Energy Efficiency in Buildings and Industry: A Low Carbon Future

James E. "Jim" McMahon

(JEMcMahon@LBL.gov)

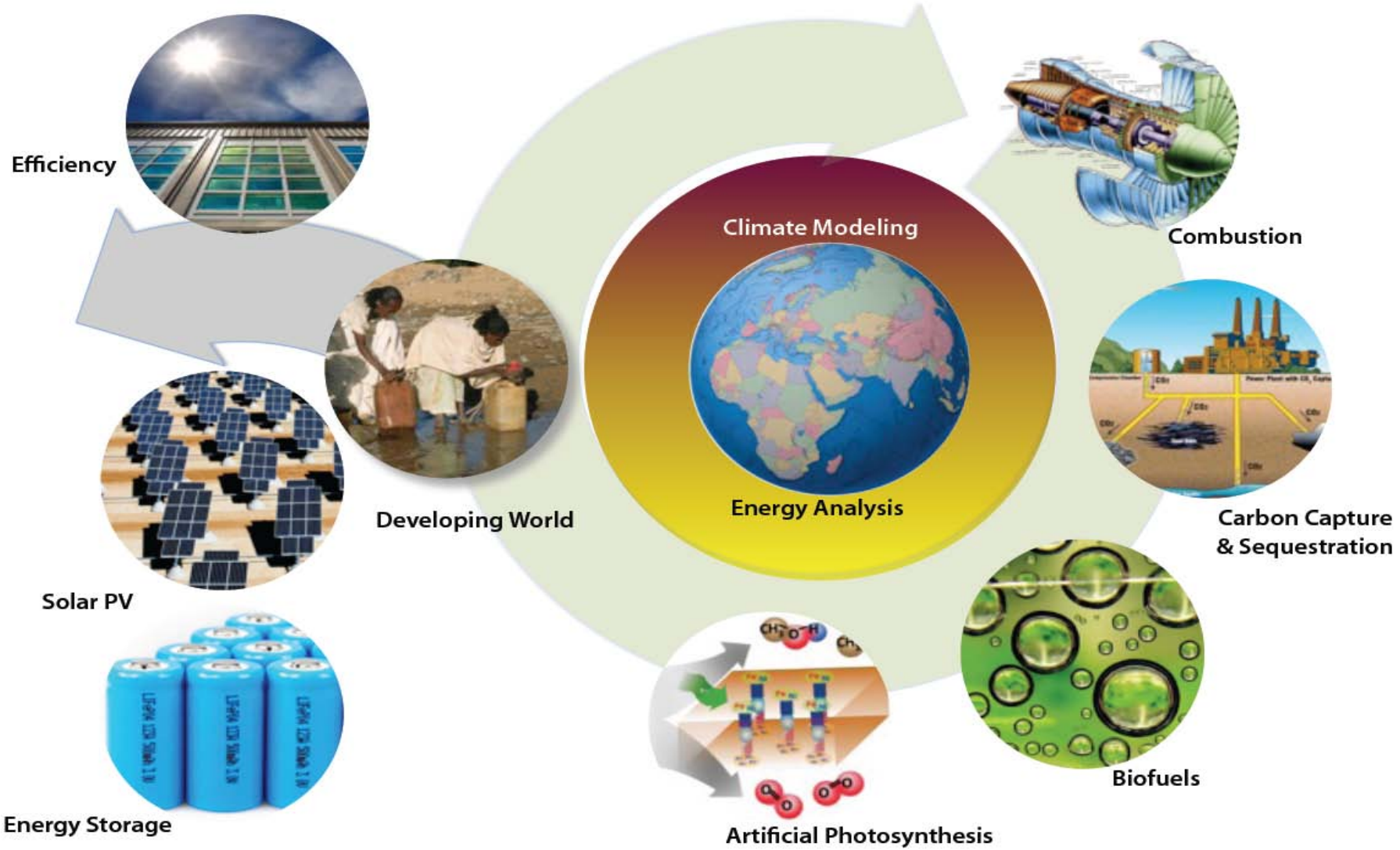
Department Head, Energy Analysis

Leader, Energy Efficiency Standards Group

At National Renewable Energy Laboratory

2010 September 13

Carbon Cycle 2.0 Initiative at Berkeley Lab



OUTLINE

- **Climate challenge can be solved**
  - **By changing technologies, policies, and behaviors**
- **Buildings are key**
- **Solutions are**
  - **Technologically feasible**
  - **Economically justified**

Where are we headed? Climate change

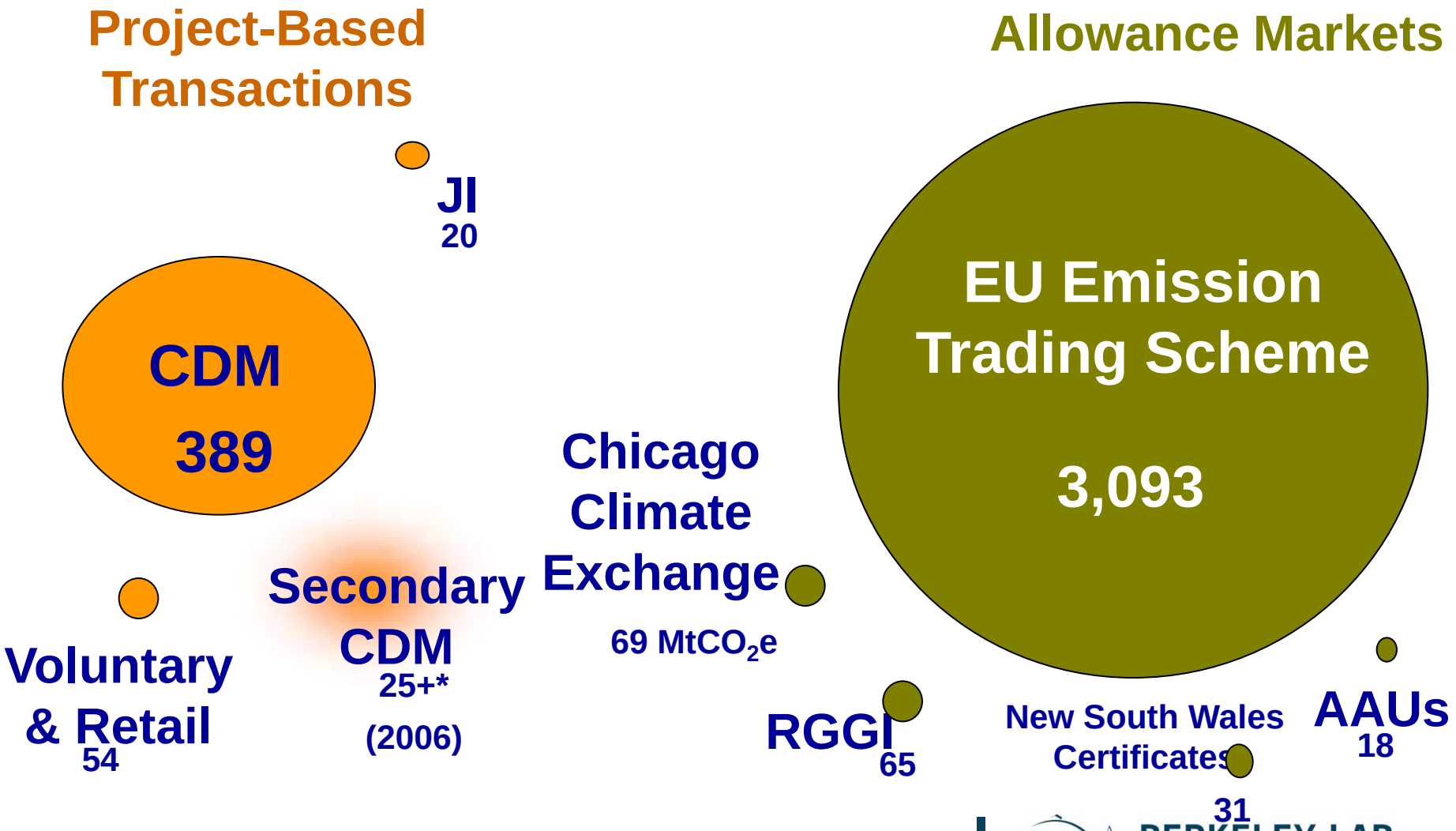
- **Bad news: physical effects**
  - **Emissions continue to increase**
  - **Observations of climate change show greater effects sooner than expected in 2004 IPCC Assessment**

- **Hope for the future: mitigation and adaptation**
  - **Local and state governments are taking action**
  - **U.S. House and Senate each developed draft legislation to address climate change**
  - **193 national governments met in Copenhagen in December 2009 and agreed that further mitigation is needed, but failed to reach binding agreement**

Global Carbon Market: $126B 2008 - doubling each of last 3 years

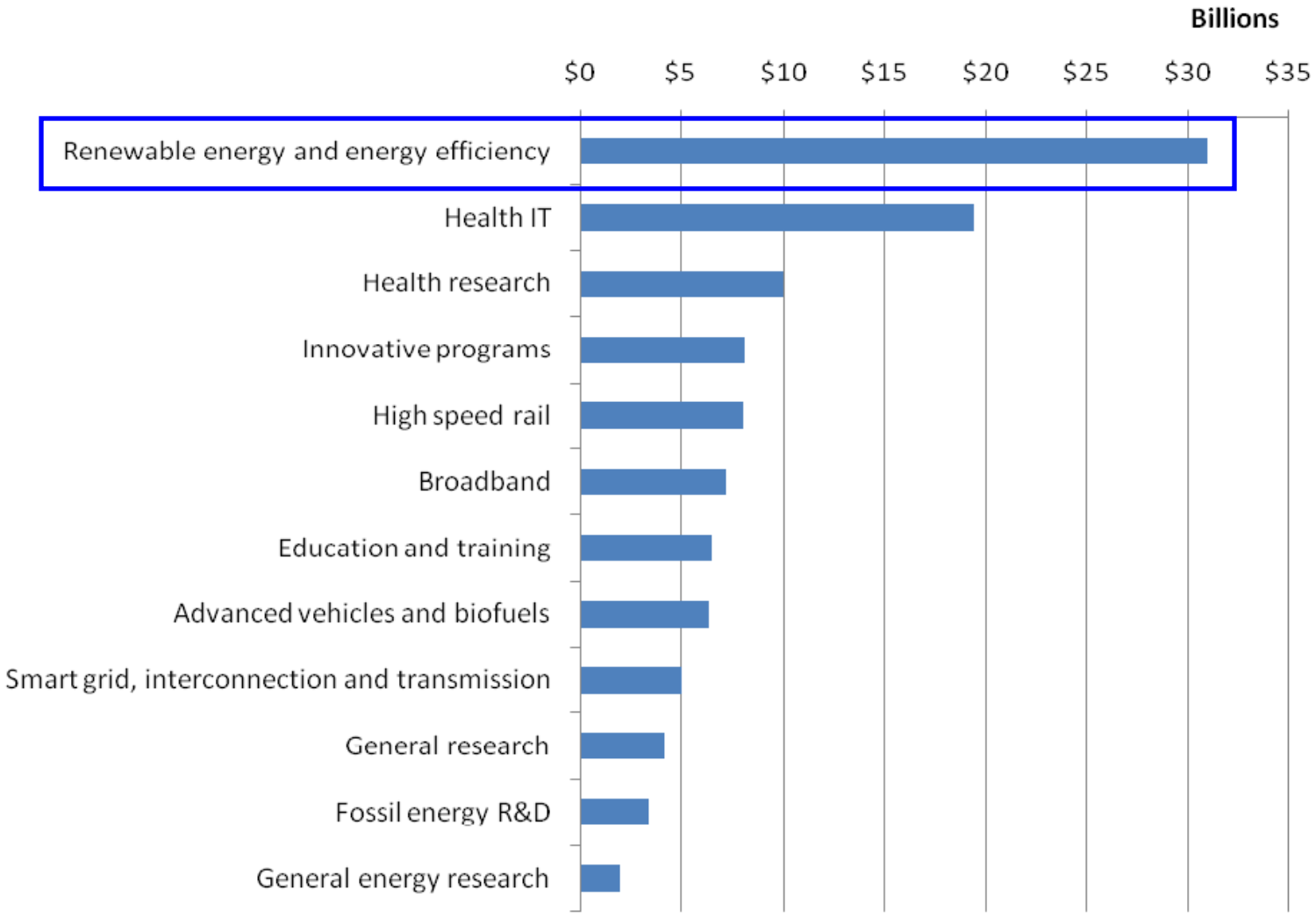
Volumes transacted in 2008 (total 4,811 $MtCO_2e$)

Source: Karan Capoor, Philippe Ambrosi, The World Bank, Washington D.C. 2009

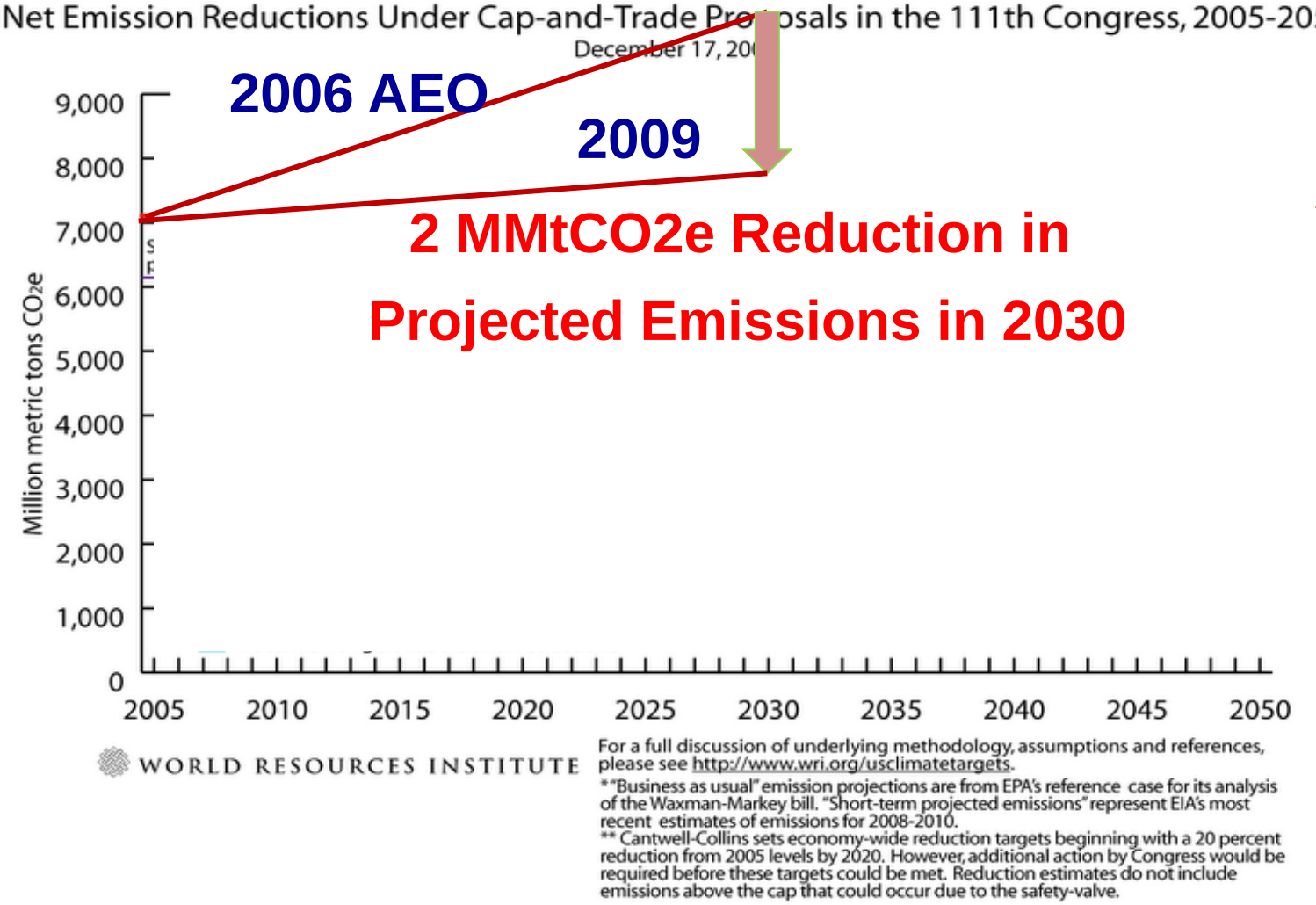


BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY

Innovation Funding in American Recovery and Reinvestment Act



U.S. Carbon Emissions & Recent Draft Legislation



APGR CO2e

+1.2% 2006

+0.3% 2009

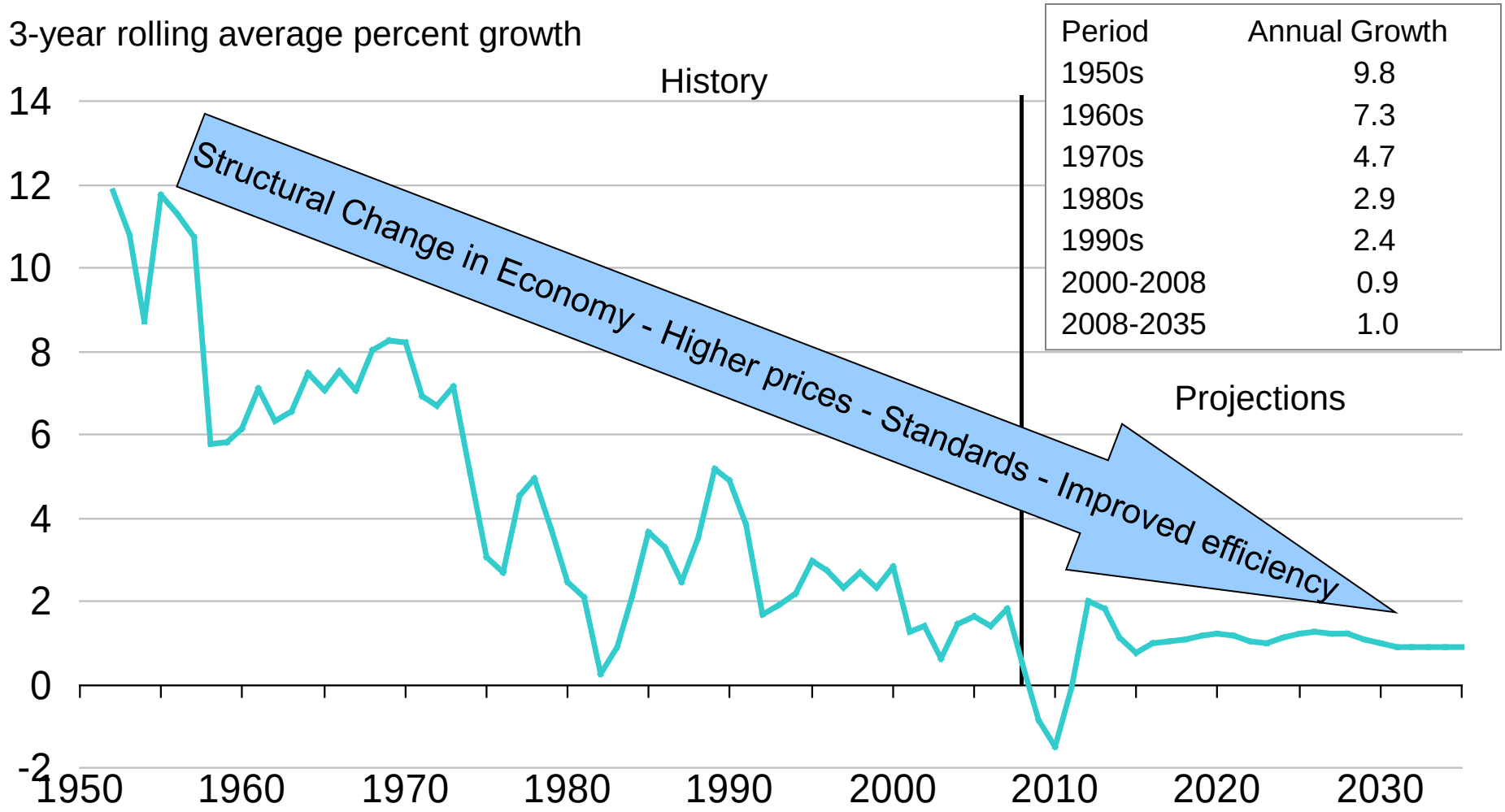
TARGET

2010-2050

-4%

Source: Larsen, John and Robert Heilmayr. 2009. Emission Reductions Under Cap-and-Trade Proposals in the 111th Congress. Washington, DC: World Resources Institute. Available online at: http://www.wri.org/publication/usclimatetargets

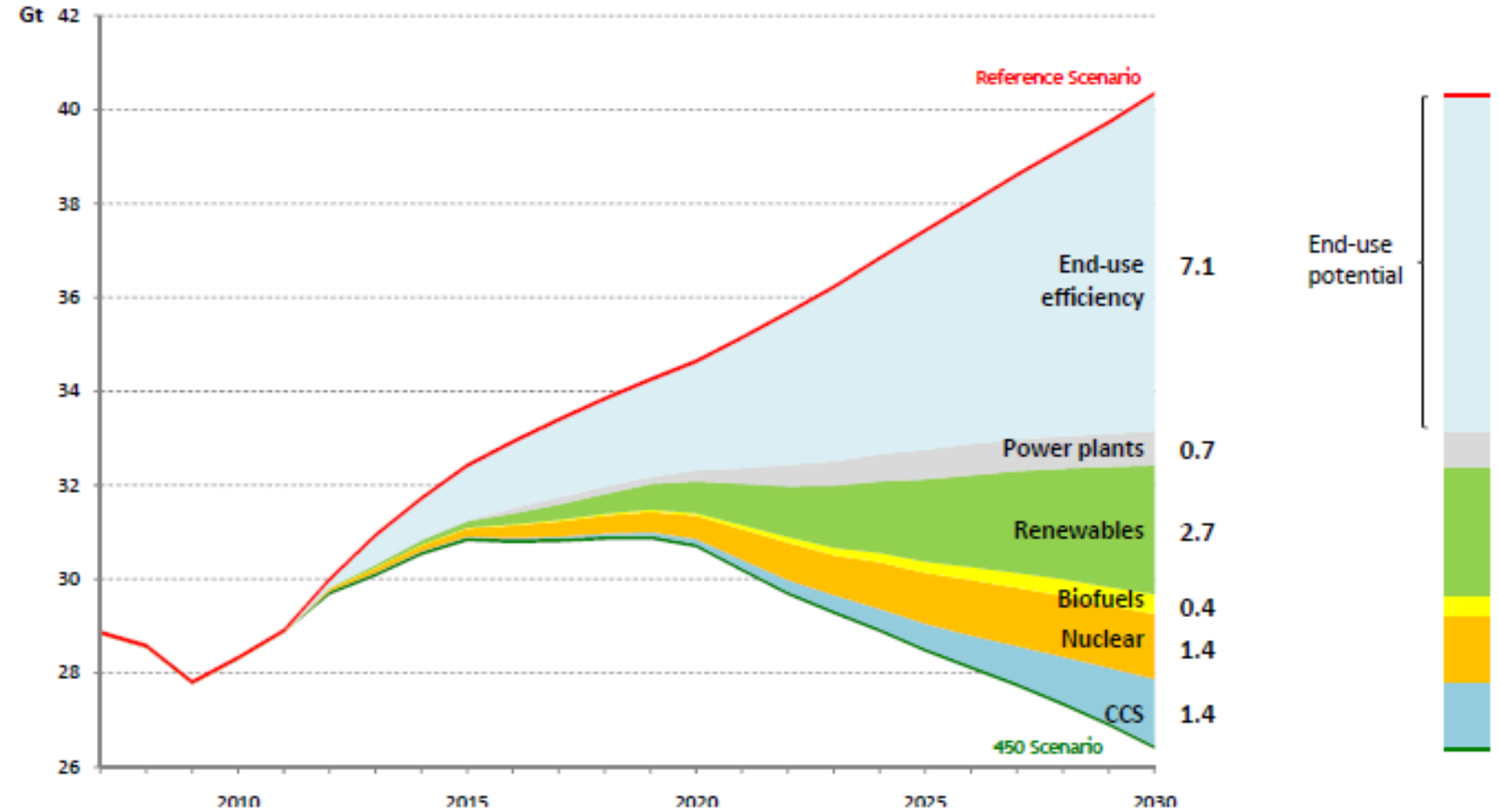
Growth in electricity use continues to slow



Period	Annual Growth
1950s	9.8
1960s	7.3
1970s	4.7
1980s	2.9
1990s	2.4
2000-2008	0.9
2008-2035	1.0

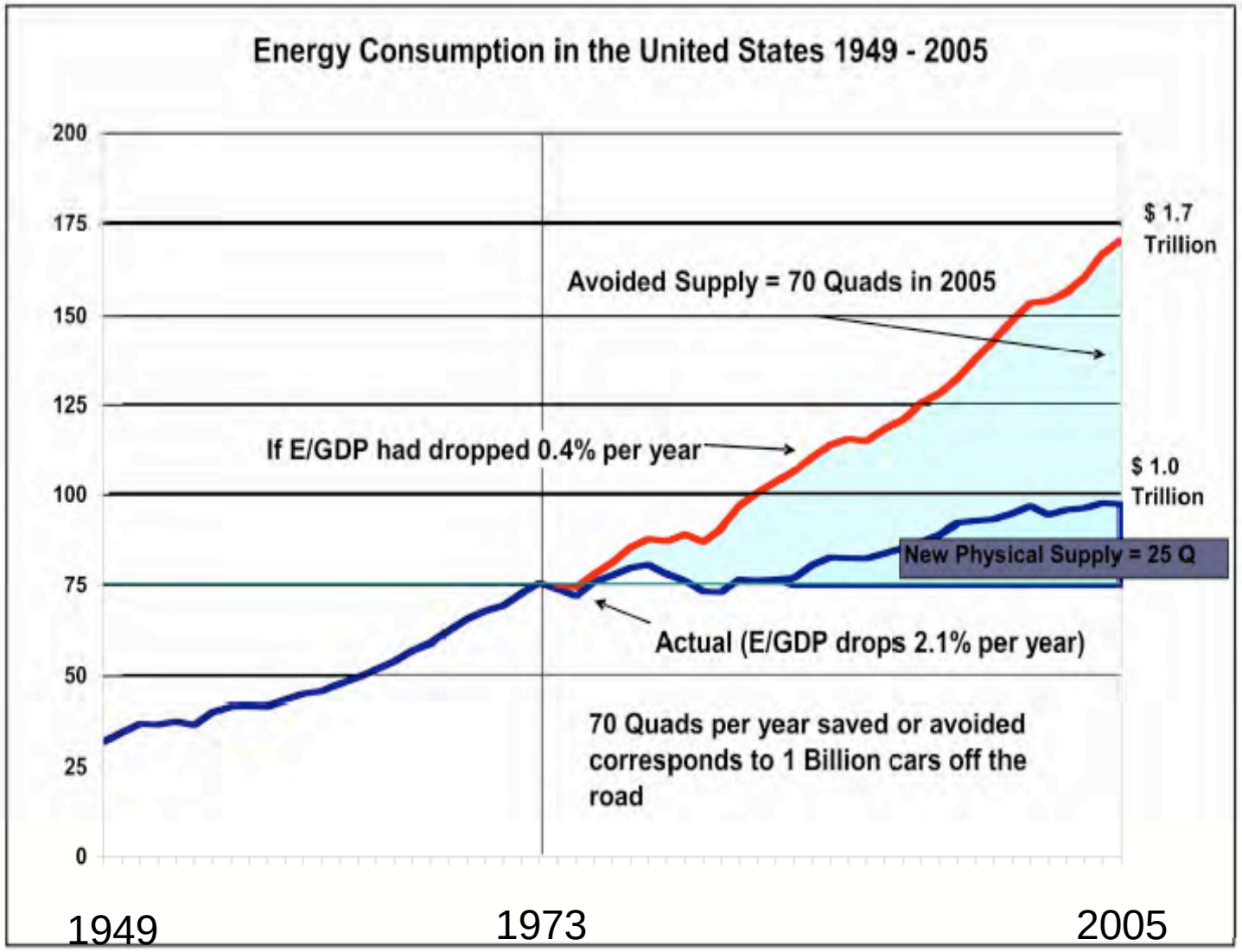
Source: *Annual Energy Outlook 2010*

“Solutions” to reducing energy/carbon use rely heavily on Energy Efficiency and Renewable Energy



Full implementation of the IEA 25 energy efficiency recommendations is essential to achieve the 450 scenario

REALITY CHECK: Back to the Future?
Efficiency contributed to large decrease in energy intensity (E/GDP) from 1973 to 2005 in U.S.



Avoided 74% of supply growth

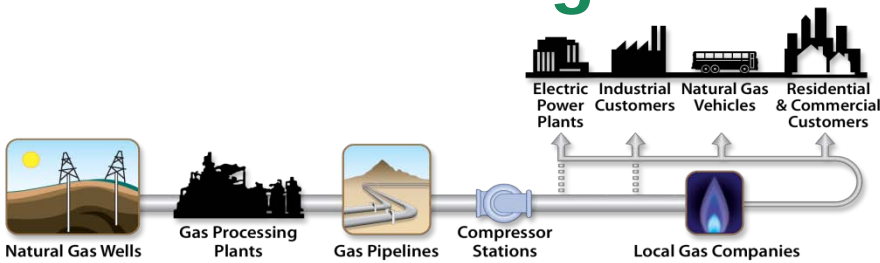
-Efficiency & conservation in buildings, cars, & industry

-Shift away from heavy industry to services

Energy Consumption by U.S. Buildings

- **71%** of U.S. **electricity** consumption

- **54%** of U.S. **natural gas** consumption

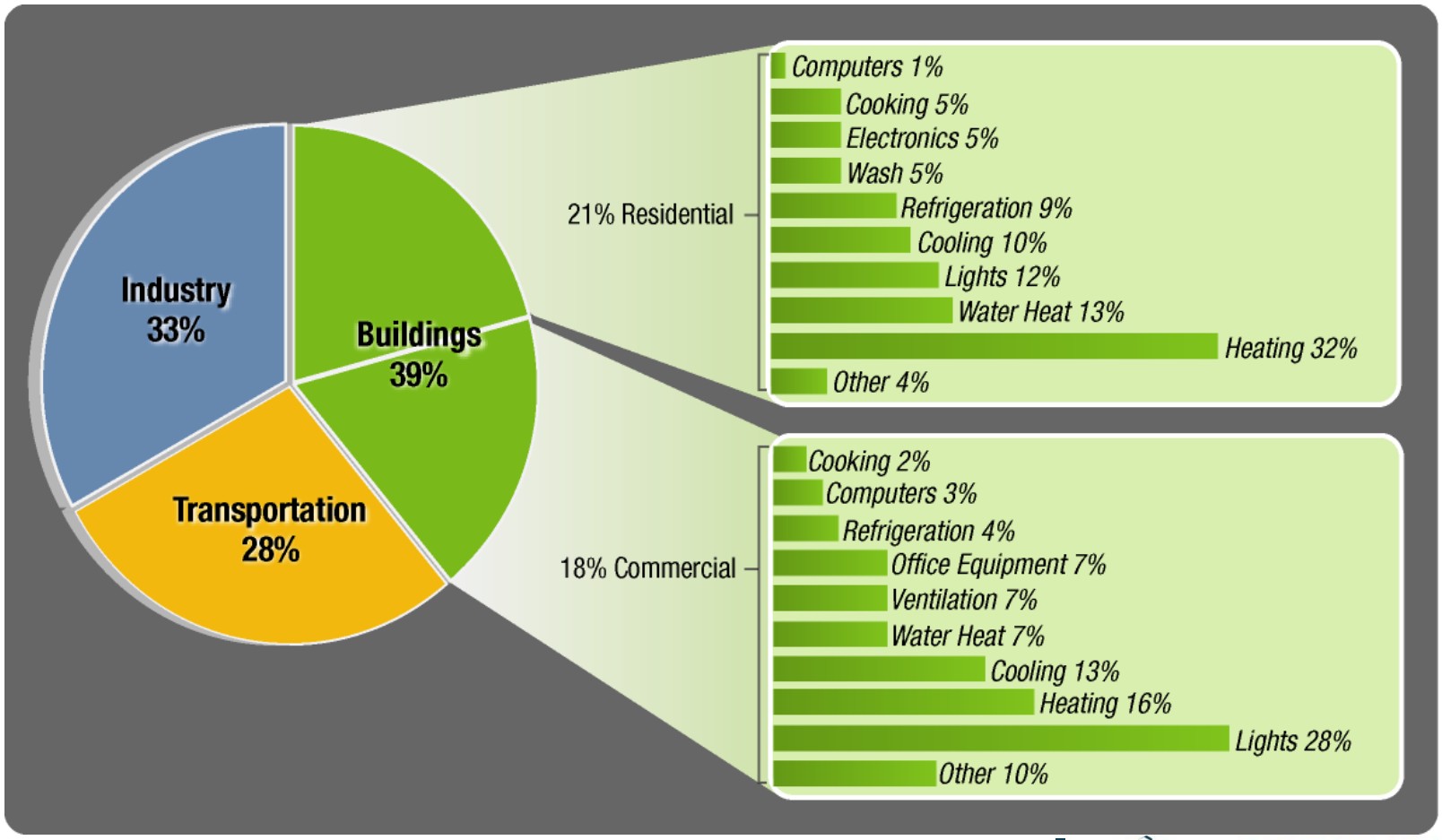


- **39%** of U.S. **carbon dioxide** emissions

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

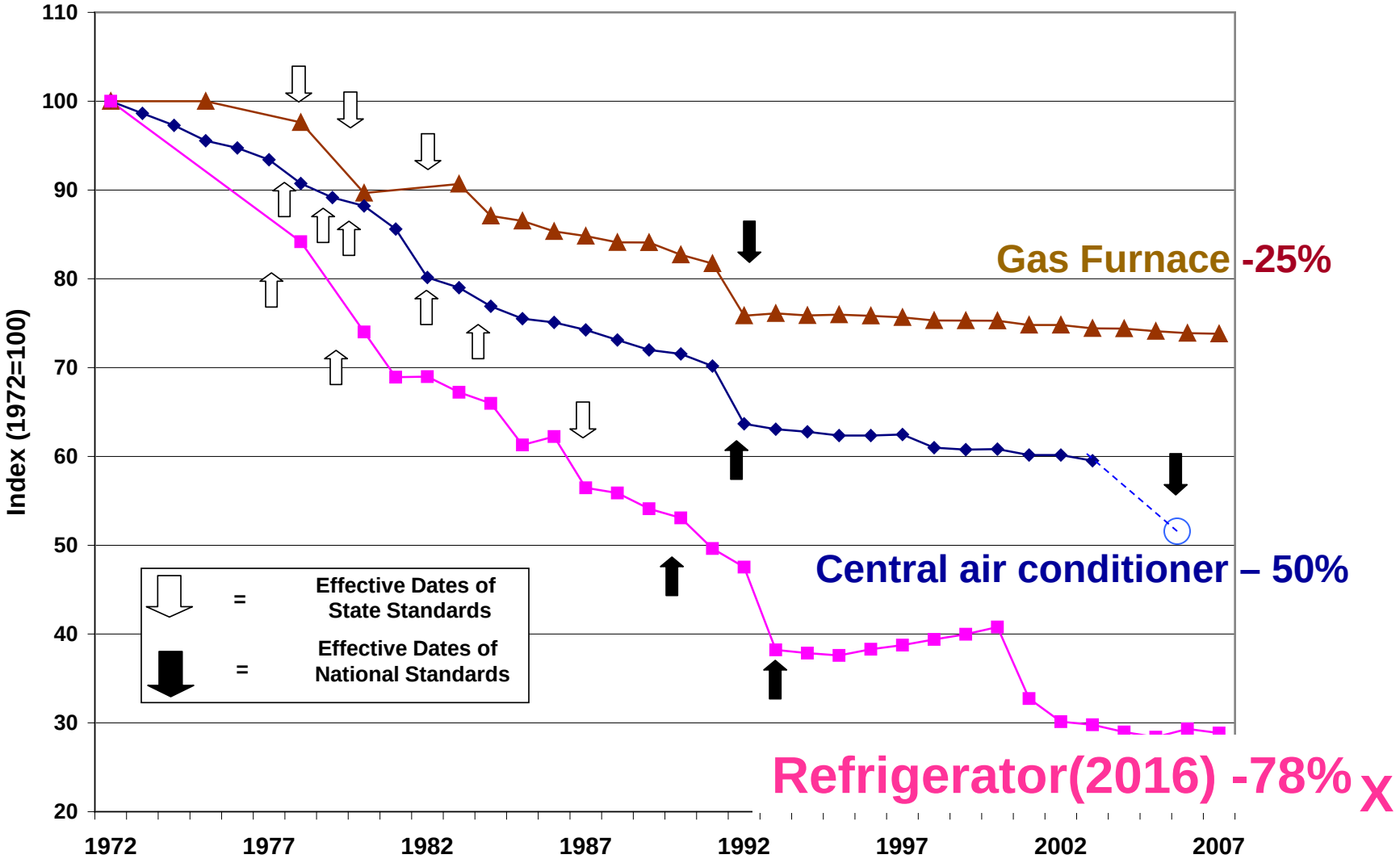
Buildings' Energy Consumption by End Use Services

Space conditioning, lighting, water heating, refrigeration and electronics account for 87% of primary energy used by buildings

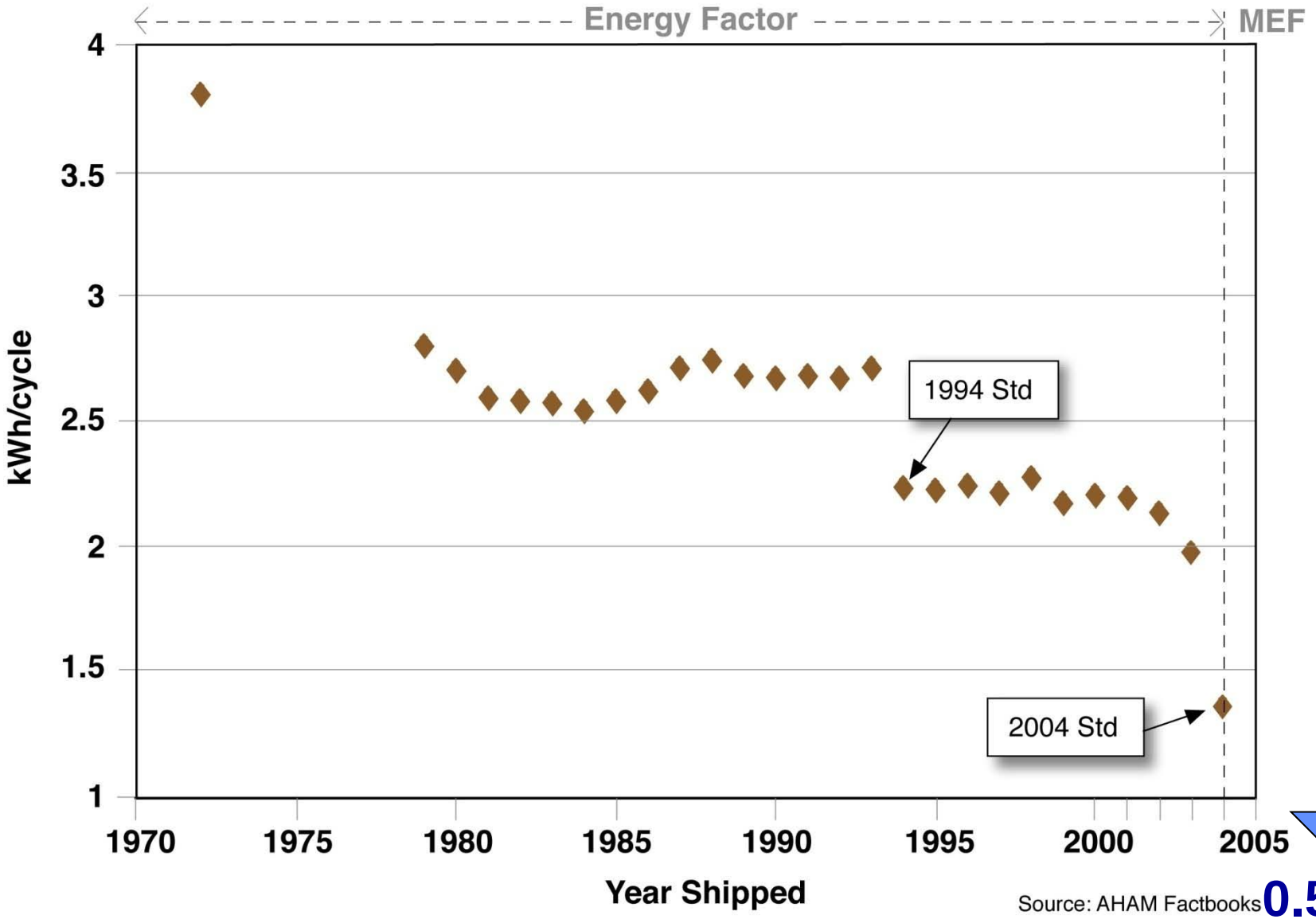


U.S. Average Energy Use per New Appliance

Index relative to 1972 = 100



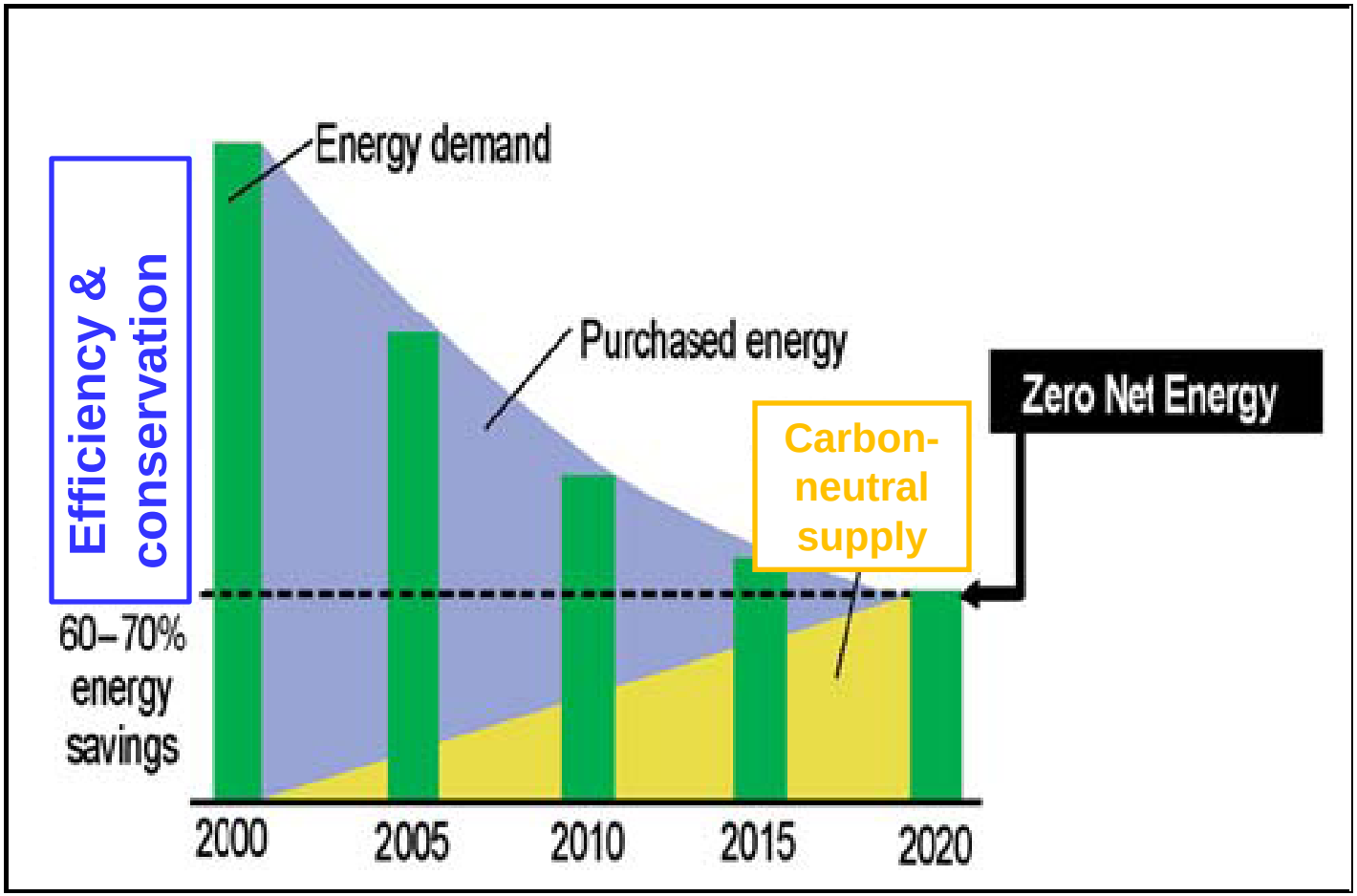
Average Energy Use Per Cycle of New Clothes Washers



Source: AHAM Factbooks

0.5-0.6

Efficiency and carbon-neutral supply are complements

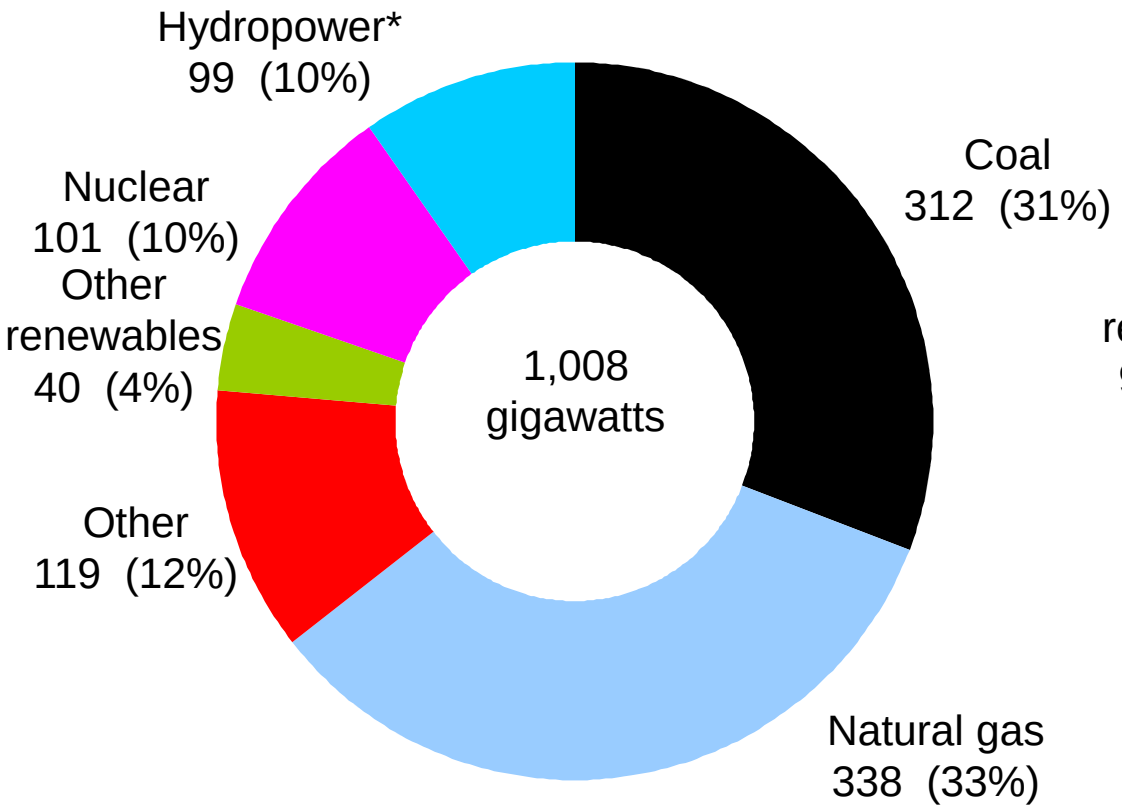


Target date: 2020 for new residential buildings

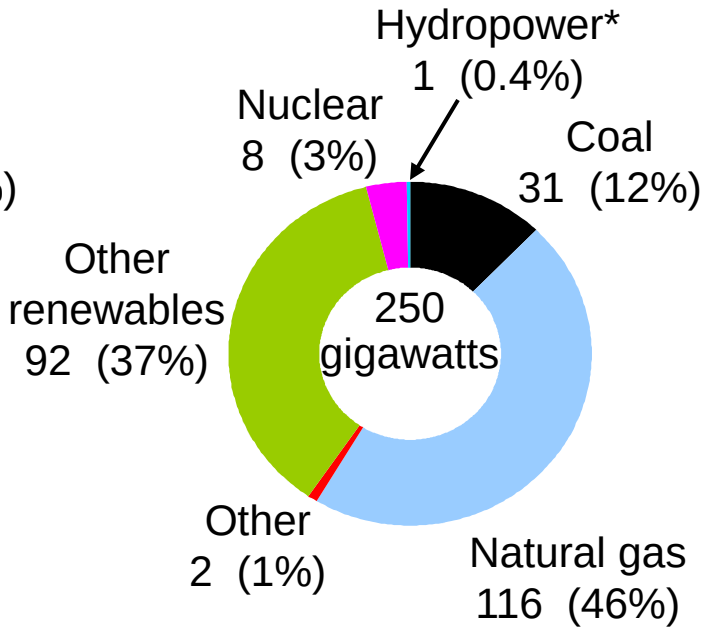
2030 for new commercial buildings

Natural gas and renewables account for the majority of capacity additions from 2008 to 2035

2008 capacity



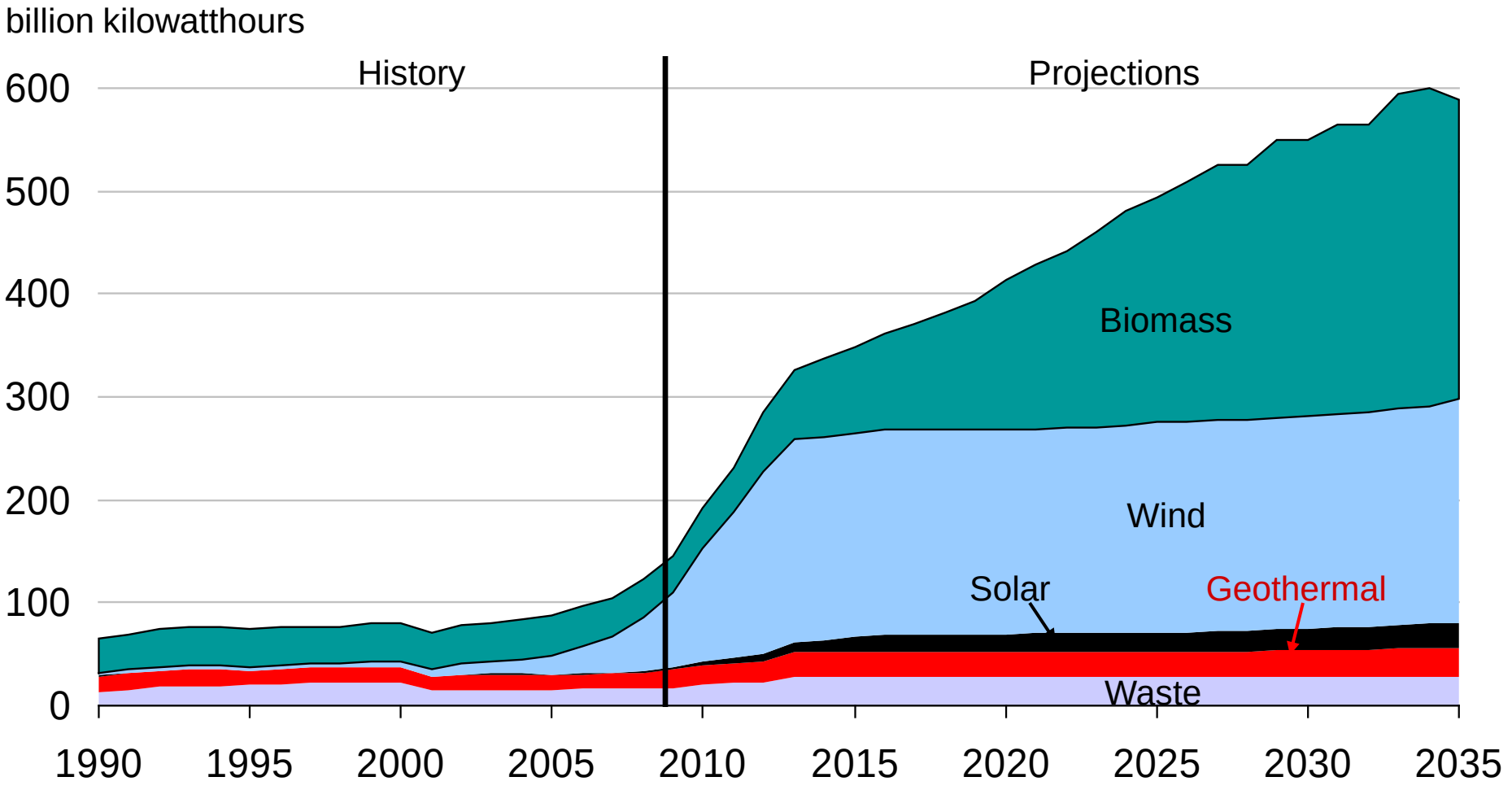
Capacity additions 2008 to 2035



* Includes pumped storage

Source: *Annual Energy Outlook 2010*

Nonhydropower renewable sources meet 41% of total electricity generation growth from 2008 to 2035



Source: *Annual Energy Outlook 2010*

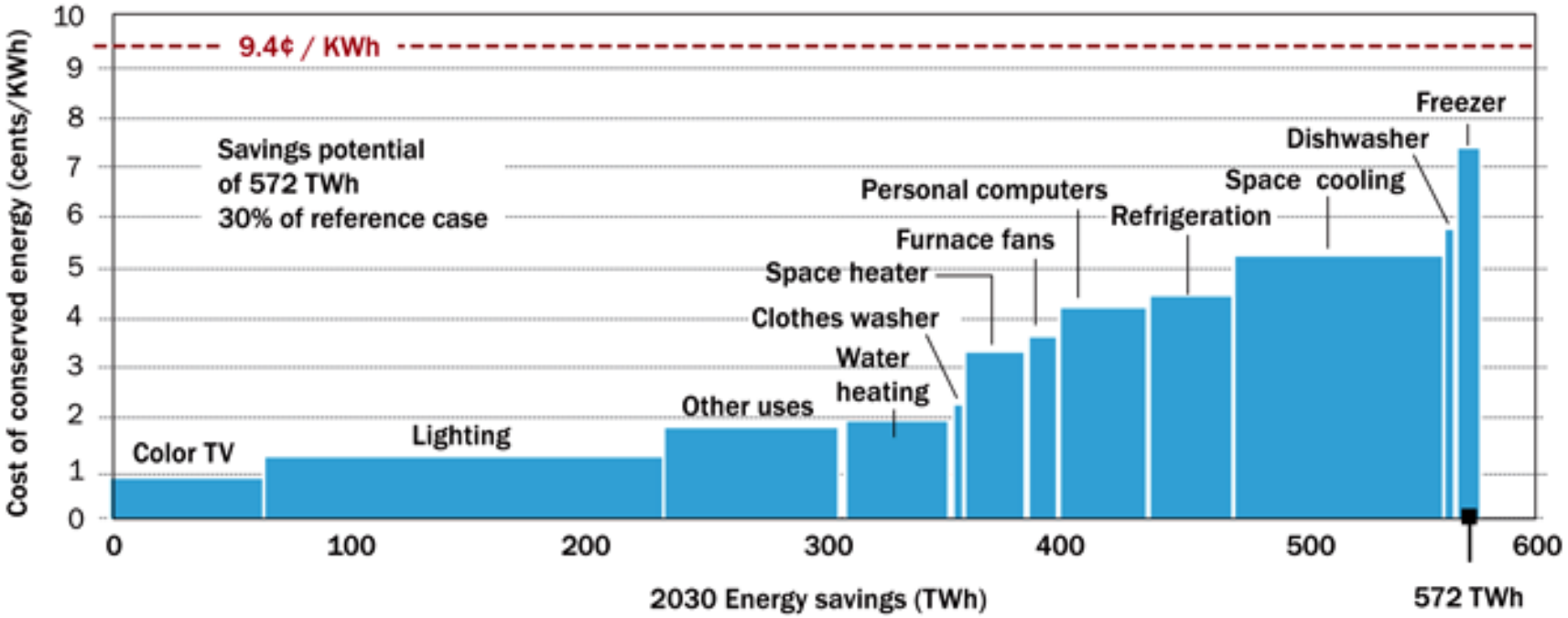
Energy efficiency is carbon mitigation

Energy Future: Think Efficiency, American Physical Society, September, 2008

Figure 25

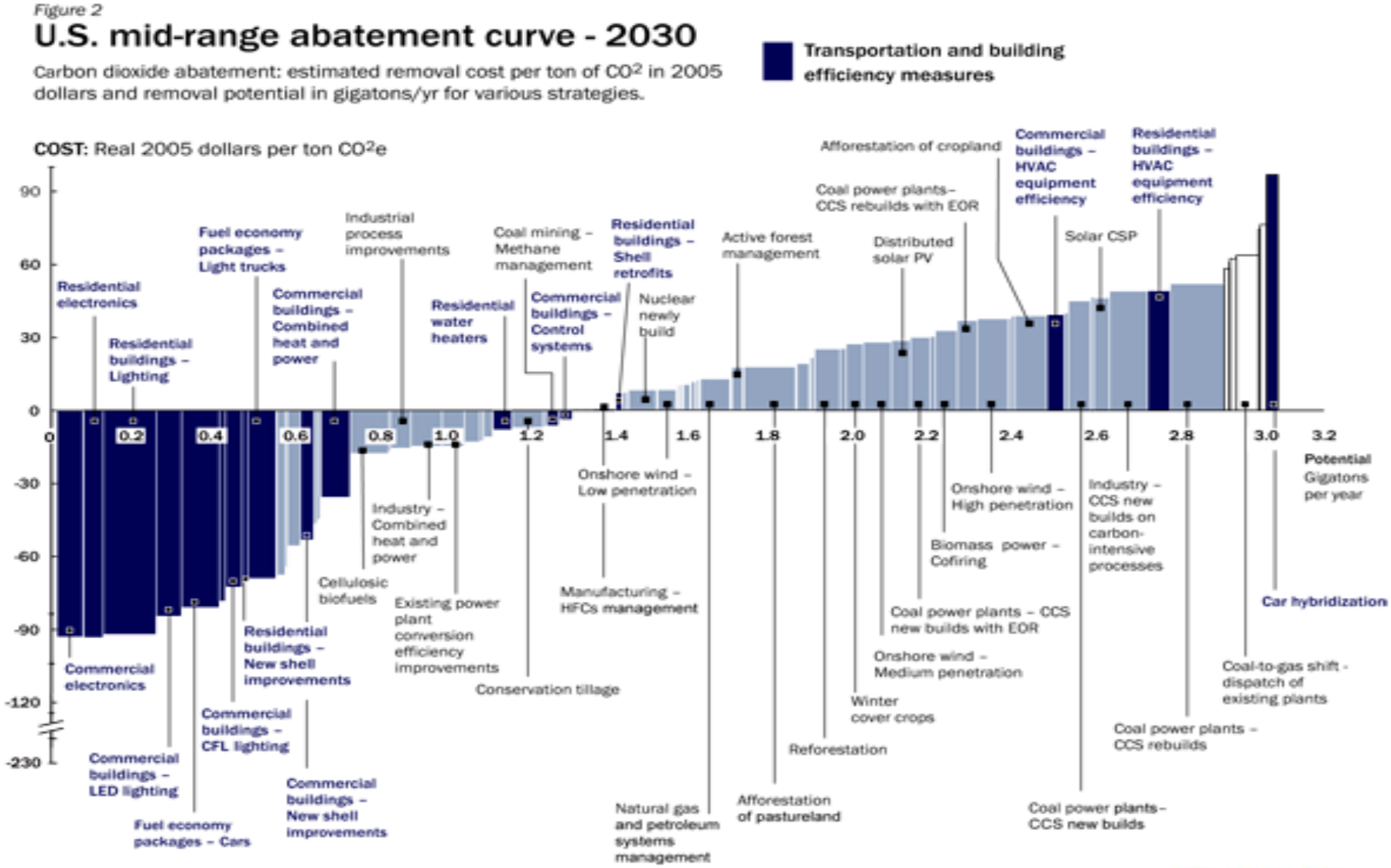
Residential electric savings potential for year 2030

Conservation supply curve for electric energy-efficiency improvements in the residential sector. For each measure considered (the energy savings is achieved at a cost per kWh less than the average residential retail price of 9.4 cents/kWh, shown as the horizontal red dashed line.



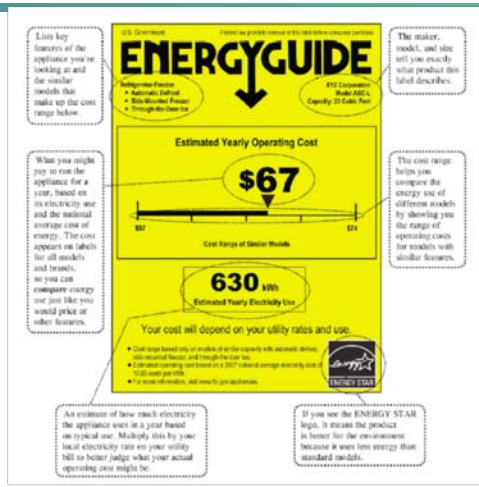
Energy efficiency reduces costs and carbon emissions

(Energy Future: Think Efficiency, American Physical Society, September, 2008)



http://www.aps.org/energyefficiencyreport/report/aps-energyreport.pdf

Programs to Reduce Energy Use in U.S. Appliances, Lighting and Equipment



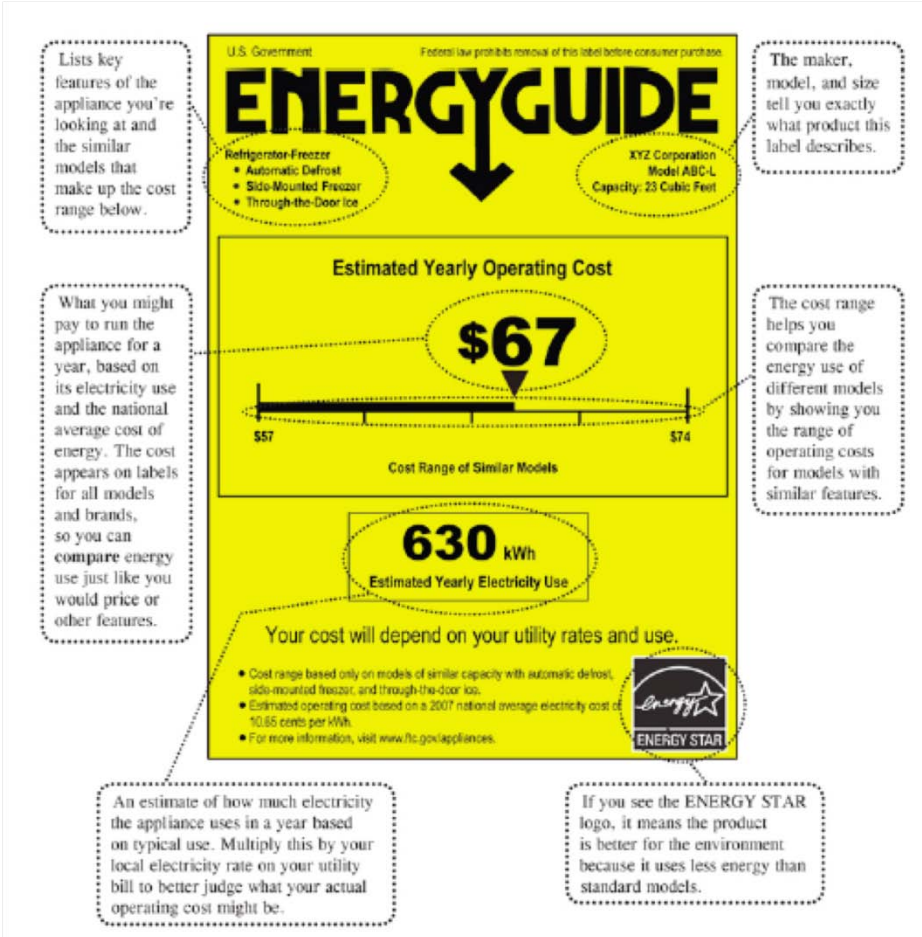
- **EnergyGuide Labels** "information"
  - Identify and compare efficiency of models
- **Tax incentives**
- **Utility energy efficiency programs**
- **Minimum Efficiency Standards** "regulation"
  - Require energy performance
- **ENERGY STAR Label** "endorsement"
  - Voluntary branding of more efficient models

EnergyGuide Label

The mandatory EnergyGuide label allows consumers to compare the energy use of different appliances

Products include:

- **clothes washers, dishwashers, refrigerators, freezers,**
- **water heaters,**
- **window air conditioners, central air conditioners, heat pumps,**
- **furnaces, boilers, ceiling fans,**
- **plumbing products,**
- **pool heaters**

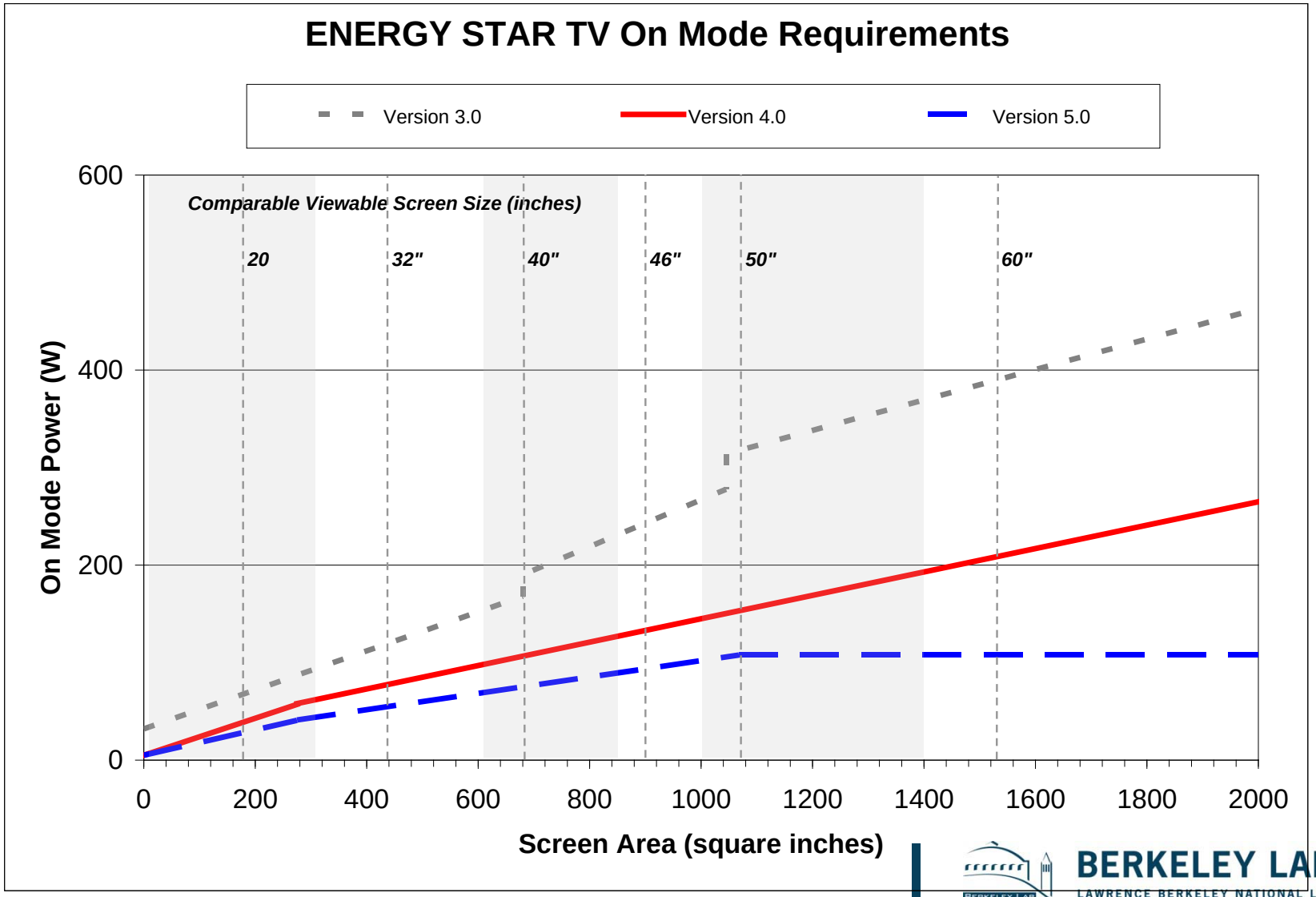


ENERGY STAR

- **ENERGY STAR identifies products in more than 60 categories that use less energy without sacrificing quality or performance**
  - **>2,000 manufacturers labeling**
  - **>40,000 product models**
  - **>1,000 retail partners**
  - **>550 utility partners promoting ENERGY STAR**

- *Americans with the help of ENERGY STAR prevented 40 million metric tons of GHG emissions - equivalent to 29 million vehicles and saved $19 billion on energy bills in 2008*

ENERGY STAR TVs: On Mode Limits



U.S. Efficiency Standards Rulemaking Activities

Six Final Rules in 2009

- 14 Products with standards prescribed by EISA 2007
- Ranges and Ovens
- General Service Fluorescent Lamps (GSFL) and Infrared (IRL) Lamps
- Commercial Package Boilers and Very Large Commercial Package Air-conditioners & Heat Pumps
- Refrigerated Beverage Vending Machines
- Commercial Clothes Washers

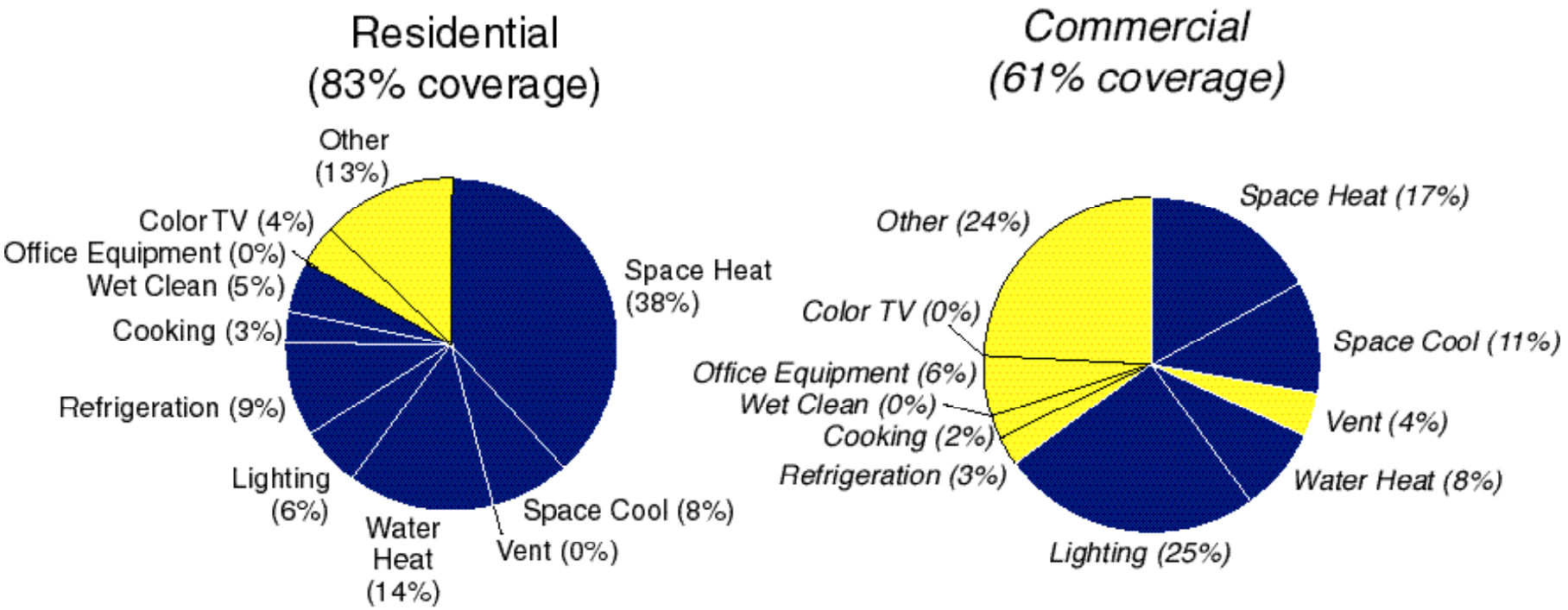
Five Final Rules in 2010

- Water Heaters (Residential)(COMPLETED)
- Direct Heating Equipment (COMPLETED)
- Pool Heaters (COMPLETED)
- Small Electric Motors (COMPLETED)
- Refrigerators (12/2010)

Ten Final Rules in 2011

- Microwave Ovens
- Residential Furnaces
- Fluorescent Lamp Ballasts
- Clothes Dryers (Residential)
- Room Air Conditioners
- Central Air Conditioners and Heat Pumps (Residential)
- Battery Chargers
- External Power Supplies (Class A)
- ER, BR, and Small Diameter Incandescent Reflector Lamps
- Residential Clothes Washers

U.S. Energy Efficiency Standards Affect Products Using Most of Buildings' Primary Energy



***Primary energy* savings = 9% of 2025 residential energy use**

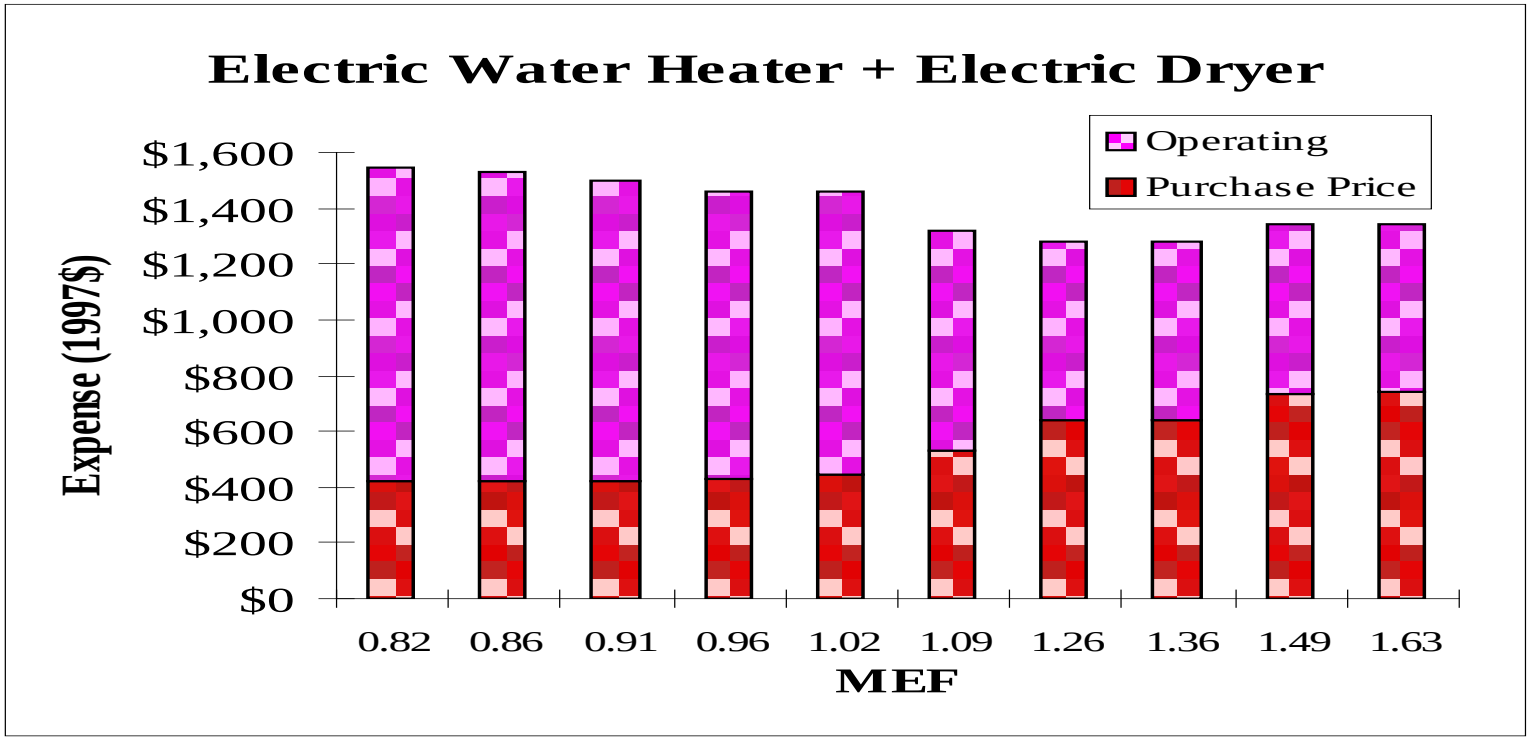
***Carbon reductions* = 9% of projected levels**
132 million metric tons CO_2/year in 2025

***Peak power* savings = 20% of 2001-2020 growth**

Energy savings offset increased purchase price

Life Cycle Cost (LCC) Analysis

Example: CLOTHES WASHER (12-year life, 7% real discount rate) **with**

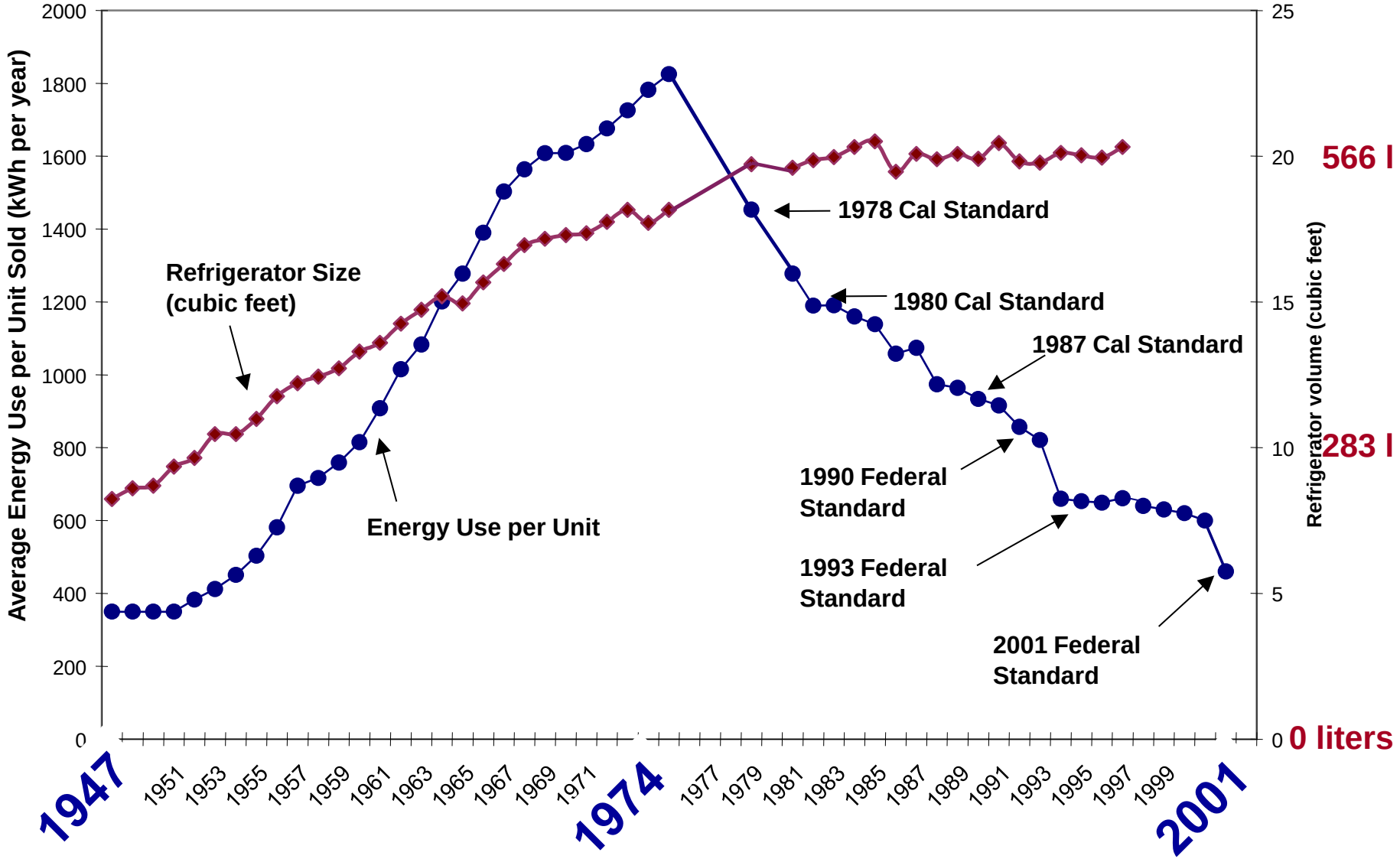


LCC = all initial costs plus operating costs

- Discount future expenses to the present and sum over lifetime of equipment

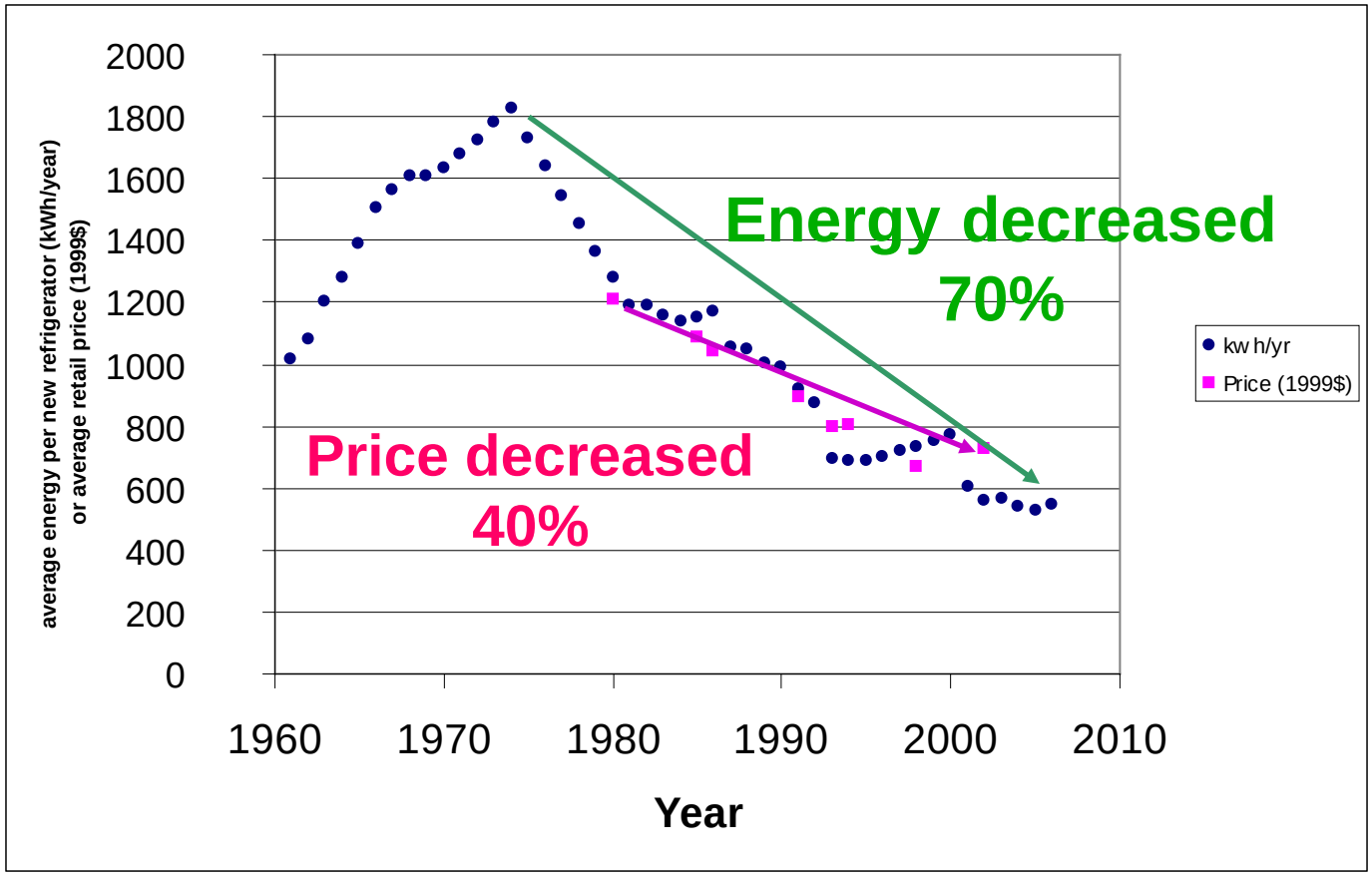
U.S. Refrigerator Electricity Use and Size

Unit energy 1974 to 2006 = -4% per year



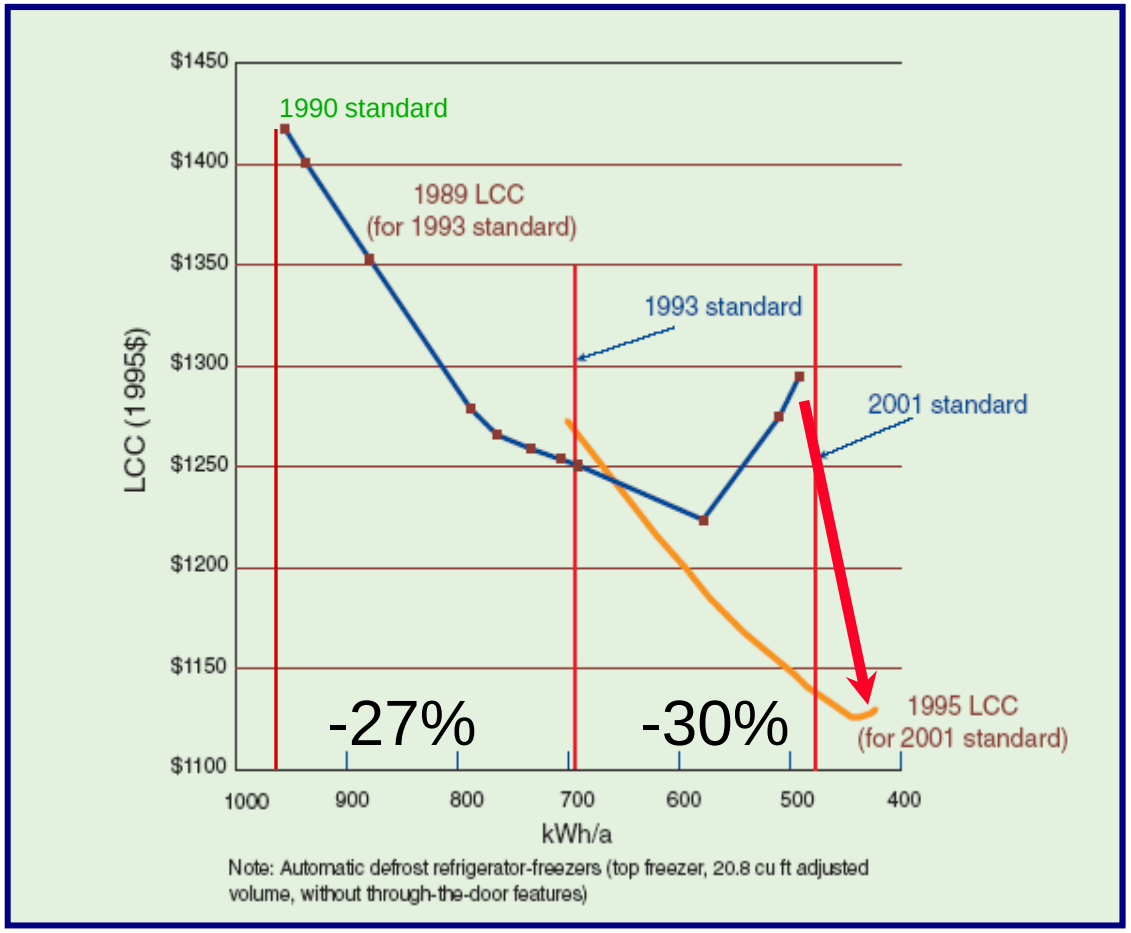
U.S. New Refrigerator kWh/year Decreased 70%

Annual Drop from 1974 to 2006 = 4% Per Year (average)



Real retail price in 2002 was 40% lower than in 1980

Affordable Energy-Efficiency is a Renewable Resource



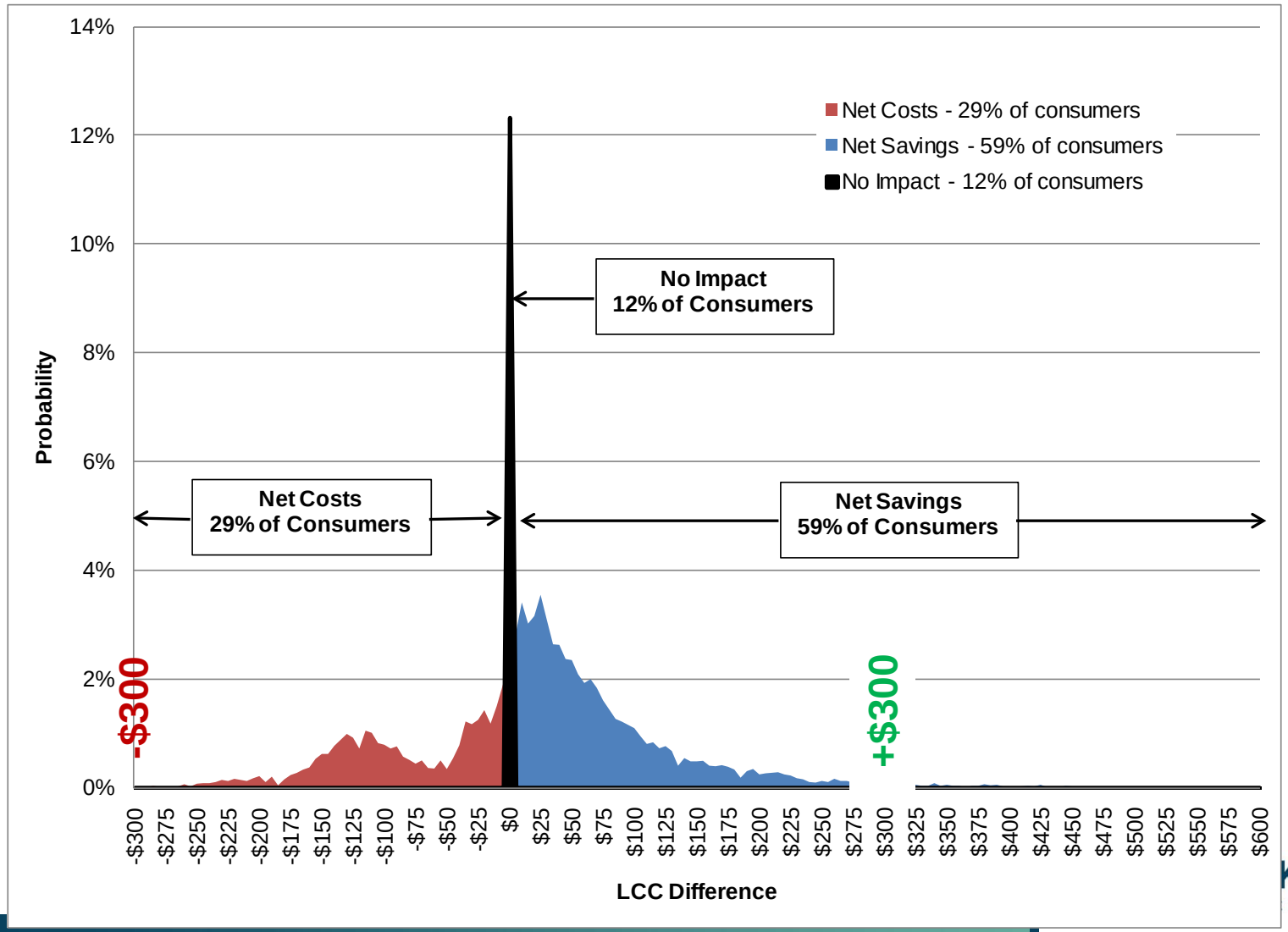
The maximum technology kWh/a in refrigerators changed 14% in 6 years - from 495 kWh/a (1989) to 425 kWh/a (1995) –

and became cheaper to manufacture.

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

Efficiency improvements have small net effect on TOTAL (Life Cycle) Cost for most consumers

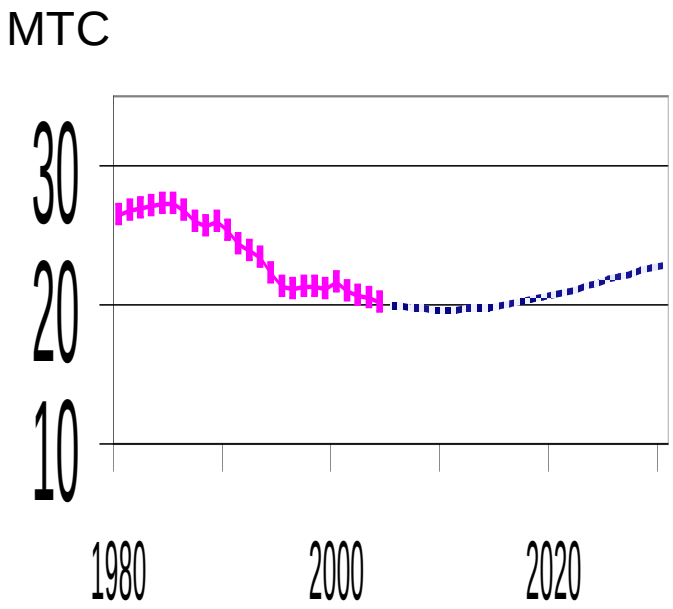
- **Example: Residential Electric Storage Water Heaters, 0.95 EF**



Average LCC = $3,236 (2009$)

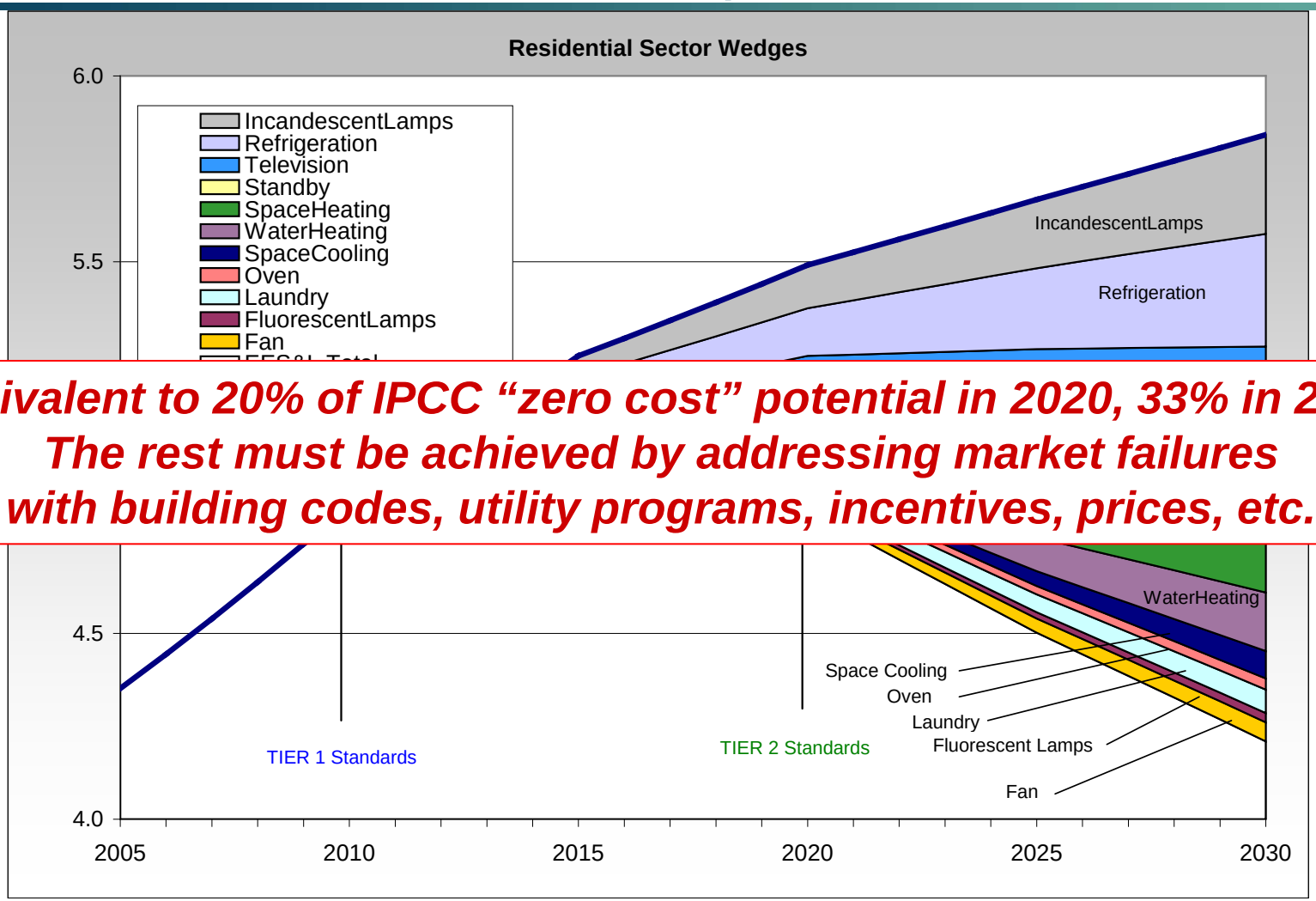
CO_2 Emissions Declined

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



- **Technology and policy together achieved this result**
- **Inflation-adjusted retail prices declined**
- **Lessons learned can be applied to other energy technologies and services**

Standards: Path to Lower Emissions by 2030
Residential Sector, All Countries



Equivalent to 20% of IPCC "zero cost" potential in 2020, 33% in 2030. The rest must be achieved by addressing market failures with building codes, utility programs, incentives, prices, 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)

Additional Savings from Systems

- From individual technologies to *whole building*
- *Demand response* incorporates price signals to deliver automatic reductions
- *Digital networks* can maximize comfort and utility while minimizing energy
- Efficient (electricity and cooling) *data centers*

- *Combined heat and power* can improve efficiency and reduce peak
- Neighborhood systems (e.g., *district heating/cooling*)
- *Micro-grids* provide local power, desired power quality

- Energy-efficient *wastewater treatment*
- Regional *integrated resource planning* (energy, water)