The Energy Crisis
A Neglected Solution

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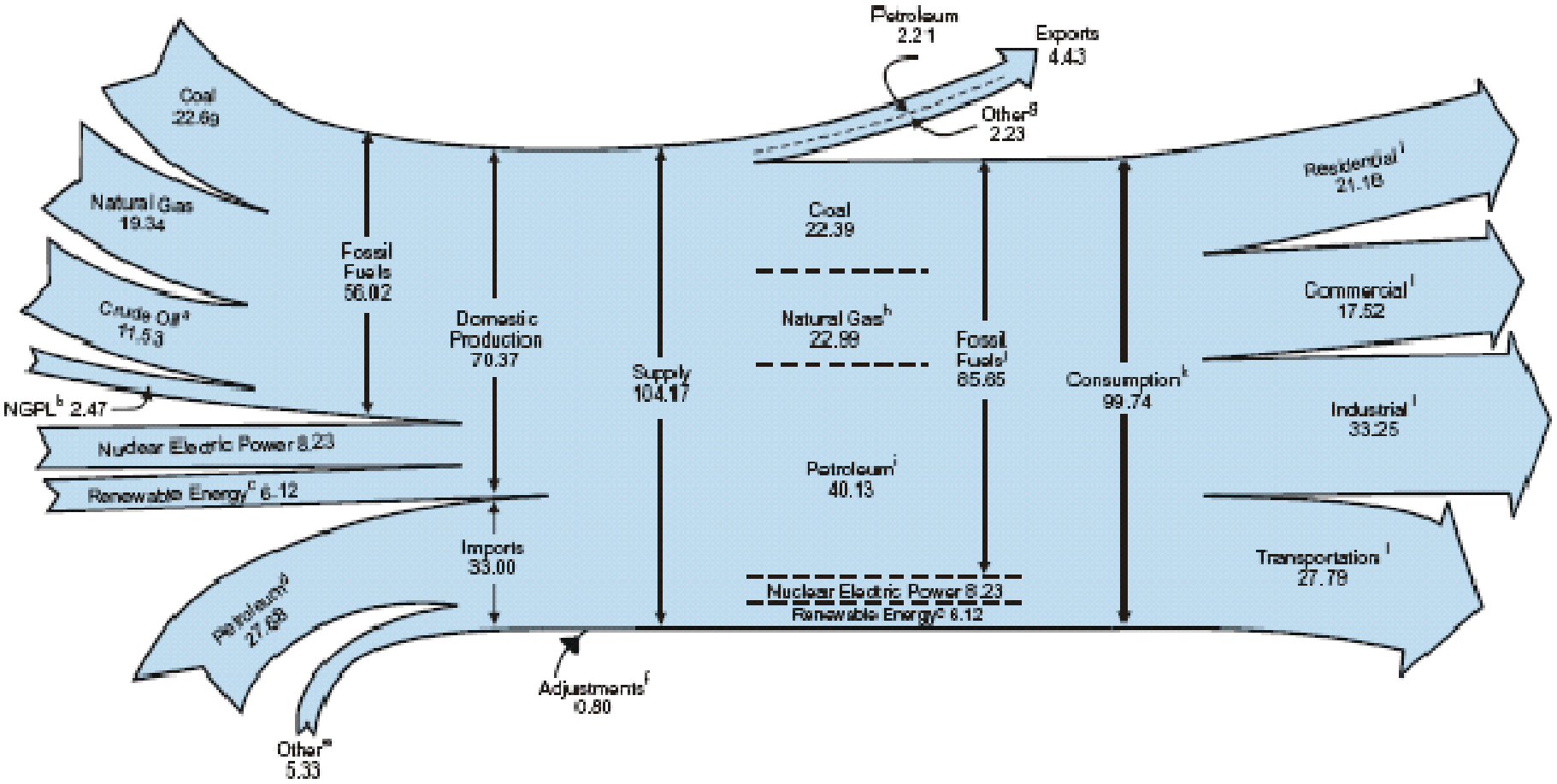
Building Technology Program

December, 2010

U.S. Energy Flow 2004

(Quadrillion BTU)

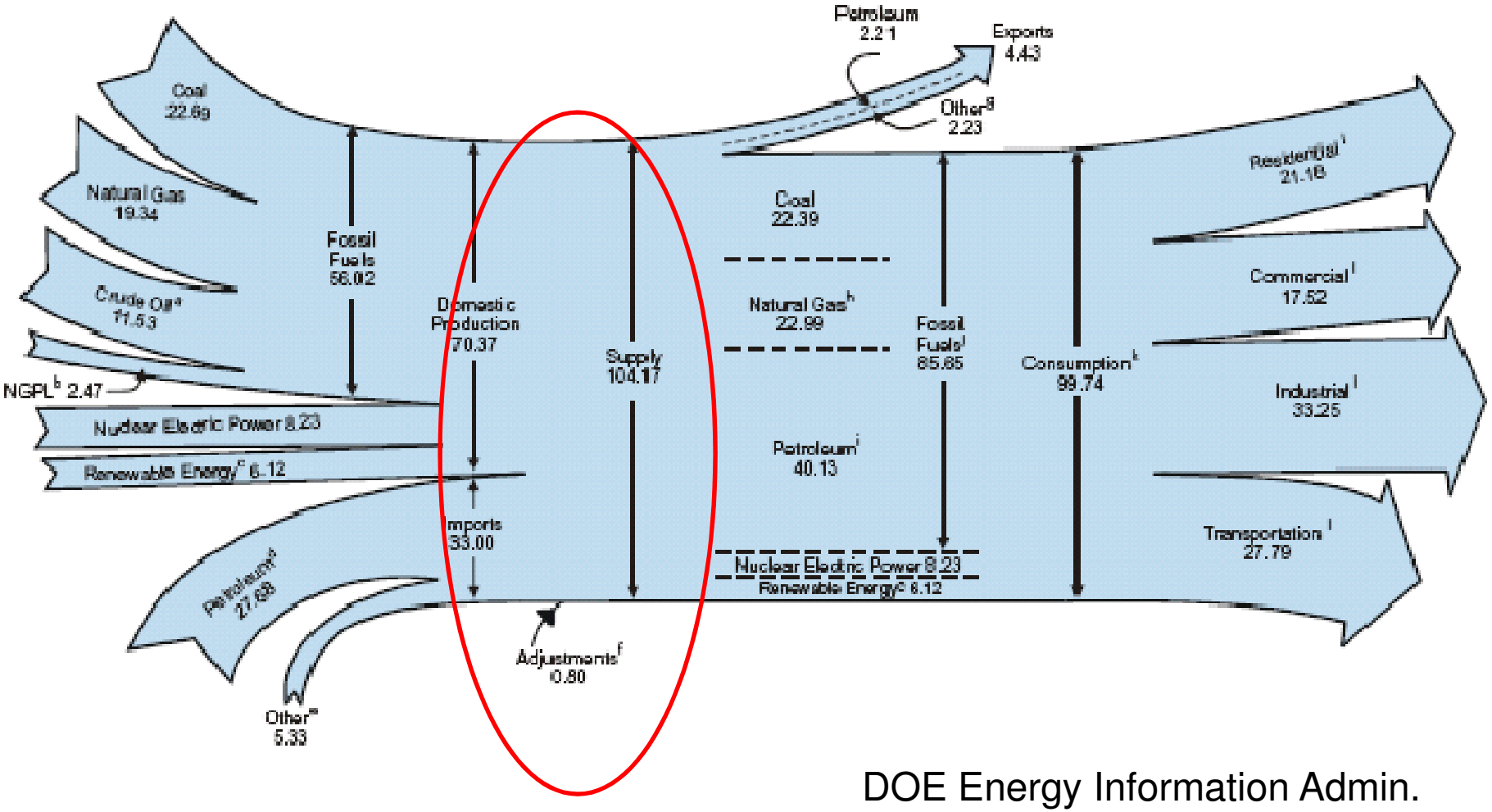


DOE Energy Information Admin.

Solutions?

- Drill in Alaska
- Hydrogen Fuel for Cars
- Renewable Energy Sources
- Nuclear
- Clean Coal
- Energy Efficiency
- Economic Stagnation

U.S. Energy Flow 2004
Traditional Solution Focus



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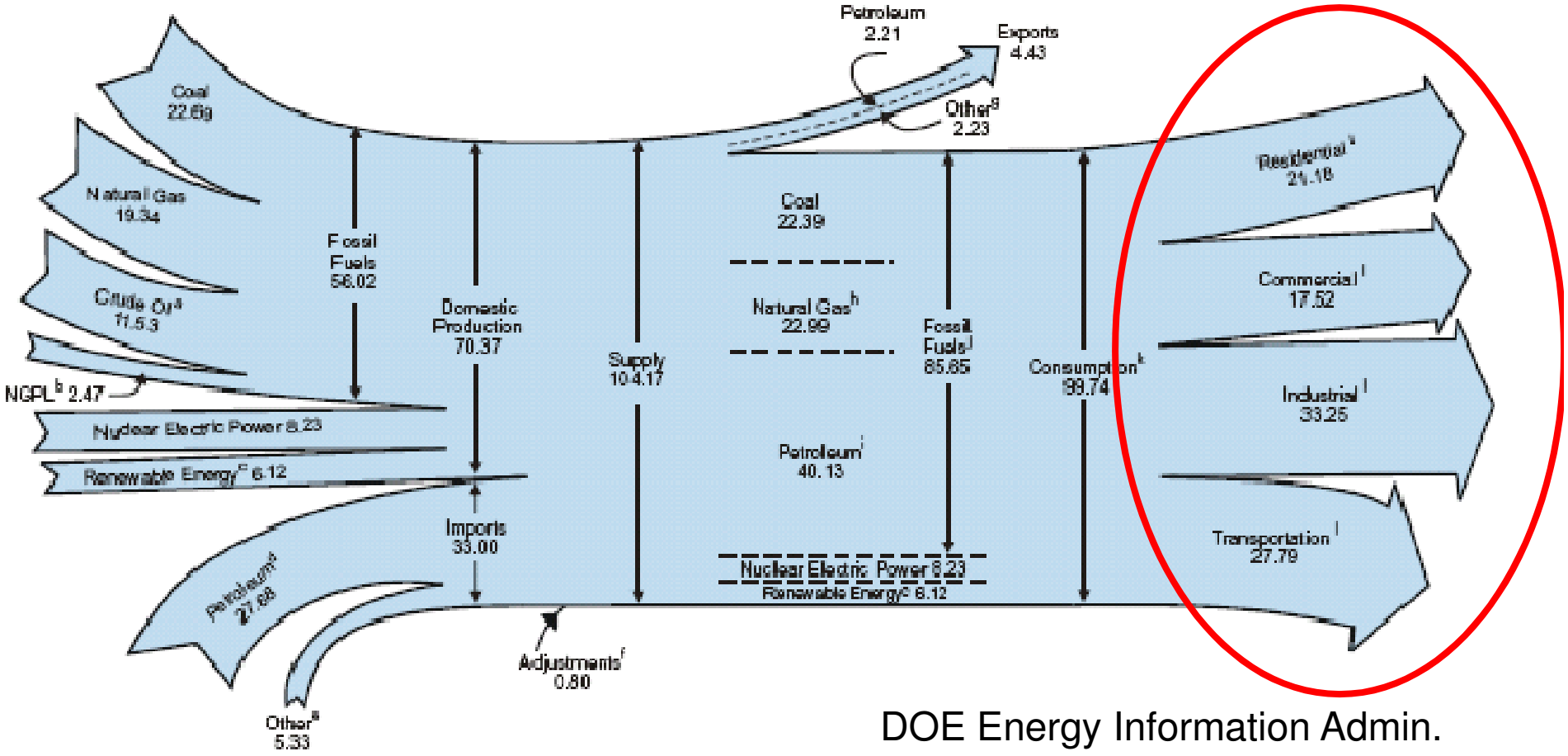
U.S. Energy Flow 2004
Neglected Focus

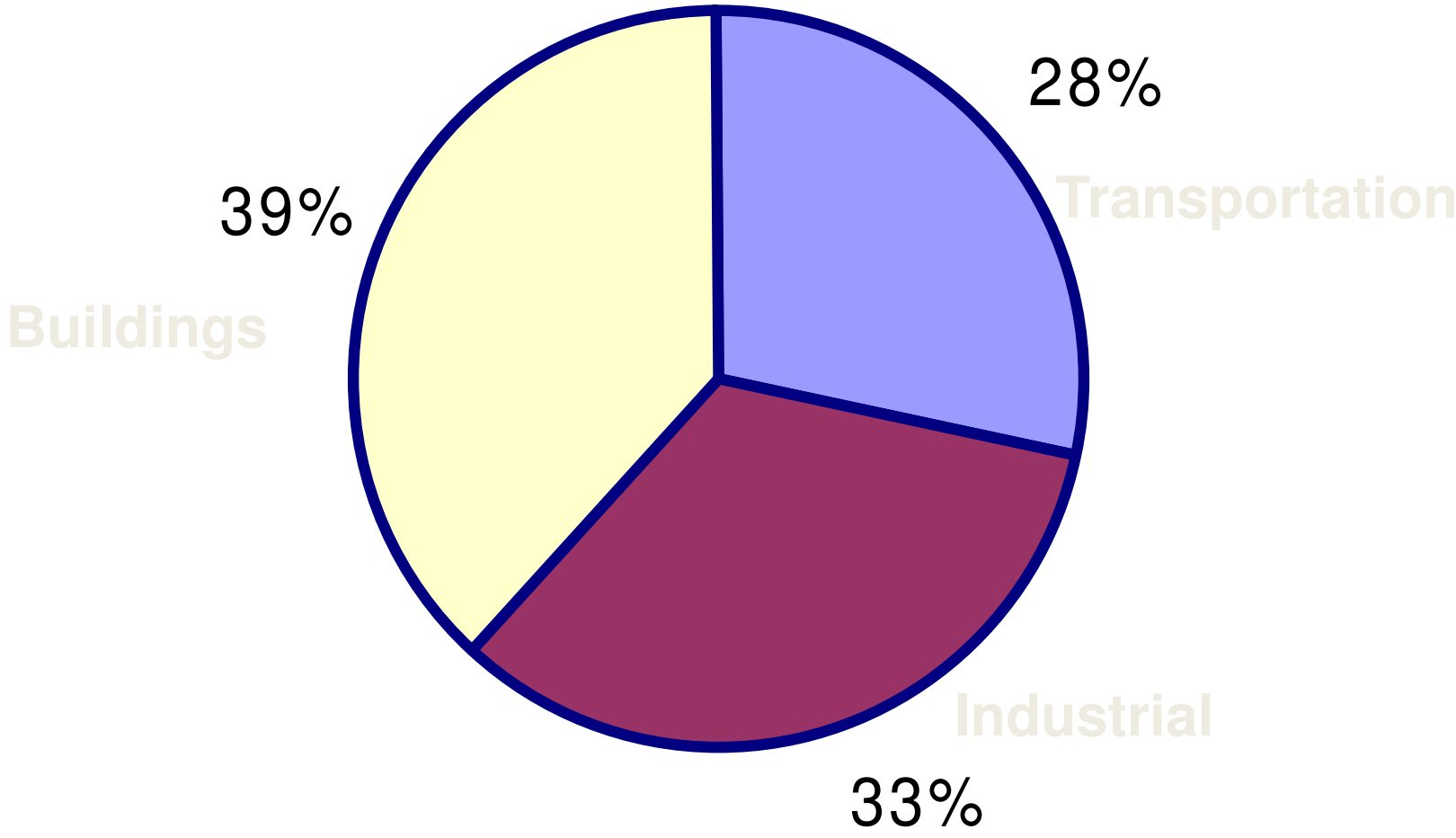


DOE Energy Information Admin.

New York Times
April 6, 2008

“Circles sized according to the amount of energy that sector consumes”

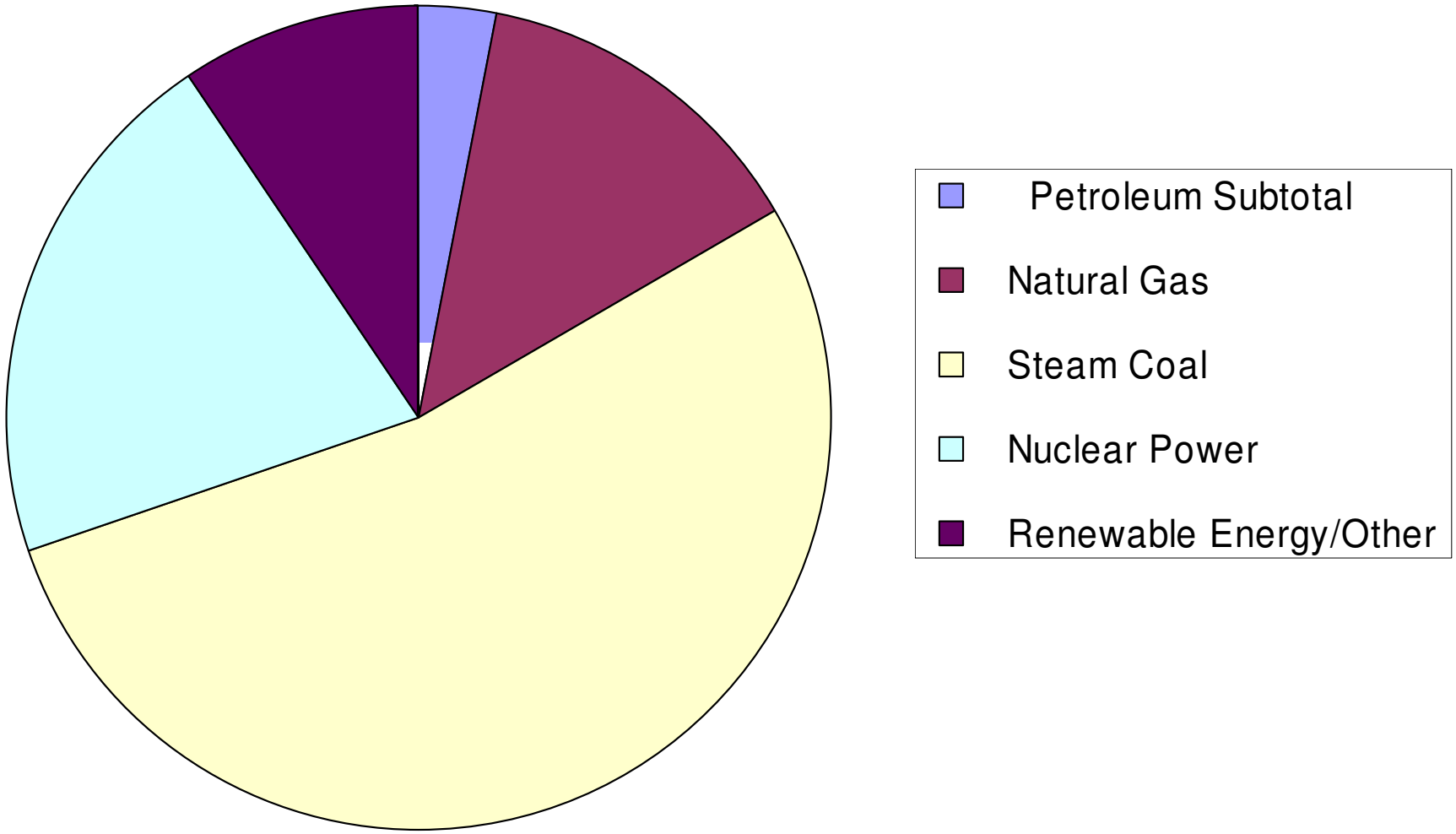
US Energy Consumption



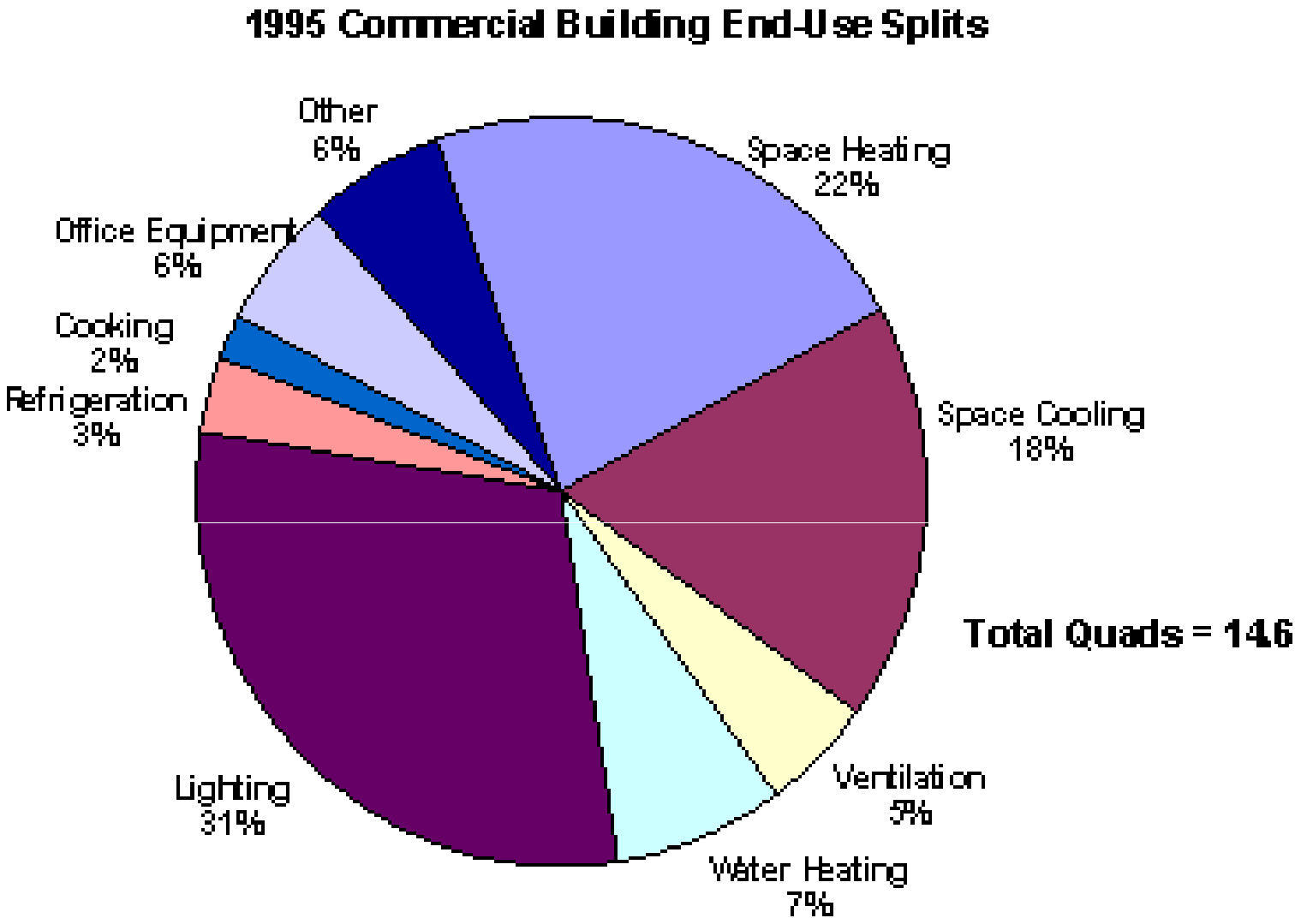
U.S. Buildings

- 38 % of total energy (in UK 50 %)
- 67 % of electricity
- 90% of time spent indoors
- Major health problems: indoor climate

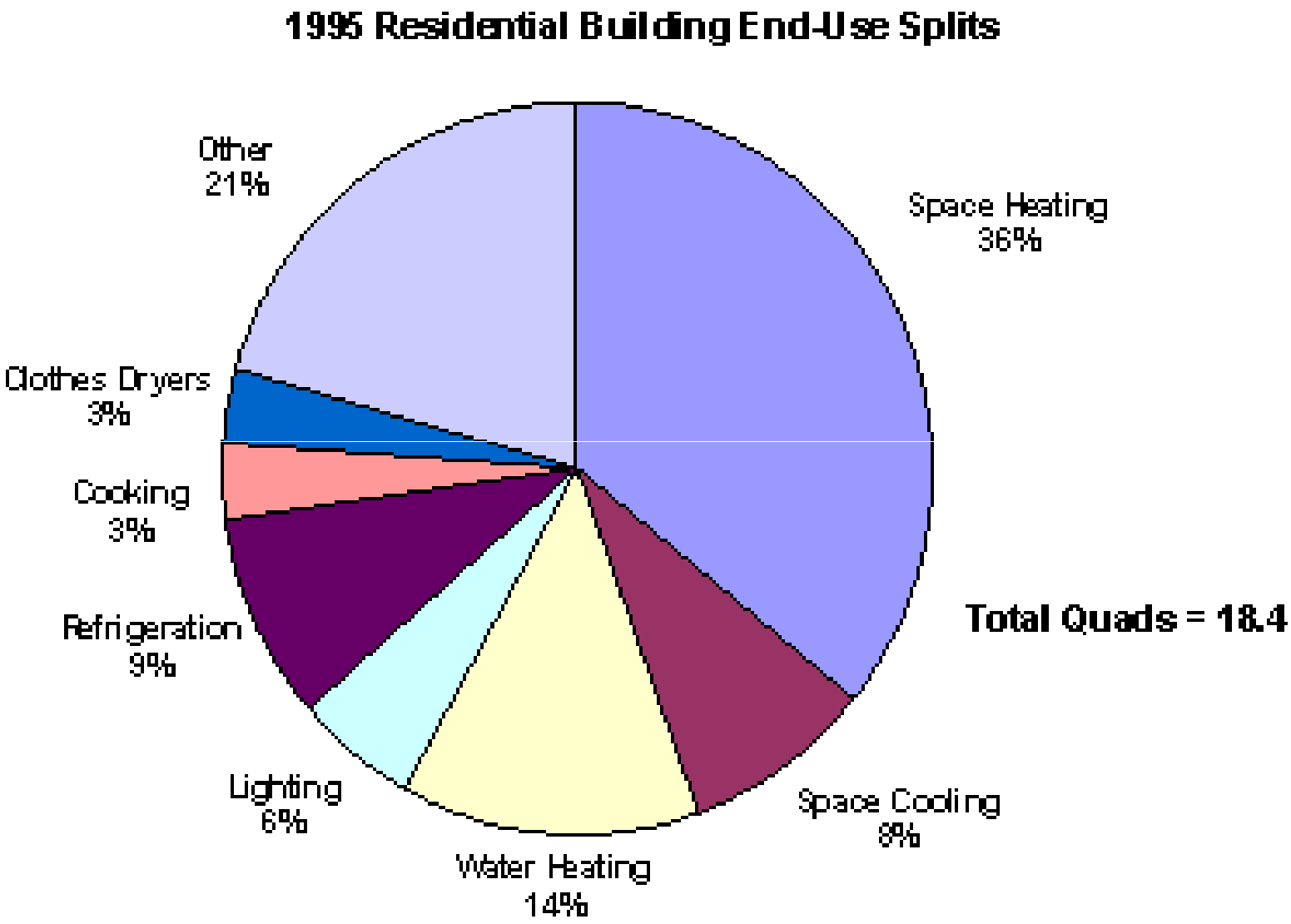
U.S. Electricity Production Energy Sources 2003



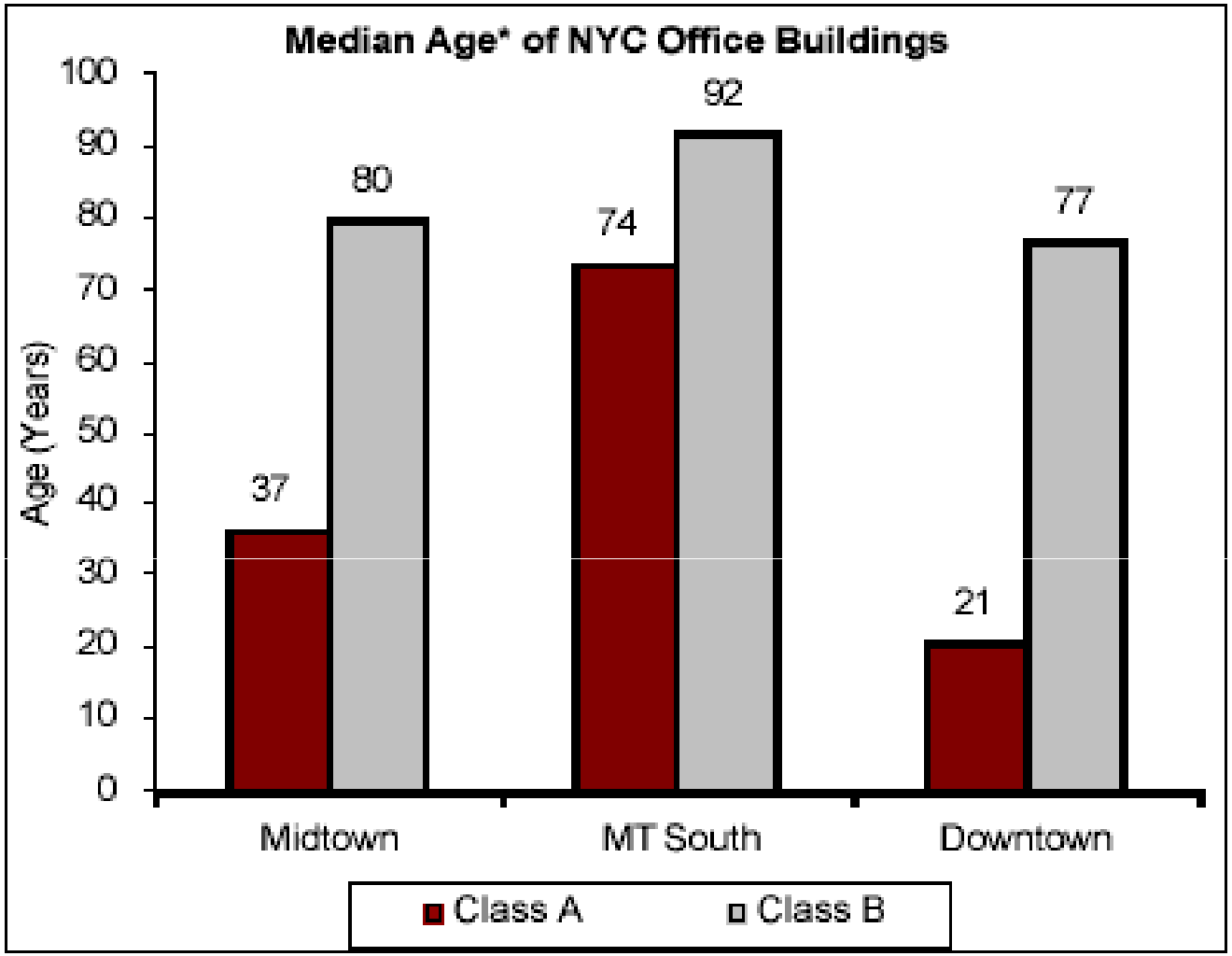
US DOE EIA



1Quad = 10^{15} BTU


1995 Residential Building End-Use Splits
Other
21%
Space Heating
36%
Clothes Dryers
3%
Cooking
3%
Refrigeration
9%
Lighting
6%
Water Heating
14%
Space Cooling
8%
Total Quads = 18.4

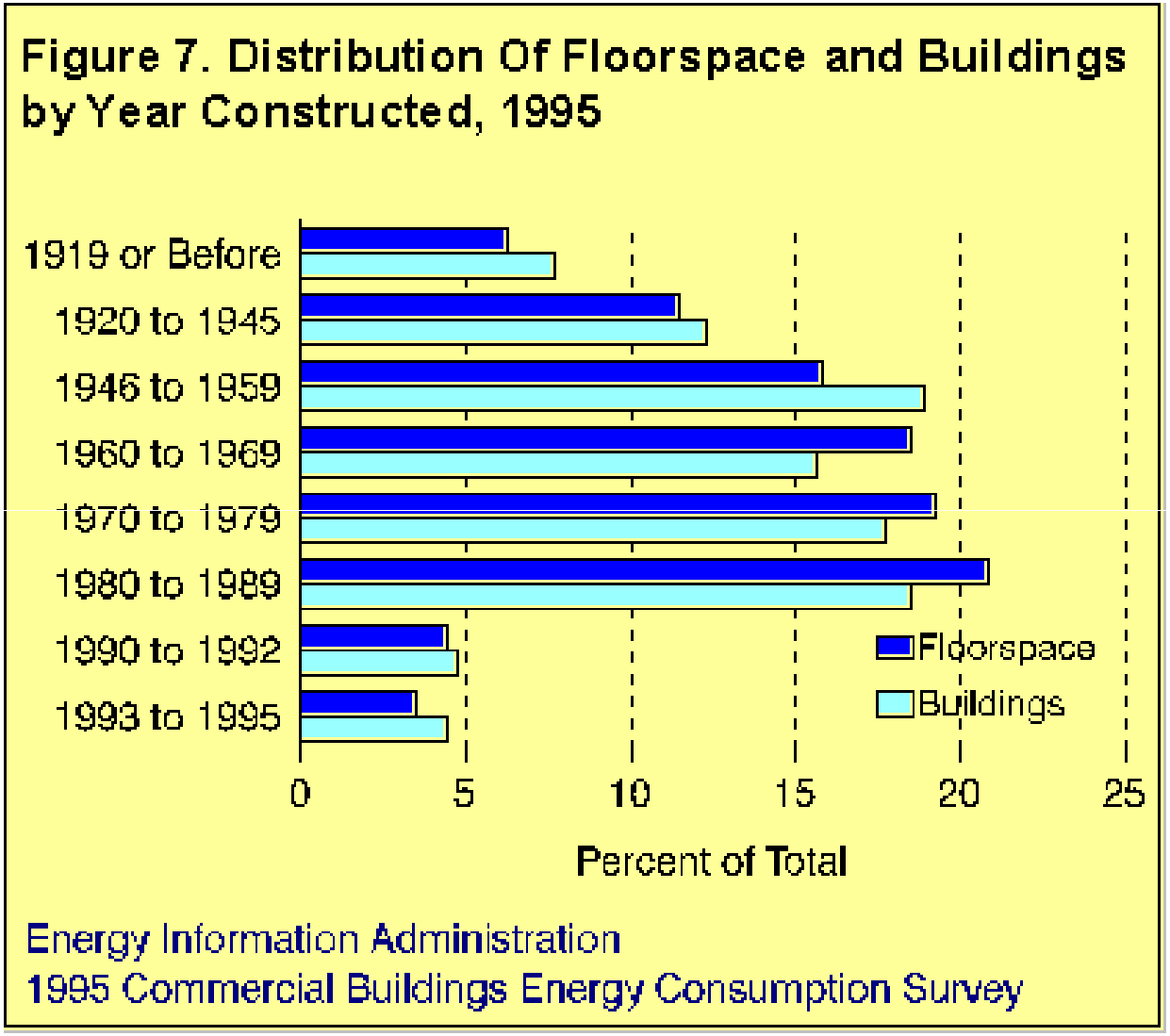
Average Lifetime of Buildings



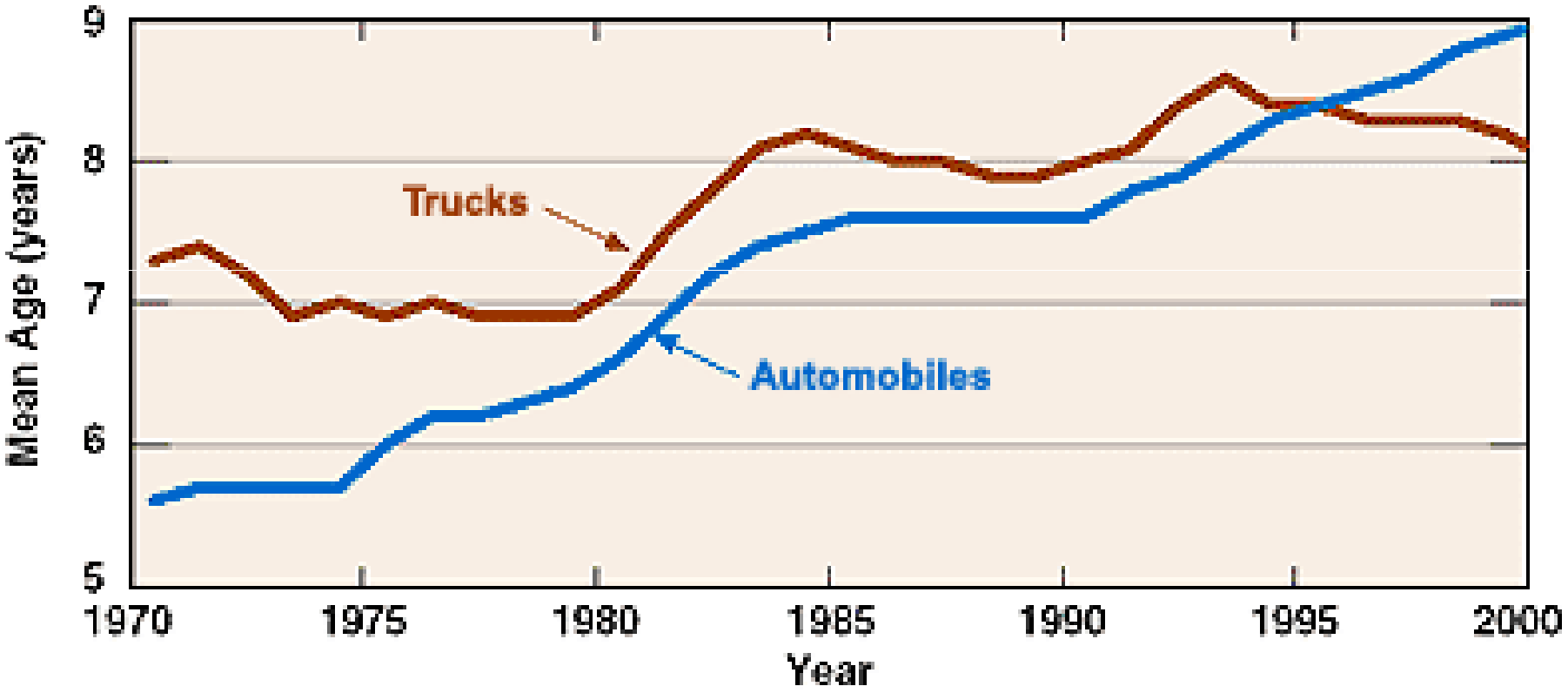
Source: CoStar database, September 2003

*Median Age incorporates building renovation dates as beginning dates of buildings.

United States Commercial Buildings



Average Age of US Cars and Trucks



US Dept of Transportation

“Exudes Green”
vs.
Green Performance

Heritage 2000 Artist's Rendering

Concept drawing of the Ford Rouge Center renovation project removed due to copyright restrictions.

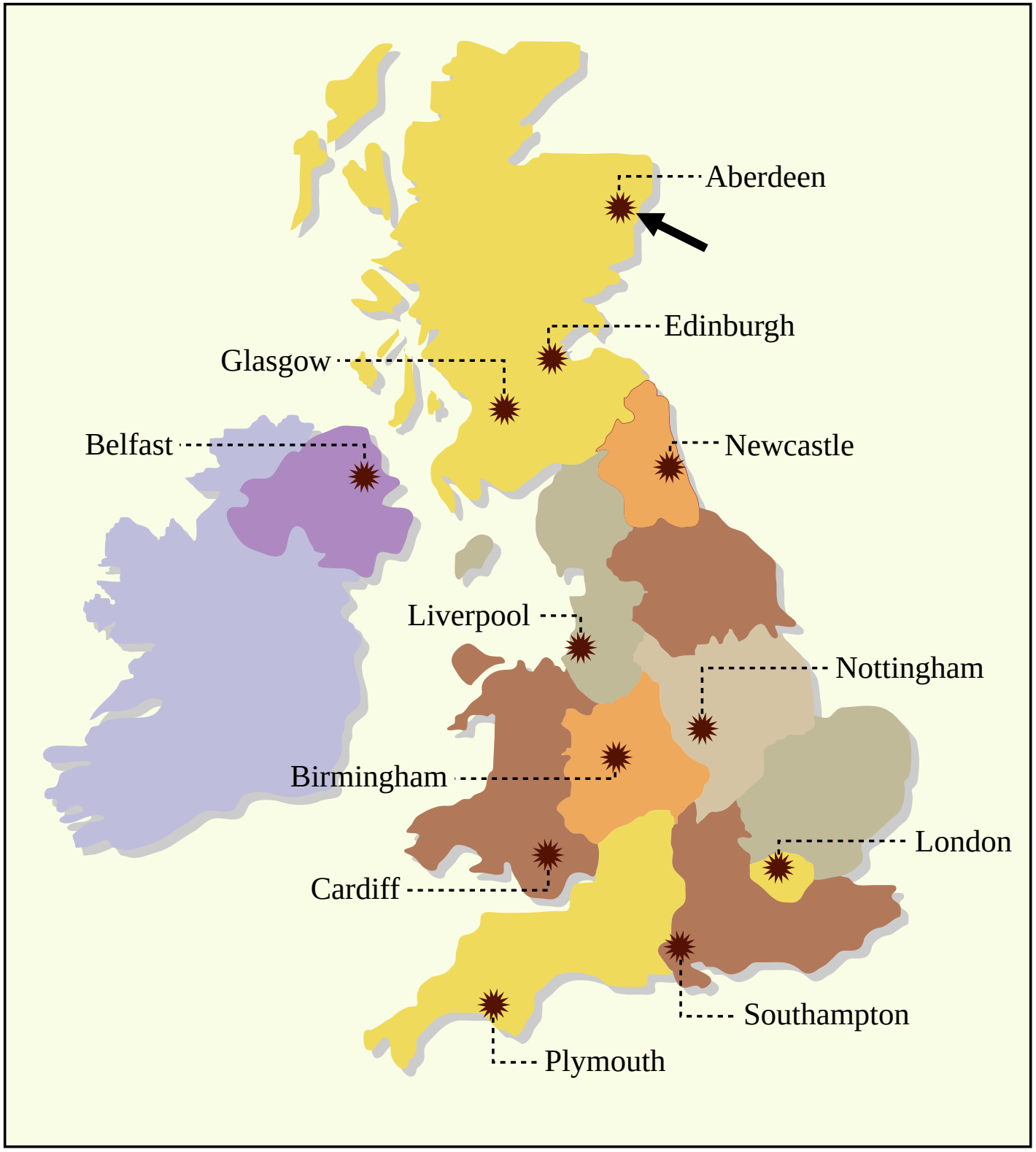
The Conde Nast Building

15 kW of PV

500 kW of fuel cells

Sustainable??

Photo by Rustycale on Wikimedia Commons.



NOW THE WINDOWLESS BUILDING WITH ITS OWN CLIMATE

By C. F. TALMAN.Francis Keally, Architect.
New York Times 1857; Aug 10, 1930; ProQuest Historical Newspapers The New York Times
pg. XX4

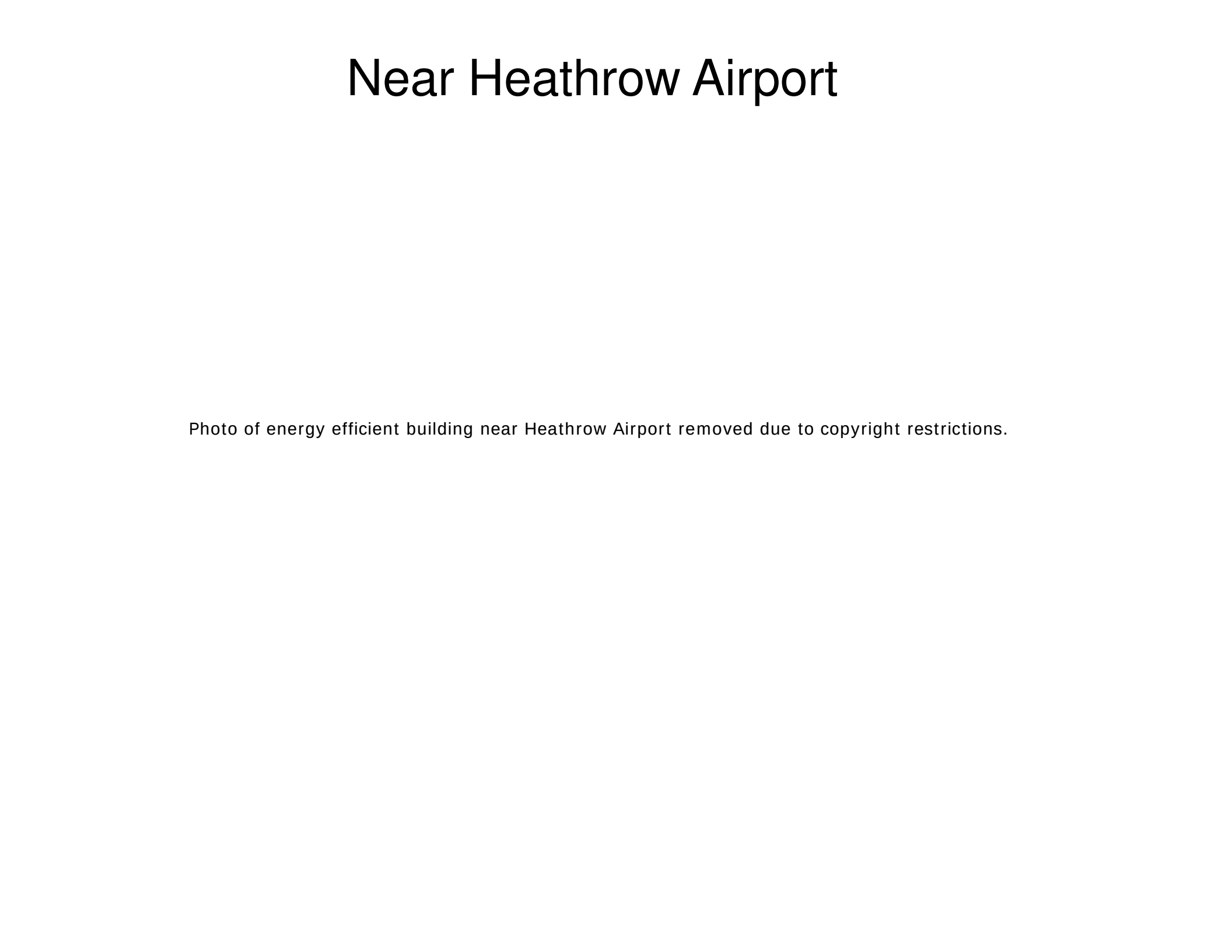
Energy Efficient Copenhagen: Cooled only by Natural Ventilation

Photo of Aston IT headquarters in Copenhagen removed due to copyright restrictions.

Not very energy efficient

Photo by Lars K on Flickr.

Near Heathrow Airport



Some promising technologies

Natural Ventilation for Commercial Buildings

- Reduce Energy Consumption
- Improve Indoor Air Quality
- Improve Productivity

Energy performance and good design

Photo by Bob Gorman on Flickr.

San Francisco Federal Building

Morphosis

Zion National ParkVisitor Center

Photo by Niels van Eck on Flickr.

Use of Solar Energy

- Acceptable Interior Lighting Level :

  1/10 to 1/100 of exterior level
- Associated thermal load of solar less than that for artificial lighting
- How to control it?
- How to bring it deeper into interior?

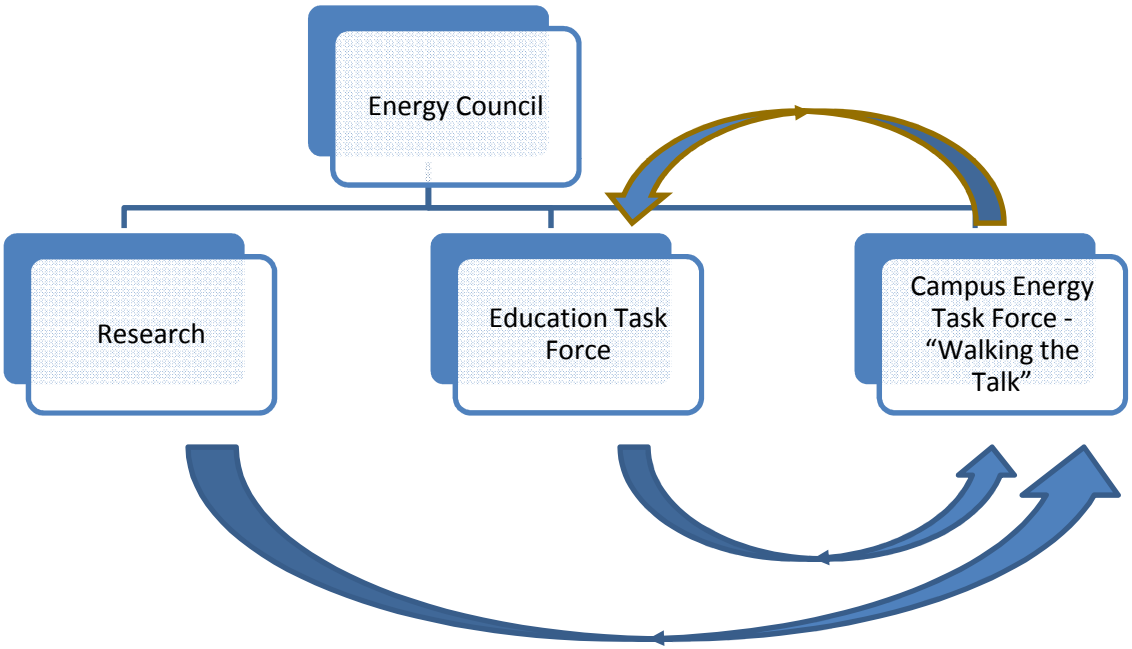
Enhancing daylight deeper in rooms

- Anidolics (based on non-imaging optics: research made at LESO-PB/EPFL)
  - Photos show 2 identical rooms at the same time, one equipped with an anidol system, the other without

Diagrams and photos of LESO-PB anidolic systems research removed due to copyright restrictions

Greening the Tech Campus: MIT's Campus Energy Initiative

MITei MIT Energy Initiative

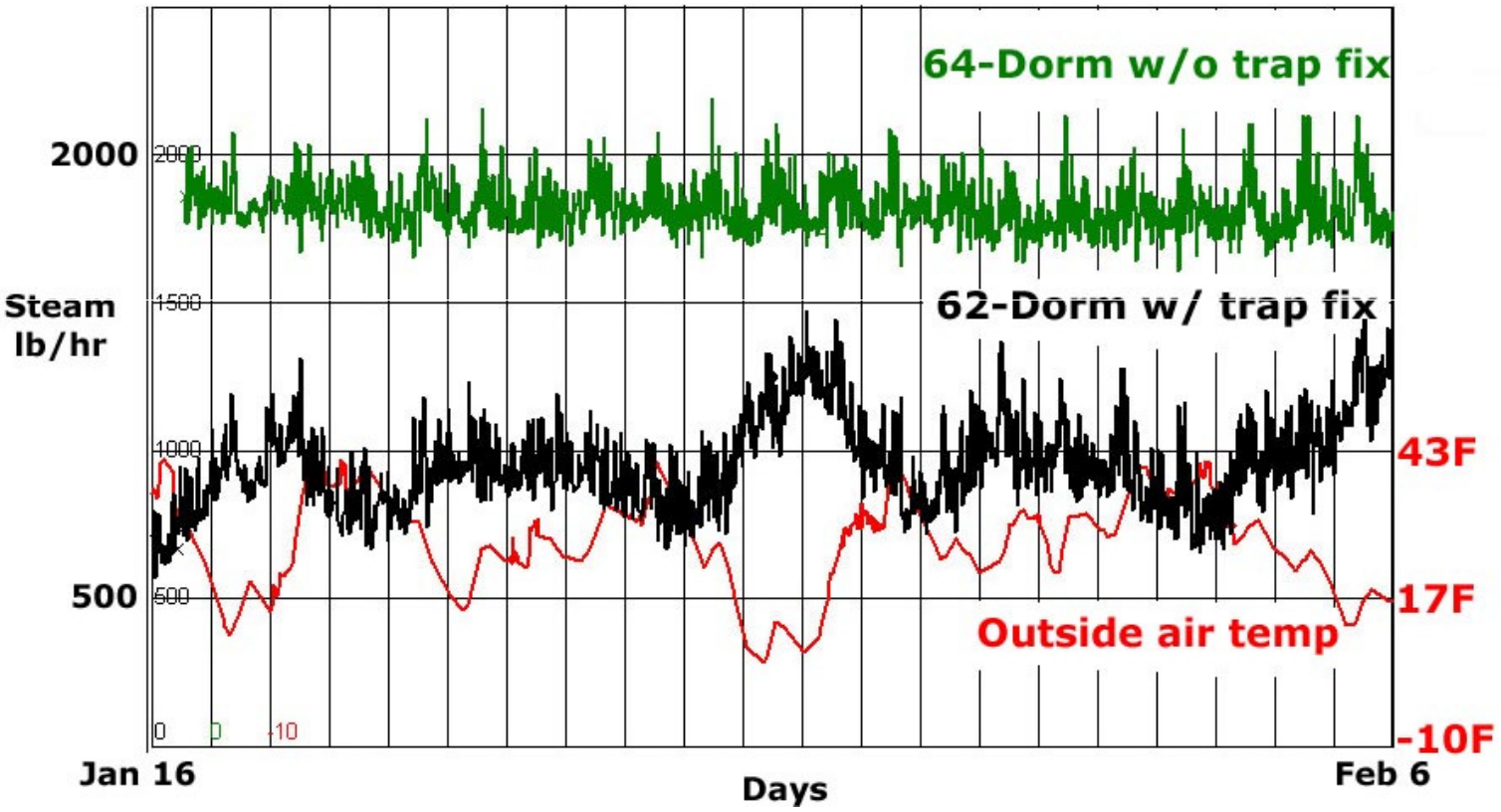


MIT should be a leader: A model for others

New Energy Conservation Investments

- Recent allocation of $500,000 for strategic energy conservation measures including lighting retrofits, building continuous commissioning, fume hood sash controls
- Monitoring of performance improvement, economics
- Establish energy savings, return on investment
- Prototype for larger scale programs
- A model for others

Retrofit of one East Campus Parallel



MIT Building 18 at 2PM Steve Amanti

5PM

2AM

Energy Efficient Ventilation Design for New Cancer Research Facility

Photo by Dan4th Nicholas on Flickr.

New Sloan School Building Anticipated to Achieve LEED Gold

Image removed due to copyright restrictions.

Please see Fig. 23 in "Energy Future: Think Efficiency."
American Physical Society, September 2008.

Energy Efficient

A good example: Terrace houses in Göteborg

Photos of terraced houses removed due to copyright restrictions.

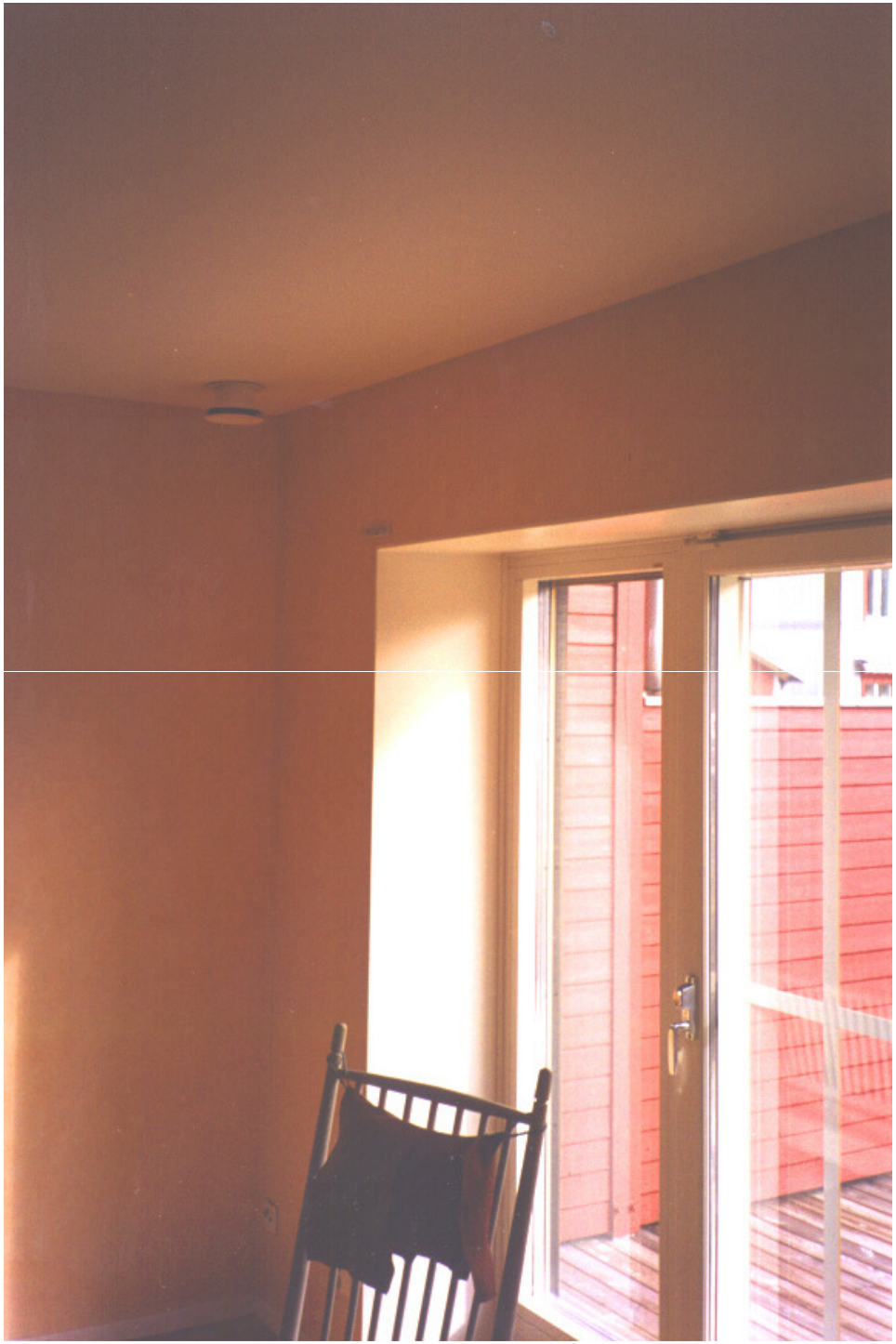
- No heating system!
- Well-insulated
- High performance windows
- Air tight building envelope
- Heat recovery/ventilation
- Solar panels/tap water
- Good workmanship
- Control of performance

U-value: 0.08-0.85 W/m^2K
Total energy use: 6 000 kWh/year
(normal value: 13 500 kWh/year)

Swedish Homes

Comfortable

No Central Heating System!



Genzyme Cambridge MA

Image by MIT OpenCourseWare.

Genzyme Cambridge

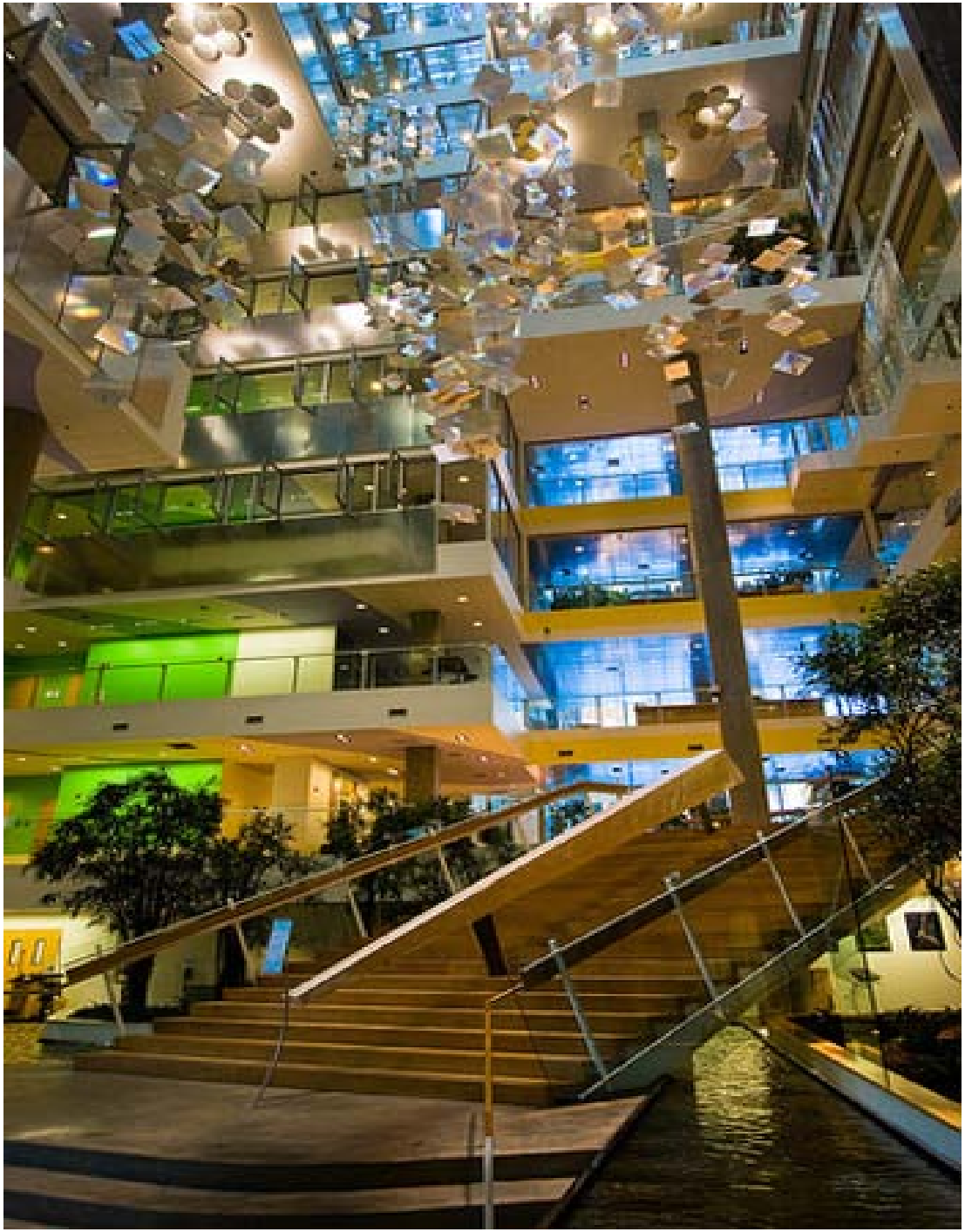
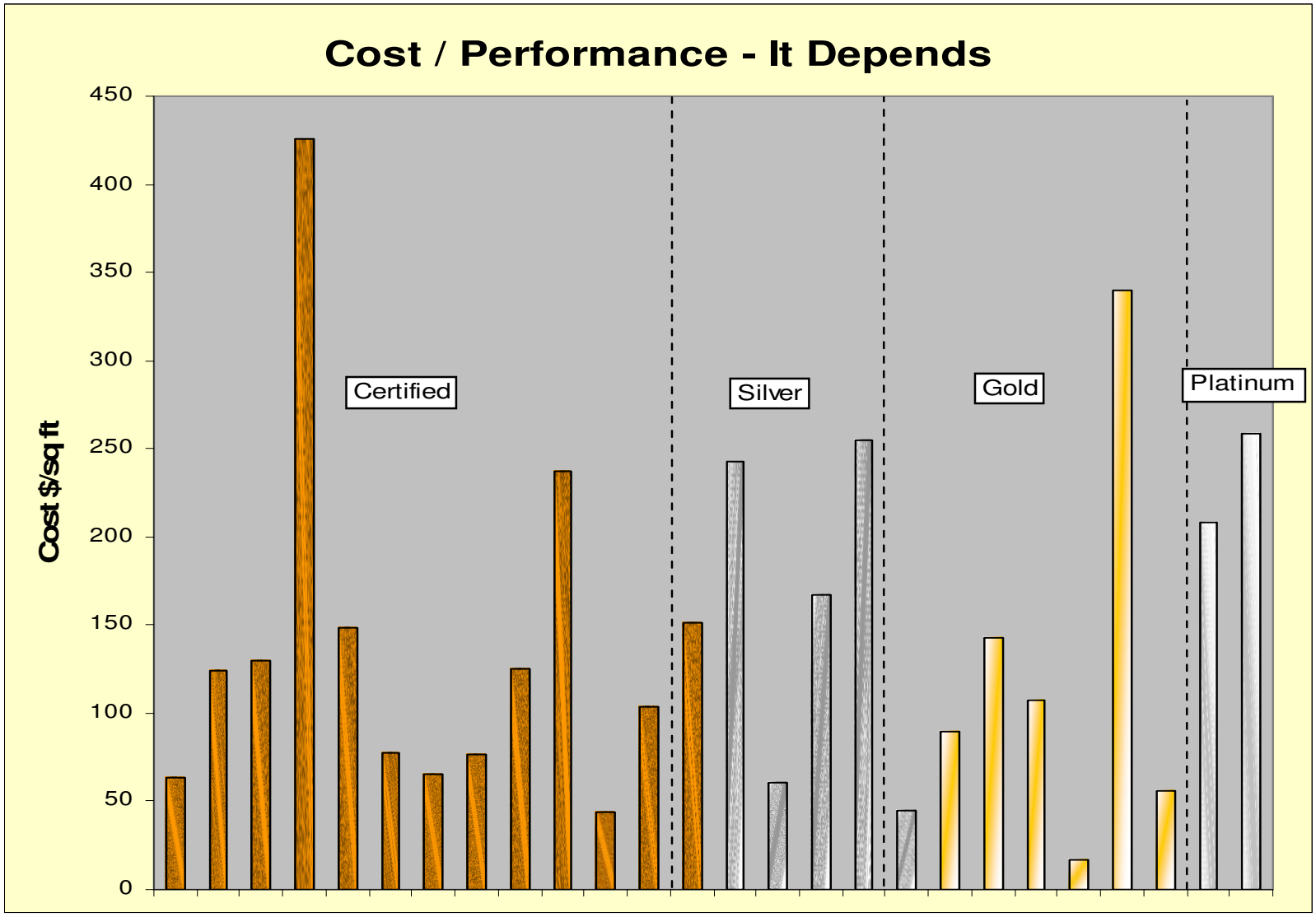


Photo by Mike Champion on Flickr.

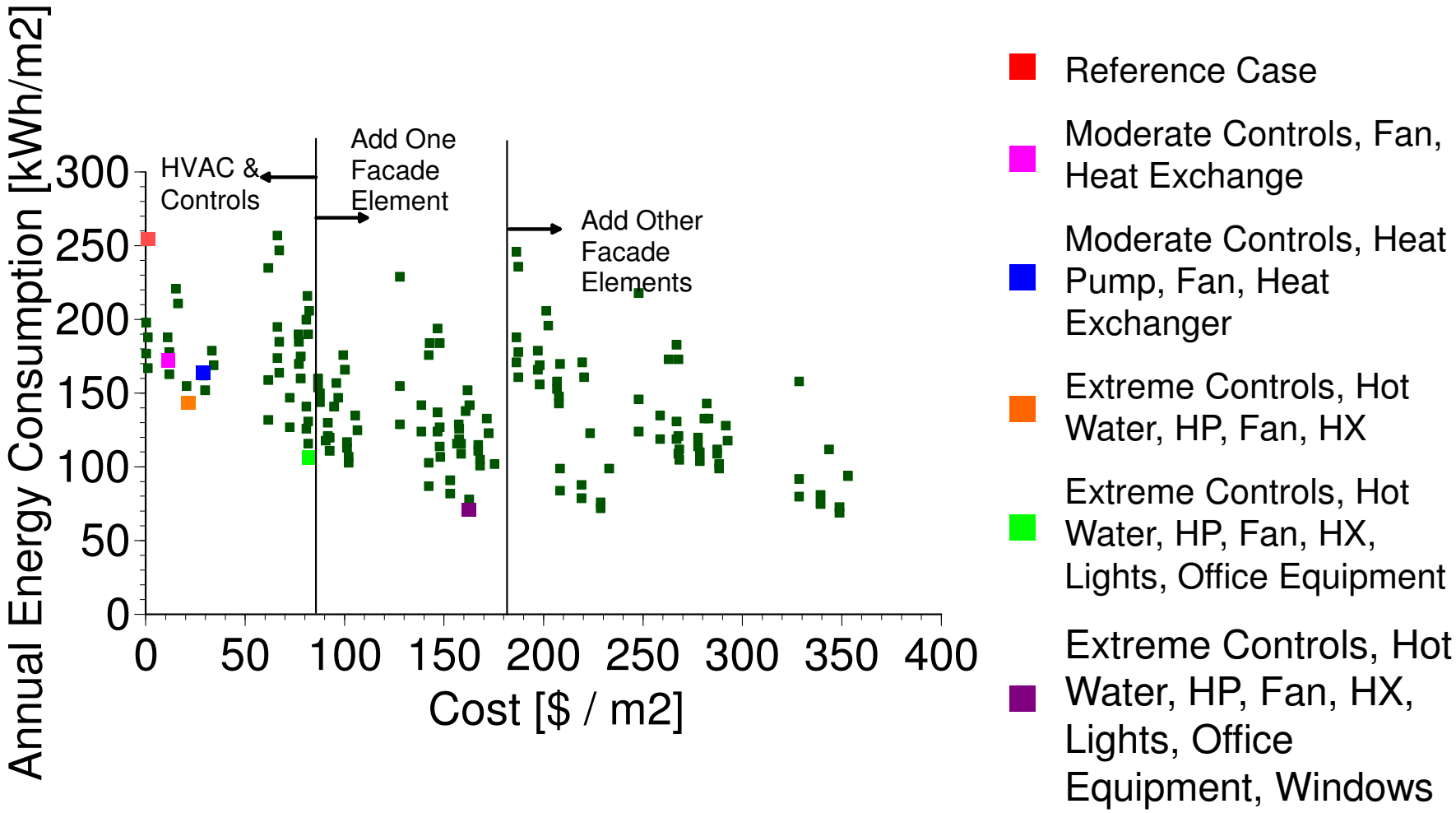
Photos of office space in the Genzyme Center, Cambridge, MA removed due to copyright restrictions.

Cost of Energy Efficiency

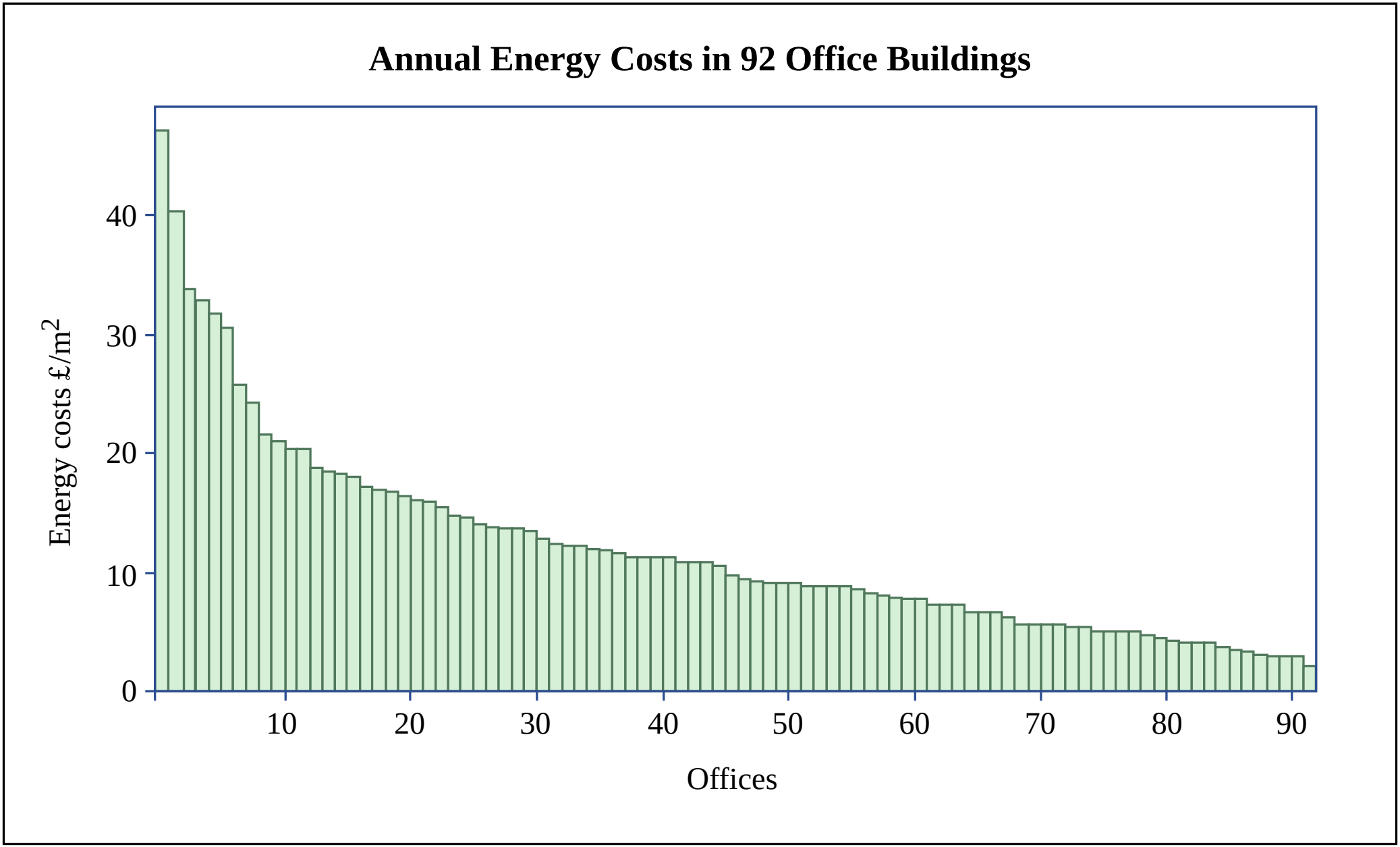
Evidence from Certified Projects



Retrofit of Office Buildings in Norway – Post 1997 Lisa Engblom



Energy Costs in 92 “Best Practice” Office Buildings K. Steemers, Cambridge Univ,



Electric Power Costs

Technology	Cents/kWe-hr
Nuclear	4-7
Gas/Combined Cycle	4-6
Coal	4
Renewable	
Wind	3-8
Biomass (25MW)	4-9
Small Hydro	5-10
Solar Thermal Electric	12-18
Solar PV	30-80
Efficiency of Consumption	
Advanced Buildings	0-6

Sources: Deutch and Moniz, MIT study 2003; Langcake, Renewable Energy World, 2003; Kats, California study, 2003

Promoting Sustainable Buildings

- Environmental gains
- Sustainable buildings pay for themselves
- Sustainable buildings please occupants
- Why aren’t they more widespread?

Why aren't they more widespread?

- Lowest First Cost
- Lack of Incentives
- Reluctance to change
- Uncertainty, fear of poor results
- Litigation Fears
- Difficulty in convincing developers, designers, government officials
- Lack of knowledge about new technologies, materials
  - Performance Projections
  - Results from New Buildings
- New approaches and partnerships are needed

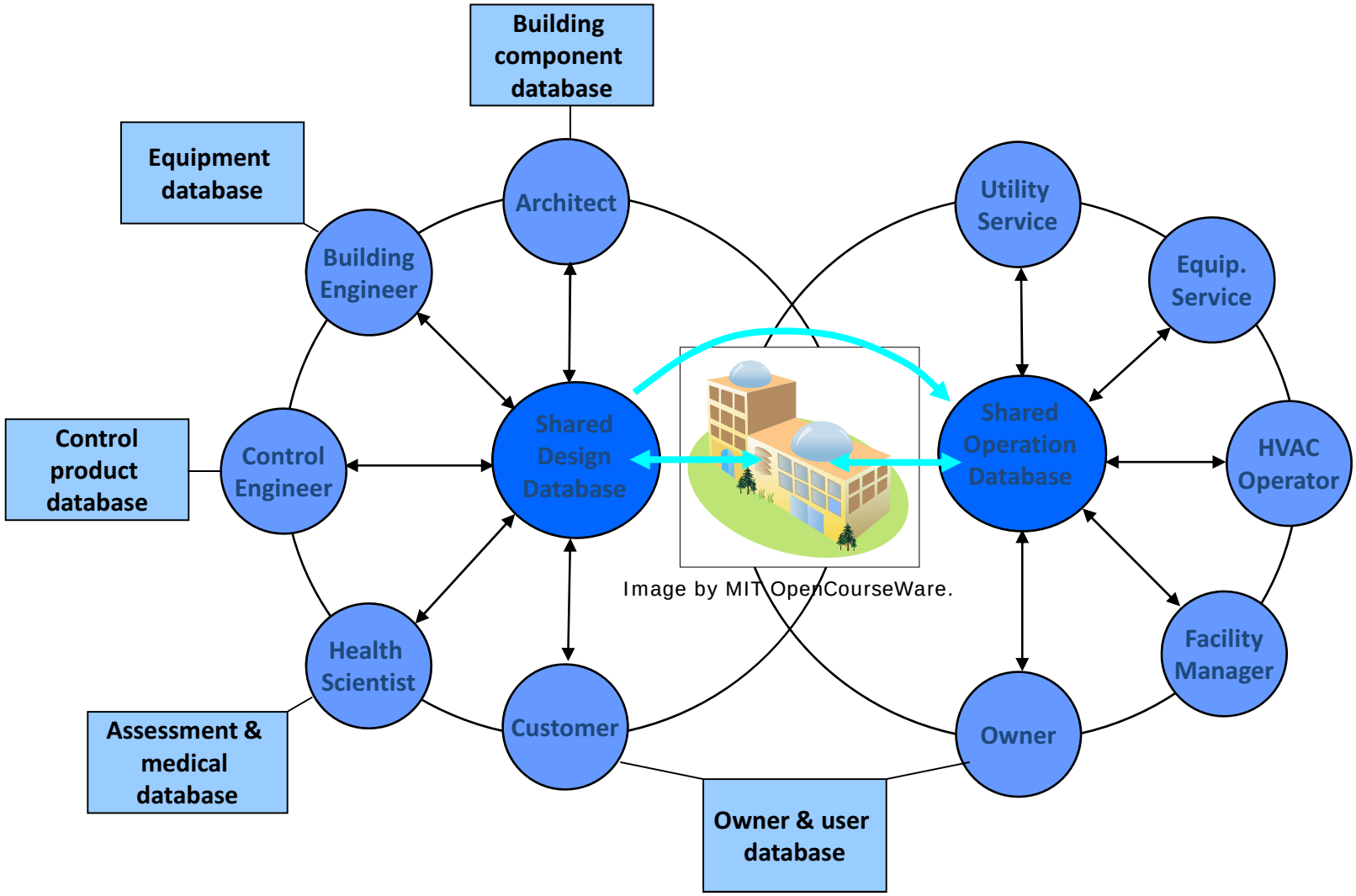
Images removed due to copyright restrictions.
Please see Fig. ES-4, ES-5 in Turner, Cathy, and Mark Frankel.
"Energy Performance of LEED for New Construction Buildings."
U.S. Green Building Council, March 4, 2008.

Critical Design Stage: Early Conceptual Phase

- Major Design Decisions
  - Orientation
  - Overall form
  - Technologies
- Sketch phase of design
- Details undetermined
- Comparisons of different concepts needed

The Need for an Integrated Team and Solution at the Outset

Integrated Design and Operation



Integrated design and operation of building and its systems

State-of-the-Art

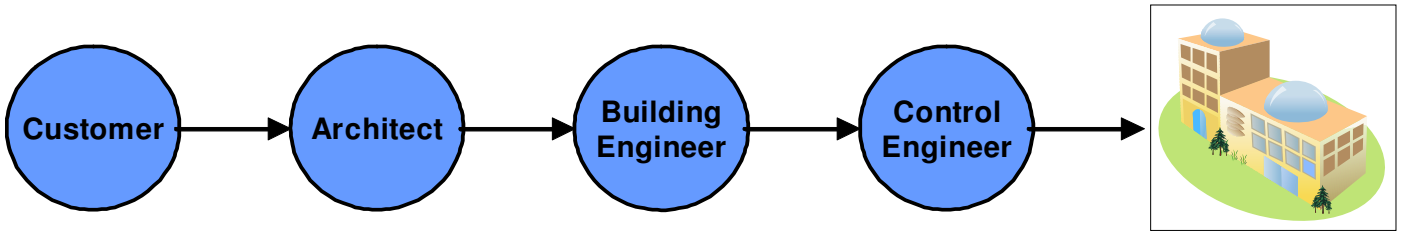


Image by MIT OpenCourseWare.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Introduction to Sustainable Energy
Fall 2010