# DEVELOPING A DESIGN METHODOLOGY FOR SUSTAINABLE SYSTEMS

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## ABSTRACT

This presentation describes a design and planning methodology formulated to achieve a sustainable built environment. Instead of inventing a new method, this approach merges several existing methodologies that have been established within a variety of scales and disciplines. The resulting reconfiguration is a comprehensive and interdisciplinary language based on sustainability principles, which assumes certain developments in the computer sciences such as object-oriented programming or pictorially- or icon-based programming. The result is a tool that I refer to as Biom-metric™ Design and Planning, which enables the practitioner to perceive complex environmental relationships in an interactive decision-making format. A new set of regionally-based virgin resources, as well as by-product resources, comprise the appropriate pallet of raw materials from which to build sustainable future. It is hoped that infrastructure elements, which are often manifested as invisible sources of environmental disruption, are made visible through this process. As a result, these elements may achieve the level of creative potential as the more spatial aspects of design have enjoyed in the past.

## INTRODUCTION

This paper assumes knowledge of the importance and meaning of the global initiative in sustainable development, which has been sanctioned by consensus of a remarkable group of international leaders, and is the cornerstone of the 1992 Earth Summit. From the standpoint of North America, this orientation may result in a drastic re-evaluation of technical emphasis, education, economic assumptions, and environmental planning as they relate to the built environment.

The underlying goals of this emerging sustainable development paradigm go beyond earlier efforts towards "limits to growth," which emphasized the source limits of concentrated resources (e.g. petroleum, copper.) Instead, what is proposed is reliance on far more dispersed and available set of resources in order to fulfill basic human needs. The methodology described in this paper assumes this new set of dispersed options shifts emphasis away from how "we mine and ship raw materials such as bauxite or nickle or copper across the planet," to how "to convert local materials into usable substitutes."[1] Once we have the means to acquire and share this knowledge, regionalized information becomes the substitute for both current resource dependency patterns and shipping.

The proposed methodology also recognizes the use of by-product resources as principal ingredients in the global resource pool, thus responding to a critical gap acknowledged by many economists. Moreover, it confirms that the "sink" constraints (air and water pollution, ozone depletion, greenhouse effect) must be dealt with as a working component of any sustainable development methodology.[2] Thus, the approach is based on an understanding of human processes as containing useful by-products, and establishes a systemic plan for their reuse (or reutilization) as much as the need to plan for the use of dispersed virgin resources as described above. This systemic planning of human processes is a procedure rapidly gaining acceptance, and is referred to as industrial metabolism, material balance methodology, and industrial ecology.[3]

Finally, despite the space limitations, the paper attempts to develop a conceptual framework based on communication tools as one underlying theme. The proposed method results from a dispersed set of

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[1] Alvin Toffler, Power Shift: Knowledge, Wealth, and Violence at the Edge of the 21st Century, Bantam, 1990, p. 87.
[2] "No More Business as Usual," Editorial, Development Forum, U.N. Dept. of Public Information, Vol. 20, #2, March-April 1992.
[3] Robert U. Ayres, "Industrial Metabolism," Technology and Environment, 1989, National Academy Press, pp. 23-49.

circumstances, culminating in a "language of sustainability." This language is based on icons or symbolic pictures that represent a myriad of actions (e.g. production technologies, transport methods, harvesting means) as well as spatial data recording in the form of maps and other performance based information. As in any language, rules are proposed that help structure symbolic sentences using already accepted technology assessment sequencing methods. There are several critical functions that the acceptance of a symbolic language would address. One of these is the mutual participation of a diverse set of users. A second is the potential for unique computer programming methods, using object-oriented programming, which can reach a critical depth of understanding within the decision-making process relative to hierarchical modes and sets of relationships. This approach to computer literacy using non-mathematical means enables a wide use of relevant computer programming know-how.

## BIOM-METRICS™

The method of interconnecting global biome-based information sharing and on-site physical development is what our Center calls Biom-metric™ planning and design. The method incorporates a Life Cycle Assessment (LCA) approach as the heart of its decision making process. The LCA measures the total impact of resource utilization, including sourcing, transportation, manufacturing, use, reuse, recycling, and disposal. Resource mapping becomes the base of the LCA ladder, while global biomes set the stage for understanding the prerequisites for these mapped resources. The organizational framework can open interdisciplinary fields of inquiry spatially bound by the biome system at one scale, be as general as needed, and incorporate highly technical information. By doing so, the approach can become operational to the point of mathematical modeling. The capacity for an icon to represent more complex formulations and even programs that can be related to other programs (or icons) to build up a design that simultaneously "reads out" in actual performance criteria is possible due to the new tools offered in the field of object oriented programming, or OOPs.

The following paragraphs will sequentially build up how the content for Biom-metric™ planning is developed, and how it is used as the basis for potentially information rich and interactive computer planning. The process is iterative; while at the same time can become continually more focused on a particular geographic location. This can be illustrated in terms of building system vocabularies, for example, which are based on low energy regional material options and manufacturing procedures that can be tracked spatially to the resources within a region. Rather than simply pulling a building system off the shelf, components are chosen for their particular regional significance. Responsible planning is only possible under a regional setting where resource use can be tracked through life cycle assessment procedures, as described above. Each of these steps not only has environmental significance as to product and by-product impacts, but also has significance in developing strategies for regional economic development.

## BIOME IDENTIFICATION

Unesco has established a precedent for global planning by using biomes as the basis for information sharing among sustainable development practitioners. Biomes are statistically similar areas of flora and fauna around the world. This planning precedent has been accomplished through Unesco's association with the United Nations Environment Programme (UNEP), Man and the Biosphere (MAB) system, the Food and Agriculture Organization (FAO), and the International Union for the Conservation of Nature (IUCN). At one level, biomes hold significance since they summarize the conditions existing on this meta-scale of ecological zonation, which is only one level down from how the global ecosystem performs.

Biome similarity can also be identified through patterns in soils, climate, and hydrology, in addition to flora and fauna, as mentioned above. This means the fundamental attributes upon which human and non-human life depend also occur in specific micro-patterns within the boundaries of biome identification. This hierarchical, spatially-based set within sets, or in mathematical terms, Venn phenomenon, is an invaluable tool for sustainably-based technology sharing in areas of food, water, building materials, fiber, energy, by-product reuse, and waste treatment. When these technologies are renewable-based and depend primarily on dispersed resources within a regional boundary, they are intimately connected to regional landforms as well as to the global network of similar land resources.

Biomes are ideally suited for establishing a basis for global information sharing. They provide a basis for learning through the experience of resource use in those parts of the world where near identical ecologies exist, as revealed through pattern recognition and the similarity of natural resource features. This, in a sense, establishes a spatially-based key word system for the environment. The capacity to trace this body of information emerges through a variety of means, including historical precedents, cultural practices, and understanding the history of technical adaptation in order to responsibly use regional resources within a particular type of ecological association. There are over 250 sustainable development groups around the world that use this mapping system to share information and to sustain the respective biological systems within the identified biomes.

From its initial phase, biome identification and analysis established certain directives as to how to carry out activities in a given region and on a given site. If the particular global, regional, and urban system patterns are comprised of what are fundamentally desertification problems, for example, or problems associated with rust belt technologies, each proposes overall issues that require particular strategies for corrective action. For example, the Temperate Broad Leaf Forest Biome, as the birthplace of the Industrial Revolution, historically has contributed an inordinate amount of carbon dioxide, sulphur dioxide, toxic waste, and other problematic by-products. On-site activities need to counteract or even correct those externalities through appropriate actions. Just as important, the responsive processes and techniques need to be shared within the region, so that the activities can serve as regional catalysts for change.

So the air, the water, the land, and all life forms become a summary of indicators at the biome level of actions needing correction, even in cases where drastic measures might be required to catalyze further response within that ecological zone. The map below identifies the 14 basic biomes on Earth through outlines, with a single global biome pattern highlighted. The seven basic regions through which the biome patterns are repeated, called "provinces," provide a spatial organizational framework, and can be used as a meta-categorization technique within which all human activities occur.

## SPATIAL MAPPING AND PLANNING

Resource mapping and land analysis occurs at many scales and among a multitude of disciplines, from large environmental management projects to site-specific inventories. The "meeting point" between atmospheric and biological sciences is, for example, at the grid scale of 100km to 10km, according to the Global Circulation Model and the U.S. National Research Council. Above this grid size, at 250km, is the scale of significant atmospheric and climatic data (desertification, acid rain, ozone depletion); below it, from 0.1km to 10km, is the scale of on-site resource data acquisition suitable for land planning. At this lower scale are resource inventory systems available through a number of vendors via microcomputer terminals, e.g. CRIES, GRID, EROS, and NICI.

Mapping procedures address a range of subject matter within a single method of representation and decision-making, from plant associations to geology, drainage systems, soil types and land use activities. Today, this method of analyzing and planning the future is transmitted over satellite photography and remote sensing to computer terminals, and is available in virtually all parts of the world. The advantage of this mapping approach is that it is the only available means to accurately incorporate the range of topics necessary to be covered in the realm of sustainable development. Below are examples of general data sets for regional site planning using renewable energy, water, and building materials.

Representing resources through spatial mapping, and then incorporating these maps in overlay planning, are methods that planners have used for many years. Such mapping is most commonly used in the area of resource conservation, as referenced above. Today we find that spatial mapping needs to be extended much further and in a manner that enables people to become "partners" with the surrounding natural systems. This means that the resources on which all life support systems depend -- including the fulfillment of a range of human needs -- must be spatially represented and included within the parameters of a region's land use policy. Once fossil fuels are deemphasized, a tremendous diversity of land use options surfaces. This diversification gives all types of land a "multiple value" well beyond the current linear view of singular land use values brought about by the specialization resulting from petroleum-based economies. These hold the potential to displace dependence on the many petroleum-based life support options we have depended on. For the past century, fossil fuel dependency has been responsible for ignoring the cooperative imperative between natural and human systems to ensure their mutual survival.

When this happens, the playing field upon which decisions are made changes. Renewable energy sources of all types become relevant, as do a range of low energy building materials, sustainable food production methods, solar aquatic waste treatment, and sustainable plant production for food, fibers, fuel, plant extracts, and other industrial feedstocks. These become viable options with a multitude of uses for each land resource unit.

**SPATIALLY MAPPING TECHNOLOGY**

Correlating regional technologies that are necessary for a range of human activities to the global, regional, and local resources upon which they depend allows for their spatial representation. This is a fundamental planning breakthrough that has previously only been hinted at, most often in the context of purely conservation practices that foster "no touch" policies. If one can shift one's viewpoint from the concept of limited, centralized resources to that of a dispersed, diversified pool of resources that shows up as many technologies (i.e. many life support uses,) then the variety of indigenous technologies becomes very rich. The concept of resources being diverse and dissipative is the "mind shift" necessary for this methodology to take root. Below is an example of a mapped biomass resource, mesquite, along with some associated technologies of how it can be used, illustrated in the form of icons. As technologies are transposed into "icons," the maps illustrating them are called "Icono-maps™" in order to differentiate them from other resources that may be related to purely conservation uses. The important issue here is that Icono-maps™ are the link between regionally-based technologies and their spatial fields of land resources. Technologies that appear with a spatial corollary enable that technology and its use to ultimately be subjected to ecological land mapping procedures. The spatial mapping processes can also be connected to the Life Cycle Assessment Ladder (LCAL) described below, given that the first step to this ladder is represented by the source of any raw material for whatever purpose.

## RELATIONSHIP TO THE LIFE CYCLE ASSESSMENT LADDER

Integration is a more fundamental means of viewing the relationship between technologies and the environment than is conservation. Techn-ology, like ec-ology, is and should be a relational phenomenon not to be considered a stand-alone creation of mankind. In essence, conservation means reduced flow (consumption.) The resulting by-products inevitably become sinks because their existence is only identified in terms of reducing their quantity. Integration, on the other hand, requires that processes are connected into continuous flows and linked to one another in multiple functionary roles. Unlike natural systems, conservation concentrates on optimizing individual machines. In nature, conservation of resources depends on highly integrated systems in which the waste of all metabolic units becomes "food" for all others. In human systems, these metabolic units are technologies of various types. Together, they deal with all human activities as they relate to life support and the land.

Our reassessment of technology in integration terms matches the global economic and taxation systems under consideration. The aim is an integrated economic system that will balance the use and replenishment of resources. "In mining or logging, for example, we can calculate the using up of a resource with the need to replace its value. When a production process causes environmental damage, we can estimate the cost and include it in the pricing of a product."[4]

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[4] Winifred Armstrong, "Sustainability Requires New Economic Concepts," Development Forum, Vol. 20, #2, p. 13.

This "cradle to grave" approach of understanding where and how materials of all kinds affect each other, the environment, and people perhaps will be the most complex issue facing "Spaceship Earth" in the next century. The issue is starting to be addressed by EPA, DOE, the U.S. Department of Commerce, and others at the federal level. It is also being addressed by a myriad of professional associations such as the American Institute of Architects (AIA), National Association of Home Builders (NAHB), public interest and consumer groups, and non-profit organizations. At the international level, this activity has a relatively long history, exemplified by Nobel Laureates such as Haavelmo and Tinbergen, and World Bank economists Goodland and Daly, among others.

In the U.S. there are several efforts vying to get industry and public support behind environmental labeling programs (Green Seal, Green Cross, Ecoscale, Earthwise Consumer.) In Europe, there are at least four organizations in both the public and private sectors that share a similar focus. Germany's "Blue Angel" product guide includes over 3,000 individual items ranked according to environmental criteria. Only a few programs, however, admit to an operational approach that is inclusive of all the issues requiring consideration. These include tracking a product back to its initial land resource basis, which would enable the LCA model to be connected to the land resource inventory methods described in the previous section using the Icono-map™ procedure.

The basic LCA theme or ladder, as we call it, is referred to by several of the above product organizations. It includes: (1) source; (2) transport and distribution; (3) manufacture, process, formulation; (4) use, maintenance; and (5) reuse, recycling, storage. The manufacturing and processing component includes such resources as energy input and water. Although only a few of these assessment procedures include building materials, the model becomes a comprehensive means of critiquing the built environment, and is used as the central component of our Biom-Metric™ approach to planning. Below is a typical diagram of this ladder. The ladder shows product tracking from virgin and by-product sources, and is described in pictorial forms, or icons. The LCAL is illustrated in the Biom-metric™ model at the end of this paper.

## ICONS

If the mapped resources represent the spatial attributes of technology, icons of processes represent the functional attributes of the built environment, and offer the time-use component of sustainable design. Once the structure of the LCAL is accepted as the basis for this sustainable language, planning and design can be accomplished with greater understanding from the viewpoint of on- and off-site integration levels. In essence, icons can be thought of as transformation processes or metabolic units that need to be linked according to the LCAL, and to each other. Depending on the boundary (e.g. home and yard as compared to neighborhood and park) one can work within different scales of integration.

Each icon represents an actual process or product that possesses certain performance characteristics. When they are linked in the appropriate manner, according to the LCAL sequence, they model a certain performance of total use (i.e. as one changes individual performance, total performance also changes.) This enables one to assess decisions as they are being made.

The creativity potential offered regarding infrastructure principles that normally become the hidden processes that actually determine environmental impact is the principal contribution of this sustainable development methodology. Particularly when computer support is operating in tandem with design performance can decisions be constantly reassessed in an interactive manner. Spatial planning of superstructure in performance terms conceptually becomes larger sets of smaller fractals that have been combined to satisfy certain overall system performance. Creativity in space use is as much responsive to Earth's metabolic requirements as it is to human metabolic and psychological requirements. Good design is determined at the interface or cusp between human needs and nature's needs, and is determined by the translatability between these two worlds.

There are two different design dimensions within which we as architects and planners operate. One is in plan, the other is in section. Two-dimensional planning and two-dimensional vertical building design can both be accomplished through the use of icons. In both cases, one admits to a boundary that is representative of the site or project under consideration. Source, transport, and manufacturing can be planned to occur inside or outside the boundary. Built form is determined by how we incorporate the <u>use</u> icon and its relationship to other <u>use</u> icons. The relationships between how one artifact or <u>use</u> icon functions with respect to others can be understood by using <u>The Building Systems Integration Handbook</u>, by Rush, published by AIA. Five levels of integration can occur between icons using the system described in this book. By replacing the AIA's icons with Biom-metric™ icons, one automatically extends the use of building components into the Biom-metric™ Sustainable Design Methodology, as these icons become intimately linked with the LCA Ladder under the <u>use</u> icon category. For design examples, see Section "Designing with Icons," below.

By-product integration, along with primary product integration mentioned above, is a far more complex modeling procedure, but should be possible from a mathematical sense using multi-dimensional matrix algebra analysis when necessary, but is not required in order to conceptualize the system. Conceptually, each level of the LCA Ladder can function in a source mode when by-products are used as primary sources. For example, at the transport level of the LCA Ladder, hydrogen as a fuel source provides water as a by-product and can be easily connected for further use. Many other examples of sustainable technologies can be provided at each stage of the LCA Ladder.

## SCALE DIFFERENCES BETWEEN LCA LADDERS AND TECHNOLOGY ICONS

As one becomes familiar with a range of technological types, including transportation methods, water treatment techniques, and methods of food production, one notes a repetition of techniques used to acquire these throughout different scales of activity, from home to community to region. For example, there are scales at which certain efficient transport means are more appropriate than others, yet all fit under some sort of vehicular motion of a given type. Appropriateness of scale is based on overall resource use and the LCA Ladder scale being considered. These considerations include energy and resource input-output as compared to perceptions of time and money.[5]

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[5] Ivan Illich, <u>Energy and Equity</u>.

Similarly, technologies such as plant-based grey water treatment systems at the household scale become constructed wetlands at the neighborhood or regional scale; at the large-scale, water- and waste-water treatment occurs at the estuarine or biomass farming levels. There are many more, including district heating versus home heating, and on-site water supply versus municipal or regional centralized water supply. The important point is that what occurs at one scale can always occur at other scales. This becomes a means for understanding a pattern or patterns of how whole systems work independent of size.

As important as inter-scalar pattern recognition is the fact that various types of production systems and social groupings are linked to issues of scale. A decision as to whether to include or exclude a given task within a given scalar boundary follows a maxim that says, "decisions should be taken at the lowest possible denominator within the hierarchy of that particular decision."[6] Another way of stating this is to realize that the increase in size may result in an organization with more than a linear increase in complexity. Schumacher's "Small is Beautiful" approach (1973) can afford more wholeness in its ability to deal with problems and get beyond the technical (i.e. his plea for an association with flexibility, creativity, innovation, and caring for people.) The scale of technology is signified in the Biom-metric™ model at the end of this paper.

## SIMILARITY OF SCALE WITHIN INDIVIDUAL LCA SEQUENCES

Within a given scale of operating, such as outlined above, one can choose technologies that relate to one another and to the settlement size and context, beginning with a resource's initial use on to its final (recycled) death. Regional and neighborhood technologies that are part of large land management schemes, or even household technologies, all have certain attributes that enable them to work together in continuous links of inputs and outputs. Furthermore, each scale of linkage has functional counterparts at another scale so that patterns of repeatability in terms of basic system attributes can be understood through the LCA Ladder, as indicated in the previous diagram.

Choosing the scale within which one is working, therefore, determines not only the boundaries but also the scale of all the compatible and linkable technologies. The scope of influence of an apartment dweller, for example, is really quite narrow as to how much this person can affect the world as an active participant other than engaging in environmentally sound product purchasing. This person would be limited to simple conservation practices in his or her options of how to treat sewage water or grey water. However, at the single-family household or developer scales, these relationships change. At these levels, household grey water systems are known to be effective and diminish reliance on treated water sources. Moreover, wetlands have been successfully designed to treat black- and grey water at the small community level.

Similarly, various disciplines, whether they are research oriented or professional, seem to work within certain boundaries of their respective disciplines. To have a plumber design a city sewer system is neither likely nor advisable. Yet, the plumbing schematic for a house and a civil engineer's plan for a city's water and wastewater systems for reuse should be written in the same language using the same basic vocabulary and conceptual tools to accomplish consistent environmental goals of using water and wastewater wisely. As logical as this sounds, this synchronicity is missing. Plumbing at a household level is never viewed as an entire LCA Ladder, yet it is essentially the same LCA Ladder used at the city or regional scale. The maxim of the lowest common denominator mentioned above is not possible due to our training, while the net effect of specialization has been vertical thinking, resulting in a virtual void of horizontal, or

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[6] Dr. Francesco di Castri & Dr. Malcolm Hadley, "Enhancing the Credibility of Ecology: Interacting Along and Across Hierarchical Scales," GeoJournal, 17.1 5.

integrative, thinking. Horizontal integration within scalar boundaries is a significant part in the Biom-metric™ model.

## ICONS AS COMMUNICATION TOOLS

The use of icons as basic communication and design tools dates back several thousand years. The Greek example of representing an entire building with simple abbreviations instead of dimensioned plans is a milestone in architectural history. Indeed, it is only recently that the significance of this approach has regained recognition as a means of developing universal systems of thinking. Probably the most thoroughly developed attempt to explore this in recent times by the design profession was in 1986. In this effort, AIA's The Building Systems Integration Handbook by Richard D. Rush, whole buildings were represented through symbolic relationships starting with the relationship of the parts and how they relate to one another. The limitation with both the Greek and AIA attempts, however, lies in their limited boundary of concern, for the system of symbolic representation ended literally at the building's wall.

The advent of operational icons on the computer, or symbols that actually perform functions within a program, will become the hallmark of integrated design. Their importance lies in their value as components of a universal language using the LCA Ladder that not only brings disciplines together, but is instrumental in linking processes into generally structured relationships not unlike the classic Greek orders. Today, our "sentence structuring" must become the LCA Ladder, thus relating our buildings and other designed and engineered artifacts to their origin and to the land's resources. We foresee this approach as critical to the teaching professions and equally important as a participatory design tool.

The recent merger of IBM and Apple may be due in part to the concept of icons and their hierarchical and operational components, and to object-oriented programming, in which major new efforts will be placed on developing vocabularies based on pictorial images that can be put into "sentences" or relationships that represent programmable entities that can be mocked up together as blocks of information and relationships. One of the best examples of the significance of this approach relative to the design profession is at the Advanced Visualization Laboratory at Rice University.[7] Their programming is close to enabling students to visualize the design process in an extremely holistic manner, while being rich in information yet creative in how and why elements go together.

Icon design is an easy to understand, "user friendly" system that represents different depths of complexity in a way that matches the user to his or her own level of design or capability to a variety of operational levels. This ranges from the purely symbolic and aesthetic to the purely functional and physical, and from the general to the specific. The depth of understanding is enhanced by the fact that a hierarchy of icons enables pictorial or symbolic depth in a way that parallels performance depth. This capacity to conceptually zoom in and out graphically as well as technically enables communication to occur among many disciplines without introducing individualized jargon. In graphic terms, we refer to this hierarchical relationship as an Icono-group™, while the technical performances that "live" behind these icons are an Icono-graph™. These terms have been developed to better communicate these basic relationships. Icons should become "regional vocabularies" that are built up by users as well as by regional design and engineering professionals. The relationship between icons, Icono-maps™, Icono-groups™, and Icono-graphs™ is depicted above.

## DESIGNING WITH ICONS (INCORPORATING USE ICONS IN ARCHITECTURAL DESIGN)

In the Biom-metric™ methodology, icons become interchangeable and mean different things to different people; yet, they are part of the same language. All related disciplines are viewed as equally creative participants because of an easily manipulated language that deals as much with the inner workings as the way components function relative to each other.

Below is a building design and farm system for the lower temperate grassland of Nearctic Province (predominately North American and Canada.) Biome-based conditions dictated a tendency toward

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[7] Bill Bavinger, "The Exploration of the Programmer's Hierarchical Interactive Graphics Systems as an Architectural Design Support Medium," Advanced Visualization Laboratory, Rice University, Houston, Texas.

desertification if non-wood based resources are not used. The design process involved virgin resources (such as straw) as well as by-product resources from the region. Solar intensity prevents crop production during an entire season of otherwise productive yearly plant growth. Water, particularly in the farming arena with the use of center pivot irrigation, is over-used, creating non-sustainable hydrology conditions. Water quality in the Rio Grande River is rapidly deteriorating to a degree that water treatment is necessary in order to produce healthy food crops.

At a more specific level, the declining oil industry has produced surplus waste drilling stem useful for construction purposes, used to support the buildings and shade systems. These enable the straw bales, stuccoed with coal-derived flyash, to be used as non-supporting infill material. Due to drastic price fluctuations during the past ten years in energy, food, water, and building materials, the farm design is viewed as a renewable energy based flexible manufacturing system where food, biomass for building materials, as well as for energy, are produced. Since the farm treats its own water, it can potentially be a clean water supplier for whatever purpose. Organic waste by-products in the form of urban solid waste is made into fertilizer and soil conditioner, and constitute another potential farm output. In this way, the farm becomes a dynamic metabolic component of this region's particular metabolism.

The design of the farming system can be represented totally in icons at the point of use in terms of the LCA Ladder. Below we have depicted only the building system with its accompanying icons. The boundary of the site is depicted conceptually with a dotted line, while the boundary of the region is indicated in a double dotted line in order to signify source scales. A key indicates how icons are graphically connected according to how parts function relative to each other, according to the Integrated Building Systems Handbook.

## PLANNING WITH ICONS (USING THE LCA LADDER TO MODEL PERFORMANCE)

When determining performance from source to sink as the scale of the project warrants, whole systems can be modeled using the LCA Ladder as a basic structure. We have chosen the example of water use in a home using two sources to start the model: one, the city water supply; the other, a cistern sized for collecting water off the roof. The challenge is to balance the availability of source with the different quantities of water used by a typical family under conservation conditions in central Texas. As one works through the icon sequence from source to transport to manufacture (treatment,) then use, reuse (and storage), performances associated with each icon (product) are supplied with an overall performance demonstrating the possibility of receiving a large percentage of one's household water from a roof cistern (of prime importance in Texas due to surface water pollution and ground water depletion.) Ideally, this model is now only an interactive decision-making tool, but is also representative of a series of actual products or technologies associated with each icon with specific costs so that costing can simultaneously be accomplished with differing design alternatives.

The example below illustrates icon sequencing and the resulting performance read-out.

## THE BIOM-METRIC™ MODEL

The Biom-metric™ model is therefore made up of a series of overlapping horizontally and vertically integrated procedures for dealing with the complexity of global sustainability. Vertically different scales of environmental issues are identified that represent conditions recognized by a variety of environmental disciplines. Horizontally a single scale is represented from source to sink using the LCA sequence. All facets of the model are viewed as icons that introduce various degrees of information depth "behind" them depending on the scale represented by the LCA Ladder. Resource planning and physical design procedures are framed within this Biom-metric™ matrix of icons. The biome system itself, for example, is recognized in the top left corner as well as the various scales of resource analysis and macro-planning efforts based on varying geographic information systems. Of those methods operating vertically, we find the AIA Building Systems Integration Handbook, Christopher Alexander's Pattern Language, and "Ekistics" information categorizing technique. All basically deal with the use icon at varying scale ranges with some techniques such as Alexander's Pattern Language operating partially within the manufacturing icon but does not make any attempt other than through the usability of the final product to critique manufacturing. The current work going on in industrial ecology, material balance methods, for the most part deal with by-product reuse at the regional or inter-regional scale between manufacturers. Building techniques and material systems in the built environment are critiqued in some depth by the Environmental Resource Guide put out by the AIA in the U.S., the BEPAC from Canada, and the BREEAM system from England. Of these the BEPAC system is about to be implemented through codes in British Columbia. All these building assessment tools operate up to the point of source critique using the LDA ladder but do not go further into admitting a spatial resource planning strategy. The SETAC model is similar to the above three but is mainly concentrated in the area of chemicals themselves and does not again offer any strategy for planning source issues other than through the rest of the LCA sequence.

It is important to emphasize that this model is presented as much as a tool for gaining perspective on some critical issues in a way that fosters creativity. The sensible way of using the model is only at the scale or scales that one is accustomed to operating within and not to consider that each time one makes a single decision that the entirety has to be taken into consideration.  Since a design vocabulary does not exist in our culture, perhaps issues of global sustainability will offer the opportunity to establish at least the beginning of such a vocabulary in a relevant manner.

Various resources