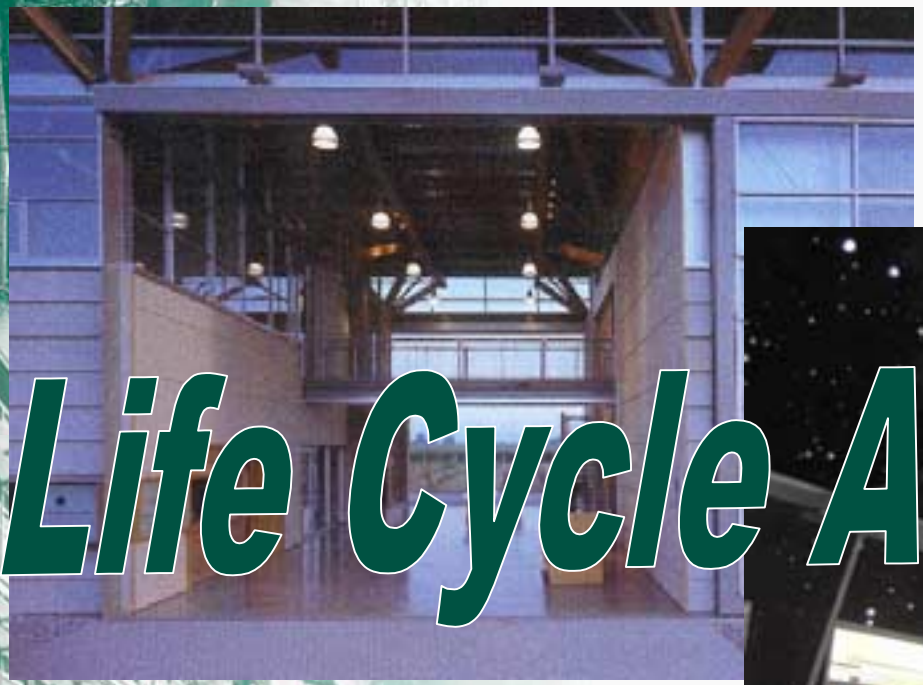
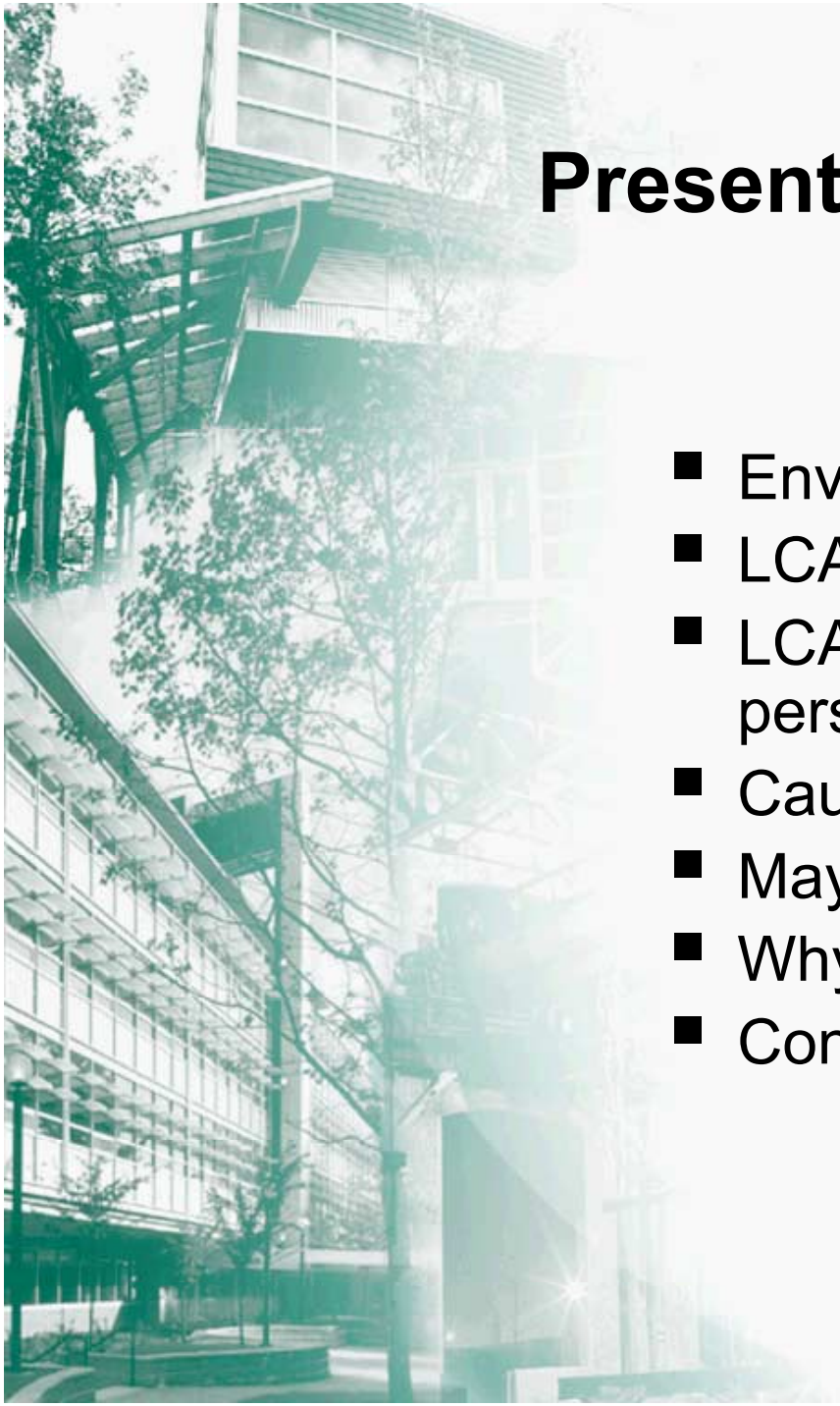


Life Cycle Assessment

Wayne Trusty

Athena Sustainable Materials Institute

Sustainable Design of Canadian Buildings
SDCB 201 – Green Building Tools and Techniques



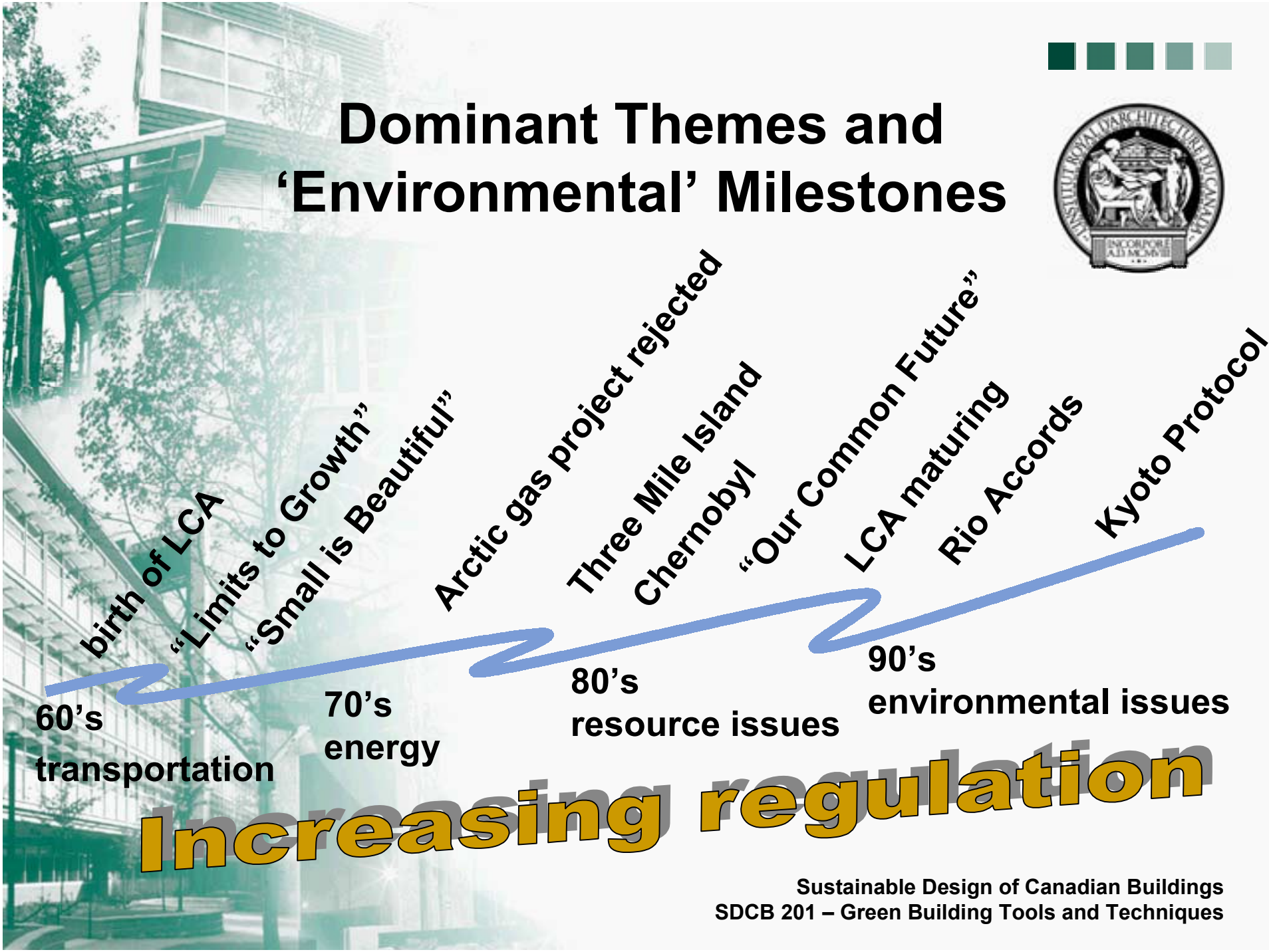
Presentation Outline

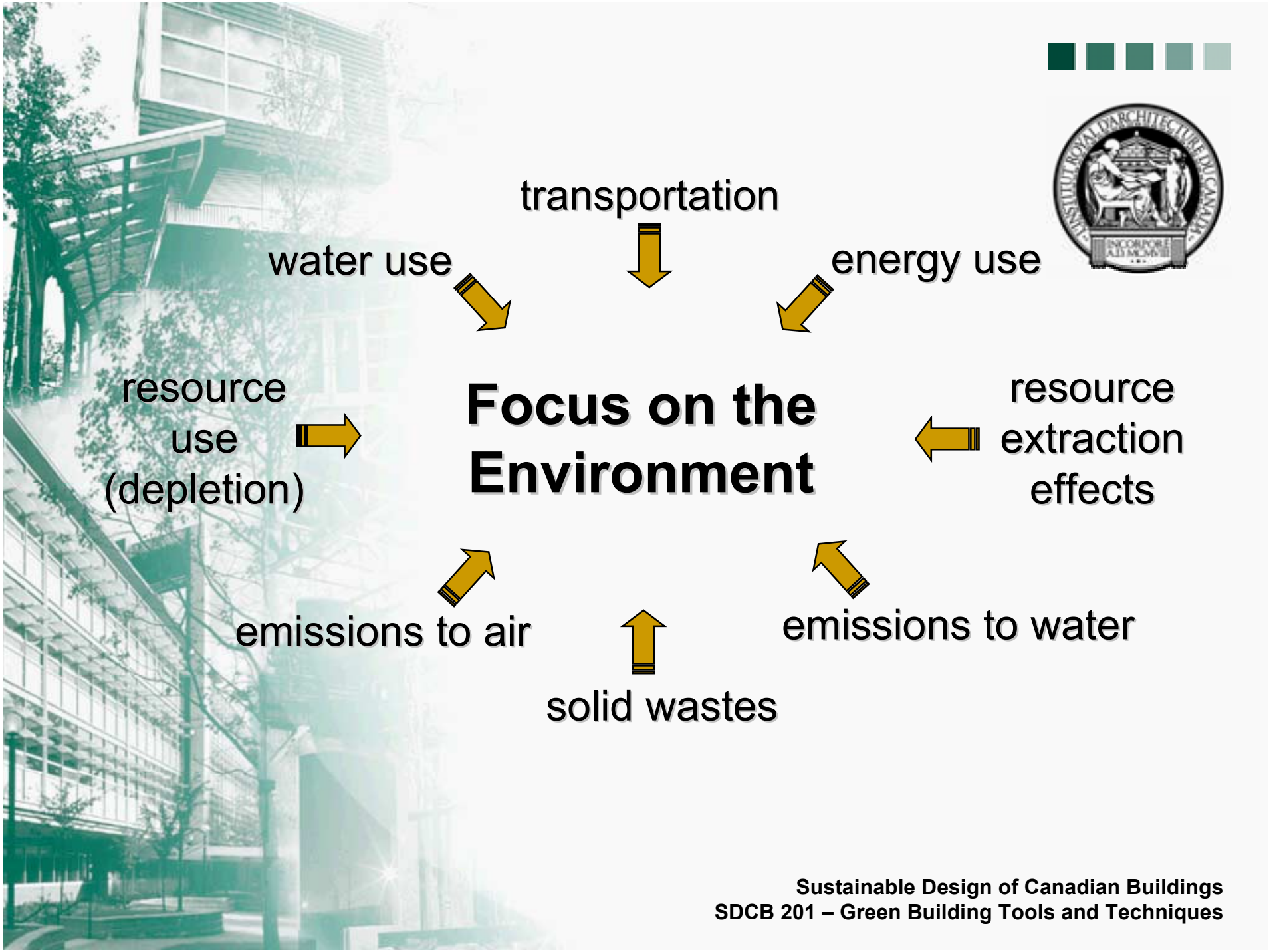
- Environmental issues in perspective
- LCA definitions and terms
- LCA in practice: building industry perspective
- Cautions and concerns
- Mayo school example
- Why LCA: the proxies problem
- Concluding message

Environmental Issues in Perspective

Sustainable Design of Canadian Buildings
SDCB 201 – Green Building Tools and Techniques

Dominant Themes and ‘Environmental’ Milestones

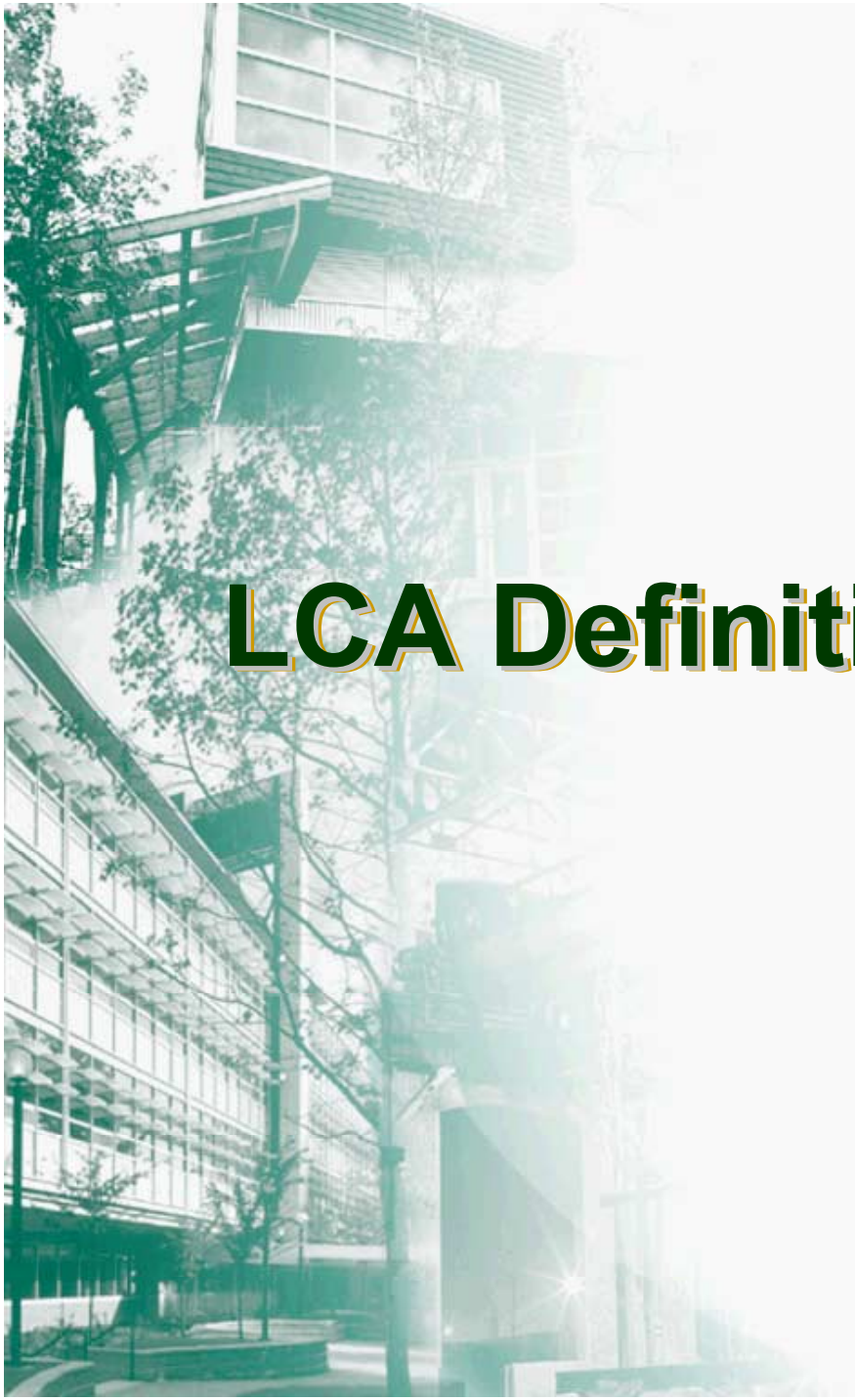



transportation
water use
energy use
resource use (depletion)
Focus on the Environment
resource extraction effects
emissions to air
emissions to water
solid wastes

Environmental Realities

- Environmental events & decisions increasingly transnational
- Environment is geopolitics
- Clutter and confusion — eco-methods, eco-events, eco-orgs
- Misinformation and speculation often push aside science
- Wrong answers may carry as much weight as correct ones

LCA can help . . .



LCA Definitions and Terms

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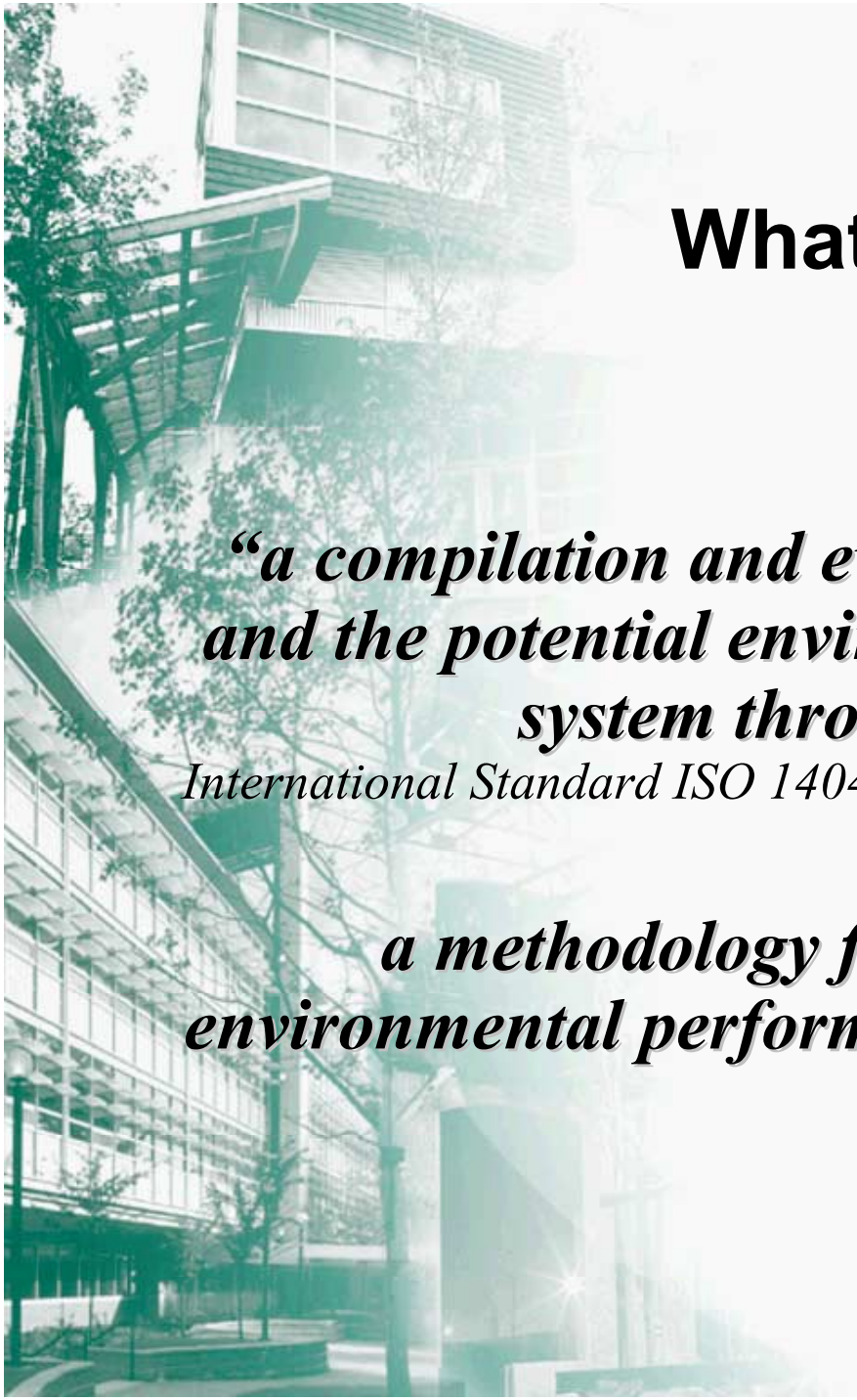


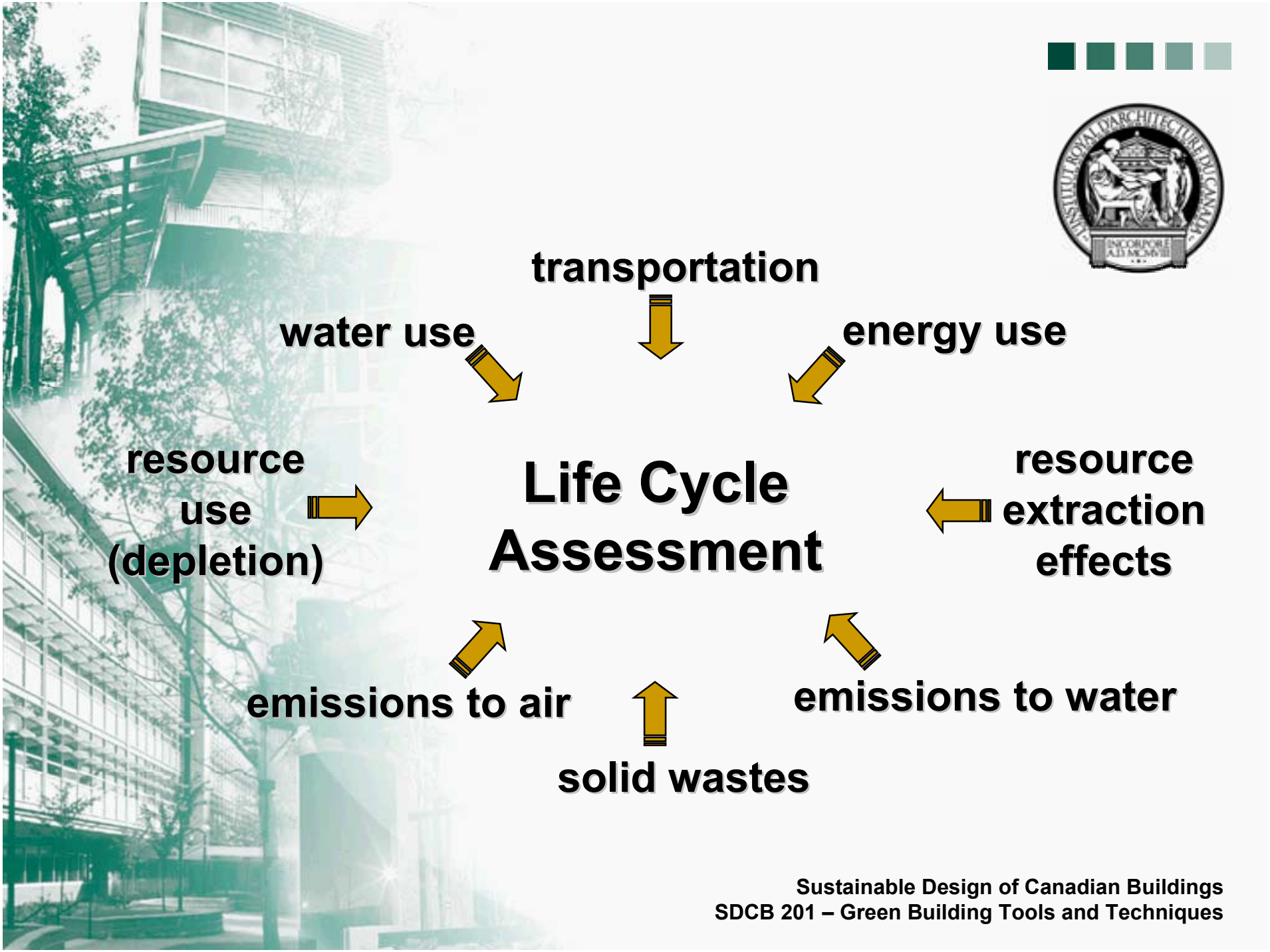
What is LCA?

"a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle"

International Standard ISO 14040, Reference Number ISO 14040:1997(E), p2

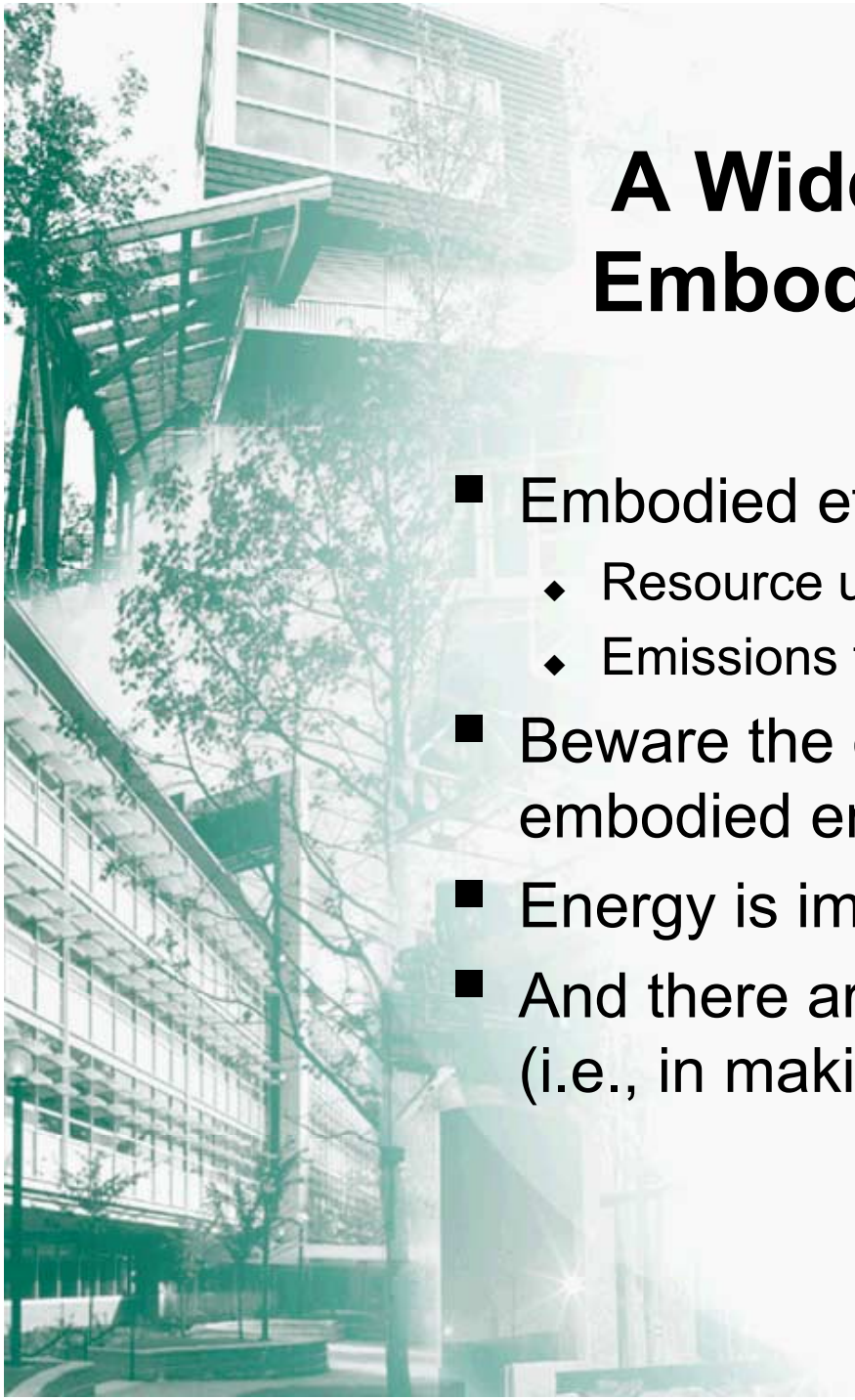
or

a methodology for assessing the life cycle environmental performance of products and processes


transportation
water use
energy use
resource use (depletion)
Life Cycle Assessment
resource extraction effects
emissions to air
emissions to water
solid wastes

Building Life Cycle Stages and Effects

Life Cycle Stages	Environmental Effects
Cradle - to - gate (Manufacturing)	Initial embodied
On-site construction	
Operations & Maintenance (Occupancy)	Recurring embodied + Operating
End - of - Life	Final Embodied



A Wide Range of Embodied Effects

- Embodied effects include:
  - Resource use (raw materials,land, water, energy)
  - Emissions to air, water and land
- Beware the common tendency to think only of embodied energy
- Energy is important, but not the whole story
- And there are embodied effects in energy itself (i.e., in making and moving energy)

LCA in Practice

A Building Community Perspective

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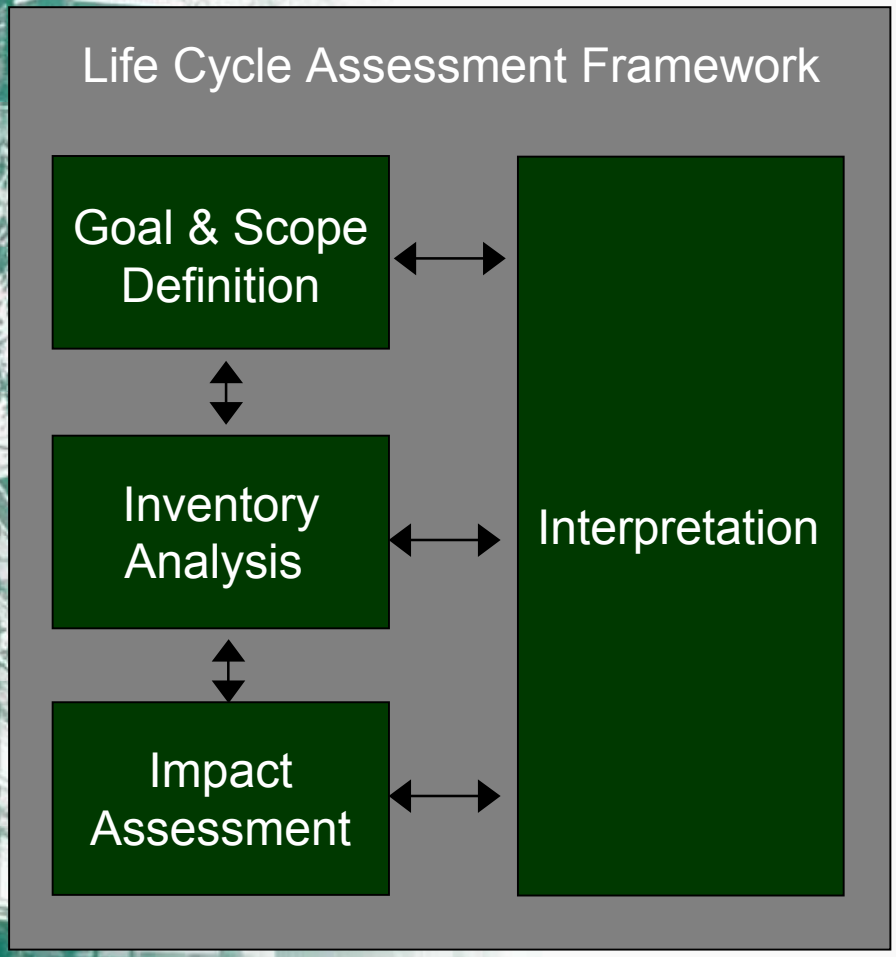
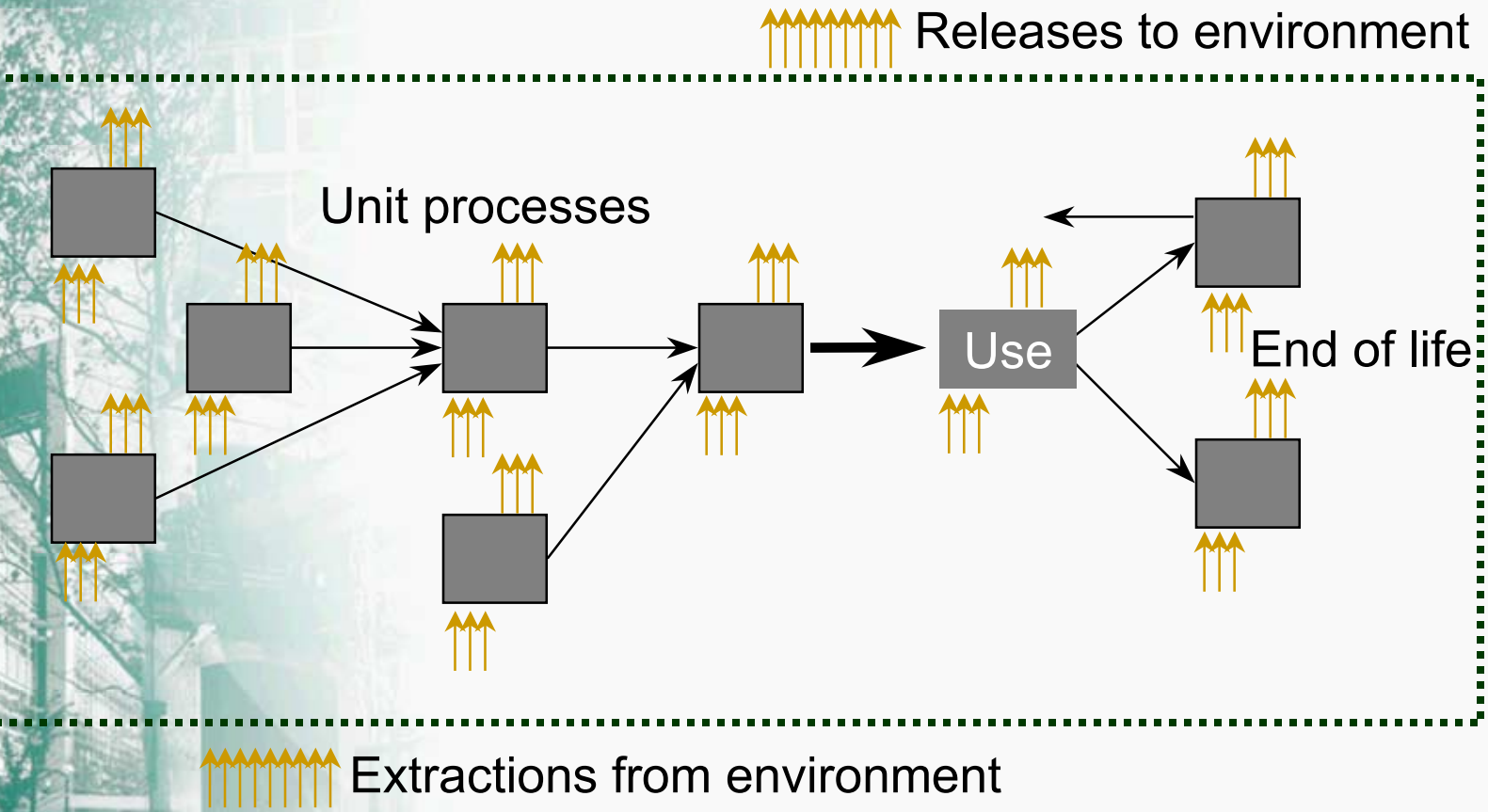
The ISO 14040 Framework ('97)



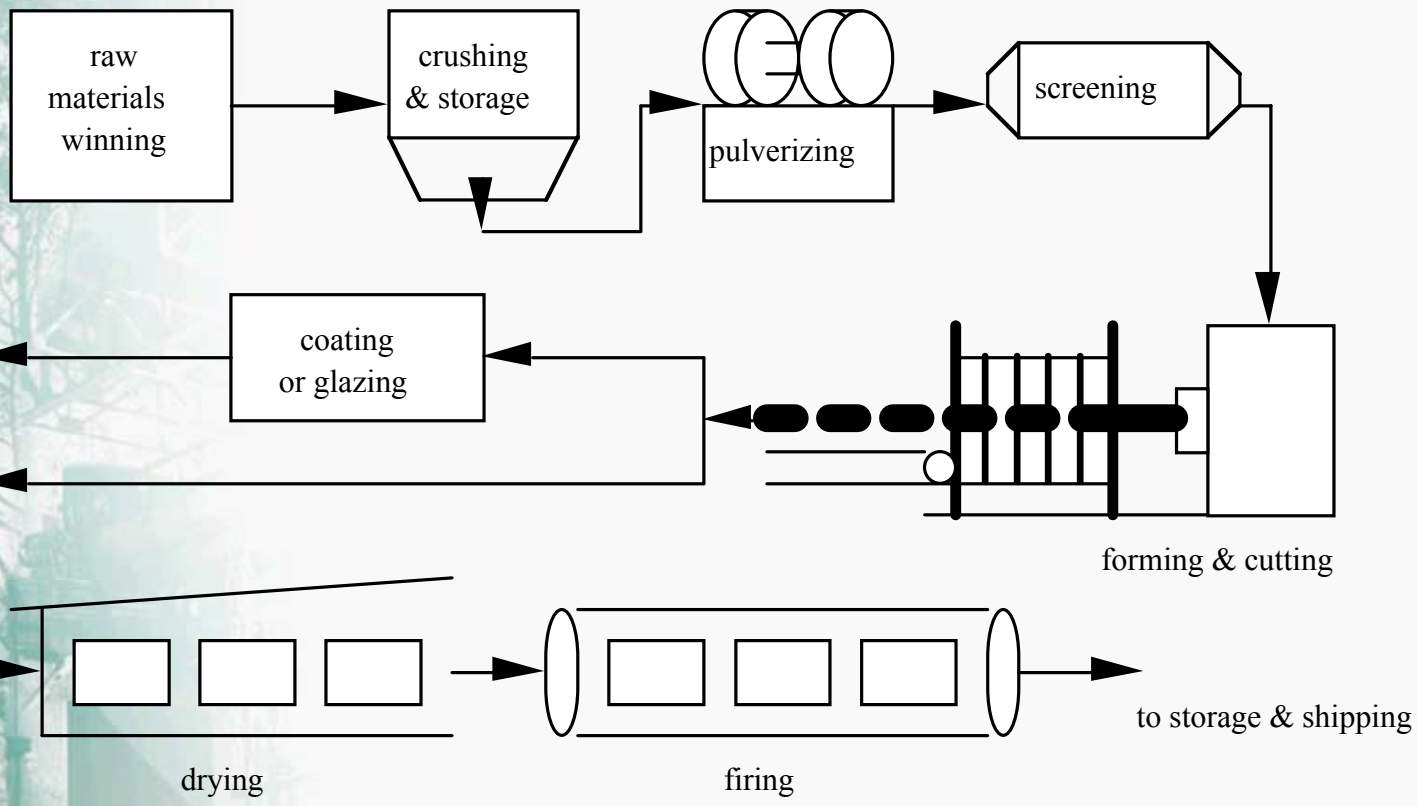
Direct Applications

- •Product Development & Improvement
- •Strategic planning
- •Public policy making
- •Marketing
- •Other

Life Cycle Inventory Analysis

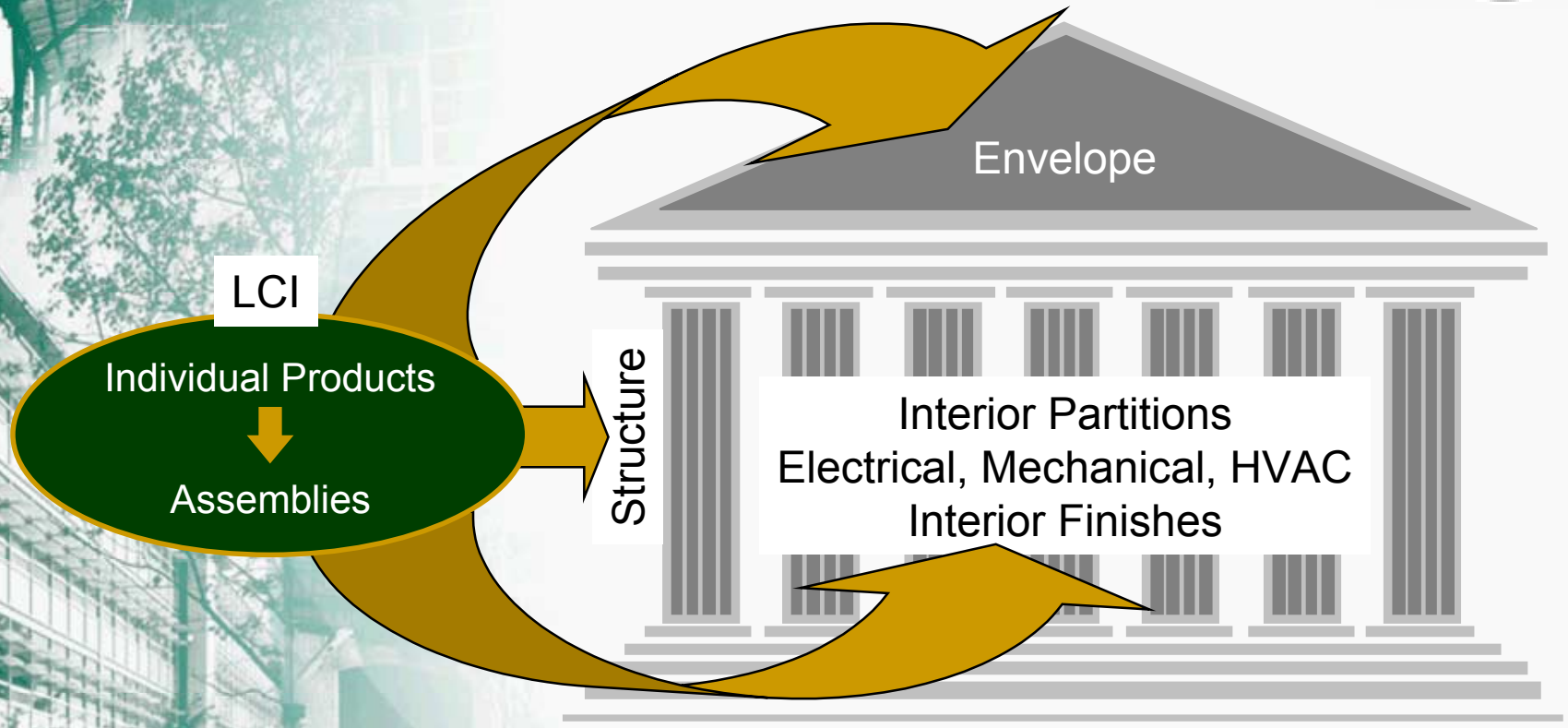


Clay Brick Production Unit Processes



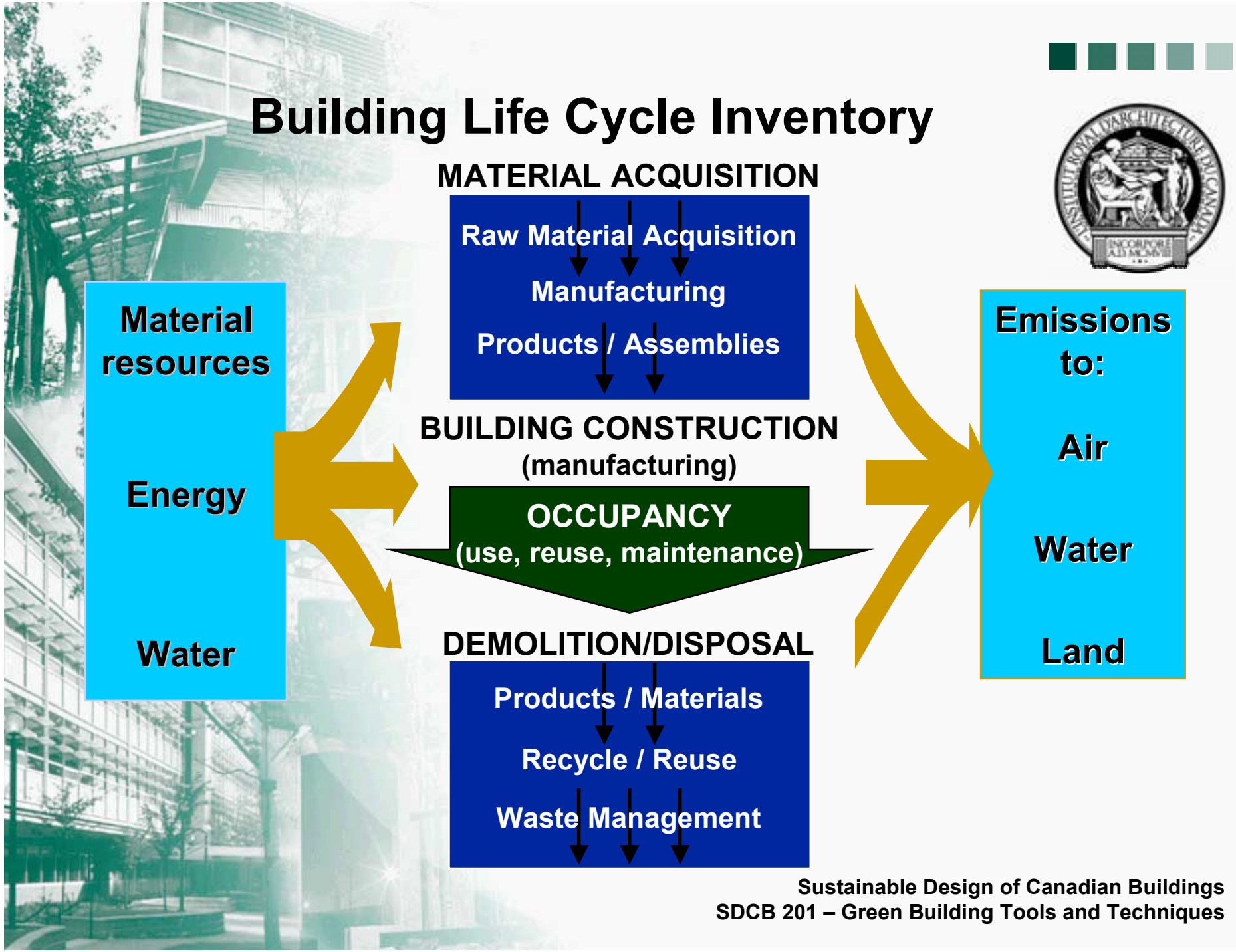
Product & Building LCIs

tracking the flows to and from nature . . .



. . . over the complete life cycle

Building Life Cycle Inventory



Impact Assessment Phase

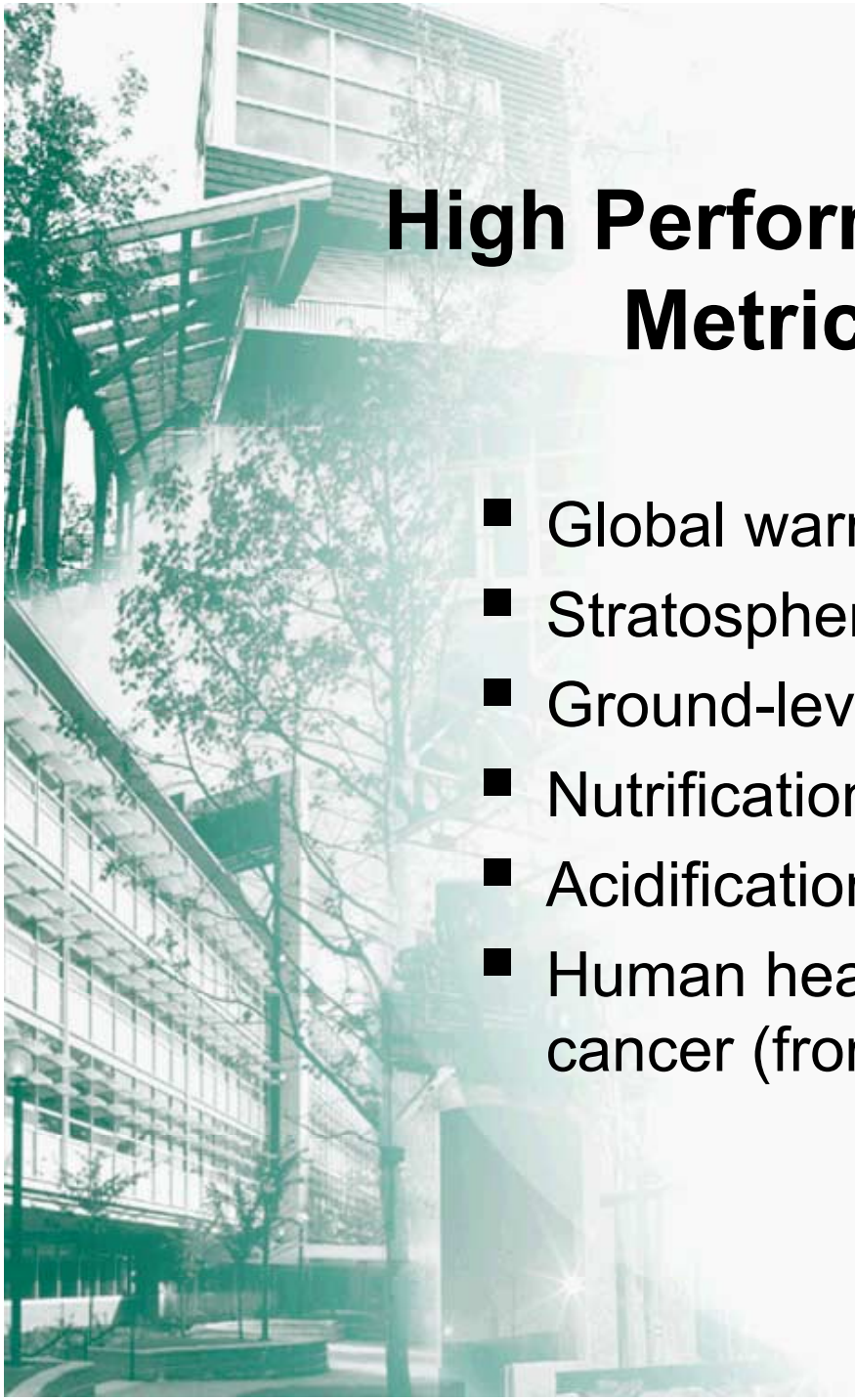
Inventory

Impact Indicators

- global warming potential
- ozone depletion
- acid rain
- etc.

Impact Assessment (Valuation)

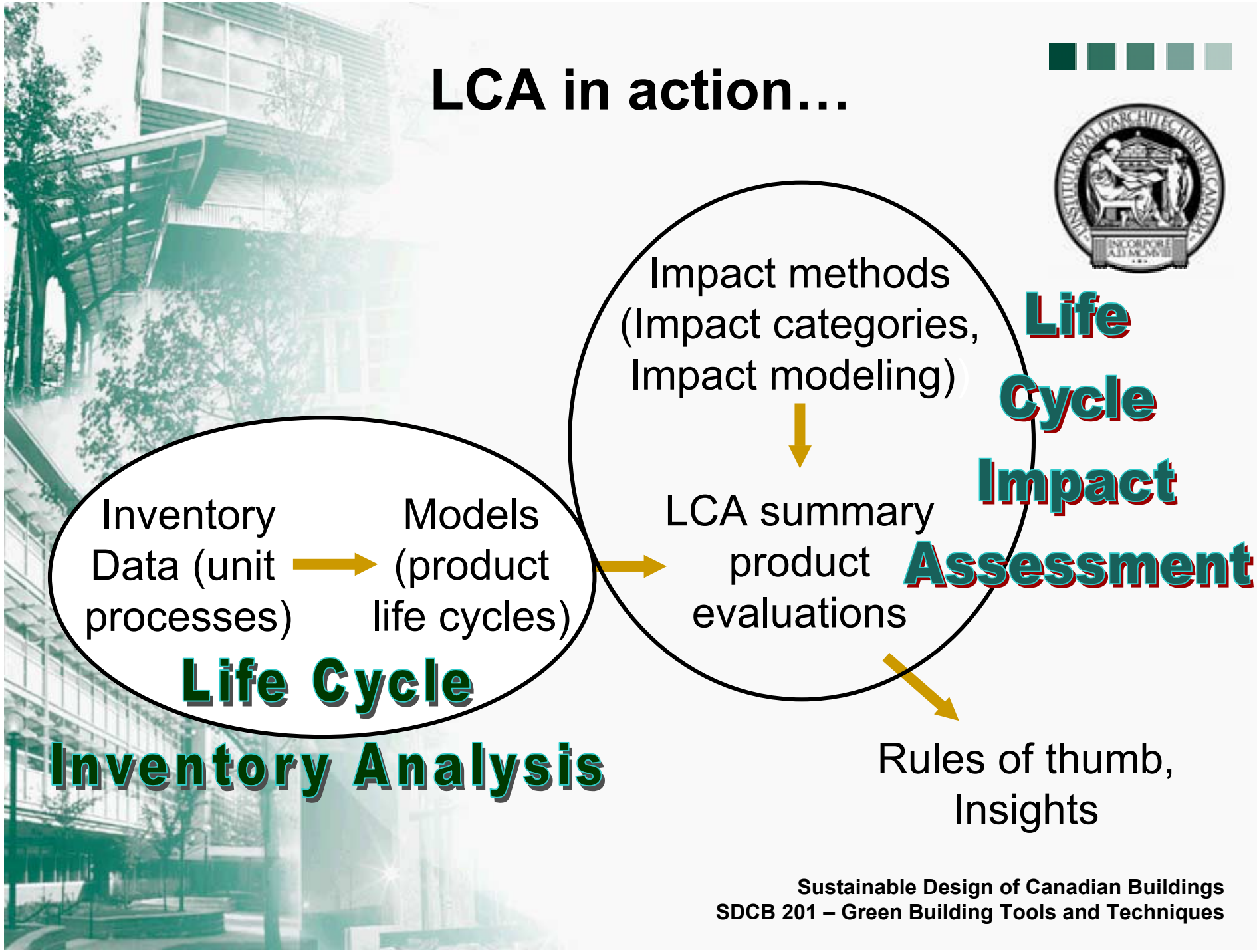
THE GOAL: to measure ultimate impacts on human and ecosystem health



High Performance Building Metrics (NREL)

- Global warming potential
- Stratospheric ozone depletion
- Ground-level ozone or smog
- Nutrification/eutrophication of water bodies
- Acidification & acid deposition (dry and wet)
- Human health effects — cancer and non-cancer (from toxic releases to air, water, land)

LCA in action…



A key distinction between . . .

LCA Practitioners

- Work at the level of materials & products
- Understand LCA and the relevant unit processes
- LCA is in their job description

Architects & Engineers

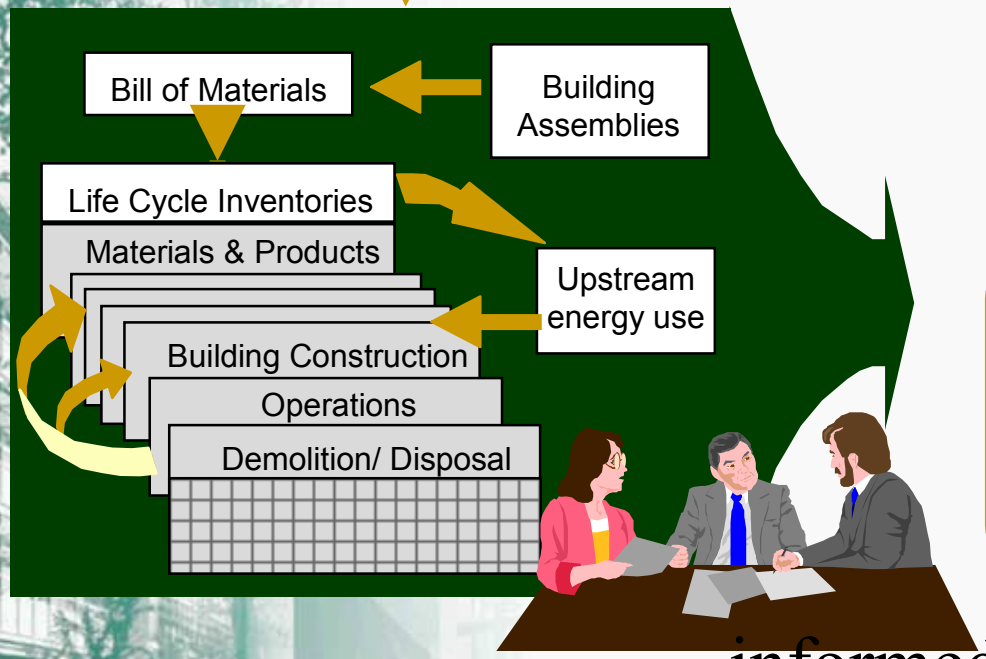
- Work at the level of the whole building
- May not understand LCA or the production processes
- Often not paid to be green

ATHENA™ at work . . .

Design 1

Design 2

Regional
- Electricity grids
- Transportation
- Production Processes



INVENTORY

- Raw Materials
- Energy Use
- Water Use
- Emissions to Air
- Emission to Water
- Solid Wastes

SUMMARY MEASURES

- Global Warming Potential
- Air Pollution
- Water Pollution
- Resource Extraction Effects

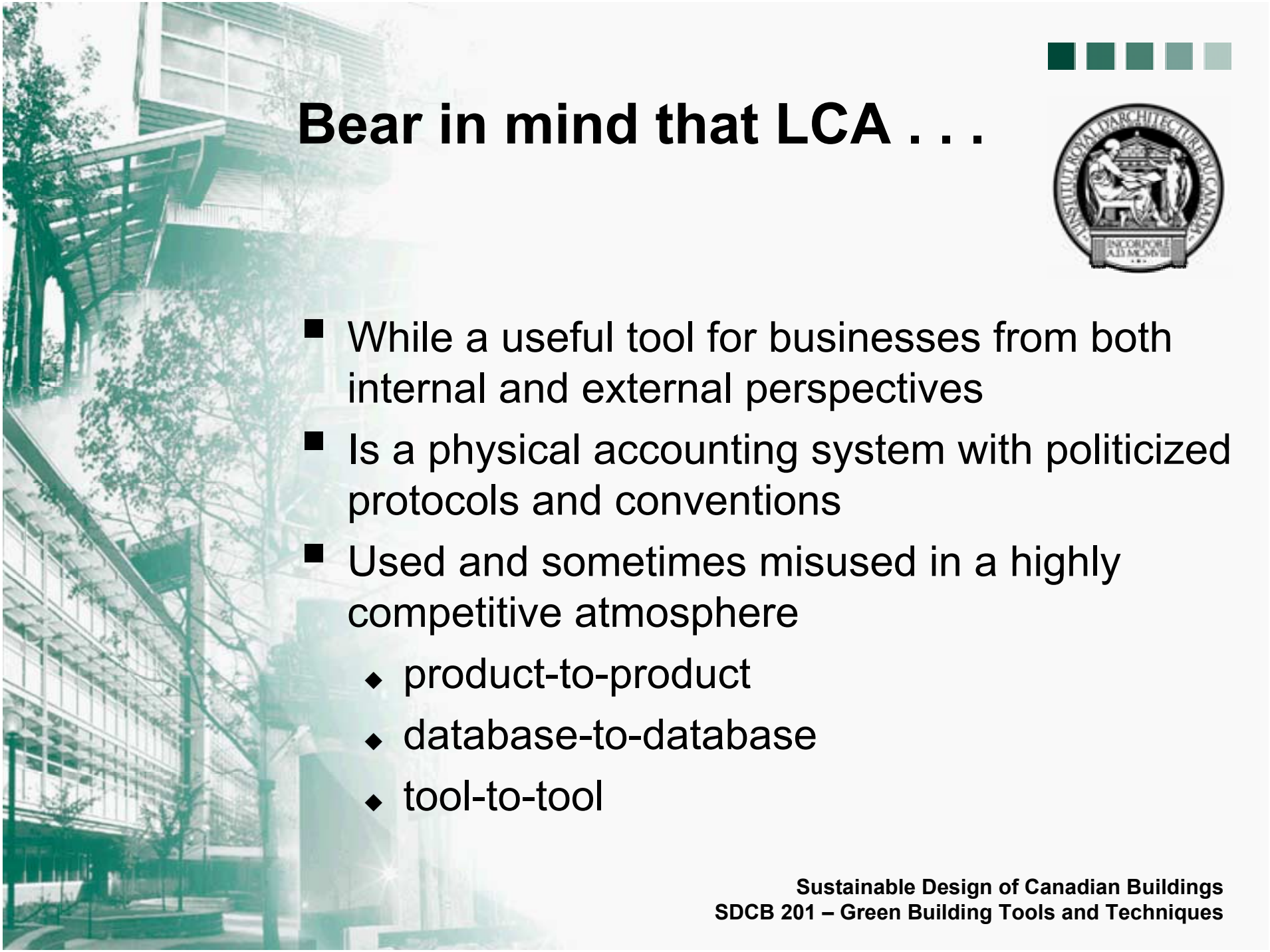
. . . informed environmental choices

Cautions and Concerns

The LCI is Critical

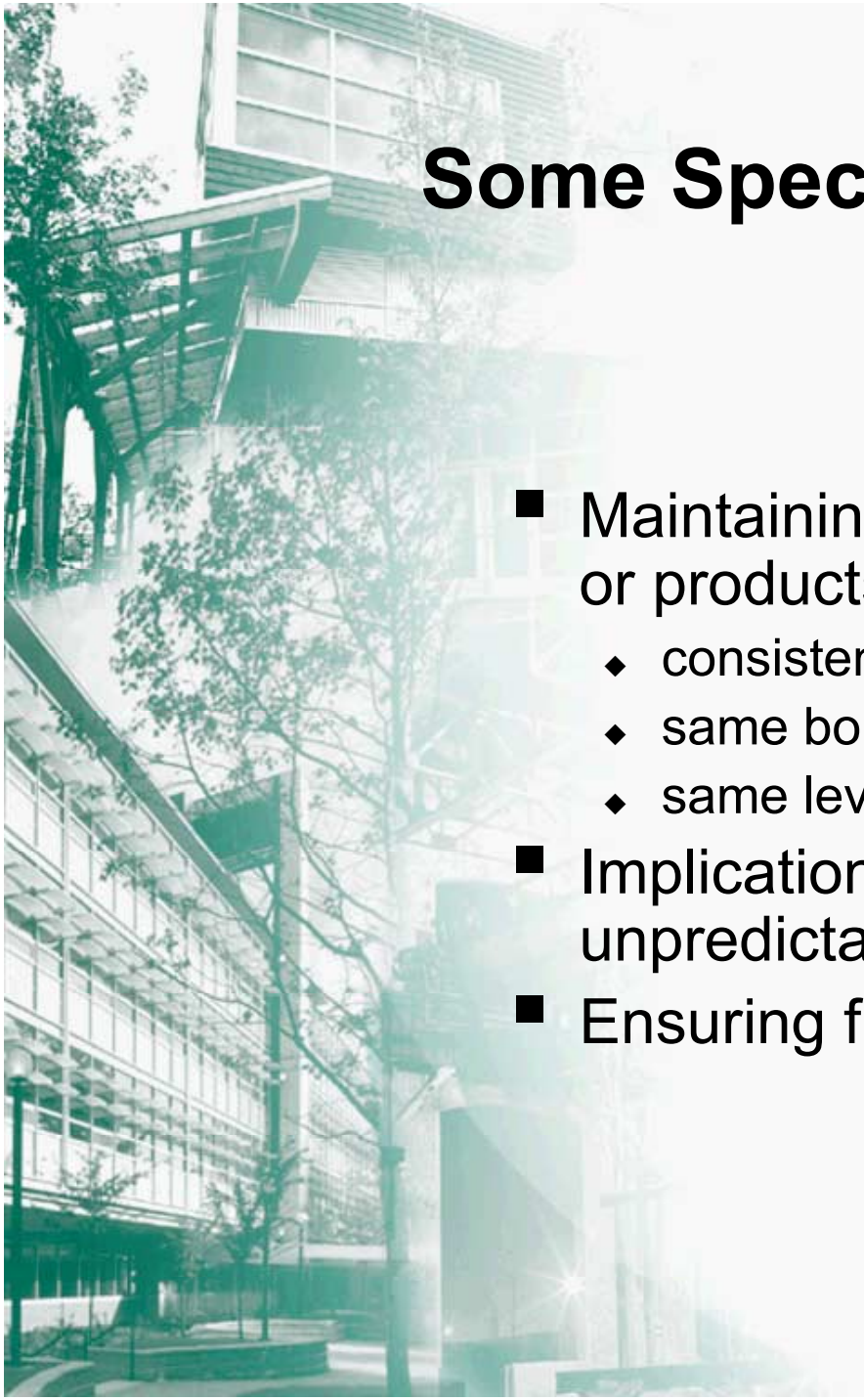
Quality of LCA results ≤ Quality of LCI data

No matter what tool is used or
how results are presented



Bear in mind that LCA . . .

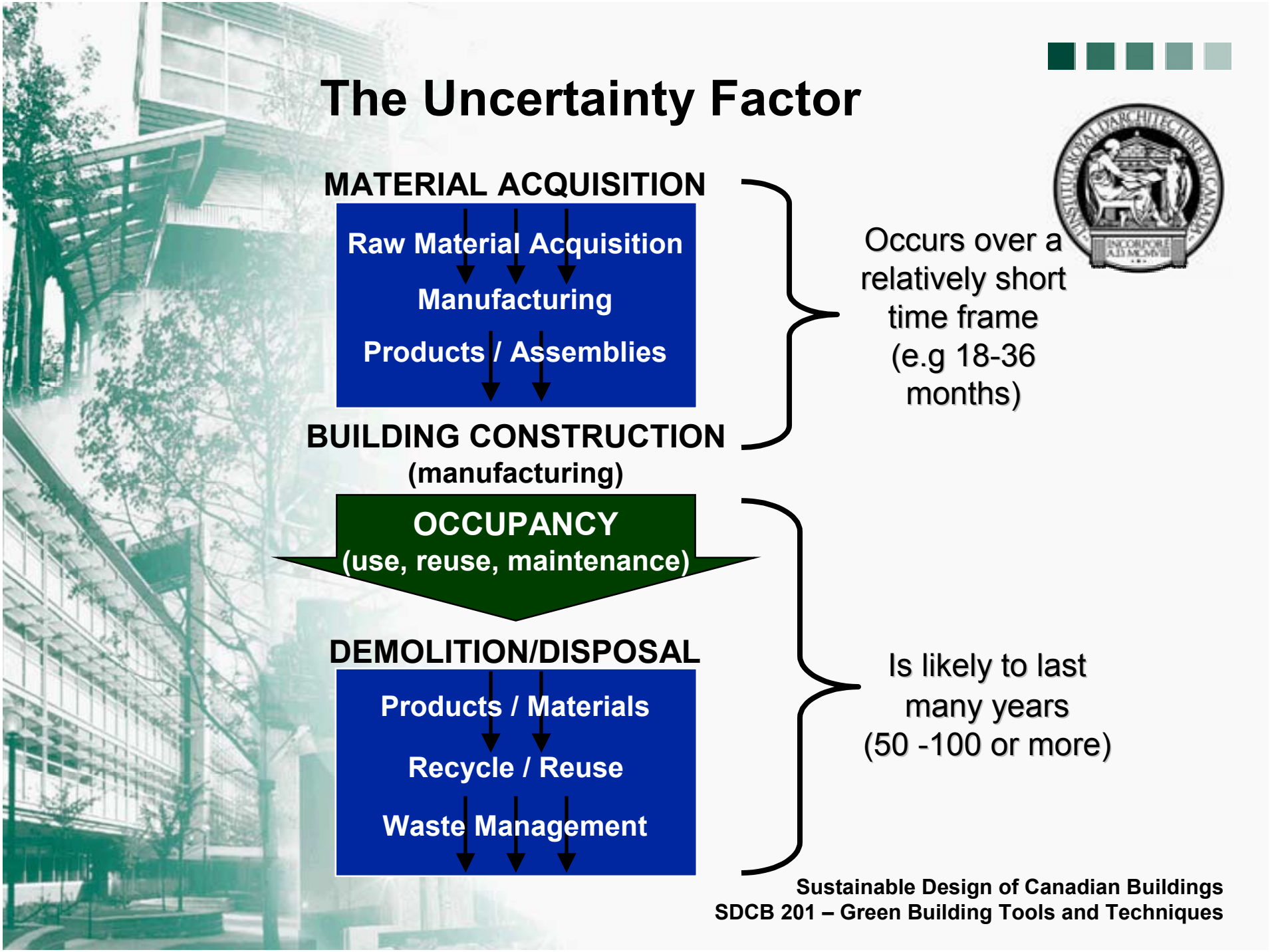
- While a useful tool for businesses from both internal and external perspectives
- Is a physical accounting system with politicized protocols and conventions
- Used and sometimes misused in a highly competitive atmosphere
  - product-to-product
  - database-to-database
  - tool-to-tool

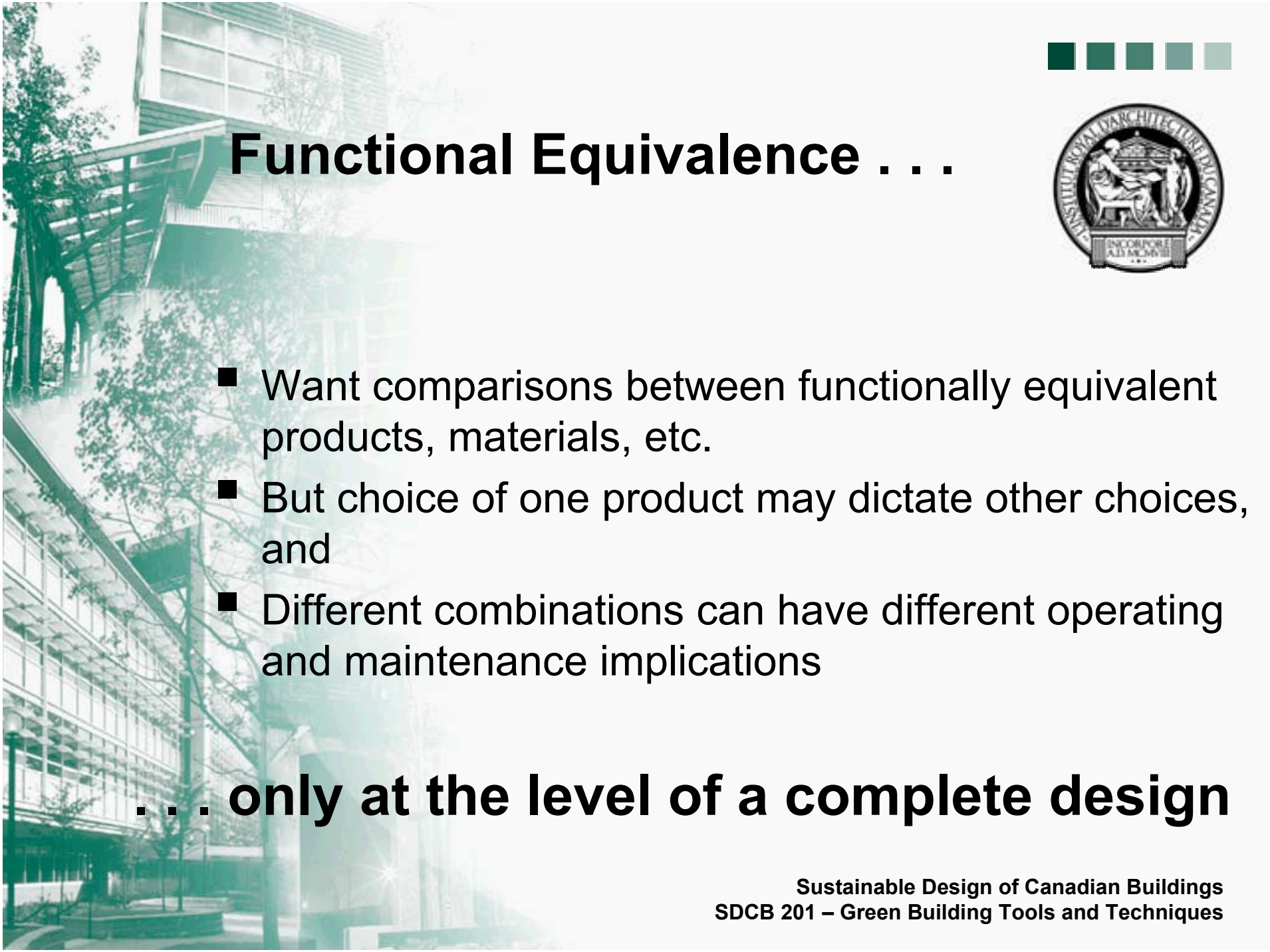


Some Specific Concerns

- Maintaining comparability among materials or products
  - consistent assumptions
  - same boundary and scope conditions
  - same level of detail
- Implications of building life cycle uncertainty, unpredictability
- Ensuring functional equivalence

The Uncertainty Factor





Functional Equivalence . . .

- Want comparisons between functionally equivalent products, materials, etc.
- But choice of one product may dictate other choices, and
- Different combinations can have different operating and maintenance implications

. . . only at the level of a complete design

Interpreting Results

- Be careful about
  - single criterion measures
  - simple or subjective scores
  - ‘green labels’
- Favour a comparative framework
- Use the ‘less is better’ rule, but with care
- Judge significance by benchmarking

QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

Mayo School Example

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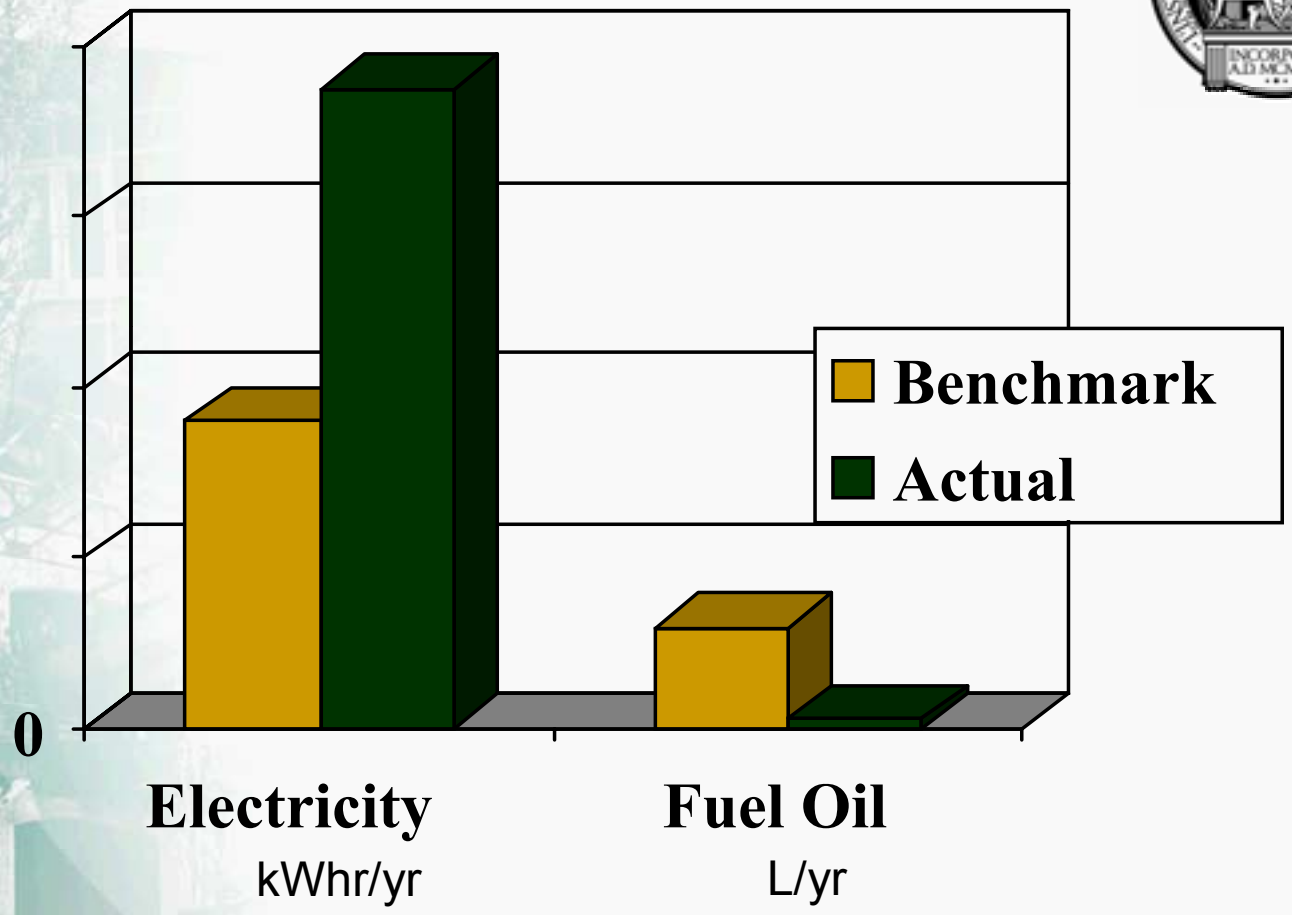
Mayo School
Material & Dimensional Design

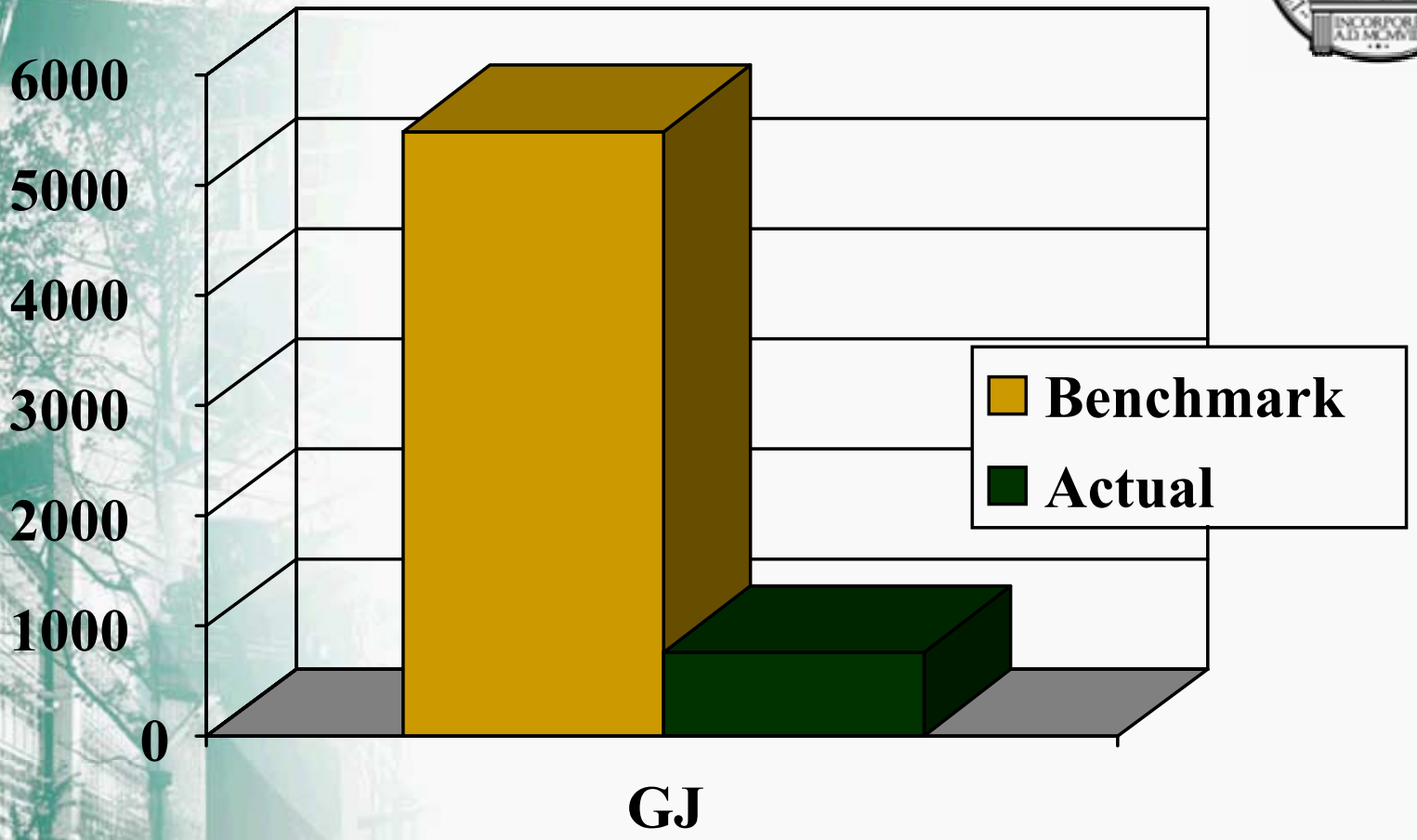
Building Component	Benchmark Design	Actual Design
Gross Floor Area	3220 m^2	3220 m^2
Design life	80 yrs	80 yrs
Primary Structure	Single storey, traditional light frame wood construction	Single storey, engineered wood light frame construction
Envelope	2x6 wood studs, 140 mm fibreglass insulation	Double wood stud wall, 209 mm fibreglass insulation
Exterior cladding/ fenestration	Wood shiplap siding/ aluminium fixed frame window, Low 'E' argon	Wood shiplap siding/ PVC operable frame window, Low 'E' argon
Roofing system/ insulation	Conventional 2-ply Mod Bit membrane, 100 mm XPS	Conventional 2-ply Mod Bit membrane, 250 mm cellulose

Mayo School
End Use Operating Energy



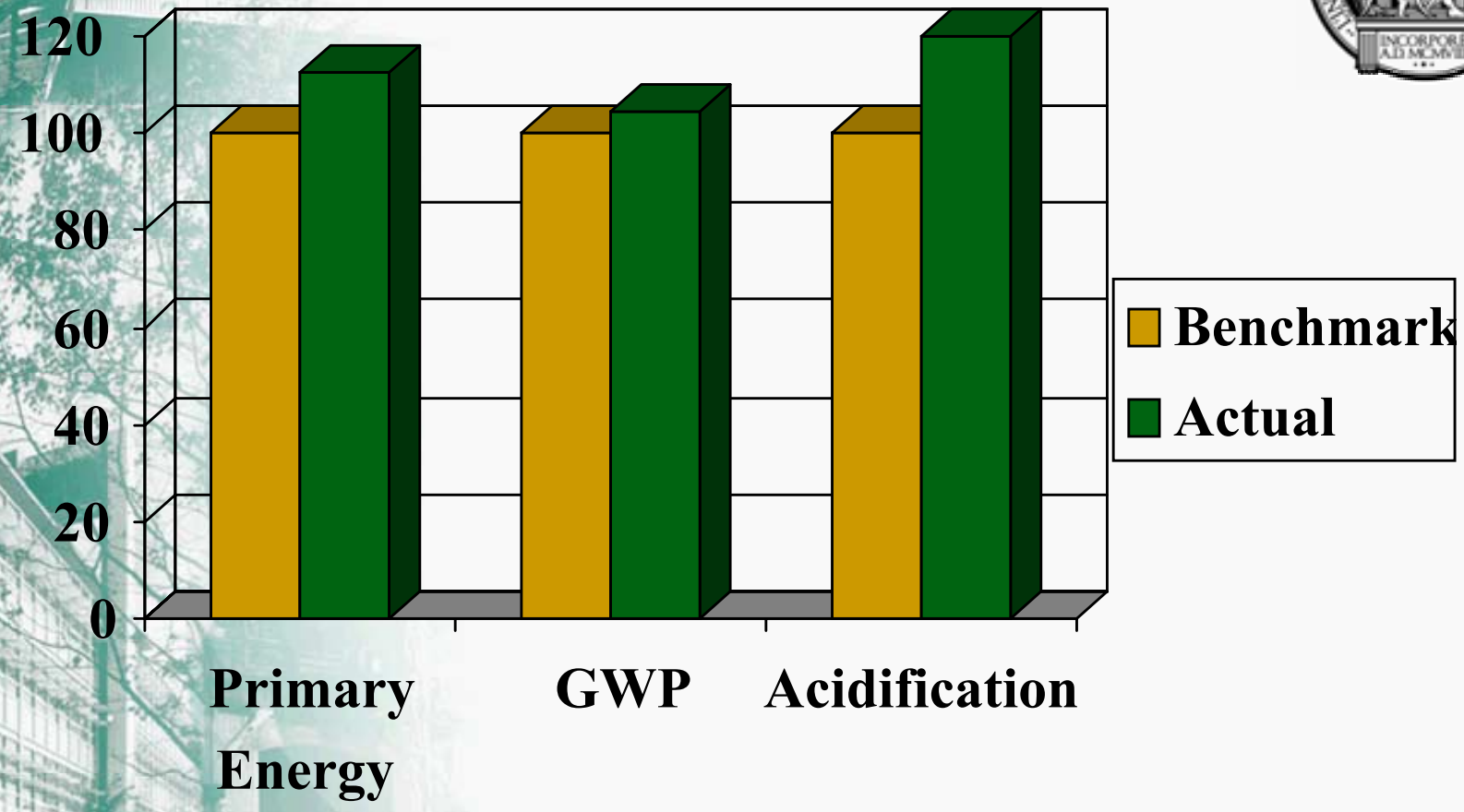
Source: S. Pope using CBIP estimating procedure

Mayo School
Primary Operating Energy



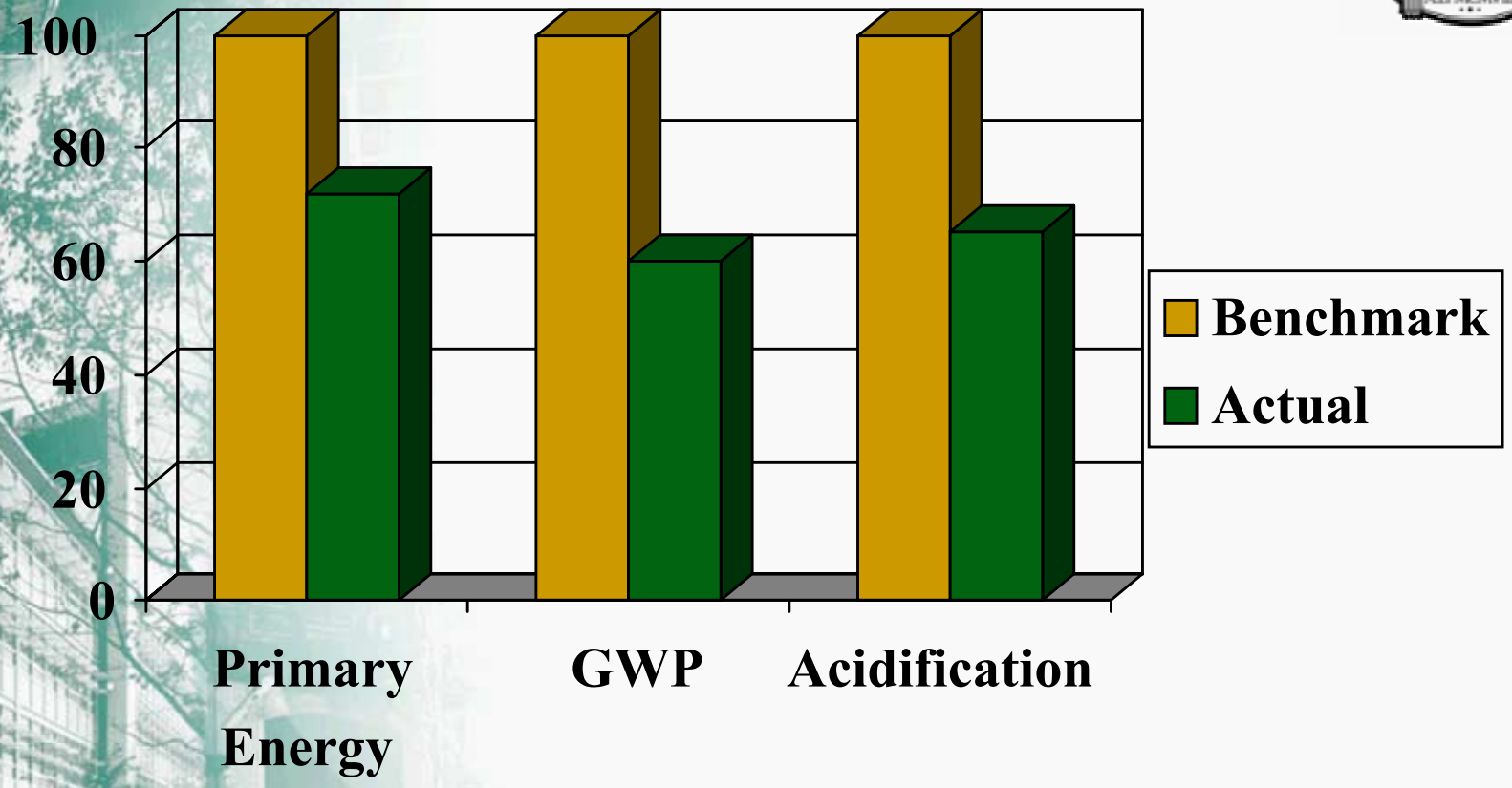
Source: Athena™ Environmental Impact Estimator

Mayo School
Embodied Effects



Source: Athena™ Environmental Impact Estimator

Mayo School
Total Embodied + Operating Effects



Source: Athena™ Environmental Impact Estimator

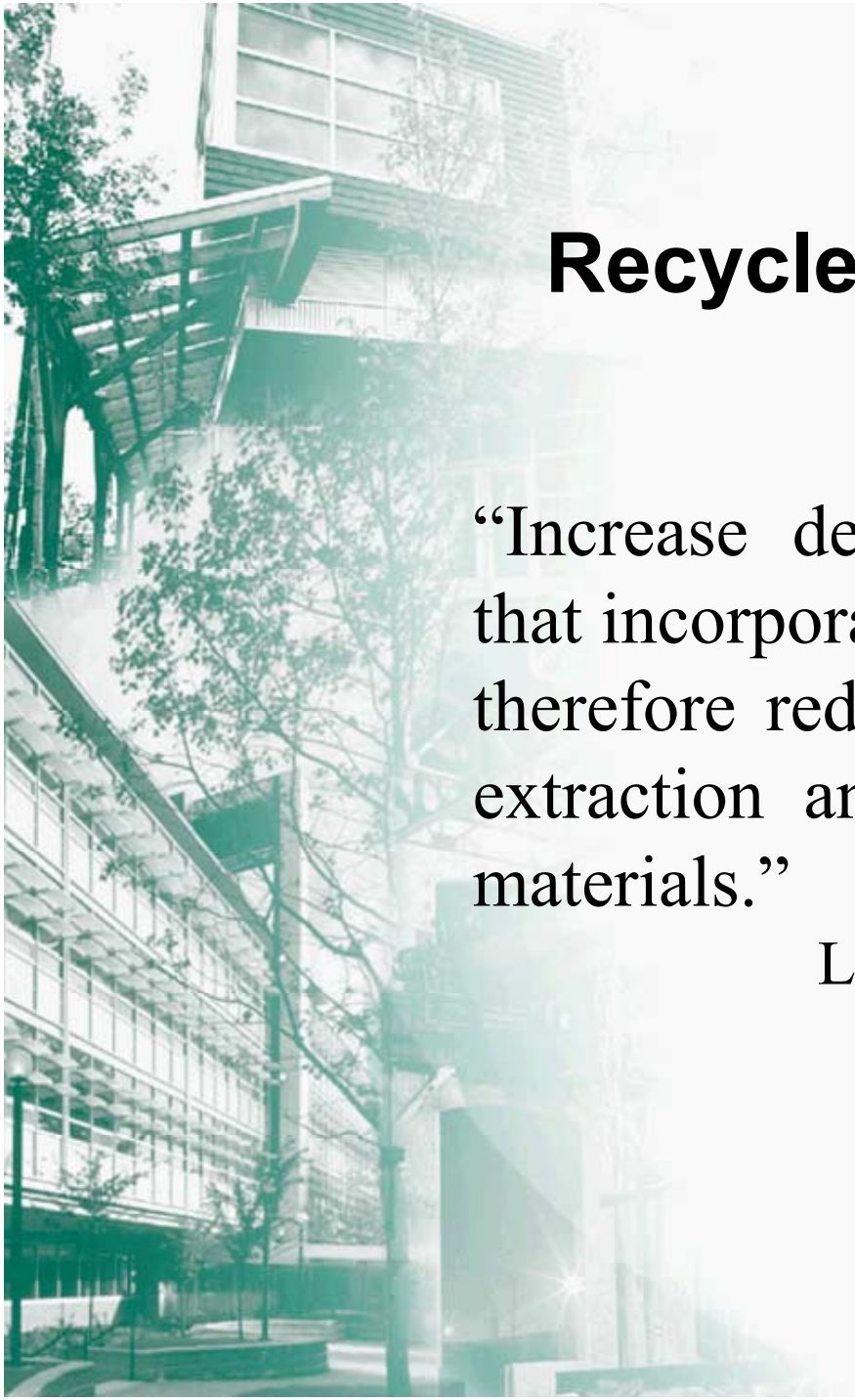
Why LCA?

The Proxies Problem

Example Proxies in Level 3 Assessment Systems

- Recycled content
- Regional purchasing
- Rapid rotation renewables

. . . Tend to Confuse Ends & Means



Recycled Content

"Increase demand for building products that incorporate recycled content materials, therefore reducing impacts resulting from extraction and processing of new virgin materials."

LEED™2.1 Intent, MR Credits 4.1, 4.2

BUT . . .

- Recycling does not always result in reduced burdens
- Tends to weight land fill concerns over energy use, global warming, etc.
- Favours metals over other potentially more benign materials
- Greater use of metals does little to meet the intent (simply rewards business as usual practices)

SIMILARLY . . .

- Regional purchasing may or may not result in lower burdens, depending on various factors, e.g.:
  - Environmental performance of local producers
  - Source of inputs to local producers
- For short rotation renewables, have to consider:
  - Fertilizers, pesticides, herbicides
  - Harvesting and processing effects
  - Land use & soil depletion effects
  - Water use

AND . . .

- Even in the case of operating energy, we should consider:
  - Source (e.g., of electricity)
  - Type (e.g., oil vs. natural gas)
  - Pre-combustion effects (energy to make and move energy)
- Not a single LEED credit if all embodied effects cut in half for a final design compared to a benchmark
- No credit for intentional increases in embodied effects that lead to decreased life cycle effects

Concluding Message

- LCA is a powerful environmental assessment approach
- It complements life cycle costing
- The only known way to replace the sometimes misleading proxies in Level 3 assessment systems
- Its widespread application requires reliable tools for non-practitioners based on sound LCI data
- It also requires benchmarking so we know when we are losing and gaining