Systems-Based Sustainability Analysis Building 170, Fort McPherson Atlanta, GA

Dr. Annie R. Pearce
Sustainable Facilities & Infrastructure Program
Georgia Tech Research Institute

Overview

- Project History
- Goals and Approach
- Systems-Based Sustainability Assessment
- Comparison of LEED with Systems-Based Assessment
- Conclusions and Future Work

Project History
Building 170, Fort McPherson, GA

- Formerly a hospital
- Historically significant
- Cornerstone for Fort Mac's historic district
- Presently abandoned
- Goal: new headquarters building for Army Environmental Policy Institute (AEPI)

Project History
Building 170, Fort McPherson, GA

- AEPI's needs:
  - Avoid leasing private office space
  - Create a living example to demonstrate core values
  - Provide a sustainable role model for future Army building activities
  - Demonstrate an alternate approach to reuse of historic structures

Project History
Building 170, Fort McPherson, GA

- Prior studies:
  - Initial overview of sustainability opportunities (Southface)
  - Sustainable design workshop (30+ experts plus installation personnel)
  - Deconstruction analysis (University of Florida)

Project History
Building 170, Fort McPherson, GA

- Point of departure:
  - Overview of facility functional requirements of AEPI
  - Initial condition assessment of the existing facility
  - Set of recommendations for building retrofit to achieve a LEED Gold rating

Goals and Approach
Research Questions

- How sustainable is the proposed retrofit state, i.e., a LEED Gold rating?
- Can the proposed retrofit plan be improved using Best Available Technologies & Strategies (BATS)?
- Which BATS make the most sense in terms of sustainability bang for buck?
- What technologies should be developed to improve the sustainability of future buildings?
- How can the process be generalized to other Army facilities?

Goals and Approach
Project Objectives

- To determine if any improvements can be made to recommendations developed in prior studies
- To identify existing BATS that could be implemented to improve the proposed retrofit
- To delineate areas where R&D is needed to develop technologies and strategies for facility sustainability
- To compare the outcomes of LEED-based solution development with systems-based solution development

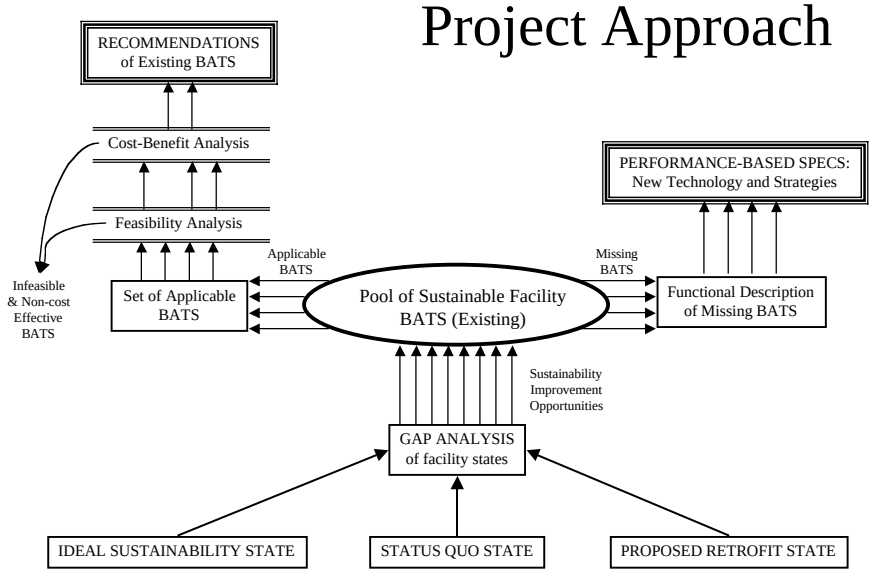
Goals and Approach
Project Strategy

1) Describe the ideally sustainable Building 170
2) Benchmark status quo (SQ) and proposed retrofit (PR) states of sustainability compared to the ideal sustainability (IS) state
3) Perform gap analysis to identify sustainability improvement opportunities

Goals and Approach
Project Strategy, cont'd.

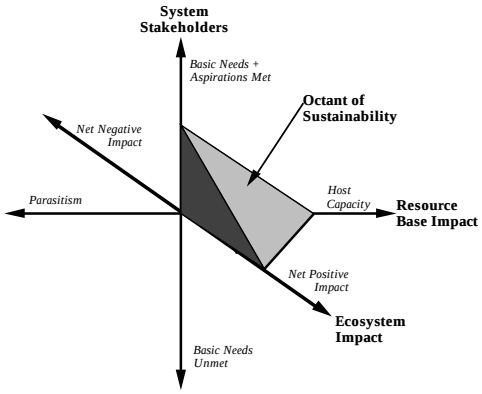
4) Review existing BATS to see if the proposed retrofit state can be improved
5) Perform cost-benefit analysis to evaluate any identified BATS
6) Identify areas of needed R&D and develop performance-based specifications for development of new technology

Project Approach



In the context of this study, a "sustainable facility" is one in which current and future states of the facility cause no net negative impacts to resource bases or ecosystems, while satisfying the needs of its stakeholders.

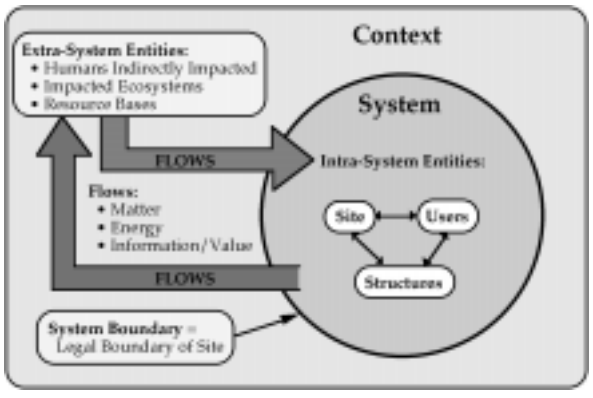
Defining Ideal Sustainability State



- Stakeholder Satisfaction ≥ Basic needs met
- Resource Base Impact ≥ No or neutral impacts
- Ecosystem Impact ≥ No or neutral impacts

Systems-Based Sustainability Assessment

- Define the facility as a system:



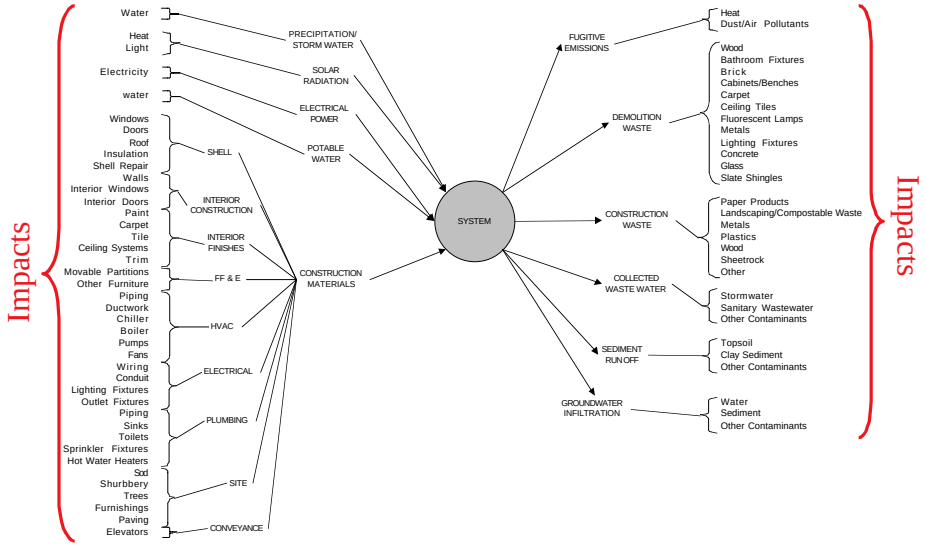
Systems-Based Sustainability Assessment

- Impacts to ecosystems and resource bases are caused by imports/exports of matter and energy to/from the system.
- These flows of matter and energy are used by the system to meet stakeholder requirements.
- Goal = find ways to meet stakeholder requirements while minimizing, eliminating, or offsetting negative impacts.

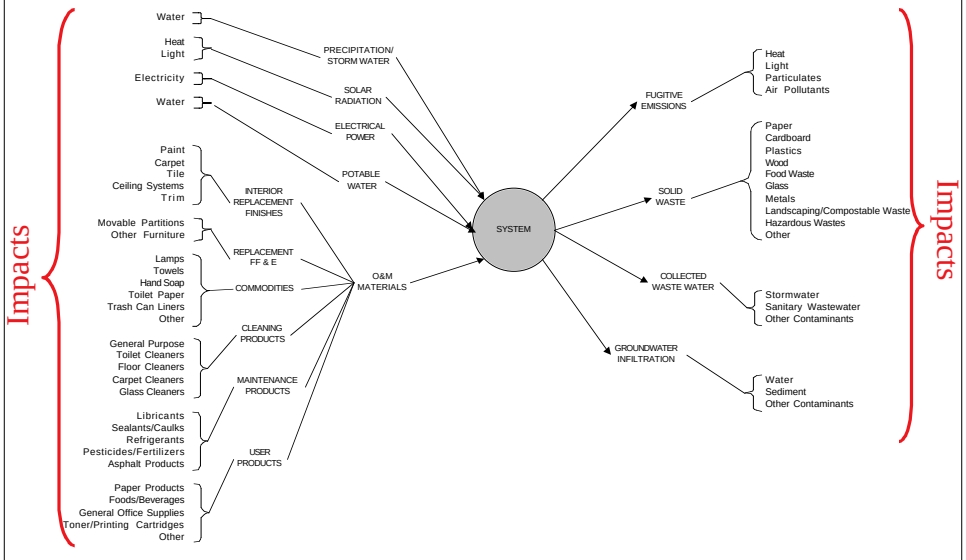
Systems-Based Sustainability Assessment

- To compare sustainability states, develop profiles of system states (SQ, PR, IS):
  - During construction and operations/maintenance
  - Flows into the system and flows out of system
  - Likely sources/sinks of flows
  - Likely impacts of flows (positive, neutral, negative)
- Flows with negative impacts = unsustainable

Baseline Systems Model - Construction



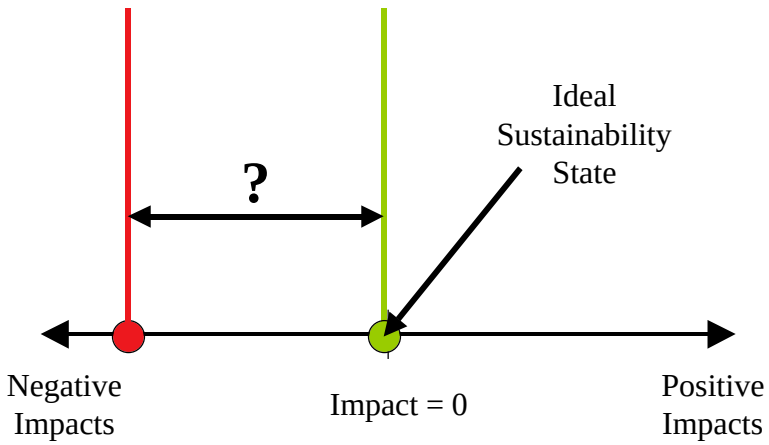
Baseline Systems Model - Operations and Maintenance



Similar profiles were constructed for all three states, then compared via gap analysis in terms of the impacts associated with each flow.

Impact = change in source or sink over time (quantity, quality, viability for meeting human needs)

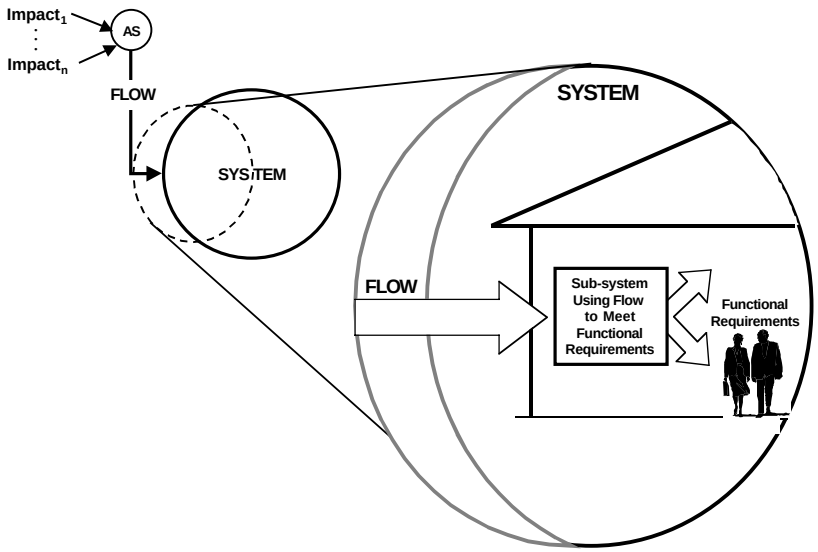
Gap Analysis



After gaps were identified, Impact Chain Analysis was used to understand the root cause of the negative impact from the perspective of the facility system.

What stakeholder needs are being met by the flow that causes the negative impact?

Impact Chain Analysis



By understanding *why* flows are being imported/exported, we can begin to identify alternatives to address their negative impacts.

We can also see what kinds of new technologies and strategies need to be developed that can meet stakeholder needs without causing negative impacts.

BATS Review & Evaluation

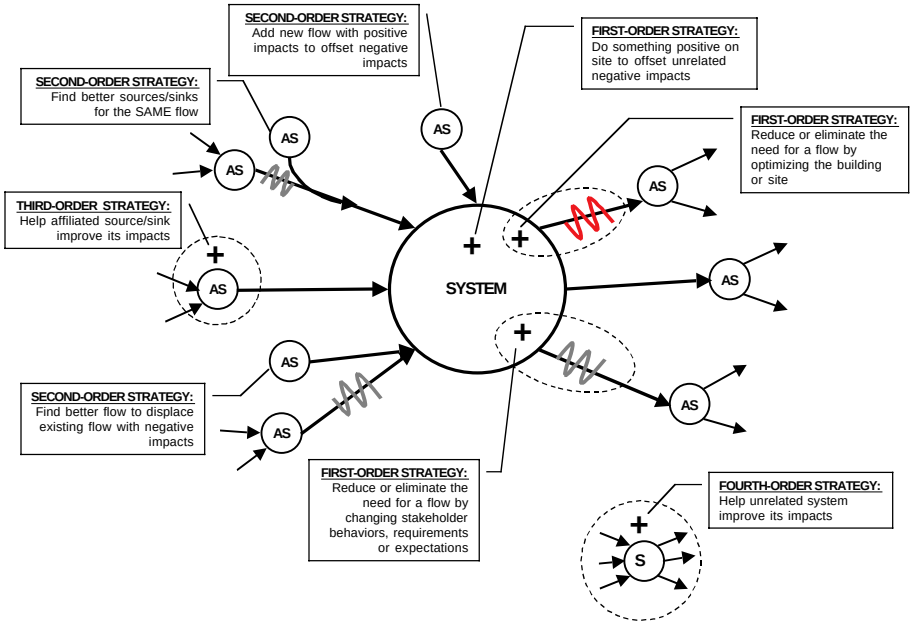
Having identified sustainability improvement opportunities, the next step was to search for existing Best Available Technologies and Strategies (BATS) that could be used to improve sustainability.

Georgia Tech's Sustainable Facilities Heuristics Database was used as a source of BATS for this project.

BATS Review & Evaluation

- Identified BATS fell into four categories:
  - 1st order: changes *inside* the system
  - 2nd order: changes to flows into/out of system
  - 3rd order: changes to source/sink systems supplying flows
  - 4th order: changes to unrelated systems to offset unavoidable impacts within the system

Sustainability Improvement Opportunities



BATS Review & Evaluation

- Over 150 improvement recommendations were identified, including:
  - Construction Inputs
    "Keep existing plumbing system in place."
  - Construction Outputs
    "Stage all equipment on paved areas to avoid landscape disturbance."
  - Operation & Maintenance Inputs
    "Use LED lighting that requires less frequent replacement and has lower energy requirements."
  - Operation & Maintenance Outputs
    "Minimize or eliminate external site lighting."

BATS Review & Evaluation
Feasibility Check

- Stakeholder requirements:
  - Environmental performance
  - Historic preservation
  - Building performance
  - Project performance
- Feasibility constraints:
  - Army regulations
  - Historic preservation regulations
  - Building codes and standards
  - Project delivery constraints

BATS Review & Evaluation

Cost/Benefit & Likelihood of Success Ratings

- Each feasible BATS was rated qualitatively and prioritized according to four additional factors:
  - Risk: likelihood of successful implementation
  - Reliability: likelihood of getting the desired result after the BATS has been successfully implemented
  - Value: amount of sustainability impact per effort expended (or dollar spent)
  - Difficulty: a function of resources required and number/significance of barriers to implementation

Research Agenda Development

- The last task was to develop performance-based specifications for new BATS that would need to be developed to create a truly sustainable Building 170, i.e., one with
  - No net negative impacts to resource bases and ecosystems
  - No sacrifice in the degree to which stakeholder expectations are met

Research Agenda Development

1) Imports of new products to the system, causing inevitable manufacture and transport impacts of those products
2) Unavoidable export of waste from the system, including transport, recovery, and/or storage
3) Fugitive or unintended emissions
4) Importing potable water
5) Large-scale wastewater treatment using current best practices
6) Landscape disturbance due to construction processes
7) Electrical power generation using current practices

LEED vs. Systems-Based Assessment

- LEED and the systems-based assessment method are complementary:
  - LEED is an easy to understand way of finding and capturing low hanging fruit, although it has some blind spots
  - Systems-based sustainability assessment helps to identify and fill in the gaps
  - Used together, the tools can result in a more sustainable building than LEED alone

Conclusions

- LEED provides a well-understood method for identifying sustainable best practices, but it does not address all the possible impacts of a building that could affect its sustainability
- It presently is limited in the scope of building types and life cycle phases it considers
- The systems-based method addresses these issues by being generalizable to multiple system types and phases and by providing a systematic means for identifying *all* impacts

Conclusions

- There are negative impacts associated with buildings that are presently unavoidable
- With present technologies, offsets are the only way to cost-effectively neutralize some kinds of negative impacts
- Existing constraints on this project will make achieving sustainability very challenging
- There is significant room for improvement in current practice using existing BATS - stakeholders need to look beyond minimum LEED requirements!

Questions Raised

- Is it possible to create a “truly sustainable” building?
- How far can technology take us before we are forced to seek behavioral solutions?
- To what extent must we predict future needs and issues in order to achieve sustainability? Should we plan for and invest in a solution, for example, that would enable the building to become a hospital again? What is the limit of reasonable responsibility?

Future Work

- Quantitative impact models (although ordinal models provide sufficient resolution to support a great deal of decision making)
- Impact tradeoff methodology
- Interfaces with other design tools
- Building systems interaction models
- Better ways to elicit and validate stakeholder satisfaction requirements

- The second generation of software for systems-based assessment is being developed now at Georgia Tech

Questions?

The report will be available online at:

http://maven.gtri.gatech.edu/sfi

http://www.aepi.army.mil