Challenges and Opportunities for Low-Carbon Buildings

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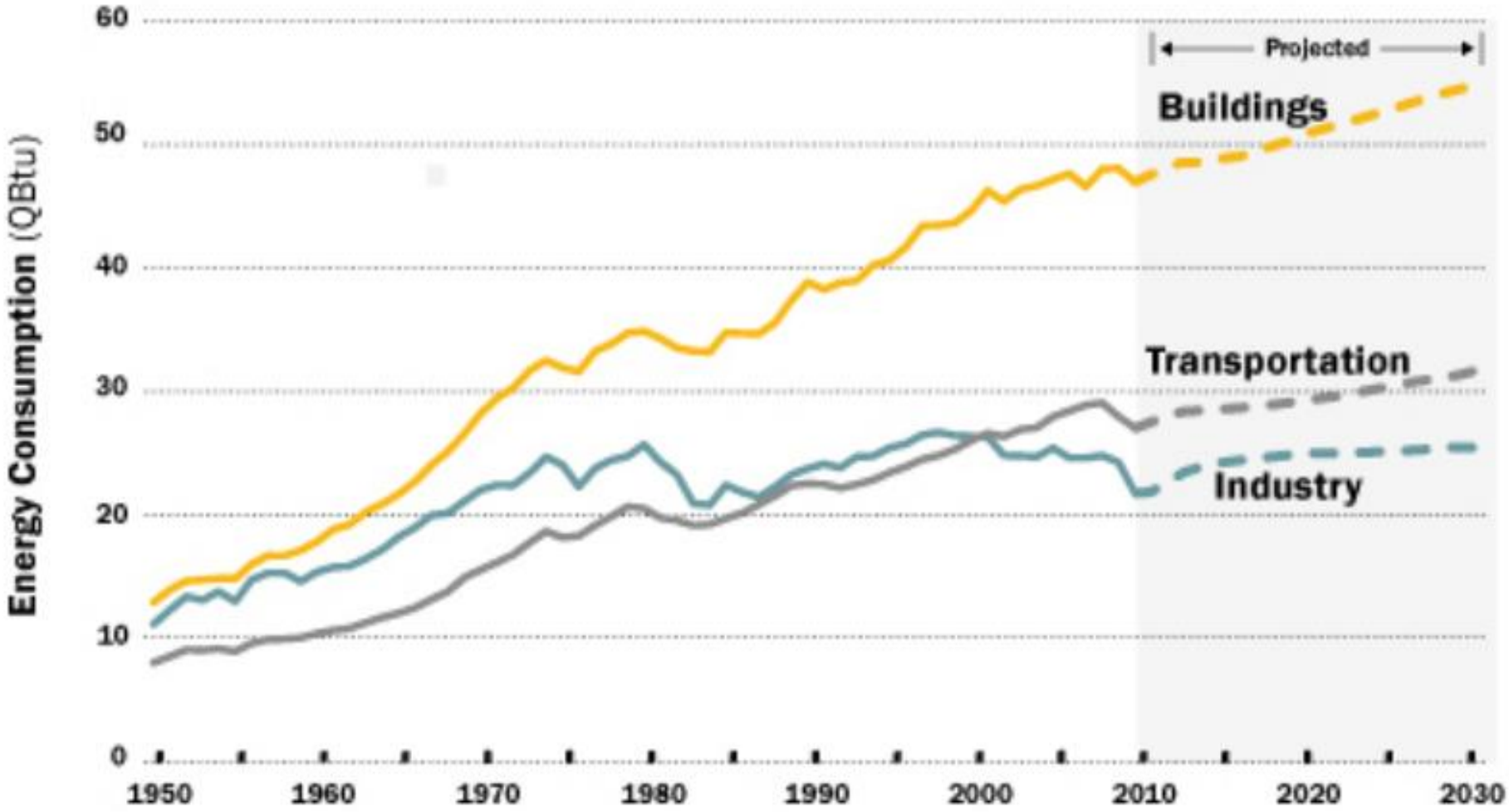

U.S. Energy Consumption by Sector (Historic / Projected)

Data Source: U.S. Energy Information Administration.

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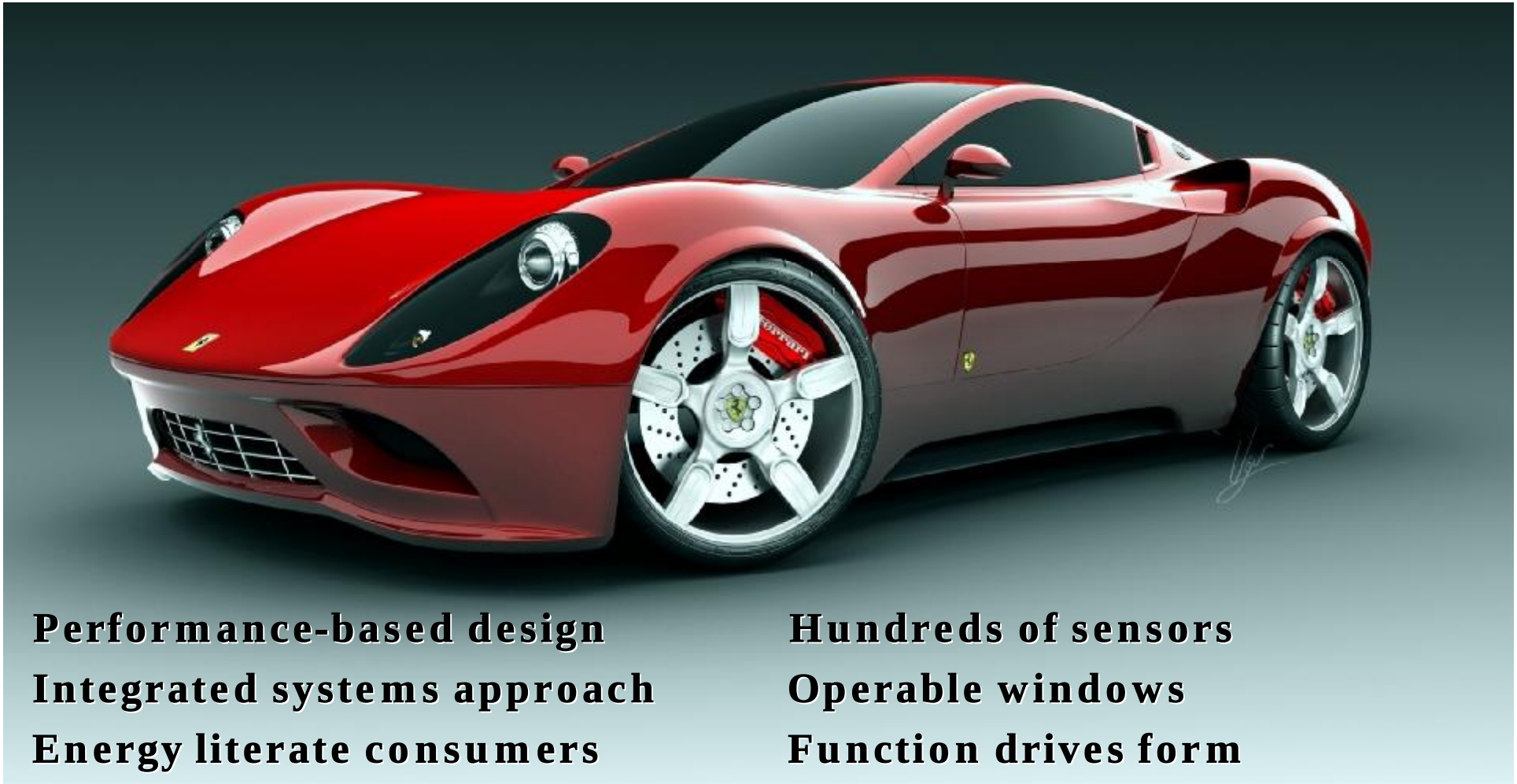


Performance-based design

Integrated systems approach

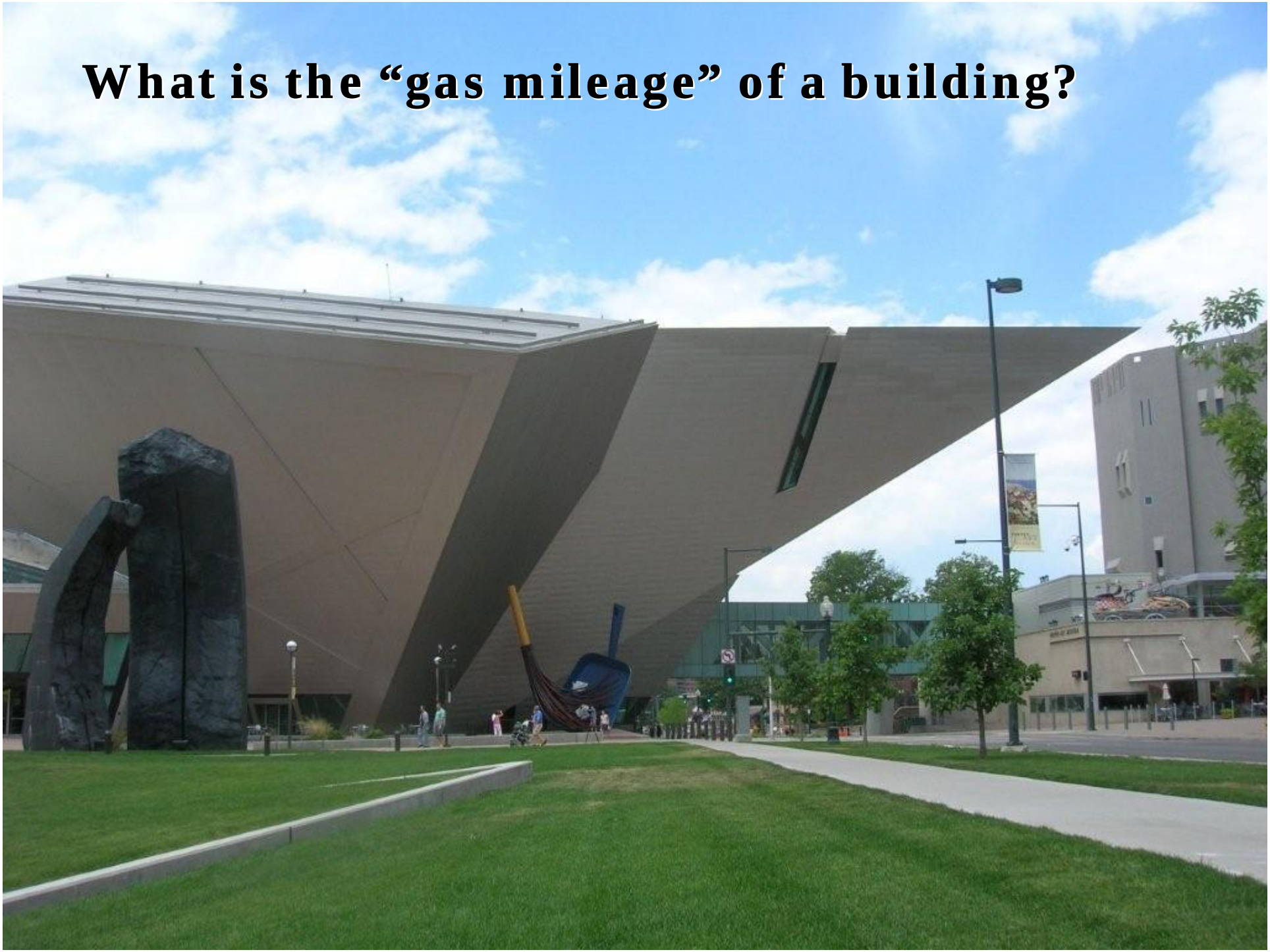
Energy literate consumers

Hundreds of sensors

Operable windows

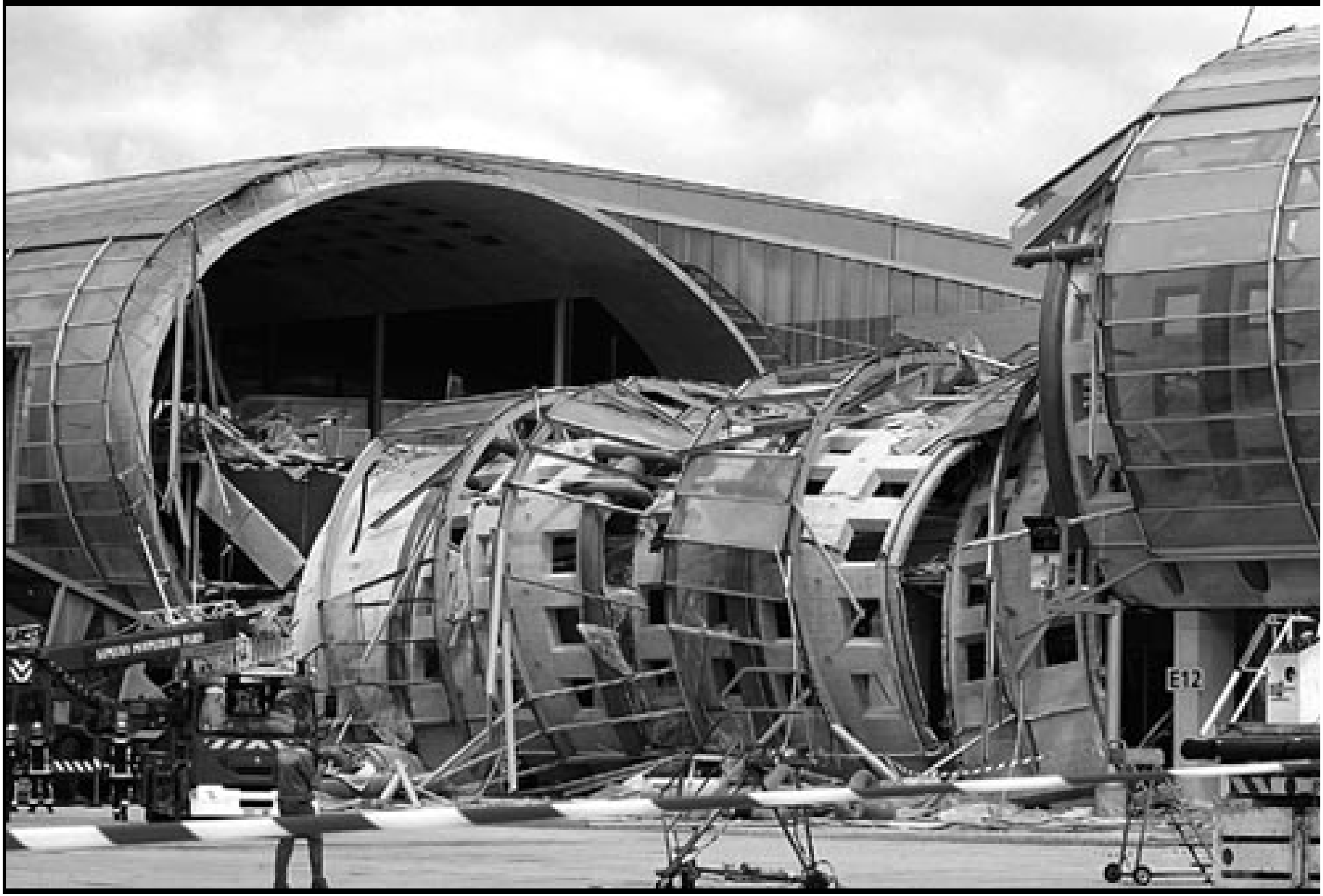
Function drives form

What is the “gas mileage” of a building?



Engineers often are asked to optimize poor designs

Which can lead to catastrophe

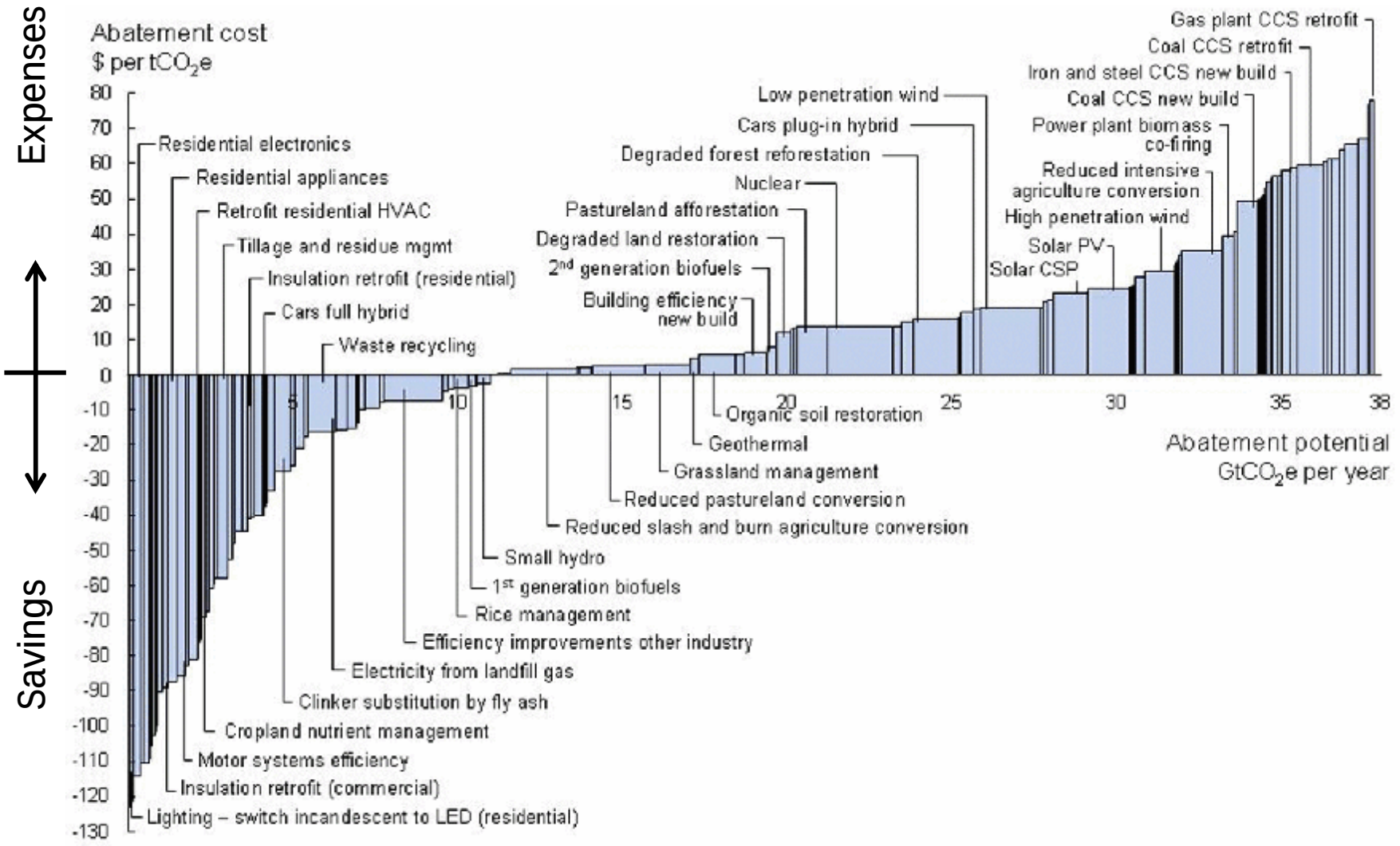


If covered in photovoltaics, this would provide only ~20% of the required energy for the John Hancock Tower

(Source: L. Glicksman)

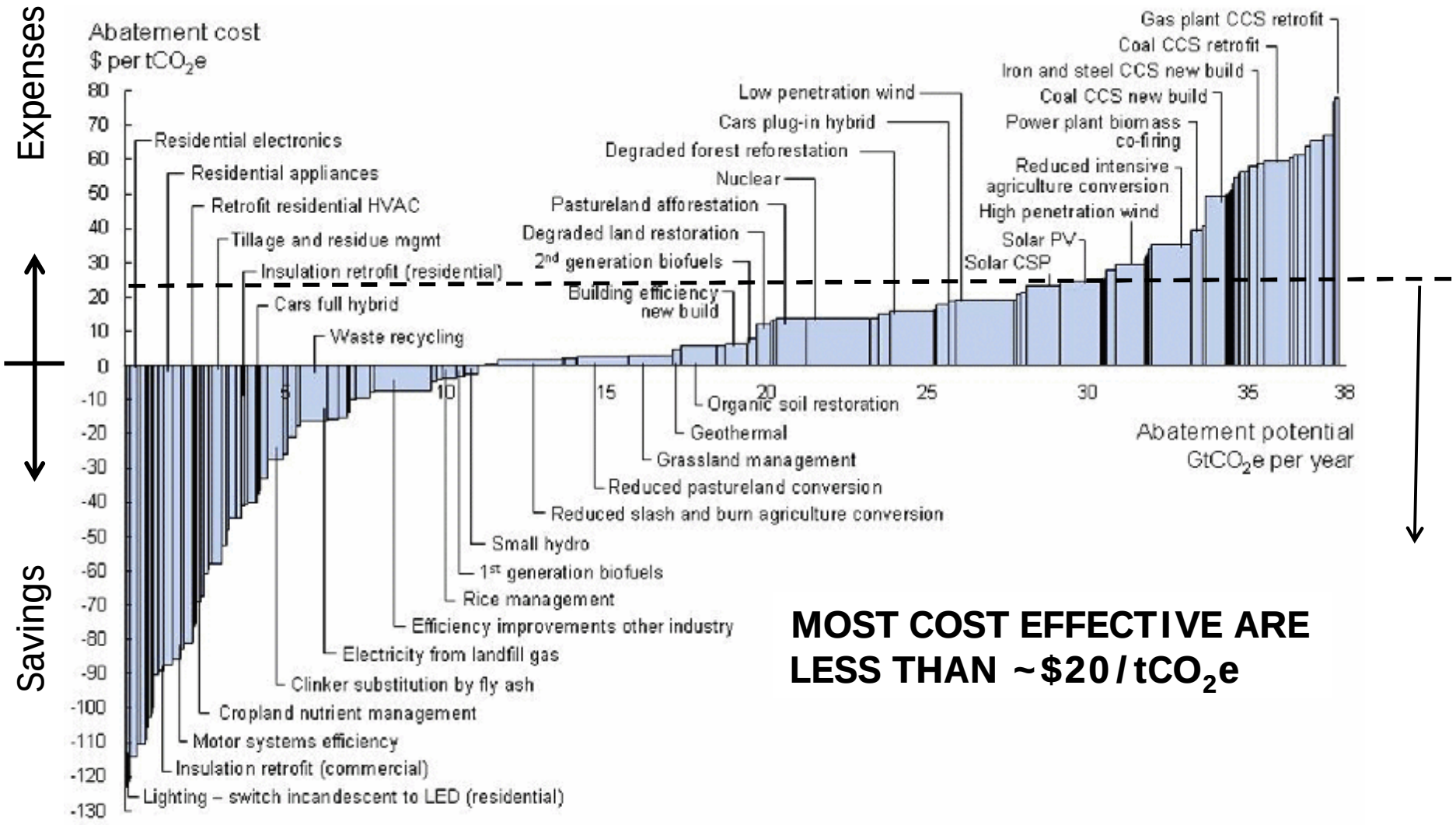
We must focus on the demand side

Cost of Carbon Reductions



Source: McKinsey Consulting (2009)

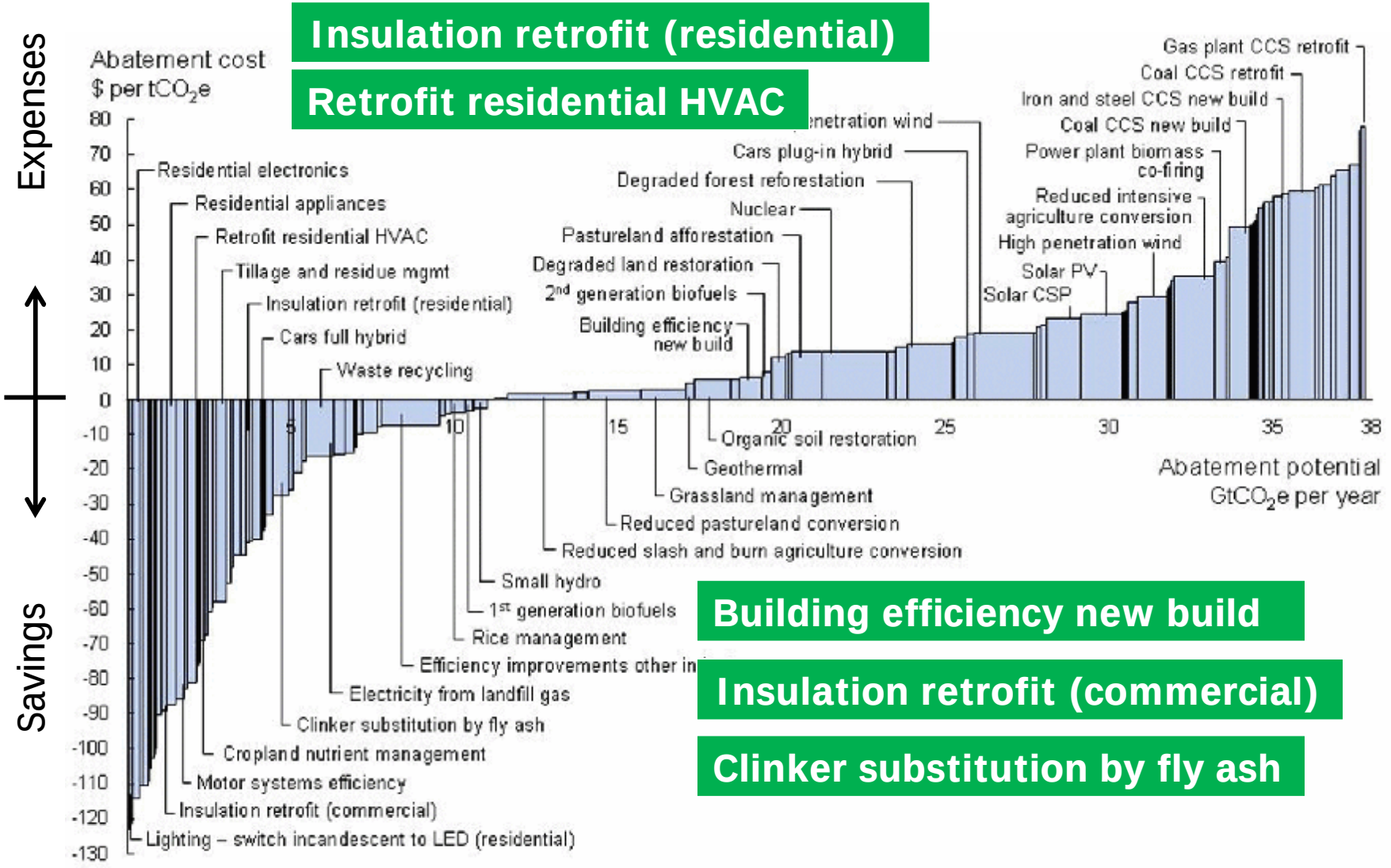
Cost of Carbon Reductions



MOST COST EFFECTIVE ARE LESS THAN ~$20/tCO$_2$e

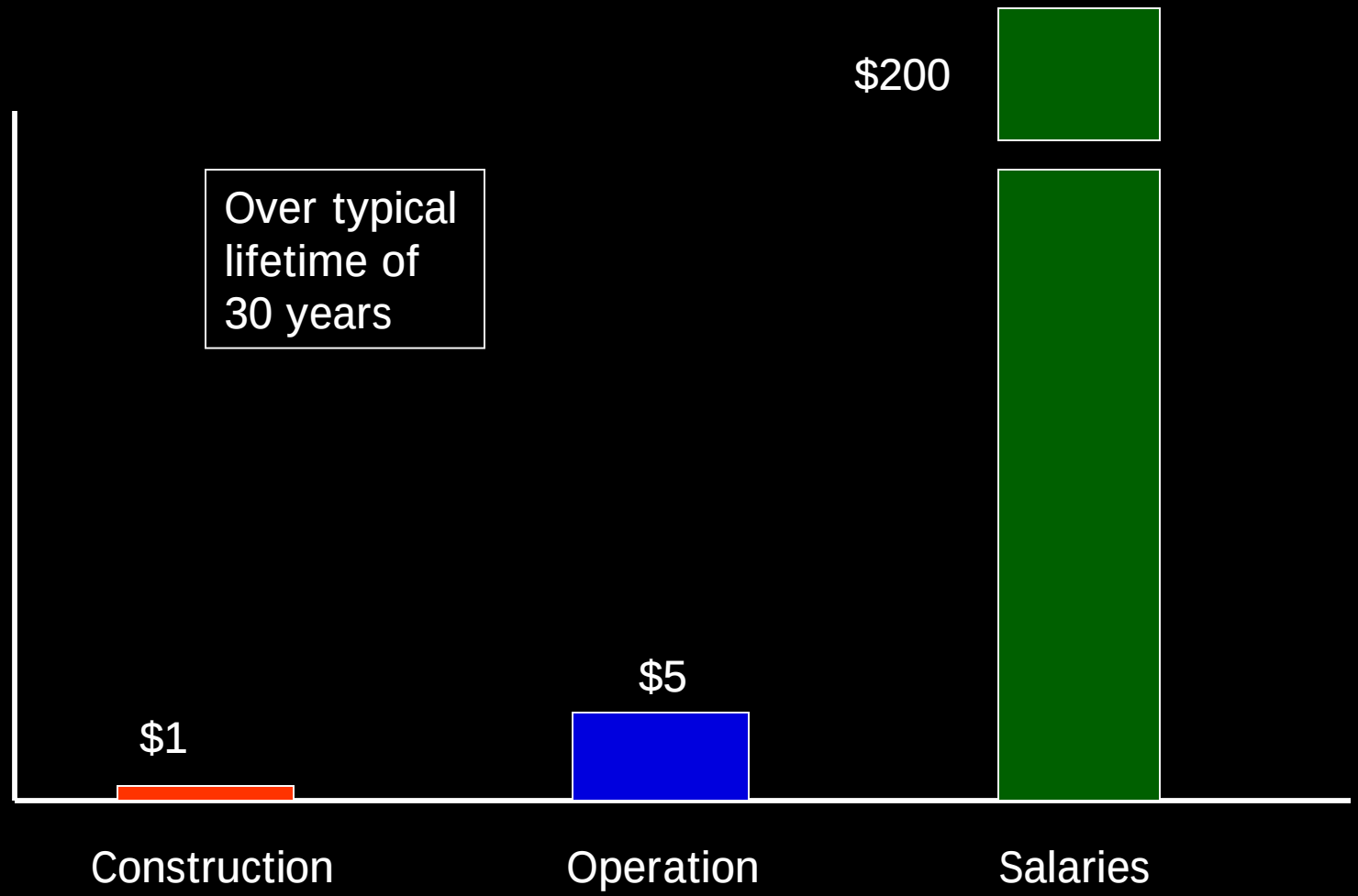
Source: McKinsey Consulting (2009)

Buildings offer cost-effective CO_2e reductions



Source: McKinsey Consulting (2009)

Economics of Office Buildings



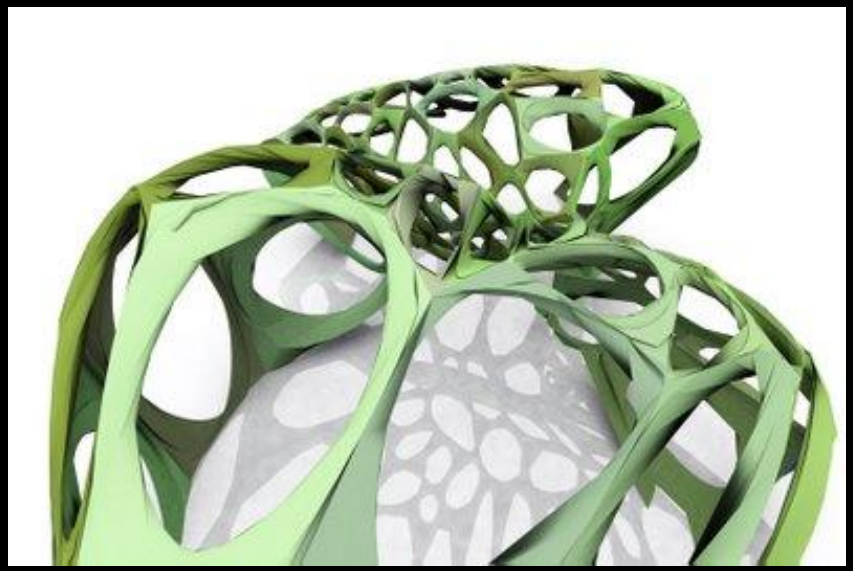
Challenges

- Improved tools for the conceptual design stage to overcome gulf between professions
- Life-cycle metrics for designers, policy makers, and public
- Lack of R&D in a conservative industry

Current Structural Tools

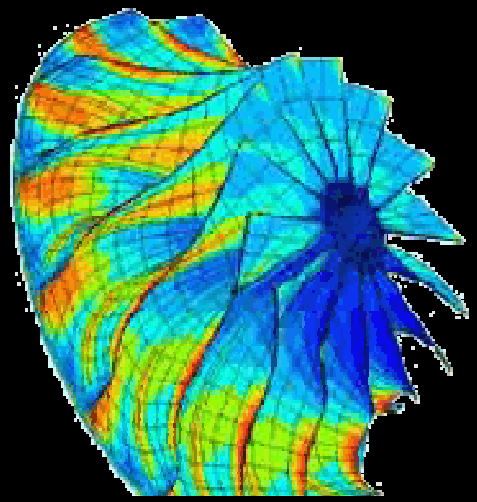
Architectural Design

- Computational design tools are widespread
- Emphasis on generative ability
- Lack legitimate performance evaluation



Structural Analysis

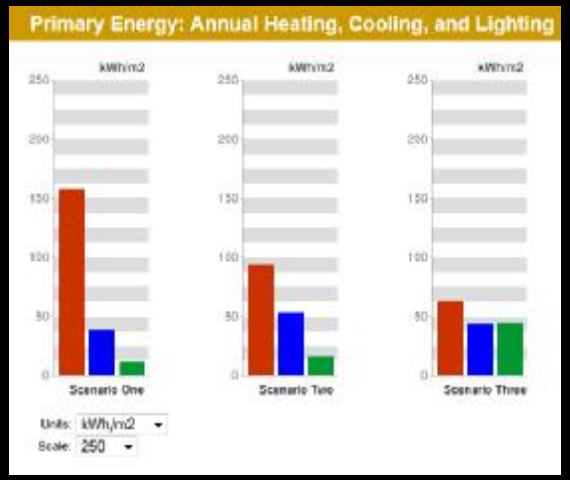
- Computational analysis tools are widespread
- Emphasis on sophisticated performance predictions
- Not useful in conceptual design

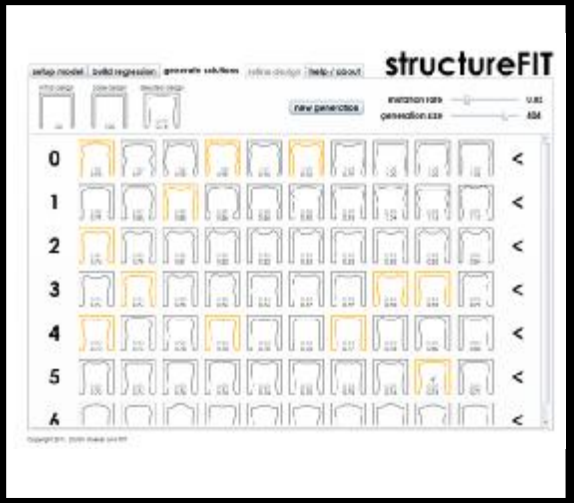


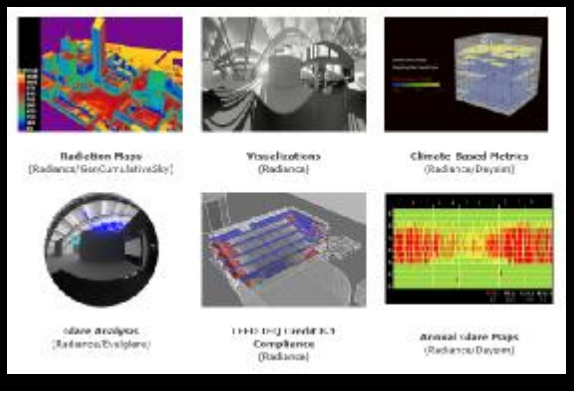
We have *analysis* tools, but we need more *design* tools

Some conceptual design tools under development

- Energy
  - MIT Design Advisor
- Structure
  - Optimally directed
  - Interactive
- Integrated systems
  - DIVA







Metrics for designers and policy makers

- Greater literacy needed on environmental impacts of buildings
- We have focused on global warming potential (CO_2e)
- Life Cycle Assessment (LCA) provides a rigorous approach for quantifying emissions


Coca-Cola
Trade-mark®
CLASSIC

The story of a can of Coke....

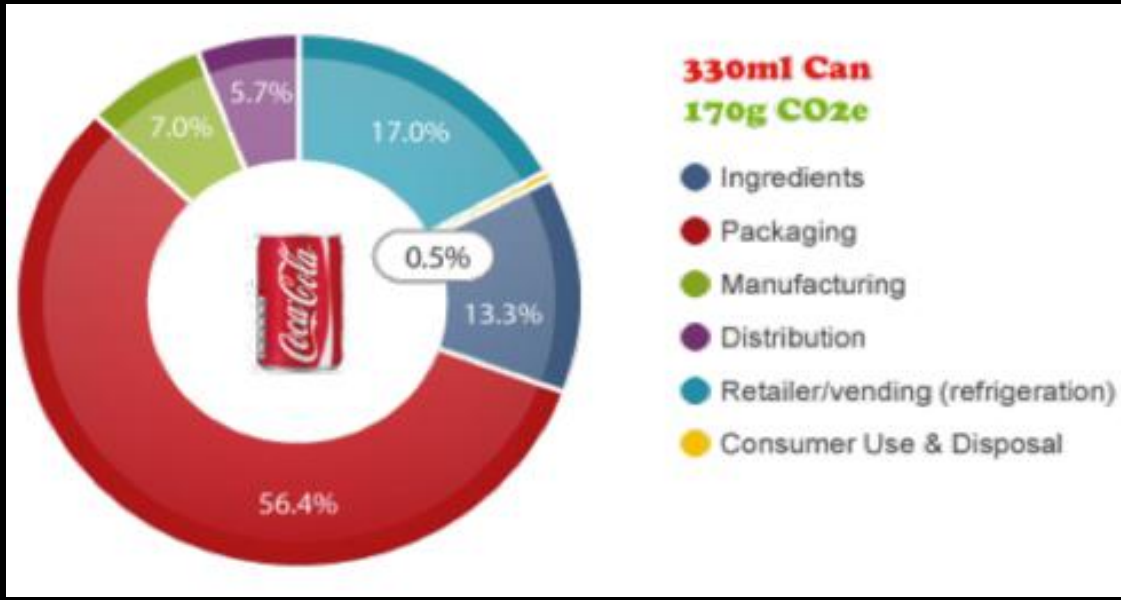
"In England, consumers discard 84% of all cans, which means that the overall rate of aluminum waste, after counting production losses, is 88%. The United States still gets three fifths of its aluminum from virgin ore, at twenty times the energy intensity of recycled aluminum, and throws away enough aluminum to replace its entire commercial aircraft fleet every three months."

(Natural Capitalism)

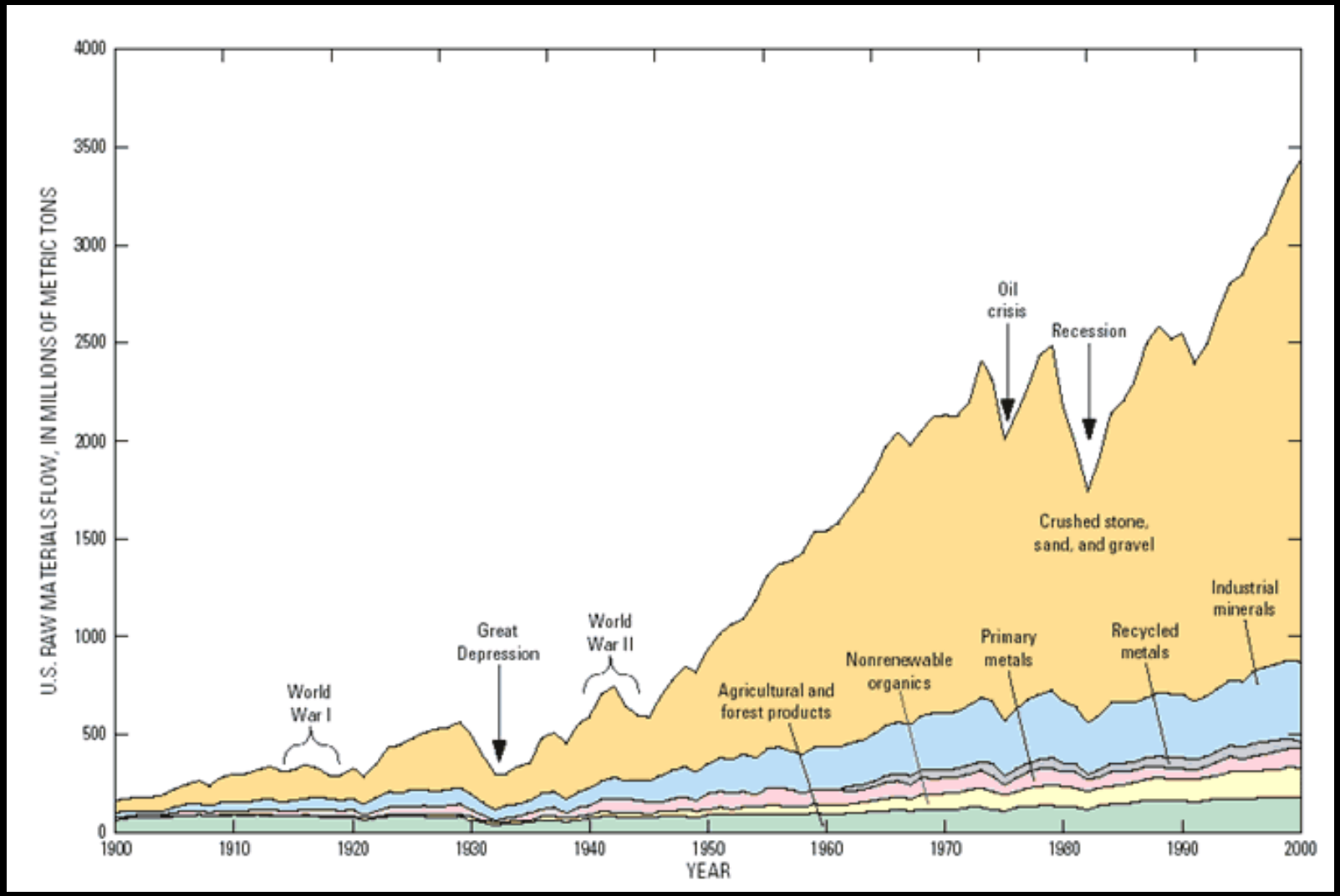
(Charles Ainger , Cambridge University)

Why Life Cycle Assessment (LCA)?

- LCA quantifies environmental impacts
- Gives direction on areas for reductions
- Must look up and down the supply chain



Growing Use of Raw Materials

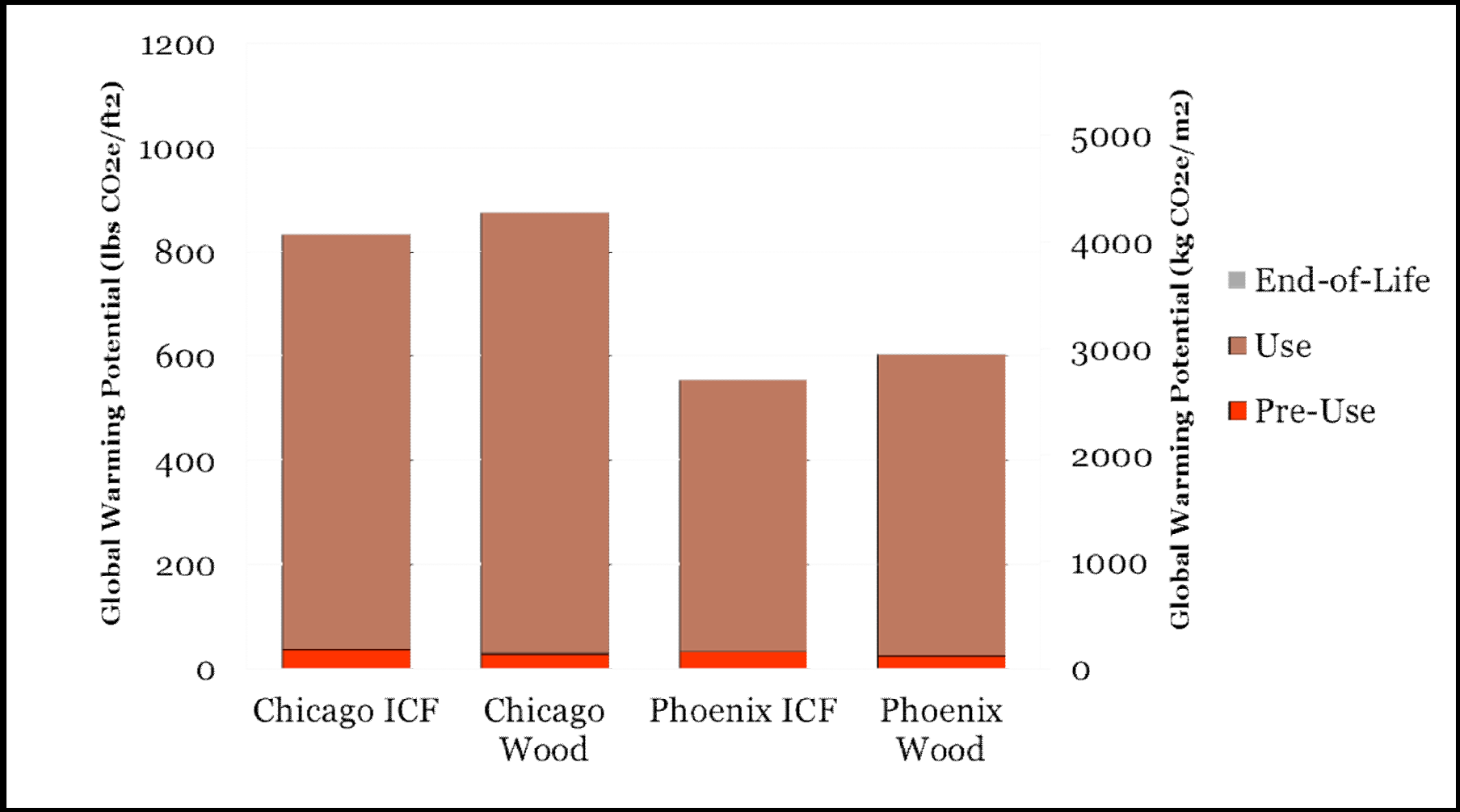


Source: Wagner (2002)

Life Cycle Assessment (LCA) of Buildings

Pre-use phase	Use phase	End of life
Extraction	Heating	Disposal
Manufacturing	Cooling	Recycling
Transportation	Lighting	Reuse
Concrete	Fans	Transportation
Steel	Plug loads	
Insulation	Maintenance	
Glass	Energy Mix	

Total 60-year emissions for single-family houses



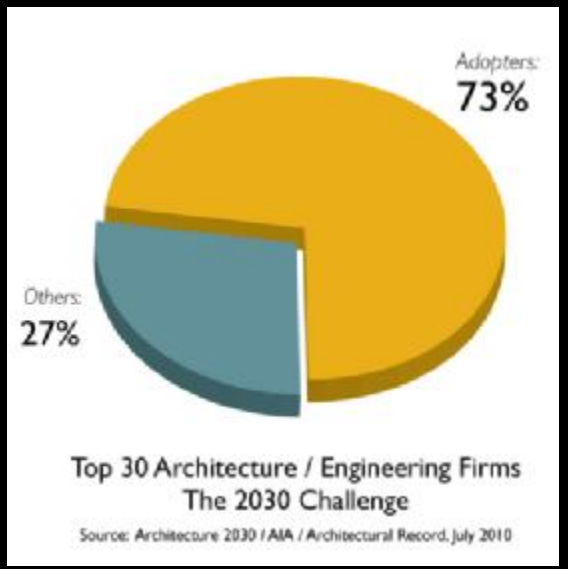
Source: Concrete Sustainability Hub @ MIT

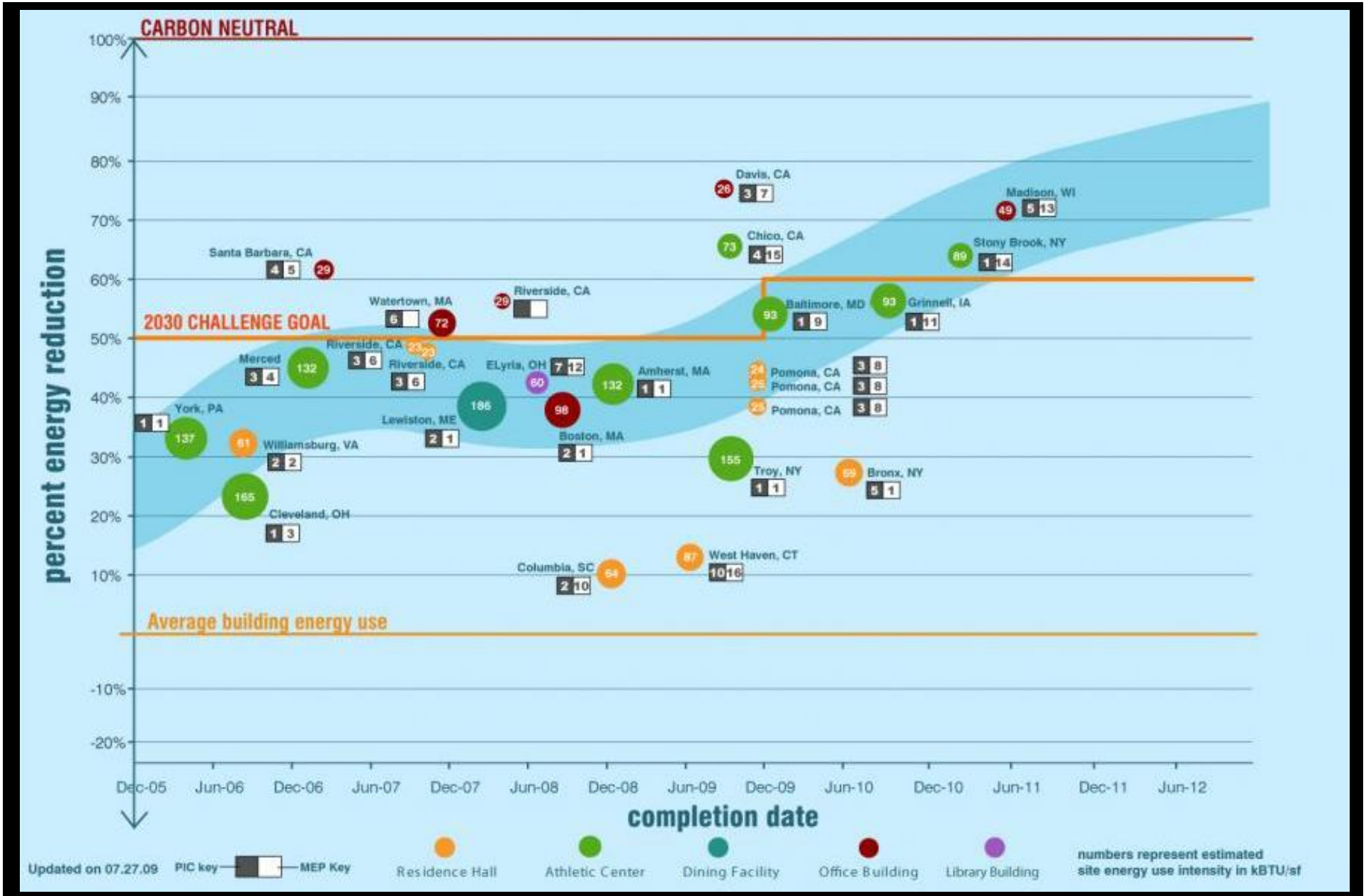
Motivations for LCA work

Growing demand for quantifying performance of structures

2030 Challenge **calls for carbon reductions of:**

60% in 2010 (of average carbon emissions for building type)
70% in 2015
80% in 2020
90% in 2025
Carbon-neutral in 2030





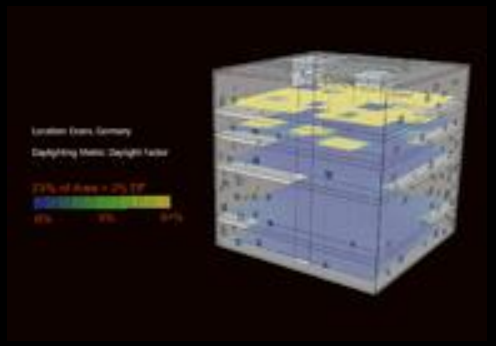
Source: Sasaki Associates

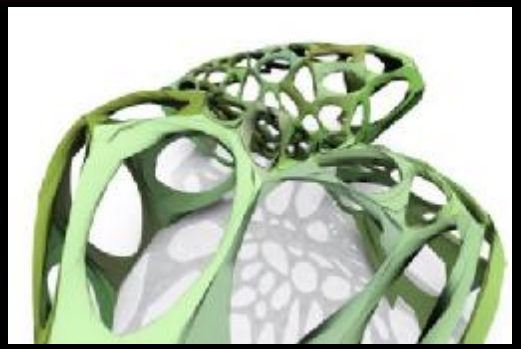
Opportunities

- Conceptual design tools are in their infancy

- Design education can bridge gaps between engineering and architecture

- Industry, government, academic partnerships can overcome poor history of R&D in construction industry





DESIGN STRATEGIES

The largest energy reductions can be achieved through design.

+

TECHNOLOGIES AND SYSTEMS

Including on-site renewable energy systems.

+

OFF-SITE RENEWABLE ENERGY

20% maximum.

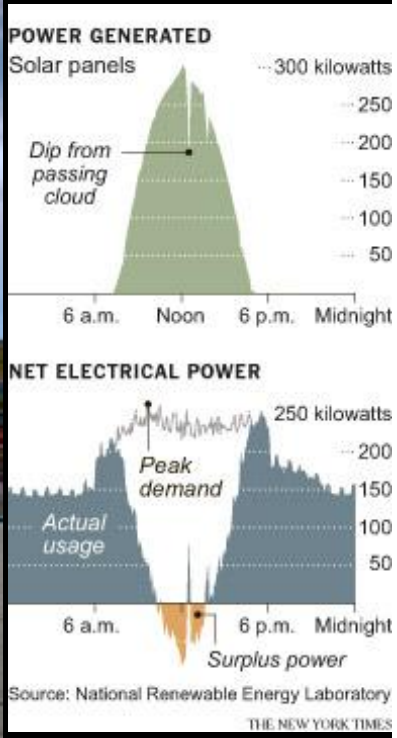
Source: Architecture2030

Net-Zero: Richardsville School, KY

- Reduce demand to 30 kBtu/sf/yr
- Generate energy on site with PVs
- Many integrated technologies

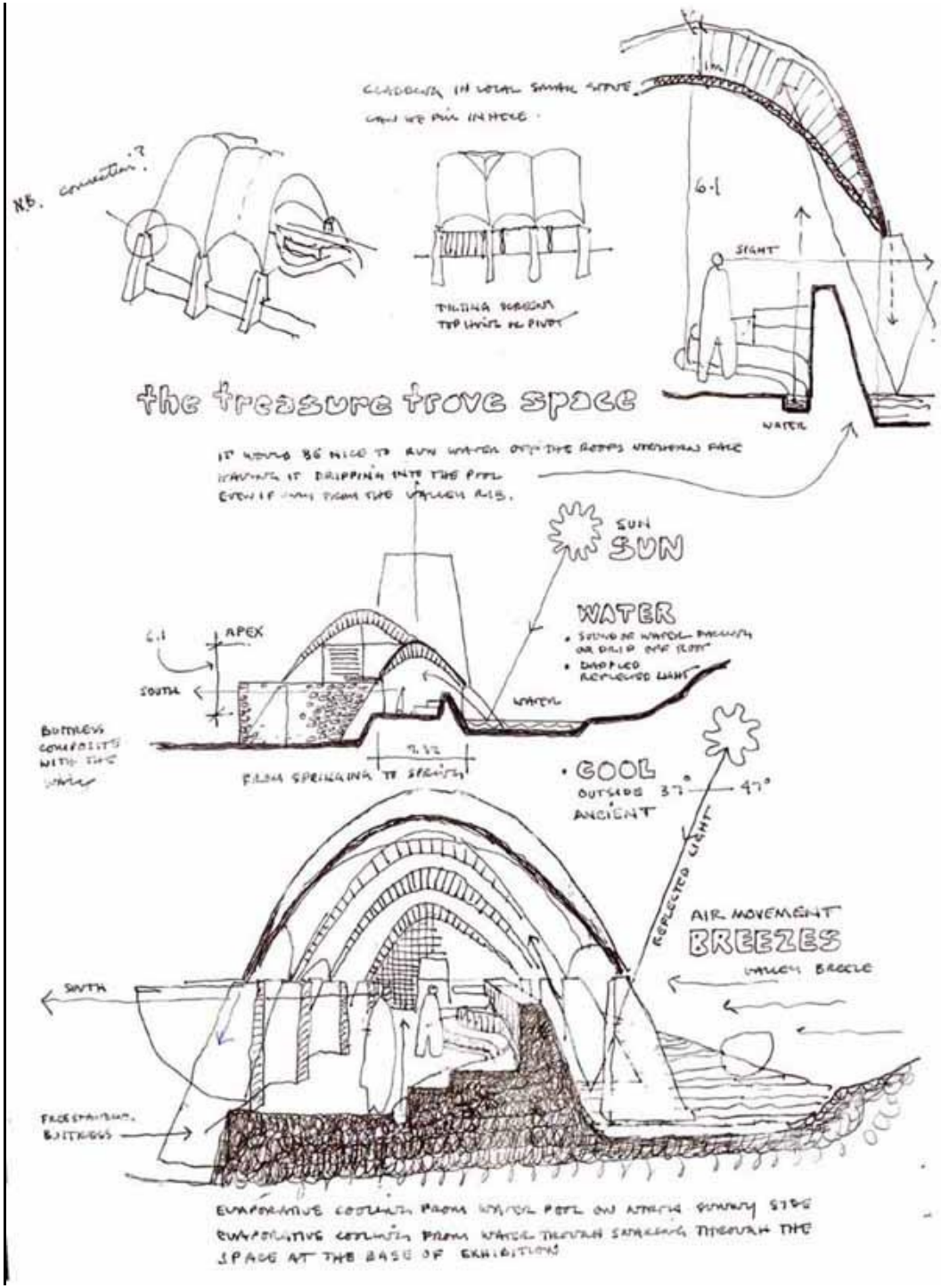
Net-Zero: NREL RSF, Golden, CO

- Reduce demand to 35 kBtu/sf/yr
- Generate energy on site with PVs



South Africa National Parks asked for a new visitor's center with:

- local materials and local labor
- passive energy strategies
- poverty relief program



Mapungubwe Visitor's Centre
Peter Rich, Architect
Henry Fagan, Engineer

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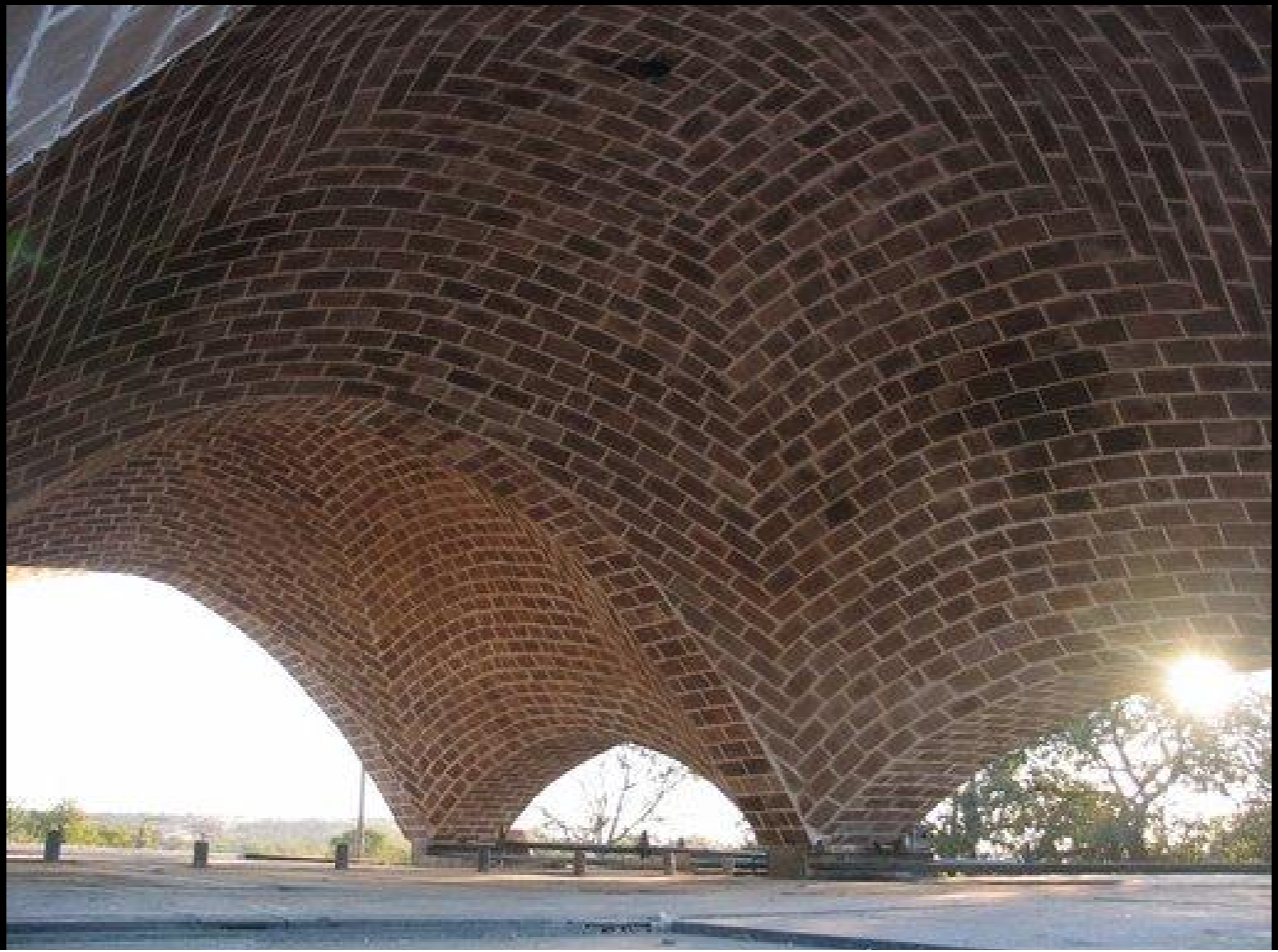
Integrated design team developed low-cost soil-cement structural shells



Mapungubwe Visitor's Centre
Peter Rich Architects

World Architecture Festival
Building of the Year, 2009

Earth Awards Finalist, 2010

Measuring, managing, and reducing carbon emissions will be the norm

Cost-effective carbon reductions will transform the built environment

LCA provides rigorous bench-marking of life-cycle building performance

New conceptual design tools and software are sorely needed

Thank you

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Mapungubwe Visitor's Centre
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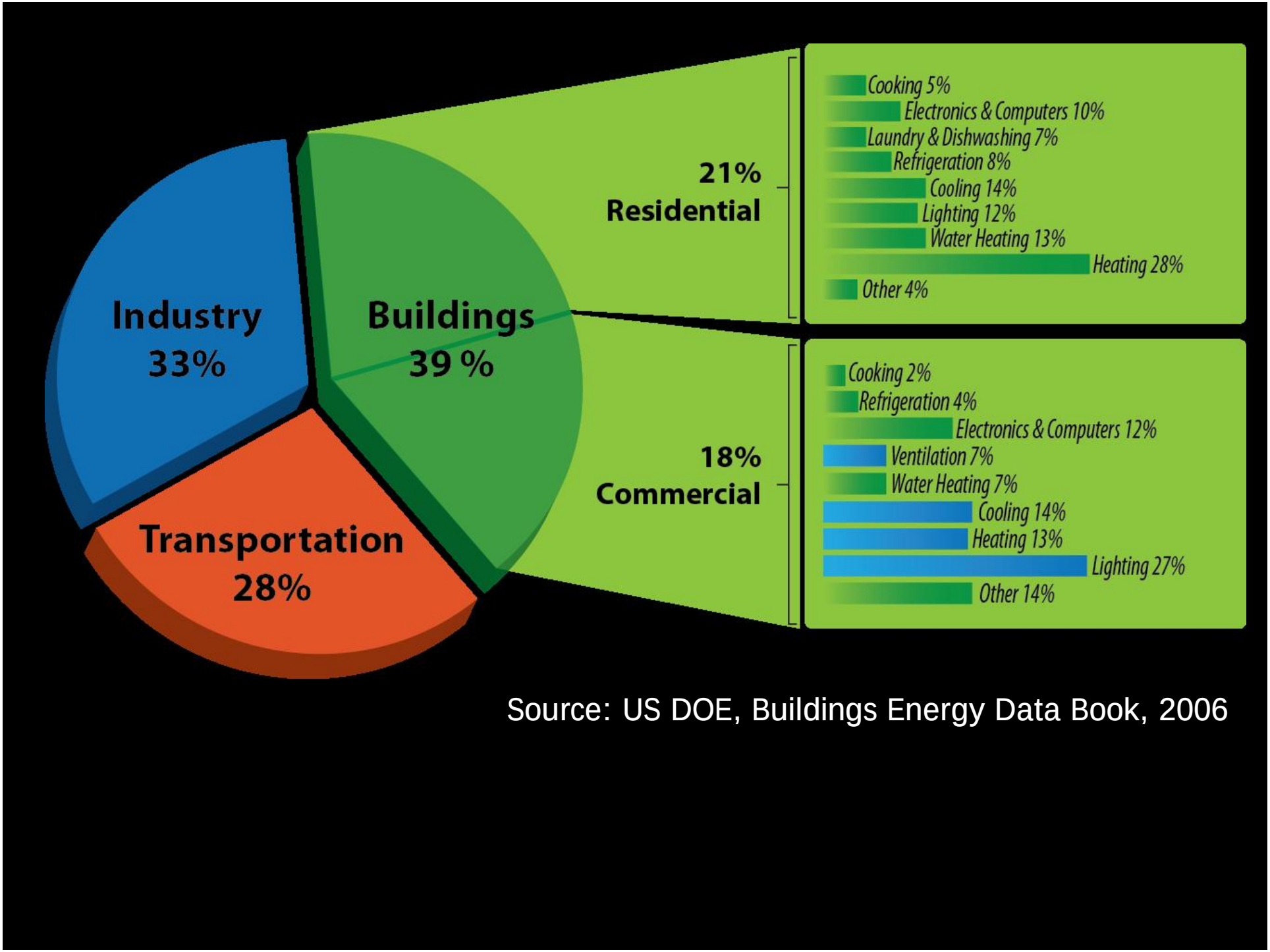

Source: US DOE, Buildings Energy Data Book, 2006