Chapter 16
Ecodesign and the Transition of the Built Environment

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Ecodesign constitutes a fundamental redefinition of building and urban design. The abandoning of the design paradigms inherited from the age of oil is distinguished from the previous performance and hardware-driven approaches to building augmentation, to fundamentally re-examine the climatic, material and biological framework of cities, infrastructure and buildings.

Ecodesign is design for bio-integration. It can be regarded as having three facets: *physical*, *systemic* and *temporal*. Addressing each of these facets successfully is the challenge of building and urban designers.

Ecodesigners look at nature for guidance. Nature in its entirety without humans exists in stasis. Can our cities, communities, businesses and our built environment imitate nature's processes, structures, and functions? Natural ecosystems have no waste; everything is recycled within. Thus by imitating ecosystems the built environment should produce no waste; all emissions and products would be continuously reused or recycled and eventually reintegrated with the natural environment. Designing to imitate ecosystems is *ecomimesis*. This is the fundamental premise for ecodesign: the built environment can imitate ecosystems in all respects.

Buildings are enclosures erected to protect humans, their assets and livestock from inclement weather and enable activities – whether residential, office, manufacturing, warehousing, etc. – to take place. Seen from an ecological point of view, a building represents a high concentration of materials extracted and manufactured, using largely non-renewable energy resources, from some distant place in the biosphere and transported to a particular location and assembled into a built form or an infrastructure – road, bridge, sewer etc. – whose subsequent operations create further environmental consequences and whose eventual after-life must also be accommodated.

There is a great deal of confusion and misperception as to what exactly constitutes ecological design. It is easy to be misled by technology and to think that if we assemble enough eco-gadgetry such as solar collectors, photovoltaic cells, biological recycling systems, building automation systems and double-skin facades in one single building that this can automatically be considered ecological architecture. Although these technologies are commendable applications of low energy systems they are merely useful components leading towards ecological architecture; they represent some of the means of achieving an ecological end product. Ecological design is not just about low energy systems; to be fully effective these technologies need to be thoroughly integrated into the building fabric; they will also be influenced by the physical and climatic conditions of the site. The nature of the problem is therefore site specific: there will never be a standard 'one size fits all' solution.

The other misperception is that if a building achieves a high score on a green rating scale then all is well. Green rating systems are useful in publicizing certain goals – however, they should be considered as threshold standards that designers should aim at achieving and exceeding.

Ecodesign should be viewed as the design of the built environment as just one system within the natural environment. The system's existence has ecological consequences; the way it functions and interactions with other systems over its entire life cycle must be benignly integrated with the natural environment. In this way it is the life cycle analysis of the system, rather than its value at any one particular point in time, that gives a better idea of its cumulative effect on its neighbouring systems.

Ecosystems are definable units in a biosphere; as such they should contain both biotic (living) and abiotic (non life-supporting) constituents acting together as a whole. Following this model our businesses and our built environment should be designed analogously to the ecosystem's physical content, composition and processes. For instance, besides regarding buildings as currently done as artistic aspirations or serviced enclosures, we should regard them as artifacts that need to be operationally integrated with nature. It should be self-evident that the material composition of our built environment is almost entirely inorganic, whereas ecosystems contain a complement of both biotic and abiotic constituents, i.e. organic and inorganic components.

The enormous number of existing buildings as well as our current manufacturing and processing activities are making the biosphere more and more inorganic and increasingly simplified biologically. To continue doing what we have always done without balancing the abiotic with the biotic content means simply adding to the biosphere's artificiality, thereby making it increasingly inorganic and reducing its complexity and diversity. We must first reverse this trend by starting to balance our built environment with greater levels of biomass; by ameliorating biodiversity and ecological connectivity in the built forms and by complementing their inorganic content with appropriate organic biomass.

We should improve the ecological linkages between our activities, be they design or business processes, with the surrounding landscape in ways that connect them both horizontally and vertically. Achieving these linkages ensures a wider level of species connectivity, interaction, mobility and sharing of resources across boundaries. Such real improvements in connectivity enhance biodiversity and further increase habitat resilience and species survival. An obvious demonstration of horizontal connectivity is the provision of ecological corridors and linkages in regional planning which are crucial in making urban patterns more biologically viable. Besides improved horizontal connectivity, vertical connectivity within the built form is also necessary since most buildings are not single storey but multi-storey. Design must extend ecological linkages vertically from the foundations to the rooftops.

More important than the enhancement of ecological linkages is the biological integration of the inorganic products inherent in the built environment with the landscape so that the two become mutually *ecosystemic*. In this way we can create 'human-made ecosystems' compatible with nature's ecosystems and by doing so we will enhance the ability of human-made ecosystems to sustain life in the biosphere.

Ecodesign is also about discerning the ecology of a site; any building or business activity should take place with the objective of interacting productively with an ecosystem. In the case of site planning we must first understand the properties of the locality's ecosystem before imposing any intended human activity upon it. Every site has an ecological system with a limited capacity to withstand the stresses imposed upon it; if stressed beyond this capacity the ecology will be damaged irrevocably. Stress can be caused just as much by minimal localized impact – such as the clearing of a small land area for access – as by the total devastation of the entire landscape, such as the clearing of all trees and vegetation, levelling the topography and the diversion of existing waterways.

To identify the capacity of a site to withstand human intervention an analysis of the existing ecology should be carried out; we must ascertain, for example, the structure of the site's ecosystems, energy flow and species diversity. Then we must identify which parts of the site, if any, have different ecosystems and which parts are particularly sensitive. Finally, we must consider the likely impact of the intended construction and use. This is, of course, a major undertaking; however, it needs to be done to better understand and appreciate the nature of a site. To be thorough and effective this type of detailed analysis should be carried out diurnally and seasonally over a period of a year or more. To reduce this lengthy process landscape architects have developed the 'layer-cake' method; this sieve-mapping technique enables designers to map the landscape as a series of separate layers that provide a simplified matrix for the investigation of a site's ecology.

As the layers are mapped they can be overlaid and the interaction of the layers can be evaluated in relation to the proposed land use. The final product of this study is a composite map that can be used to guide the proposed site planning (e.g. the disposition of the access roads, water management, drainage patterns and shaping of the built forms). It is important to understand that the sieve-mapping method generally treats the site's ecosystems statically and may ignore the dynamic forces taking place between the layers within an ecosystem. As mentioned above the separation of the layers is a convenient intellectual construct that simplifies the complex natural interactions between layers. Therefore the comprehensive analysis of an ecosystem requires more than sieve mapping – the inter-layer relationships should also be examined.

As designers we should also look into ways of configuring built forms, the operational systems for our built environment and our businesses as low energy systems. In addressing these systems we need to look into ways of improving the internal comfort conditions of our buildings. There are essentially five ways of doing this: *Passive Mode*, *Mixed Mode*, *Full Mode*, *Productive Mode* and *Composite Mode*, the latter being a composite of all the preceding modes.

The practice of sustainable design requires that we look first at Passive Mode (or bioclimatic) design strategies, then we can move on to Mixed Mode, Full Mode, Productive Mode and Composite Mode, all the while adopting progressive strategies to improve comfort conditions relative to external conditions.

Contemporary expectations for office environment comfort conditions cannot generally be met by Passive Mode or by Mixed Mode alone. The internal environment often needs to be supplemented by the use of external sources of energy, as in Full Mode. Full Mode uses electromechanical systems often powered by external energy sources – whether from fossil fuel derived sources or from local ambient sources such as wind or solar power.

Passive Mode means designing for improved internal comfort conditions over external conditions without the use of any electromechanical systems. Examples of Passive Mode strategies include the adoption of suitable building orientation and configuration in relation to the local climate as well as the selection of appropriate building materials. When considering the design of the facade issues of solid-to-glazed area ratios, thermal insulation values, the incorporation of natural ventilation and the use of vegetation are also important.

Building design strategy must start with Passive Mode or bioclimatic design as this can significantly influence the configuration of the built form and its enclosure systems.

Passive Mode requires an understanding of the climatic conditions of the locality; the designer should not merely synchronize the building design with the local meteorological conditions but optimize the ambient energy of the locality to create improved internal comfort conditions without the use of any electromechanical systems. The fundamental nature of these decisions clearly dictates that once the building configuration, orientation and enclosure are considered the further refinement of a design should lead to the adoption of choices that will enhance its energy efficiency. If, as an alternative, a design solution is developed that has not previously optimized the Passive Mode options then these non-energy efficient design decisions will need to be corrected by supplementary Full Mode systems. Such a remedy would make a nonsense of low energy design. Furthermore, if the design optimizes a building's Passive Modes, it remains at an improved level of comfort during any electrical power failure. If the Passive Modes have not been optimized then whenever there is no electricity or external energy source, the building may be become intolerable to occupy.

In Mixed Mode buildings use some electromechanical systems such as ceiling fans, double facades, flue atriums and evaporative cooling.

Full Mode relies entirely on the use of electromechanical systems to create suitable internal comfort conditions. This is the option chosen for most conventional buildings. If clients and users insist on having consistent comfort conditions throughout the year the result will inevitably lead to Full Mode design. It must be clear now that low energy design is essentially a user-driven condition and a lifestyle issue. We must appreciate that Passive Mode and Mixed Mode design can never compete with the comfort levels of the high energy, Full Mode conditions.

Productive Mode is where a building generates its own energy. Common examples of this today can be seen in the generation of electricity through the use of photovoltaic panels that are powered by solar power and wind turbines that harness wind energy. Ecosystems use solar energy that is transformed into chemical energy by the photosynthesis of green plants which in turn drive the ecological cycle. If ecodesign is to be ecomimetic, we should seek to do the same; however, we will need to do so on a much larger scale.

The inclusion of systems that create Productive Modes inevitably lead to sophisticated technological systems that in turn increase the use of material resources, the inorganic content of the built form, the embodied energy content and the attendant impact on the environment.

Composite Mode is a combination of all the above modes in proportions that vary over the seasons of the year.

Ecodesign also requires the designer to use materials and assemblies that facilitate reuse, recycling and their eventual reintegration with ecological systems. Here again we need to be ecomimetic in our use of materials in the built environment: in ecosystems, all living organisms feed on continual flows of matter and energy from their environment to stay alive, and all living organisms continually produce 'waste'. However, ecosystems do not actually generate waste since one species' waste is really another species' food. Thus matter cycles continually through the web of life. To be truly ecomimetic the materials we produce should also take their place within the closed loop where waste becomes food.

Currently we regard everything produced by humans as eventually becoming garbage: waste material that is either burned or ends up in landfill sites. The new question for designers, manufacturers and businesses is: how can we use this waste material? If our materials are readily biodegradable, they can return into the environment through decomposition. If we want to be ecomimetic we should think, at the very early design stages, how a building, its components and its outputs can be reused and recycled. These design considerations will determine the materials to be used, the ways in which the building fabric is to be assembled, how the building can be adapted over time and how the materials can be reused after the building has reached the limits of its useful life.

If we consider the last point, reuse, in a little more detail we come to an increasingly important conclusion. To facilitate the reuse of, let us say, a structural component, the connection between the components should be mechanical, i.e. bolted rather than welded so that the joint can be released easily. If, in addition to being easily demountable, the components were modular then the structure could be easily demounted and reassembled elsewhere. This leads to the concept of Design for Disassembly (DfD) which has its roots in sustainable design.

Another major design issue is the systemic integration of our built forms, operational systems and internal processes with the natural ecosystems that surround us. Such integration is crucial because without it these systems will remain disparate artificial items that could be potential pollutants. Unfortunately many of today's buildings only achieve eventual integration through biodegradation that requires a long-term process of natural decomposition.

While manufacture and design for recycling and reuse relieves the problem of deposition of waste, we should integrate both the organic waste (e.g. sewage, rainwater runoff, wastewater, food wastes, etc.) and the inorganic waste.

There is a very appropriate analogy between ecodesign and surgical prosthetics. Ecodesign is essentially design that integrates human-made systems both mechanically and organically with the natural host system – the ecosystems. A surgical prosthetic device also has to integrate with its organic host being – the human body. Failure to integrate will result in dislocation in both cases. These are the exemplars for what our buildings and our businesses should achieve: the total physical, systemic and temporal integration of our human-made, built environment with our organic host in a benign and positive way. There are, of course, a large number of theoretical and technical problems to be solved before we have a truly ecological built environment; however, we should draw encouragement from the fact that our intellect has allowed us to create prosthetic organs that can integrate with the human body. The next challenge will be to integrate our buildings, our cities and all human activities with the natural ecosystems that surround us.

The answer to a sustainable green future will not be in designing green buildings alone. It has to be at the urban dimension and at the city and regional level. The challenge is to take the basic principles elucidated here and to apply these at the city level to create ecocities. Action ultimately has to be at the political level. Governments must recognize the reality of the current environmental condition and take action to realize this vision.