation**
  - Equivalent to current three-year plan for CA utilities
  - Est. cost per kWh about 50% lower than electric plan

Potential 19% National Lighting Savings

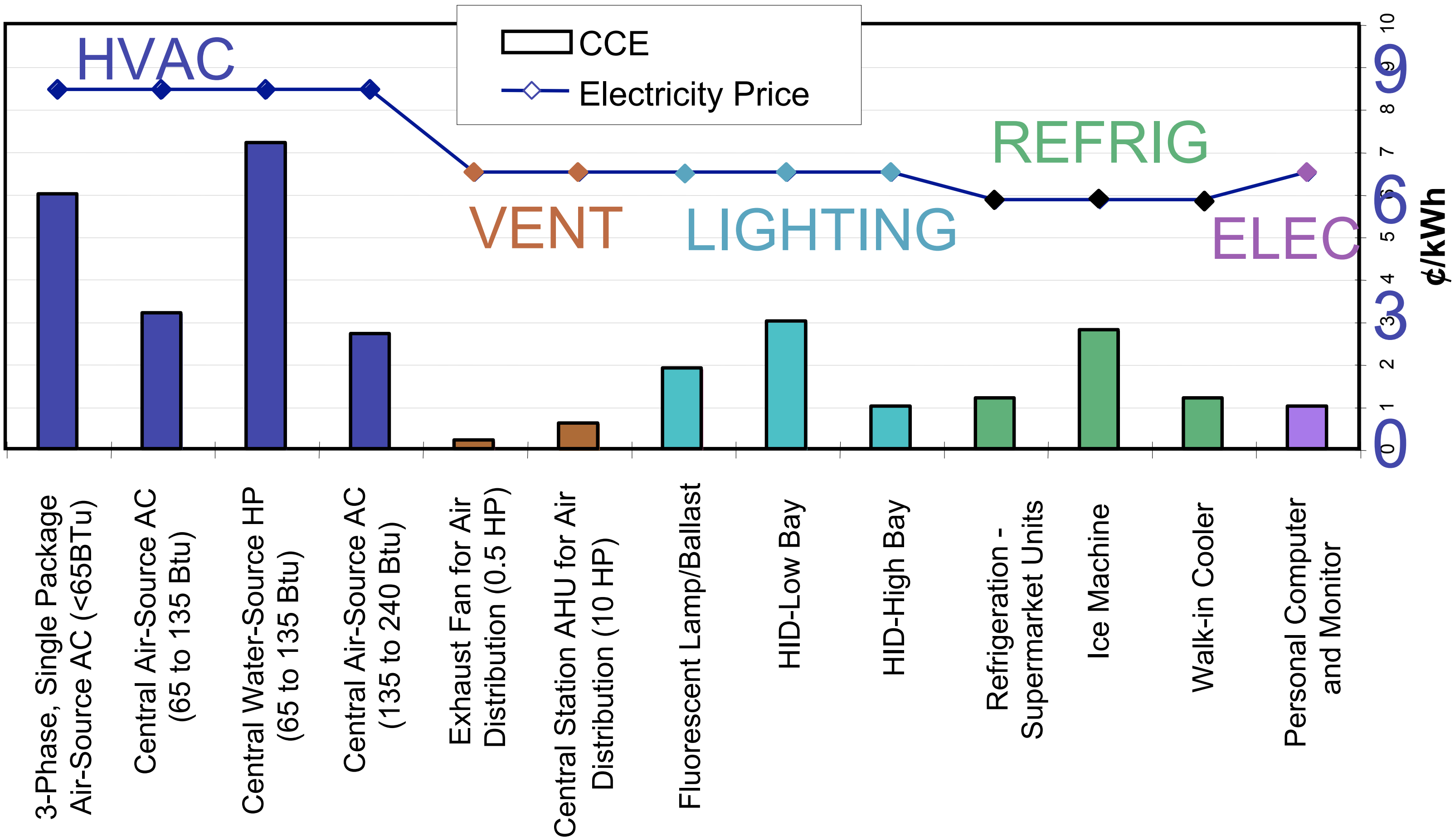
Sector	*Lighting Upgrade Measure*	*Estimated Energy/Cost Savings*	*Carbon Reduction (MMTCe)*	*Equivalent Cars Removed*
Offices	Replace T-12 magnetic with controlled T-8 electronic	35 BkWh $2.6 billion	7	4.7 million
Homes	Replace Incandescent Bulbs with Energy-Efficient Lamps	55 BkWh $4 billion	11	7.3 million
Stores	Replace PAR/R-lamps with Ceramic Metal Halide	10 BkWh $750 million	2	1.3 million
Roadways	Replace Mercury lamps with modern HIDs	20 BkWh $1.5 billion	4	2.7 million
Total	**All Measures**	**120 BkWh** **$10 billion**	**24**	**16 million**

Modernizing Our Nation's Lighting



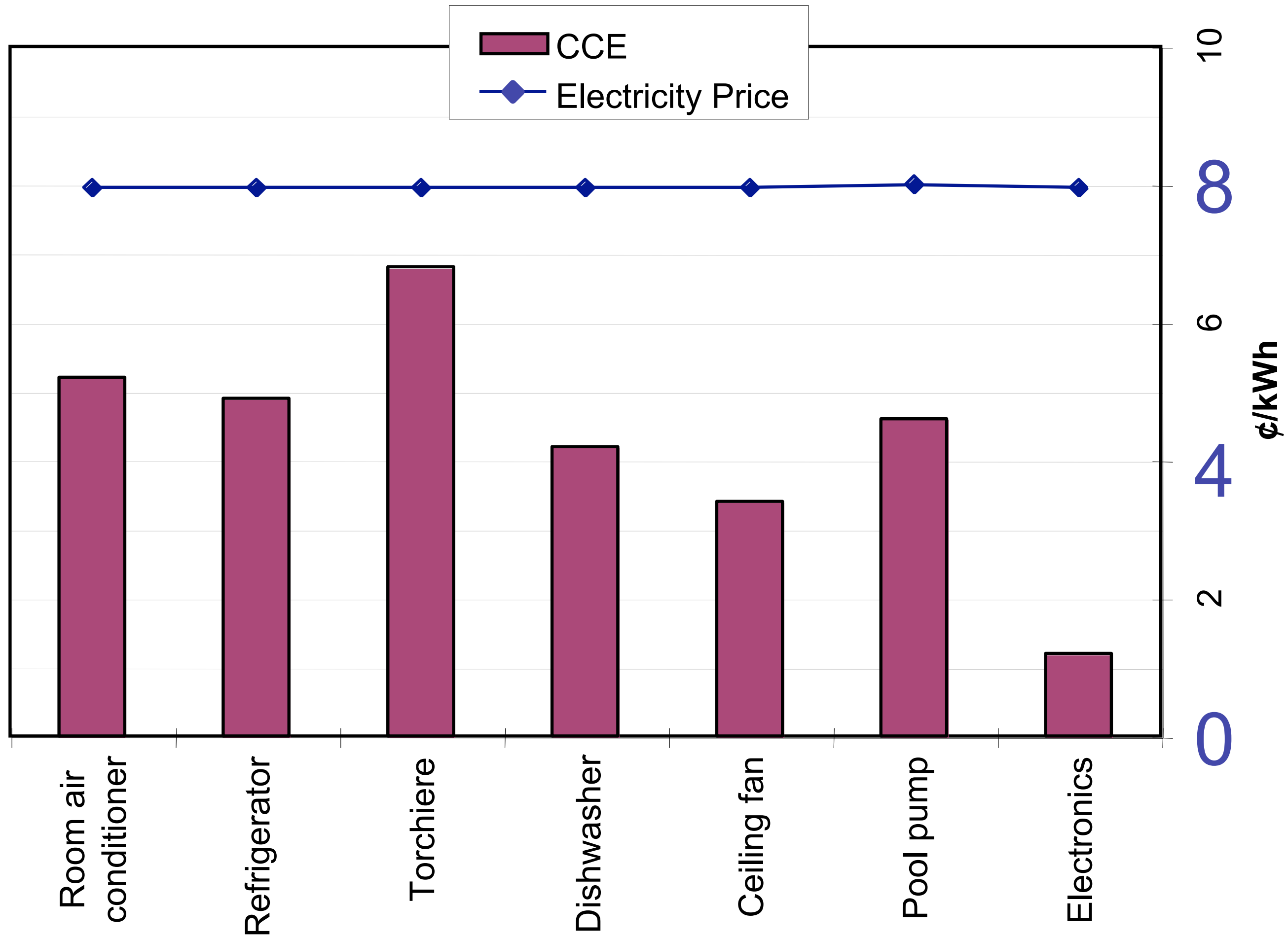
Cost of Conserved Energy (CCE) is Lower than Electricity Price for Many Energy Efficiency Increases

(Commercial, 2010)



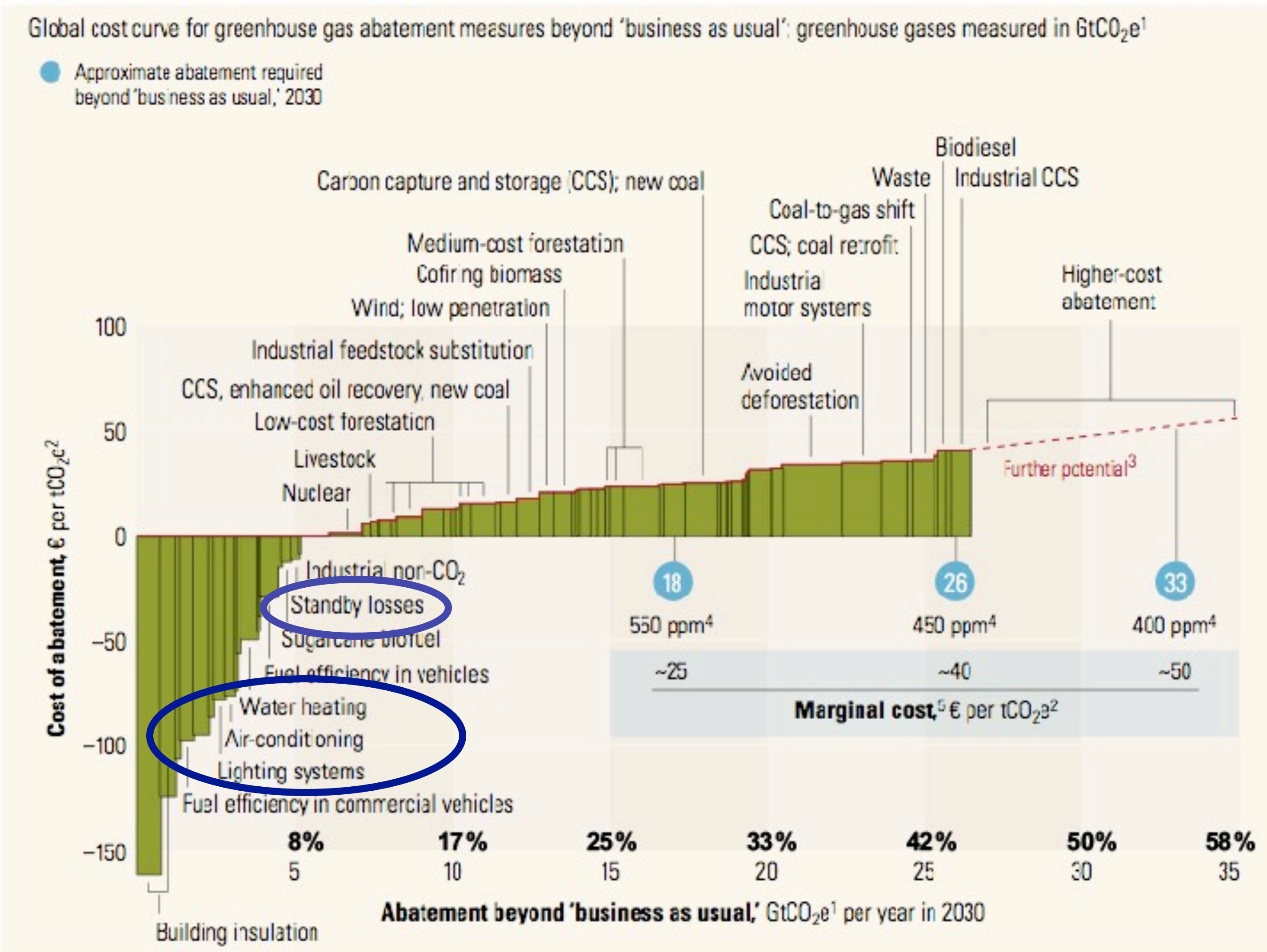
Source: National Commission on Energy Policy, 2004

Cost of Conserved Energy (CCE) is Lower Than Electricity Price for Many Energy Efficiency Increases (Residential, 2010)



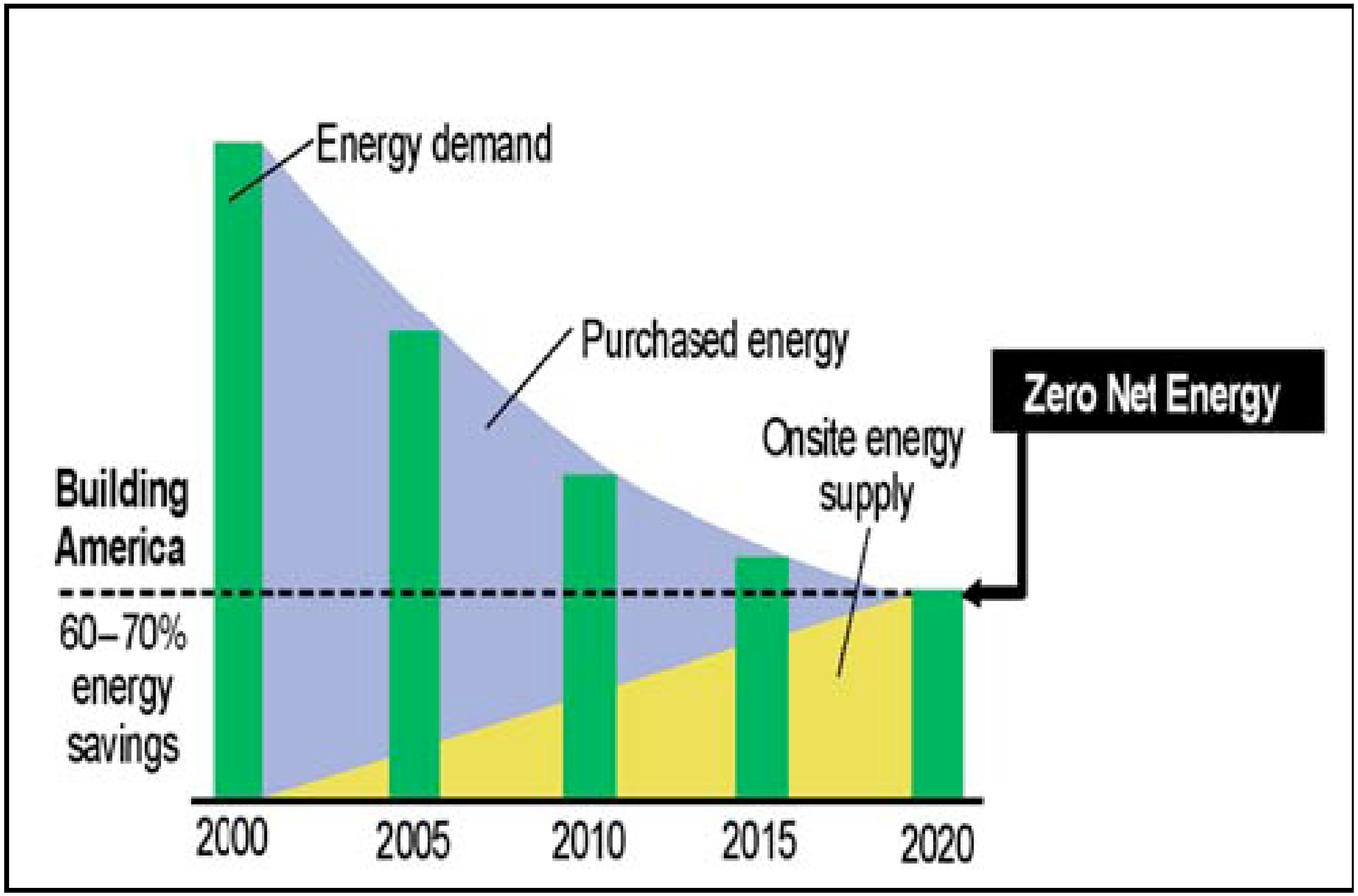
Source: National Commission on Energy Policy, 2004

EE reduces carbon and saves money



Source: McKinsey Global Institute, 2007

Efficiency and carbon-neutral supply are complements



Current Best Practices Can Reduce Emissions from New Buildings by at Least 70% for Homes and 60% for Offices

- DOE's Building America has a goal of achieving 70% energy consumption reduction by 2020 compared to code requirements
- Leadership in Energy & Environmental Design (LEED) certifies energy reductions of up to 60% for new commercial buildings, compared to code requirements

California plans to achieve zero net energy for new Residential in 2020, Commercial in 2030

Whole Building Approach (with PV) Can Save More Than Just Equipment Improvements

- NREL results show it is possible today to build a 2592 ft2 home in Sacramento at incremental cost about [illegible]% above code to achieve:
  - zero peak cooling demand
  - reduce annual heating energy 70%
  - reduce annual cooling energy by 60% and
  - reduce total source energy use by 60%

Size matters

Source: Ren Anderson, C Christensen, S Horowitz, "Program Design Analysis using BEopt Building Energy Optimization Software: Defining a Technology Pathway Leading to New Homes with Zero Peak Cooling Demand" (Preprint Conference Paper NREL/CP-550-39827), May 2006

Additional Savings from Systems

- Efficient *data centers* (electricity and cooling)
- *Digital networks*: opportunities to maximize comfort and utility while minimizing energy
- *Combined heat and power* can improve efficiency and reduce peak
- Neighborhood systems (e.g., *district heating*)
- *Micro-grids* provide local power
- *Demand response* incorporates price signals

California Policies affecting EE

- CEC - Research, Building codes, Standards
- CPUC – regulate utilities and rates
  - PRIORITY: Efficiency, demand response, renewables, clean fossil
  - "Big, Bold" utility programs (new residential, new commercial, HVAC)
  - Industrial, existing commercial, existing residential
- CARB – implementing AB32

Federal Policies affecting EE

- Labels
  - EnergyGuide
  - Energy Star
- Mandatory Energy Performance Standards (MEPS)
  - US
  - Others (China, Australia, EU, Canada, Mexico)
- Tax credits
  - To manufacturers
  - To consumers

- (FUTURE) GHG cap-and-trade or taxes/fees

R&D investment in US buildings sector has been low

- Private “Clean Tech” investing is increasing
  - $5.18 B in 2007, up from $3.6B in 2006
    - energy efficiency
    - water efficiency
    - renewable energy

- Annualized returns in 2007
  - CTIUS 42.9%, NASDAQ 10.6%, S&P 500 5.5%
  - Low-hanging fruit

- Innovation will increase

Increasing Financial and Political Pressure for EE

- GHG markets ($30 B in 2006)
  - EU, Kyoto
  - Chicago Climate Exchange (CCX) (voluntary)

- Global GHG negotiations – Kyoto, Bali
- US legislation: Draft energy bills
  - E.g., Lieberman-Warner: cap and trade
- States
  - RGGI 2009
  - CA 2012
  - Western Climate Initiative
  - others

Global Potential of Energy Efficiency Standards and Labeling Programs (DRAFT)

- Across all countries, potential to reduce

GHG Emissions	Residential	Commercial
From electricity	25%	11%
From fuels	8%	3%
CO_2 Gt 2030 (cumulative)	1.5 (11)	0.4 (3.6)

Equivalent to 25% of IPCC "zero cost" potential in 2020, 33% in 2030.
The rest can be achieved with building codes, utility programs, incentives, etc.

M. McNeil, V. Letschert, S. de la Rue du Can, LBNL- personal communication, February 27, 2008
Work in progress for Collaborative Labeling and Appliance Standards Programs (CLASP)

AN EXAMPLE OF ONE BUILDING

“Greening the Capitol”

Goal: Reduce the impact of operations of the Capitol complex to “carbon neutral”

Conclusions

- Energy efficiency (EE) has proven itself for thirty years
  - Technologically feasible
  - Economically justified

- Public and private investment will increase
  - Clean tech venture capital investments are up
  - EE is fastest, most cost-effective option to reduce carbon emissions

- Low-hanging energy efficiency is a renewable resource

Suggested Reading

- American Solar Energy Society, 2007. "Tackling Climate Change in the U.S."
- Gallagher, K.S., J.P. Holdren, and A.D. Sagar, "Energy-Technology Innovation" in *Ann. Rev. Environ. Resour. 2006*, 31: 193-237
- Interlaboratory Working Group on Energy-Efficient and Clean-Energy Technologies, 2000. "Scenarios for a Clean Energy Future"
- McKinsey Global Institute, 2007. "Curbing Global Energy Demand Growth: The Energy Productivity Opportunity"
- National Research Council, 2001. "Energy Research at DOE: Was It Worth It?"

CALIFORNIA ENERGY COMMISSION