

# Comparative Life Cycle Analysis of Five Low Slope Roofing Systems

InLCA/LCM 2006  
October 5, 2006

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# LCA Project

- Conduct an LCA on the most common roof materials used in North America
- Goals:
  - Determine which membrane generates the least environmental impacts
  - Establish the relative magnitude of the membrane's impact in the entire system

The study was conducted by  
Carbotech AG  
Basel, Switzerland

# Purpose of Presentation:

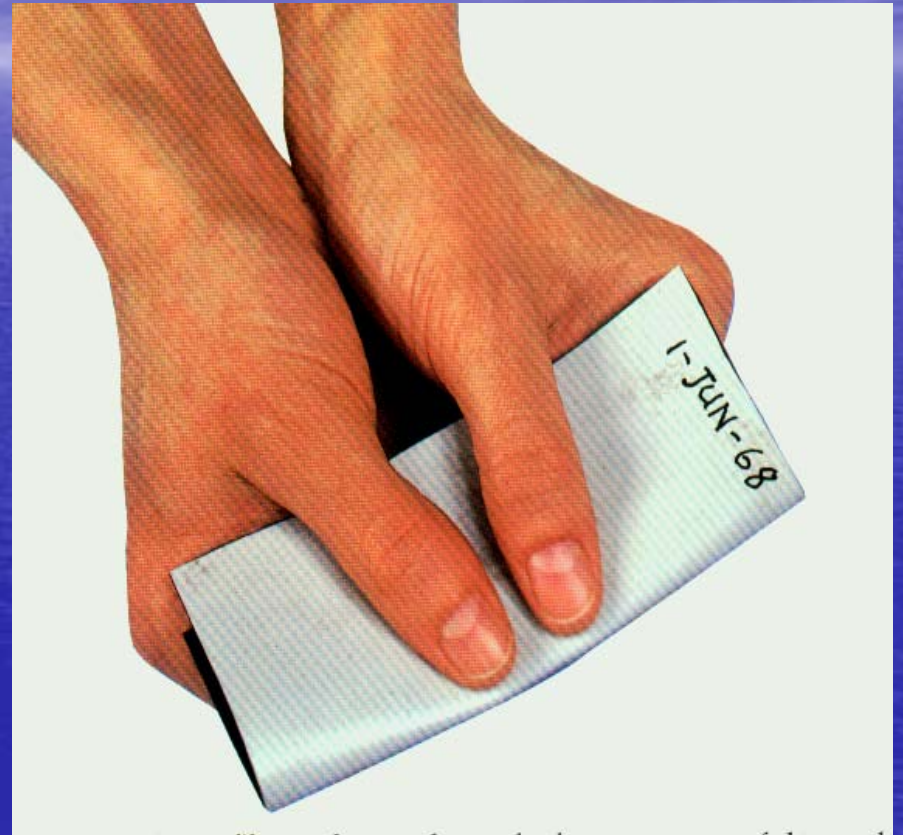
Discuss Process

More

Than Results

# Scope

- **Material only?**
  - Simple to conduct
  - Easy to understand



# Scope

- **Complete system?**
  - Increased complexity
  - Input data requirements
  - Output presentation
  
  - More comprehensive
  - Reflects reality
    - Interdependence between components
    - System's impact on energy consumption



# Chose to analyze entire systems

- F01: poly VR/ Iso/ MF PVC membrane
- F02: poly VR/ EPS/ DD/ MF PVC mem.
- F03: poly VR/ Iso/ MF TPO membrane
- F04: bit. VR/ Iso/ 2 ply MB., gran. surf.
- F05: poly VR/ Iso/ MF EPDM
- F06: bit. VR/ Iso/ DD/ 4 ply BUR/ gravel

NOTE: All insulation R: 18.9

# Study Parameters

- **Assessment Model**
  - EPA's TRACI
- **Unit of Analysis**
  - Square meter
  - Annualized
- **Criteria**
  - Non renewable primary energy
  - Global warming
  - Photochemical smog
  - Acidification

# Data Sources

- Minimal LCI data for commercial roofing (e.g. BEES: only residential, shingles)
- Relevance of what is available (e.g. Athena)?
  - Raw materials and energy: likely acceptable within a generic group of products

# Life Expectancy Data

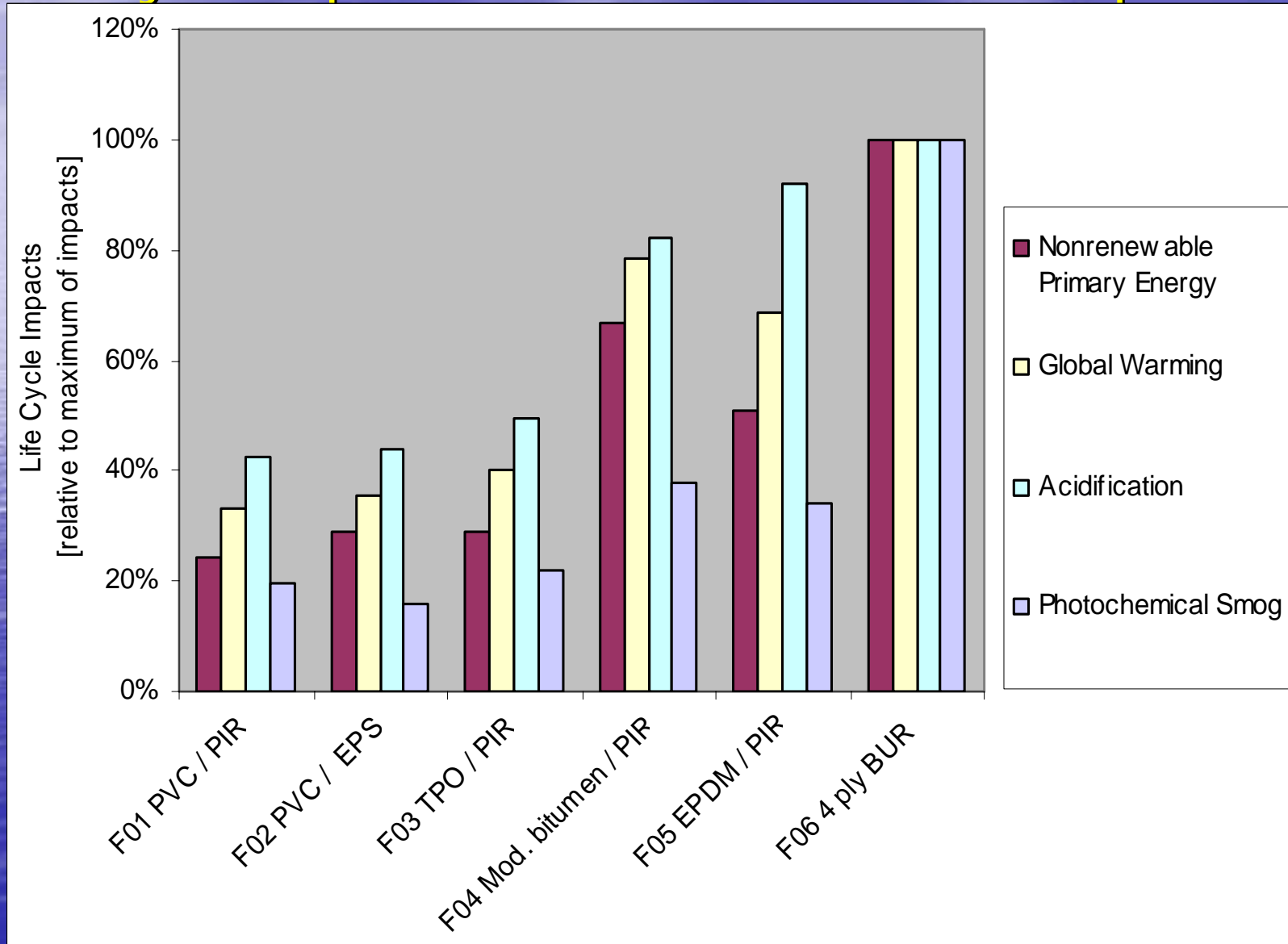
- **Industry surveys**
  - Typically more anecdotal than statistically valid
  - Often contradictory
- **Specific Product vs Generic Group**
  - Significant differences in quality/ track record within a generic group
  - Varying formulations over time
- **Third Party Assessments**
  - Product specific (e.g. British Board of Agreement)
- **Membrane vs other system components (insulation, adhesives, fasteners, vapor retarders, etc.)**
  - Reasonable to assume all components will last as long as the membrane?

# May require using mixed data sources

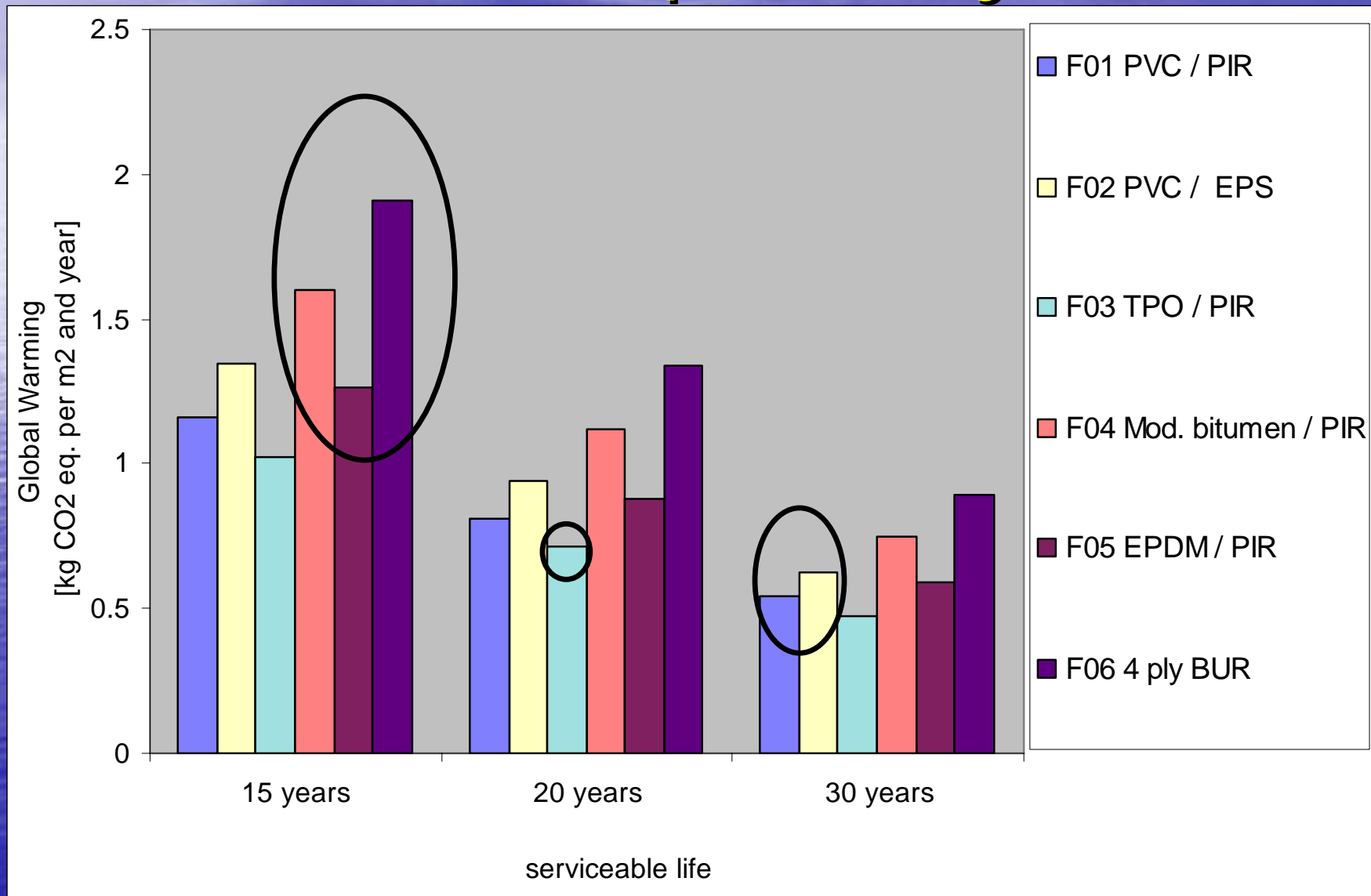
| Membrane  | Service Life | Data Source     |
|-----------|--------------|-----------------|
| PVC       | 30           | BBA Certificate |
| TPO       | 20           | BBA Certificate |
| Mod. Bit. | 15.9         | Survey*         |
| EPDM      | 14.2         | Survey*         |
| 4 ply BUR | 16.7         | Survey*         |

\*: The Relative Durability of Low Slope Roofing, Proceedings of the Fourth International Symposium on Roofing Technology, 1996, Cash, Carl, G.

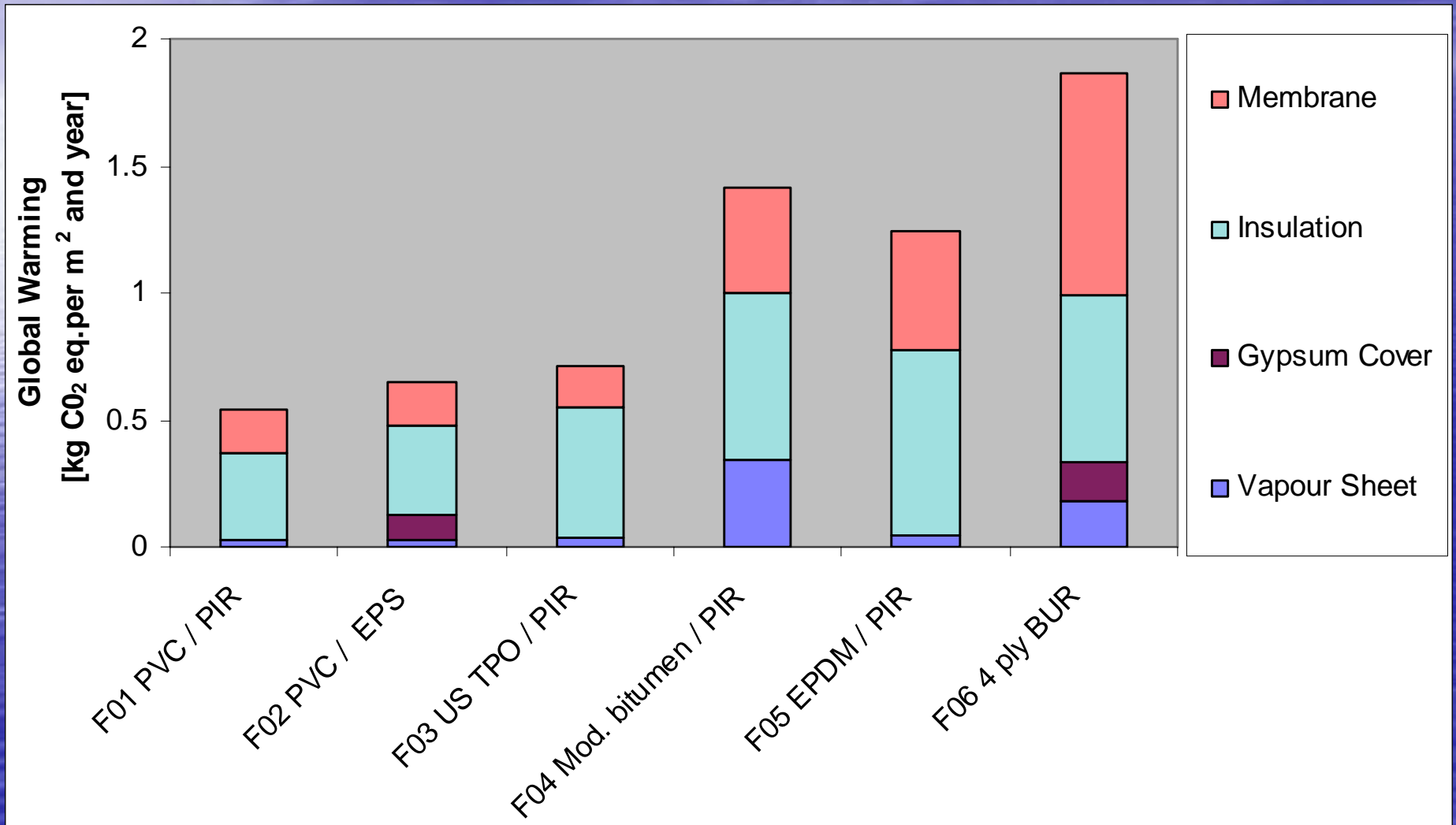
# Life cycle impacts relative to maximum impacts



# Effect of life expectancy



# Impact of each component

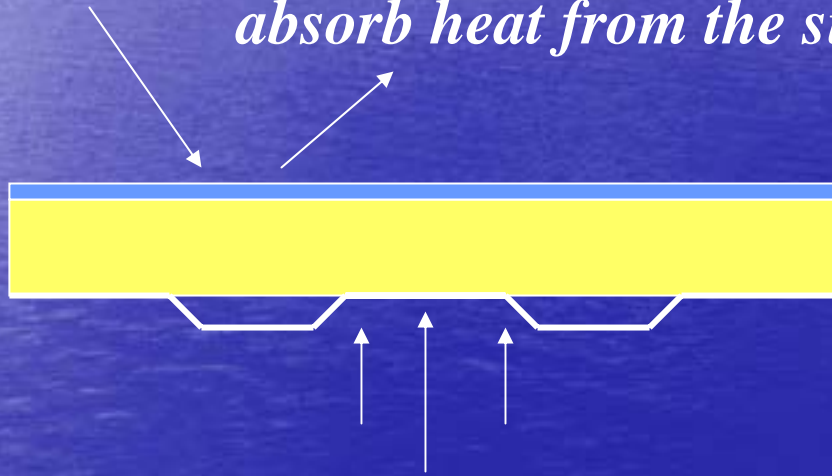


# Key life cycle impact drivers

- **Life expectancy**
  - Quality of data is critical
- **Raw material consumption**
  - General industry data probably sufficient
  - Within a generic group likely minimal differences
- **For single ply membranes, insulation generates greater impacts**
  - Highlights the need to study systems versus materials

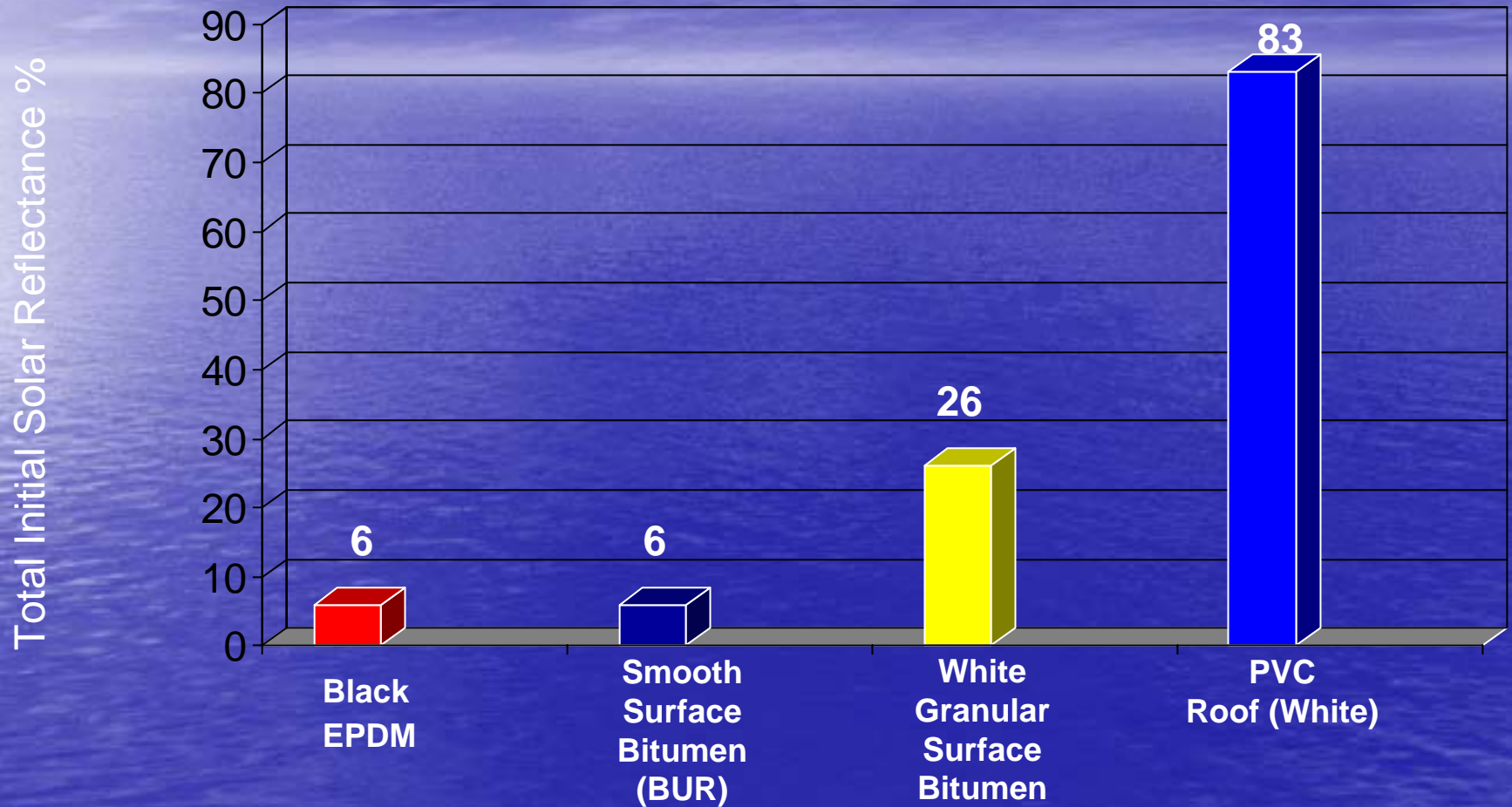
# Roof's contribution to operational impacts?

*1. The roof surface will either reflect or absorb heat from the sun's rays*



*2. Roof insulation will retard transfer of heat to / from the building interior*

# REFLECTANCE OF COMMON ROOFING MATERIALS



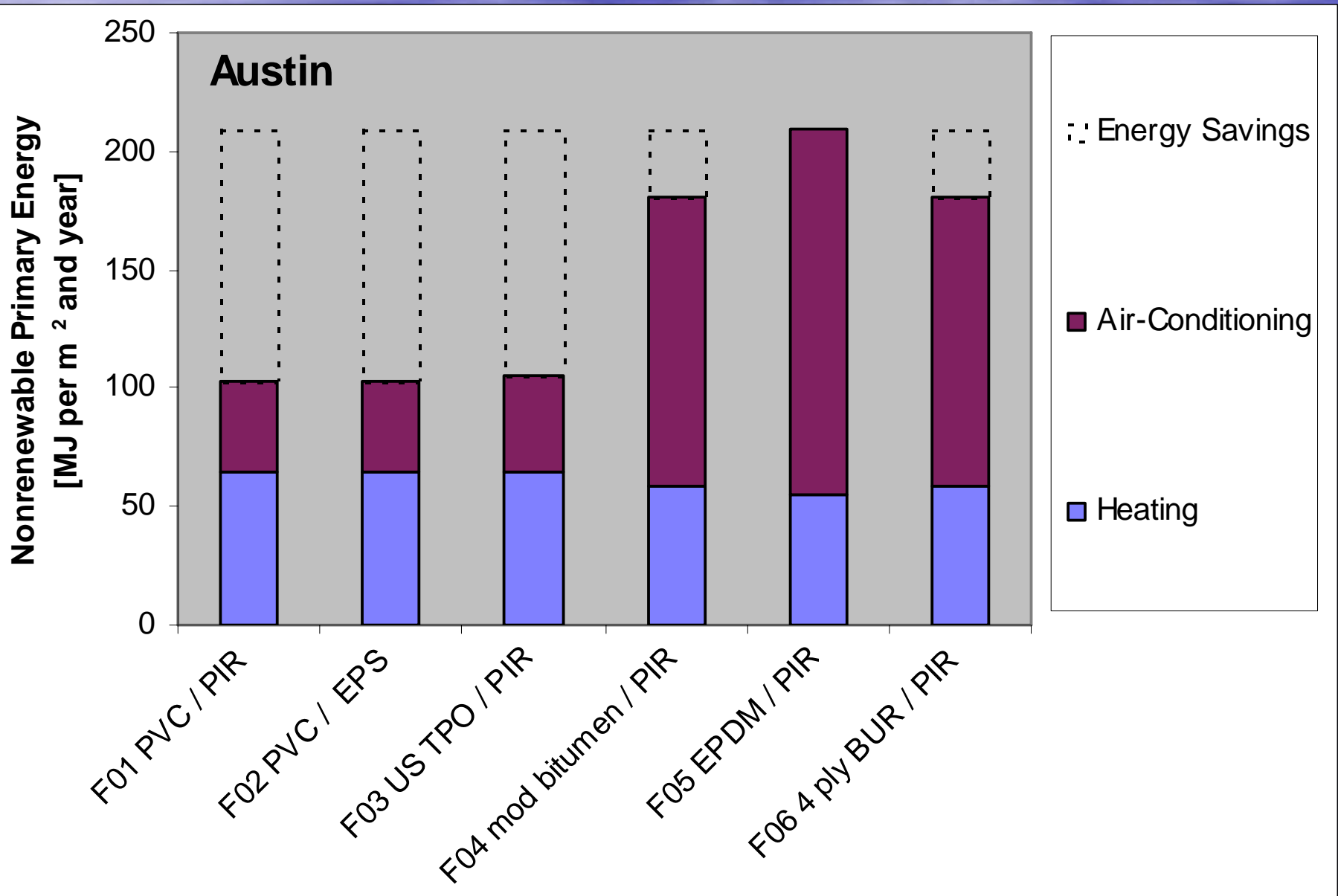
Source: Cool Roofing Material Database/Lawrence Berkeley National Laboratory  
<http://eedtd.lbl.gov/CoolRoof/membrane.htm>

# Analysis of cooling & heating impacts

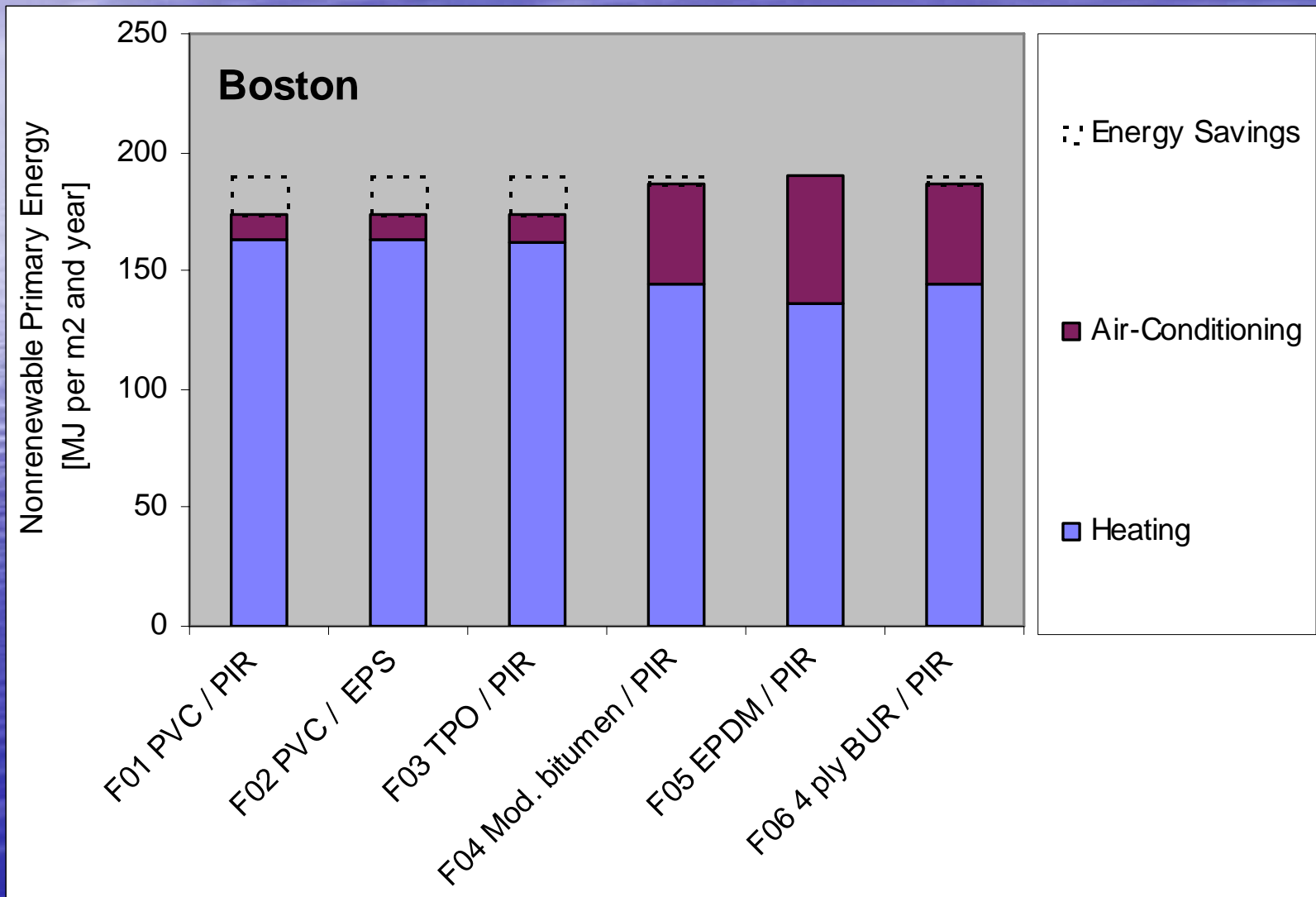
- 100,000 ft<sup>2</sup>, single story retail facility\*
- Evaluated for three locations:
  - Austin, TX
  - Boston, MA
  - Los Angeles, CA
- Evaluated using the DOE's Cool Roof Calculator

\*: Measured Energy Savings and Demand Reduction from a Reflective Roof Membrane on a Large Retail Store in Austin, Ernest Orlando Lawrence Berkeley National Laboratory, June 2001

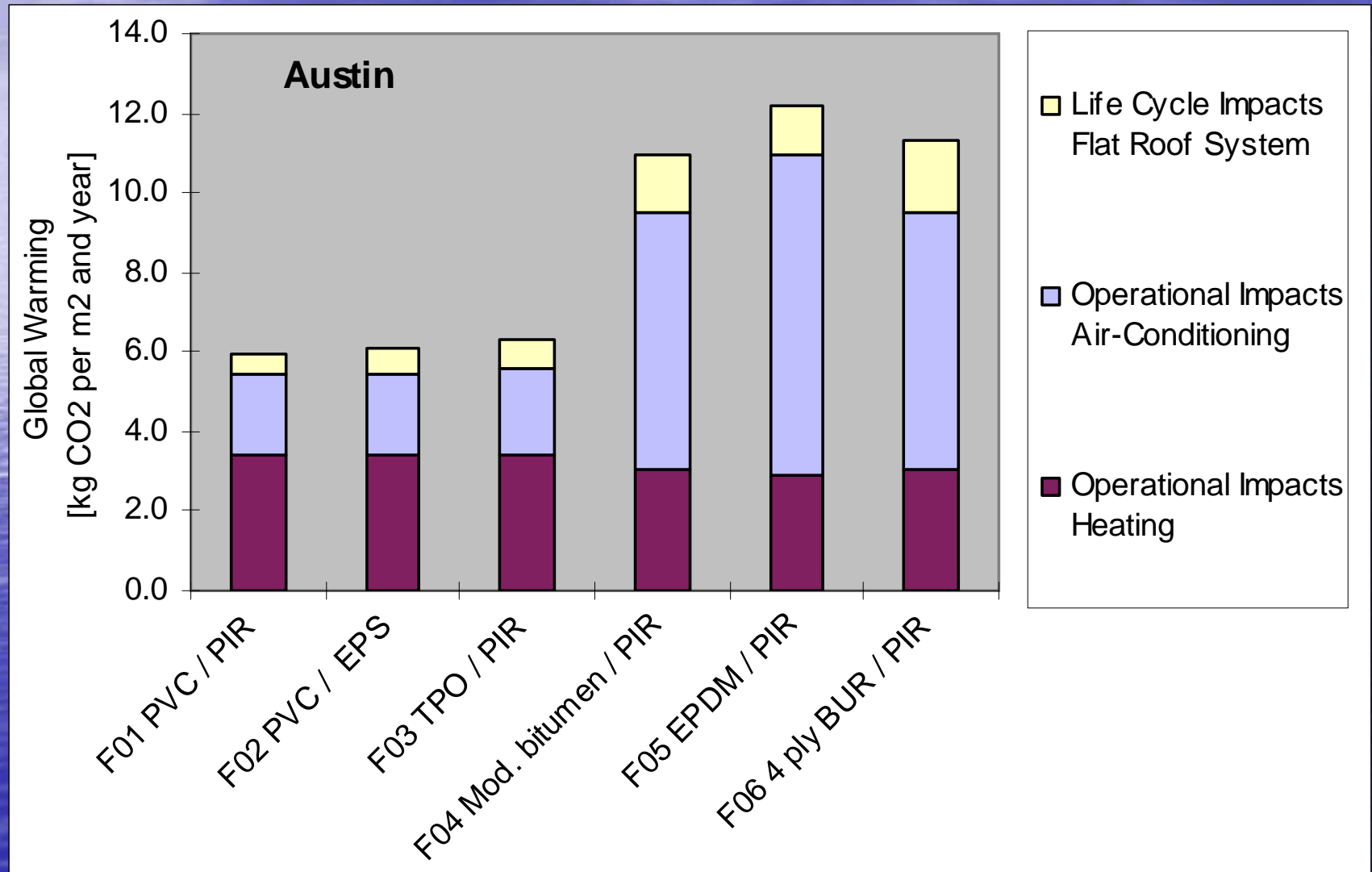
# Energy consumption and savings for Austin



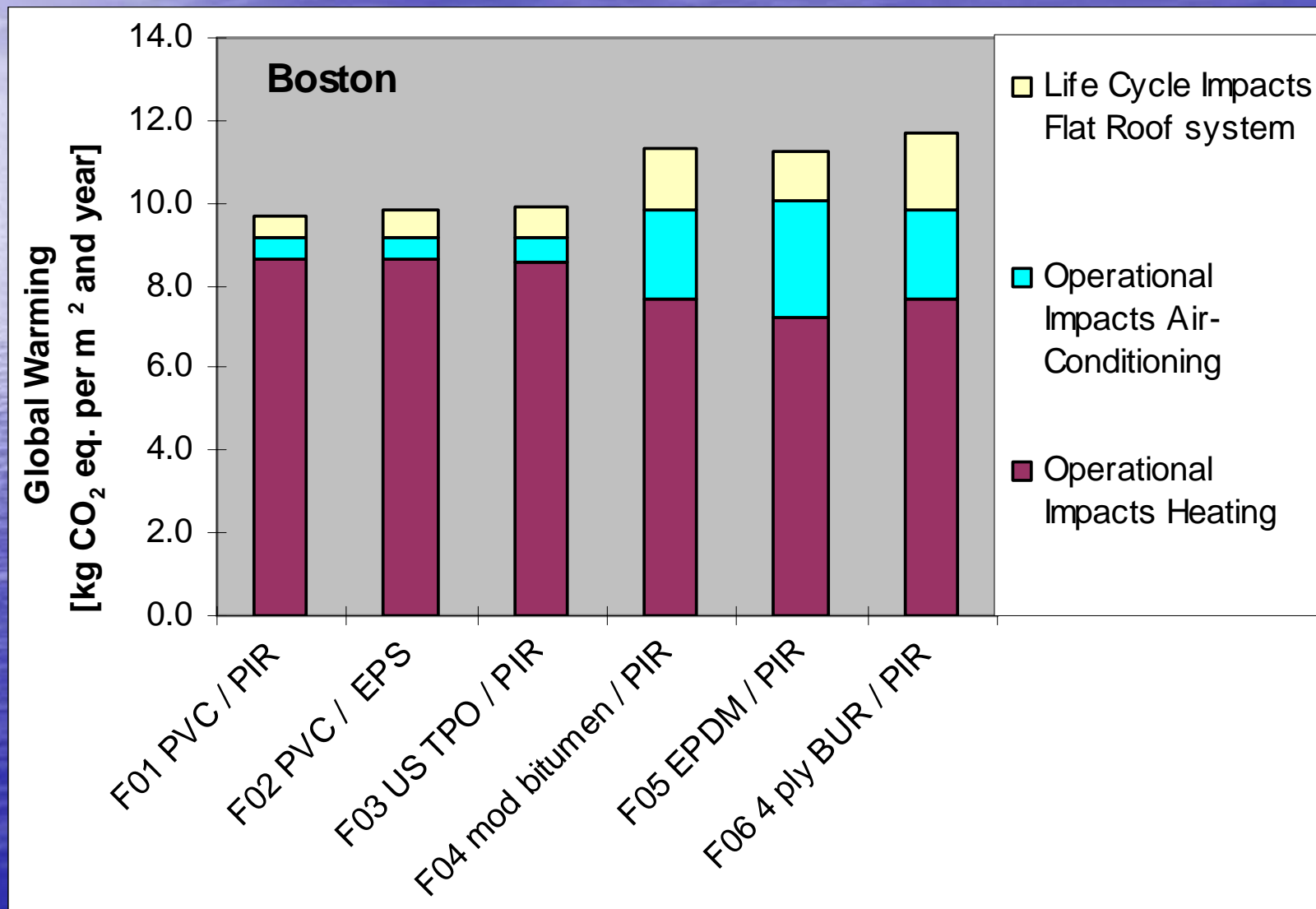
# Energy consumption and savings for Boston



# Total impacts for Austin



# Total impacts for Boston



# Operational Impacts

- For these systems/ materials, Operational greater than LC Impacts
- Climate/ location dependent
- Much less Life Expectancy dependent
  - Likely very similar across generic groups

Economical Sustainability  
Should Also be  
Considered

# Methodology

- **Analagous to impacts**

- Life Cycle Costs

- Installation
    - Maintenance
    - Disposal

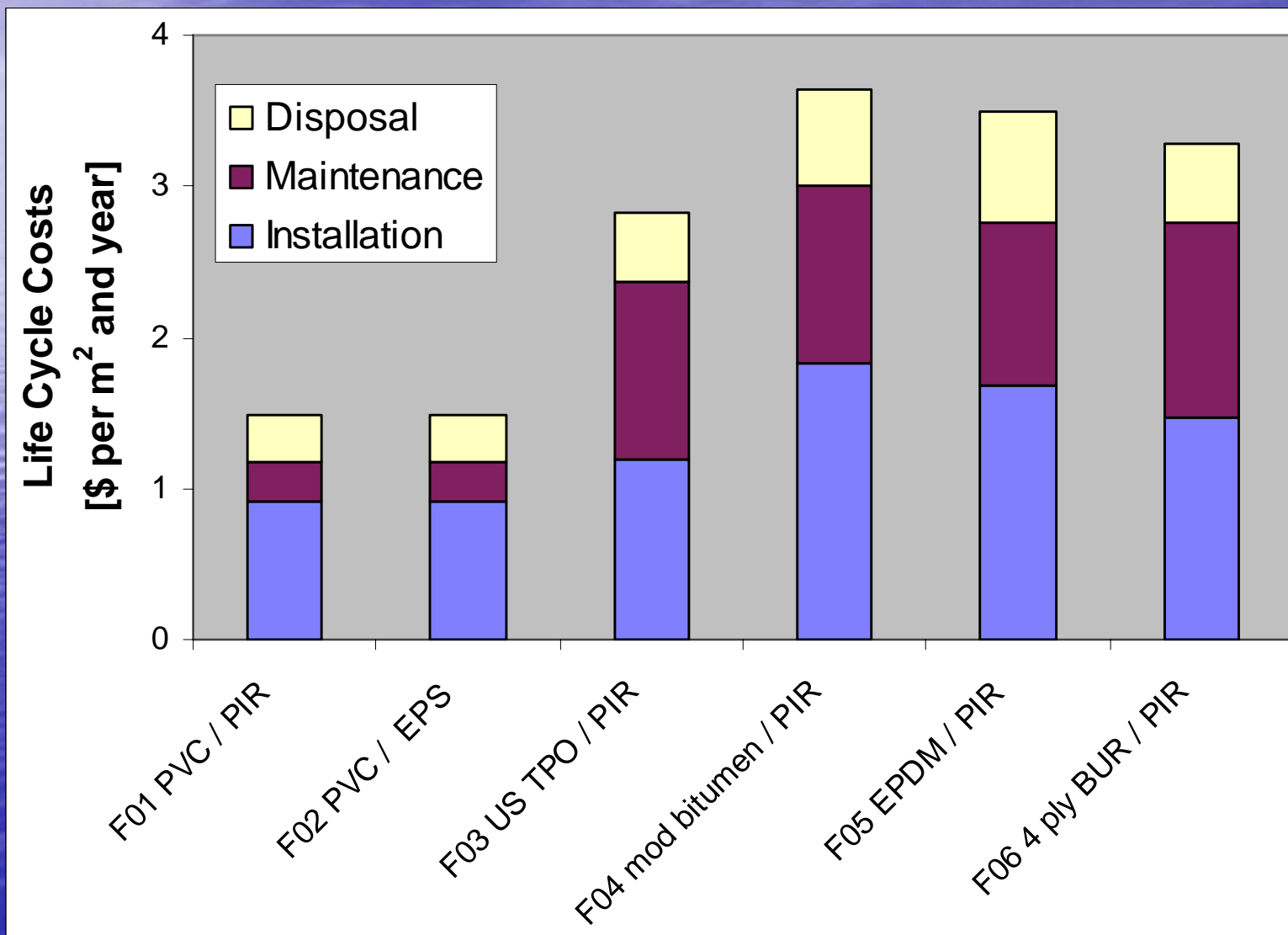
- (data based on the Relative Durability report, supplemented by additional survey information)

- Operational Costs

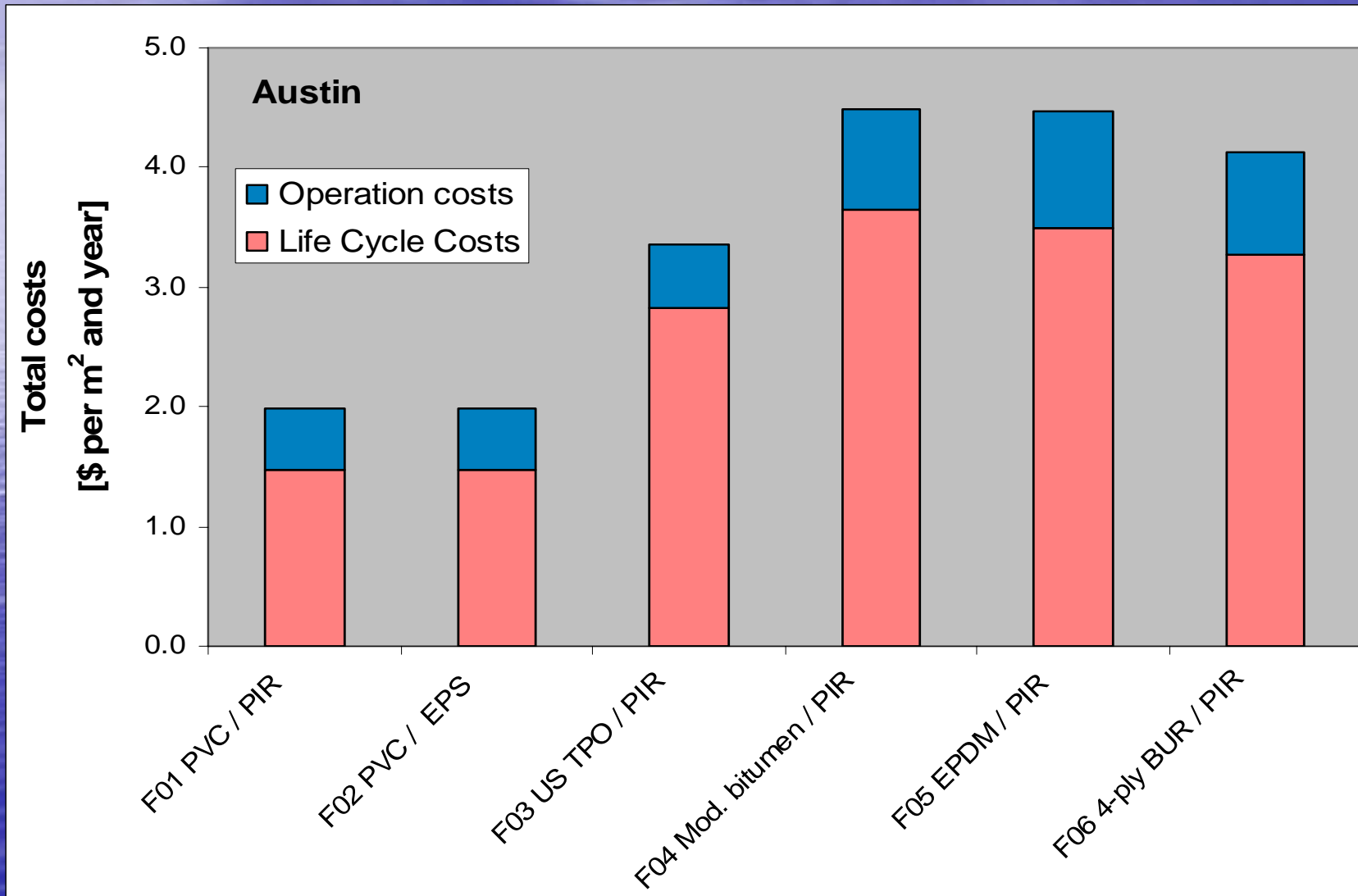
- Roofing related heating
    - Roofing related cooling

- (based on DOE's Cool Roofing calculator)

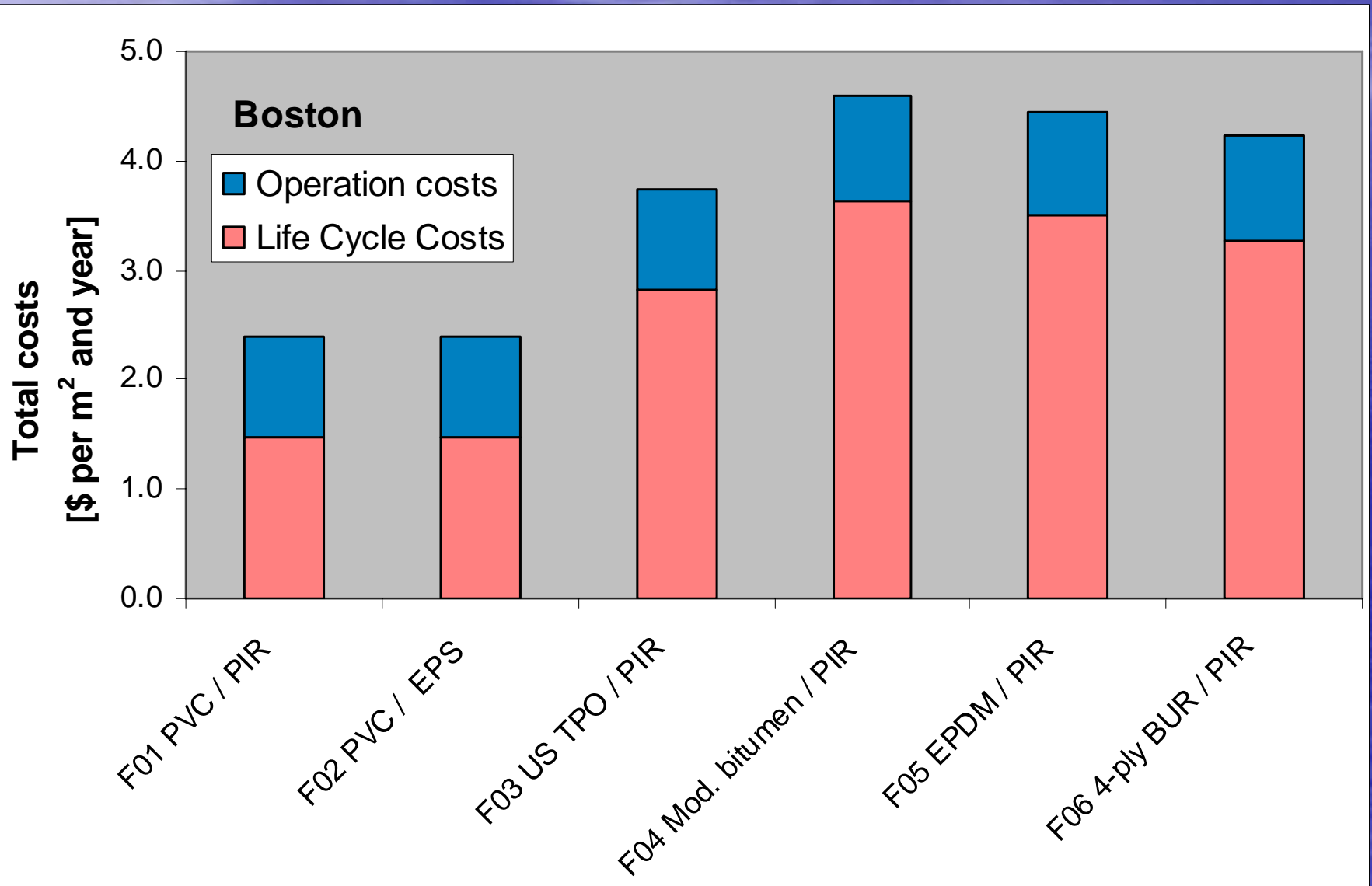
# Life Cycle Costs



# Total costs (life cycle and operational)



# Total costs (life cycle and operational)



# Data

- **Highly dependent on Life Expectancy**
  - Same challenges as Life Cycle Impacts
- **Introduces cost variables**
  - Based on industry averages at a point in time
  - With the exception of energy costs, difficult to reflect costs associated with regional differences (e.g. differences in amounts of insulation)

How to consider both Ecological  
and Economical  
factors simultaneously?

**Life Cycle  
Impacts**

**Operational  
Impacts**

**Life Cycle  
Costs**

**Operational  
Costs**



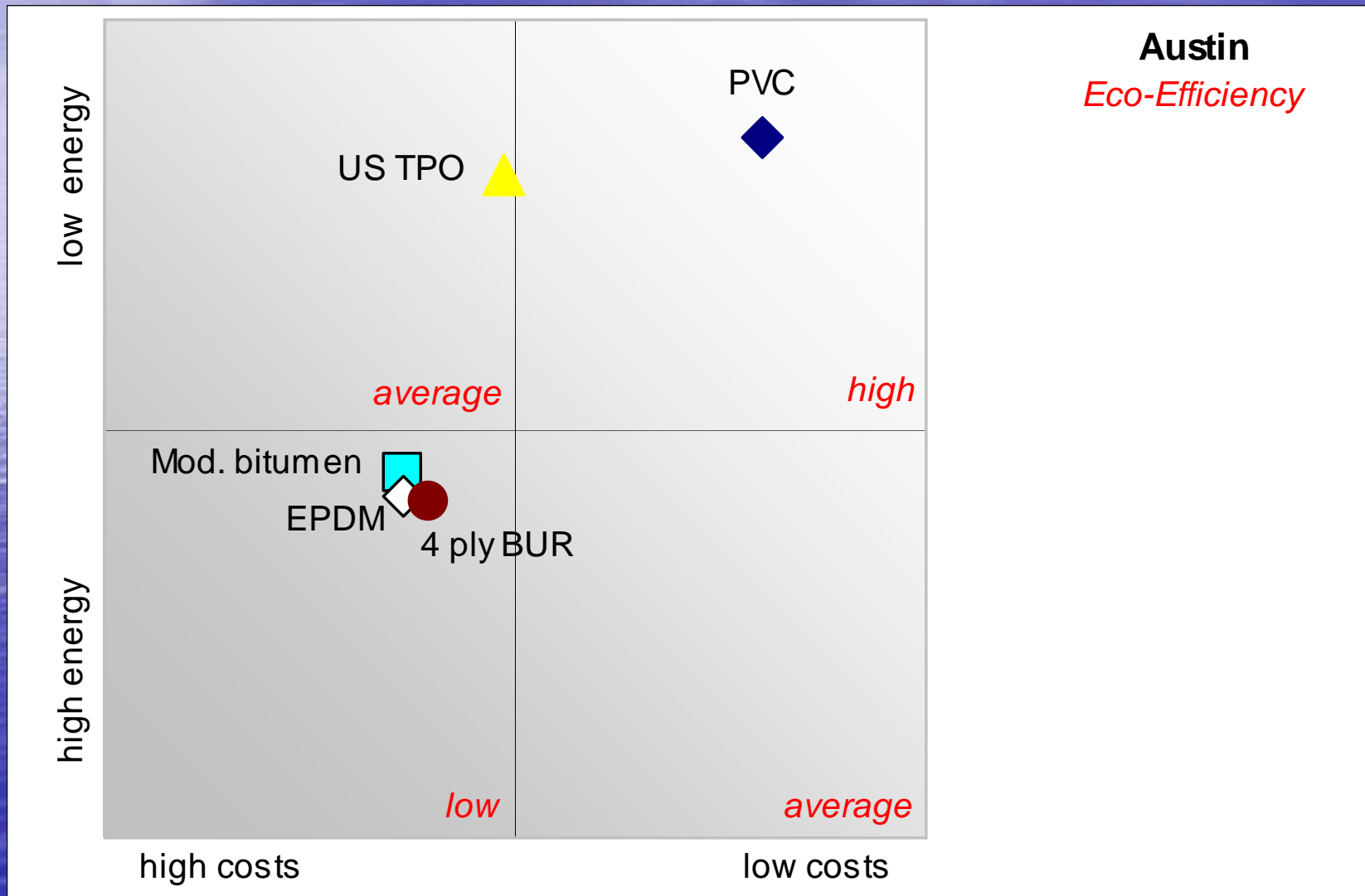
**Total  
Impacts**

**Total  
Costs**

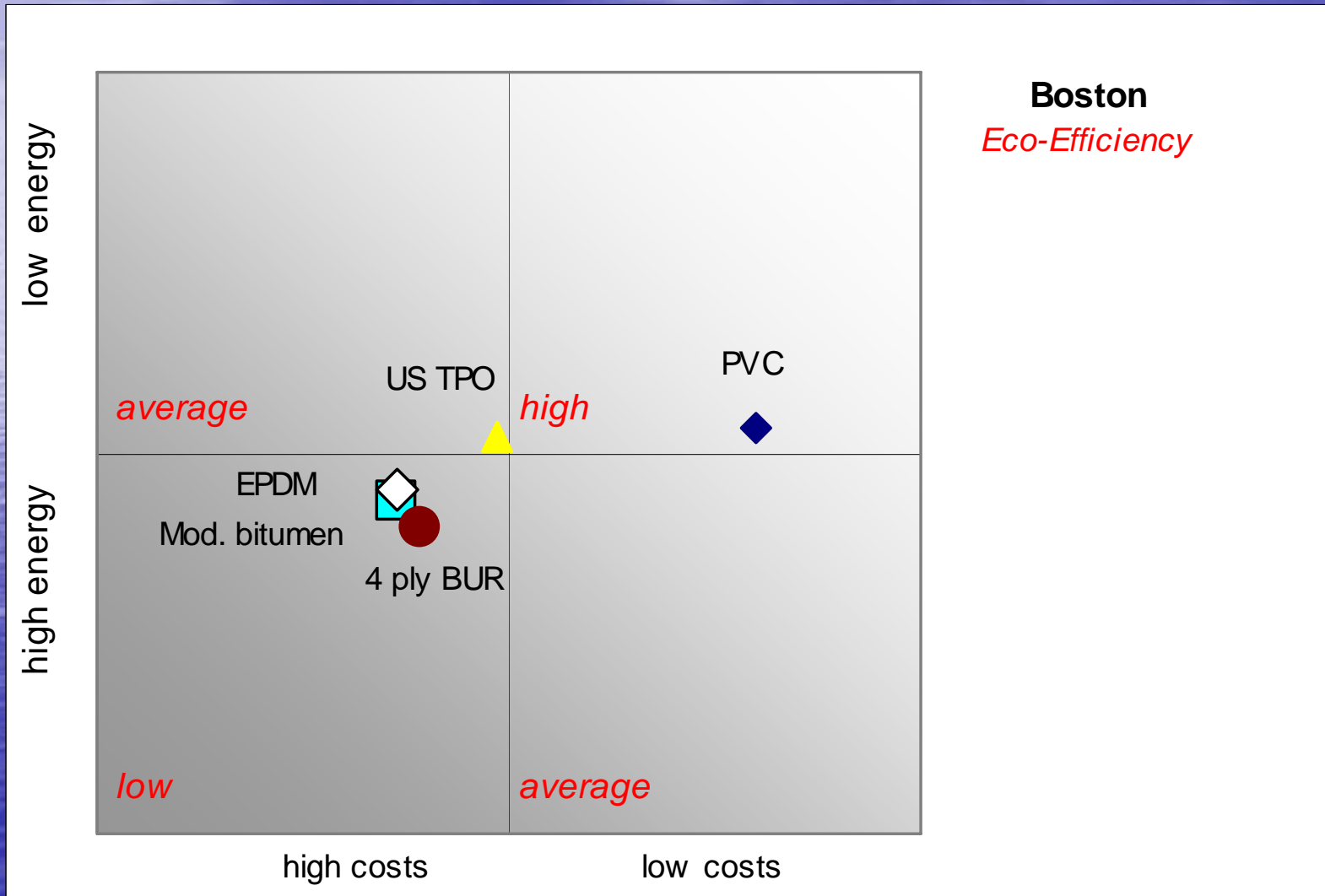


**Eco-efficiency**

# Eco – Efficiency for Austin



# Eco – Efficiency for Boston



# Cost & Ecology

- For roofing, systems imposing the least life cycle impacts appear to also have the lowest life cycle costs
  - Beneficial in promoting concept to building owners

# Life Cycle Assessment

- Valuable tool to assess environmental impacts quantitatively
- Still in its infancy as a tool in the construction industry
- Need to assess complete systems
  - For many need to consider location/climate to achieve a complete picture.
- Critical challenge
  - Life Expectancy data is critical
- Will no doubt grow in importance, usage

# Available upon request

- Ecological and Economical Balance Assessment of US Flat Roofing Systems, **Carbotech AG, Basel, Switzerland, 2004**
- LCA's Role in the Manufacture of Construction Materials, Life Cycle Assessment and Sustainability, **a Supplement to Building Design & Construction, November 2005, Graveline, S.P.**



Questions?