



Energy Efficiency in Buildings and Industry: A Low Carbon Future

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At National Renewable Energy Laboratory

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Carbon Cycle 2.0 Initiative at Berkeley Lab



- **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

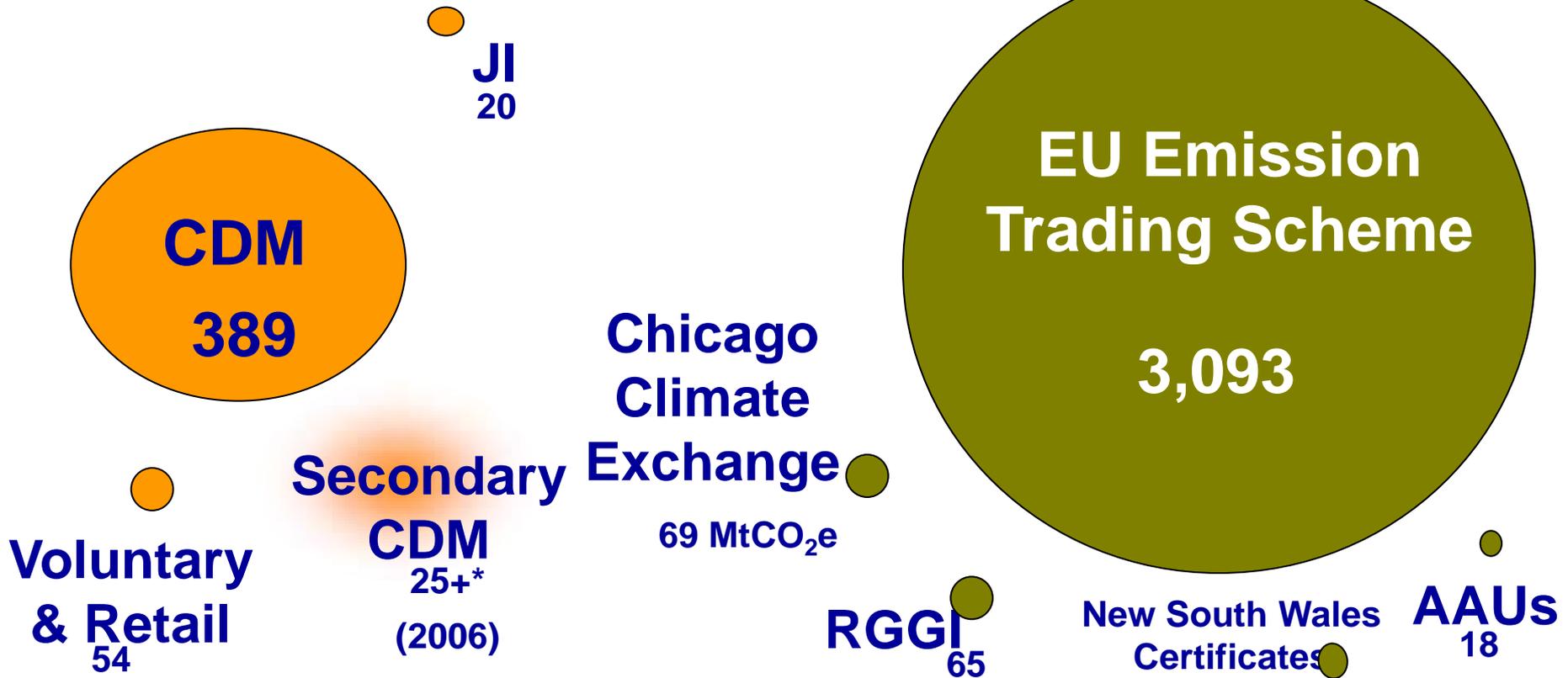
Global Carbon Market: \$126B 2008 - doubling each of last 3 years

Volumes transacted in 2008 (total 4,811 MtCO₂e)

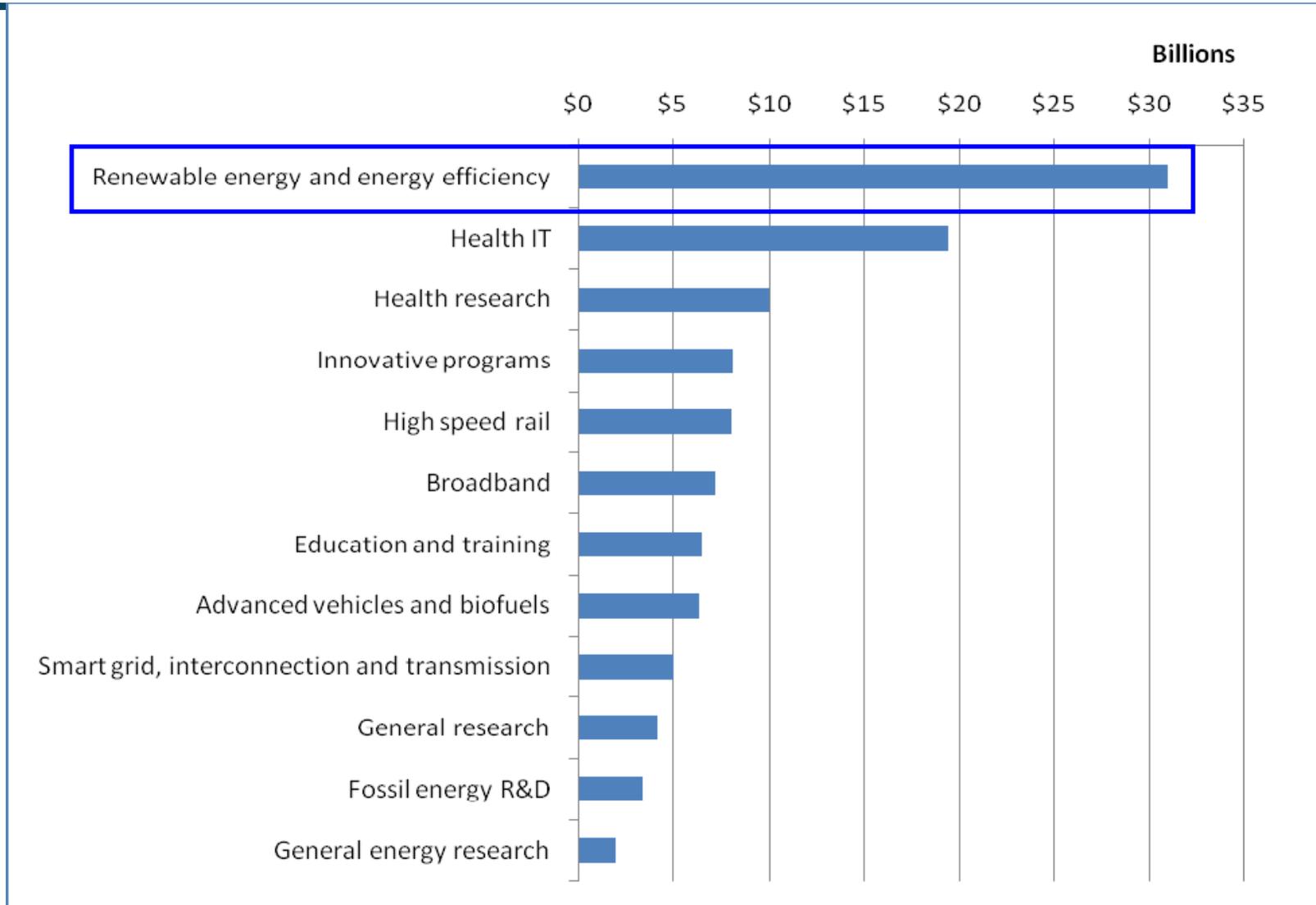
Source: Karan Capoor, Philippe Ambrosi, The World Bank, Washington D.C. 2009

Project-Based Transactions

Allowance Markets

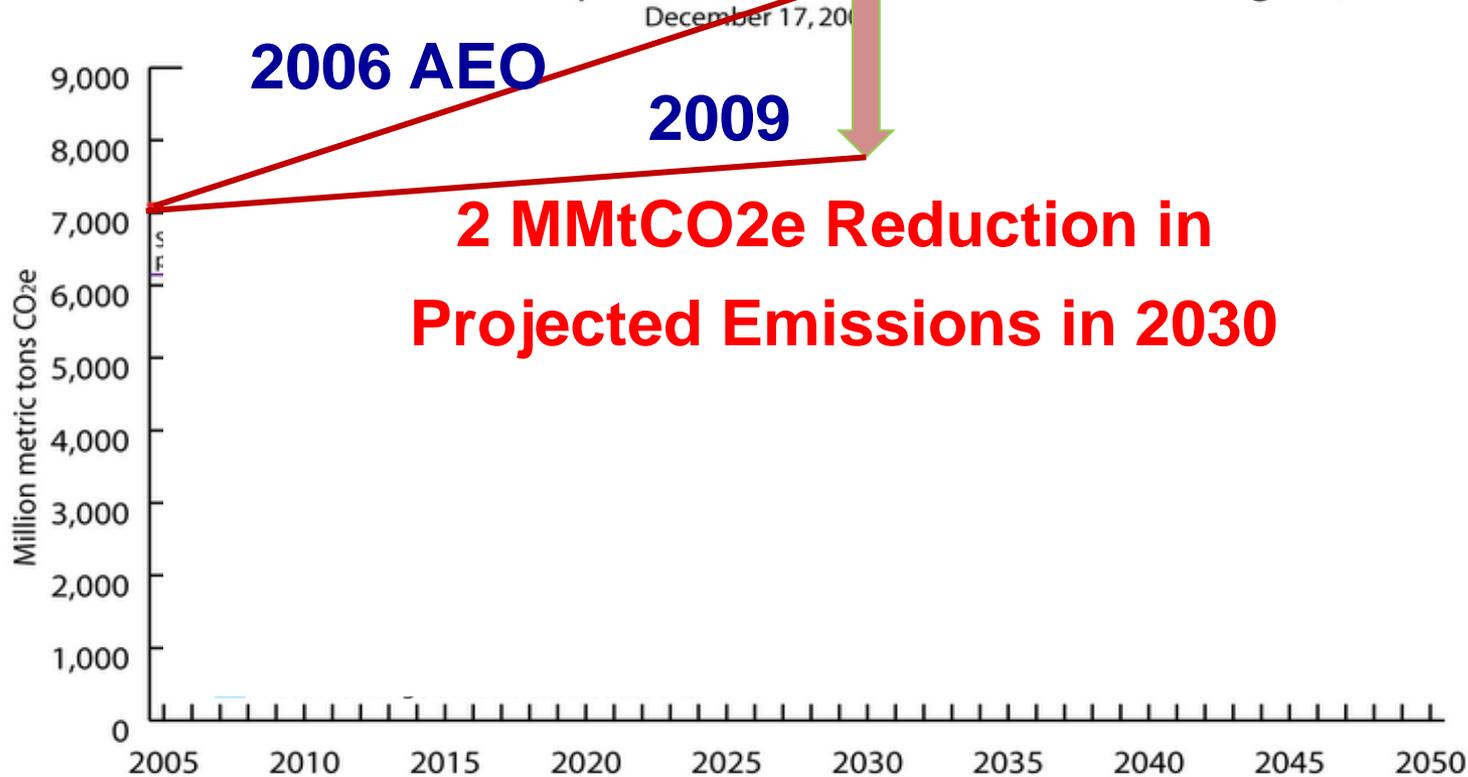


Innovation Funding in American Recovery and Reinvestment Act



U.S. Carbon Emissions & Recent Draft Legislation

Net Emission Reductions Under Cap-and-Trade Proposals in the 111th Congress, 2005-2050



APGR CO₂e
+1.2% 2006
+0.3% 2009

TARGET
2010-2050
-4%

WORLD RESOURCES INSTITUTE

For a full discussion of underlying methodology, assumptions and references, please see <http://www.wri.org/usclimatetargets>.

**"Business as usual" emission projections are from EPA's reference case for its analysis of the Waxman-Markey bill. "Short-term projected emissions" represent EIA's most recent estimates of emissions for 2008-2010.

** Cantwell-Collins sets economy-wide reduction targets beginning with a 20 percent reduction from 2005 levels by 2020. However, additional action by Congress would be required before these targets could be met. Reduction estimates do not include emissions above the cap that could occur due to the safety-valve.

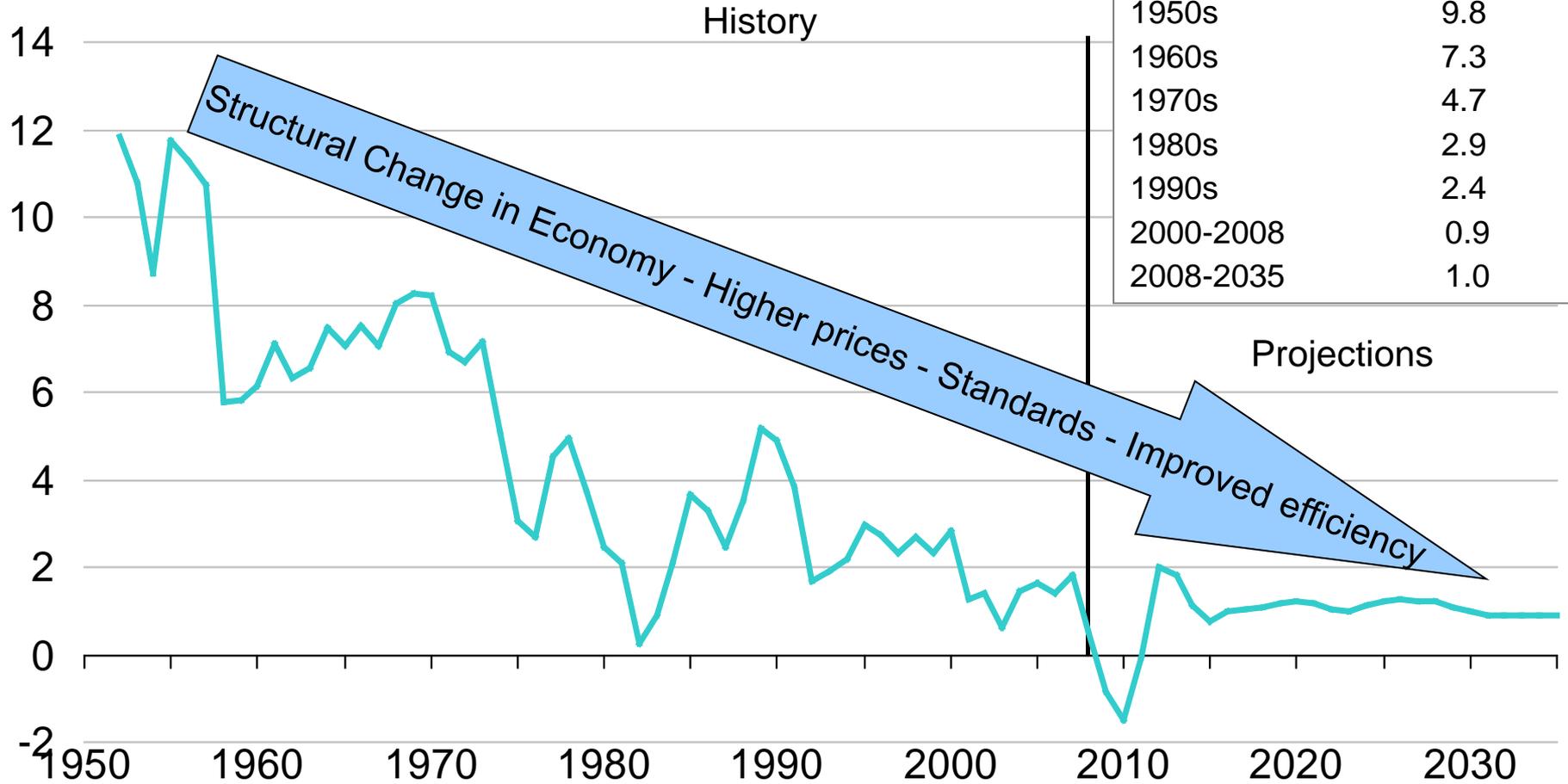
Source: Larsen, John and Robert Heilmayr. 2009. Emission Reductions Under Cap-and-Trade Proposals in the 111th Congress. Washington, DC: World Resources Institute. Available online at: <http://www.wri.org/publication/usclimatetargets>



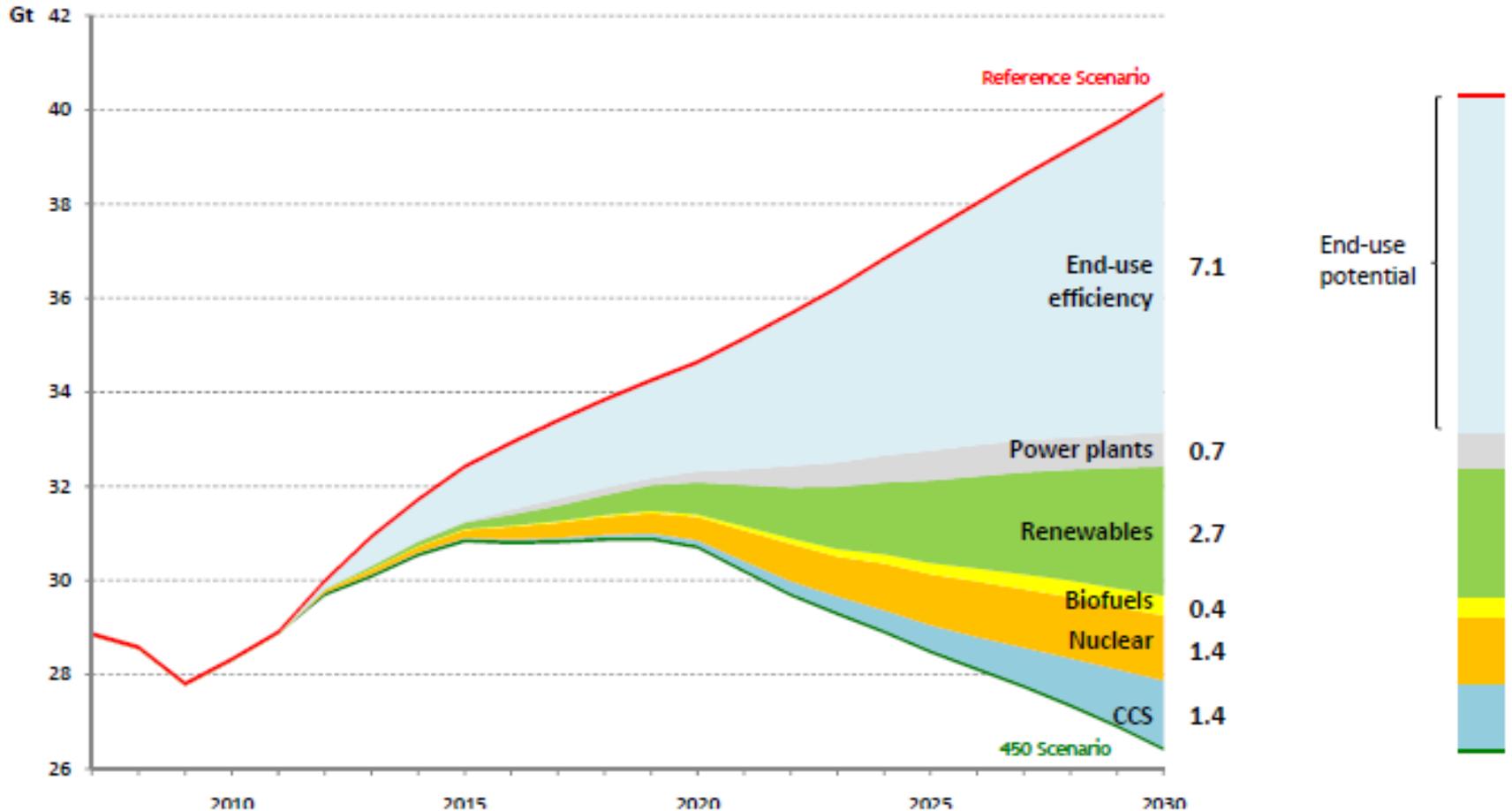
BERKELEY LAB
 LAWRENCE BERKELEY NATIONAL LABORATORY

Growth in electricity use continues to slow

3-year rolling average percent growth



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

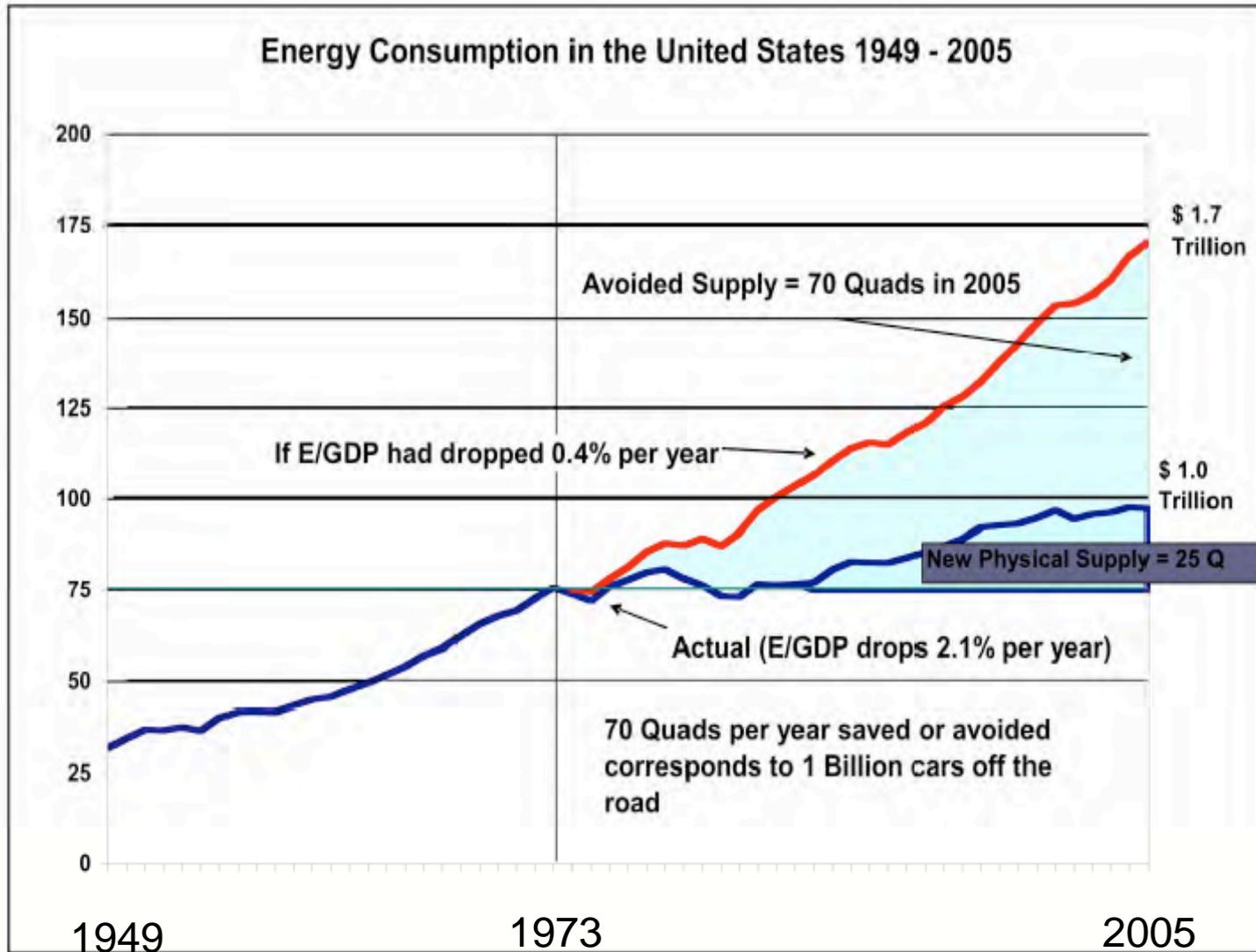


Full implementation of the IEA 25 energy efficiency recommendations is essential to achieve the 450 scenario

OECD/IEA 2009

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

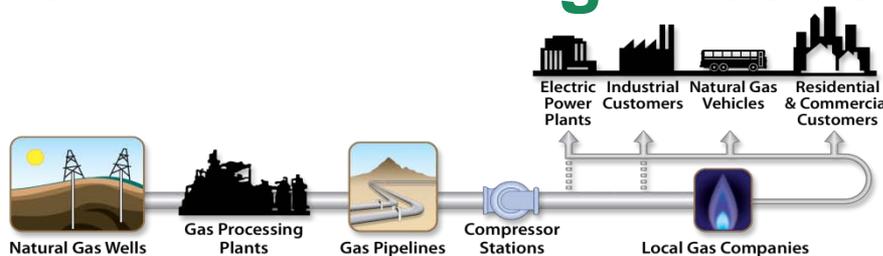
- Efficiency & conservation in buildings, cars, & industry
- Shift away from heavy industry to services

Energy Consumption by U.S. Buildings

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



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

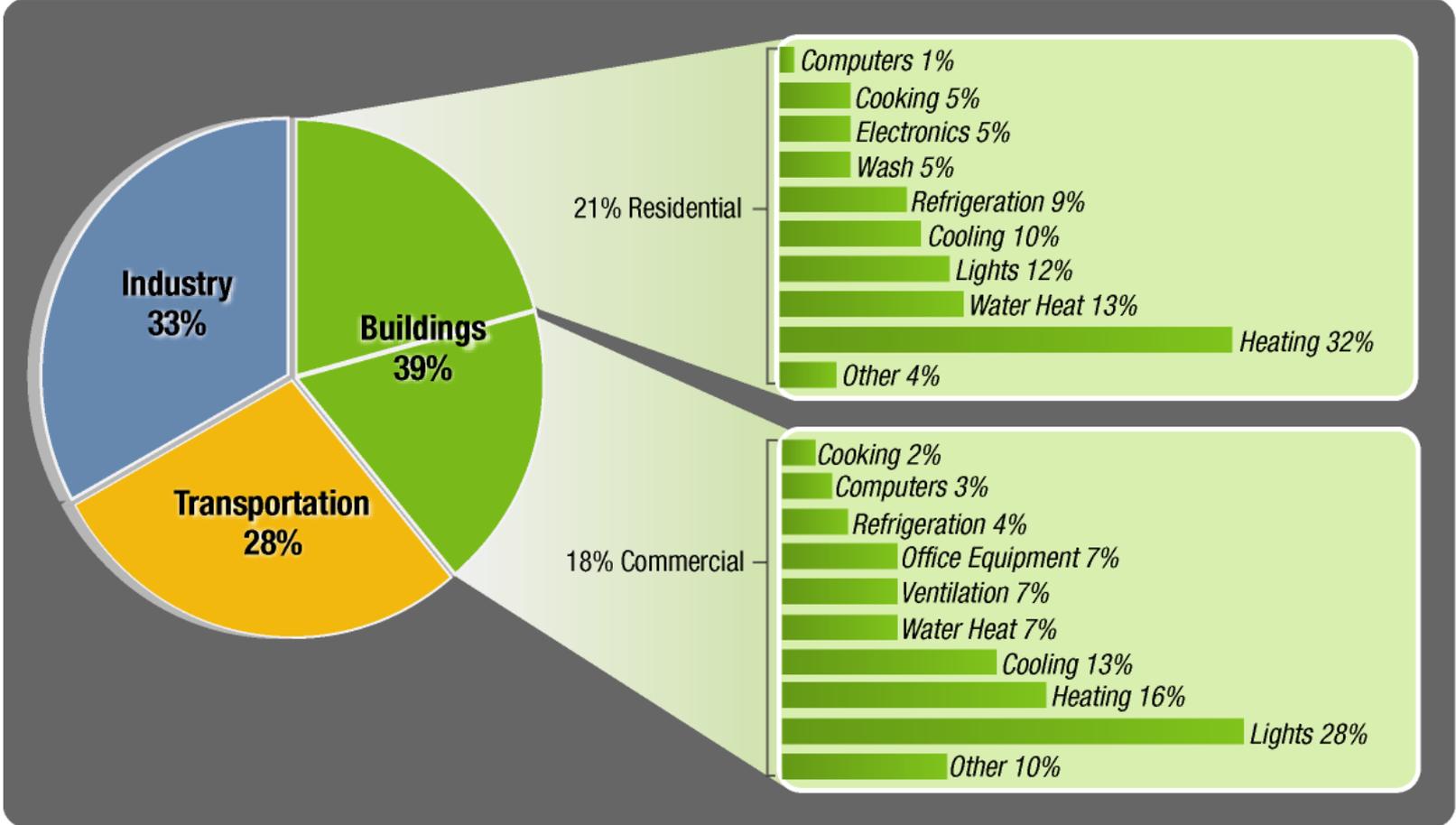


- **39% of U.S. carbon dioxide emissions**

.U.S. buildings are responsible for more CO₂ emissions than any country in the world except China & US

Buildings' Energy Consumption by End Use Services

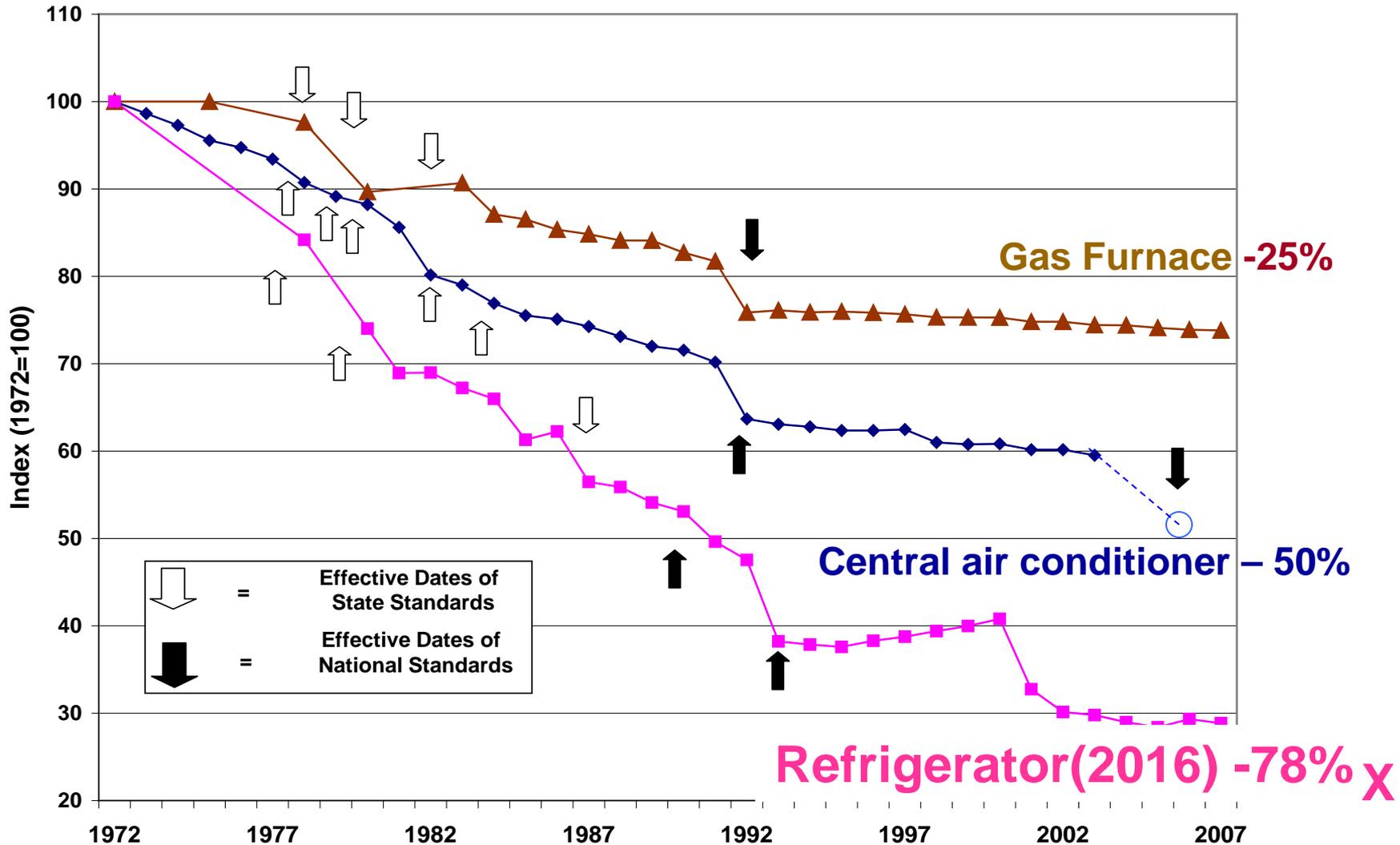
Space conditioning, lighting, water heating, refrigeration and electronics account for 87% of primary energy used by buildings



U.S. Average Energy Use per New Appliance

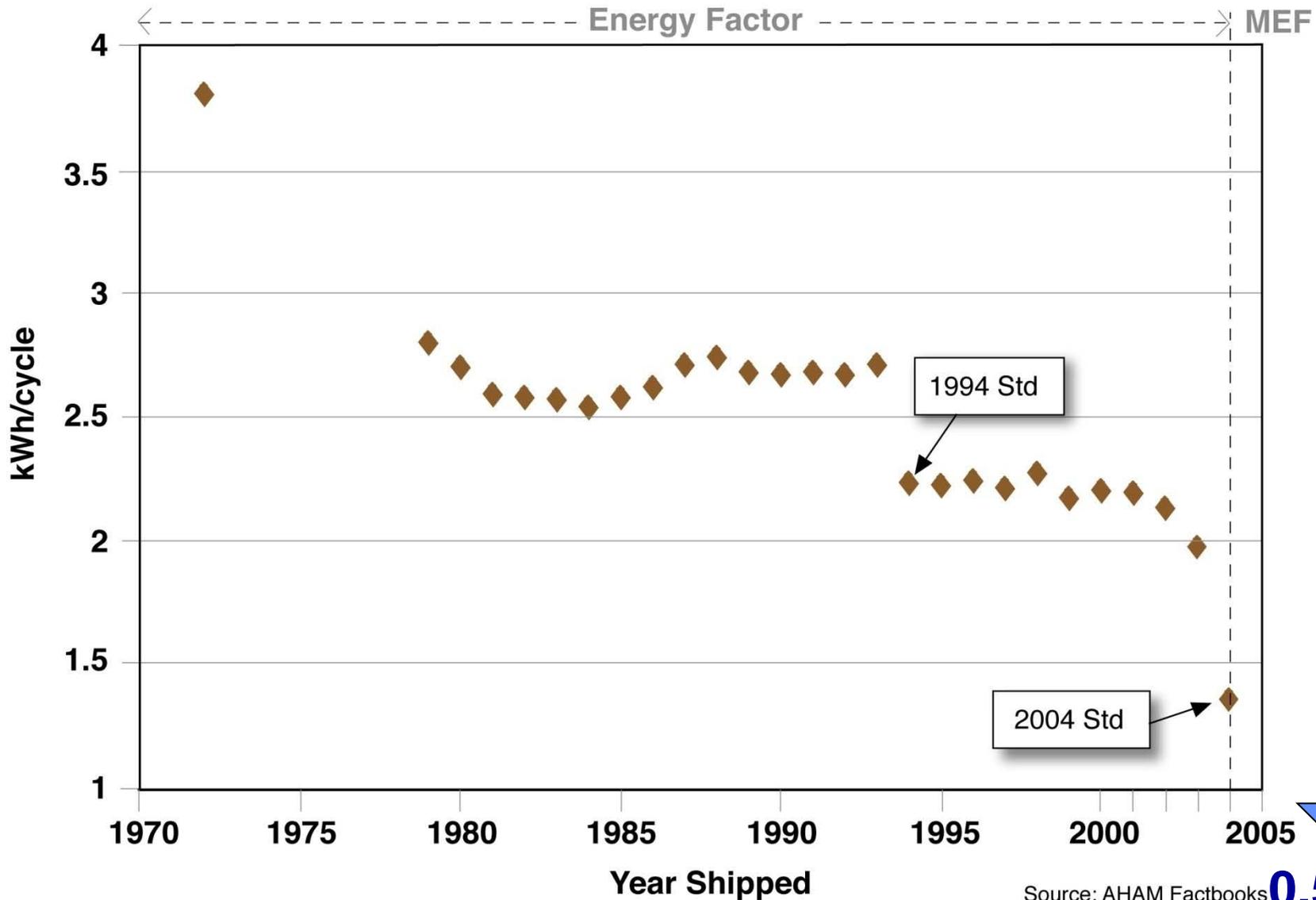


Index relative to 1972 = 100



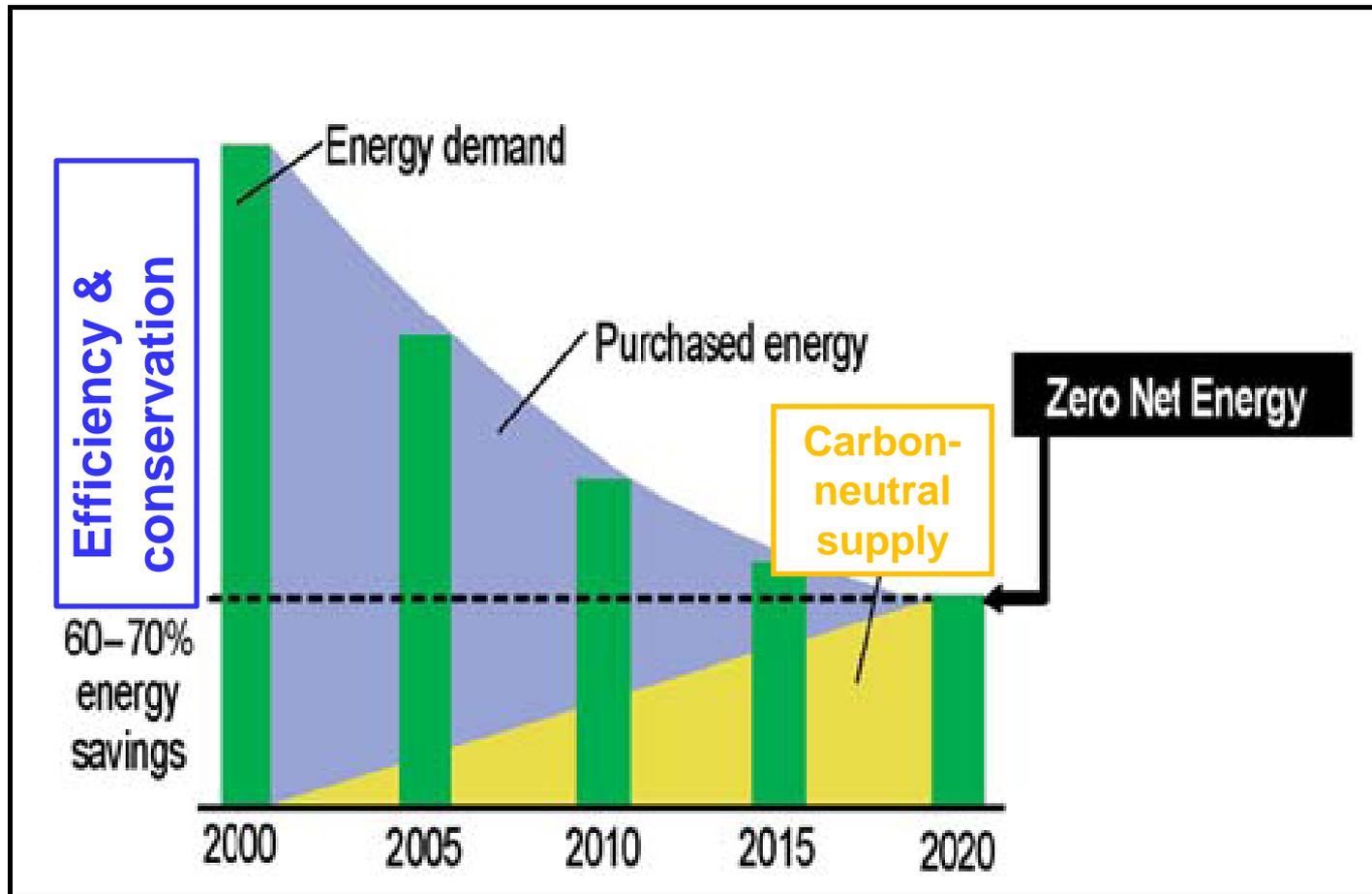


Average Energy Use Per Cycle of New Clothes Washers



Source: AHAM Factbooks

Efficiency and carbon-neutral supply are complements

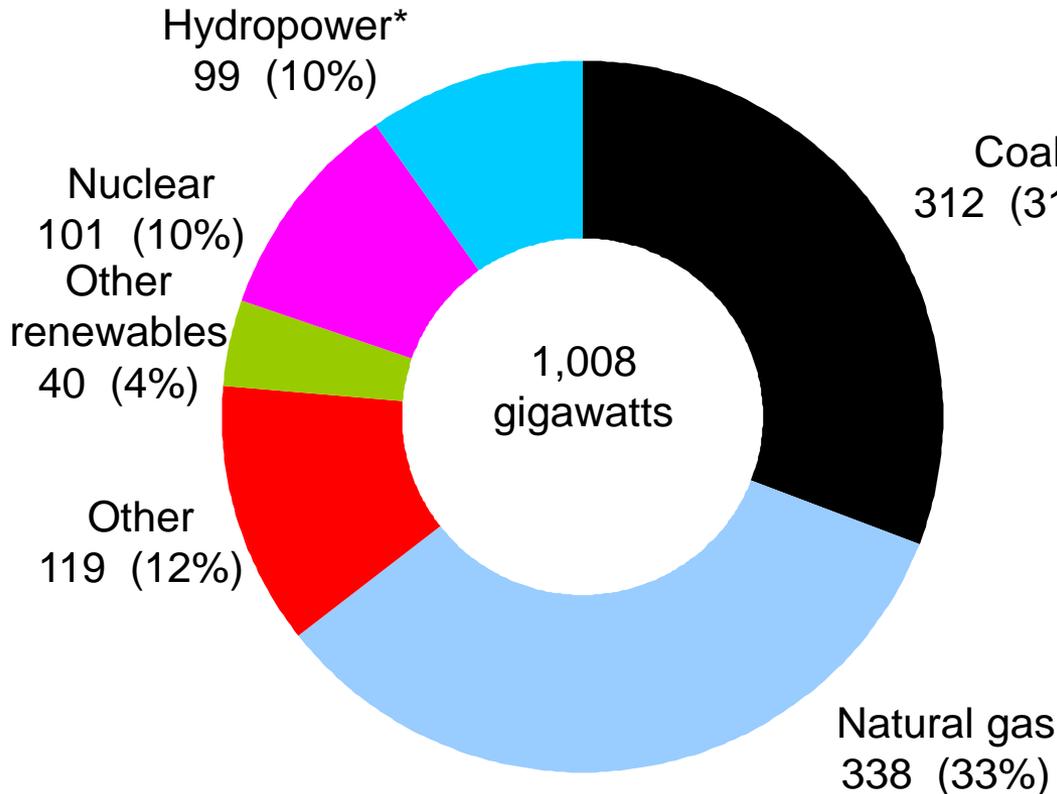


Target date: 2020 for new residential buildings

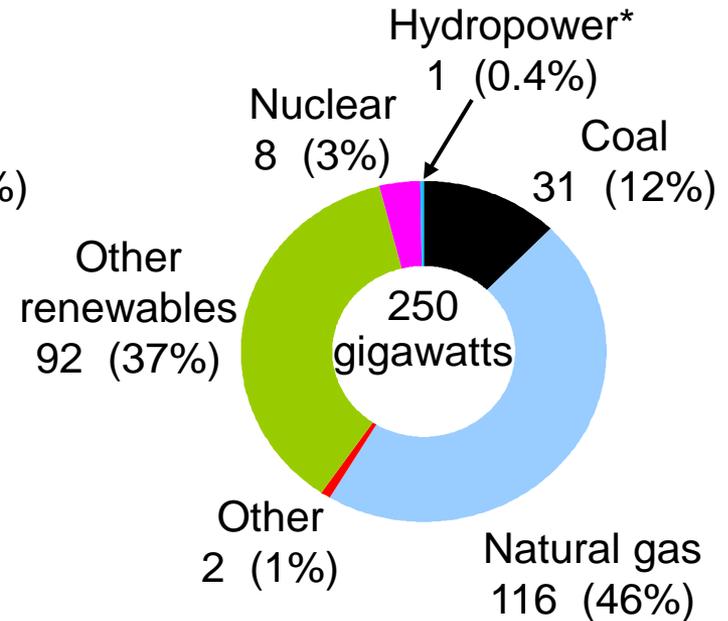
2030 for new commercial buildings

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

2008 capacity

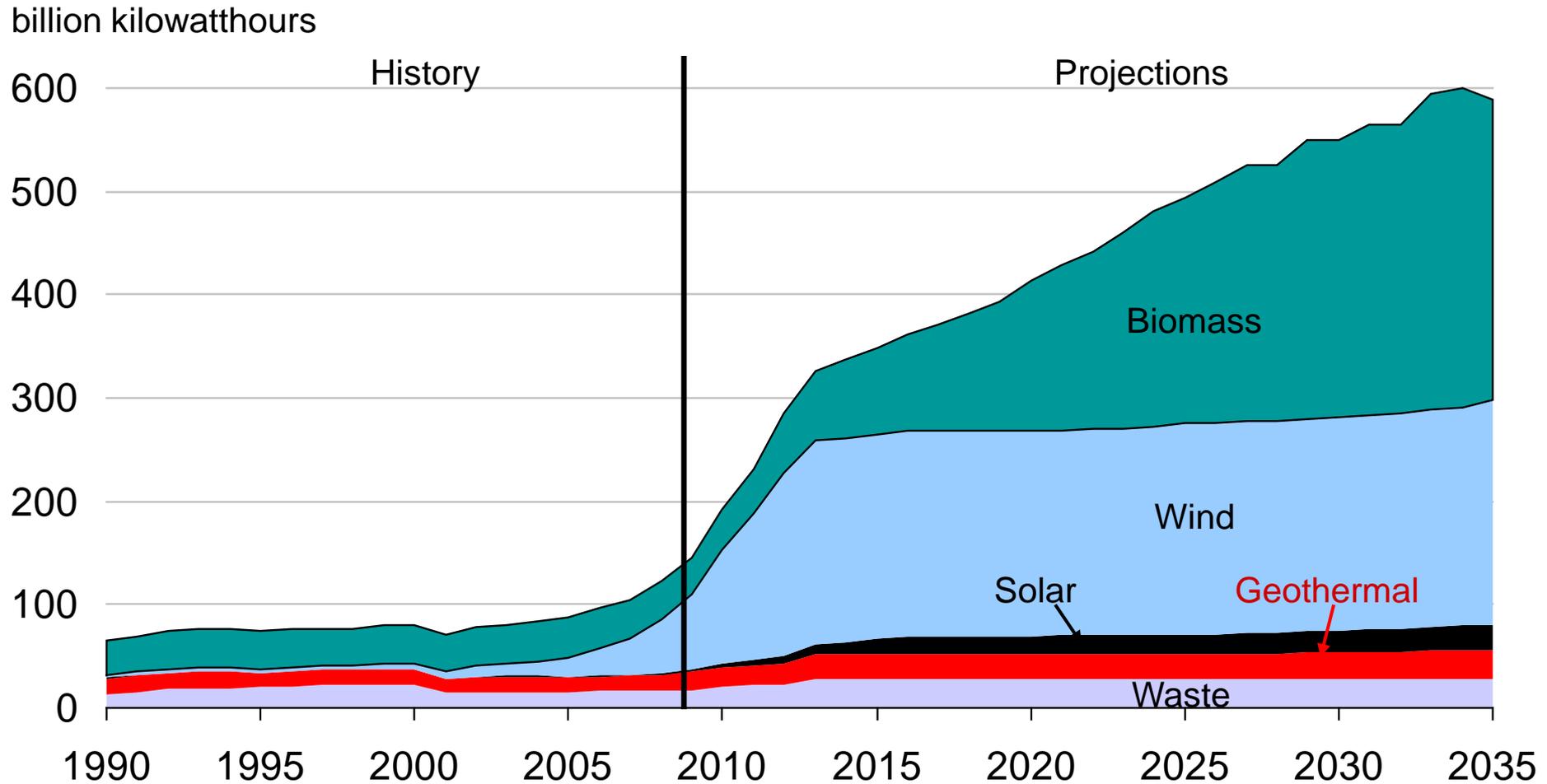


Capacity additions 2008 to 2035



* Includes pumped storage

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



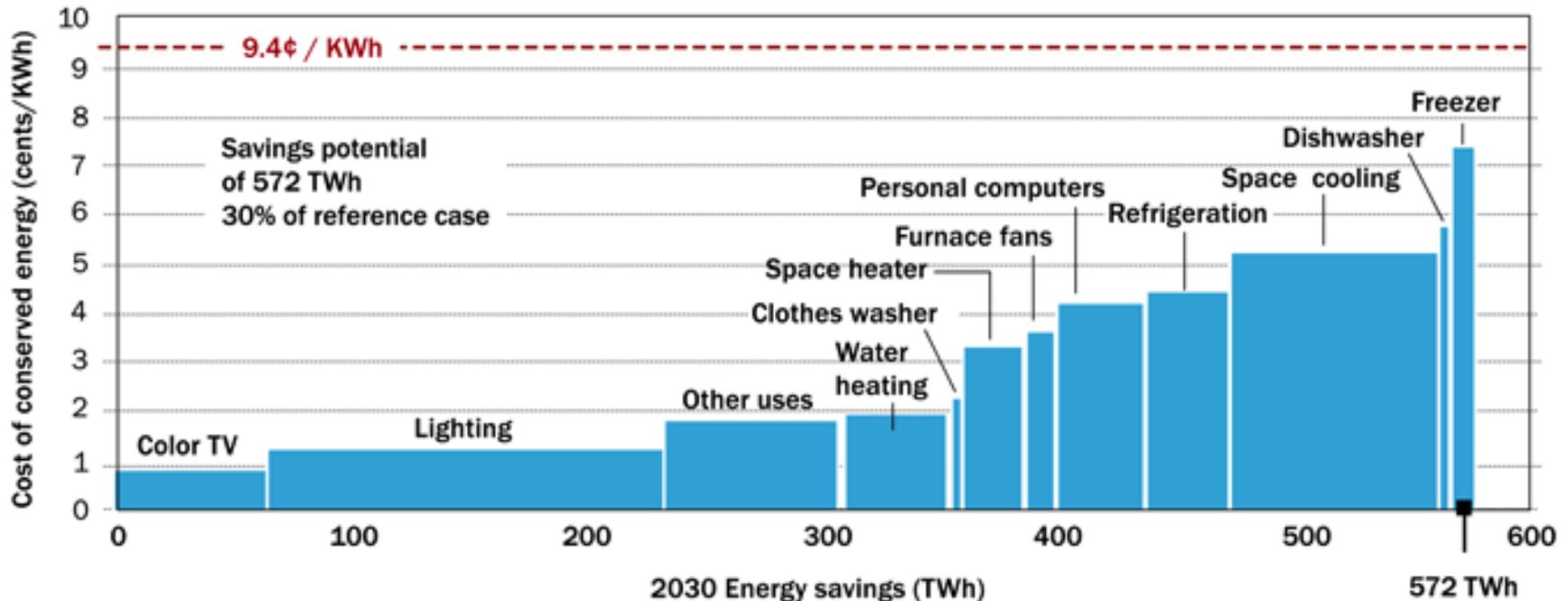
Energy efficiency is carbon mitigation

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).

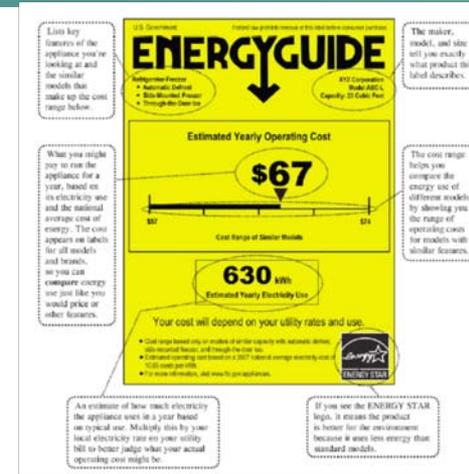


Carbon Mitigation Potentials & Economics



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

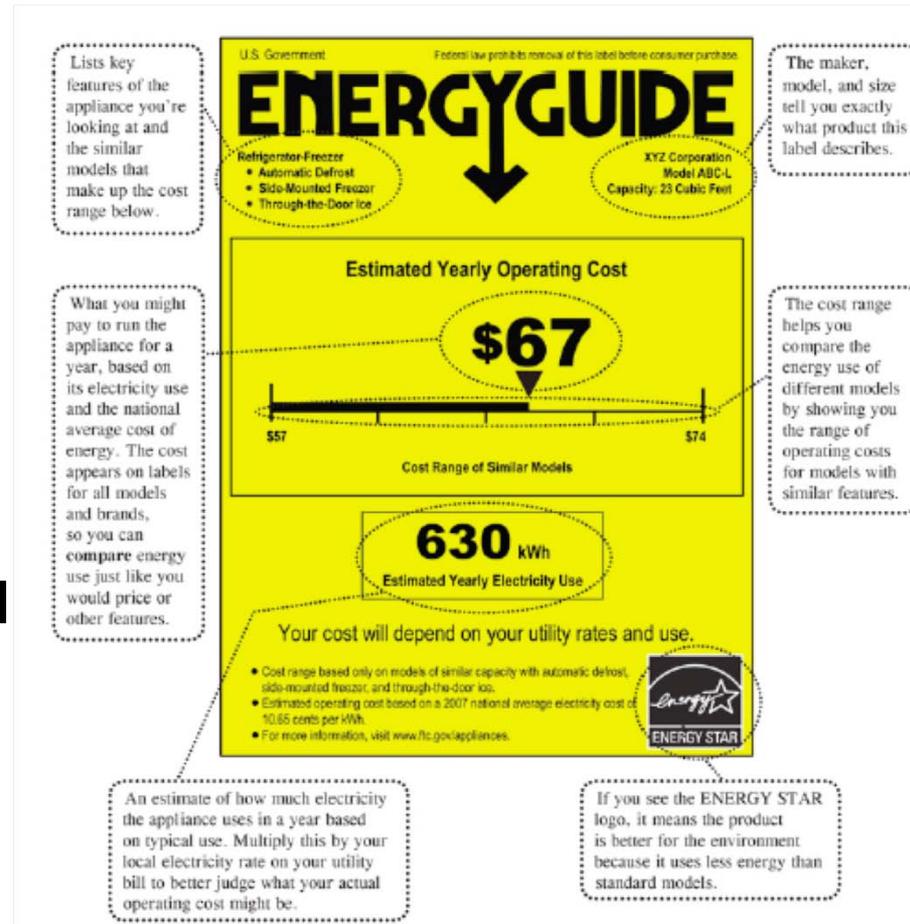


EnergyGuide Label

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



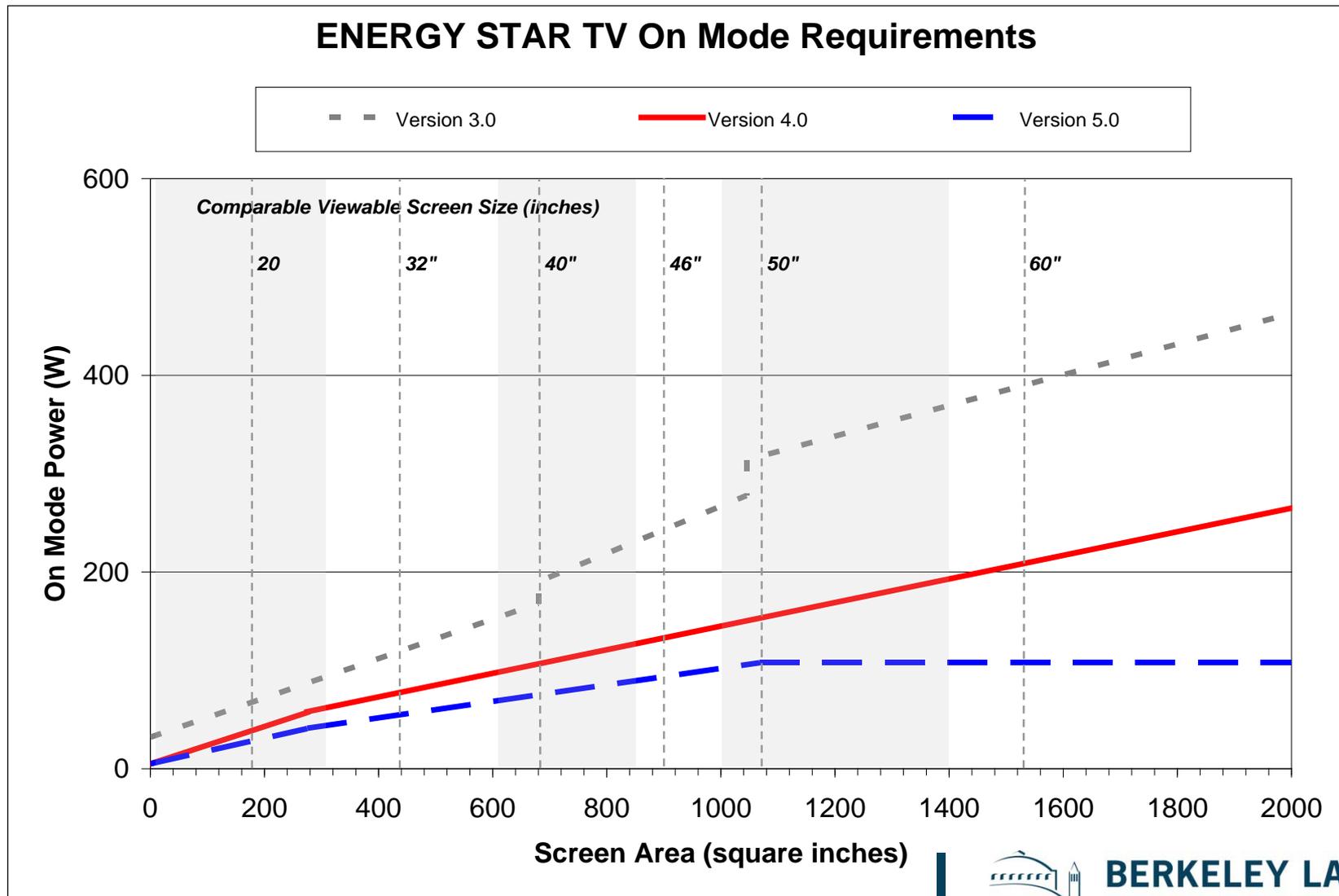
ENERGY STAR

- **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)

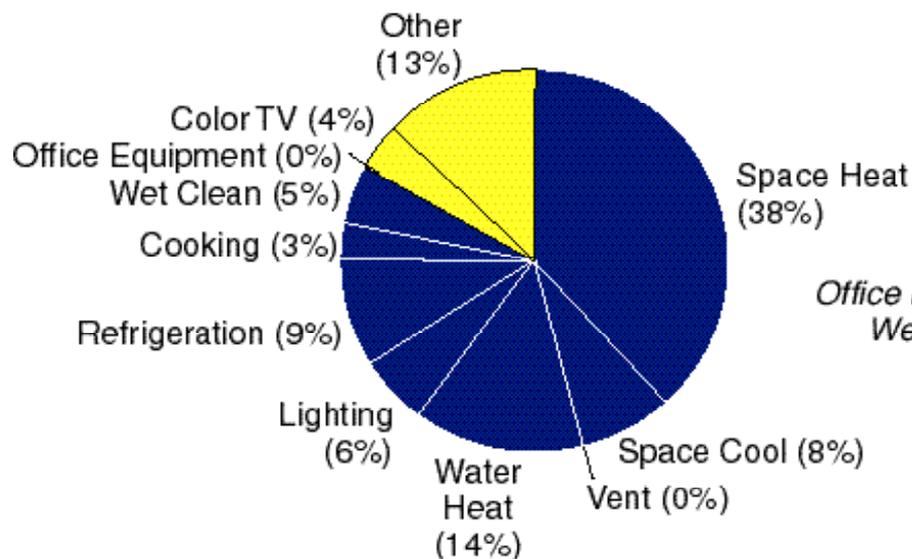
Ten Final Rules in 2011

- 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

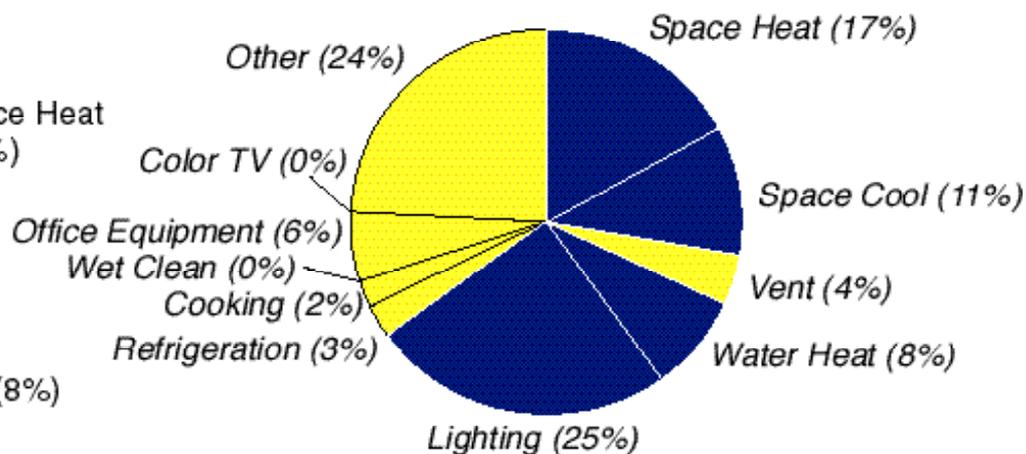
U.S. Energy Efficiency Standards Affect Products Using Most of Buildings' Primary Energy



Residential
(83% coverage)



Commercial
(61% coverage)



Primary energy savings = 9% of 2025 residential energy use

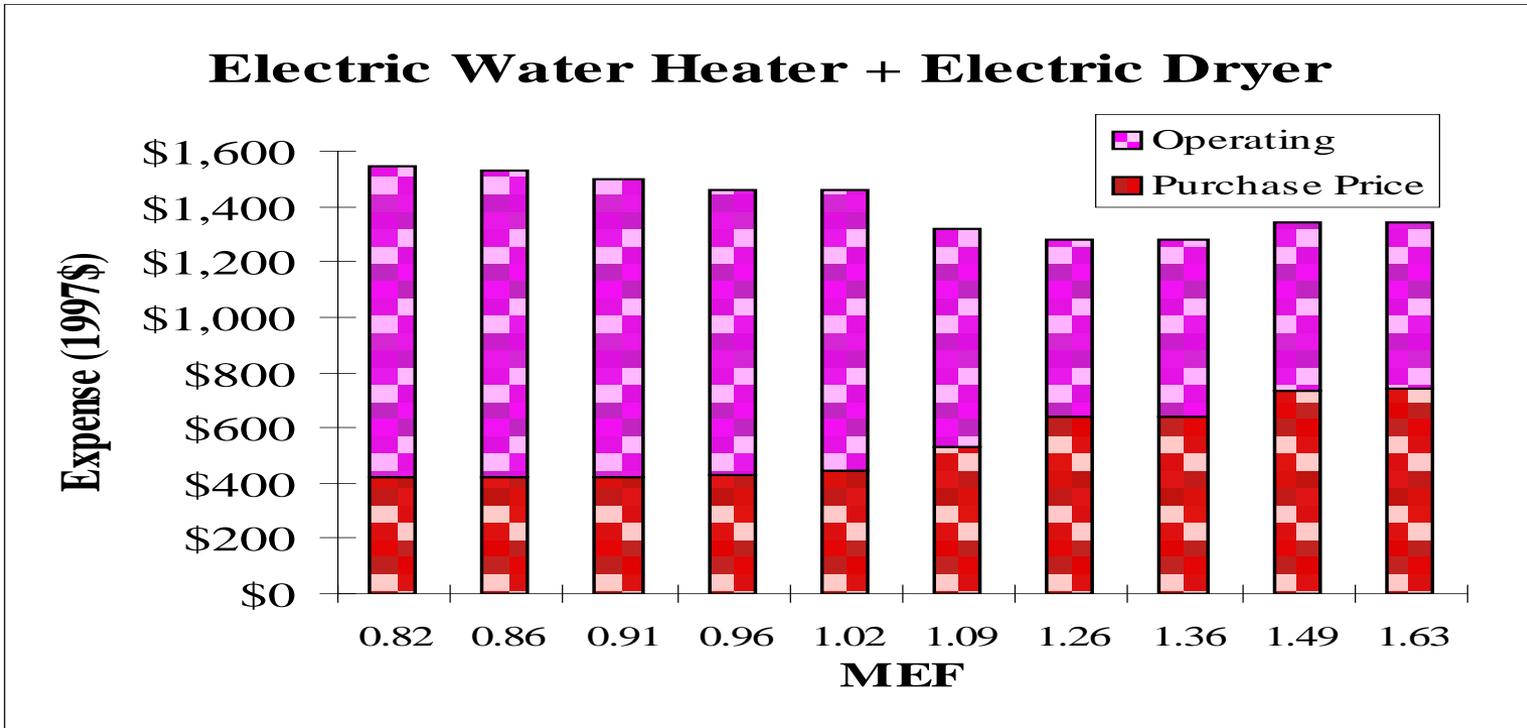
**Carbon reductions = 9% of projected levels
132 million metric tons CO₂/year in 2025**

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

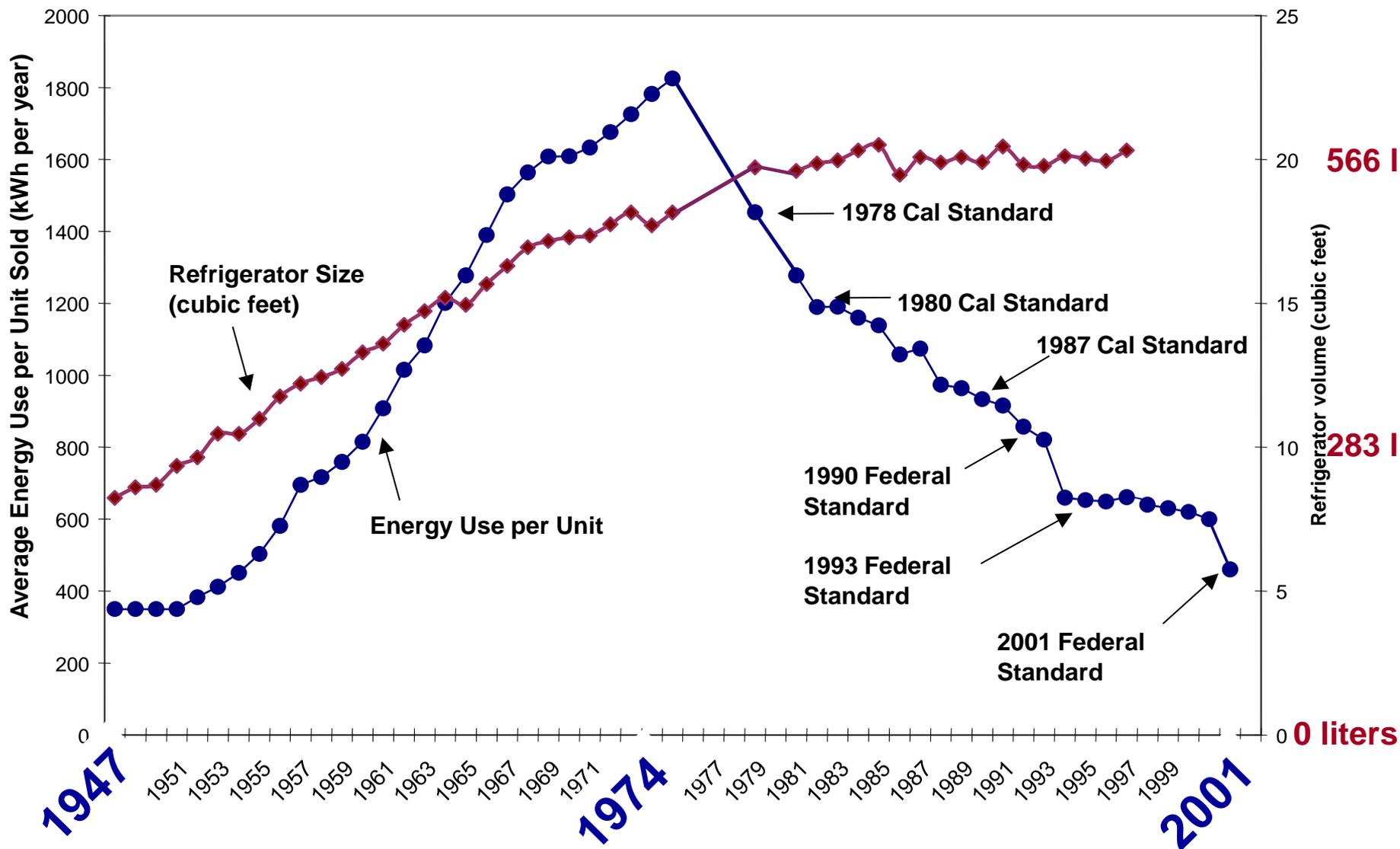


LCC = all initial costs plus operating costs

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

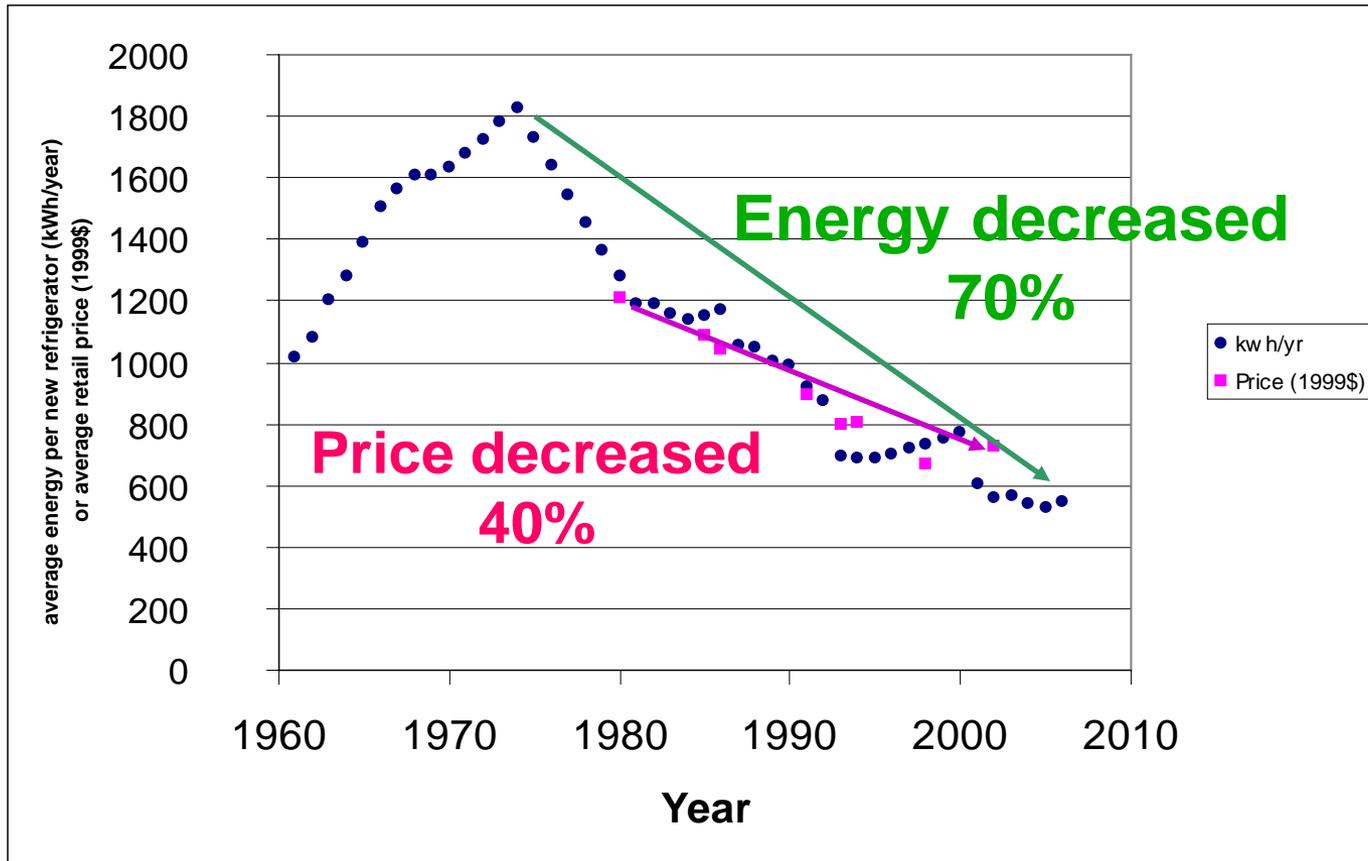
U.S. Refrigerator Electricity Use and Size

Unit energy 1974 to 2006 = -4% per year



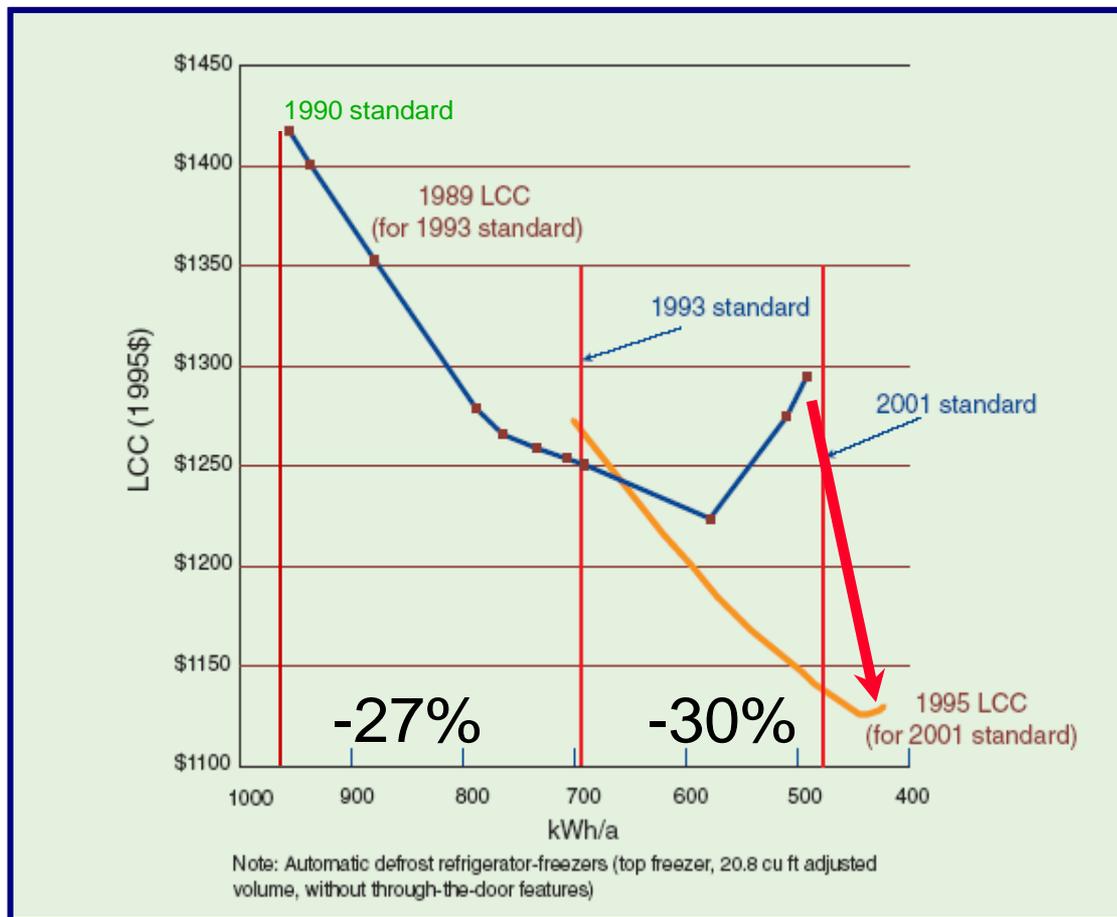
U.S. New Refrigerator kWh/year Decreased 70%

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.

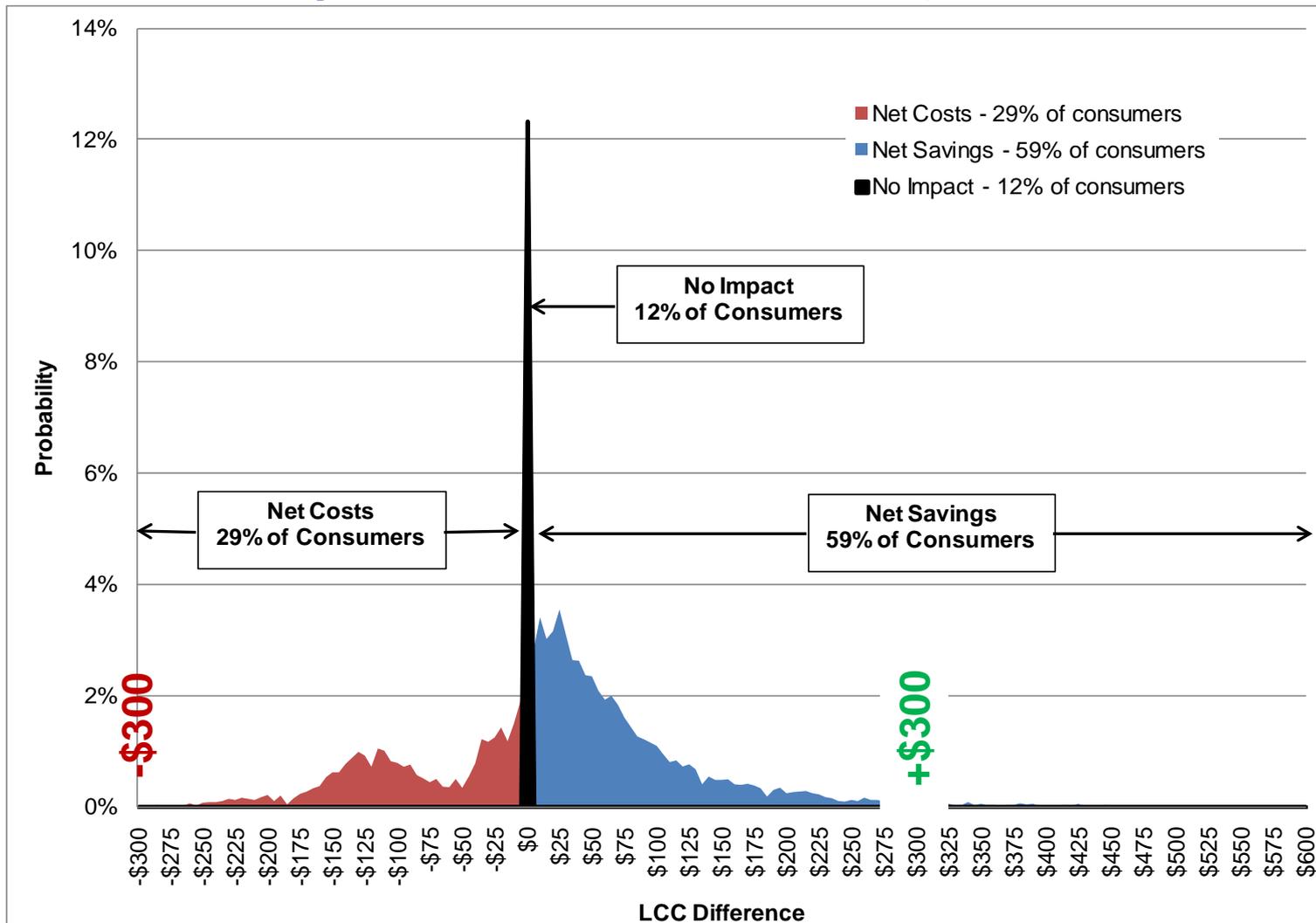
Average standards, % change, effective date:

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

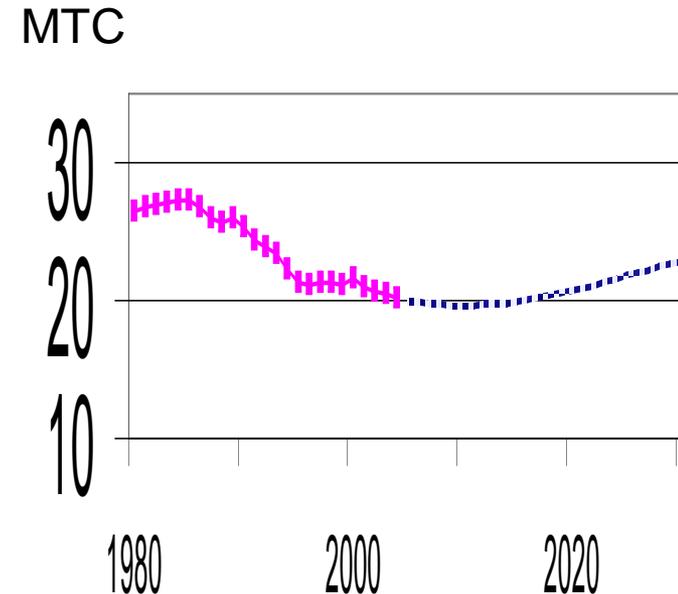


Average
LCC =
\$3,236
(2009\$)

CO₂ Emissions Declined



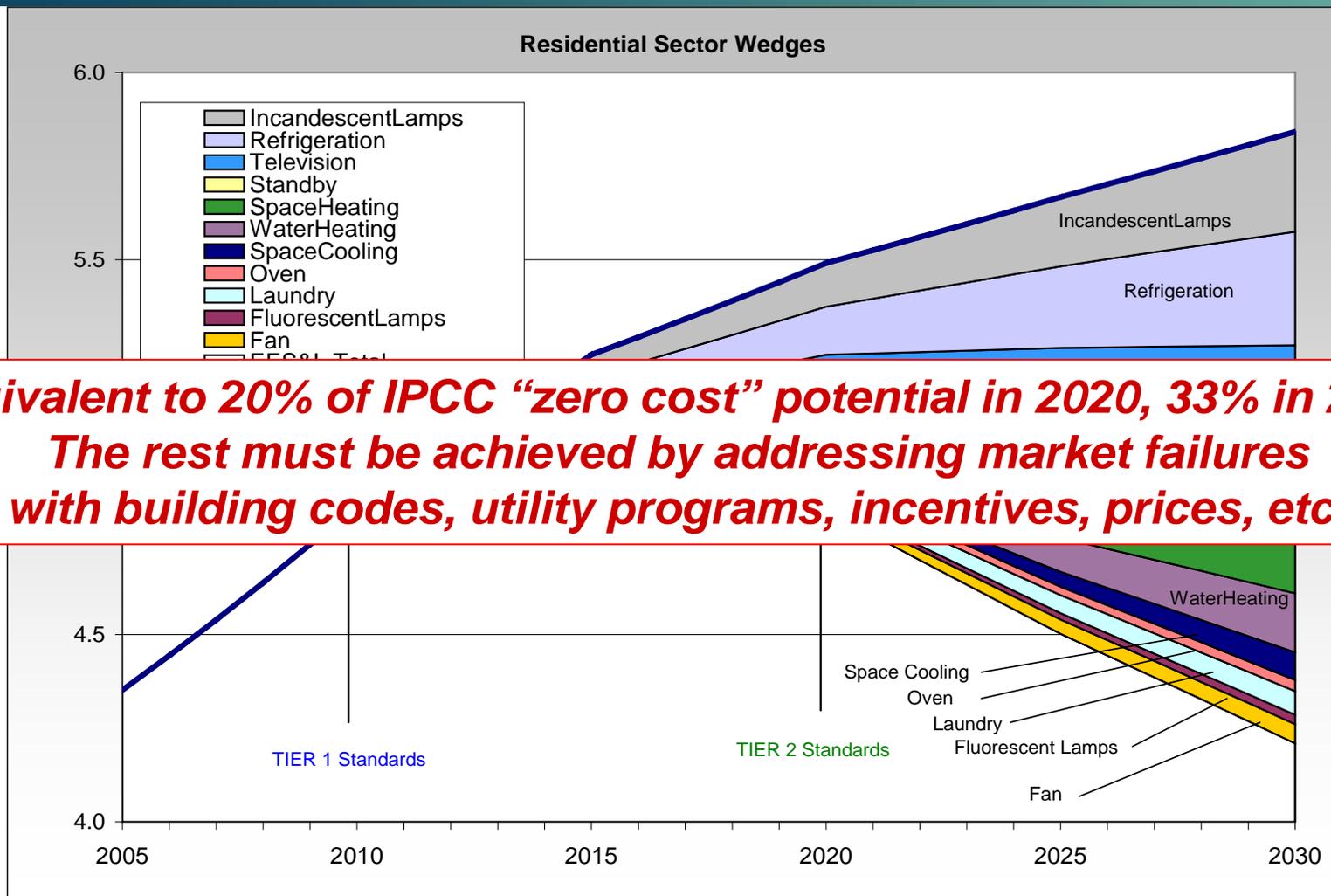
- Absolute amount of energy consumption – ***and carbon dioxide emissions*** – for U.S. household refrigeration decreased



- **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)