Architecture: in quest for a sustainable future

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ABSTRACT

Sustainability and Architecture are synonymous terms. While sustainability, physically and economically, is to a large extent manifest in the habitat built form, it is the scientific temper that will lend a design methodology and process, in order to render Architecture sustainable. To achieve this, an 'Energy, Resource Flow—Ecological Foot Print' model is suggested which can help optimize input–output parameters and their relationship. Possible formulations of these parameters leading to a Sustainability Indicator are also suggested. This leads to a process of design and various actual projects in response to critical issues thus suggesting *A New Language of Architecture*.

PREAMBLE

Sustainability, the 'keyword' and 'catch word', has been an integral part of life cycle since mankind took charge of its destiny. Although it did not have the high profile definition then—sustainability—it has a definition now.

Human habitat and nature were synonymous—habitat of Cold deserts of Ladakh (India), the hot deserts of Jaiselmer (India), the plains of Hyderabad (Sind) stand as testimony.

Yet, today, as the entire planet seems to be hurtling perhaps towards an unsustainable future: Architecture—the human habitat—which is the largest consumer of natural and man made resources, in my considered opinion, offers a potent tool for moving towards a sustainable future. It more than ever calls for: A New Language of Architecture.

PRESENT SCENARIO—URBAN DILEMMA

Central to the issue of sustainability at the global scale is the human–habitat condition that now prevails in large and most populated countries, for example, India and China, which together make a third of the total world population.

Rising urbanization in India –12% in 1940 to 27.52% in 1991 and increase in urban centres with a total of 218 million urban population marks a shift in rural population to urban centres.

ENERGY, RESOURCE FLOW—ECOLOGICAL FOOT PRINT MODEL

Human habitat, a physical manifestation of socio-economic ecological context, is the major consumer and generator of energy and resource. Energy–Resource Flow Model developed and presented below illustrates the input–output relationships.

While air, water and land are the major environmental resource inputs, materials (embodied energy) and fossil fuels (primary energy) are the major natural resource inputs. Outputs like emissions are the major source that modifies the environmental context.

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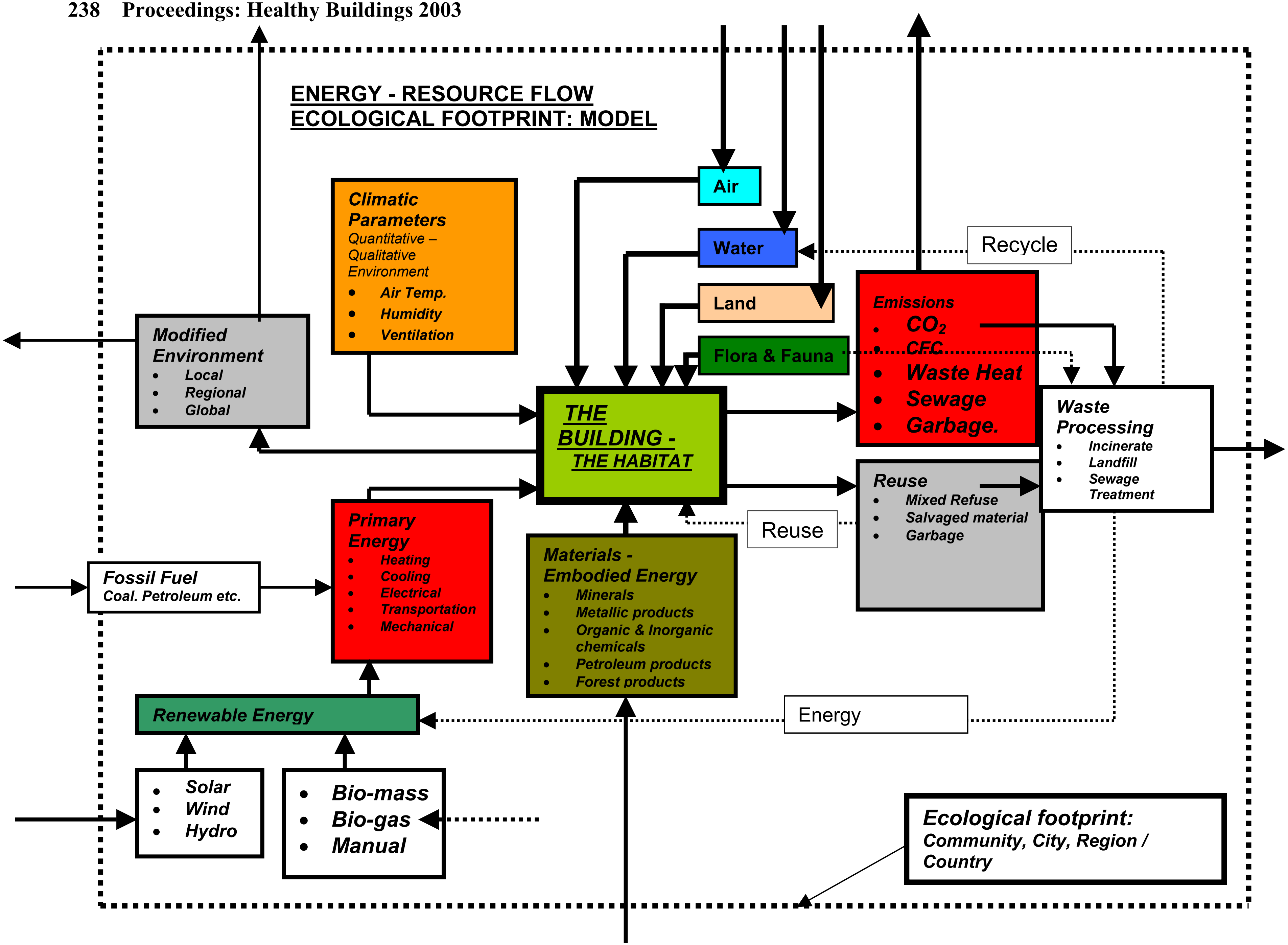

ENERGY - RESOURCE FLOW
ECOLOGICAL FOOTPRINT: MODEL
Climatic Parameters
Quantitative – Qualitative Environment
• Air Temp.
• Humidity
• Ventilation
Modified Environment
• Local
• Regional
• Global
Air
Water
Land
Flora & Fauna
Recycle
Emissions
• CO_2
• CFC
• Waste Heat
• Sewage
• Garbage.
Waste Processing
• Incinerate
• Landfill
• Sewage Treatment
THE BUILDING - THE HABITAT
Reuse
• Mixed Refuse
• Salvaged material
• Garbage
Reuse
Primary Energy
• Heating
• Cooling
• Electrical
• Transportation
• Mechanical
Materials - Embodied Energy
• Minerals
• Metallic products
• Organic & Inorganic chemicals
• Petroleum products
• Forest products
Fossil Fuel
Coal. Petroleum etc.
Renewable Energy
Energy
• Solar
• Wind
• Hydro
• Bio-mass
• Bio-gas
• Manual
Ecological footprint:
Community, City, Region / Country

This input–output intrinsic relationship determines the ecological footprint: the community, city or the region/country—the ultimate determinant of sustainability.

Central to this entire flow model is the habitat/building. It is both in the construction and operation of this habitat/building that energy-resource flow can be optimized, outlining the criticality of planning and design of the habitat/building. Wherein, Climate-Responsive Architectural design and Ecological Planning become the determinants of energy-resource flow and offer a powerful tool for optimization.

CLIMATE-RESPONSIVE ARCHITECTURE—THE TOOL AND THE PROCESS

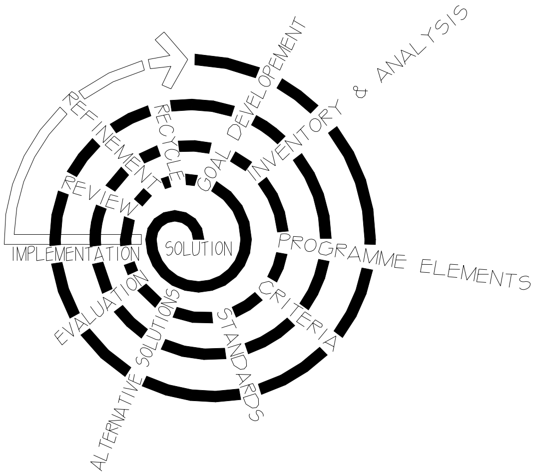
This leads to defining a process of architectural design that is scientific and developed on an ecological basis.

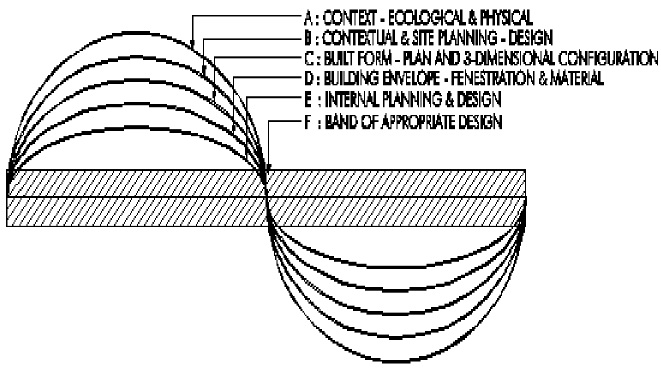
The process of architectural design is a complex exercise, involving interactive relationships between parameters of diverse nature and varying magnitude. Yet, it is the prime generator of architecture as we see and experience.

The idea of climatically responsive design is to modulate the conditions such that they are always within or as close as possible to the band of appropriate design as illustrated in the ecological process of design

Ecological Process of Design

Based on this premise, a design decision-making knowledge based expert system has been developed by the author and published in C*limate Responsive Architecture—A Design Handbook* (Tata McGraw Hill, New Delhi, 2001).





Graphical Representation of Process of Design Ecological process of design

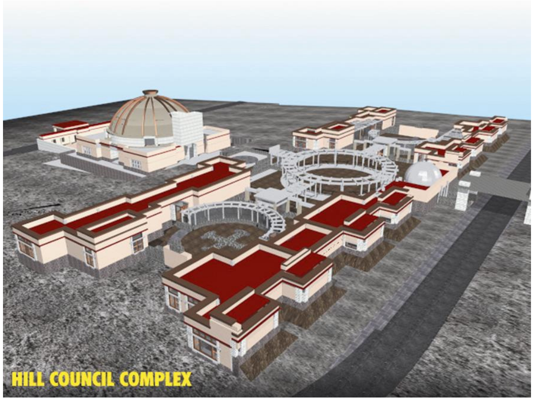
SOME CONTEMPORARY SOLUTIONS

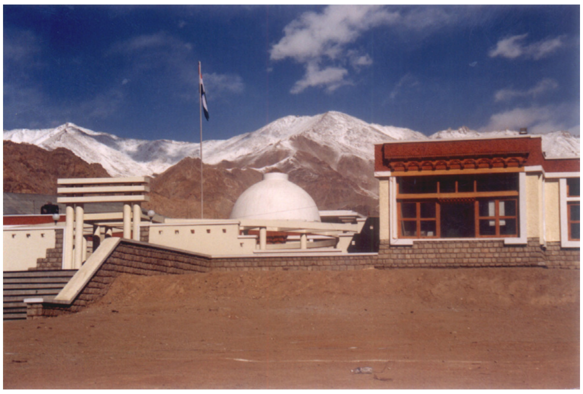
One single parameter that embodies the state and use of natural resources in their various forms is energy. The author presents some contemporary solutions that optimize energy use/consumption through architectural design.

High Altitude Extreme Cold–Dry Ecological Context
Hill Council complex, Leh, India

A major Civic Structure was designed and built as architectural design solutions for this context.

Located at 3514 m above m.s.l. in cold–dry climate with a severe long winter: October to March end (Min. DBT—30°).





Birds Eye View of the Complex Main approach & front façade of complex.

The main objectives and features of the design besides elements as sustainable solutions are:

- Earth sheltering and earth-berming on the north side and a sunken lobby reduces northern exposure and stabilizes internal temperatures even in a critical period.
- Optimize solar heat gain to office and assembly hall during critical periods of the year.
- Glare-free daylight to minimize lighting load.
- A new expression of 'Ladakhi' architecture by harmonizing indigenous with modern and incorporating local materials has been created. This helps sustain the artisan and the local art of construction as well.

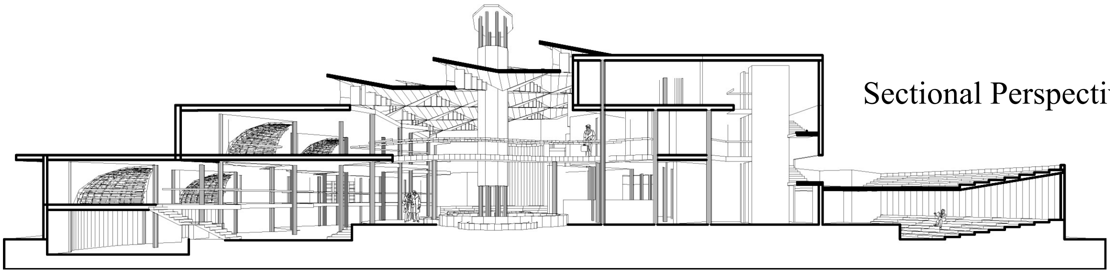
Composite Climate and Context of Urbanity of Chandigarh
PEDA Office complex, Chandigarh, India

Climatic conditions: Very hot and dry period of almost two and a half months (max. DBT 44°C); cold period of shorter duration (min. DBT 3°C). The hot dry period is followed by a hot humid monsoon period (max. DBT 38°C and max RH 90%) of about two months with intervening periods of milder climate.

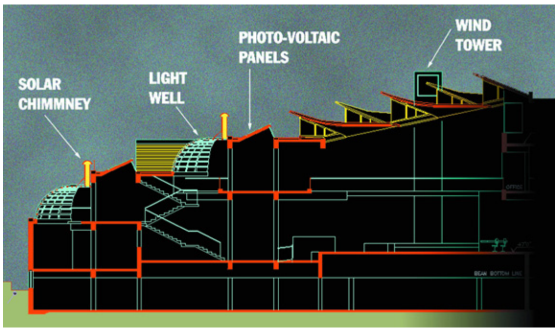
Chandigarh is a bold experiment in city planning and architecture. Le Corbusier put into practice his theory on 'Brise Soleil'. Many residences designed by Pierre Jeanneret, Maxwell Fry and Jane Drew made solar shading devices as a major element of design and expression. Yet, in its application both the method and 'device' lack a scientific basis.

- Can the design of a building be based on a scientific process, which responds to the ecological context and yet does not violate the urbanity and its urban palette?
- The form of the building has been developed in response to solar geometry, i.e. minimizing solar heat gain in hot–dry period and maximizing it in winters.
- The PEDA building is a series of overlapping floors at different levels in space floating in a large volume of air, with inter-penetrating large vertical cut-outs integrated with light wells and solar activated naturally ventilating domical structures.

- The design is thermally responsive to its climatic context and very good daylight distribution is achieved, thereby minimizing consumption of electrical energy.



Sectional Perspective

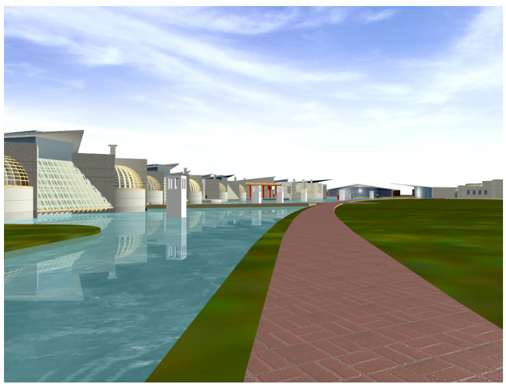


A New Ecological Language for an Innovative Institute
Sardar Swaran Singh—National Institute of Renewable Energy, Ministry of Non-Conventional Energy Sources, Government of India
The author was invited to participate in limited competition for the above project. An innovative architectural design evolving a language of ecological architecture presented by the author was selected by the jury for implementation of the project.

Strategies for planning and design

- Control of micro-climate of the site by generating a water-body drawn of the canal and by forestation of the site.
- Entire complex and each building designed as a climate responsive, solar passive building.
- Architectural design: the primary generator/tool for developing a low energy building design.
- Maximize environmental control through naturally conditioned laboratories and spaces.
- Maximize use of daylight to minimize electricity consumption in day time.
- Couple evaporative cooling from water body with building design.

Ecological architectural design of R&D wings

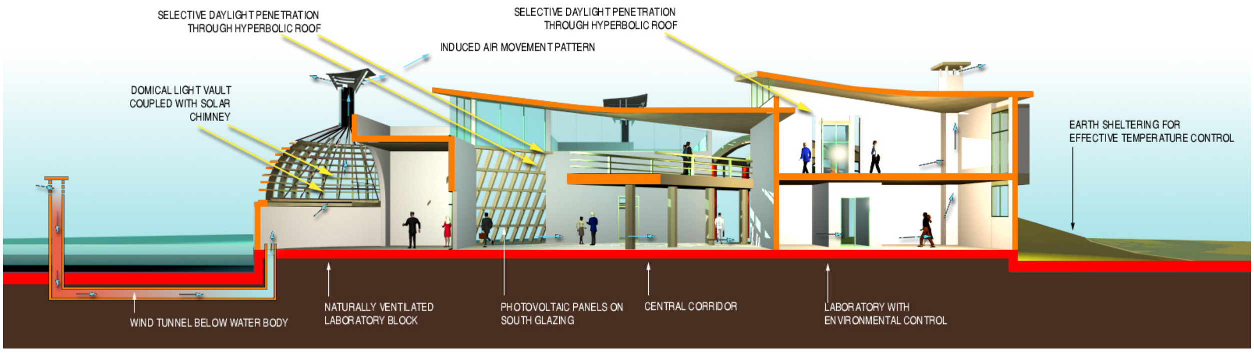


Since sophisticated R&D work is to be carried out in these wings, it is envisaged that three types of laboratories will be required:

- naturally conditioned laboratory;
- hybrid;
- environmentally controlled through HVAC systems.

R&D wing has therefore been designed to couple the naturally conditioned laboratories and spaces to the water-body through wind towers coupled with earth-tunnels to the laboratory and building spaces.

Domical light vault designed for adequate daylight distribution integrated with solar chimney on domical vault coupled to wind towers.



Roof system

- The roof forms the critical element of the building design since it attracts the maximum solar heat gain and can be used as an element to generate efficient daylight distribution.
- Hyperbolic paraboloid used as the structural element for the roof to:
  - optimize on structural design since this is the only doubly curved surface generated by a straight line making it simple to construct and since it generates only direct stresses;
  - double curved surface responds naturally to solar geometry cutting of solar heat gain due to summer sum and allowing penetration solar heat gain for winters.

Integration of renewable energy systems

- Photovoltaic panels sandwiched in translucent panels on the south facing central spaces for generating electricity and allowing penetration of diffused daylight.
- Water management system coupled with entire building complex for recycling of water and waste management and rain-harvesting.