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Incorporating Life Cycle thinking in Green Building Design

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200 people in 10 offices

Private developments & Public institutions

Leading International Green Engineering firm

Minimization, Cost reduction, Energy reduction

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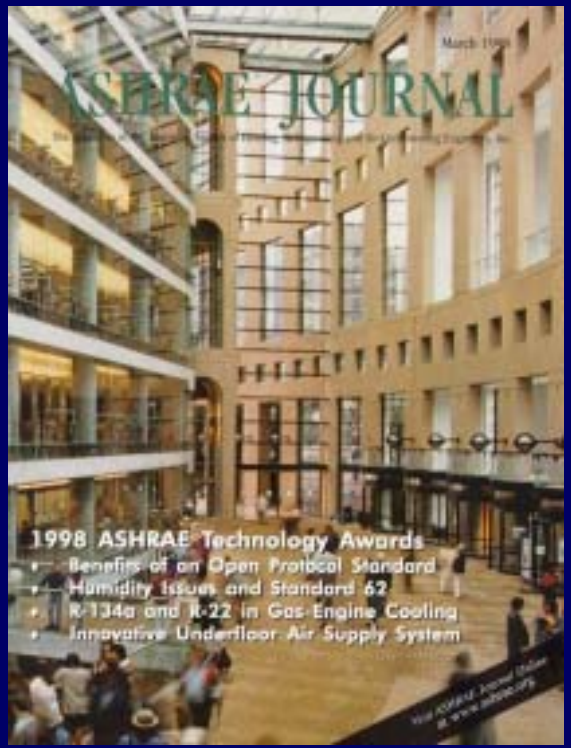
Awards



2 LEED™ Gold Projects

2 ASHRAE Technology Awards

2 AIA COTE Projects

22 Industry Design Awards

2 Engineering Environmental Design Awards

3 BOMA Earth Awards

1 Office of Energy Efficiency Award of Excellence

Green Building Challenge - 1998 World Conference - 4 projects

Green Building Challenge - 2000 World Conference - 6 projects

Green Building Challenge - 2002 World Conference - 5 projects

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- 5 people based in San Francisco
- Project Management & Cost Consulting
- Leading Green Cost Consulting firm in the US
- Developers of effective decision-making tools that are the product of collaboration, consistency and process

Introduction

- LCCA - what is it?
  - is a key decision-making tool
  - requires integrated design team
  - gives a better end product = better design practice
  - starting to reflect whole cost accounting
- LCCA - what is it not?
  - not “value engineering”

Outline

- LCCA - methodologies and myths
- Connection with sustainable development
  - Sustainability = long-term decisions
- Key considerations
  - Cost transfer, not cost increase
  - Study period/length, economic factors, energy forecasting
  - Other costs e.g. churn, productivity, employee sick time, external costs to society
- What's ahead for use of LCCA

LCCA - Methodologies

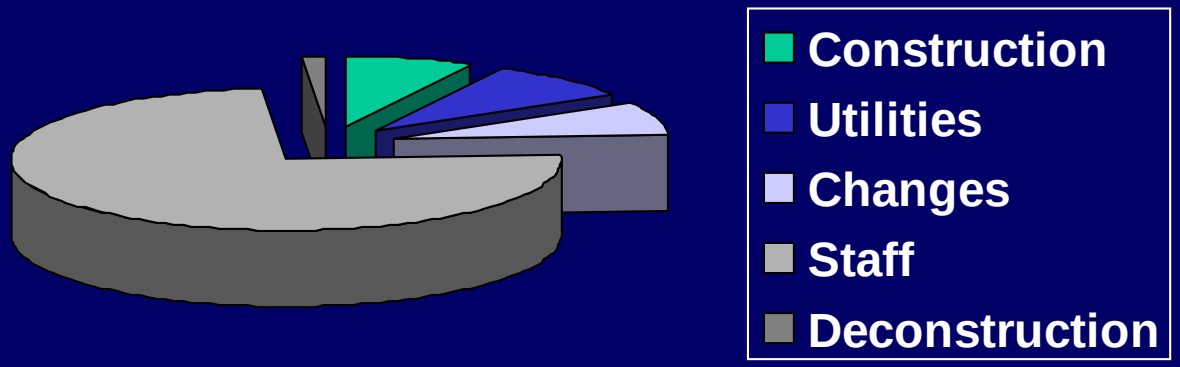
- Use net present value (NPV) of all building capital and annual costs
  - NPV = Capital Cost + Annual Costs * $(1 + i)^{-n}$ where i is the interest rate or cost of capital and n is the number of years
- "n" or the number of years that the study is carried out for is called the study period
  - Typically, study period is 20 - 100 years
  - Study period and building life are not the same!
  - Usually, the study period = life span of the most durable solution

LCCA - Myths

- In the past, long-term decision making has gained negative associations
  - Life Cycle Cost Analysis = Value Analysis = Value Engineering = Cutting all the good design features
- This association is incorrect - this analysis is about adding value, not removing it!

Cost and Performance

Life Cycle Cost of Buildings



York University - Life Cycle Costing

CAPITAL COSTS

REFERENCE	PROPOSED
$16.63m (CAD)	$16.58m (CAD)
$11.18m (USD)	$11.10m (USD)
?13.06m (EUR)	?13.03m (EUR)

NPV OPERATING & MAINTENANCE COSTS
(over life of building - 75 years, r = 3%)

REFERENCE	PROPOSED
$125.3m (CAD)	$49.75m (CAD)
$83.88m (USD)	$33.31m (USD)
?98.46m (EUR)	?39.01m (EUR)

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Challenges in LCCA

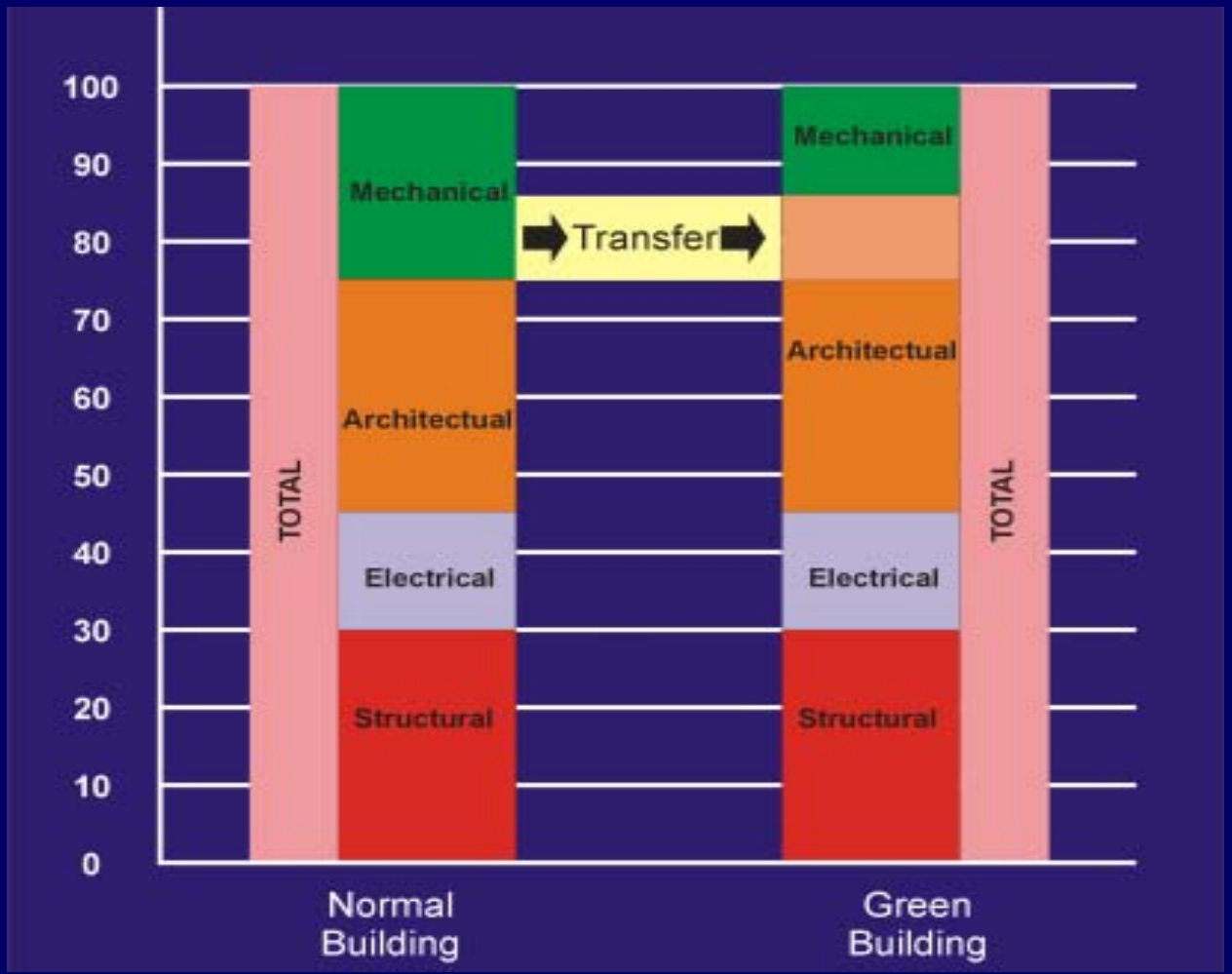
- Draw the right picture
  - Respond to the client's needs
  - Make sure it fits the capital budget
  - Process requires integrated team
  - If it can't be built or no one likes it, LCCA is irrelevant
- Make the right assumptions
  - Analysis must be defensible
- Communicate the ideas clearly
  - Graphical is best

LCCA - Drawing the Right Picture - Owner's Needs

- Establish & prioritize owner's needs early through a charrette
- Document decisions made during design so that the reasons for them are not forgotten
- Ensure that budget decisions meet these goals
  - Owner's needs set baseline for comparison

LCCA - Drawing the Right Picture - Costs

- Cost transfer is needed to ensure sustainability is cost-neutral
- Shift costs from M&E to better shaped building, more durable finishes, higher performance envelope, less “stuff”
- If capital costs are equal, long term costs are the deciding factor



Cost Transfer

- Total cost same
- Mechanical costs less
- Invest in Architecture
- Active to passive
- Fragile to robust
- Longer life
- Less cost over life
- Simpler

LCCA - Make the Right Assumptions

- Assumptions made during LCCA can dramatically alter results
- Work with the whole design team to ensure the assumptions are correct
- Owners frequently have economic factors set for their organization
- Assumptions include:
  - Length of study period, economic factors, capital costs, energy escalation, annual maintenance & operating costs

LCCA - Make the Right Assumptions (2)

- Design team must assess what annual costs will be included
- Typically, annual costs include:
  - Equipment operation, equipment maintenance, cleaning costs, etc.
- Costs that should be considered:
  - Churn, productivity factors, employee sick time, costs from pollution
  - More difficult to quantify these but models do exist

LCCA - Make the Right Assumptions - Capital Costs

- Ensure that all cost transfers are accounted for
  - M&E should be lower as the systems get simpler
  - Controls can get simpler too
  - Assumptions must be consistent between schemes

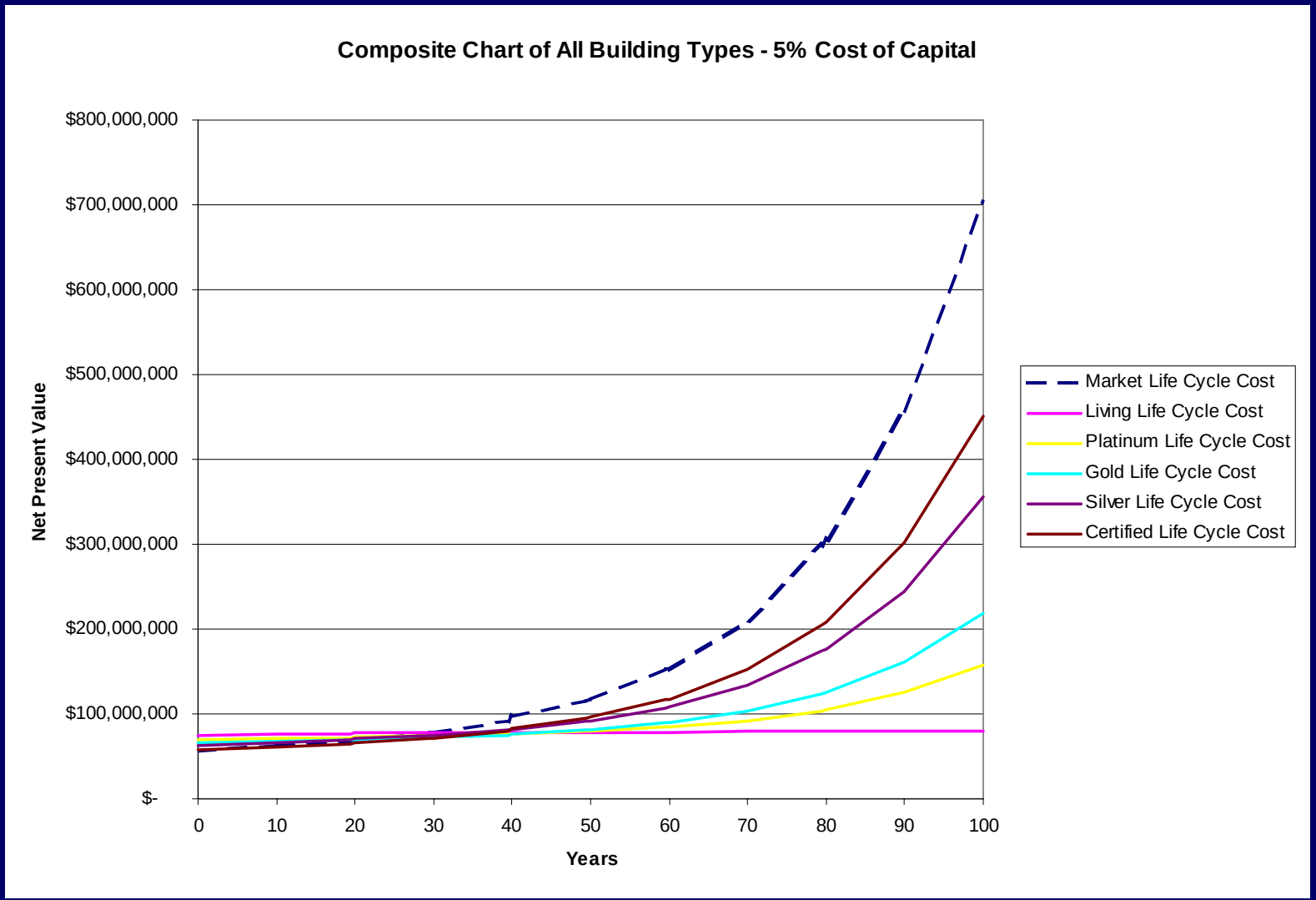
LCCA - Make the Right Assumptions - Study Period

- Determining the Study Period is a crucial decision
- Typical study period is the life of the most durable component
- Sustainable buildings are designed for longer lives than conventional buildings - must be reflected!
- 100 year study can mean 3 “builds” of a conventional (30 year) building

LCCA - Make the Right Assumptions - Example

- E.g. Packard Foundation Study
- 30, 60 and 100 year studies were needed
- Benefits of sustainability more pronounced over longer period

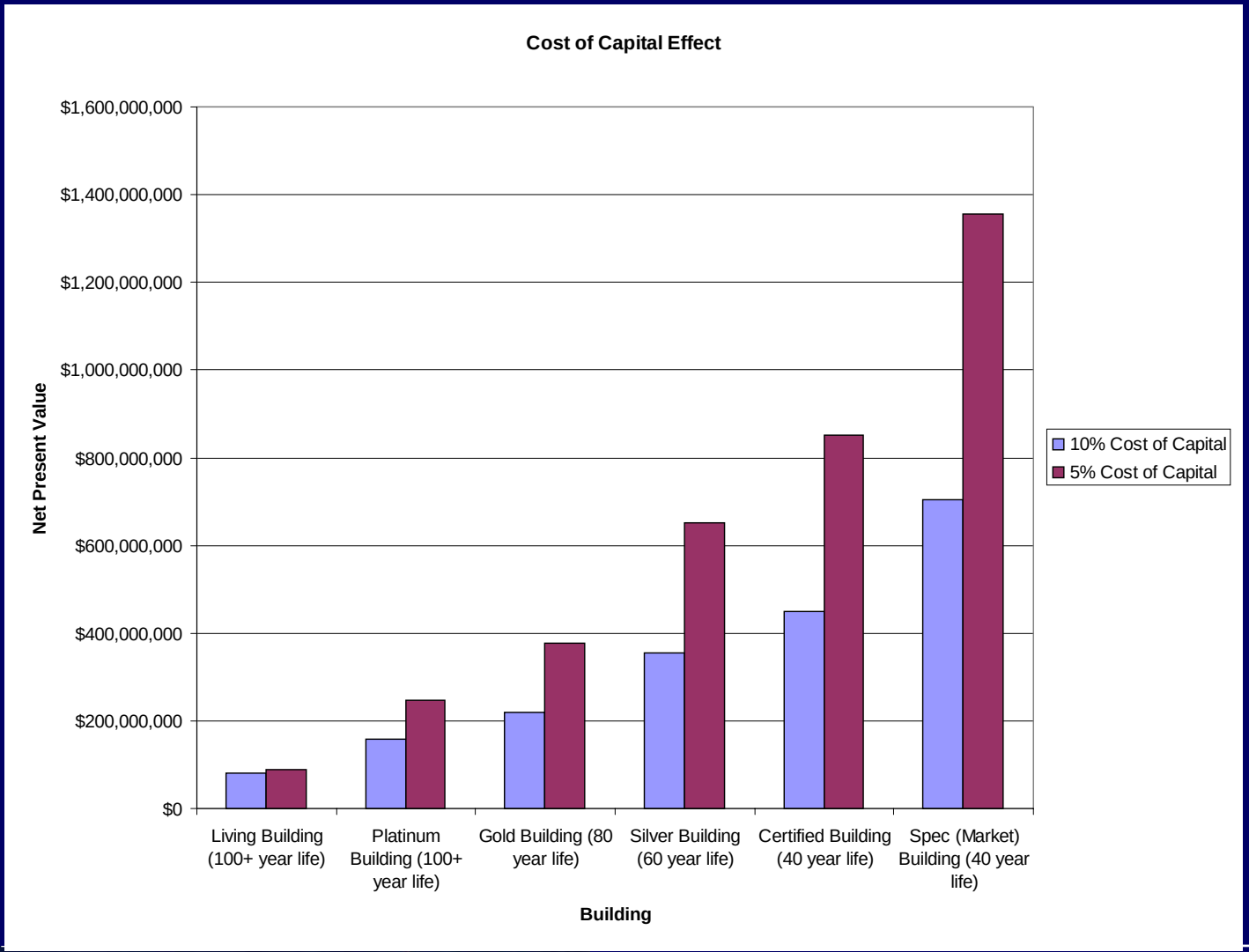
LCCA - Make the Right Assumptions - Study Period



LCCA - Make the Right Assumptions - Economics

- Owners typically have their own economic factors
  - Should be used so this analysis matches their economic forecasts
- If not, typical values are:
  - Cost of capital/interest rate: 5-10%
  - Inflation: 0.5-3% (energy rates usually are different)
- Sensitivity must be assessed so analysis is defensible
  - Plug in a variety of study periods, economic factors & determine the limits of the analysis

LCCA - Make the Right Assumptions - Economics



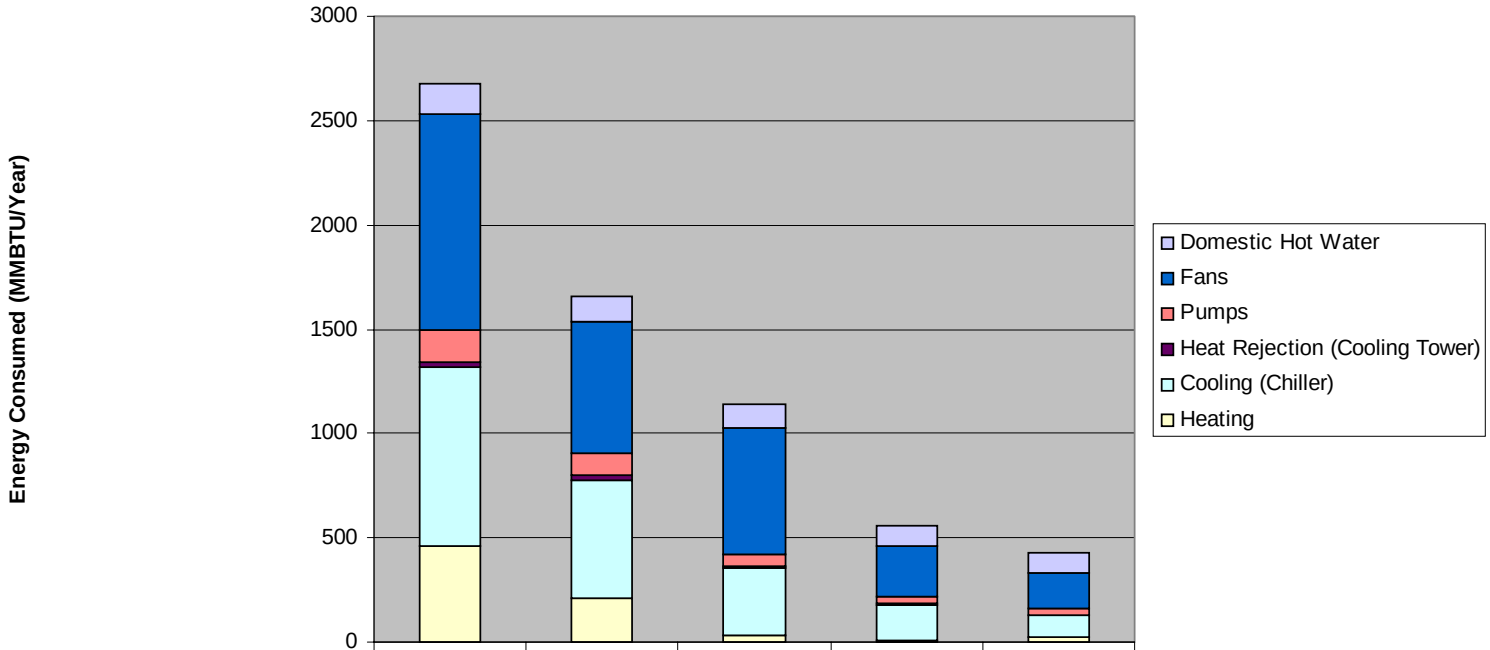
Cost of capital

- Right number is key
- Bigger interest rate means lower NPV
- In this example, order doesn't change - shows insensitive over this region

LCCA - Make the Right Assumptions - Energy Use

- Several possibilities to get energy consumption:
  - energy model can be developed
  - typical data e.g. BOMA Experience Report
  - PG&E database of existing buildings
  - code baseline consumption less X%
- Energy model is the most accurate:
  - site specific factors such as lot shape and building configuration are accounted for
  - impact of different techniques can be evaluated

Annual Energy Consumption



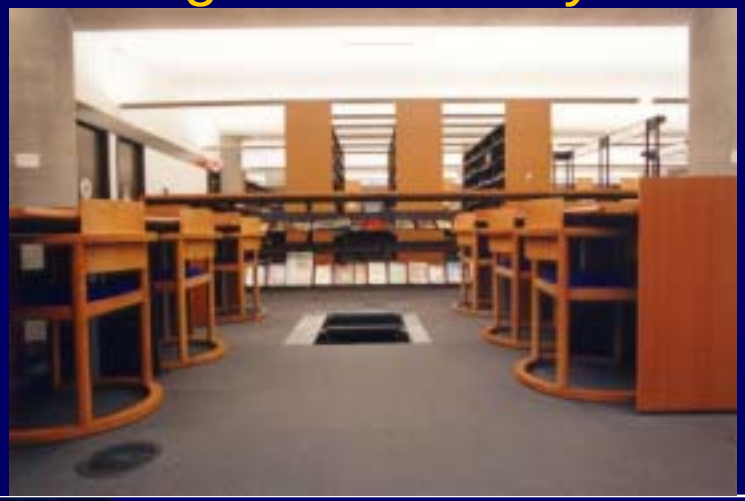
	Market	Certified	Silver	Gold	Platinum
Domestic Hot Water	143.3	114.6	114.6	100.3	100.3
Fans	1037.6	637.7	611.3	243.3	172.1
Pumps	149.7	105.5	53.4	33.7	24.7
Heat Rejection (Cooling Tower)	26.2	18.3	10	6	4.2
Cooling (Chiller)	858.3	565.8	320.5	167.8	108.2
Heating	459.8	212.5	33.2	10.5	20.7

LCCA - Make the Right Assumptions - Energy Cost

- Once energy consumption is known, need to translate into cost:
  - use current utility data typically available on websites
- Energy costs sometimes vary differently to other inflation
  - 0.5% - 5% typical range of values
- Must be consistent between cases and believable!
- The use of net metering can complicate this significantly

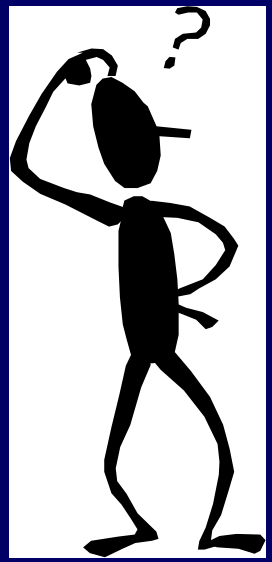
LCCA - Make the Right Assumptions - Equipment

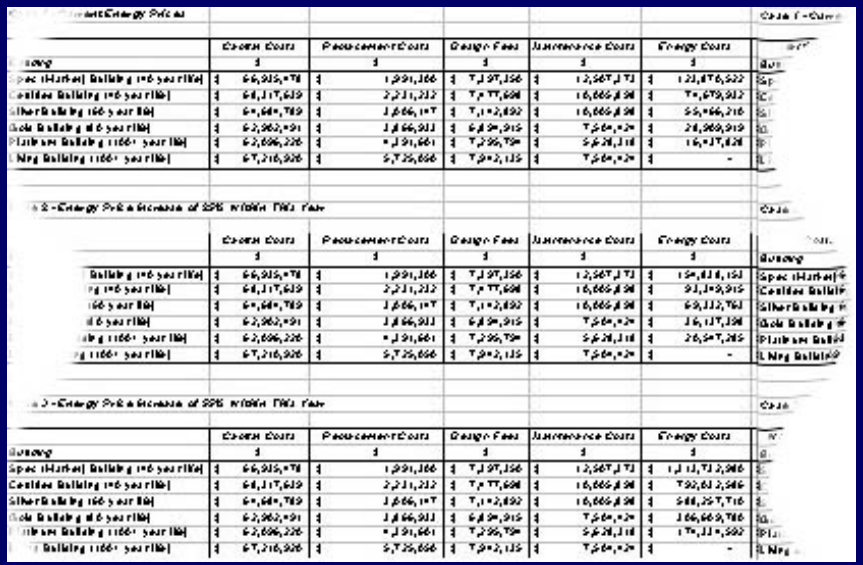
- Most mechanical & electrical equipment and furnishings are replaced periodically
- Industry standard replacement times e.g. 20 years
- Be sure to get this right if durability is the key issue



LCCA - Communicate Clearly

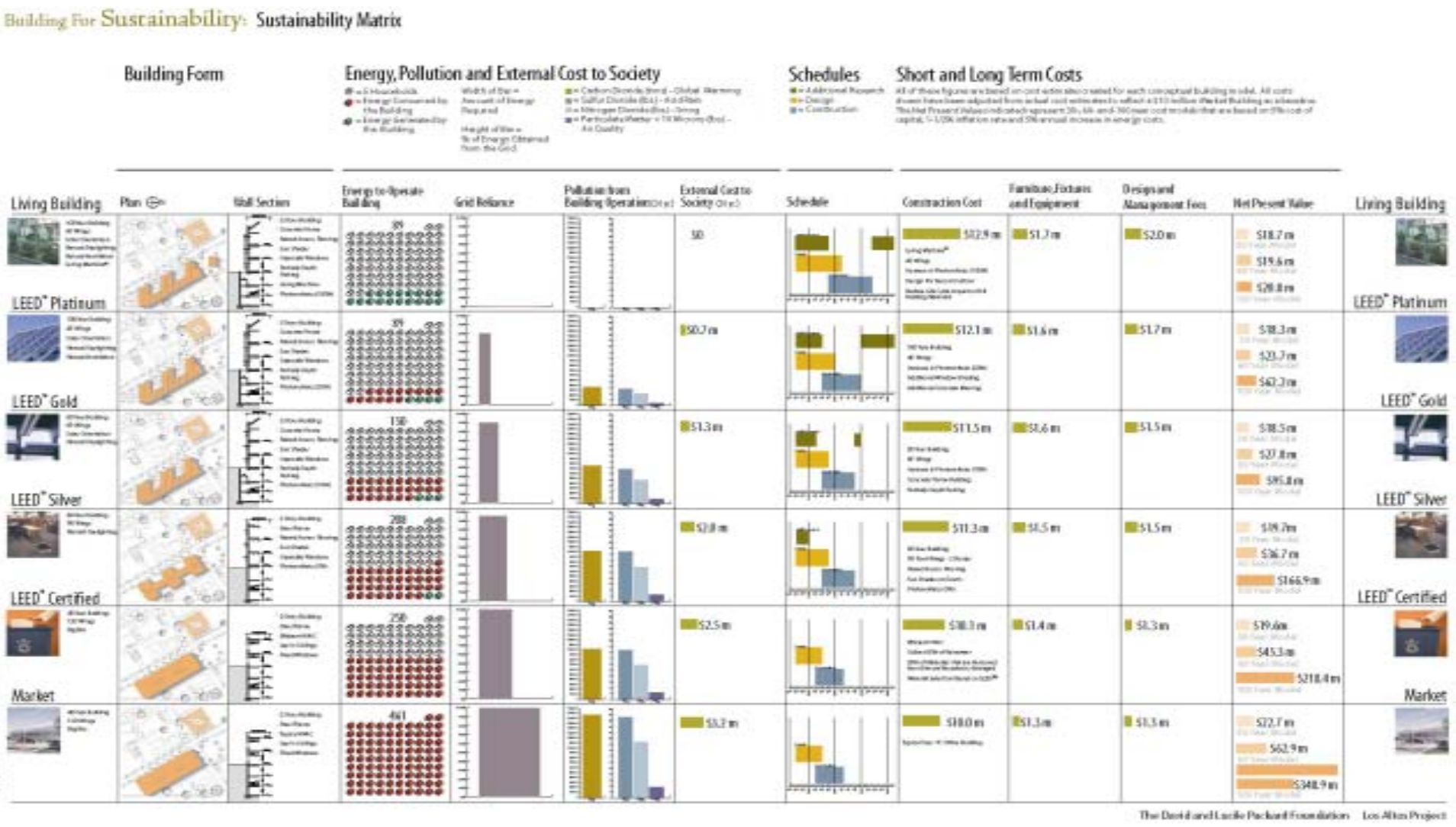
- Too much information is deadly
  - Boil results down to a few numbers
  - Display graphically wherever possible





Sustainability Matrix

1 | 2 | 3 | 4



LCCA - Examples

- LCCA has been successfully used on several projects to support individual design concepts:
  - Underfloor air
  - Good envelope vs. Perimeter heating system

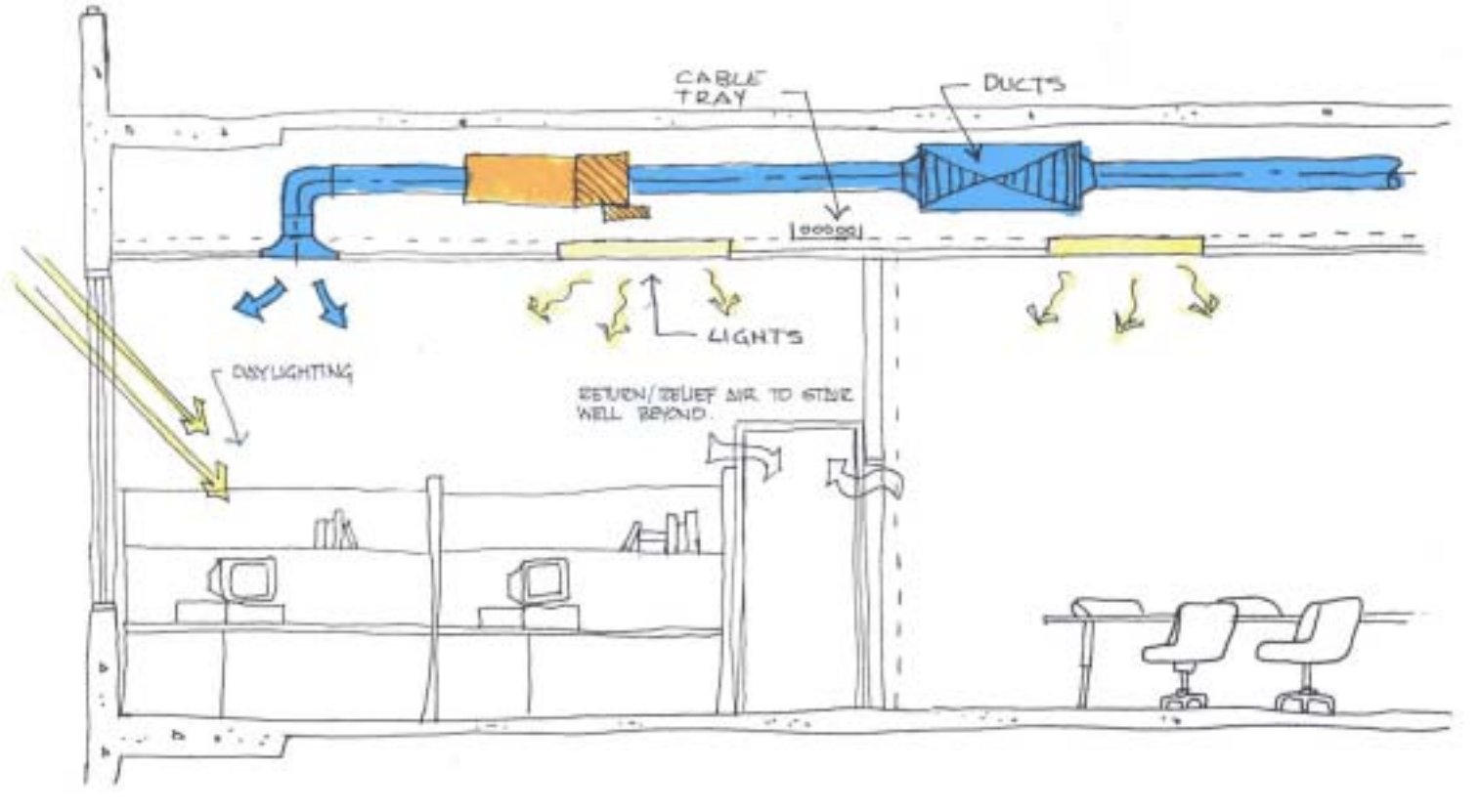
LCCA - Example - Underfloor Air Delivery Systems

- Underfloor systems can have several benefits over conventional ceiling delivery systems:
  - Better IAQ
  - Occupant Control
  - Reduced Churn Costs
- Can use LCCA to demonstrate benefits
  - Capital Cost Transfer

Underfloor Air

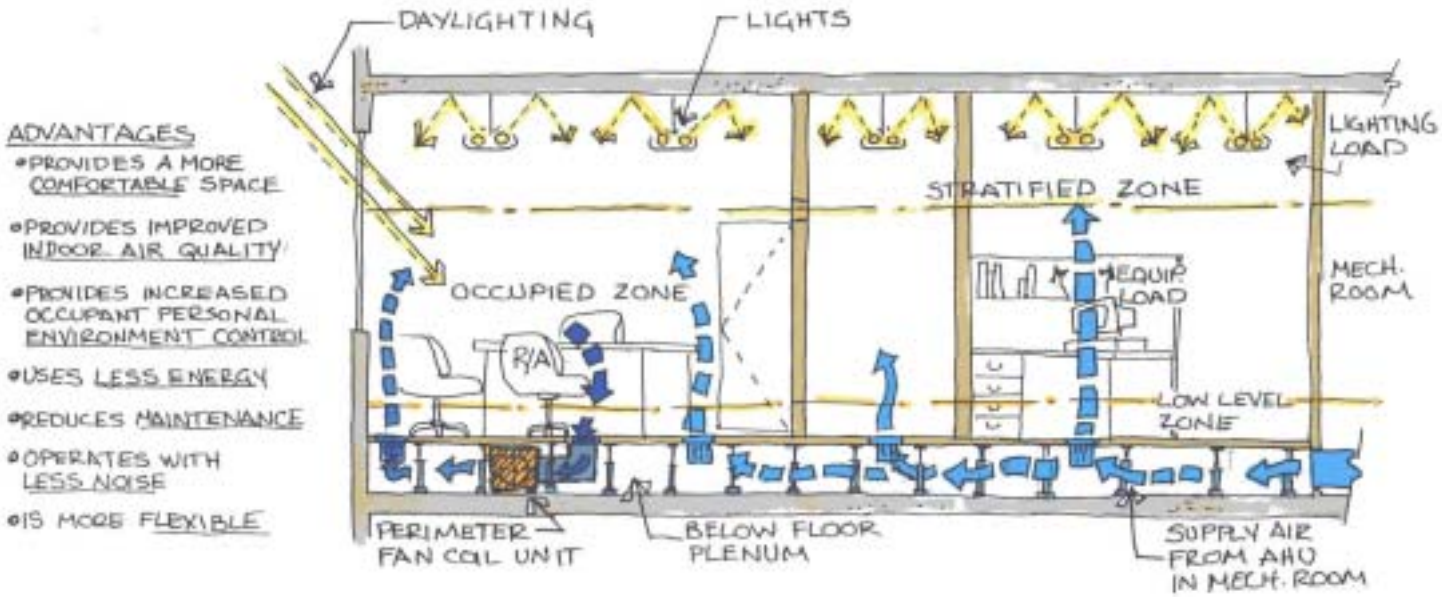
- What is Underfloor Air?
  - Raised floor panels with a supply air plenum in the void between the raised floor and the concrete structure.
  - Supply air grilles are flush mounted to the floor to create a flat floor and walking surface
  - Supply (fresh) air is provided at the level where the building occupants are

Conventional System



Underfloor Air

ACCESS FLOOR



ADVANTAGES

- PROVIDES A MORE COMFORTABLE SPACE
- PROVIDES IMPROVED INDOOR AIR QUALITY
- PROVIDES INCREASED OCCUPANT PERSONAL ENVIRONMENT CONTROL
- USES LESS ENERGY
- REDUCES MAINTENANCE
- OPERATES WITH LESS NOISE
- IS MORE FLEXIBLE

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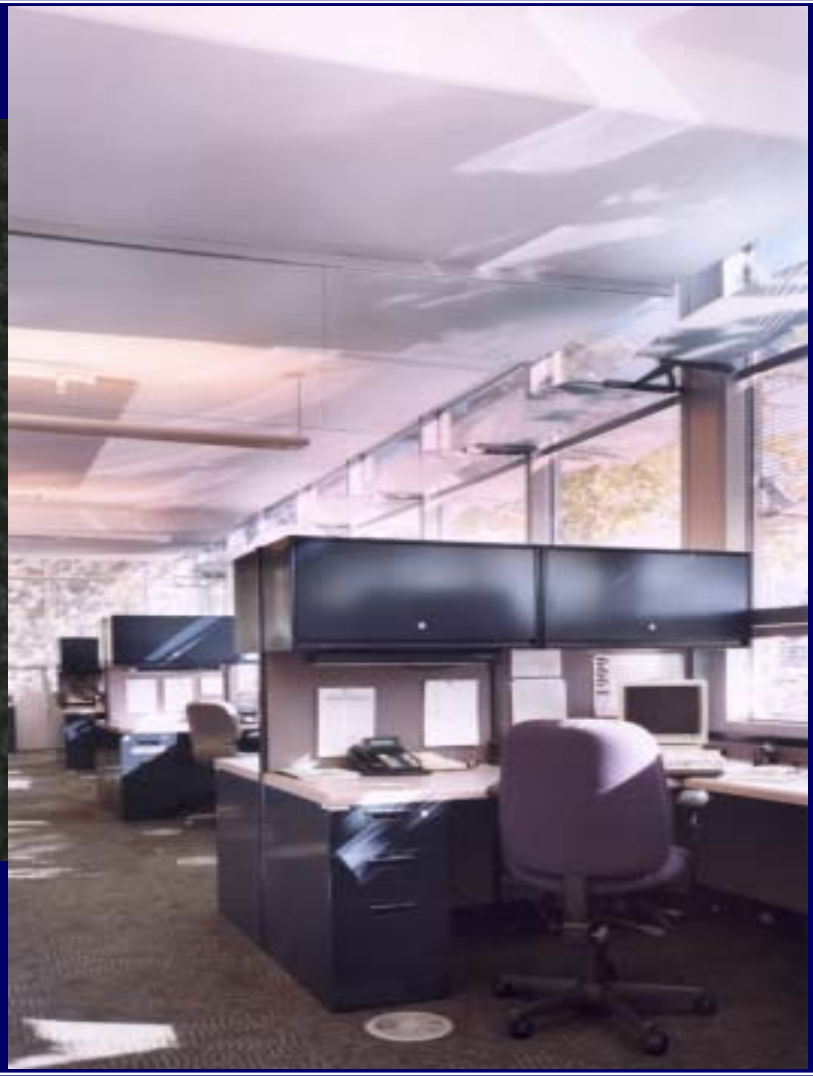


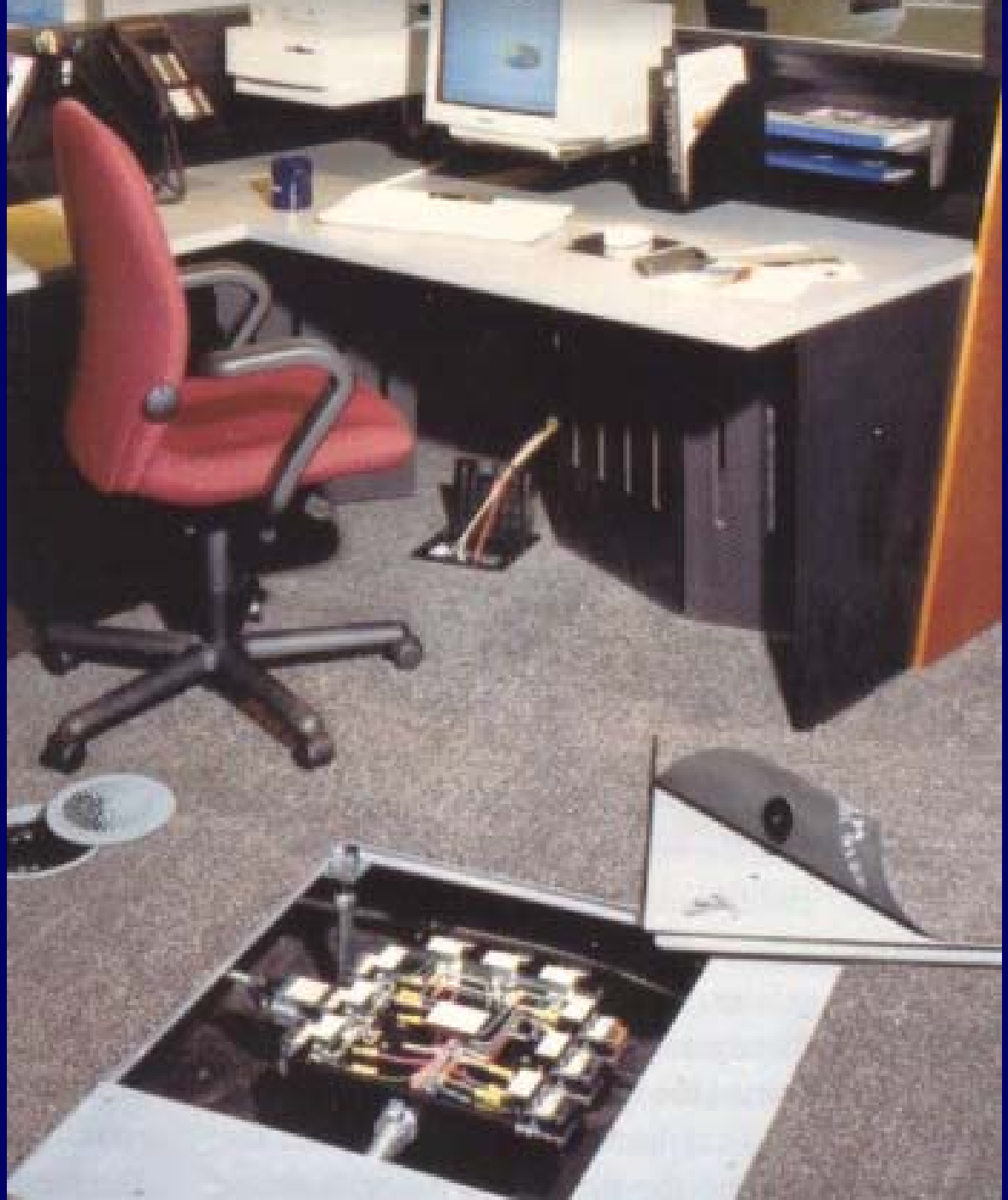
Underfloor Air

- Why Use Underfloor Air?
  - Increased user comfort and control
  - Improved ventilation and indoor air quality
  - Lower energy consumption, resulting in lower operating costs for building owners and users
  - Maximum flexibility during computer and equipment wiring changes and staff movement

Underfloor Air

Energy Use

- Many of our Underfloor Air Projects are low energy ~ 62% of ASHRAE 90.1 - independently audited
- Underfloor can be combined with natural ventilation for mixed mode strategies, reducing operating costs further



Underfloor Air

Flexibility and Churn - Savings

- There ARE savings for Mechanical TI's
- There ARE savings in wiring changes
- Savings are in time frame as well as cost

Capital Cost Analysis

Cost Component	Overhead	Underfloor
Architectural Work	$17.00	$14.50
Raised Access Floor	N/A	$ 7.00
Mechanical Work	$16.50	$12.40
Electrical	$ 7.00	$ 6.00
Total Cost	$40.50	$39.90

Costs Shown are US Dollars per Square Foot Gross Floor Area

Source: Energy Savings Potential…, V Loftness et al, June 2002; OLI data

Reconfiguration Costs

Workstation Reconfiguration Costs (RAY Eng. Study 1998; GSA)

- **Cellular Deck System** **$5.35/sq.ft.**
  - Installation and Connection of New Outlets
  - Deactivate and Cap Old Box
  - Remove Abandoned Cable
  - Downtime (6 hours to Accomplish Task)
- **RAF System with Modular Wiring** **$0.69/sq.ft.**
  - Relocate or Add Power/Communications Outlets
  - Downtime (3 hrs. to Accomplish Task)

IFMA Survey Indicates Mean Churn Rate of 44%

Underfloor Air - Conclusions

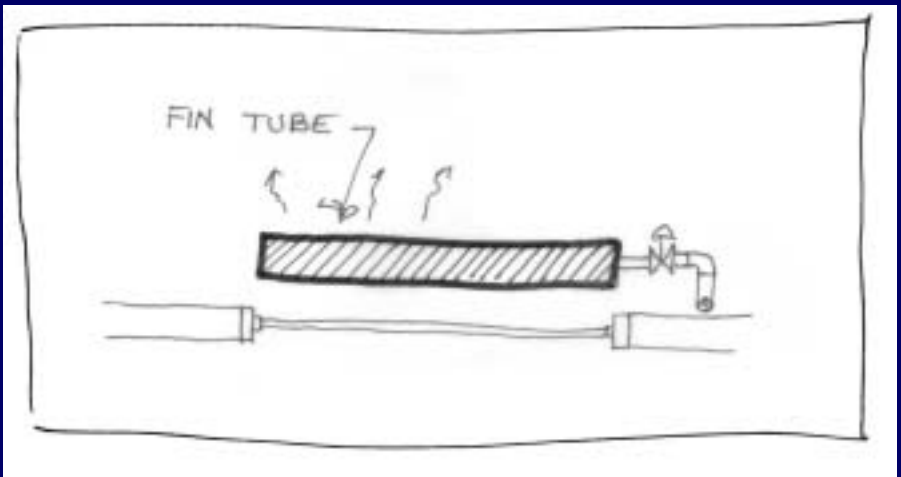
- Generally, any premium that may be paid at the outset can be recovered with first year's churn
- Used LCCA to demonstrate benefits

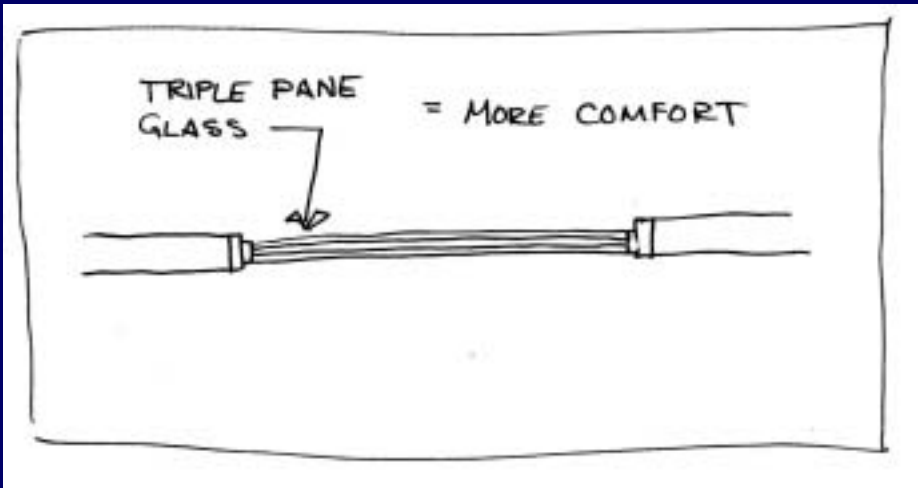
LCCA - Example - Envelope Cost Transfer

- In mild climates such as the San Francisco Bay Area, heating systems are not used often during the year but serious occupant comfort problems if omitted
- UNLESS envelope is good enough that perimeter heating isn't needed!
- Clear life-cycle benefits of passive vs. active systems

LCCA - Example - Envelope Cost Transfer

Radiant Heating vs Triple Pane Glass





LCCA - Example - Envelope Cost Transfer

- Cost of triple skin/high performance envelope: $60/sq ft
  - 20% premium
- Cost of perimeter heating system: $50/lin ft
- Energy savings available: $0.05 - $0.10/sq ft
- Simple payback: less than 1 year!
- Sometimes financing opportunities are available from envelope component manufacturers

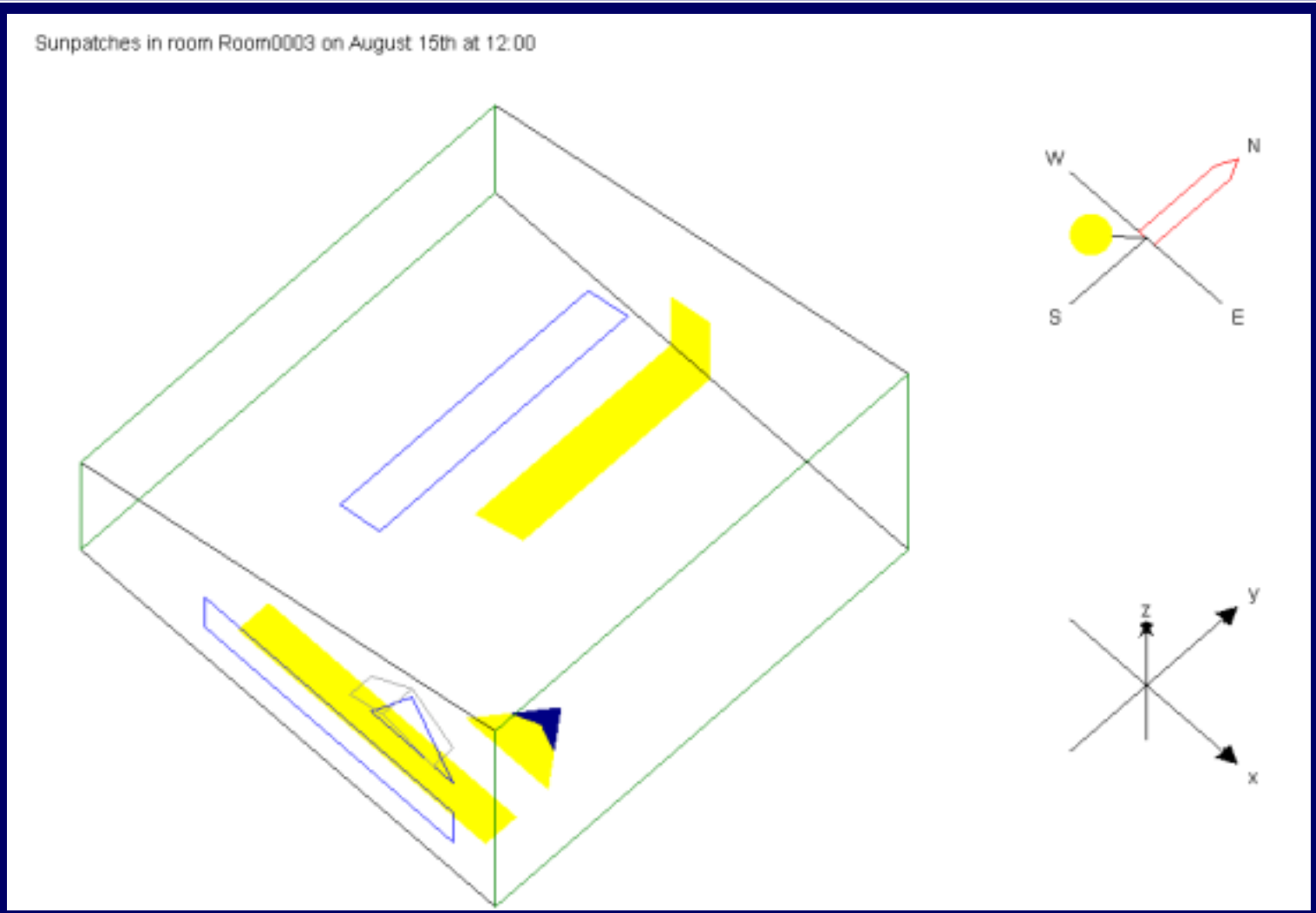
LCCA - Example - Envelope Cost Transfer

- Also, occupant comfort related to radiant effects of windows.
  - Productivity costs can go up with poor occupant comfort
  - Electricity costs can go up because people bring in their own heaters

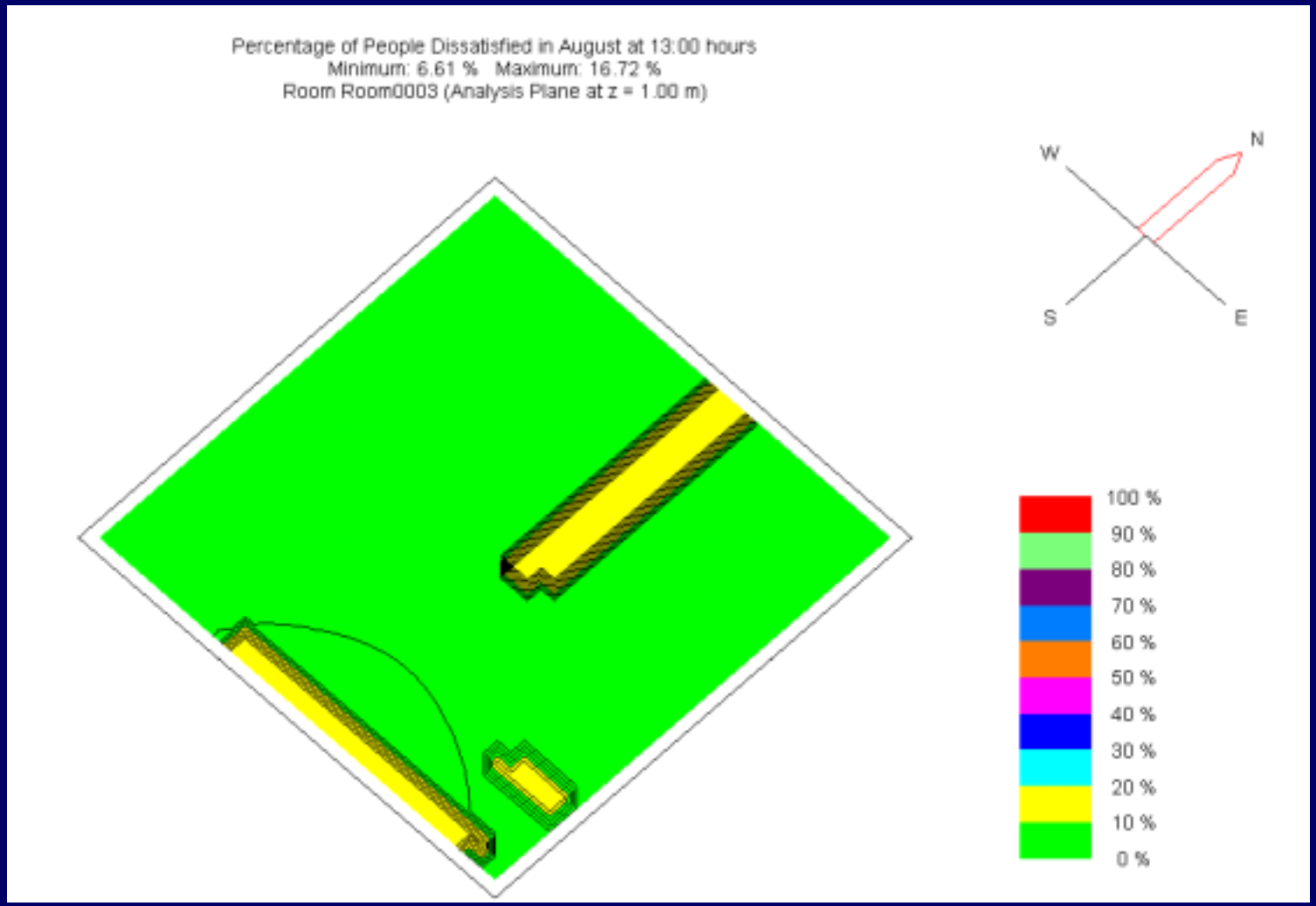
LCCA - Example - Envelope Cost Transfer

- Techniques and Tools to analyze benefits:
- Software, rules of thumb, common sense can be used to:
  - analyze occupant comfort
  - determine airflow for natural ventilation
  - analyze thermal conditions

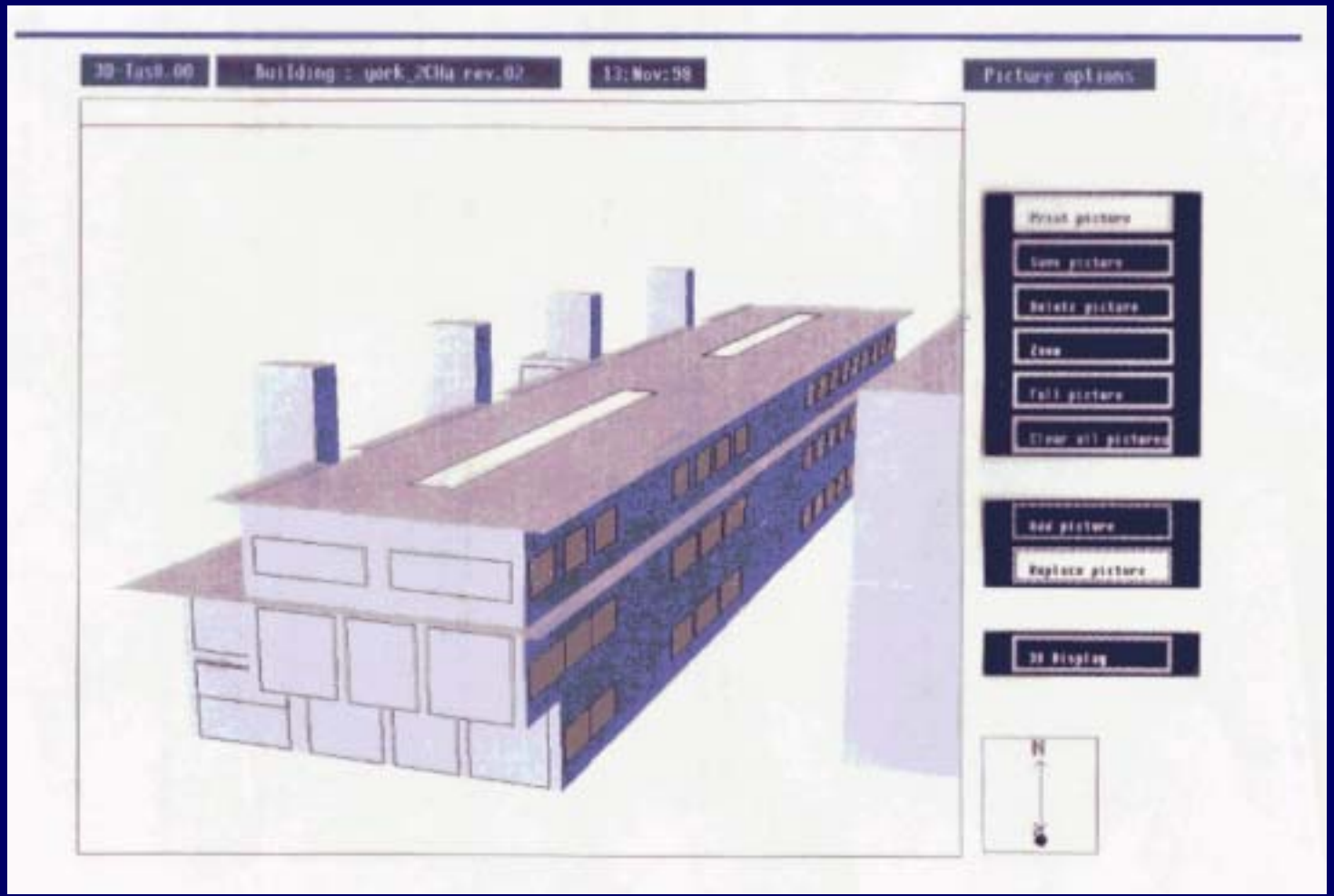
Comfort Software



Comfort Software



Thermal Analysis

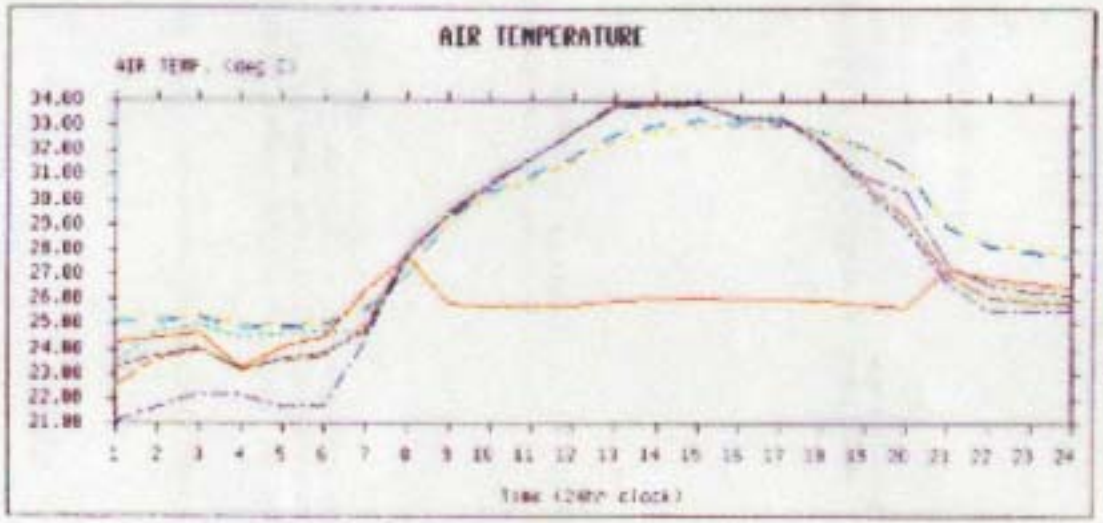


Analysis for:

- Thermal conditions over time
- Effects of thermal mass
- Airflow effectiveness

Thermal Analysis

Page	Building Name	Building Data File	Version	Time	Date	Consultant	Program
110	york_cool	york_cool.bdf.02	15	20:10:52	13:Nov:98	las - HP 400	A-Tas 8.00



Zone	Heating (kWh)
7 2nd Flr Labs	0.00
8 2nd Flr SW Corner sm	0.00
9 2nd Flr W Central sm	0.00
10 2nd Flr NW sm	0.00
11 2nd Flr NW Corner BI	0.00
12 2nd Flr NE Corner BI	0.00
Outside	

Envelope Cost Transfer - Conclusions

- Optimized envelope means lower cost and greater comfort
- Energy, maintenance, productivity savings make life cycle sense for passive approach

LCCA - Examples

- As shown, LCCA has been successfully used on several projects to support these individual design concepts:
  - Underfloor air
  - Good envelope vs. Perimeter heating system
- …but it can be used on other building concepts:
  - Eco-roofs
  - Central vs distributed plants
  - Most LEED credits
  - Durability of finishes
  - Many others...

LCCA - Future Directions

- Owners learning importance of technique
- User-driven
- More and more performance data available for comparison purposes
- USGBC developing extensive list of data
  - Also groups at Carnegie Mellon, UCBerkeley