UT-BATTELLE

Energy Efficiency: How Big a Role Can It Play?

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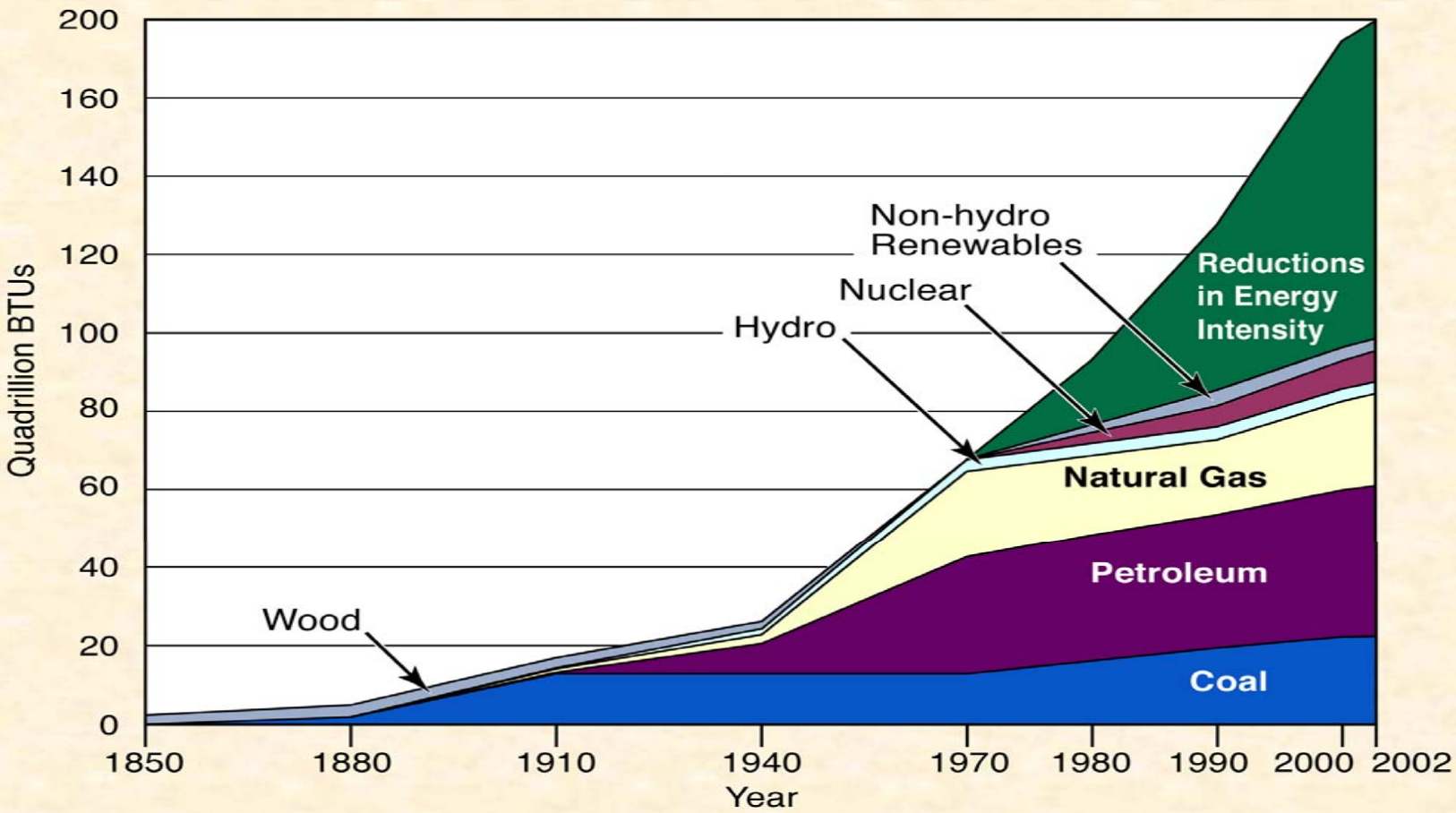
The Context

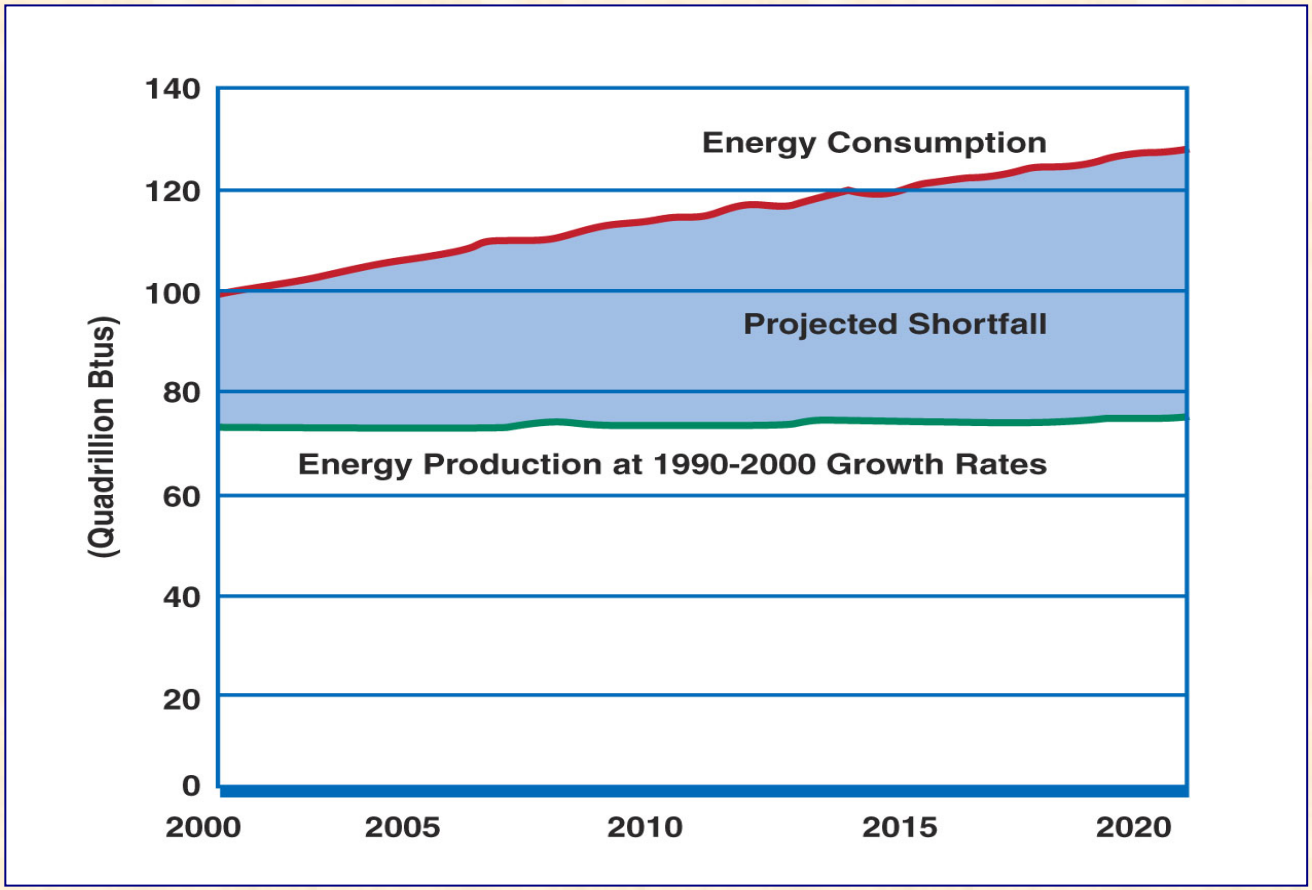
- **The United States and the World face enormous energy challenges**
- **Using energy more efficiently can help to address each of these**
  - **Allows energy resources to stretch further**
  - **Enhances energy security and reliability**
  - **Strengthens the economy**
  - **Protects global environment and public health**
- **The question is: How big a role can energy efficiency play?**

Energy efficiency in the U.S. has played a significant role



Source: *EIA Annual Energy Review 2003*, Table 1.3

U.S. Energy Supplies are Inadequate to Meet the Nation's Future Needs



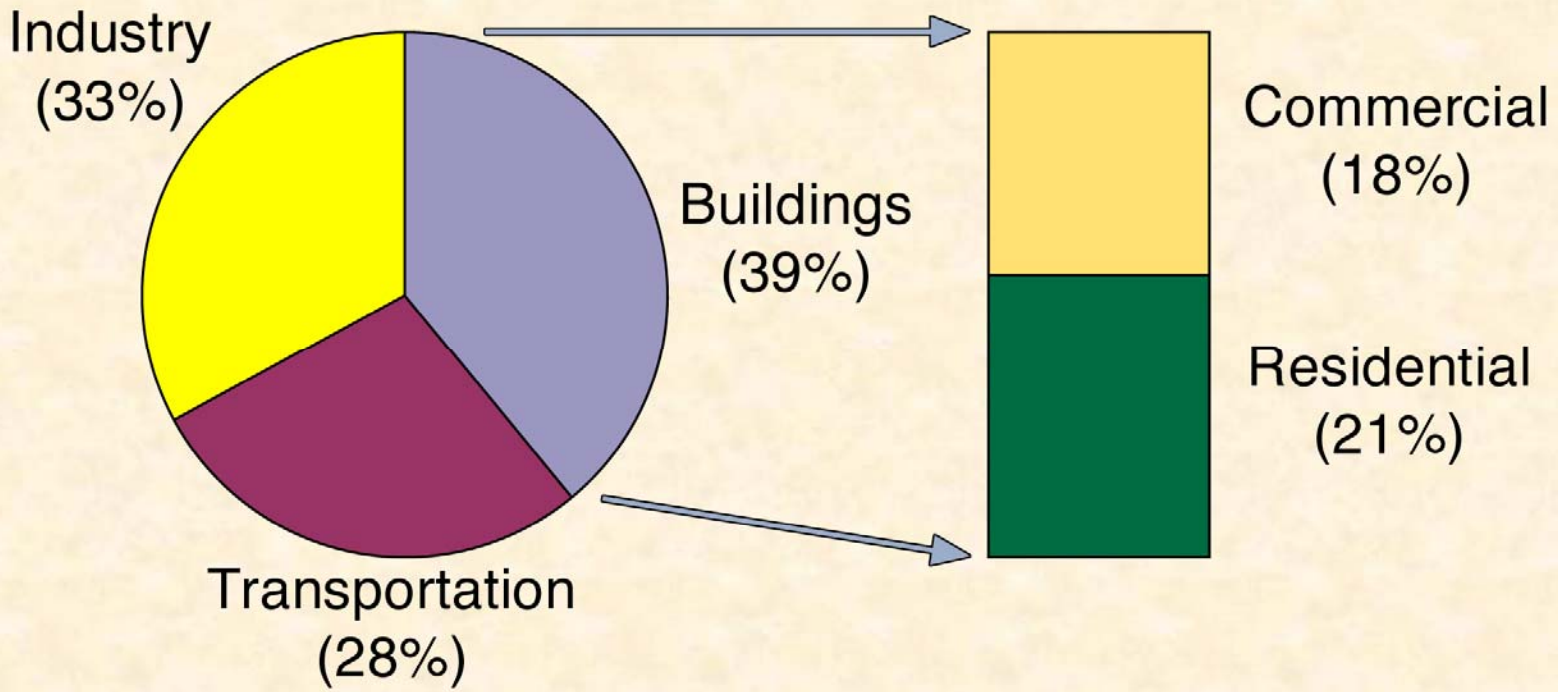
Assuming an annual growth rate of 1.5%:

~40% increase by 2025
~4.4X increase by 2100

With a 0.75% growth rate:

~16% increase by 2025
~2.1X increase by 2100

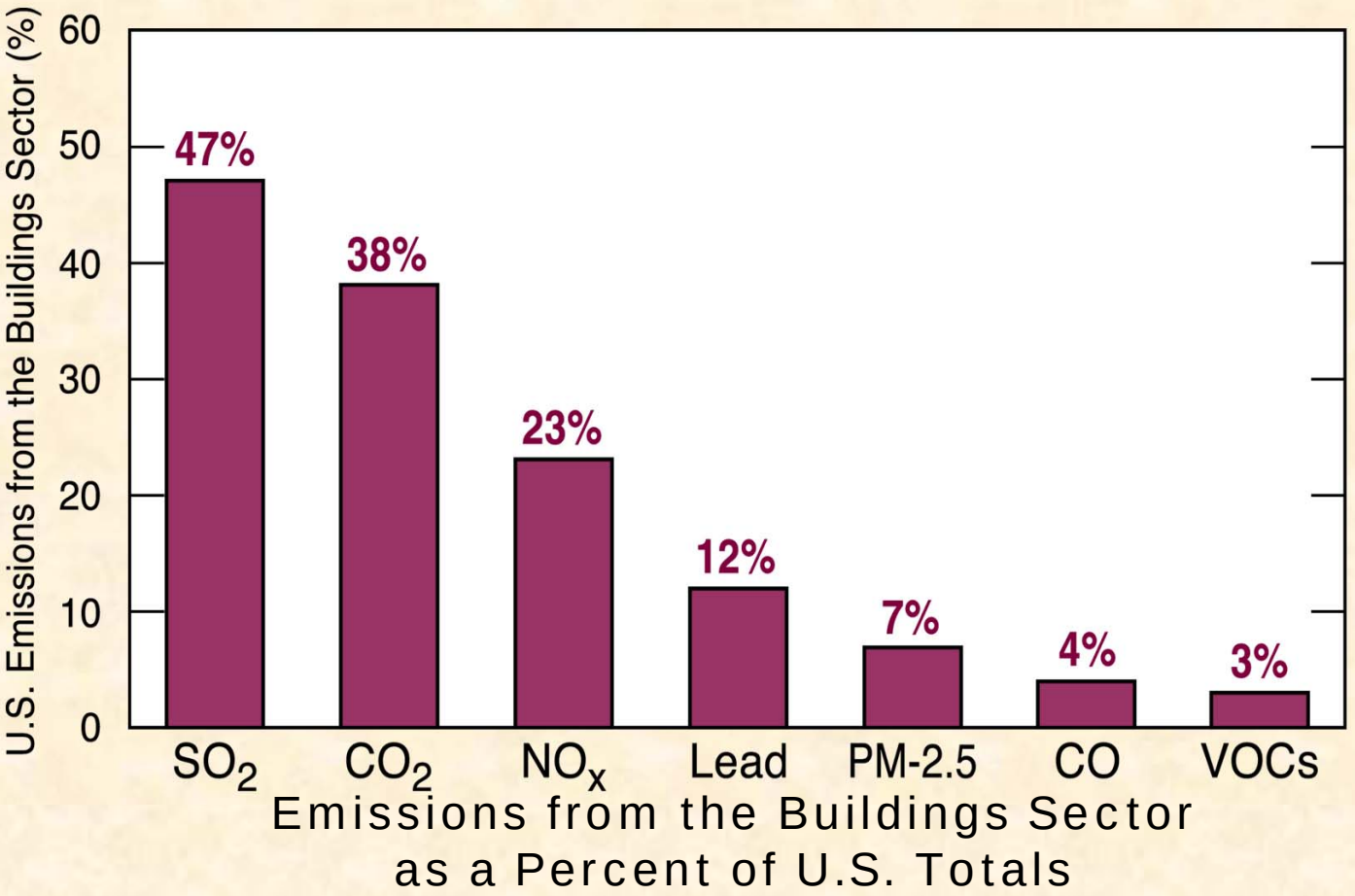
Energy Efficiency Improvements are Needed in Every Sector



U.S. Energy Consumption by Sector: 2002

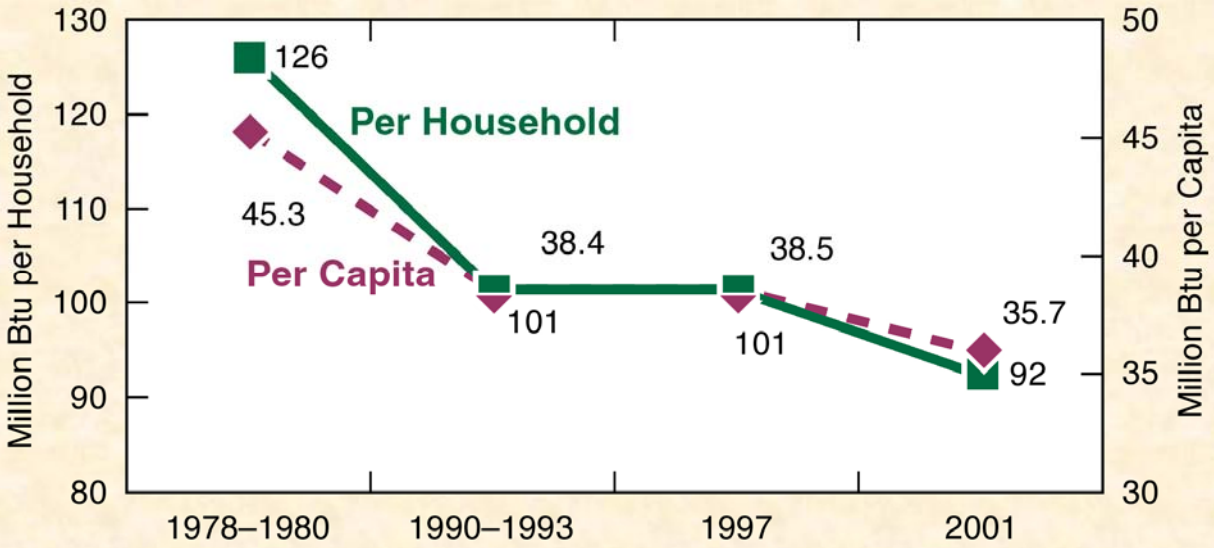
Source: EIA, *Annual Energy Outlook 2004,* Table A2

Energy efficiency in buildings is especially key to environmental protection



Building energy use has increased less than half the GDP since 1972

- **Since the late 1970s, residential energy use has declined 27% per capita (37% per household)**
- **Commercial energy use has declined 25% per square foot**



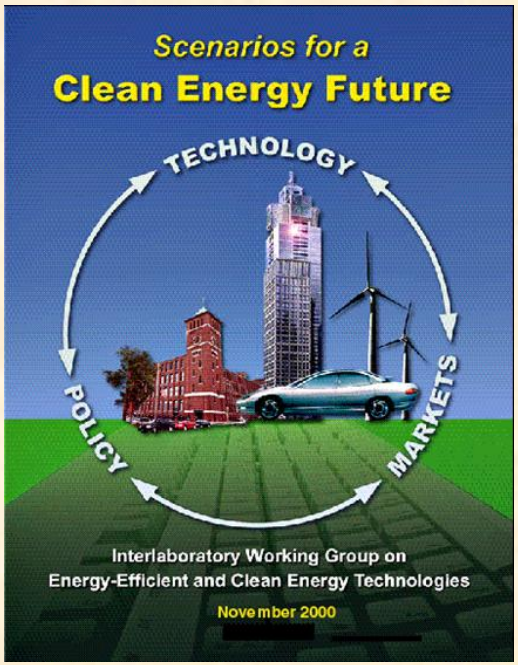
Technology improvements in buildings over past 30 years have been significant

- **Electronic ballasts and low-E windows had yet to be invented in 1970**
- **New refrigerators today use three-quarters less energy**
- **Horizontal-axis clothes washers are 50% more efficient**
- **Electronic equipment has achieved order-of-magnitude efficiency gains every 2 to 3 years**
- **Typical levels of insulation have increased:**
  - In walls from R-11 to R-13
  - In ceilings and attics from R-19 to R-30
- **Ozone-depleting CFCs have been replaced in foam insulation and refrigerants**

Remaining opportunities are enormous

- **Less than 40% of new window sales are low-E and gas-filled**
- **Only 30% of commercial buildings have roof insulation and fewer have insulated walls**
- **Reflective roofing materials comprise less than 10% of the roofing market**
- **Asphalt comprises 95% of urban pavements**
- **Design tools for energy efficiency are used by <2% of professionals involved in the design and construction of commercial buildings**

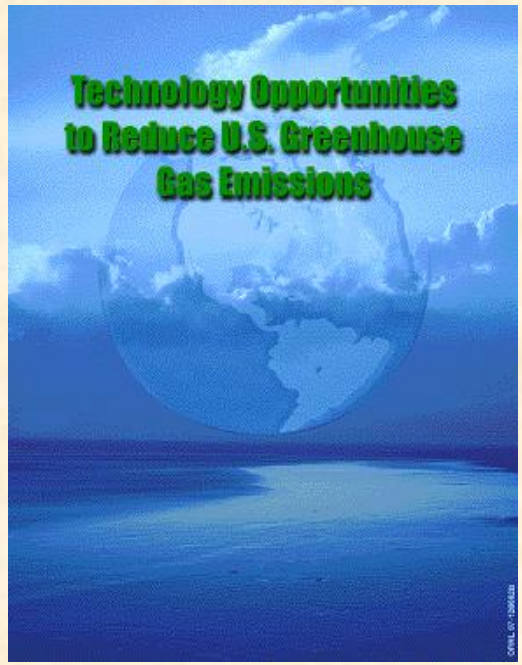
Numerous studies have detailed the potential for improved energy efficiency



www.ornl.gov/eere/CEF
/index.htm

Technology Options for the Near and Long Term (2003)
www.climatetechnology.gov

The 10-50 Solution: Technologies and Policies for a Low-Carbon Future
www.pewclimate.org



www.ornl.gov/~webworks/cppr/y2003/rpt/110512.pdf

U.S. energy models have historically underestimated energy efficiency

- **Five projections in early 1980s of U.S. energy forecasts, 1982-2000 were reviewed***
- **Energy demand median error for year 2000 was –5.2%**
- **This suggests a serious underestimation of past technological change and energy efficiency improvements**

*Alan H. Sanstad, John A. “Skip” Laitner, and Jonathan G. Koomey, “Back To The Future: Long-Range U. S. Energy Price And Quantity Projections In Retrospect,” Lawrence Berkeley National Laboratory, June 2004 (in revision).

In the short-term, markets for existing "best practices" can be transformed

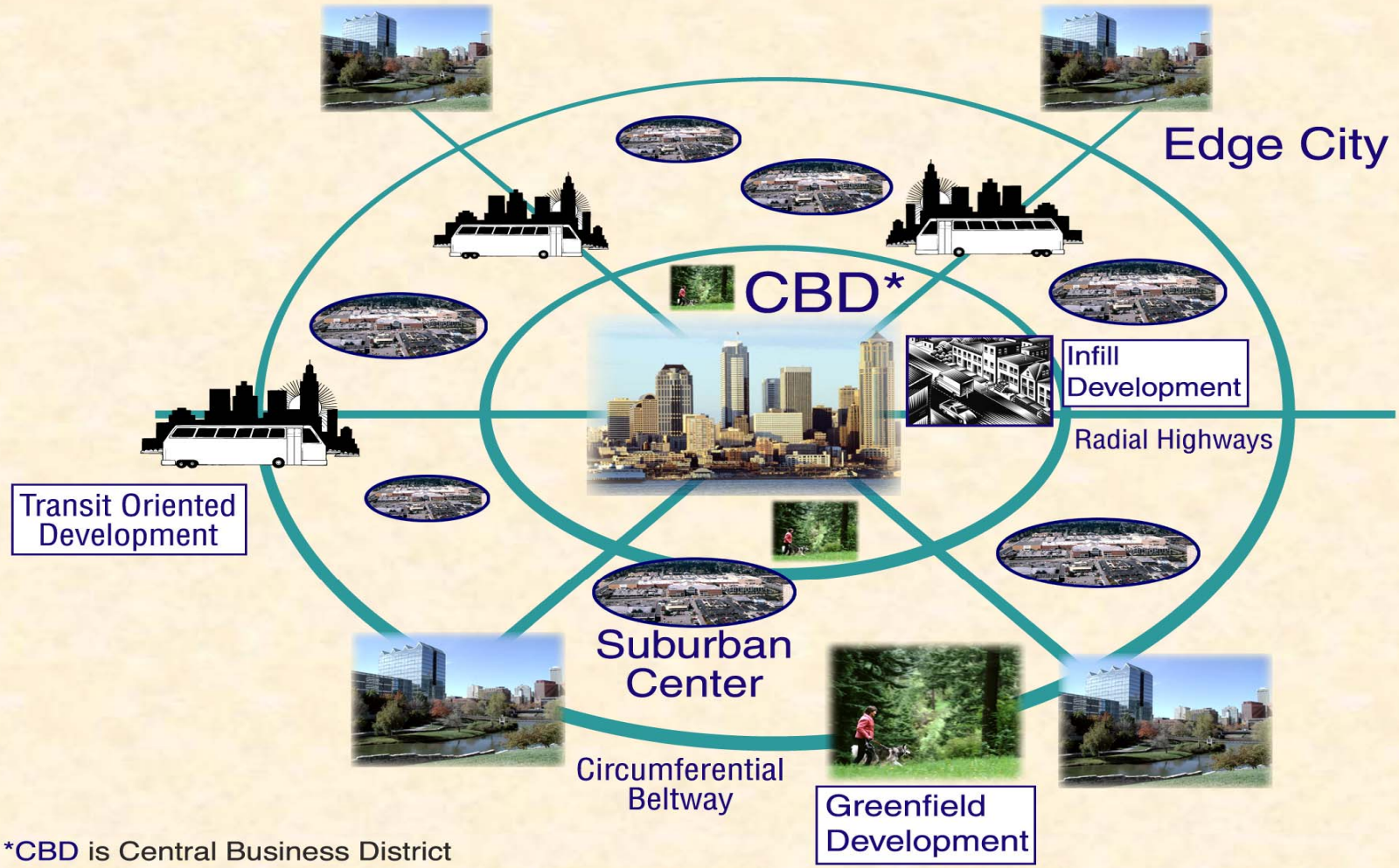
- ***Natural Gas Price Effects of Energy Efficiency and Renewable Energy Practices and Policies*** **by Neal Elliott, et al. (2003) (http://aceee.org)**
  - **by 2008 the U.S. could reduce:**
    - **electricity consumption by 3.2%**
    - **natural gas consumption by 4.1%**
- ***California's Secret Energy Surplus: The Potential for Energy Efficiency*** **by Michael Rufo and Fred Coito (2002) (www.Hewlett.org)**
  - **estimates that CA has an economic energy potential of:**
    - **13% of total base electricity usage in 2011**
    - **15% of total base demand in 2011**

By the mid-term, new breakthrough technologies can be developed

- **Lightfoot and Green (2002)* estimate a maximum 1% decline in energy intensity through 2100:**
  - Upper limits on attainable energy efficiency:
    110 mpg for vehicles
    50% efficiency for combined heat & power
- **Laitner (and others) suggests that energy intensity reductions of 2% annually are possible, considering:**
  - Advanced technologies and
  - Policies that affect transportation modes, land use patterns, and distances traveled

***Energy Intensity Decline Implications for Stabilization of Atmospheric CO2 Content,* ww.mcgill.ca/ccgcr/**

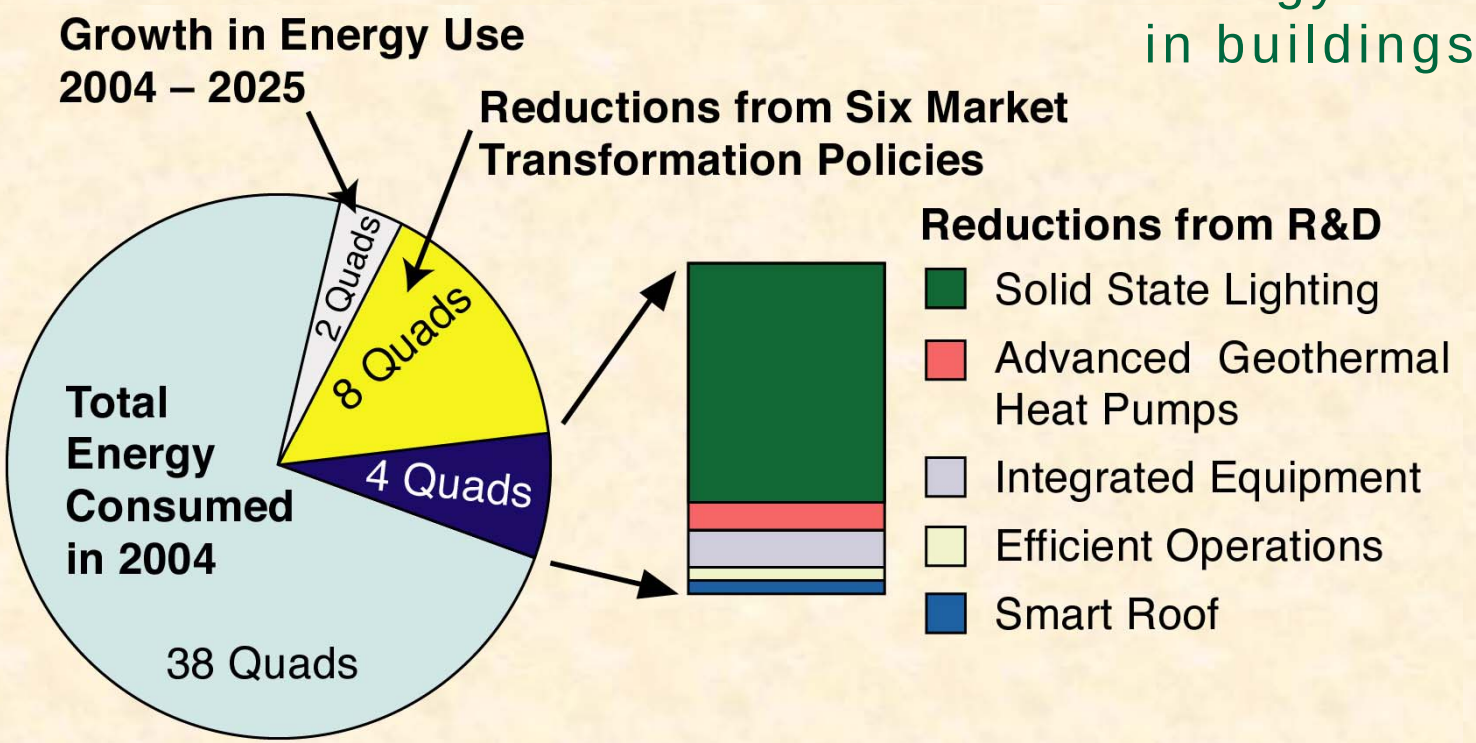
In the long run,“smart growth” could significantly reduce energy needs of cities



*CBD is Central Business District

Consider the preliminary results of a study for the Pew Center

In 2025, 12 Quads of energy could be saved in buildings



52 Quads Buildings Sector Energy Use in 2025

*Marilyn A. Brown, Frank Southworth, and Therese K. Stovall, *Toward A Climate Friendly Built Environment,* August 2004 (draft)

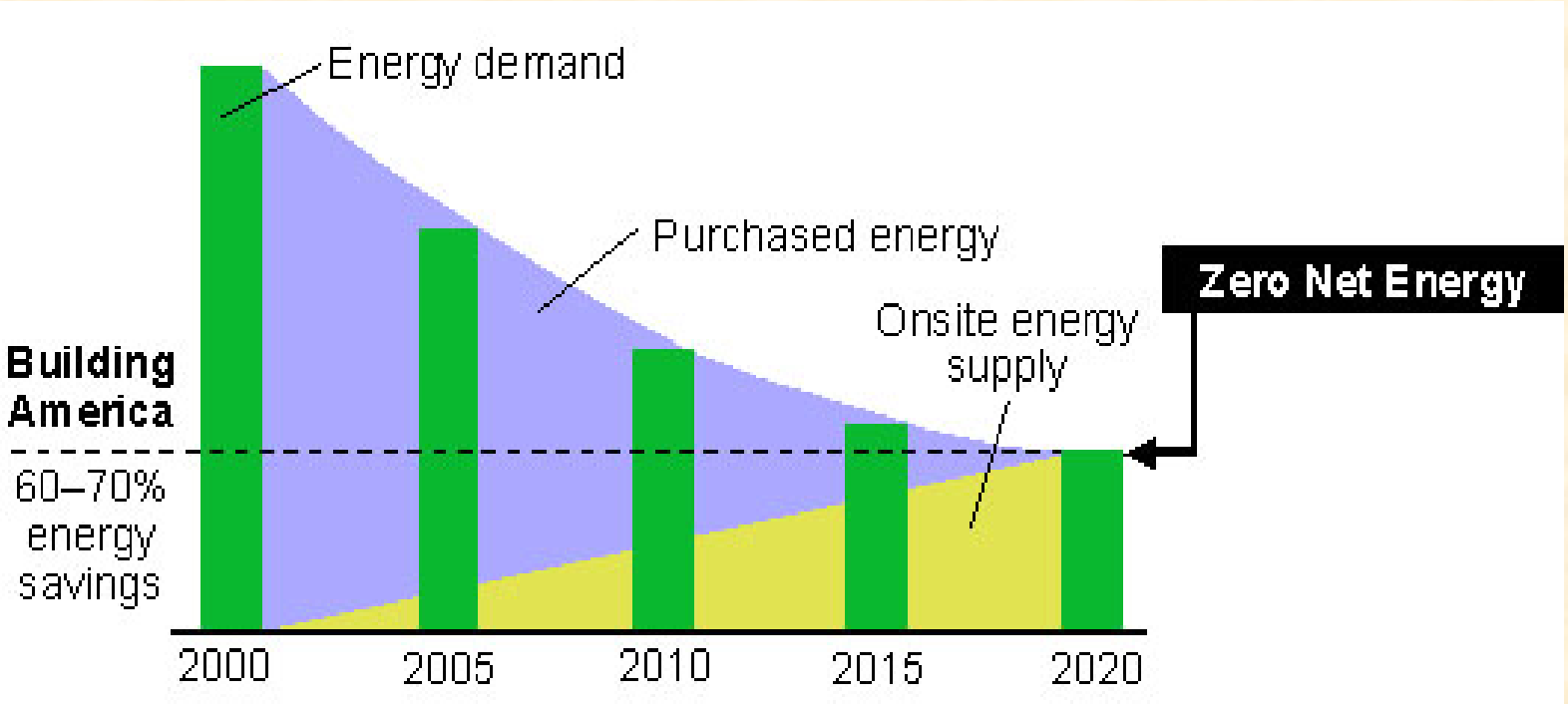
Six Market Transformation Policies were Studied:

- **Building codes**
- **Appliance standards**
- **Utility-based financial incentive programs**
- **Weatherization Assistance**
- **Energy Star® Program**
- **Federal Energy Management**

Five Breakthrough Building Technologies were Examined:

- **Solid state lighting** (uses the emission of semi-conductor diodes to directly produce light)
- **Advanced geothermal heat pumps** (selective water sorbents that greatly reduce the cost of geothermal heat pumps)
- **Integrated energy equipment** (integration of multiple energy services into single pieces of equipment)
- **Efficient operations technologies** (abundant sensors dispersed through buildings with continuously recommissioning control devices)
- **Smart roofs** (nano-technologies that change the reflectance and infra-red emissivity of roof materials as a function of temperature)

The United States is Striving for "Zero Net Energy" Homes by 2020



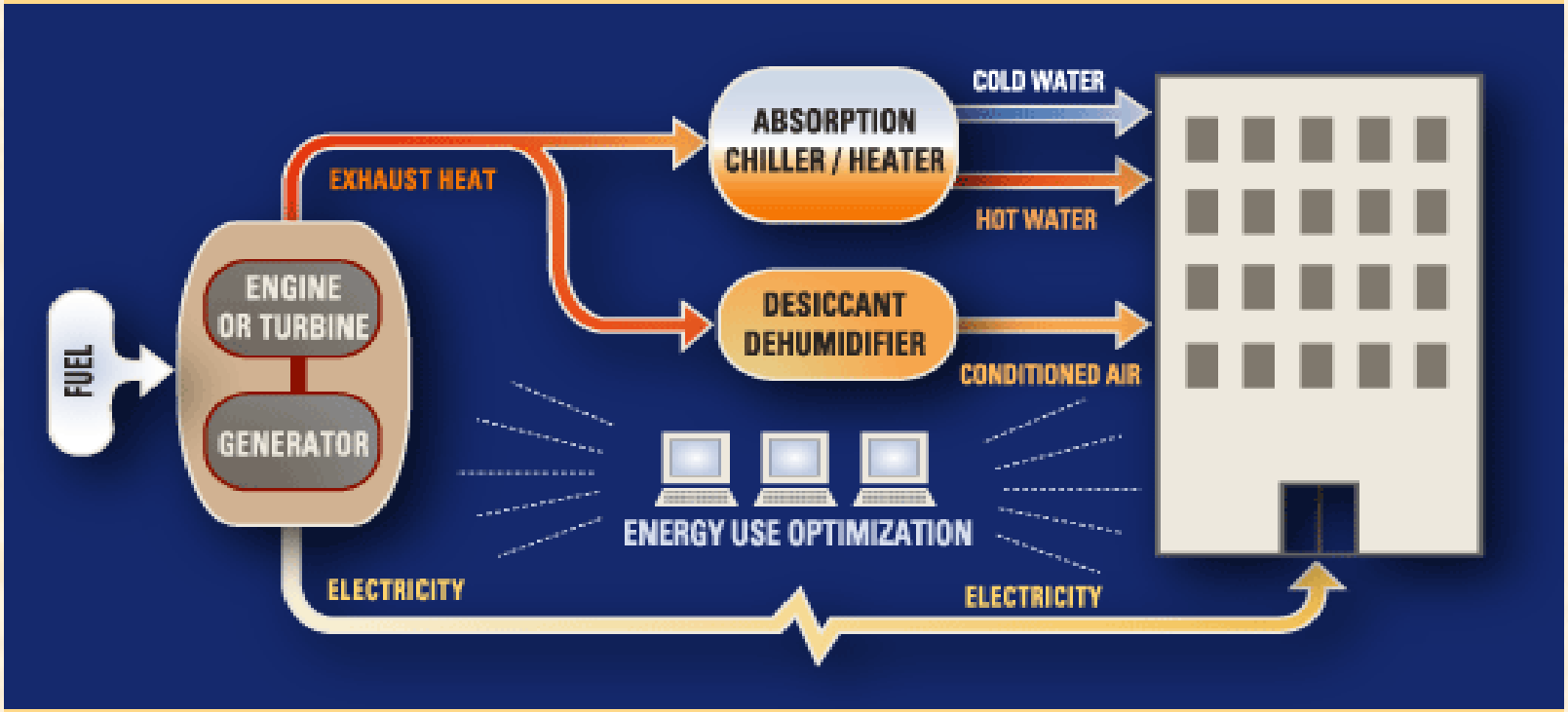
Near "Zero Net Energy" Homes are Being Built Today

- **Advanced energy technologies being researched with Habitat for Humanity**
  - **Integrated heat pump water heaters**
  - **High velocity ducts**
  - **Structural insulated panels**
  - **Photovoltaics & GHPs**
- **Annual heating cost = $92, cooling cost = $74 with ASHP, and hot water cost = $90**
- **82 cents per day for total energy including plug loads**

Sponsors: DOE's Building America Program, TVA, and industry partners

CHP by 2015: Integrated Energy Systems Is a Key to Cost-Effectiveness

- **$500 / KW**
- **80%+ system efficiencies**

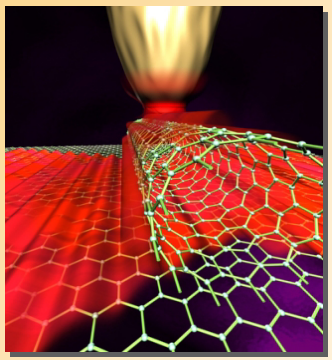


Science will continue to enable new solutions

New energy technologies

Science to meet national energy needs

Nano



Manipulating atoms

Bio

DNA to living organisms

Info

PCs to petaflops

Renewable Energy & Energy Efficiency Need to be Promoted Worldwide