



## *Overview of 3 SE Green Papers*



- Paper 1: Mark Reiner
  - Embodied Energy of Materials are a significant total carbon footprint of buildings.
  - Transportation energy and “low-embodied energy”
- Paper 2: Mike Whitaker
  - Substantiating environmental claims of green buildings
  - Implications of the FTC guidelines, Renewable Energy Certificates, and Carbon Cap and Trade
- Paper 3: Mark Pitterle
  - Comparing LEED Energy Points to Life Cycle Impacts
    - A comparison of passive and PV systems

*Major Points*

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Cradle-to-Cradle (C2C)



Cradle-to-Grave (Landfill)

Cradle-to-Gate (Embodied)



Assumptions

**Material  
Extraction,  
Processing  
and Transport**

**Site Prep  
including  
demolition**

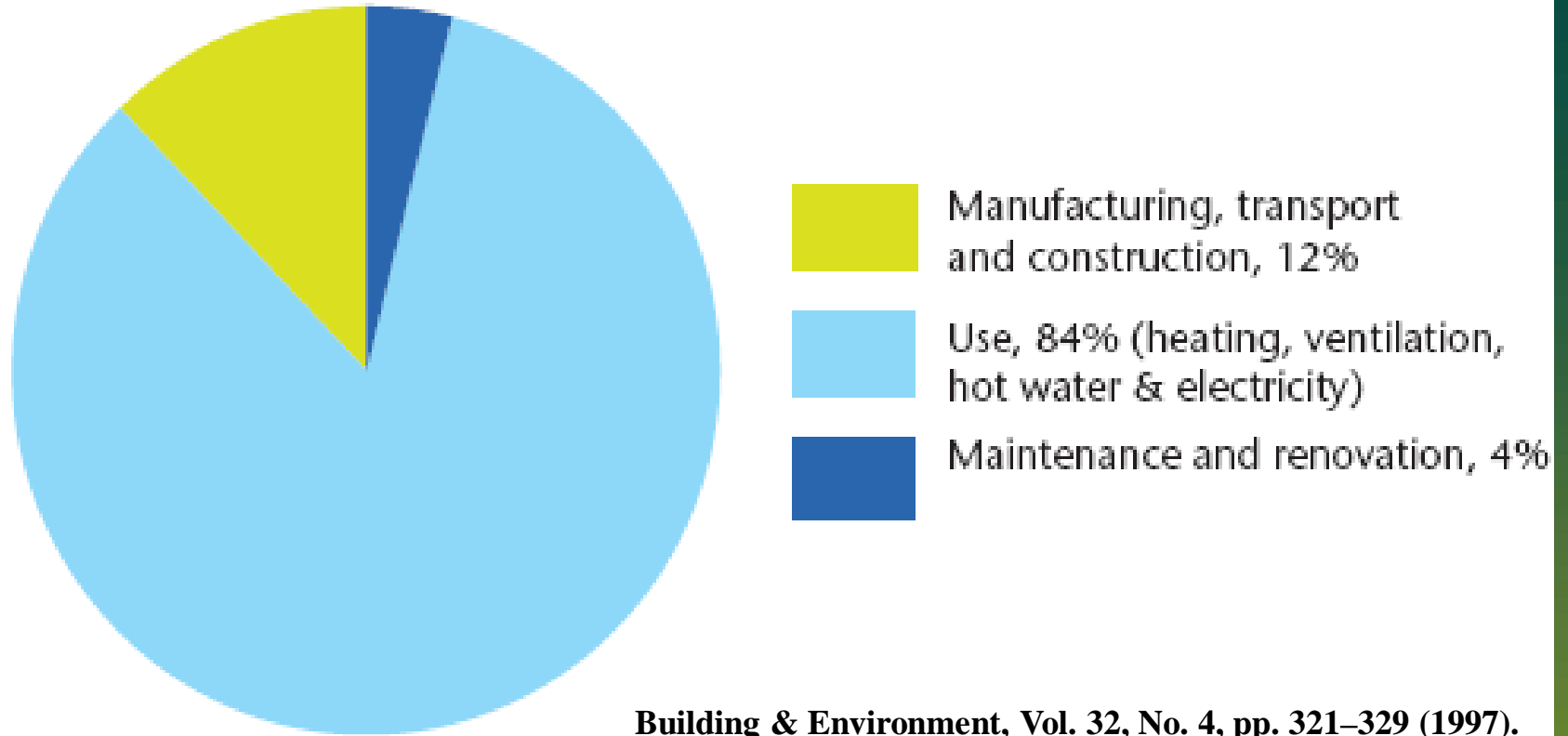
**Construction**

**Operation**

**End-of-Life**

**Energy, Material, Embodied Energy, and Water**

*Whole Building LCA*

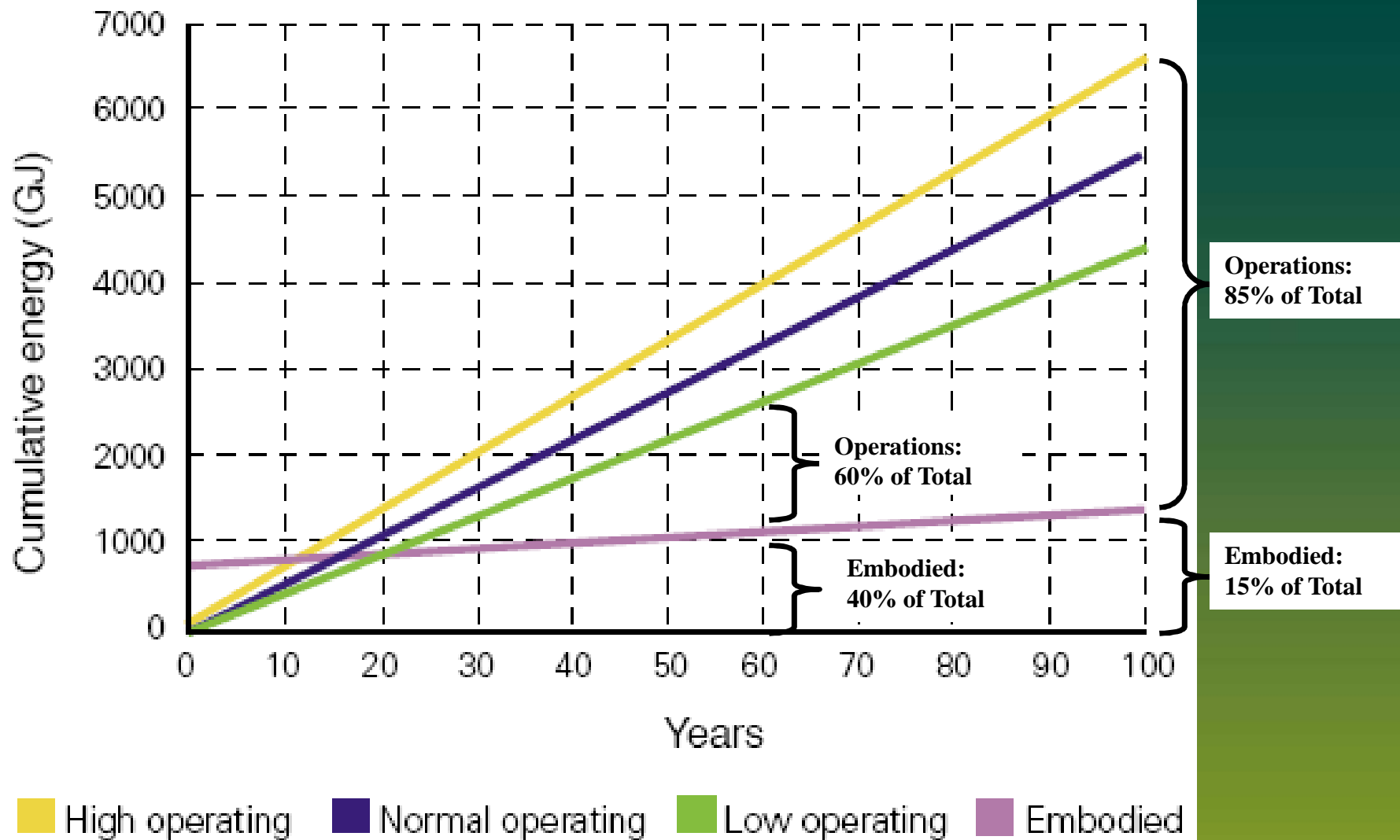


**Building & Environment, Vol. 32, No. 4, pp. 321–329 (1997).**

Cited in WBCSD: “Energy Efficiency in Buildings: Business Realities and Opportunities – Summary Report”, August 2007

*Embodied Energy as a Percent of Total*





Source: CSIRO Built Environment – Online Brochure. <http://www.dbce.csiro.au/ind-serv/brochures/embodied/embodied.htm>

## Total Building Energy Use

- Temporal –
  - Longer service life reduces the overall contribution of embodied energy
- Building Efficiency –
  - Higher efficiency buildings increase the contribution of embodied energy
- Climate Zone –
  - A more temperate climate will raise the contribution of embodied energy to the total

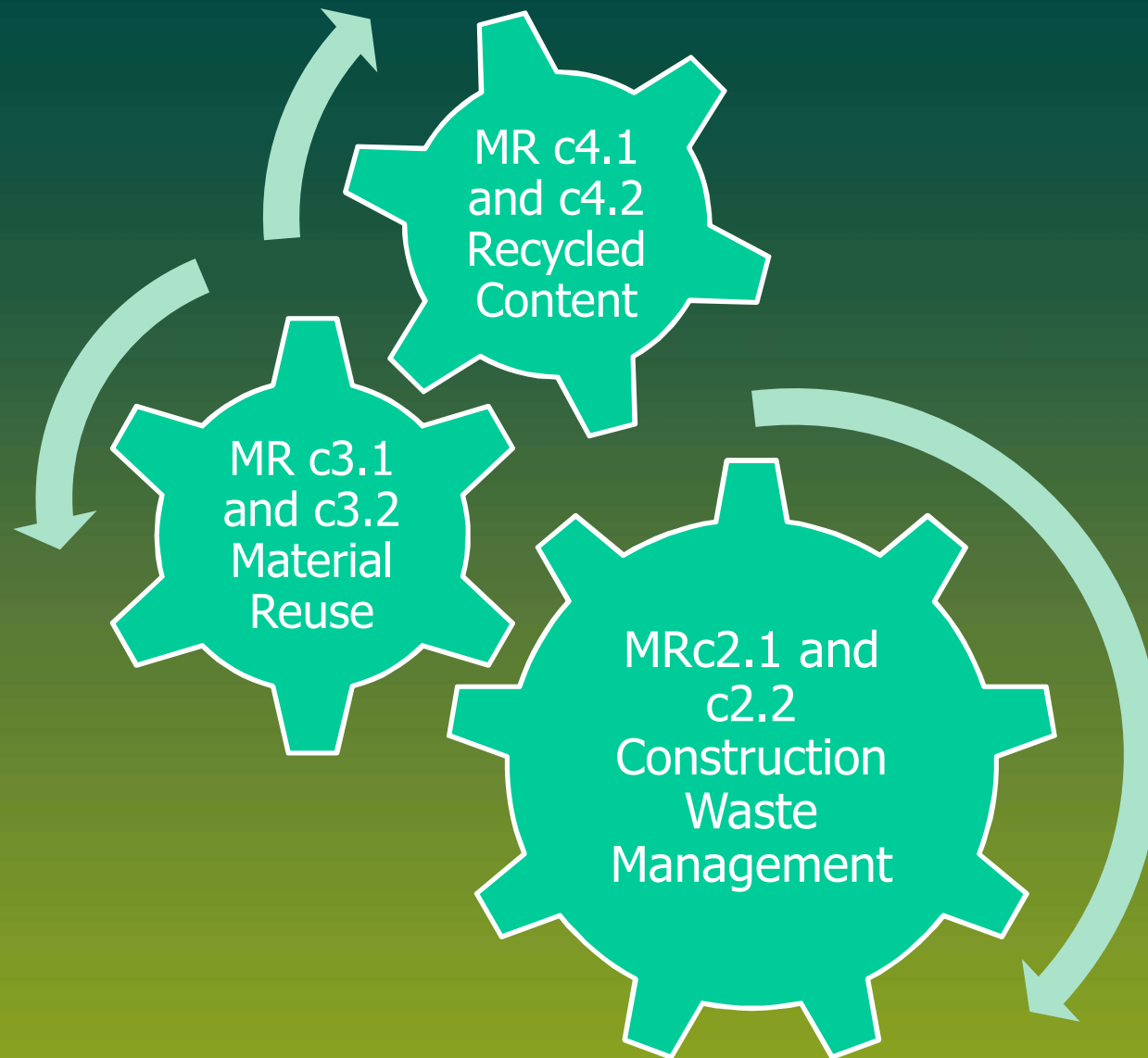
*Embodied Energy's Relation to Total*

- How do LEED credits work to reducing the embodied energy of a green building?

*LEED and Embodied Energy*

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*Synergy to Reduce Embodied Energy*

MR c5.1 and c5.2  
Regional  
Materials

Intent:  
Reduce  
Transport  
Impact

MR c6  
Rapidly Renewable

*Potential to Cancel Intent*

- Question: Which material has a higher embodied energy?
  - 1 ton of Bamboo Flooring from the “Bamboo Sea” in the Hunan Province delivered to Denver, Colorado
  - 1 ton of concrete from local sources delivered to a project in Denver, Colorado

*Embodied Energy Trivia*

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**Table 1: Emissions and Embodied Energy of Transport per Ton-Mile Freight**

|                          | <b>Energy Use</b><br>MJ/ton-mile | <b>GWP</b><br>lb CO <sub>2</sub> e/ton-mi | <b>Reference</b>           |
|--------------------------|----------------------------------|---|----------------------------|
| <b>Ocean Freighter</b>   | 0.28                             | 0.05                                      | NREL US LCI Database, 2007 |
| <b>Locomotive</b>        | 0.37                             | 0.06                                      | NREL US LCI Database, 2007 |
| <b>Barge</b>             | 0.54                             | 0.09                                      | NREL US LCI Database, 2007 |
| <b>Cargo Plane*</b>      | 1.15                             | 0.17                                      | NREL US LCI Database, 2007 |
| <b>Combination Truck</b> | 1.54                             | 0.26                                      | NREL US LCI Database, 2007 |
| <b>Single Unit Truck</b> | 3.29                             | 0.56                                      | NREL US LCI Database, 2007 |

\* = Cargo Plane database only includes CO<sub>2</sub>-related GHG emissions. Additional GHG releases, such as N<sub>2</sub>O and CH<sub>4</sub>, would likely increase GWP (lb CO<sub>2</sub>e/ton-mi) by an additional 1%.

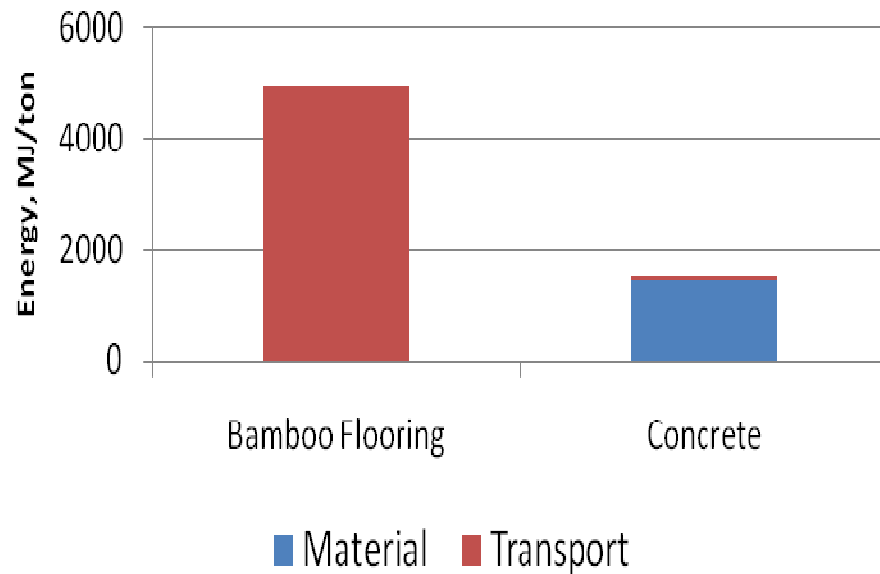
- Ocean freighter 32% more efficient than rail
- Rail 4x more efficient than combination truck and 9x more than single unit truck.

**Table 2: Energy and Emissions Associated with Manufacture and Transport of One-ton of Bamboo Flooring and One-ton of Concrete**

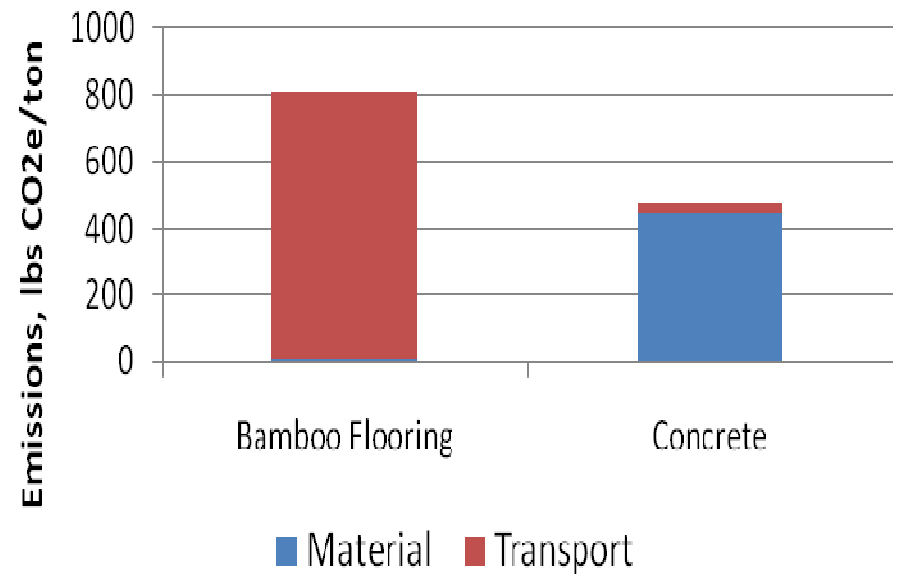
| Material               |                |                                 | Transportation |               |            |                                  | Cumulative Impact |                                 |
|------------------------|----------------|---------------------------------|----------------|---------------|------------|----------------------------------|-------------------|---------------------------------|
| Item                   | Energy, MJ/ton | Emissions, lb CO <sub>2</sub> e | Mode           | Distance, mi. | Energy, MJ | Emissions, lbs CO <sub>2</sub> e | Energy, MJ        | Emissions lbs CO <sub>2</sub> e |
| Bamboo Flooring        | 15             | 4.5                             | Truck          | 500           | 1645.0     | 280.0                            | 4943.1            | 809.4                           |
|                        |                |                                 | Ship           | 7,362         | 2061.4     | 368.1                            |                   |                                 |
|                        |                |                                 | Rail           | 1,221         | 451.8      | 73.3                             |                   |                                 |
| Concrete <sup>10</sup> | 1452.3         | 446.7                           | Rail           | 177           | 32         | 12.0                             | 1537.3            | 475.4                           |
|                        |                |                                 | Truck          | 58            | 53         | 16.3                             |                   |                                 |

*Material and Transportation Energy*

### Embodied Energy (per ton of material delivered)



### Emissions, CO2e (per ton of material delivered)



*Which Material is Low-Energy?*

*Paper 2: “Substantiating the Environmental  
Benefits of Green Buildings”*

Are Green Buildings Improving the Environment?

What Environmental Claims Can Green Buildings Make?

How Can the USGBC Increase the Substantiated Environmental Benefits of Green Buildings?

- Guides for the Use of Environmental Marketing Claims (FTC/USEPA)
- Help ensure that green claims do not violate the law
- Substantiate all environmental claims including reasonable interpretations

*Federal Trade Commission*

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- Building Sector and GHG Emissions
  - 48% of all U.S. GHG emissions
  - 76% of U.S. power plant output
- **Goal: Carbon-neutral buildings by 2030**
- What does a carbon-neutral building really mean?

*Building Sector Impacts*

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- Embodied Energy
  - Material production
  - Transport
- Site Carbon Impacts
  - 10 mt carbon/acre in top soil in CO
  - Can oxidize from project activities
- Operational Energy

*Carbon Footprint of a Building*

- Building uses no greenhouse gas emitting energy
- Up to 20% can be covered through purchase of carbon offsets or renewable energy certificates (RECs)
- Embodied energy and site carbon are not included in the definition of a carbon-neutral building

*Carbon-neutral Buildings*

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Solar Panels on Office Roof



REC

\$2 / DC watt  
\$115 / MWh  
for RECs



Coal Power



REC

Coal Electricity

Null Electricity to Office  
(no claim of environmental benefits)

Renewable Energy to User

*Renewable Energy Certificates*

- Carbon Offsets
  - Pay for GHG reductions made through outside projects
  - Renewable energy, energy efficiency, tree planting
  - Domestic or international
  - Wide variation in quality – Buyer Beware
    - CDM Gold Standard, Voluntary Carbon Standard
    - Additional, verifiable, permanent

*Carbon Offsets*

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- How can a well-intentioned environmental policy fail to make a significant environmental impact?
- A Colorado Example
  - Renewable portfolio standard
    - 20% by 2020 – reduces GHG emissions/kWh
    - However, Comanche 3 coal plant in Pueblo cancels RE emission benefits
- How does this example serve as a precautionary tale for the USGBC?

- Carbon Cap and Trade
  - Sets a maximum level for GHG emissions
  - Allowances given freely or auctioned, traded in markets
  - Cap lowered over time
- Major players
  - Direct Emitters (DEs)
    - Electric utilities, cement plants
  - Renewable Energy Generators (REGs)
    - Distributed solar, wind
  - Indirect Actors (IAs)
    - Buildings, consumers, USGBC

*Carbon Cap and Trade*

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Do reductions in building energy use lower GHG emissions under a carbon cap and trade system?

*Cap and Trade & USGBC*

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**Cap:** 100,000 mtCO<sub>2</sub>e

GHG Emissions

**Direct Emitters:**  
Responsible for  
acquiring allowances

**Renewable Energy  
Generators:** Can  
reduce DE burden by  
generating electricity

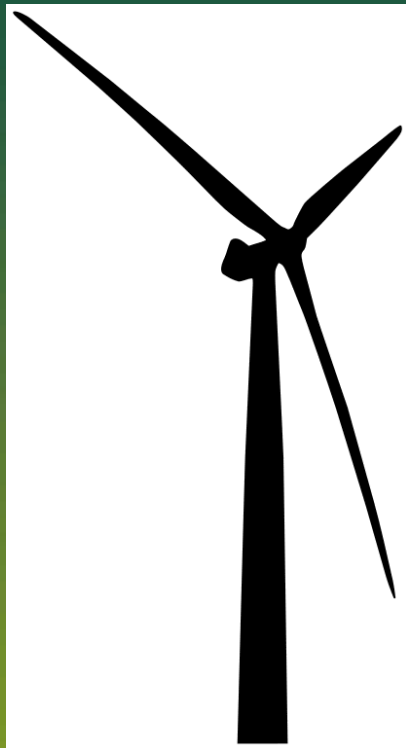
**Indirect Actors:**  
Influence DEs through  
demand on resources

Retired allowances

REGs and IAs do not own allowances, cannot impact cap

*Cap and Trade Schematic*

## Renewable Energy Generator



## Energy Efficient Green Building



*What's the Difference?*

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What policy options are available to ensure that energy efficient green buildings generate substantiated GHG emission reductions under a cap and trade system?

*Demand Side Policy Options*

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- Set-Aside
  - Certain percentage of allowances specified for “eligible activities” (renewable energy and energy efficiency)
  - Retiring allowances provides clear claim of environmental benefits
- Should there be set-asides for the lowest carbon footprint buildings?

*Set-Aside*

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- Output-based Allocation
  - Allowances granted to generators based on the quantity of energy produced
- Should energy efficient buildings be given allowances based on reduced electricity demand?

*Output-based*

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- Cap reduction
  - Demand for renewable energy is considered when setting or reducing the cap
- Could the USGBC lobby for a lower cap based on building energy use reduction initiatives like the 2030 Challenge's carbon neutral building goal?

*Cap Reduction*

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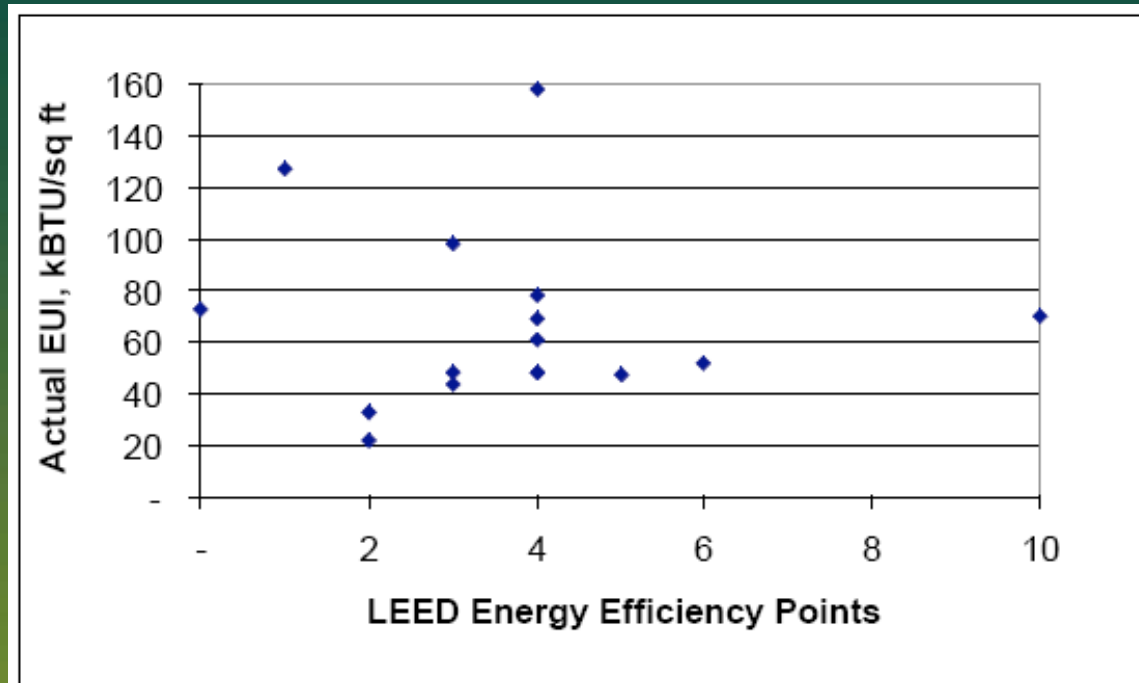
How can the USGBC best ensure that its positive environmental initiatives translate into real, substantiated environmental benefits?

Consider:

- Embodied Energy
- Ownership of Renewable Energy Credits
- Influence as Demand Side Actors

*Paper 3: “Comparing LEED Energy  
Points to Life Cycle Impacts”*

- Should LEED reward points based on modeled or actual energy use?



Diamond et al., 2006, Lawrence Berkeley National Laboratory

- No correlation between actual building energy use and awarded LEED points

*Actual LEED Building Energy Use*

- For illustrative purposes, consider the June 26<sup>th</sup>, 2007 update to the EA points for a 65,000 ft<sup>2</sup> commercial building with equivalent 14% energy savings from:
  - Case I: Only energy efficiency
  - Case II: Only on-site renewable energy

*Example*

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## Case I



## Case II

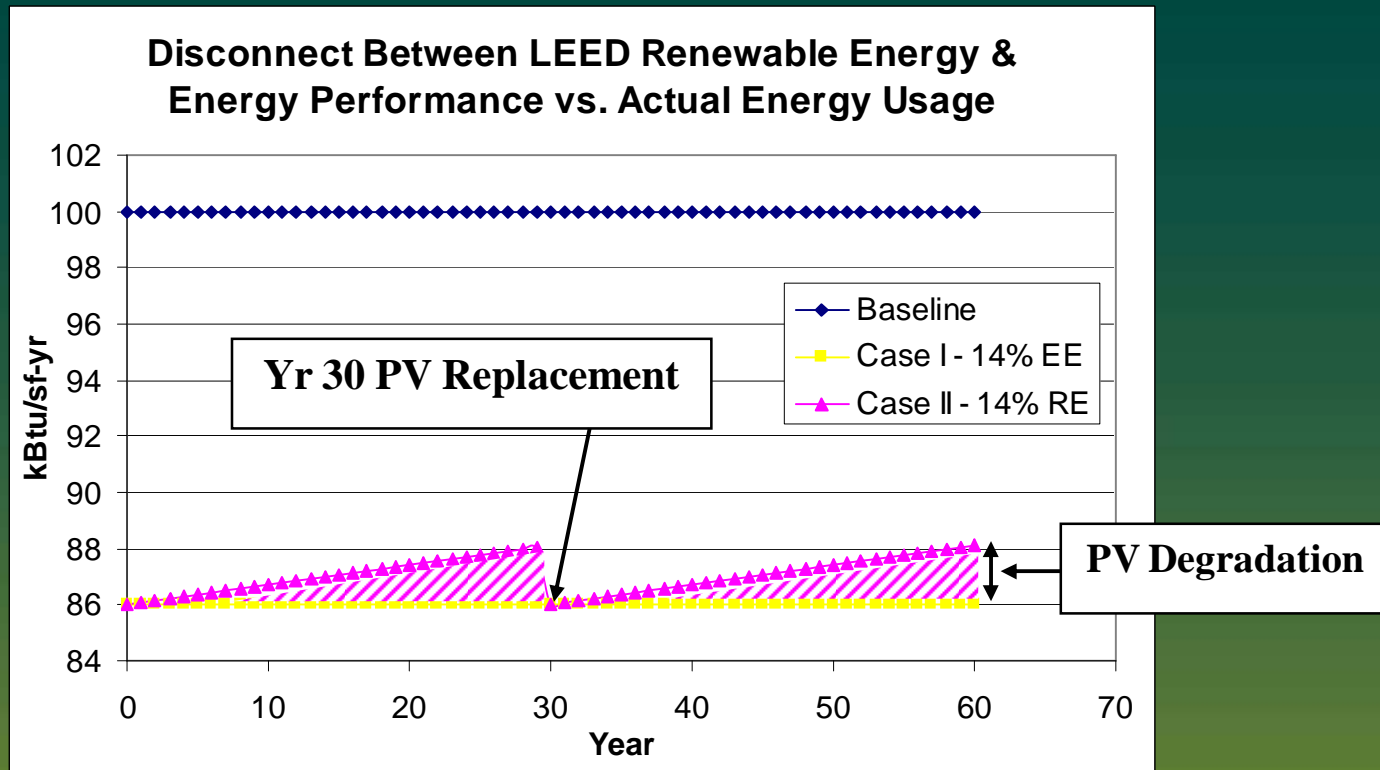


..... **Baseline**  
- - - **Total Energy**  
—— **LEED Energy**

- Total building energy use only reduced with EE improvements
- For equivalent 14% energy savings, LEED rewards more points to renewable energy (5) vs. energy efficiency (2)

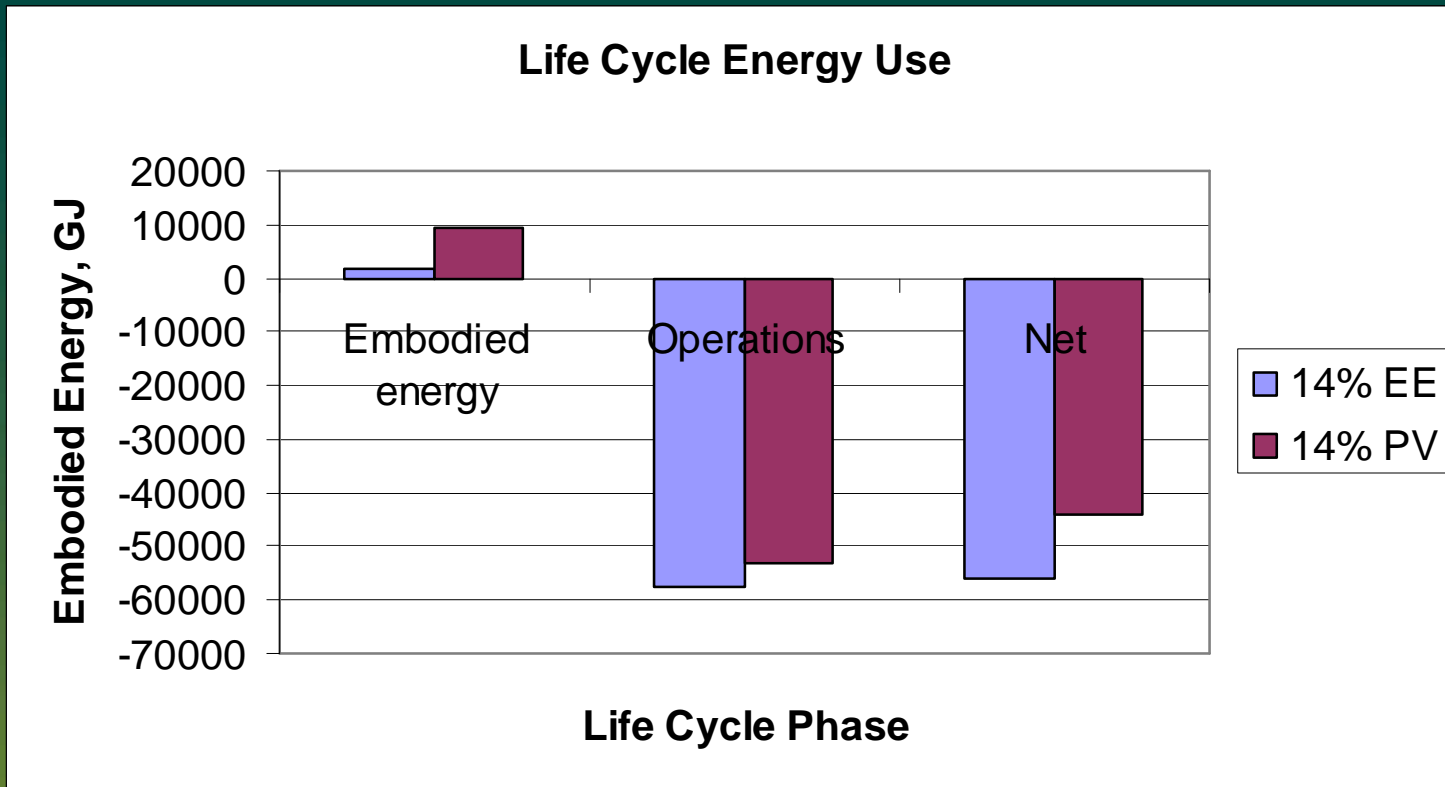
*LEED Energy*

- LEED points awarded should be weighted based on life cycle impacts....



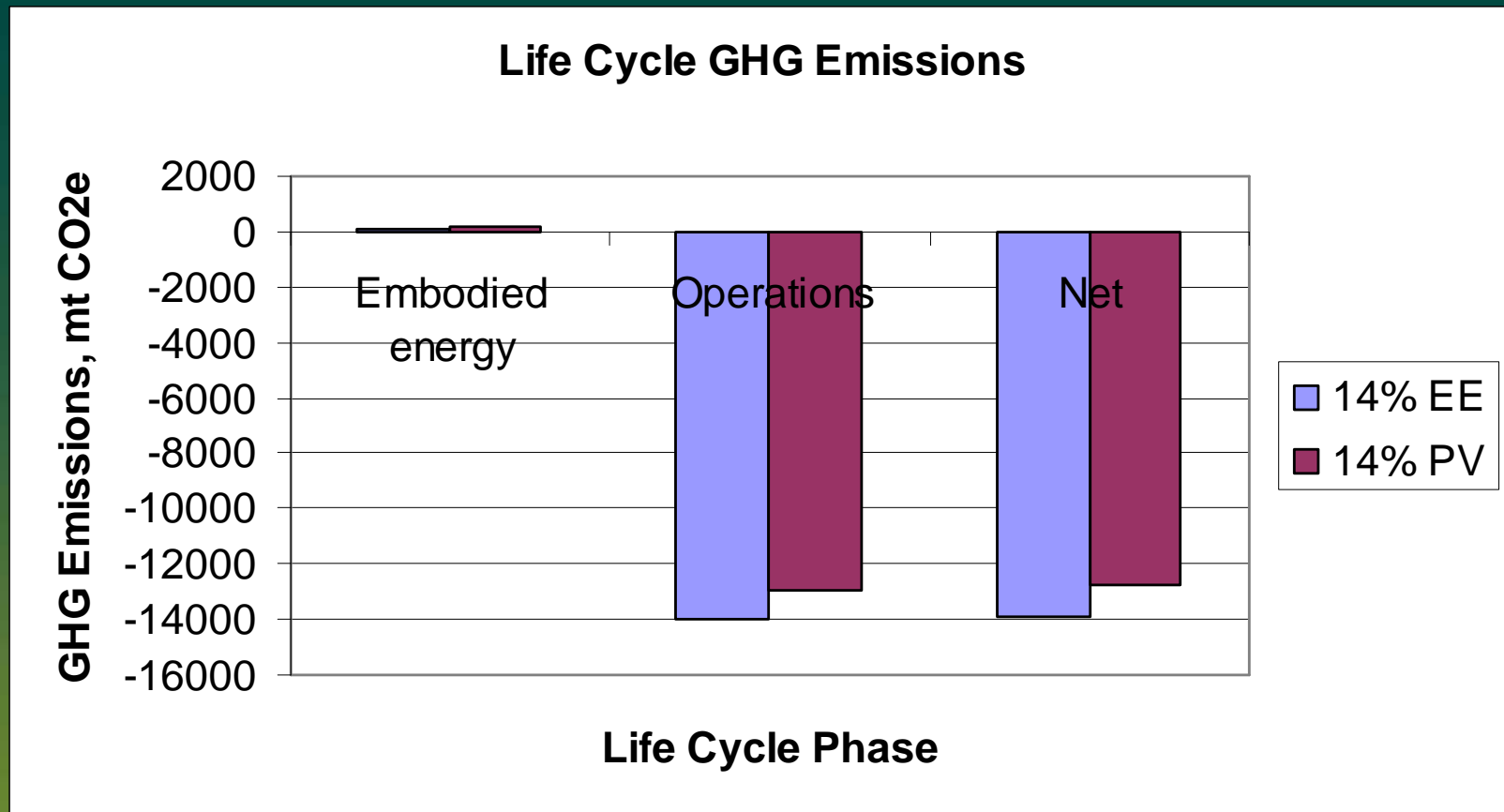
- Life cycle energy use and GHG emissions are lower for energy efficiency
  - PV degradation causes an increase in grid energy use equivalent to adding over 50 cars to the road for one year
  - Panel replacement doubles RE's embodied energy of materials

*LEED 60 Year Life Cycle*

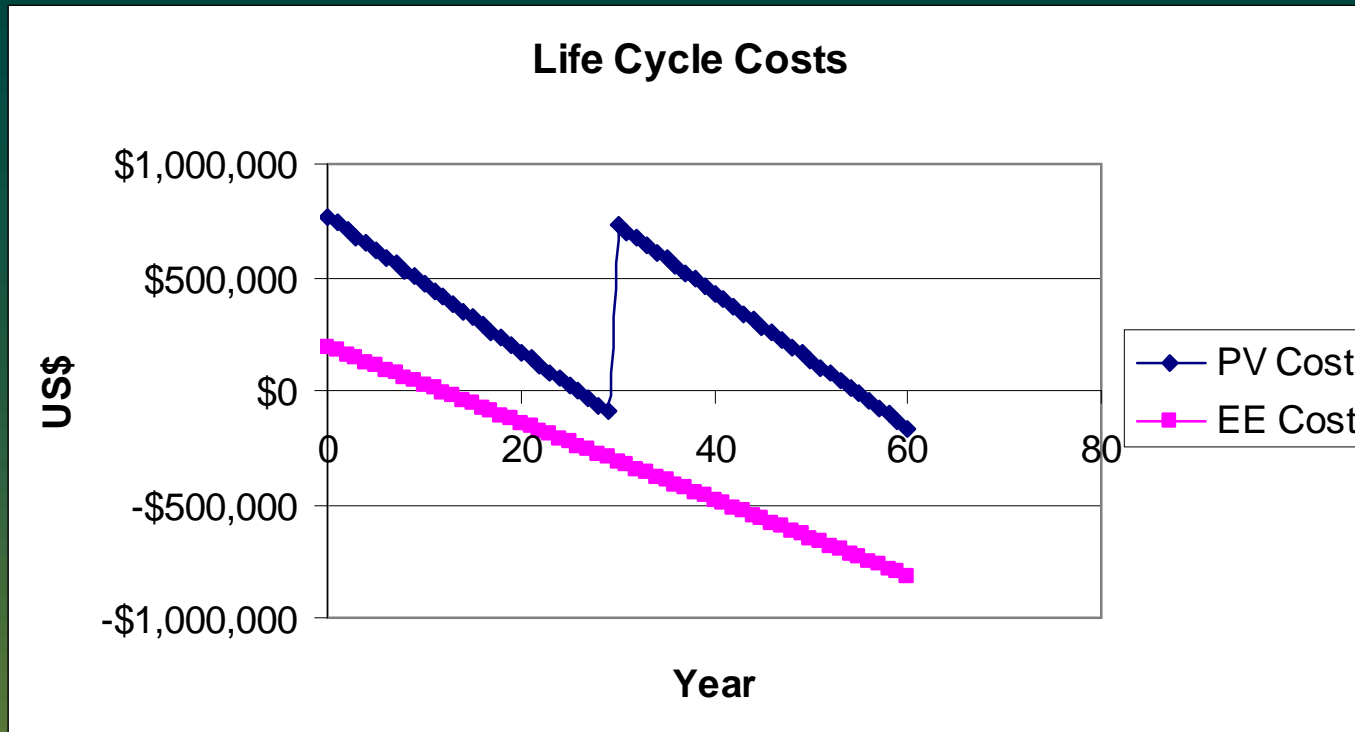


- Energy Efficiency Case saves over 12,000 GJ over its life cycle, when compared to the PV Case

*Life Cycle Energy*



- Energy Efficiency Case reduces an additional 10,000 mt CO2e over its life cycle



- Energy Efficiency Case saves over \$600,000 over its life cycle when compared to the PV system
  - Primarily due to:
    - Lower initial investment
    - No replacement costs

*Life Cycle Costs*

- Awarded LEED points do not correlate with actual building performance
- 14% Passive system receives 3 fewer LEED points, but has lower costs, life cycle energy use, and life cycle GHG emissions
- LEED points should be awarded based on weighted life cycle impacts

*LEED Passive-PV Conclusions*

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*Thank You*

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