



Environmental Considerations in Design and Construction

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Overview



- ◆ Opportunities for improving school design and construction
- ◆ A holistic perspective on cost
- ◆ Examples of best practices
- ◆ Some questions to consider
- ◆ Recommendations

A dark blue world map is centered in the background of the slide. The map shows the outlines of continents in a slightly lighter shade of blue. The overall background is a dark blue color with a fine, light-colored grid pattern.

Opportunities for Improving School Design and Construction

- ◆ Prescriptive standards (a.k.a. prototype designs)
- ◆ Performance-based standards
- ◆ Value engineering
- ◆ Holistic cost management

Prescriptive Standards

- ◆ The state mandates the “how”, and local systems can improve on it if they have the resources to do so
- ◆ Minimizes design time/costs (but requires site adaptation, and the standard should be updated regularly)
- ◆ May provide optimized features (but probably not in all situations)
- ◆ Can produce economies of scale
- ◆ Encourages over-design - worst case scenario

Performance-based Standards

- ◆ The state prescribes the “what”, but local systems determine the “how”
- ◆ Allows context-specific designs to be created that take local conditions into account
- ◆ Not technology dependent
- ◆ Requires more design time and effort (but does not preclude use of prototypes)
- ◆ Design time can be reduced by providing a library of best practices

Value Engineering

- ◆ When used properly, VE can:
 - Identify design conflicts, errors, or omissions
 - Function as a constructability review
 - Optimize performance of facility elements
 - Identify opportunities for cost savings through substitutions of less expensive alternatives that do not affect quality

Value Engineering

- ◆ When used carelessly, VE can:
 - Substitute alternatives that cost less but defeat design intentions
 - Increase life cycle costs
 - Result in a building that never performs properly
 - Result in contractor callbacks, blaming of architects, and other negative ramifications (that could have been prevented)
- ◆ Value Engineering must be conducted from a systems standpoint!

Holistic Cost Management

- ◆ Considers the following from the very beginning of the project:
 - What will be the impacts of design/construction decisions on life cycle costs?
 - What opportunities exist to *offset* increases in first cost for design improvements?
 - What externalities should be considered that could result in a better decision about costs?

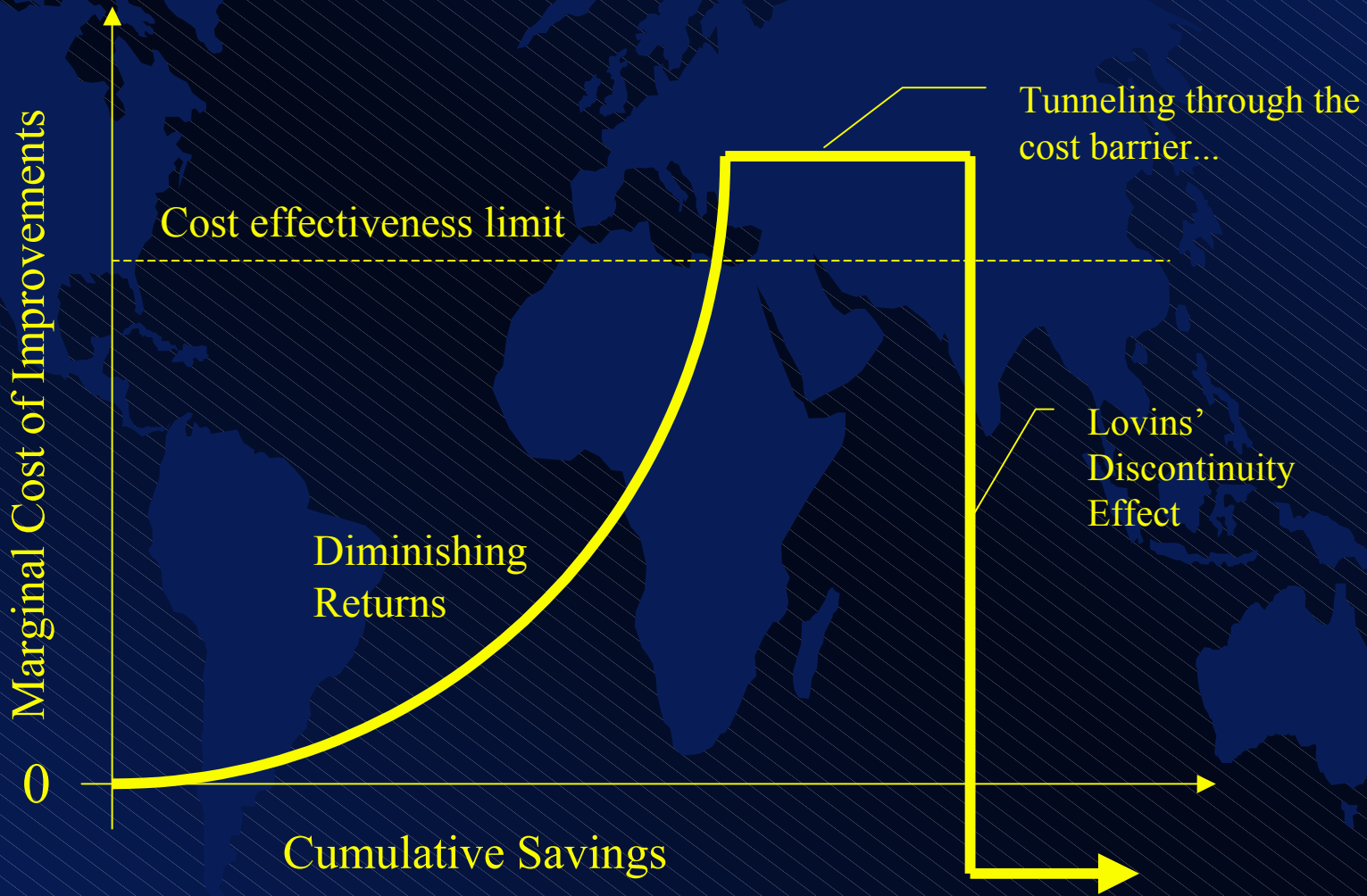
Expectations about Sustainable Projects



Opportunities to Offset First Costs

- ◆ Example: High-performance windows
 - Windows cost more
 - Cooling load reduced => HVAC system smaller
 - Smaller ducts, fans, motors, and pumps
 - Smaller plenum => smaller floor to floor height
 - Reduced building height => reduced exterior enclosure size => reduced material and labor

Lovins' Discontinuity Effect



(Source: Hawken et al. 1999)

Implications of Integrated Design



- ◆ **Considered in isolation**, high-performance windows increase the cost of the building (and might be value-engineered out)
- ◆ From a **whole building standpoint**, the cost of high-performance windows can be offset by savings in other systems
- ◆ Savings in life cycle energy costs is significant
- ◆ Let's consider an example...

Durant Middle School, Raleigh, NC

◆ Building characteristics:

- 1 story building, 150,000 sq. ft.
- Construction cost = \$82.50/sq. ft. (\$12.3 million total)
- Constructed in 1995

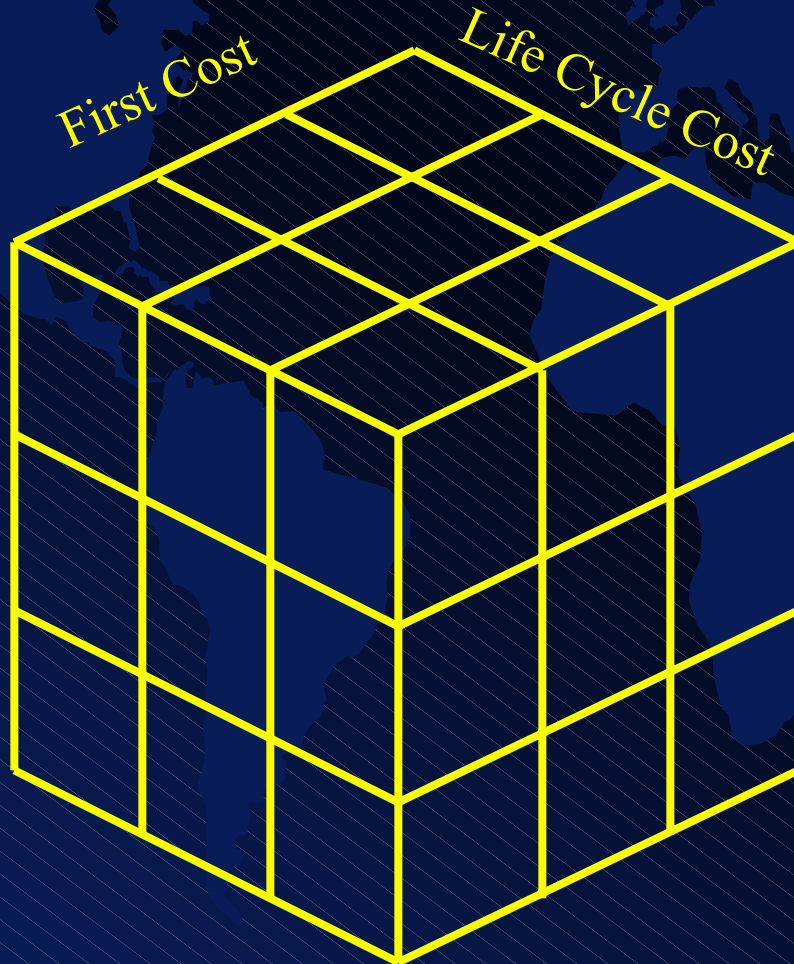
Durant Middle School, Raleigh, NC

- ◆ Energy-saving features:
 - East-west solar orientation, south & north facing roof monitor glazing for daylighting (30% increase)
 - Radiant barrier in roof
 - Low-e glazing throughout (reduces heat gain)
 - High-efficiency lighting equipment & controls
 - Energy management system

Durant Middle School, Raleigh, NC

- ◆ First cost comparison:
 - Added cost of efficiency features = \$230,000
 - Savings from downsizing HVAC = \$115,000
- ◆ Annual energy cost savings:
 - Estimated savings = \$165,000
- ◆ Payback for efficiency investments < 1 year

Revised Whole Project Cost Model



Qualitative costs

Nontraditional
quantifiable costs

Traditionally considered
quantifiable costs

What nontraditional costs should be considered in cost-based decisions?

- ◆ Nontraditional quantifiable costs:
 - Reduced teacher absenteeism
 - Improved productivity
 - Reduced vandalism
- ◆ Qualitative costs:
 - Improved achievement test performance
 - Increased morale
 - Increased occupant health (and growth)

Daylighting Studies

- ◆ Students in daylit middle schools performed between 5-14% better on their reading, language, and math skills as measured by the California Achievement Test
- ◆ Durant Middle School has the best attendance record in the county (>100 schools)
- ◆ A similar Canadian study found correlation between full spectrum lighting and increased student growth/improved dental records

Other Evidence

- ◆ Several studies have found correlation between building condition and student achievement and behavior
- ◆ Indoor air quality was found to significantly influence students' ability to concentrate
- ◆ Building conditions were correlated to teachers' effectiveness, morale, job satisfaction, enthusiasm, and absence rate

Buildings as Teaching Tools



- ◆ Henry Ford Museum/Greenfield Village, Dearborn, MI:
 - 400 student charter school located in a museum
 - Students learn math skills by calculating window, wall, and ceiling areas

Buildings as Teaching Tools

- ◆ Ohio Foundation for Environmental Education:
 - 200 photovoltaic systems are being installed to offset energy loads
 - Web-based tools allow students to analyze power generation and consumption
 - Other curricula connections in math and science

Buildings as Teaching Tools

◆ Other examples:

- On-site rainwater harvesting for toilet flushing and ecological wastewater treatment supports learning in biology and other disciplines (Ostratornskolan, Sweden)
- Preserved wetlands, environmental science yard, and experimental garden support learning in ecology and biology (Tavernier, FL)
- Building energy management system, HVAC, and lighting systems support learning in science (Brunswick, ME)

Holistic Cost Management

- ◆ If the school design process seeks opportunities for integrated systems improvement, increases in first cost can be significantly offset by savings in other downsized systems
- ◆ Many opportunities become feasible if life cycle costs are considered
- ◆ When intangible costs are considered, better school design and construction is nearly always preferable

How important is it *who* bears the costs of school construction, and when?

◆ First cost vs. life cycle costs

- Color of money
- How a school is constructed determines its legacy of life cycle costs

◆ Tangible costs vs. intangible costs

- Externalities
- How a school is constructed affects the kinds of externalities its constituency will have to bear (or the benefits they can realize)

What is the *real* objective we're trying to achieve?

- ◆ How should the State of Georgia address the construction backlog?
 - What are the effects of current conditions on student achievement?
 - What are the drivers of cost and schedule?
 - What will be the tradeoffs between time, cost, and quality?
 - What are the options for state intervention?

What is the state's role in creating quality learning environments at minimal cost?

- ◆ Prescriptive vs. performance-based standards
 - How much responsibility does the state want for creating and updating a “state standard”?
 - What means of evaluation will be used?
- ◆ Centralized control vs. local control
 - What are the design capabilities at the local level?
 - Who has responsibility for the outcomes?
 - What incentives are possible?

Recommendations

- ◆ Performance-based standards maintain local flexibility while allowing opportunities for the state to encourage better buildings (but some school systems may need technical assistance)
- ◆ Any new efforts should include checkpoints for evaluation and feedback - documentation is paramount!
- ◆ Documentation of school cost and performance data should be undertaken to support cost control and management



Questions?