The Solutions Network

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Life-Cycle Effect of Buildings on Sustainability and Climate Change – Business Case

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United Nations

Global Warming

Human activities
Human induced emissions of CO_2 and other greenhouse gases (methane, nitrous oxide, fluorocarbons)

cause

Global warming and consequent global climate changes

Impact of Buildings

- Industrial revolution of mid-18th century
  - Showed us how to harness productive energy in diverse forms from fossil fuels
  - Brought the human race prosperity, conveniences and faster modes of transport
- The emphasis on built environment required greater emphasis on heating and cooling, which led to greater use of fossil fuels and fluorocarbons for air conditioning.
- Human beings spend more than 90% of their time indoors and hence health, safety, productivity and quality of life depends on quality of indoor environment.
- Result:

35% from oil
24% from coal
21% from natural gas

80 % of energy is generated by fossil fuels.

vs.

<10 % of energy is generated from cleaner, renewable sources.

Solar
Wind
Geothermal
Bio-mass
Others

Impact of Construction and Buildings

- By its very process, land development and associated construction and operational activities have a wide range of negative impacts on:
  - Environment
  - Energy and materials
  - Wasteful transportation patterns
  - Quality of life for the current and future generations
- Example: United States
  - <5% of world's population, but produces 25% of all CO_2 emissions
  - Construction and operation of buildings = account for 37% of all U.S. CO_2 emissions
  - Buildings account for 30% of total energy use, consume 2/3 of the nation's electricity, and generate 30% of greenhouse gases.
  - Buildings consume 30% of raw materials and 12% of potable water, and generate 40% of the solid waste in the U.S., most of which is construction waste – either as new construction or as alterations and improvements.
  - 25% of all wood is harvested for use in residential and commercial buildings

Emphasis on End Users

- Even though the inter-governmental dialogues, agreements and treaties are important to promote sustainable processes, the ultimate results depend upon the end users.
- Sustainability cannot become underline consideration unless it comes out of its mystical esoteric "buzz word" mentality and is justified as a business case.
- Awareness of the dangers of not considering the environment would prompt governments, developers and contractors to respond.
- Recommendation: Since the task of reversing environmental damage seems overwhelming, we should break the issue into smaller parts to get better participation.

Greening of Facilities

- ***Greening*** pertains to a wide range of actions needed to reduce the impact of relocations, demolition, construction, materials, services and occupancy of built environment on natural environment. The focus is on providing a safe and healthy built environment, while protecting the natural environment.
- The terms, ***Sustainability*** and ***Greening***, are used interchangeably and encompass the following principles:
  - **Minimize life-cycle costs** through resource management.
  - **Reduce resource consumption for comfortable and safe work environment:** energy, water, land, materials.
  - **Reduce resource waste:** energy, water, materials.
  - **Increase equipment and systems efficiency:** efficient replacement equipment that is properly tuned/maintained.
  - **Create an environment for and emphasize source and waste reduction** in facility planning, design, construction and operation.
  - **Create healthy environments** by improving indoor air, light, noise, temperature, humidity.

Drivers for Change

- Major drivers for change towards sustainable design, construction, operation and use of buildings:
  - Public awareness and public demand – strong push for change
  - Observed impacts of global warming and associated climate changes and respiratory diseases
  - Significant savings in life cycle operating costs due to lower energy and maintenance costs
  - Political inter-governmental agreements
  - Scientific knowledge and growing consensus regarding release of greenhouse gases, global warming and climatic changes
  - Emerging technologies for cost-effective carbon-saving, greening and more efficient operations
  - Likely insurance companies requirements for greening
  - Increasing asset value of efficient buildings versus liability of inefficient buildings
  - Stockholders' interest in companies that promote greening and sustainability

Unified International Actions

- Key examples of unified international actions under the UN leadership:
  - Promote dialogue on sustainability and environmental controls
  - Widespread support for the Montreal Protocol to reduce the ozone layer depletion
  - Kyoto Protocol to reduce the release of carbon-based emissions
- Energy and environmental battles can be won, provided there is concerted global action, coordinated at the regional, national and local levels.

Unified International Actions

- There is also an increasing trend towards:
  - Greening is no longer a "bragging-rights" buzzword.
  - Voluntary responsible actions from private corporations and industries to reduce consumption of resources, eliminate waste and adopt cleaner production systems. This is because over the life-cycle of a facility, it makes economic and social sense to have sustainable, efficient buildings with indoor environment suited for a productive workforce.
  - The evolving partnership between the public and private sectors with regard to bringing cleaner and sustainable energy to the people all over the world has been encouraging.

Framework for a Systems Approach

- In an effort to better understand the use and consumption patterns, we should develop a systems approach that takes a holistic view to sustainable design and considers all aspects of systems, needs and characteristics of the surrounding community.
- Buildings are ecosystems with huge inputs of materials, resources and energy that the occupants and processes consume, yielding enormous outputs of greenhouse gases and waste.

Framework for a Systems Approach

Relative contribution of various buildings towards emission of the greenhouse gases based on available estimates for the year 2000 in the United States:

Sector	Total CO_2 emissions (million metric tons)	% of U.S. energy related CO_2 emissions	% annual growth since 1990
Residential	313.4	20%	1.9%
Commercial	267.8	17%	2.4%
Industrial	465.7	30%	0.3%
Transportation	514.8	33%	1.8%

Phases in a Building's Life

- Life-cycle stages and related aspects:
  - Land development and planning (recurring impact)
  - Initial supply of materials, furnishings, and construction and occupancy (one-time impact)
  - Operations with energy use, heating and cooling systems releases, and services for performing functions (recurring daily, major impact)
  - Maintenance, alterations, improvements and refurbishments (periodic impact)
  - Transport of workers, visitors, goods and services (recurring daily, major impact)
  - Demolition (one-time impact, reduced by reusing the shell and recycling materials)

Phases in a Building's Life

- Sustainability is promoted by pursuing the following principles:
  - Land use and site selection
  - Planning, design and commissioning
  - Use of natural and renewable means for healthy indoor environment
  - Conservation
  - Operations and maintenance

Phases in a Building's Life

"Leadership in Energy & Environmental Design (LEED)" – ranking system used by USGBC for new and existing buildings, with relative weights along the following lines:

Factor	*No. of Points*	*% of Total*
Sustainable Sites	14	20%
Water Efficiency	5	7%
Energy & Atmosphere	17	25%
Materials & Resources	13	19%
Indoor Environmental Quality	15	22%
Innovation & Design Process	5	7%
TOTAL	69	100%

USGBC rates buildings for sustainability, as follows:

- Certified: 26-32 points
- Silver: 33-38 points
- Gold: 39-51 points
- Platinum: 52-69 points

Holistic Building Concept Life Cycle Analysis

- Buildings are Eco-Systems where a number of systems interact.
- Performance and indoor environment can only be improved if we understand and apply interaction and inter-dependency of the facility's orientation, façade, windows, lighting, utilities, mechanical, electrical, water and waste stream systems.
- Materials and building's usage are other important interactions.
- Proper design, construction, commissioning, and continued integrated operations and maintenance are critical to achieving the desired results.
- Use of renewable sources – geothermal, solar and wind mills are necessary adjunct to improvements in central plant, lighting, variable speed drives and adaptive buildings management systems.
- Consolidate utilities and energy design and procurement with other area customers.

Compelling Business Case

- Lower energy and resource use due to higher performance design and operations.
- Greater environmental and social responsibility.
- Reduced construction waste and disposal costs.
- Lower life cycle costs when all capital, operating, and value-added factors are considered.
- Enhanced health and well-being – estimated potential savings of $58 billion annually.
- Improved employee productivity – potential benefit from better buildings of $200 billion.
- Reduced liability due to sick building and related concerns.
- Lower insurance premiums.
- Increased property values for building owners and better value for tenants.

Compelling Business Case

- There are two suggested ways to look at Systems Approach
- Other system concepts can similarly be used to suit the purpose of the analysis.
- FIRST WAY – By life cycle phases of a building
- Findings of recent study on building in New Zealand:
  - Approximate 10% impact of initial construction
  - 1/3 each for transport and operational recurring factors
  - Remaining impact from land development and maintenance/ refurbishment activities

Compelling Business Case

- SECOND WAY – By resource and functional savings
- A well-structured Green LEED SILVER rated design adds approximately 2% to upfront (Lawrence Berkeley Lab study of 40 California agencies).
- This may add $3 to $5 per sq ft of building upfront construction costs.
- Life cycle savings estimated at 20% of initial construction costs (>10 times of initial investment).
- Financial benefits are likely to be between $50 and $70 per sq ft over life cycle, as follows:

	Life Cycle Net Present Value
Energy	$5.80
Emissions	$1.20
Water Savings	$0.50
Operations and Maintenance	$8.50
Productivity and Health Value	$36.90 to $55.30
Total Life Cycle Savings	$52.90 to $71.30
Average Extra Cost of a Silver Green Design	$3 to $5

Compelling Business Case

- More than 10 times financial benefits – Lawrence Berkeley Laboratory study.
- Use of renewable energy from wind mills purchased by GSA and the UN incurs higher unit rate costs, but avoids significant savings of varying costs of fossil fuels.
- Predictive building management and maintenance management as part of Green Design lowers higher deferred costs.
- Greater accountability for energy and resource use and generating waste.

Challenges – Demand & Supply Side Control

- Ability to purchase the electricity, steam, gas and other utilities at the lowest cost in a competitive environment from environmentally friendly sources in a restricted energy market.
  - Consolidate the loads with other area facilities.
  - Procure 10% or more of power from renewable resources.
  - Purchase utilities for Senior Executive's Residence from renewable resources.
  - Further progressively expand such programs.

Challenges – Demand & Supply Side Control

- Take full advantage of the competitive market place by incorporating:
  - Supply side controls
    - Use of alternate cooling methods.
    - Use optimal mix of steam (heating and chillers) and electricity to limit demand charges.
    - On-site diesel generators.
    - Consideration of other on-site generation sources.
  - Demand side controls
    - Through phased alterations and improvements and operational and maintenance measures, reduce demand by up to 30% with buildings systems and infrastructure upgrades in service to shave the demand during the peak loads conditions.

Conclusion

- This presentation outlines an input-output type of systems analysis framework for the buildings and construction sector to understand the impact on the environment during different phases in the life span of buildings, and thereby develop innovative measures, education and training to promote efficiency and sustainability.
- Buildings' location, design and operations are the chief determinates of buildings' costs and environmental impact.
- The more in-depth understanding we have of factors affecting the environment, the more likely there will be progress towards sustainable and green buildings.

Hope for the Future

- History is always a great teacher. We need to always learn from experience in the past to better design the future.
- Any new technology takes time to mature.
- For a sustainable future, there is a need for incentives and commitments.
- Experiences have proven that national economies can not be fostered by public or private sector alone, but only when the two sectors work as partners in the spirit of cooperation.
- Such a partnership provides the flexibility and diversity to adjust to changing situations in the world for a sustained growth.