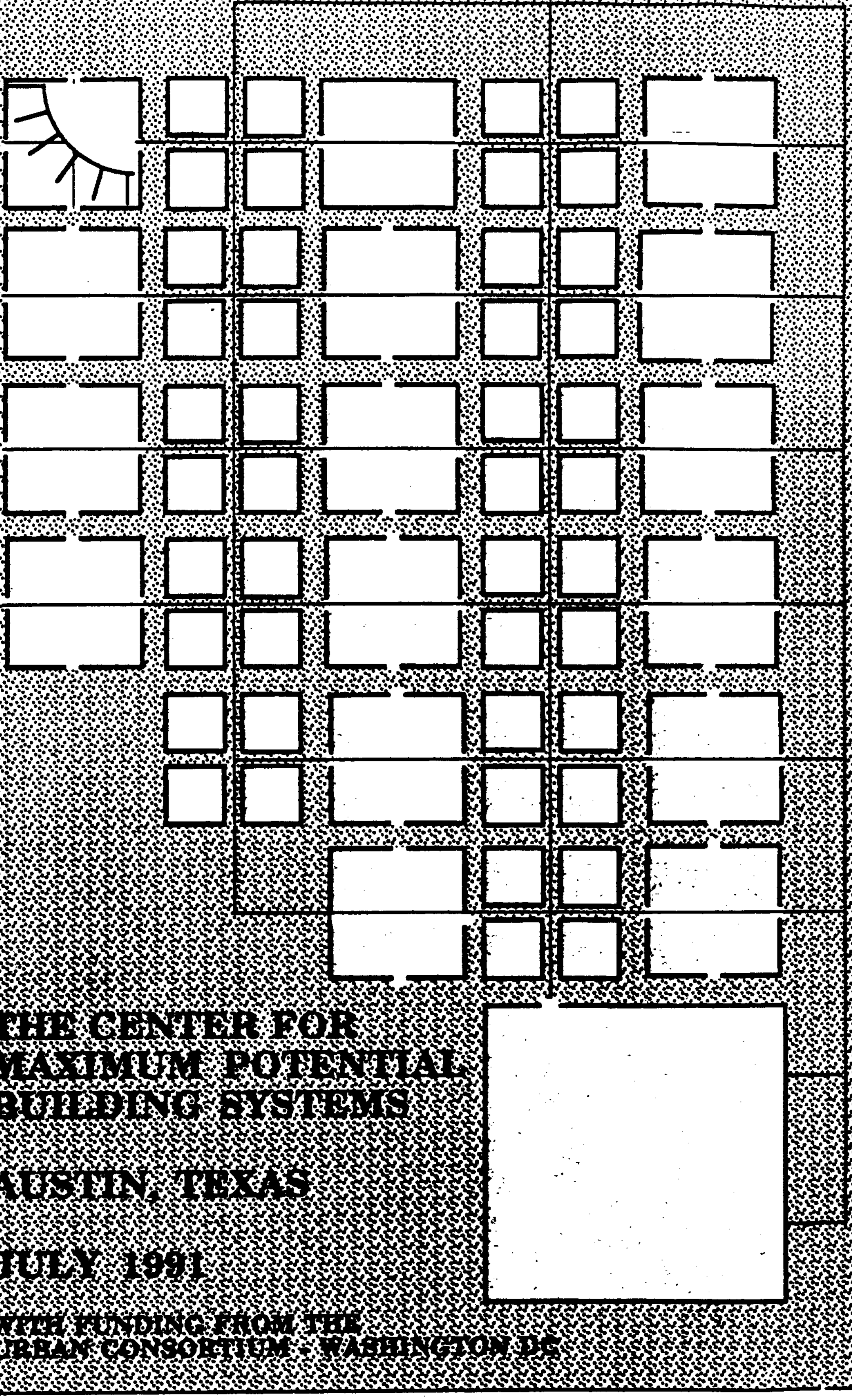
SUSTAINABLE RATING SYSTEM

A CONCEPTUAL AND CONTEXTUAL OVERVIEW FOR THE CITY OF AUSTIN



THE CENTER FOR
MAXIMUM POTENTIAL
BUILDING SYSTEMS

AUSTIN, TEXAS

JULY 1991

WITH FUNDING FROM THE
URBAN CONSORTIUM - WASHINGTON DC

SUSTAINABLE RATING SYSTEM:

A Conceptual & Contextual Framework for the City of Austin

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Pliny Fisk III
Gail Vittori

August 1991

Section One: Sustainability Rating System

INTRODUCTION

The City of Austin is in a unique position to introduce basic sustainability concepts into a framework that could shape the future of the city's built environment. With over a ten-year history of nationally recognized, effective energy conservation programs in place, the introduction of other resource issues--water, materials, waste--and energy with a different focus, into the City's market-driven programs is timely and appropriate. The resulting Energy Star Sustainable Systems Rating Program and associated Green Builder Program are designed to evaluate the relative sustainability of resource options, and provide incentives for builders, designers, and potential homebuyers to implement sustainable technologies and design options.

At its inception in Summer 1990, the Energy Star Sustainable Systems Rating Program appeared unique in concept and to break new ground in what seemed to be the logical evolution of almost three decades of environmental design which, for the most part, concentrated on optimizing energy efficiency and promoting energy conservation. (Similar efforts, limited to a few geographic regions, including Texas, also highlighted water efficiency.) Such efforts brought to the public's attention the enormous resource dependencies created by the way buildings were built and technical systems designed, and resulted in a design approach and an array of technologies to enhance energy efficiency.

However, the singular focus on energy conservation obscured from the public's view a multitude of other ecological impacts--equally if not more important--brought on by the built environment, and virtually ignored opportunities for integrating the various resource issues into a comprehensive approach. Non-point source pollution, soil erosion, ozone depletion, global warming, deforestation are only a few of the ecological phenomena that have become familiar concepts to the American public over the past decade, each of which have obvious links to a built environment void of a comprehensive approach. Clearly, the ecological impact of these shifts in global equilibrium places as big a threat on local and global environments as do those resulting from an over-dependence on fossil fuels. Even so, public awareness, institutional attention, and appropriate responses have, for the most part, been long overdue.

Just over a year after this project's conception, there is mounting evidence that the elements of sustainable design have begun to penetrate the architectural and development professions and the mainstream public:

- The American Institute of Architects' initiation of a multi-year Environmental Resource Guide project (funded by the U.S. Environmental Protection Agency);
- The 1991 Third Annual "Visions of Quality Development" seminar, a statewide conference designed for builders, architects, and developers, sponsored by the Florida Solar Energy Center and funded by the State of Florida's Governor's Office;
- "A Sourcebook for Environmentally Responsible Design", copyright 1991, published by Architects for Social Responsibility, a multidisciplinary committee of the Boston Society of Architects;
- 1991 "Visions of Sustainability" seminar sponsored by Architects for Social Responsibility and held at Harvard University Graduate School of Design;
- The May 1991 issue of Architecture Magazine, dedicated in its entirety to ecologically-oriented design;
- Regular features in Family Circle Magazine, "the world's largest selling women's magazine," including its "Environment" section, which raises such issues as "Saving the Forests," "Keeping Cool," "Asbestos Alert," and "5 Steps to a Healthy Lawn," all of which relate to the built environment.
- The July 1991 issue of Builder Magazine, published by the National Association of Homebuilders, dedicated to "green" building.

Throughout the course of this project, there has been lengthy discussion to determine appropriate measures to introduce the information to two principal markets:

- Professionals involved with the built environment, including builders, architects, developers, real estate brokers, and designers
- Prospective homebuyers

Since there is a fundamental conceptual leap involved to take these two audiences from understanding "conservation," which, essentially, is a linear function, to grasping the more complex notion of "sustainability," considerable time has been spent on the graphic representation of the body of information resulting from this project. Specific recommendations for the project's initial public outreach include:

- Easy-to-identify **icons** developed to identify the particular resources, systems, and subsystems
- A **self-rating system**, designed to enable builders and home-buyers to evaluate material and technology options, from source, to use, to re-use/recycle potentials
- The selection of **themes** to introduce the public to each resource issue; the specific themes are chosen because of their potential high impact and easy implementation
- Identification of **positive, viable options**

I. Sustainability vs. Conservation as the Basis for Rating

The development of any rating system is determined by how one defines the benchmark upon which the rating is based. For example, a benchmark based on the best state of the art technology using reduced use or reduced flow criteria is one method. Such an approach assumes a constantly sliding benchmark point as technological innovations develop, and may change from month to month. However, as soon as one realizes the multitude of technologies addressed in this effort related to energy, water, solid waste, and materials, one can appreciate its magnitude. Adopting such a benchmark approach would mean that each individual technology would constantly have to be rated relative to a constantly changing pool of technologies to indicate relative values. New criteria would also have to be added as new concerns arose.

The potential unwieldiness of this type of approach, coupled with a basic inability to systematically track thousands of products each year or even depend on others to track such products, led to a decision to rethink the fundamental nature of a benchmark specifically as it relates to a sustainable rating system.

During the project's early stages, it seemed appropriate to develop an approach which more closely reflected the basic elements of sustainability. Primary to this was formulating a systems-oriented approach which could absorb the key issues under consideration relative to the four resource areas: energy, water, solid waste, and materials. The approach stresses the importance of the **relationship** between technologies, not simply the energy input/output relationships, or the efficiency of water use, or material use, or solid waste use within a particular process.

Therefore, a comprehensive assessment of resource use is undertaken, resulting from analysing the general sequence of where a particular resource comes from (SOURCE), how it is used (USE), and opportunities for secondary and tertiary uses (INTEGRATE.) In this sense, optimizing quantity used in the USE category is less important than matching SOURCE with USE, and providing for proper cycling of the particular resource in the INTEGRATE category.

In summary, the approach assumes that linkage, or resource cycling, is more important than optimization of individual technologies. Evaluating how inputs, outputs and, especially, by-products of one technology's relationship to another within and among businesses, homes, and factories is a vital step in assessing the nature of pollution. Also provided is a different model for how the environment can be used through reliance on certain technologies, and how other technologies can replenish the environment.

II. Relational vs. Numeric Rating Systems

If inter-relationships are more important than individual entities, what should a rating system be for sustainable technologies? We believe it can be far simpler than rating systems based on numeric- or inter-comparisons of efficiency within families of technologies. For example, if it is agreed that, in terms of sustainability, it is more important that the waste heat from an air conditioner is used to heat a home's water, and thereby replaces the need for a water heater, then this integration has greater significance in saving overall energy and material resources than would result from the individual optimization and rating of each one of these technologies. Such a framework for evaluation can be extended to virtually every technology within the four resource categories of concern. For example:

- Is it more resource conserving to install a less efficient air conditioner in a weatherized home than simply optimizing with a high EER air conditioner in a non-weatherized home?

- Is it more resource conserving to use wastewater for watering the garden rather than lowering water use through a low water shower and sink heads and then using potable (treated) water for landscape irrigation?

- Is it more resource conserving to buy petroleum-based containers than ones made of paper, the latter of which can be composted and used for landscaping (growing more trees) and gardening, thus reducing the waste stream through recycling?

- Is it more resource conserving to insulate a building with cellulose made of recycled paper (thus potentially supporting local industries) instead of importing foam-based insulation manufactured in another region of the U.S. which has some questionable impacts on human health?

Even though these examples are simple, they represent the essence of a sustainable rating program. Moreover, this type of thinking can be extended into every facet of how sustainable systems are viewed as compared with conservation systems in the traditional sense. The importance of this approach is that by using **relational thinking** instead of

quantitative data, greater and broader participation occurs since the basic evaluation methodology is easy to understand. The simplicity, then, makes it possible for the rating to be initiated by individuals in the community as well as coordinated through and reinforced by the City program. The important point here is that the consistency is maintained in the system regardless of user.

How, then, does one actually rate or assess technologies by using such an approach? At this point there are a number of other questions that must be asked relative to developing a rating system. A key issue, obviously, is whether the system is likely to be used. A rating system's ability to be used depends on three key elements:

- First, is it relatively easy to develop without needing to create complicated testing and rating criteria?

- Second, is it easy to initiate, that is, are different sectors of the population able to understand it and perhaps even enjoy working with it, resulting in a broad spectrum of the population eventually participating?

- Third, is the resulting rating reliable and meaningful?

As has been implied from the onset, we believe that **linkage**, or the connection between processes, is a far more significant gauge of sustainability than simply conservation or single-use optimization. Furthermore, linkage holds enormous value relative to a comprehensive assessment of resource conservation and is, basically, an easy concept for people to grasp. Thus, a rating system based on the number of linkages between processes **can be** the rating system: A point for each linkage, or point of integration. From the users' end will emerge an appreciation of resource cycling, and a rich array of opportunities once options and evaluative criteria are clearly expressed.

III. Establishing a Sustainability Model and Defining Parameters as the Basis for Rating

What, then, are the overall implications if the rating system is based on how well a given technology connects to another, or to a spectrum of regional processes? The type of technology chosen and the extent to which a particular technology is used is determined by the enviroment's capacity to supply a certain resource under conditions of a **sustained yield.** For example, it has been shown that 600 acres of northwest timber forest can supply about 25 homes each year using typical wood framing techniques without depleting the forest floor of essential organic matter and minerals, or resulting in excessive run-off or erosion. Moreover, it can be shown that through a systematic approach to replenish nutrients into the forest floor, that this yield may be increased, thus creating a full cycle, sustainable system. In Austin, part of a similar cycle is underway at the Hornsby Bend wastewater treatment facility where higher plant species (hyacinth or duckweed) are used to treat wastewater. By co-composting these plants with sludge from the City's wastewater treatment plants, a highly marketable product, "Dillo Dirt" is produced. The Dillo Dirt is available for City landscaping projects and for sale to local landscaping businesses and retail outlets. In this way, the region's soils are replenished.

Other examples exist that are specifically relevant to our local ecology. We know, for example, that structural lumber is not one of Austin's dominant native flora, but that the region does have many soil types suitable for construction. Thus, an important exercise would be to assess the extent to which these soils could be used for building without conflicting with the region's agricultural activities, or otherwise threatening ecological balance. Similar analyses could be made for the region's agricultural wastes which have been shown to have value as construction materials.

Sustained yield implies a full cycling or replenishment of resources. Thus, overall linkage between technologies and the environment becomes the ultimate benchmark in the rating process. For example, if one were to base their development or individual home on the use of any number of regional resources--from rainwater catchment, to earthen walls, flyash cement (from coal plants) for foundations, and mesquite tile floors, for example--with attention to the concept of sustained yield, and employ some means to replenish the resources used, the cycle would be sustainable. Therefore, as our understanding of the local ecology becomes more refined and sophisticated, one can comfortably extract within the parameters of the region's carrying capacity.

Boundaries are particularly important in systems thinking since they help provide operational criteria necessary for developing conceptual and operational models. Boundaries appear to be different according to the human life support system being addresed, whether it be renewable energy, materials, water, or solid waste assimilation. Thus, boundaries imply not only different geographic areas, but reveal the variable natures of the individual life support systems. One of the challenges associated with devising a sustainable rating program, therefore, is to work as closely as possible with what is available--close at hand--thereby reducing reliance on resources from regions we know little about. A solid data base revealing the range of uses and abuses resulting from establishing regional resource reliances is key to a viable sustainable guideline and rating system.

IV. Identifying a Conceptual and Operational Model as the Basis for Sustainable Rating

Four basic components are identified as essential to an idealized sustainability model, in order to keep a city system in balance over time while using natural resources from the region and by-products within the city proper. These components are:

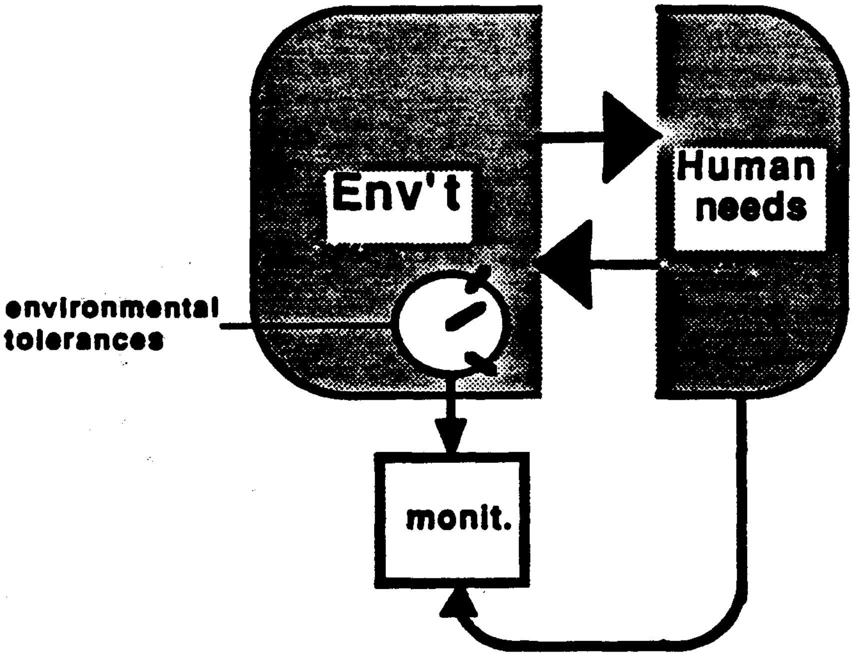
(1) a definition of the environment with respect to specific resource use and its availability

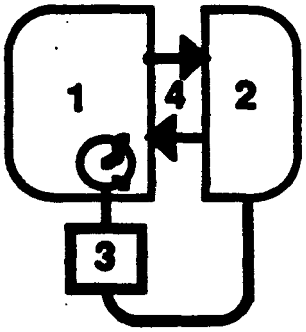
(2) the identification of life support requirements basic to human needs (such as the four identified in this project)

(3) a monitoring technique to sense environmental tolerances regarding natural resource use as well as replenishment techniques

(4) the flow or amount of resources needed by people, on the one hand, and by the environment, on the other, in order to retain the necessary balance between use and regeneration

This model is diagrammed as follows:


Env't
Human needs
environmental tolerances
monit.


1
4
2
3

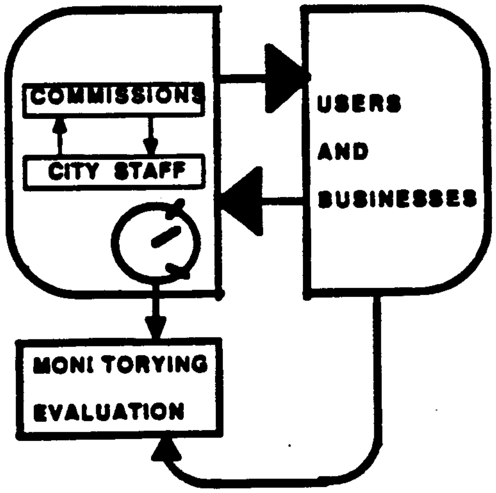
The purpose of this conceptual model is to grasp the entire cycle necessary to incorporate any technological sequence into a sustainable sequence. In other words, the goal of a sustainable rating system should be to provide the requisite functional ingredients as outlined in 1 to 4 that test the full scope of a technology-resource sequence on the environment and on people. Responsbility for making such a model operational falls into the public sector (e.g. governments and citizen groups) which actually represent the environment and its resource base, and the private sector (users and businesses) and education, which help to ensure that the integrity of the sustainability rating is maintained.

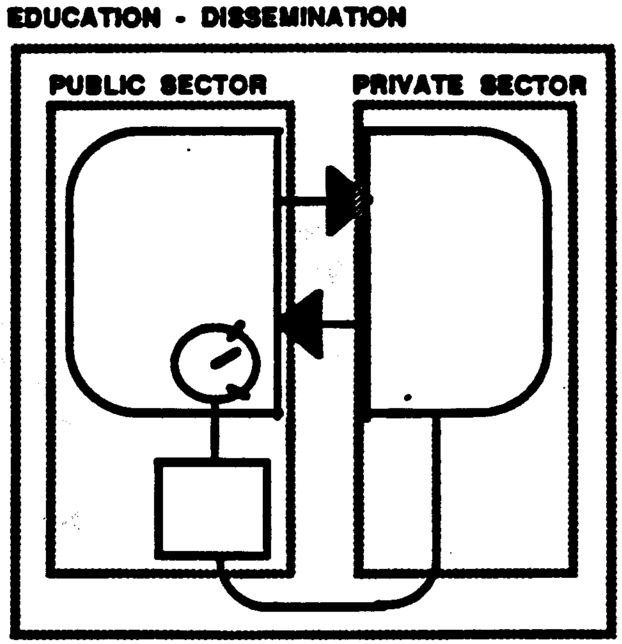
A third important sector to add is education at upper and lower levels. The education sector provides perspective relative to the viability of the conceptual framework, and intact channels to disseminate information related to the approach to people from kindergarten on up. Age appropriate information resources can be developed to effectively convey the basic sustainability concept and rating.

The public sector's role, specifically that of the government, is that of gatekeeper, which oversees monitoring activities, encourages public participation, involves business and industry, and creates opportunities between the private and education sectors. The City's role is to attract industries that are consistent with the basic tenets of sustainability, and provide reinforcement mechanisms that result in "leveling the playing field" between sustainable, conservation, and conventional industries.

The private sector becomes the hard core base of the sustainability program. Builders, real estate brokers, developers, and local industries are the essential feedback loop which communicate the extent to which monitoring can occur and how effective it is, and the economics and technical viability of fulfilling certain needs with sustainable options. In short, the private sector becomes the catalyst to change since they provide the litmus test for determining how to better establish linkages between resource use and the environment.

The transformation from a conceptual model to actors within this model, and, finally to public, private, and educational roles of influence, is shown below:


COMMISSIONS
CITY STAFF
USERS
AND
BUSINESSES
MONI TORYING
EVALUATION


EDUCATION - DISSEMINATION
PUBLIC SECTOR
PRIVATE SECTOR

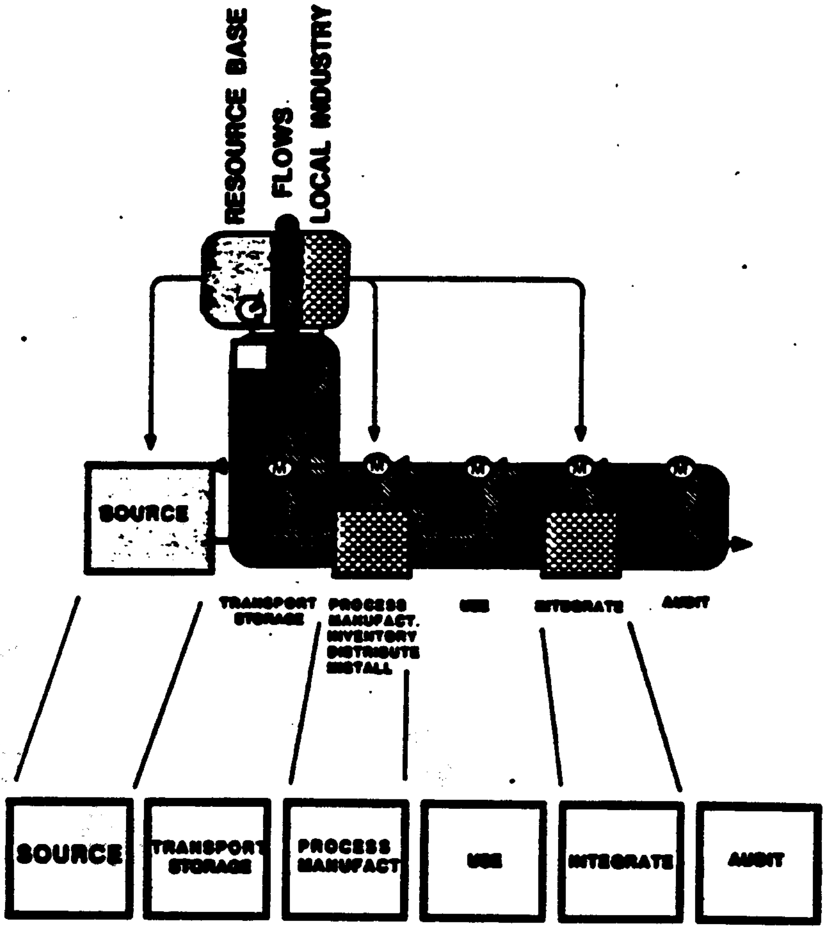
It is important to recognize that the above model is particularly viable in a city such as Austin due to a relatively high positioning on the sustainability learning curve among the principal players: the City of Austin, local industries and the development community, the school districts, and the area's universities and colleges.

V. From a Participation and Conceptual Model to an Operational Model: Putting Plumbing in the System

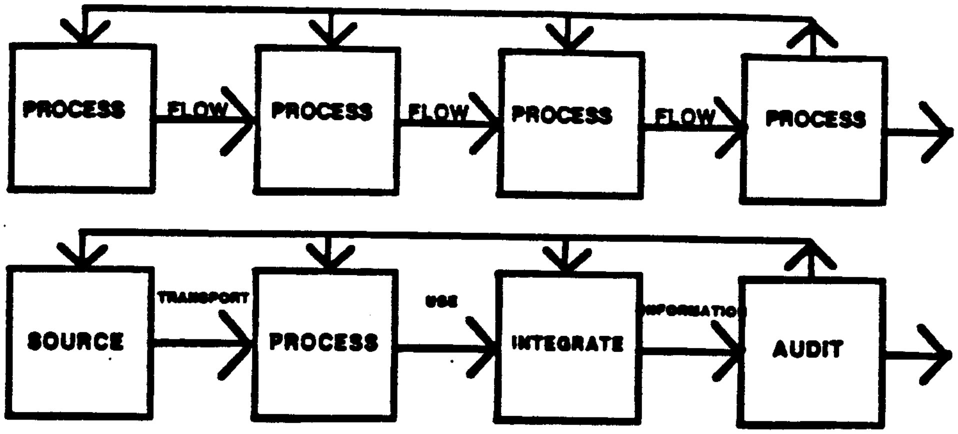
In analysing procedures to guide resource use relative to sustainable systems, beginning with the regional environment as the resource base, there develops a sequence in transformation processes from raw resources to use and finally to reuse and recycling. As mentioned earlier in the development of our conceptual and participant models, there are four principal components (energy, water, solid waste, and building material) with three principal actors (the public sector, the private sector, and the education sector.) Together components and actors take part in the sequence involving all resource utilization efforts. This sequence is summarized in the following diagram.

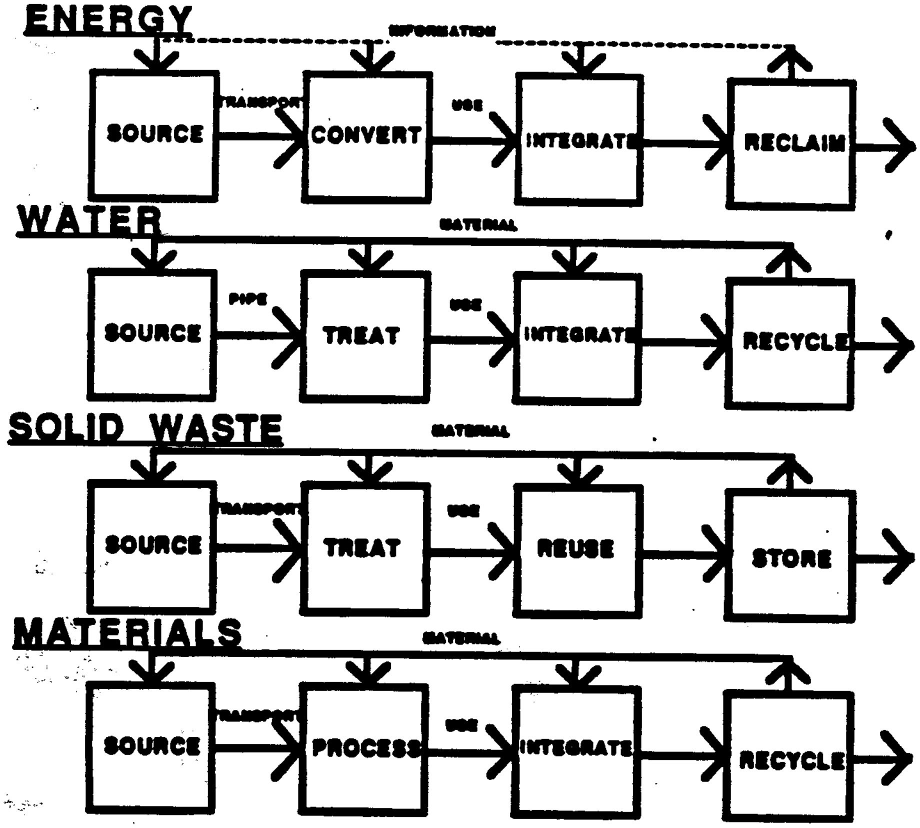
- Step One: Sourcing (mining, harvesting, collecting)
- Step Two: Transporting and Storing
- Step Three: Processing & Manufacturing, Inventorying & Distributing
- Step Four: Installing and Using
- Step Five: Integrating (with other resource uses)
- Step Six: Auditing (benefit/cost analysis)

This sequence relates to the conceptual model as follows: Ideally, there exists a sensing or monitoring mechanism at each synapse throughout the sequence, thus enabling feedback loops to be used as flow indicators. This constant feedback can provide enhanced integration over time. As is indicated in the diagram, the environment is the overall condition within which resources are used; arrows, representing flows between processes, are represented by transportation or actual use procedures; sensors appear at critical junctures between use flows and recycling/re-use feedback loops; finally, people's resource needs of energy, water, waste, and materials are represented by the sequence of the transformation process (from resource harvesting, mining, lumbering, etc. on through to the process of auditing the results.) Thus, the entire sequence can be simplified into alternating processes and flows, as shown in the two diagrams below.



GENERIC

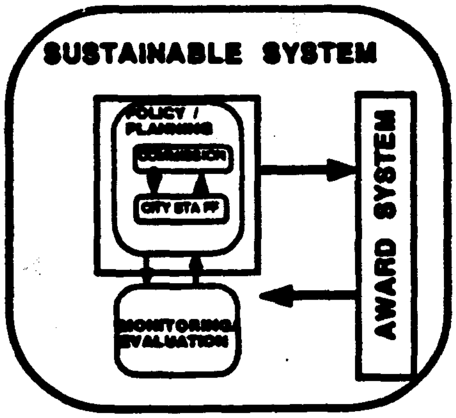

PROCESS
FLOW
PROCESS
FLOW
PROCESS
FLOW
PROCESS
SOURCE
TRANSPORT
PROCESS
USE
INTEGRATE
INFORMATION
AUDIT

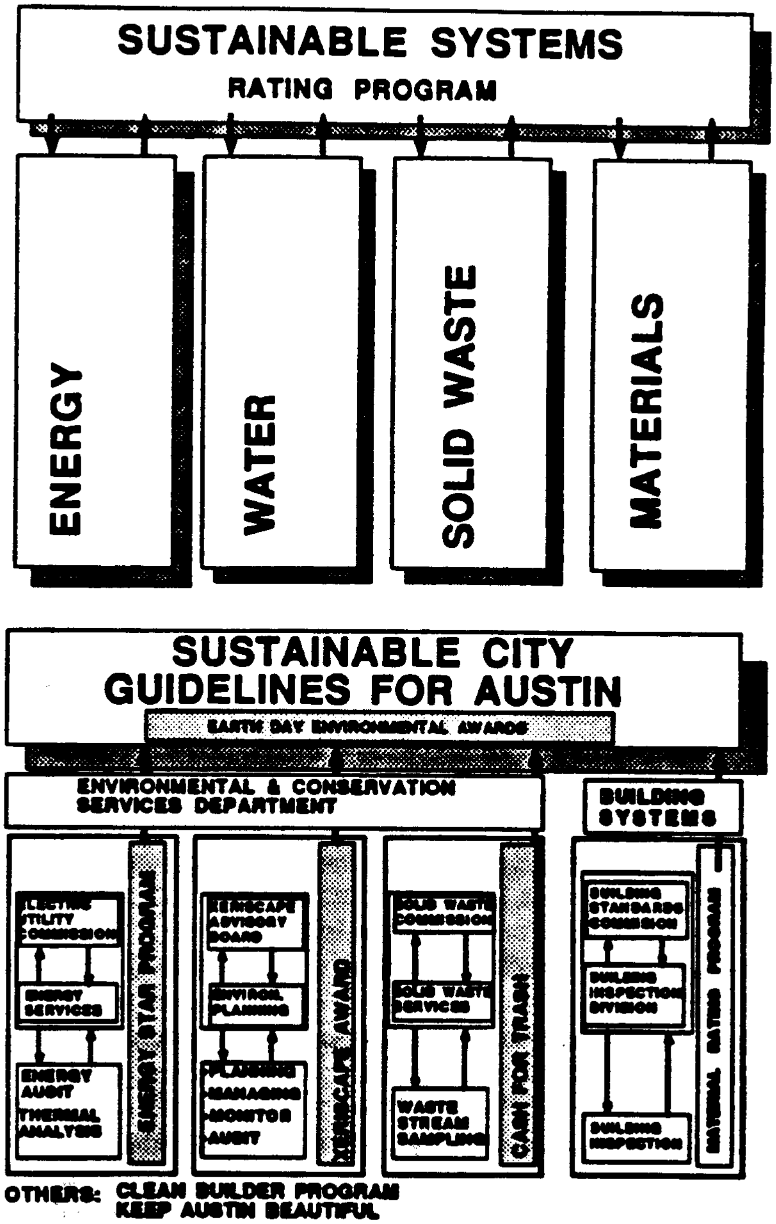

ENERGY
INFORMATION
SOURCE
TRANSPORT
CONVERT
USE
INTEGRATE
RECLAIM
WATER
MATERIAL
SOURCE
PIPE
TREAT
USE
INTEGRATE
RECYCLE
SOLID WASTE
MATERIAL
SOURCE
TRANSPORT
TREAT
USE
REUSE
STORE
MATERIALS
MATERIAL
SOURCE
TRANSPORT
PROCESS
USE
INTEGRATE
RECYCLE

VI. Operational Model and its Relation to the City of Austin and the Environmental & Conservation Services Department

It is extremely important that the conceptual model developed in this project is compatible with programs already underway. Policy is formulated through a flow pattern involving several public sectors, including citizen commissions, city staff, city manager's office, and, ultimately, city council. City departments monitor different programs in a variety of ways, from general criteria such as total energy, water, or solid waste flow, to more in-depth methods such as pressure doors for weatherization. The private sector, businesses, and users are supported through referral services, rebates, and annual award ceremonies, while the educational community of universities and non-profits provide perspective and expertise.

As one can see, the City already encourages participation and exemplary environmental activities through its sponsorship of a number of environmental awards and recognition programs, including the Energy Star Program, Xeriscape Award, Cash for Trash, Clean Builder Award (via Keep Austin Beautiful,) the Annual Environmental Awards. In a sustainable systems sense this reward system sets the stage for the necessary community values regarding the environment and serves as a constant reminder to the public that such programs exist and are valuable. Each of these model examples for different departments is diagrammed below. It is the intention of the Sustainability Rating Program, through the newly-created Green Builder Program, that an overall rating procedure inclusive of sub-programs will become the most sought after award, since it will be indicative of achievement of a more comprehensive nature. This general operational model for the city is diagrammed below, and correlates with our original conceptual model as shown.




SUSTAINABLE SYSTEMS
RATING PROGRAM
ENERGY
WATER
SOLID WASTE
MATERIALS
SUSTAINABLE CITY
GUIDELINES FOR AUSTIN
EARTH DAY ENVIRONMENTAL AWARDS
ENVIRONMENTAL & CONSERVATION
SERVICES DEPARTMENT
BUILDING
SYSTEMS
LECTRIC
TILITY
COMMISSION
ENERGY
SERVICES
ENERGY
AUDIT
THERMAL
ANALYSIS
ENERGY STAR PROGRAM
XERISCAPE
ADVISORY
BOARD
ENVIRON.
PLANNING
-PLANNING
-MANAGING
-MONITOR
-AUDIT
XERISCAPE AWARD
SOLID WASTE
COMMISSION
SOLID WASTE
SERVICES
WASTE
STREAM
SAMPLING
CASH FOR TRASH
BUILDING
STANDARDS
COMMISSION
BUILDING
INSPECTION
DIVISION
BUILDING
INSPECTION
MATERIAL RATING PROGRAM
OTHERS: CLEAN BUILDER PROGRAM
KEEP AUSTIN BEAUTIFUL

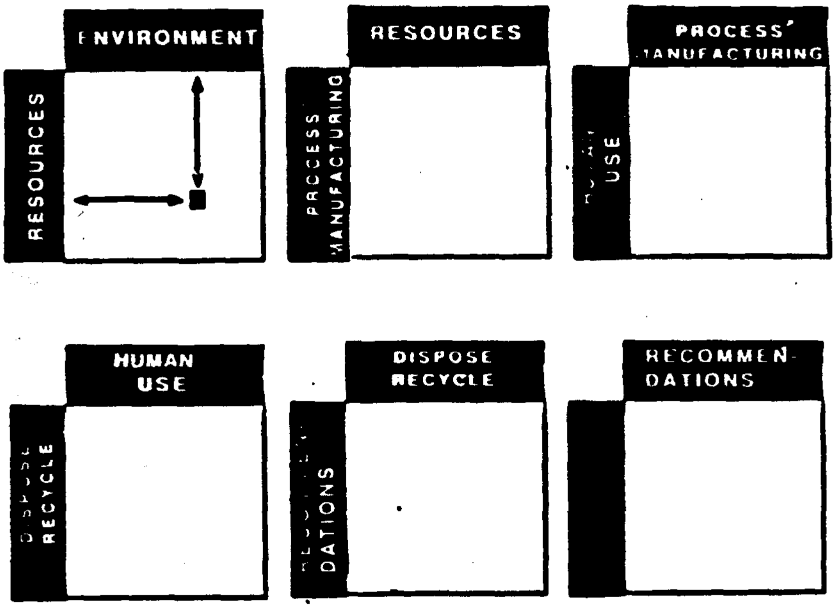
VII. How Rating Procedures are Core to the Development of the Relational Field Matrix as an Accounting Procedure

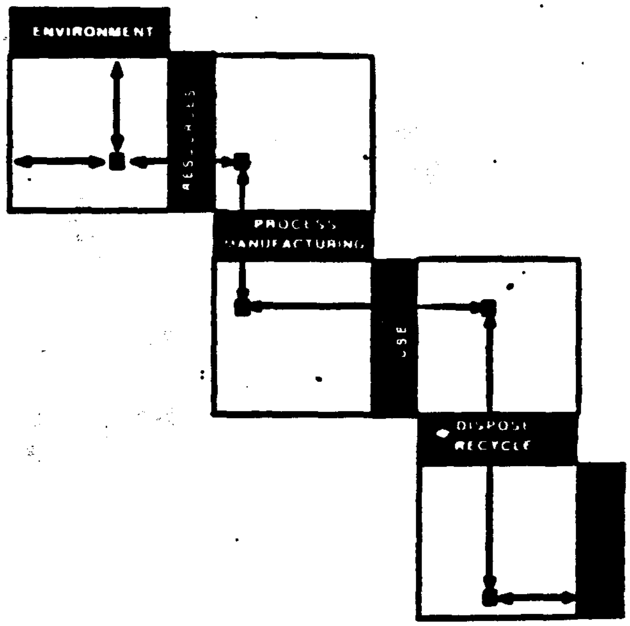
There are obviously many different possible technologies representing any one process or flow in the sequence presented earlier. In fact, it is important to realize that any single technique associated with, for example, extraction, is also associated with one or more techniques of transport or storage. In other words, under processes (or technologies) that represent extraction, harvesting, or mining, one can associate several procedures with each one. If a topic such as mesquite wood is placed in this sequence, technologies under harvesting or lumbering are narrowed even further.

Once one chooses a specific technique at this primary level of the sequence one is then faced with a series of transport or storage options. For example, if the wood is logged it indicates one set of transport means, if it is chipped, another, say, blown through piping to a central power plant instead of being transported solely by truck. One can identify a myriad of techniques even within a given topic such as biomass planting and harvesting under SOURCE. Similarly, these techniques affect the manufacturing or technologies that transform a raw material to a useful form, as with heat or a building brick.

To be consistent with our goal of providing continuous linkages to achieve integrated sustainable systems, it is important to have an accounting system that operates throughout the identified sequencing. To do this requires a special kind of matrix format that is relational by nature. In other words, for every intersection in one relationship through our sequence of processes and flows there is a certain relationship or series of relationships through the next sequence of processes and so on. The intent of this procedure is to always show how a decision or choice at one level is reflected in subsequent choices at other levels in the sequence. One way of accomplishing this is called the **relational field matrix** which has been widely used in accounting procedures for everything from industrialized building to regional land use and ecological planning to the development of the B2 bomber.

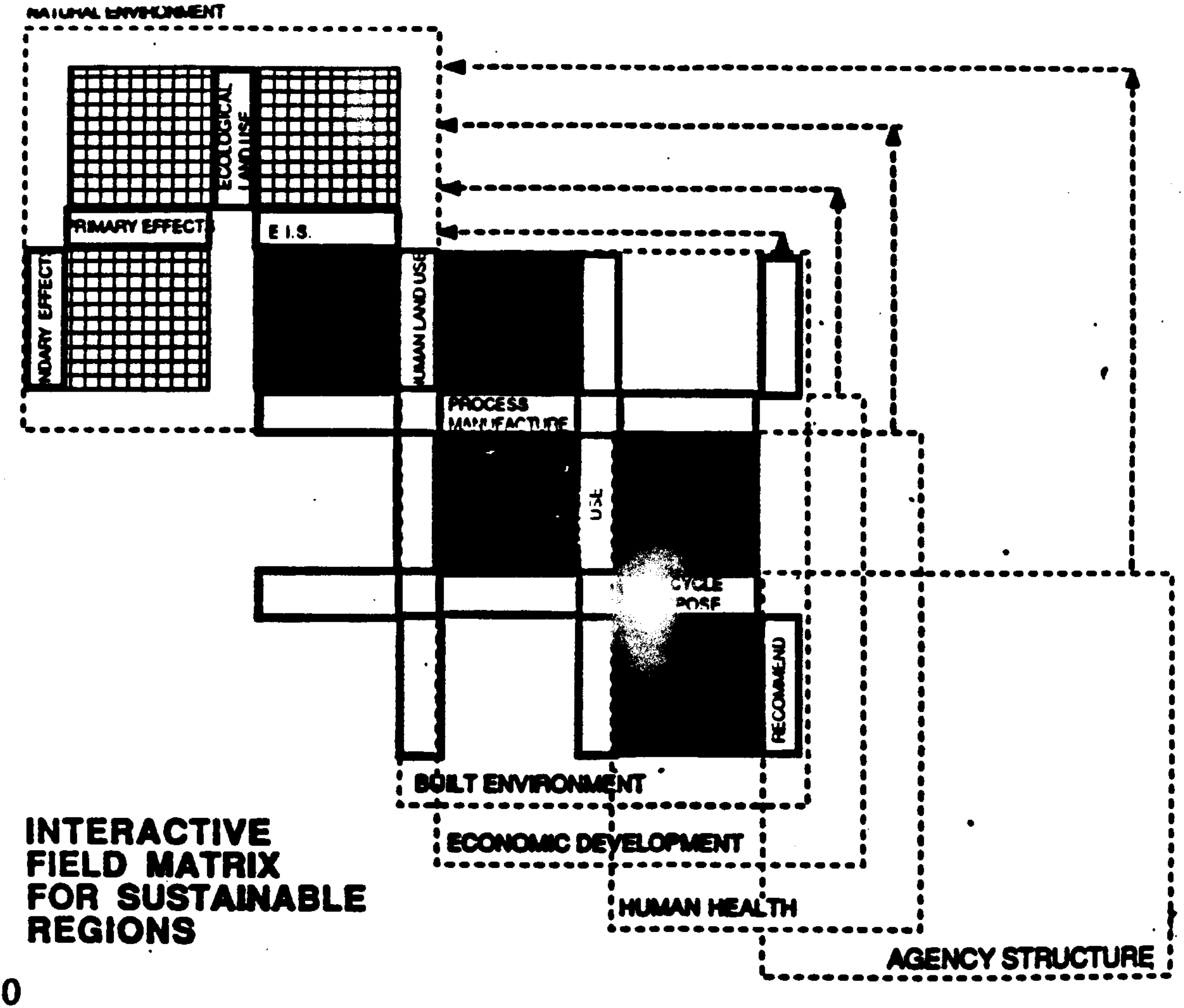
The important concept to realize early on in this accounting procedure is that since it is relational, one can begin at any point or matrix intersection throughout the system, and lead to any other point in the sequence. This means the system is totally adaptable to be entered at any point of inquiry. The transformation of the sustainability sequence to individual matrices and then to an interactive field matrix is diagrammed below. Also diagrammed is the phenomenon of multiple entry points.





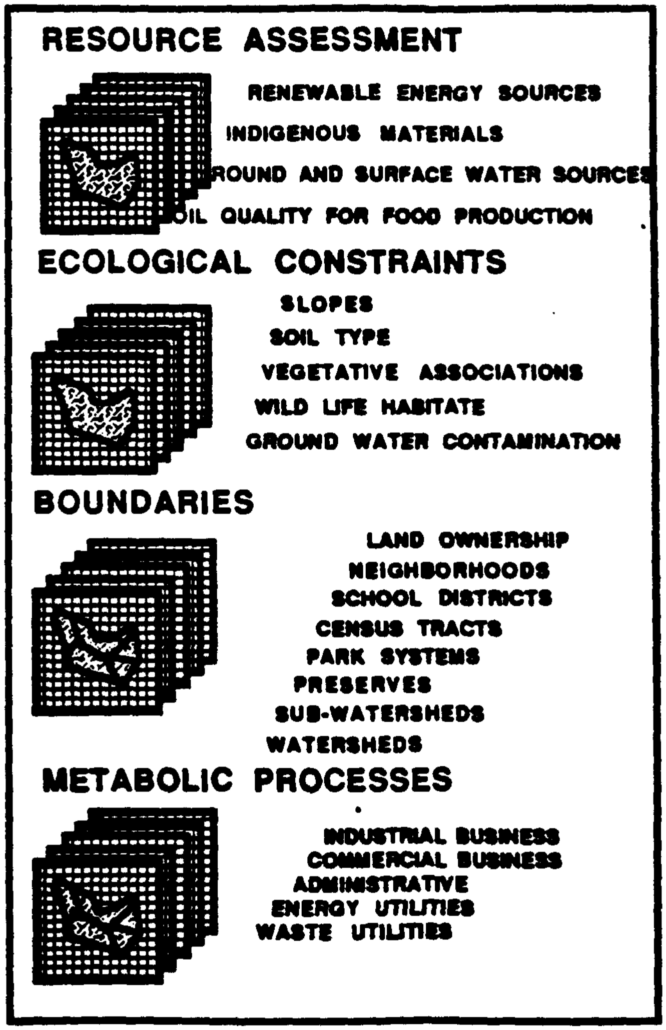
VIII. The Relational Field Matrix and its Relationship to Ecological Land Planning Procedures

In order to respond to ecological constraints, it is important that the field matrix procedure is sufficiently broad based to enable it to be useful beyond the development stages of this rating program. Thus, as has already been indicated, the procedure can establish the ecological constraint issues necessary to develop a particular resource before extraction, harvesting, or lumbering is initiated. This procedure is diagrammed as follows. Actual examples of mapping overlay procedures in each of the four sustainability issues are also indicated by example.



INTERACTIVE FIELD MATRIX FOR SUSTAINABLE REGIONS

SUSTAINABLE GUIDELINE AND RATING SYSTEM
APPLICATION TO RESOURCE MANAGEMENT



RESOURCE ASSESSMENT

- RENEWABLE ENERGY SOURCES
- INDIGENOUS MATERIALS
- ROUND AND SURFACE WATER SOURCES
- OIL QUALITY FOR FOOD PRODUCTION

ECOLOGICAL CONSTRAINTS

- SLOPES
- SOIL TYPE
- VEGETATIVE ASSOCIATIONS
- WILD LIFE HABITATE
- GROUND WATER CONTAMINATION

BOUNDARIES

- LAND OWNERSHIP
- NEIGHBORHOODS
- SCHOOL DISTRICTS
- CENSUS TRACTS
- PARK SYSTEMS
- PRESERVES
- SUB-WATERSHEDS
- WATERSHEDS

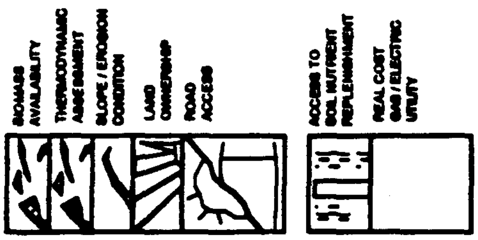
METABOLIC PROCESSES

- INDUSTRIAL BUSINESS
- COMMERCIAL BUSINESS
- ADMINISTRATIVE
- ENERGY UTILITIES
- WASTE UTILITIES

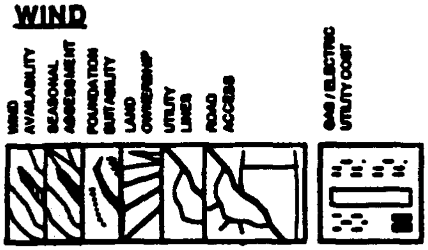
EXAMPLES OF POSSIBLE RESOURCE ASSESSMENT PROCEDURES

ENERGY

BIOMASS

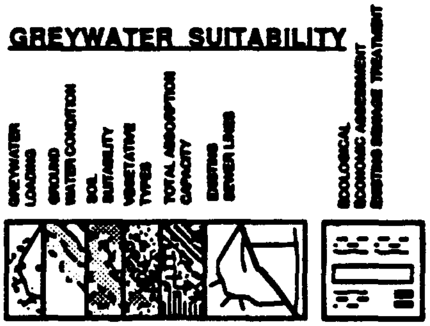


WIND

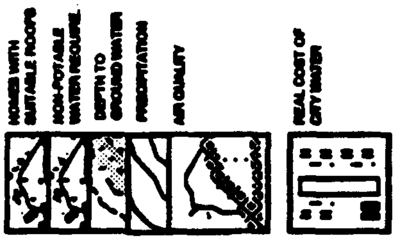


WATER

GREYWATER SUITABILITY

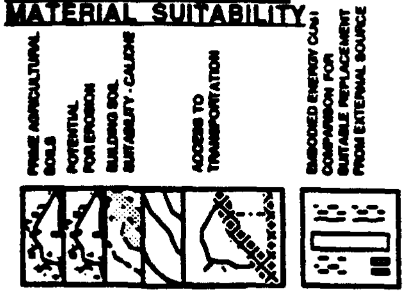


CISTERN SUITABILITY



MATERIALS

EARTHERN BUILDING MATERIAL SUITABILITY



IX. Taking the Conceptual Model to its Limits and the Introduction of Object Oriented Programming

The challenge in providing any kind of model for sustainable rating procedures is to grasp the nature of the audiences being addressed. In this instance, the two key sectors are the homebuying public and the development community, comprised of builders, developers, architects, and real estate agents. Although the requirements for these audiences are different, it is important that the methods selected for communication relate the information in a consistent fashion.

As the full breadth of the rating system was absorbed, the need for the most broad-based communication tool possible emerged as an essential element. For example, it seems that it would be important for a custom home builder or a developer to have a communications tool which conveys equally effectively to different potential audiences-- the real estate broker knowledgeable of environmental concerns and a prospective homebuyer who is not-- the particular advantages of the technologies and materials employed in his/her home. Similarly, it would be a great benefit to a potential homebuyer to evaluate a prospective home with a developer using a rating tool that he/she was comfortable with, and make suggestions based on options revealed through the rating tool to enhance the home's sustainability.

Ideally, communication of sequential processes is easy enough to understand such that designers, engineers and land planners would be able to use it for mocking up infrastructure for retrofit designs, homes, or developments. Previously, these efforts were almost solely superstructure or shell oriented in their concerns about visual aesthetics, structural integrity, internal spatial planning, or site planning. With the introduction of the sustainable rating system, equal attention would be placed on the plumbing, waste water, energy, solid waste management, utility infrastructure implications, and on the type of materials used.

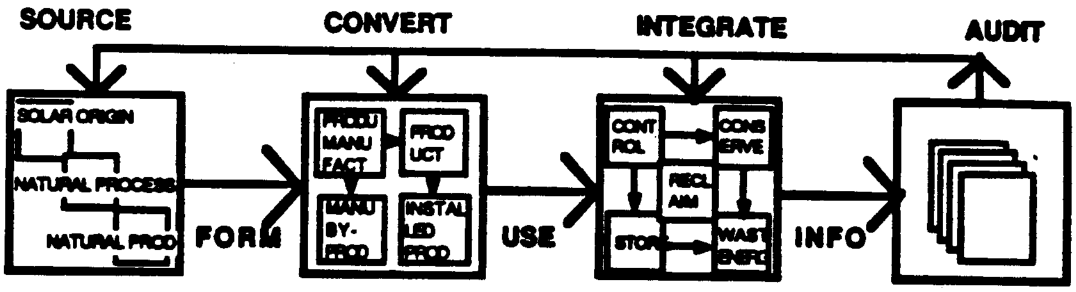
How, then, can this system be actualized in a way that provides not only a method for mock-up and inspirational diagramming, but which also has the necessary depth to carry out engineering and utility load management calculations?

The use of illustration art or pictures to describe sequences has a long history that goes back as far as hieroglyphs in ancient Egypt where entire stories were told about a civilization that, otherwise, we would know little about. During World War II fighter pilots were trained more efficiently through comic strips than in a classroom setting, and so training manuals featuring illustrations by Walt Disney were developed. Furthermore, today there is a major surge in activity in computer programming (Object Oriented Programming, or OOPs) that is likely to dominate the next generation of computer hardware and software, as well as mainstream communication and educational tools of the future.

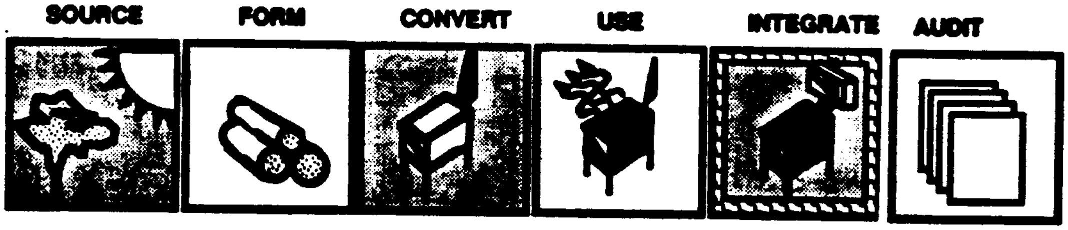
OOPs' uniqueness results from the breadth of user types to which it can relate. Because everything can be represented in pictures or computer programs, those who are artistically inclined or who relate to systems at a more general level have an equal entry point as those who are more mathematically inclined, while those who require mathematical backup in terms of operational equations can participate at that level. An example of our process and flow sequence is presented below, highlighting several different sustainability sequences covering each of the four resource areas, and using identifiable "icons" which have become standard elements of computer software programs.

We propose that an icon, or graphic-driven system become the method through which each sustainability sequence is shared and used. It will be through this graphic base that the public first becomes aware and is able to become familiar with the linkage aspects of the rating program. These icons will eventually become the pallet of tools through which designers, homeowners, engineers, and architects communicate with each other and their respective clientele. Further, it will be the basic organizational framework for the City's files and information relating to the program. This will be achieved either through the icon itself, or through a proposed numerical system which will be representative of each icon and icon sequence. We propose that this system also become the basis of educational planning kits and games for students of all ages.

ENERGY



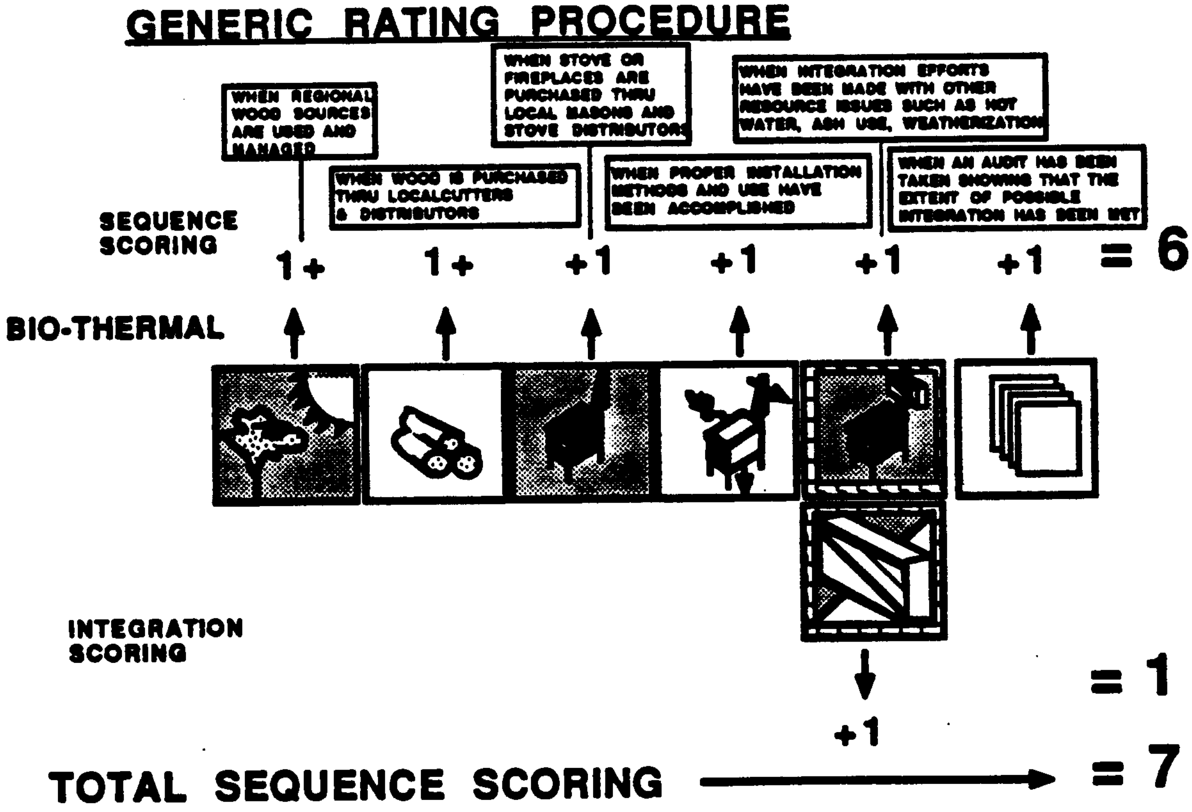
BIO-THERMAL



X. Sustainable Technology and How the Rating System Works

Below we have repeated the icon sequences shown previously along with how they would be rated in parts and in wholes. It is important to realize that a technology alone can be rated, but more than a single point cannot be gained unless one can go to some other level in the sequence. It is also important to note that one does not have to go to an adjacent icon in the sequence to earn points. For example, a stove that is manufactured outside of the region but exhibits good airtight combustion design and efficient flue cleaning, etc. might gain points for being a good stove, using local wood cutters, local transporters, and stockpilers, and even for becoming fully integrated into a building with proper weatherization, flue waste heat recovery etc.and auditing. In this instance, the total possible points would be 5 rather than 6.

GENERIC RATING PROCEDURE



(c) 1991 THE CENTER FOR MAXIMUM POTENTIAL BUILDING SYSTEMS

XI. The Importance of Binary Rating in Complex Systems

Although the previous diagram showing the generic rating procedure almost seems too simplistic and incapable of providing any meaningful impact on a development or a city's sustainable future, one must consider these sequences as basic communication tools to the public. In effect, they are responses to questions or first order inquiries, beginning at the point of fundamental introduction into what is an enormously complex system. As we have said, this is done purposely in order to develop the degree of participation needed through easy-to-understand graphic statement sequences. What one must realize is that the actual complexity resulting from thousands of such graphic statement sequences is what makes the whole system work in terms of ultimate ability to have regional impact.

Yes/No binary rating systems depend on large scale participation and, in the long run, are fundamentally different than optimizing small incremental components of the population.

XII. The User Type and their Sphere of Influence

It is beneficial at this point to review some actual examples in order to understand the degree to which the rating system works, and the role of conservation within it. For the purposes of our example comparison, we will use the same occupant number for all conditions, that is, a 2.8 member family. All units contain shower, washing machine, sinks, dishwasher, and toilet.

Example I: Occupants from a multi-family unit or single-family residence situated in a dense urban condition want to participate in the program. They have limited ability to engage in the full sequence because of their limitations imposed by their site. For example, they are without access to land to fully take advantage of greywater reuse and their relationship to the owner of the home that they are leasing approves only some conservation.

Under a pure conservation mode (since other opportunities are unavailable) the family can reduce greywater output from a non-conserving, worst case mode from 70,272 gpy to 39,492 gpy, or a 43.8% savings including a water conserving commode. The maximum rating that can be obtained is in optimization in the USE category for each of the 5 use technologies: (1) showers; (2) washing machine; (3) sinks; (4) dishwasher; (5) toilet, for a total of 5 points - we gave **6 points** by saying that the toilet insert was produced locally.

Example II: Occupants from a home with a yard apply typical water conservation practices in the home and yard. While the home remains the same as in Example I, the resident has the choice for connecting to the cities existing water system and but has the added burden of the yard, though water conservation practices are employed. Since the choice was made for using the existing system and installing good healthy piping there is an added rating of 10 in this category. (See icon example at end of report to see how rating was accomplished.) According to the City of Austin, non-conserving practices in the yard account for .62 gallons/sq. ft./week on average. With a viable Xeriscape landscape in all categories of ground cover, shrubs, and tree type the resulting total water use figure is 0 while a rating of 4 is given in each one of these three areas. Since the three main areas of Xeriscape were employed using in each case indigenous plants, labor, suppliers, proper planting and integration procedures , there is a total of 12 points for the yard, and a total sustainability rating of 5 for the house. Thus, the occupant has saved approximately 13,020 gallons of water over a five month period. The total rating for this building would be **28 points**. (See example expanded at end of report.)

Example III: The occupants of a house with a yard go through a sustainable sequence inside the home as well as in the yard, that not only captures various sustainability sequences but also integration efforts between sequences that can each add a point. The sequences are as follows: First, the household conserves the flow of water in each technical area as in Examples I and II. Second, the shower, washing machine, and non-potable sinks rely on water derived from a roof catchment system that is treated in a cistern with a small ozonation bubbler to maintain water purity. The cistern and guttering were manufactured and installed by a local supplier. A greywater system was manufactured and installed using a local company. After ozonation and U.V. pond treatment, greywater is used for food production. The garden is placed in a passive solar greenhouse for garden and home space heating during inclement seasons. The greenhouse in the summer is used as a screened porch, thus helping provide breeze and shade as well as keeping some insects from the food crops. The integration of a passive solar greenhouse in Texas as a screened breeze porch that helps keep out garden insects is the kind of integration effort that can gain even more points in our rating program.

The rating for the entire system uses the base of 28 from the previous example, but adds 9 for the greywater system; 6 for the sink using non-potable water. The total sustainability rating is 28 + 9 + 6 for **43 total points**.

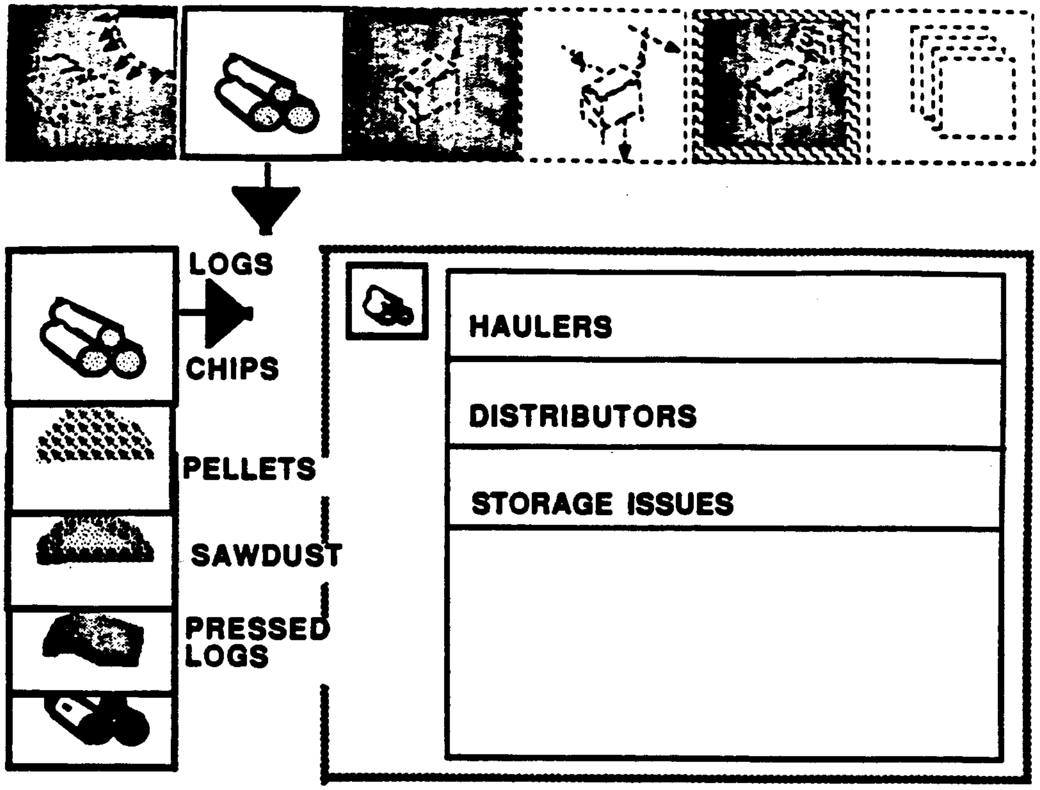
XIII. Involving Users, Self Rating, and the Role of Self-Auditing

The primary purpose of the program is to catalyze participation and enthusiasm rather than to police participants into action, or subject them to analytical machines. From the beginning, the rating program was conceived with a positive viewpoint. It would provide the framework for families, businesses, designers, and other community sectors to participate with each other in a challenging process to understand the tremendous breadth of opportunities that Green Building can have in enriching our lives and, as a side benefit, enriching the planet. The challenge to some might be the conceptualization of "Spaceship Earth" at home." To others, it might be creating beautiful, healthy enviroments, while others may participate to reap investment benefits assuming that a Green Home will have greater value in the future.

If icon graphics can successfully engage participants into a greater understanding of what can be an immensely complex undertaking, we believe that a parallel effort should be made towards a self rating system combined with self auditing. In fact self rating and self auditing can be one and the same. Below is a Hypercard representation of parts within the graphic sequence that demonstrate the kinds of questions that are to be asked in an audit / self rating program. The use of this format would appear in duplicate form enabling <u>city staff</u> to keep track of information and users and for <u>users</u> to both learn in more depth what icons mean and be able at the same time to audit. Following this audit rating and tracking Hypercard format is an example of an actual rating card with mocked-up icon sequences for the three user scales (living unit, home with yard, neighborhood/development) to show how sequencing and scoring was done.

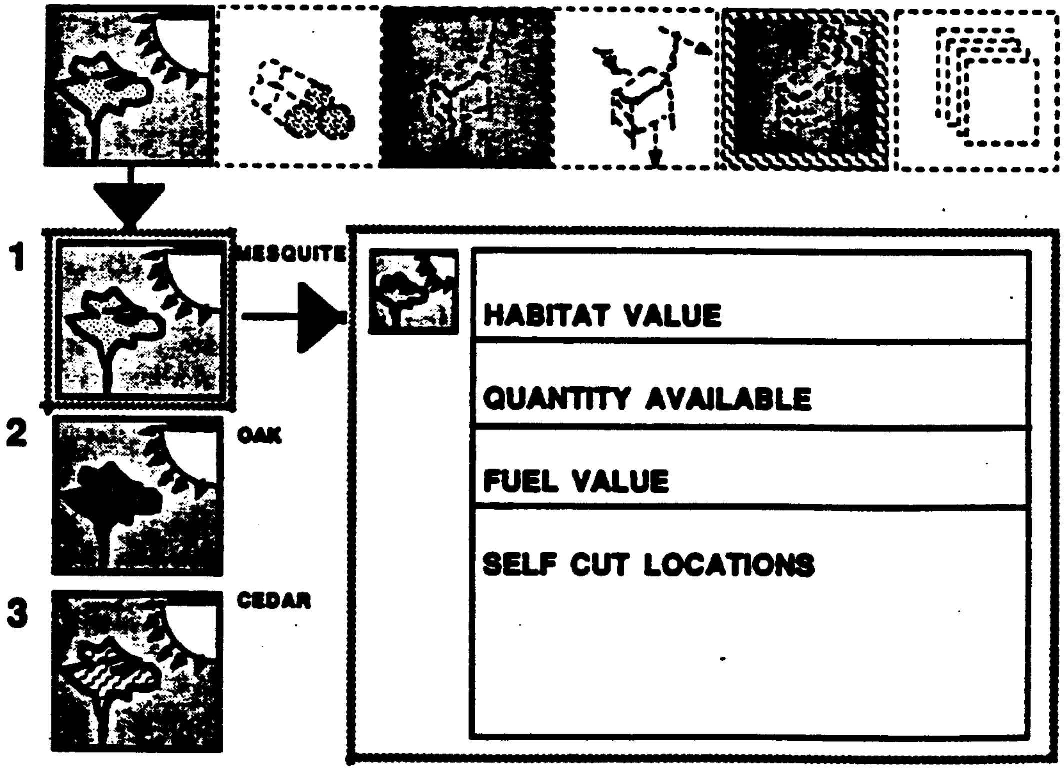
RATING INFORMATION BASE

BIOMASS



RATING INFORMATION BASE

BIOMASS



30

XIV. Involving the Business Community

In a sense, the proposed rating system is an economic development tool. It involves the full spectrum of vertical production, from raw material "extractor", transporter, manufacturer, supplier, user, designer, engineer, integrator, to even professional auditors if that component is ever placed into an actual job catagory instead of self auditing. The job production multiplier at each level for increases due to the multiplicity of implied uses and use conditions. But for the homeowner, builder, and developer, the advantages lie in the ability to take advantage of a trend towards environmentally sound living. According to recent polls published in Builder Magazine (July 1991,) 79% of the U.S. population consider themselves environmentalists; 78% support a major national effort to improve the environment; 76% want businesses to do more; and 79% of the population would pay up to 20% more for an environmentally-safe product.

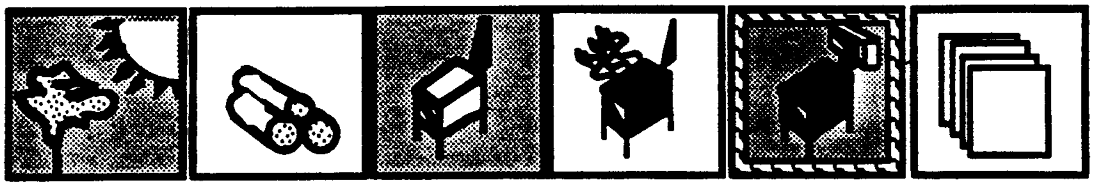
The fact is that the American dream of a single-family home with a yard, or of a planned development with open space and tightly planned multi-use activities are ideal sustainability candidates as the trend in the earlier examples illustrate. These examples offer the highest integration potential since there is greater opportunity for integration with the larger environment. Again, national buyer statistics bear out these two models of development. On the one hand, without planned, multi-unit sites (without walking distance amenities), 75% of homeowners still desire large lot zoning. However, when given the option (when amenities are planned and diverse, town-like land use features are brought together,) 34% of those polled want small town atmosphere, while only 24% would choose suburbs, 22% farms, and 19% cities. (Source: 1989 Gallup Poll.)

XV. Sustainability Guidelines and Rating for Developments

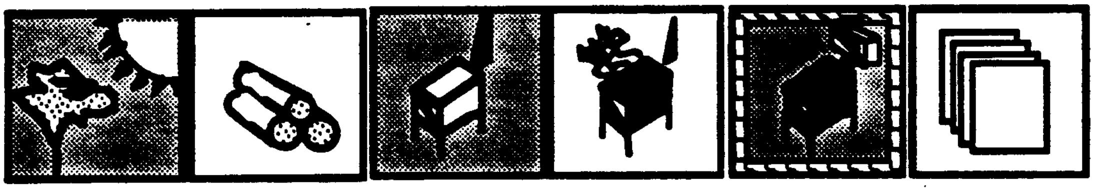
The user's sphere of influence on the environment relates to the scale at which the user works. In Example I in Section XII, above, the user's ability to participate on several levels of sustainability rating reflected their limited control of their environment. It became obvious in Example II, featuring a single-family home with a yard, that the change in living circumstances enhanced the capacity to participate in, and be rewarded through, the sustainability rating.

ECONOMIC DEVELOPMENT CORRELATION

BIO-THERMAL



BIO-THERMAL

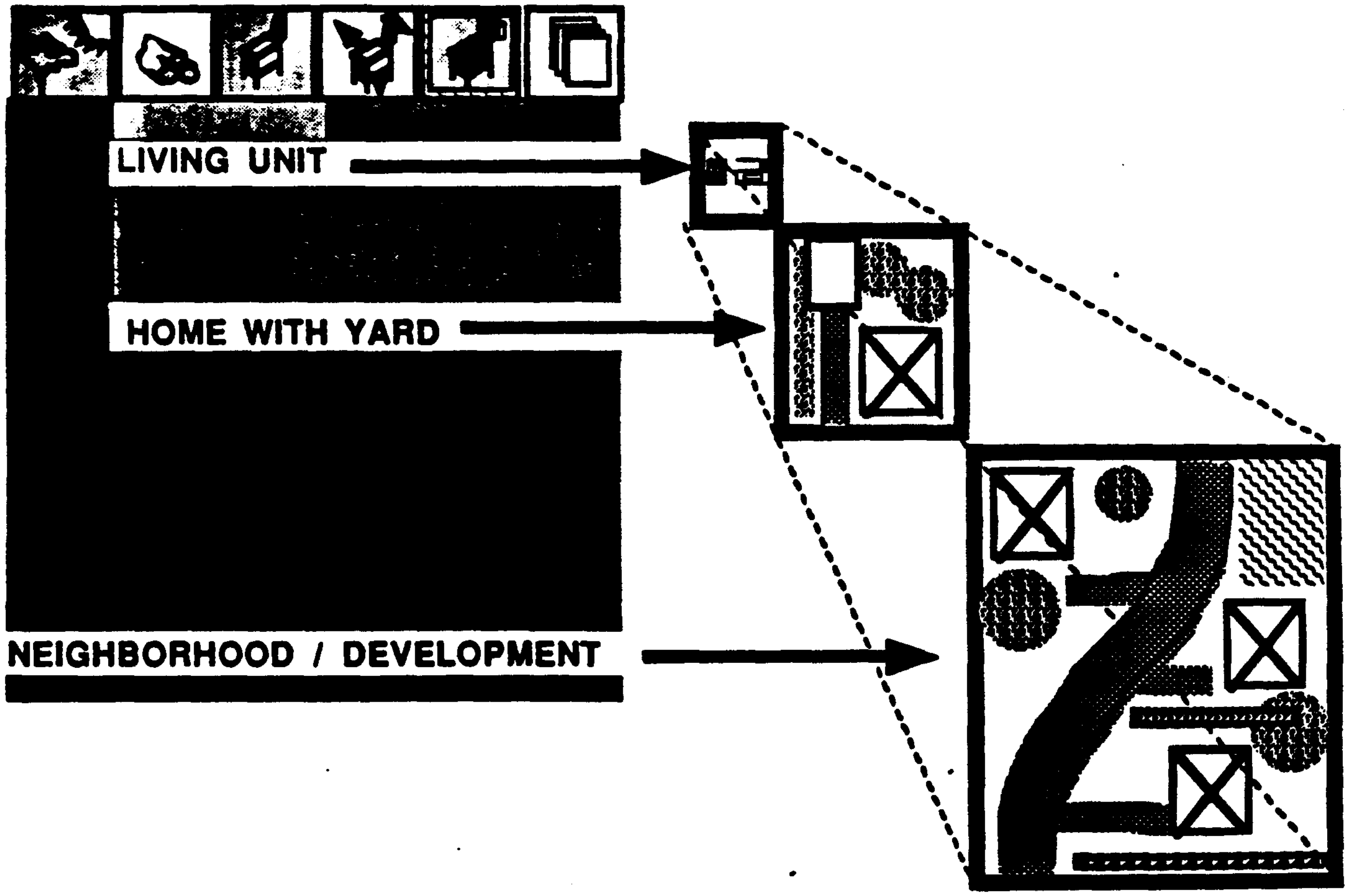


Factors other than sphere of influence enter into the picture, such as the fact that the ratio of tenants to homeowners in Austin is 52% to 48%, respectively. Thus, a majority of Austin's population is enormously limited in their ability to assume major decisions concerning the sustainability of their residence. In this sense, it is easy to absorb the magnitude of decisions made by the development community as they plan multi-family complexes and subdivisions dominated by rental units. Their participation in the Green Builder program could be the most important involvement in tangible benefits than any other sector individually.

However, the approach in many sequences in any of the category areas that a developer could take is obviously at a different scale than for an individual homeowner. What was a greywater landscape for a homeowner is now a waste metabolizing wetland for a developer. What was an integrated heat pump HVAC system coupled with a water heating system for a homeowner is now a district heating/cooling/water heating system for the developer.

Therefore, for each icon sequence, there is an implied scale that relates better to one user type than to another. This recognition of scale also aids to ensure that not only should there be icon sequence reference guides, but also parallel guides that cover different scales. This condition of scale is diagrammed below in a way that demonstrates the levels through the sequence that one would expect of the different user types. Because some sequences relate better at different scales an example of a sequence theme for grey water reduction/reuse according to the same scales of living unit, home with yard, and neighborhood/development are shown.

DEFINITION OF SCALE USING BIO-THERMAL EXAMPLE



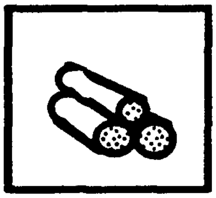
XVI. Icon Definitions, Principal Icon Sequences, and Sequences Relative to Matrices

Below are two icon sequences with appropriate definitions, both relevant to the homeowner scale. The process of defining iconography is an important task if they are to become a major element in the overall rating system. A catalog of icons would be divided into families under each of the four topic headings. These families would be derived from main topic headings under each sequence. By using both drawn graphic symbols and color differentations between sequence types, the user would be able to clearly distinguish the various sequences and topics. Example of icon definitions are below.

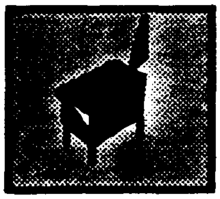
ENERGY ICON DEFINITION

WOOD BIOMASS

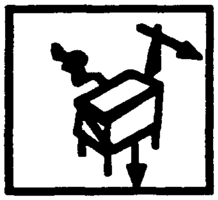
RAW MATERIAL SOURCE FOR REGIONAL WOOD SPECIES SHOWING PLACE OF ORIGIN AND QUANTITY



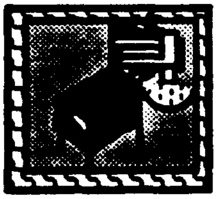
TRANSPORT BY CUTTERS, STORERS AND SUPPLIERS OF REGIONAL WOOD SPECIES IN VARIOUS PHYSICAL FORMS SUCH AS LOGS, PELLETS, PRESSED LOGS



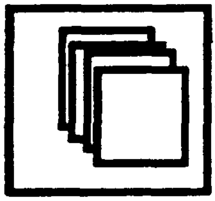
REGIONAL STOVE MANUFACTURERS, SUPPLIES, MASONS, INSTALLERS



ACTUAL STOVE OR FIREPLACE USE DEMONSTRATING PROPER INSTALLATION AND OPERATING PROCEDURES FOR MAXIMUMEFFICIENCIES



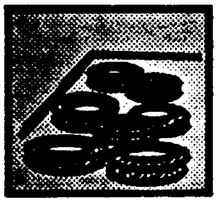
INTEGRATION INTO ENERGY OR RESOURCE NEEDS OF HOME USING REGIONAL STOVE AND MASONRY FIREPLACE DESIGNERS, ENGINEERS, ARCHITECTS



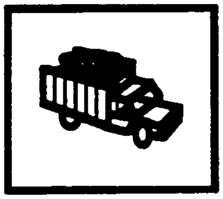
EFFECT OF STEPS ONE THROUGH FIVE ON EACH OTHER AND THE ENVIRONMENT THROUGH SELF AUDITING OR OFFICIAL AUDITING PROCEDURES

SOLID WASTE ICON IDENTIFICATION

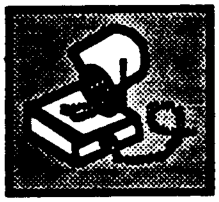
SOAKER HOSE



TIRE SOURCES; HOME GARAGES, GAS STATIONS, RECYCLERS, LANDFILLS

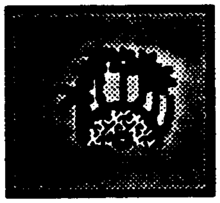


THOSE BUSINESSES WHO TRANSPORT AND STORE TIRES REGIONALLY

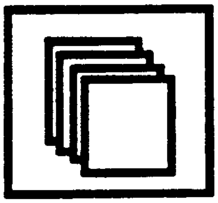


REGIONAL BUSINESSES WHO REPROCESS, RE-MANUFACTURE, INVENTORY, AND REDISTRIBUTE OLD TIRES (IN THIS CASE AS SOAKER HOSE)

ANY PROCESS USING SOAKER HOSE IN AN ENVIRONMENTALLY SAFE MANNER



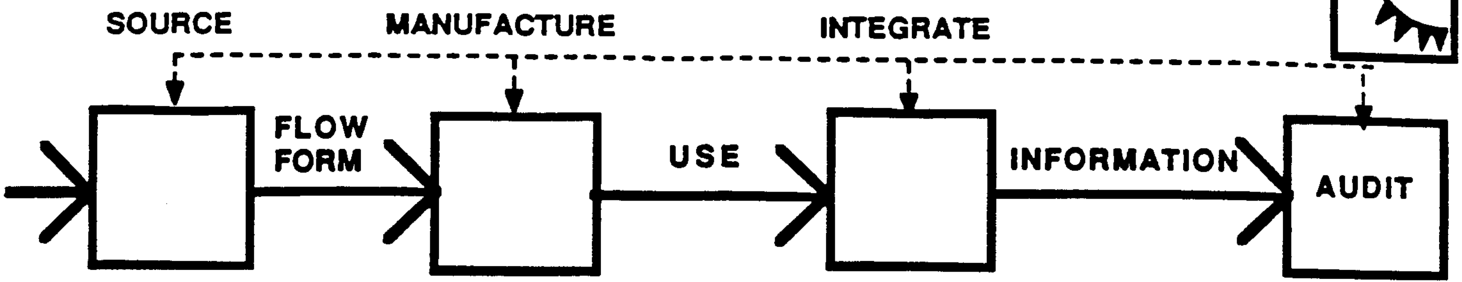
WHEN SOAKER HOSE IS USED IN AN INTEGRATED APPROACH WITH OTHER ENVIRONMENTAL ISSUES SUCH AS BURYING IT BELOW A GARDEN THAT USES ORGANIC COMPOST AND SOIL



WHEN THE USER HAS AUDITED (CHECKED INTO) ANY POSSIBLE SIDE EFFECTS OF USING TIRES IF POSSIBLE INCORPORATING ACCEPTED TESTING PROCEDURES FOR TOXINS ETC.

Main headings under the four principal sequences appear in the next eight pages. The main headings, or principal icons beginning at the left of the page, are the key to successful identification of sequences that network through the rest of the icons. It should be noted that the interactive field matrices, which follow in the last four pages of Section XVI, represent a first draft of sequencing in matrix form.

ENERGY



RENEWABLE
DIRECT SOLAR
EARTH
SOIL TEMP.
WATER TEMP.
GEOTHERMAL
CLIMATIC
AIR TEMPER
AIR MOVEMENT
PRECIPITATION
RELATIVE HUMIDITY
WATER MOVEMENT
BIOLOGICAL
VEGETATIV
BACTERIAL
NON-RENEW
PETROLEUM BASED
NUCLEAR BASED

SOLID

LOGGED WOOD

CHIPPED WOOD

PELLETIZED

PRESSED BIOMASS

LIQUID

GAS

DIESEL

ETHANO

METHAN

GAS

PROPANE

BUTANE

NATURAL GAS

COMPRES ED AIR

METHANE

HYDROGE

CARBON MONOXID

DIRECT USE
SOLAR THERMAL
INTERNAL COMBUST
SOLAR MECHANIC
WIND MECHAN
SOLAR ELECTRIC
WIND ELECTRIC
MECHANIC ELECTRIC
ELECTRIC LIGHT
ELECTRIC THERMAL

LANDSCAPE

- SOLAR ACCESS
- SHADE
- WIND PROTECT
- WIND HANNEL

ACE

'ASSIVE EAT
'ASSIVE OOLING
ORCED ENT.
EHUMIDI-CATION
IECHANIC IR CONDIT

SANITARY

- HOT WATER
- WASH. MAC
- DISH WASH
- POT. WATER TREAT
- WATER STORAGE

FOOD PREP

- FOOD PRODUCTIO
- FREEZE STORAGE
- COLD STORAGE
- COOL STOR
- DRY STORAGE
- FOOD COOKING

LIGHTING

- NATURAL
- ENERGY
- CONSERVIN
- CONVENTIO

RECREATION

- SWIM POOL
- LAKE

CONTROL
REDUCE
DIRECT
PROGRAM
CONSERVE
WEATHERIZE
RESTRICTIVE USE
FLOW EFFICIENCY
[illegible]
GREY WATER HEAT RECOVERY
AIR CONDITIONER HEAT RECOVERY
REFRIGERATOR HEAT RECOVERY
LIGHT HEAT COLLECTION
[illegible]
STORE
HEAT STORAGE
[illegible]
[illegible]
[illegible]

INFORMATION INTEGRATION

LANDSCAPE BIOMASS

METHANE FROM SEWAGE

WATER TO WATER HEAT PUMP

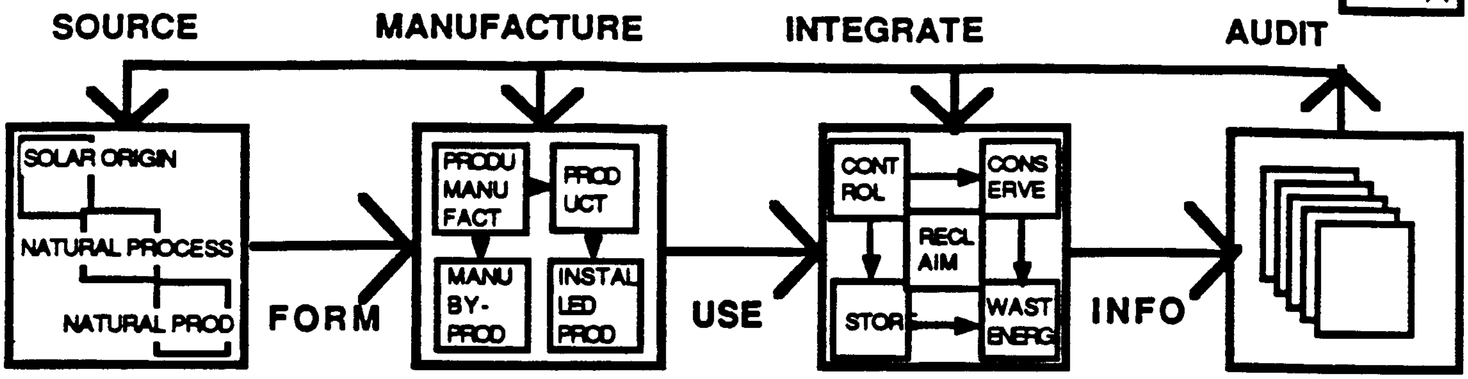
HYDROGEN SYSTEM

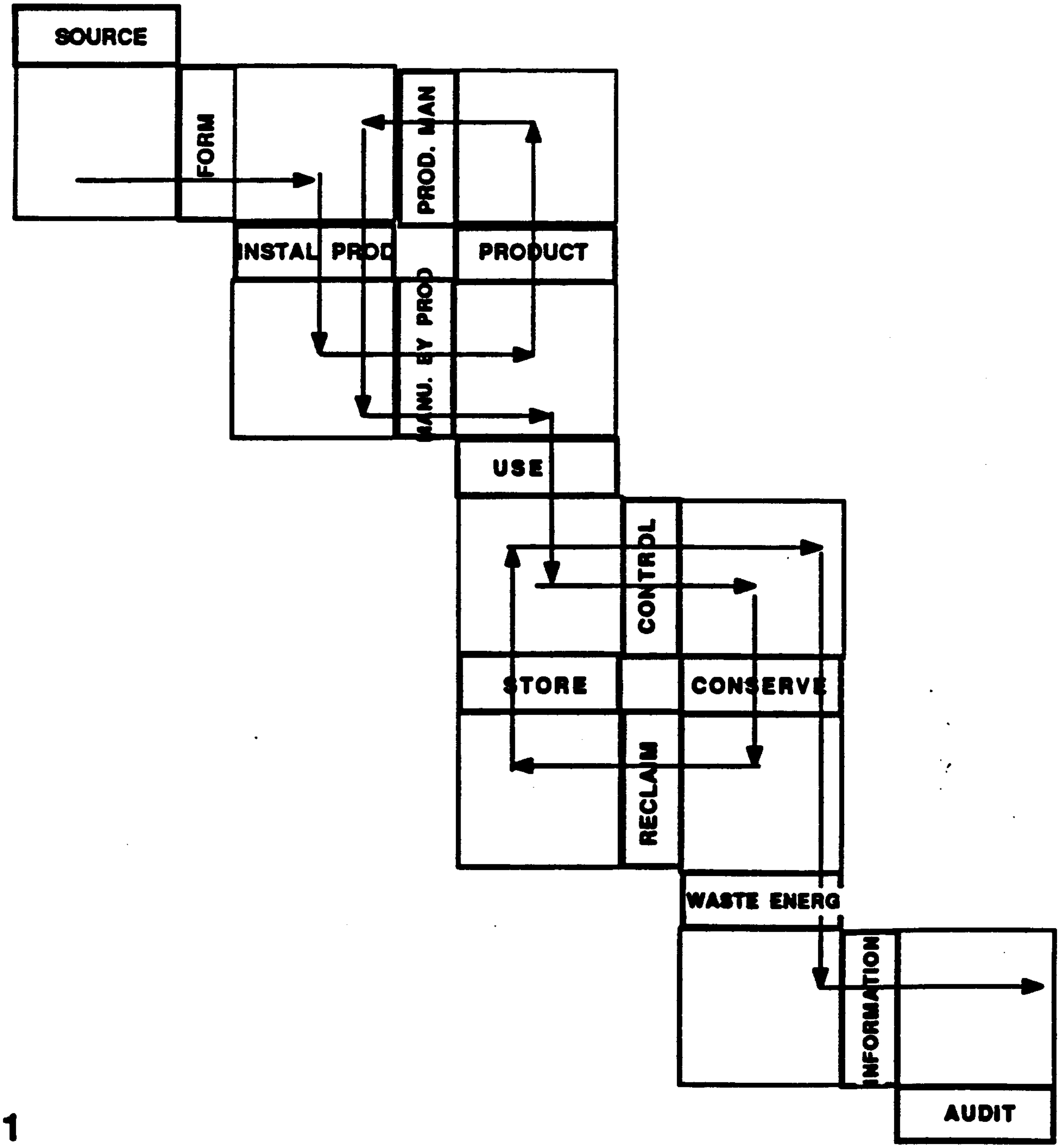
TOTAL ENERGY SYSTEM

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
ENVIRONMEN IMPACT
AIR
WATER
SOIL
SPECIES
[illegible]
PEAK LOAD SHAVING
ECONOMIC DEVELOPMEN OPORTUNITIE

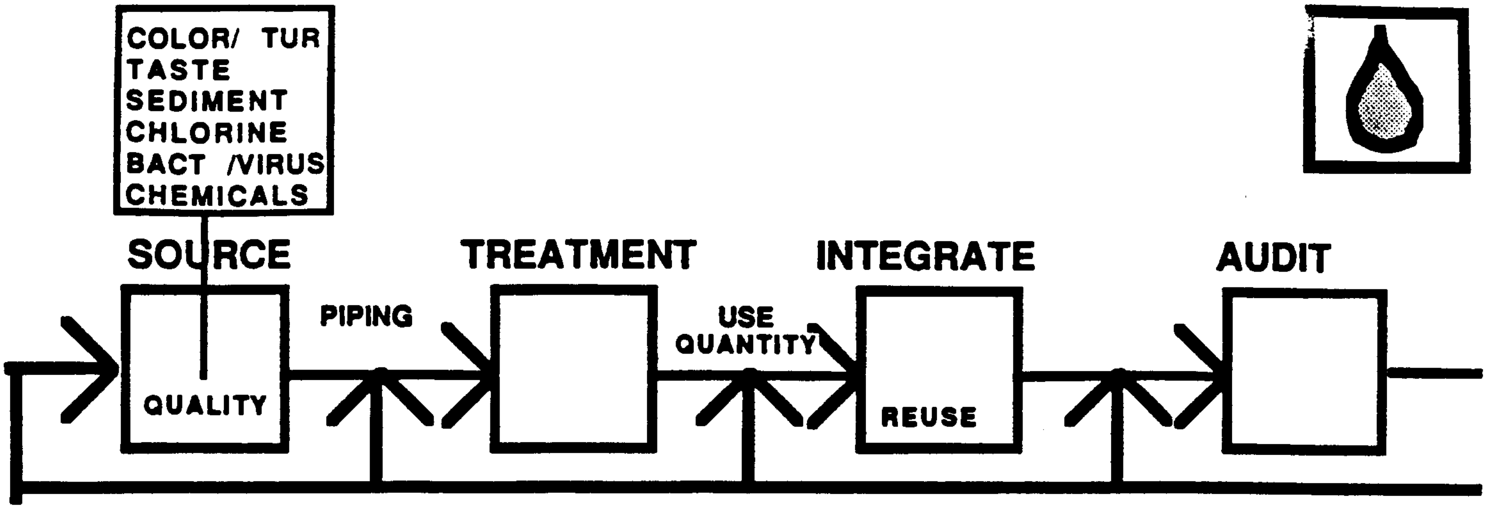
6/4/91

ENERGY


SOURCE
MANUFACTURE
INTEGRATE
AUDIT
SOLAR ORIGIN
NATURAL PROCESS
NATURAL PROD
FORM
PRODU MANU FACT
PROD UCT
MANU BY-PROD
INSTAL LED PROD
USE
CONT ROL
CONS ERVE
RECL AIM
STOR
WAST ENERG
INFO


SOURCE
FORM
PROD. MAN
INSTAL PROD
PRODUCT
MANU. BY PROD
USE
CONTROL
STORE
CONSERVE
RECLAIM
WASTE ENERG
INFORMATION
AUDIT

6/4/91



PRECIPITATION

SURFACE WATER

GROUND WATER

CITY

RECYCLED

COPPER

LEAD SOLDER

IRON

GALVANIZED

PVC

CPVC

SEDIMENTATION

CHARCOAL

OZONATION

REVERSE OSMOSIS

ACTIVATED CARBON

GREASE TRAP

LANDSCAPE

COMMODE

SHOWERS

SANITARY

DISHWASH

WASHING MACHINE

GARBAGE DISPOSAL

HOUSE PLANT WATERING

RECREATION

SHRUBS

GARDEN

ARTIFICIAL WETLAND

LAWN ABSORPT

COMMODE FLUSH

NON-POTABLE SINK

NON-POTABLE SHOWER

SOAP

ORGANIC

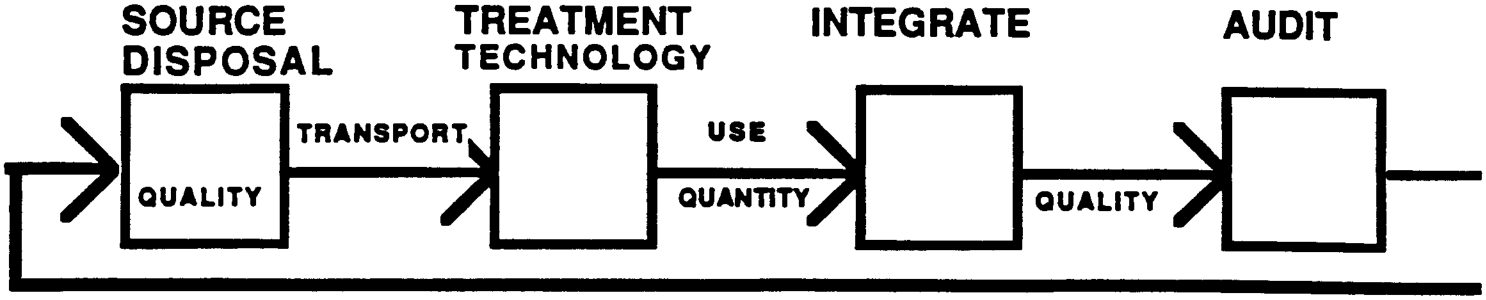
BACTERIA

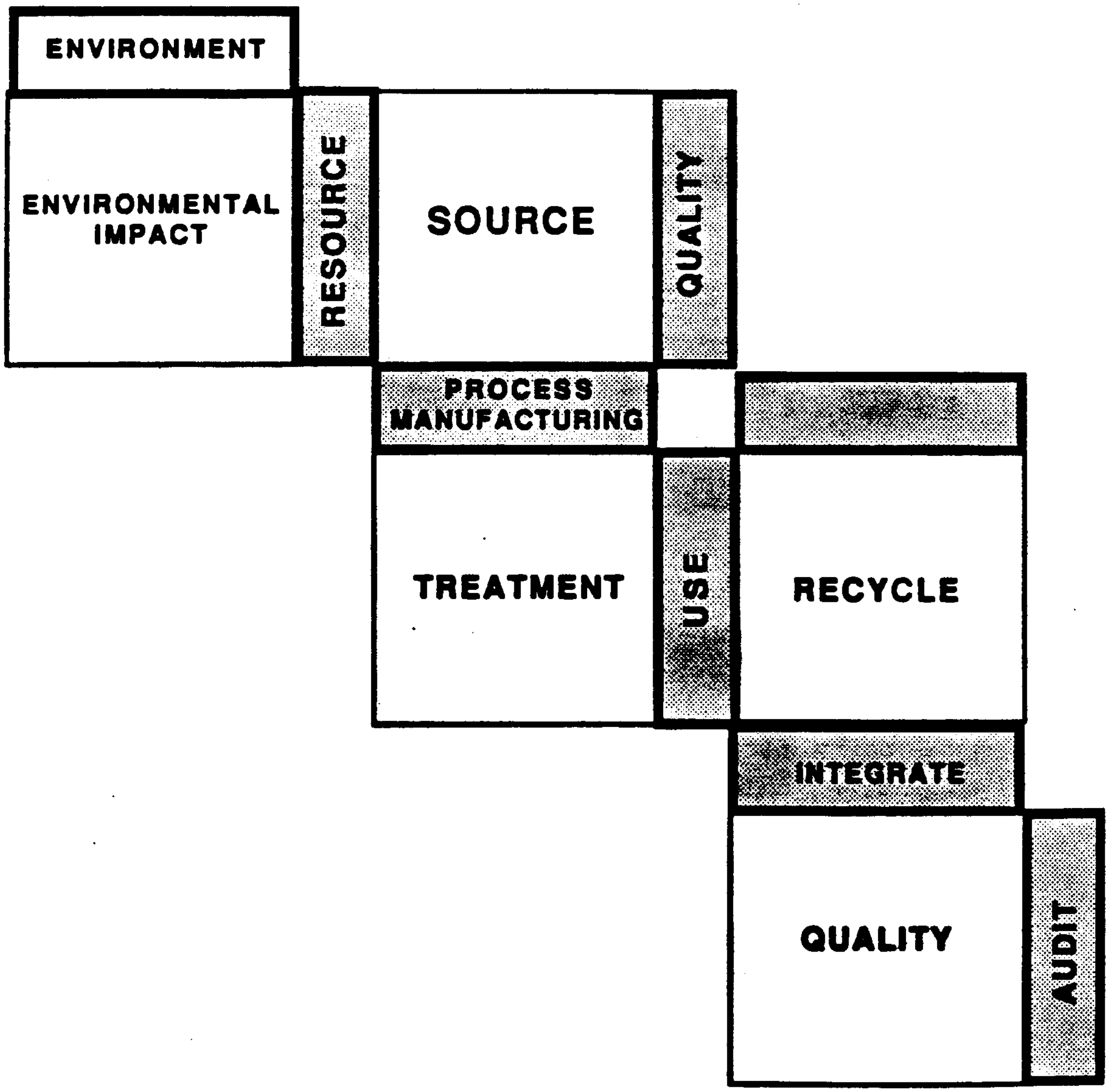
VIRUS

CHEMICAL

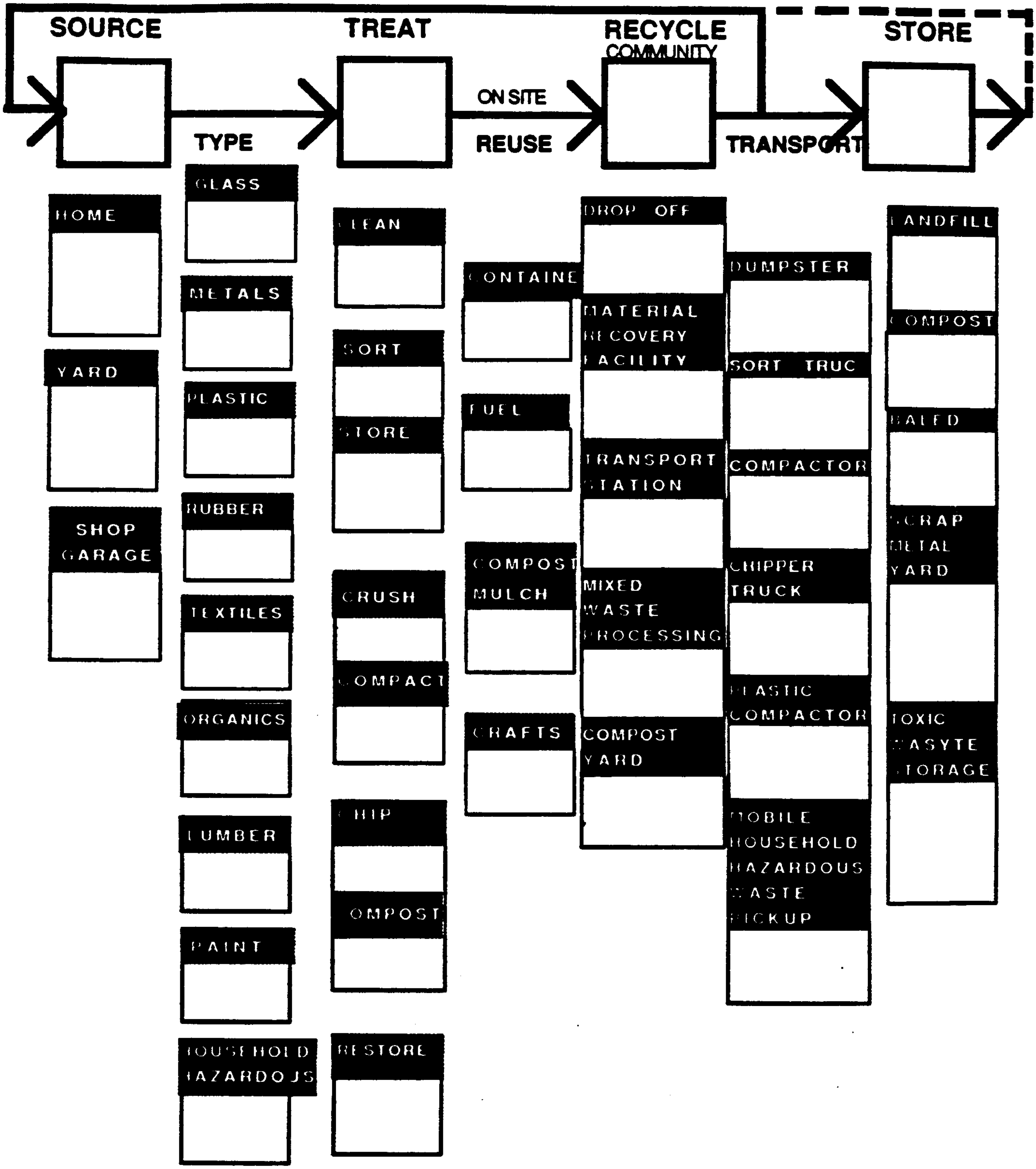
SEPTIC TANK

SEWER

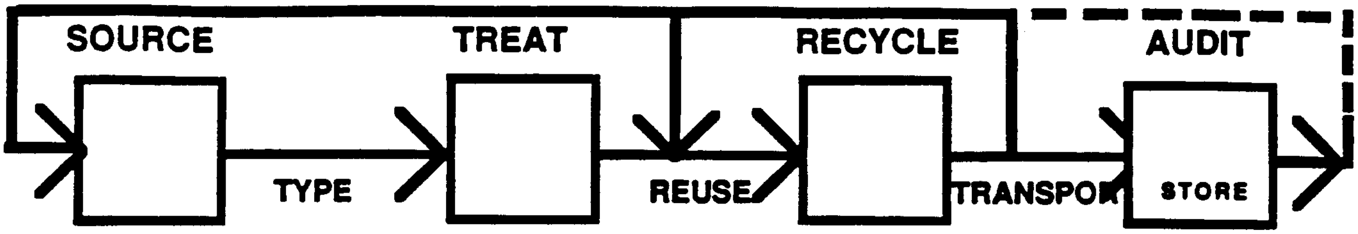

SOURCE DISPOSAL
TREATMENT TECHNOLOGY
INTEGRATE
AUDIT
QUALITY
TRANSPORT
USE
QUANTITY
QUALITY

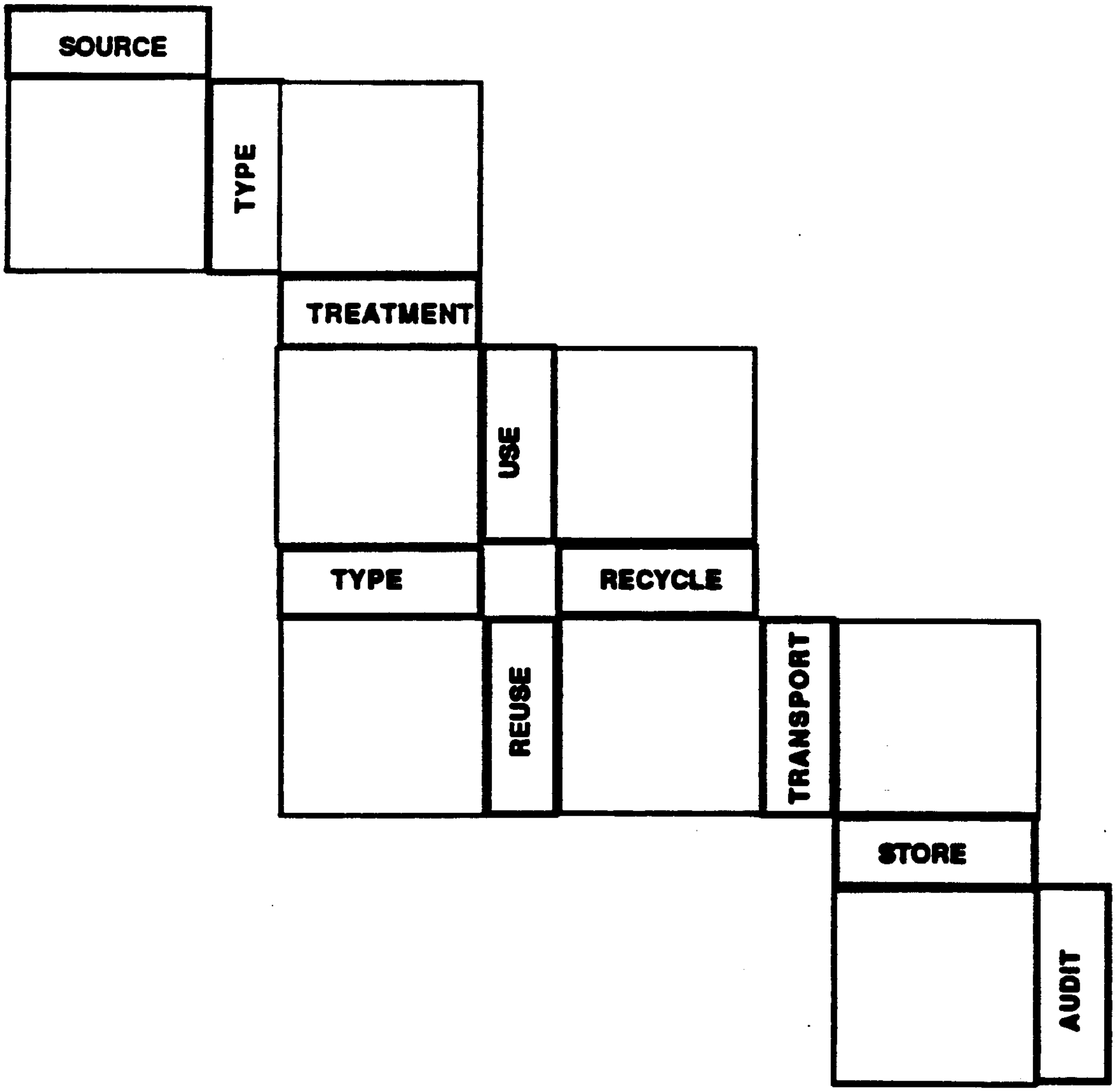

ENVIRONMENT
ENVIRONMENTAL IMPACT
RESOURCE
SOURCE
QUALITY
PROCESS MANUFACTURING
TREATMENT
USE
RECYCLE
INTEGRATE
QUALITY
AUDIT

SOLID WASTE

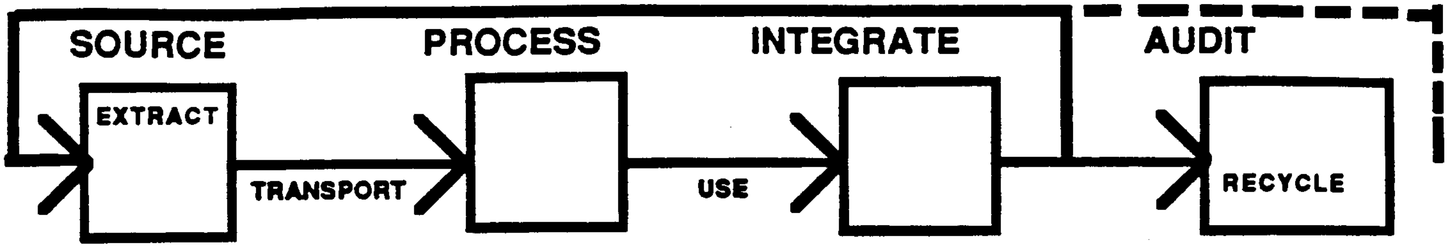

SOURCE
TREAT
RECYCLE
COMMUNITY
STORE
TYPE
ON SITE
REUSE
TRANSPORT
HOME
YARD
SHOP GARAGE
GLASS
METALS
PLASTIC
RUBBER
TEXTILES
ORGANICS
LUMBER
PAINT
HOUSEHOLD HAZARDOUS
CLEAN
SORT
STORE
CRUSH
COMPACT
CHIP
COMPOST
RESTORE
CONTAINE
FUEL
COMPOST MULCH
CRAFTS
DROP OFF
MATERIAL RECOVERY FACILITY
TRANSPORT STATION
MIXED WASTE PROCESSING
COMPOST YARD
DUMPSTER
SORT TRUC
COMPACTOR
CHIPPER TRUCK
PLASTIC COMPACTOR
MOBILE HOUSEHOLD HAZARDOUS WASTE PICKUP
LANDFILL
COMPOST
BALED
SCRAP METAL YARD
TOXIC WASYTE STORAGE

SOLID WASTE


SOURCE
TREAT
RECYCLE
AUDIT
TYPE
REUSE
TRANSPORT
STORE


SOURCE
TYPE
TREATMENT
USE
TYPE
RECYCLE
REUSE
TRANSPORT
STORE
AUDIT

MATERIALS



- SOIL MINERAL
- VEGETATIVE DEBRE
- FOREST PRODUCT
- AGRICULT.
- PETRO-CHEMICAL
- ON SITE
- BY-PROD. RECOVERY

- DIRT/ STONE TRUCKING
- LUMBER TRUCKING

- LUMBER
- MILLING
- FIRE KILN
- PRESS
- POUR MOLD
- GLUE

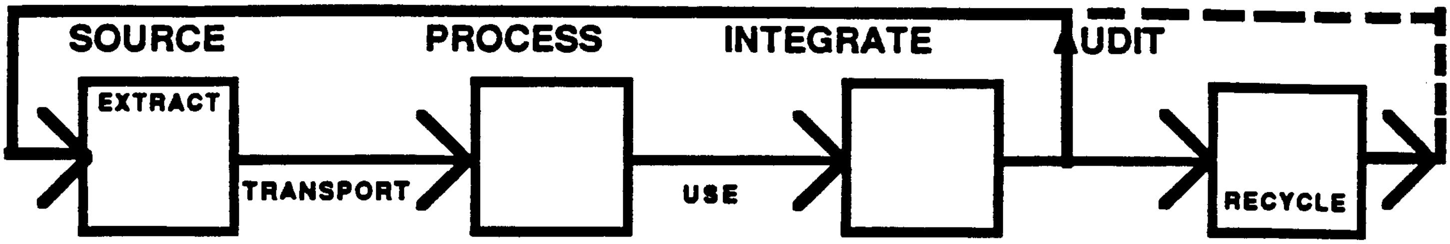
- FOUNDATION
- EXTERIOR WALL
- ROOF
- WINDOWS
- INTERIOR PARTITIN
- FLOOR
- DOOR / TRIM

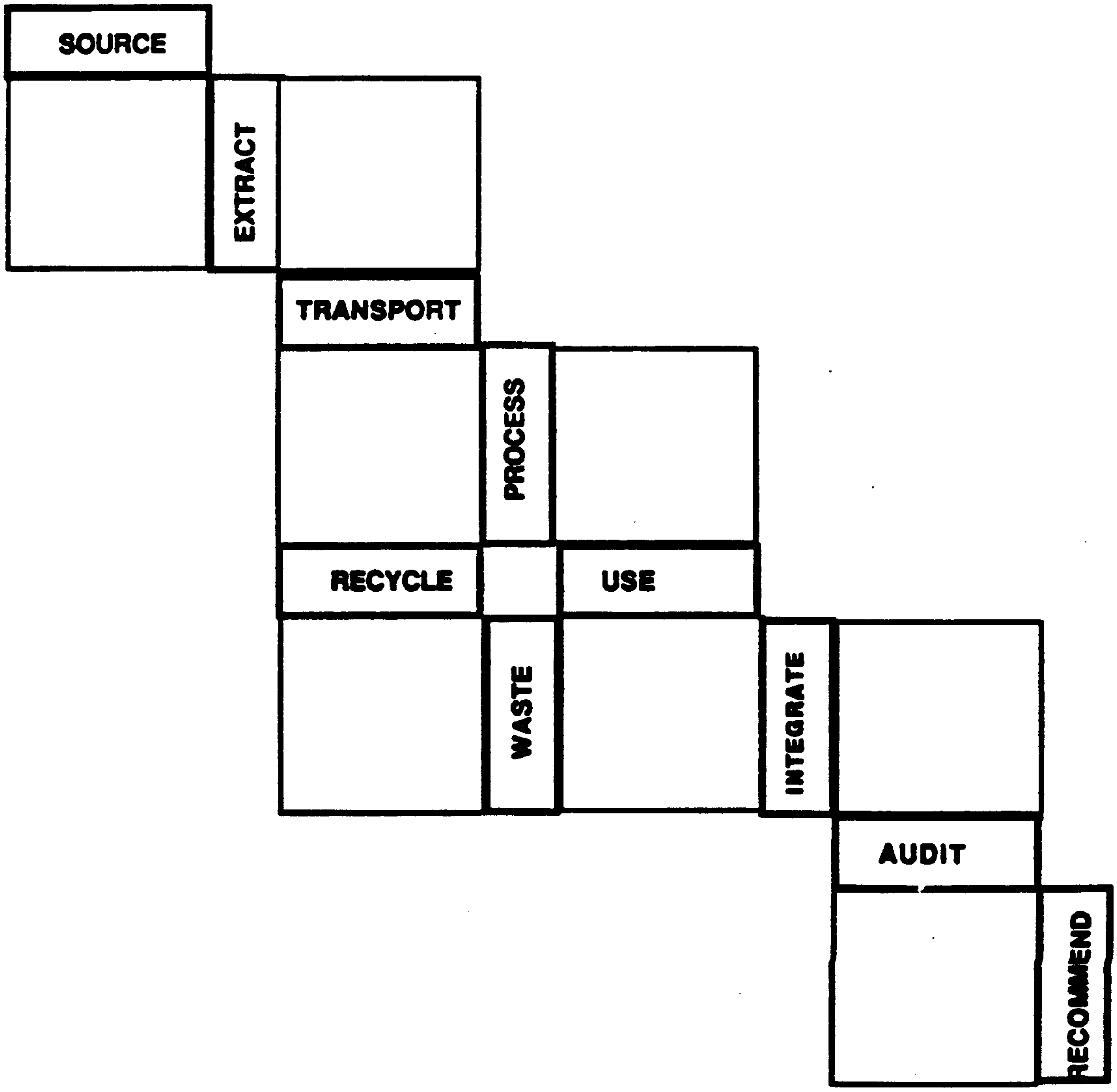
- INTEGRATE WITH ENERGY BY-PRODUCTS
- INTEGRATE WITH SOLID WASTE BY-PRODUCTS
- INTEGRATE BY-PRODUCTS OF MATERIAL INDUSTRY
- INTEGRATE WITH BY-PRODUCTS OF AGRICULTURE

- TOXICITY TO WORKERS
- TOXICITY TO USERS
- TOXICITY TO ENVIRONM.

- CONSTRUCTION REUSE
- FUEL REUSE
- USED MATERIAL STORAGE
- LUMBER SALVAGE DEPOT
- MULCH

MATERIALS


SOURCE
PROCESS
INTEGRATE
AUDIT
EXTRACT
TRANSPORT
USE
RECYCLE


SOURCE
EXTRACT
TRANSPORT
PROCESS
RECYCLE
USE
WASTE
INTEGRATE
AUDIT
RECOMMEND

XVII. Operating a Sustainable System Based on High Levels of User Participation

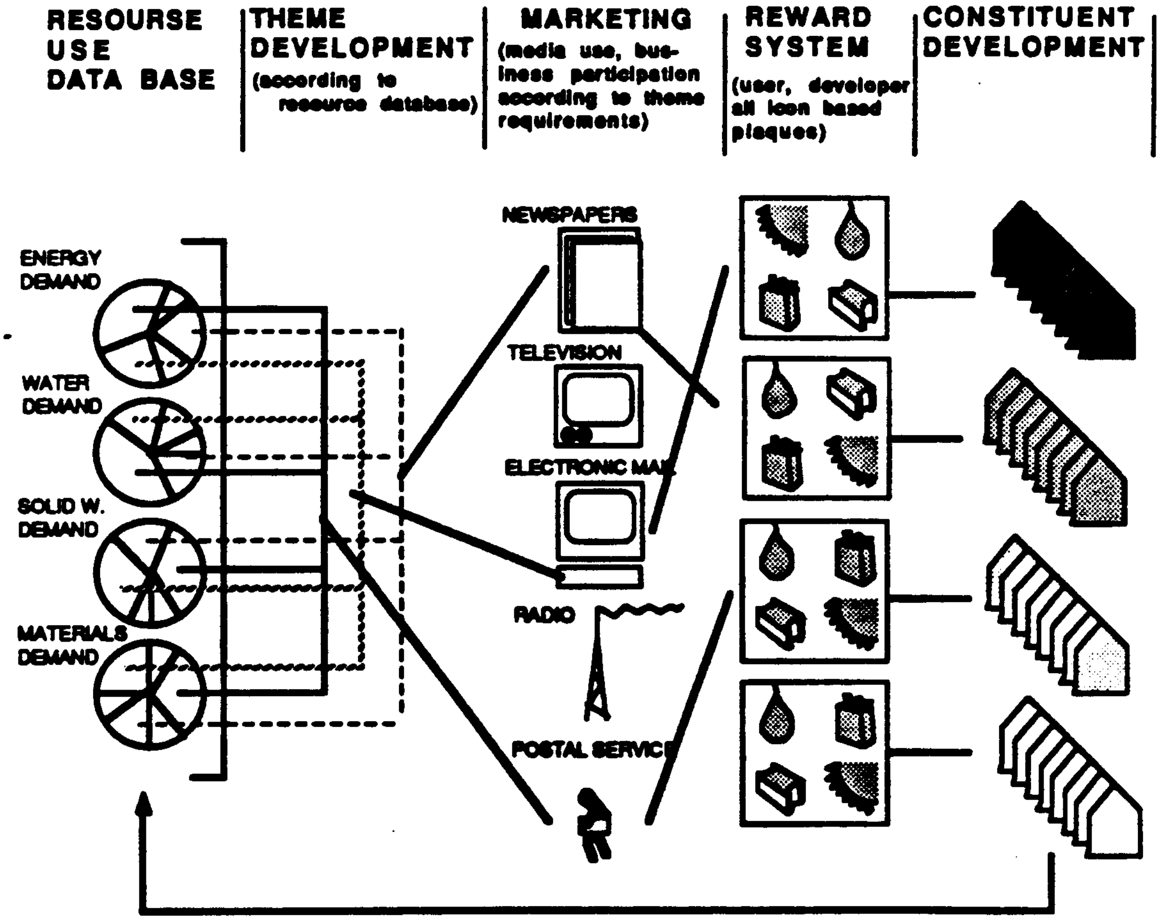
User participation is the key to making icon-based sustainability a reality. The better the user participation, the more likely it is for market demand forces to fall in to place to support the businesses and products that relate to the community's overall sustainability needs, and for the city to track (monitor) the effectiveness of previous actions. This feedback loop is continuous; therefore, the emphasis constantly changes resulting in slightly different scenarios over time.

If, for example, certain previously unknown issues relating to water were to require attention, the program would provide a method through which the city could alert the public, through the media and other public information outlets, of appropriate responses over a certain time period. Such a method is currently used in cases of severe water or energy shortages.

Essentially, the city's method to communicate overall resource and environmental conditions to the public, resulting from efficient monitoring and other feedback mechanisms, is through the use of sustainability themes that become familiar symbols in various local media, and are supported by reward systems.

The program's ability to successfully respond to evolving ecological patterns relies on a consistent communication language shared between the city, program users. This model emphasizes the need to develop such a communication tool at multiple levels, without undermining its basic commitment to the rules of sustainability. The diagram below expresses the operational aspects of the program. The appendix illustrates how icon-based modeling can be brought to a far more specific level through computer modeling efforts which demonstrate the effect that recognition of entire sequences in sustainability terms has on overall resource use (as shown in this case for water.)

FINAL OPERATIONAL MODEL SHOWING USER PARTICIPATION RELATIVE TO CITY-WIDE NEEDS



XVIII. Modeled Examples of Integration Vs. Conservation and their Relationship to Rating Procedures

The three previous examples are now evaluated using a mathematical model based on the same users and conditions. The results show that a normal, non-conserving mode resulted in a 70,272 gallons per year total water use as compared to a 39,492 gallons per year total for water conserving techniques. When this is compared to a fully integrated home with a yard, including a 600 square foot garden, greywater reuse, yet without standard conservation measures (low-flush toilets, flow restrictors, etc.) total dependence on city water dropped to 29,099 gallons per year. Adding a low-flush toilet to this example, savings dropped even further to 25,194 gpy. Moreover, if the toilet was replaced with a composting unit, using no water, savings could be even greater, with a total water use of 15,978 gpy.

Conclusions

One: Fully integrated conserving systems can reduce water consumption by 85.9% as opposed to 43.8% savings for non-integrated conserving systems.

Two: Integration saves 13.7 times as much energy than the conservation example just from reduced water pumping demand. Conservation through integration saves considerably more pumping energy from equivalent to unit water savings cubed.

Three: The relationship between binary rating and resource conservation is one of setting up a proper framework to enable the user to think in terms of sustainable, integrated methods instead of only in conservation terms. The actual benefits are far greater than those indicated by the rating system if one were to compare total rating to total resource savings. By operating under a simple premise, thus enabling higher participation levels, far greater overall benefits would be achieved.

Four: Rather than simply recycling and closing loops, i.e. making the loop as short as possible, technologies are chosen that keep loops open. For example, it is obvious that greywater could be directed to meet a toilet's water needs, as is advocated by some companies. However, from an integration perspective, greywater was instead directed towards a greywater treatment plant (a small wetland marsh,) rather than an all physical treatment greywater system. This choice enables the resulting biomass to be used as mulch, compost, etc.

Five: As in natural systems, storage is a critical function as to the functional success of an integrated system. This is because when integration utilizes unpredicatable sources, such as rainwater, the storage enables the system to maintain operation. The above example used a cistern that was 6000 gallons and was designed to make up the entire three foot high crawl space of a 2000 square foot single family residence. This cistern could also be utilized as a heat sink for heating and cooling the building.

Six: Users without access to resources, such as is the case with Austin's 52% renter population (described as living unit occupants in the model) are limited to simple conservation procedures. They are to a large degree dependent on decisions made by developers and incentive programs and ordinances promulgated by the City in terms of their access to, or potential to access, integrative uses and technologies.

EXAMPLE #1

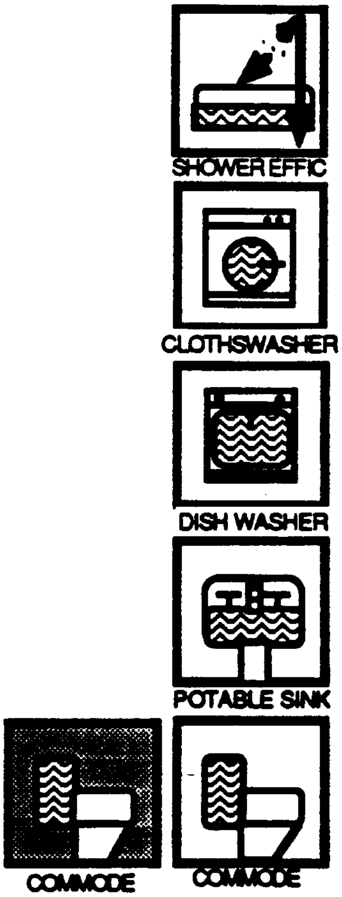
NOTE;
MODEL SHOWS
WATER CONSERVING
TOILT FIXTURES
MADE IN AUSTIN

SUSTAINABLE
RATING # = 6

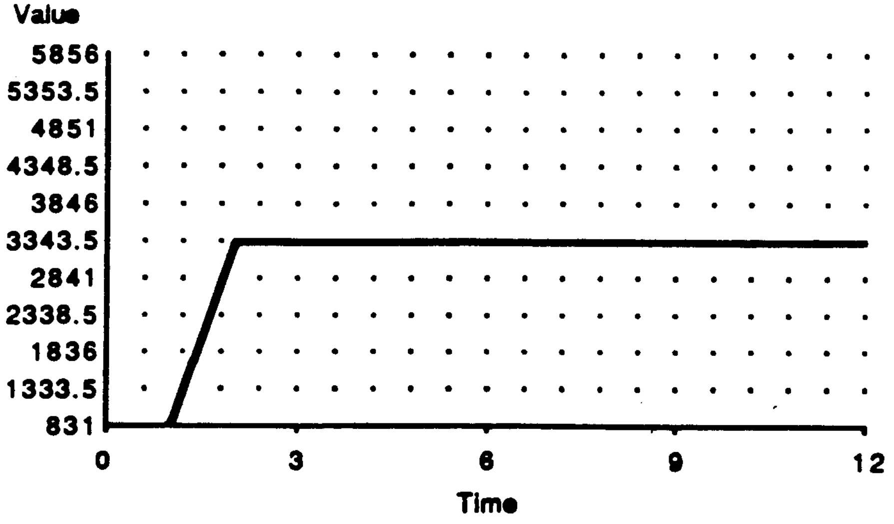
WATER
CONSERVATION
QUANTITY OVER NON
CONSERVING FAMILY
WITH NO GARDEN = 43.89

ENERGY CONSERVATION
QUANTITY OVER NON-
CONSERVING FAMILY
WITH NO GARDEN.
IS EQUAL TO - 5.8 TIMES

EXAMPLE ONE - LIVING UNIT



(8) Example One: Conserving Us....



3

Example Two: Conserving Vs. Non-Conserving Water Use

(8) Example One (Living Unit, N... - Plot Data Table

Time	Conserving
0	831
1	3291
2	3291
3	3291
4	3291
5	3291
6	3291
7	3291
8	3291
9	3291
10	3291
11	3291
12	3291

EXAMPLE #2

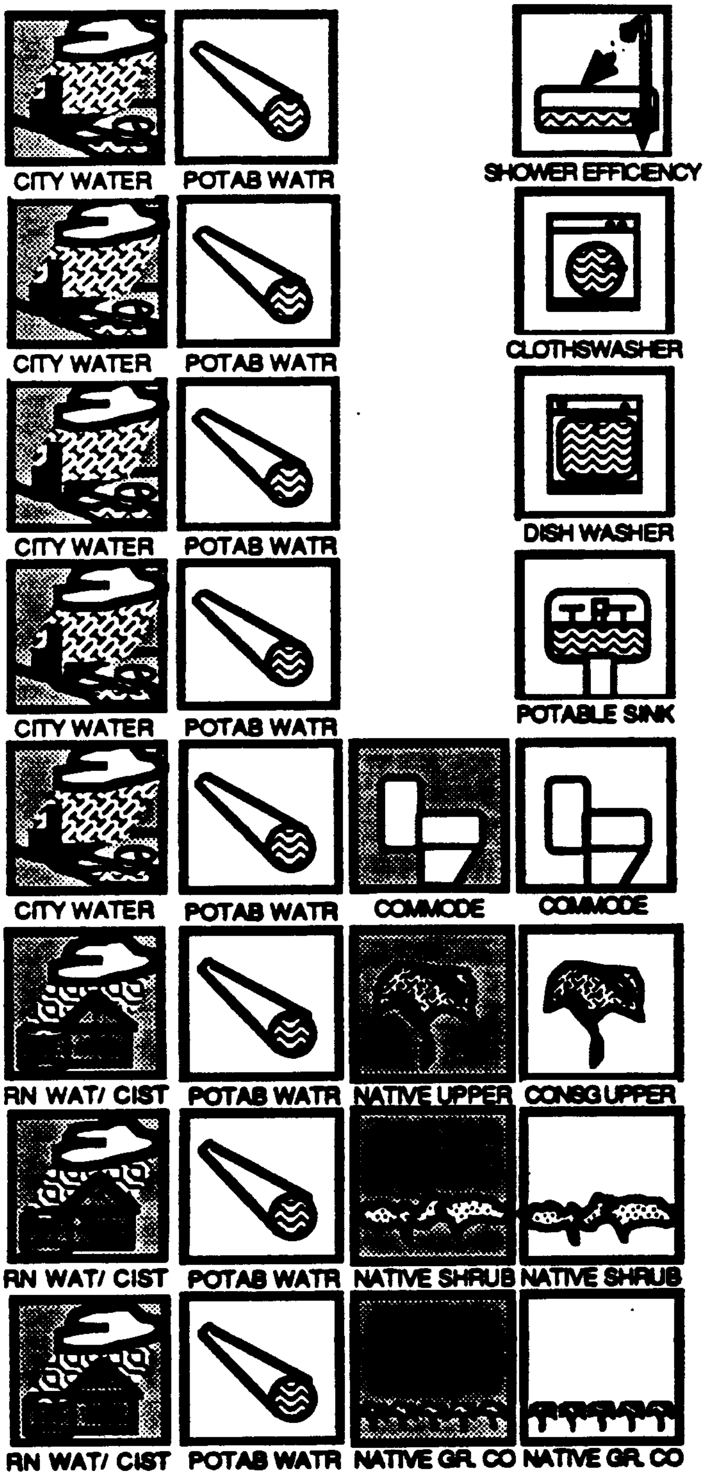
NOTE;
MODEL SHOWS WATER CONSERVING XERISCAPE USING RAINWATER

SUSTAINABLE RATING # = 28

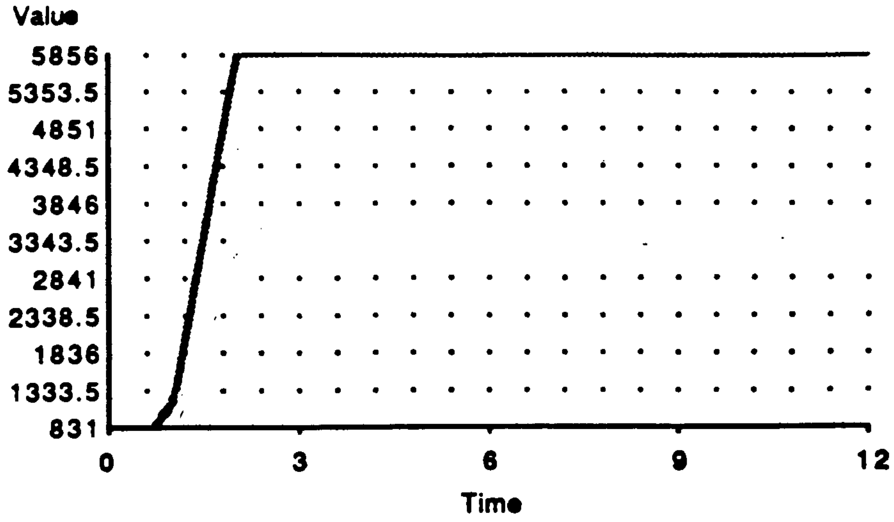
WATER CONSERVATION QUANTITY OVER NON CONSERVING FAMILY WITH . HIGH WATER LANDSCAPE AT 1200 SF = 55.9%

ENERGY CONSERVATIO QUANTITY OVER NON-CONSERVING FAMILY WITH HIGH WATER LANDSCAPE = 11.7 TIME LESS ENERGY

EXAMPLE TWO CONSERVING UNIT WITH YARD



(8) Example Two: Conserving Vs....



4 Example Two: Conserving Vs. Non-Conserving Water Use

(8) Example Two: Conserving Vs.... - Plot Data Table

Time	Conserving		Not conserving
0	0		0
1	1181		1181
2	4224		5856
3	4224		5856
4	4224		5856
5	4224		5856
6	4224		5856
7	4224		5856
8	4224		5856
9	4224		5856
10	4224		5856
11	4224		5856
12	4224		5856

EXAMPLE #3

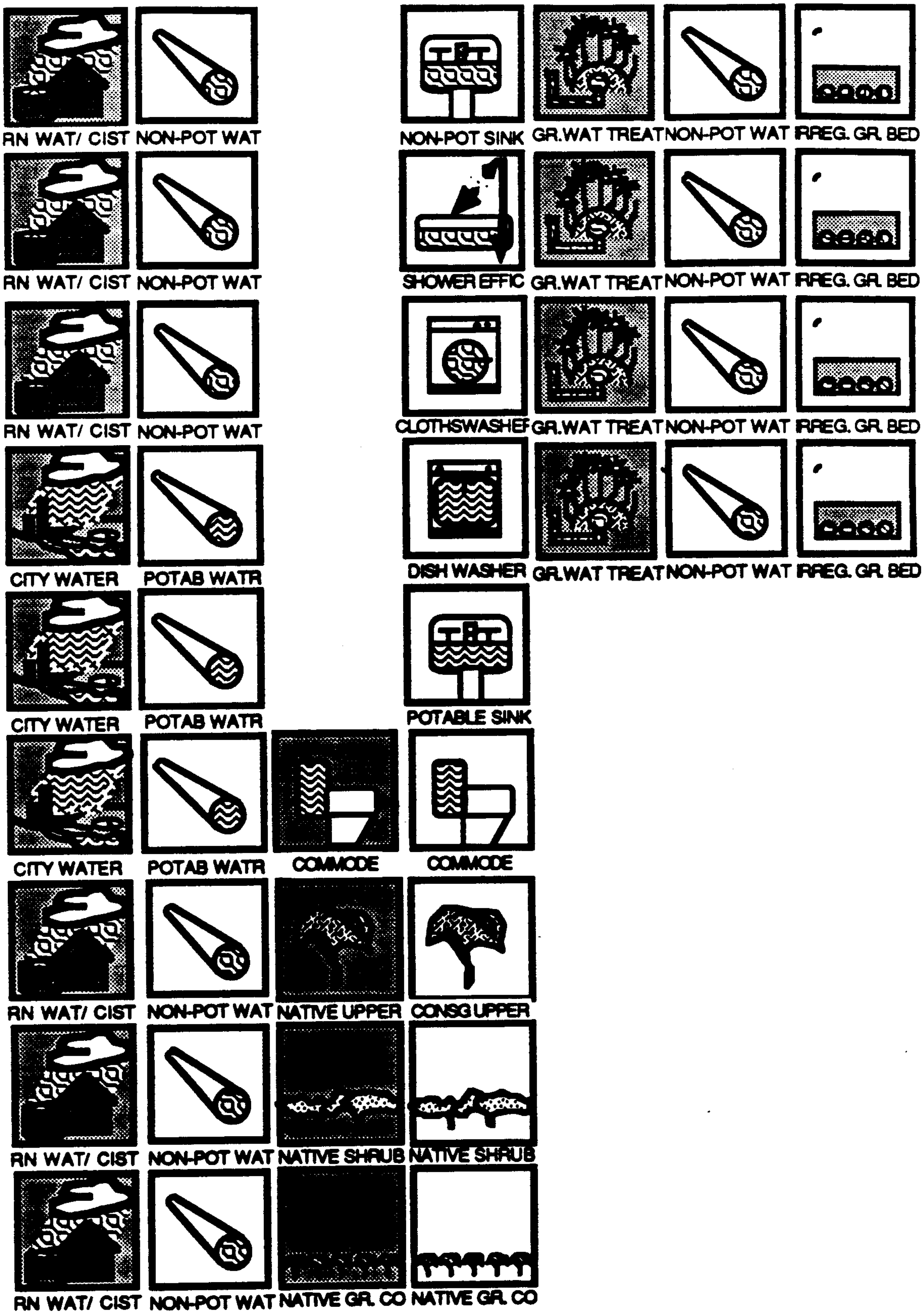
NOTE:
ICON MODEL SHOWS
WATER CONSERVING
FLUSH TOILET NOT
COMPOST PRIVY

SUSTAINABLE RATING # = 43

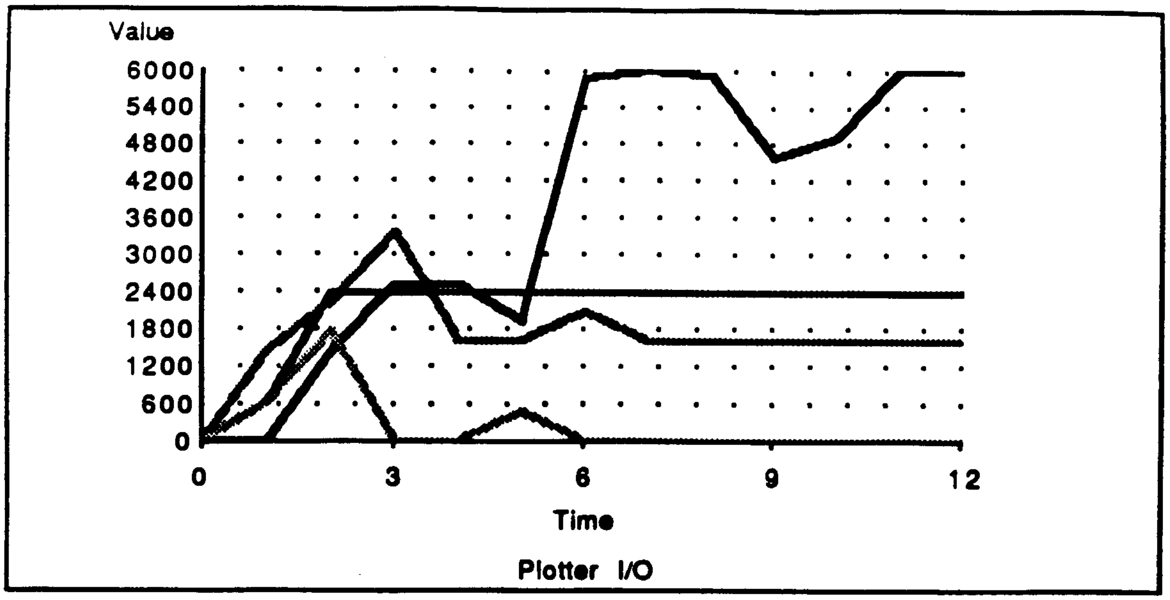
WATER
CONSERVATION
QUANTITY OVER NON
CONSERVING FAMILY
WITH NO GARDEN AND
WATER CONSERVING
LANDSCAPE= 75.6%
W. COMPOST PRIVY=85.9

ENERGY CONSERVATION
QUANTITY OVER NON-
CONSERVING FAMILY
WITH NO GARDEN NOR
WATER CONSERVING
LANDSIS EQUAL TO = 69
TIMES LESS ENERGY OR
COMPARED TONO ENERG
USING COMPOST

EXAMPLE #3 INTEGRATED HOUSE & YARD



(11) Plotter I/O



(11) Plotter I/O - Plot Data Table

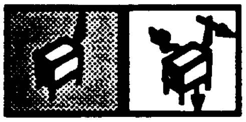
Time	Cistern Storage	Total Nonpotabl	Indoor (All App	Indoor (NonPota
0	0	0	0	0
1	0	617	1432	617
2	1426.625	2356	2216	1739
3	2503.743	2356	3338	0
4	2488.3	2356	1599	0
5	1904.437	2356	1599	451.5635
6	5873.684	2356	2050.563	0
7	6000	2356	1599	0
8	5906.539	2356	1599	0
9	4553.635	2356	1599	0
10	4894.848	2356	1599	0
11	6000	2356	1599	0
12	6000	2356	1599	0

Finally we include graphic representations of icon sequences from a simple living unit to one of full scale sustainability in abstract graphic form only in order to demonstrate the extent to which graphics alone can show the process.

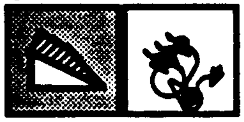
ATTACHED UNIT EXAMPLE

A B C D E F

ENERGY EN - BM - 1

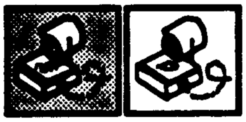


ENERGY EN - SHW - 2

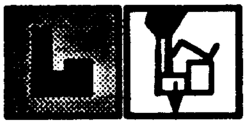


WATER WA - C - 1

SOLID WASTE SW-T-4

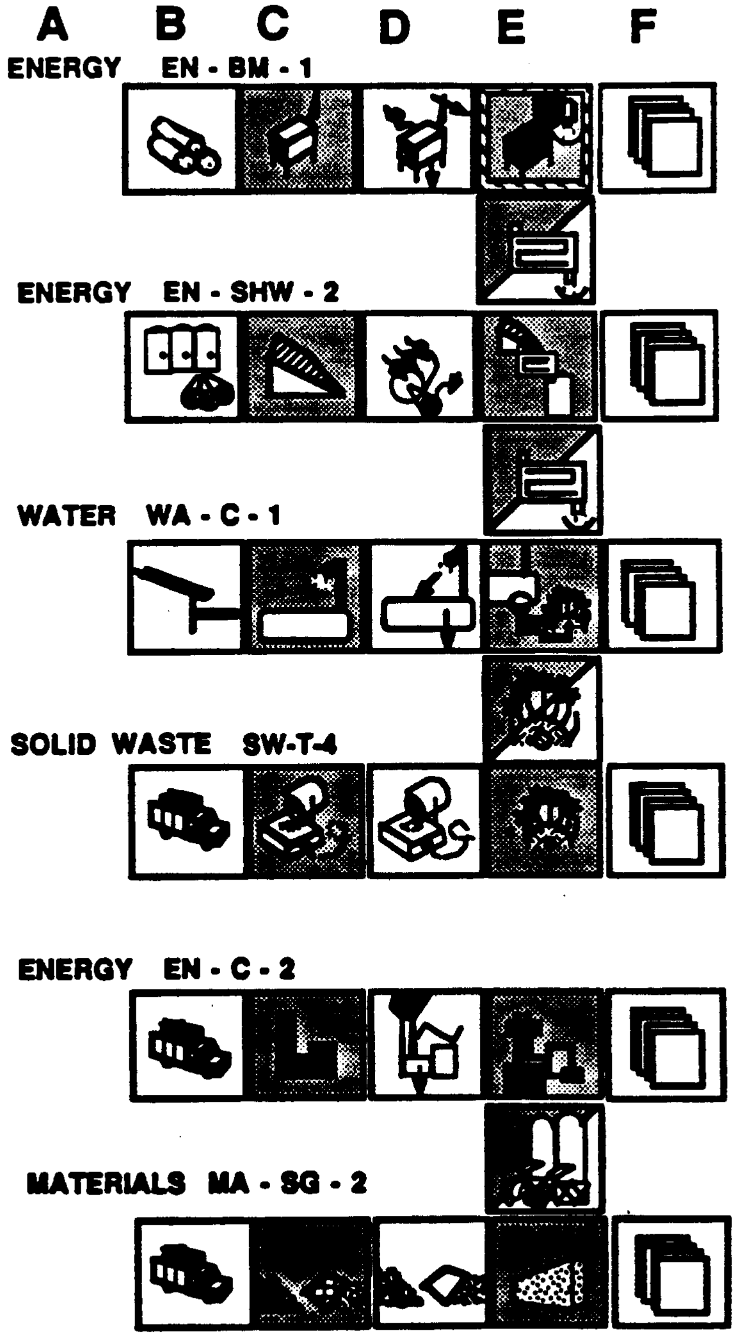


ENERGY EN - C - 2

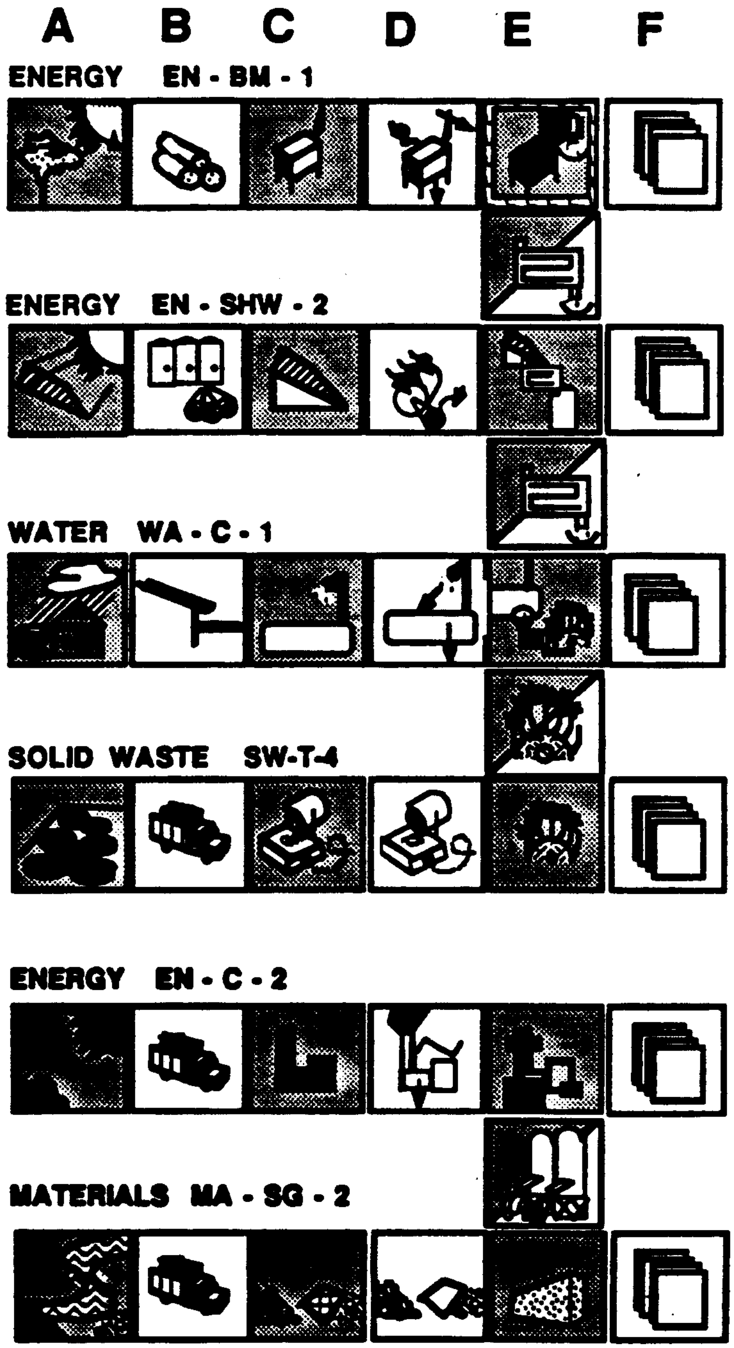


MATERIALS MA - SG - 2

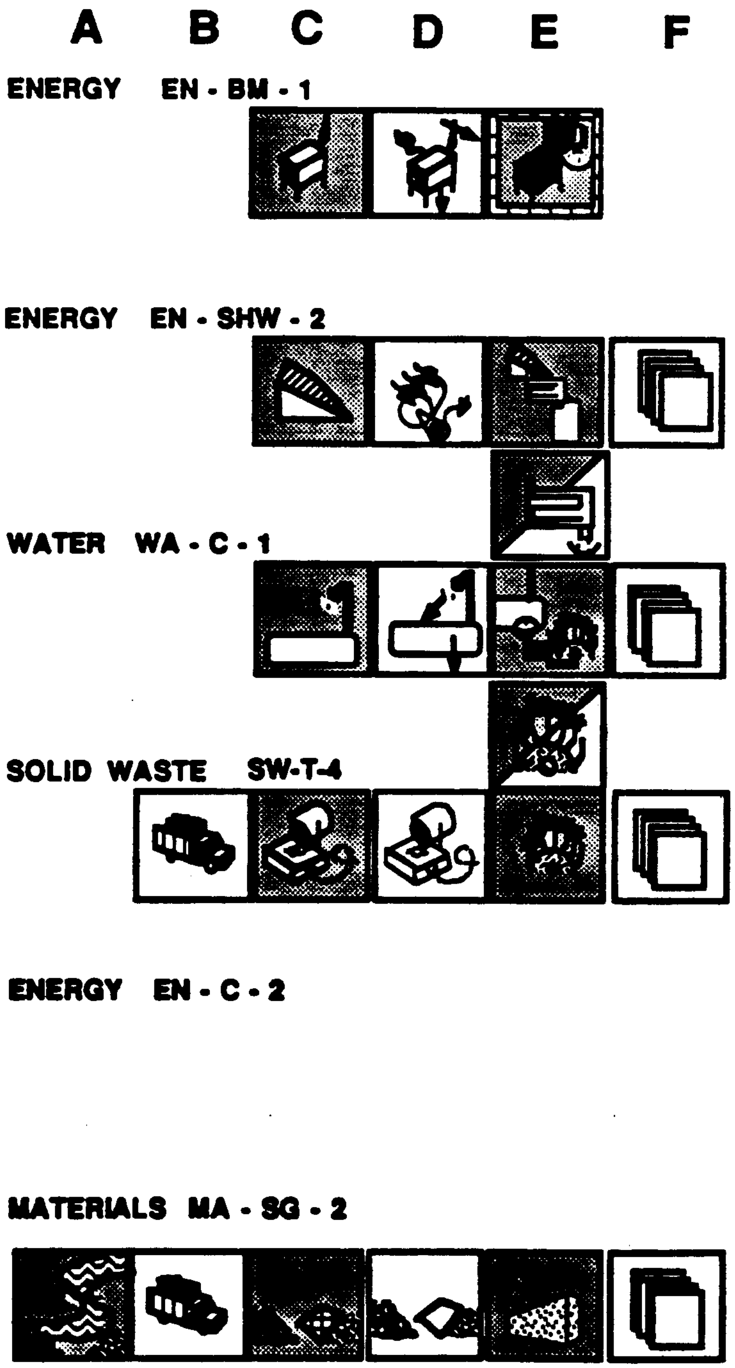
HOME WITH YARD EXAMPLE



NEIGHBORHODD DEVELOPMENT EXAMPLS



SCORING EXAMPLE



TOTAL
SCORE 25

HOUSE AND YARD RATING

NAME:
ADDRESS:
ZIP:

SCORE CARD

ENERGY

WATER

SOLID WASTE

MATERIALS

SYSTEM	LINKAGE SEQUENCE						SCORE
	A	B	C	D	E	F	
	0	0	1	1	1	0	3
	0	0	1	1	1	1	4
TOTAL INTEGRATION POINTS					1 1		2
	0	0	1	1	1	1	4
TOTAL INTEGRATION POINTS					1		1
	0	1	1	1	1	1	5
TOTAL INTEGRATION POINTS							
	1	1	1	1	1	1	6

TOTAL 25

Section Two: Regional Resource Assessment

REGIONAL RESOURCES

The following regional resource inventory provides general information regarding a number of indigenous materials appropriate for use in the Central Texas region.

- CALICHE
- RAMMED EARTH
- FIRED BRICK
- FLY ASH
- LIMESTONE
- SAND AND GRAVEL
- COMPRESSED EARTH BLOCK
- CONCRETE BLOCK
- STRAW
- BAMBOO
- CELLULOSE
- COTTON
- MESQUITE

The advantages of using regional resources, in terms of sustainability, are:

- local availability reduces energy costs related to transportation
- can match local business opportunities and job creation with capacity to "mine" local resources
- can establish carrying capacity boundaries, such that extraction is based on the concept of sustained yield, or, for non-renewable resources such as earth-based materials, that extraction is gauged based on maintaining ecological balance
- if production capacity established, prices are likely to be less than for imported materials since costs associated with transportation are eliminated

The advantages of tapping into the regional resource base, however, are offset by several disadvantages. Principal among these are (1) lack of commercial activity manufacturing the indigenous materials into marketed, readily available products; and (2) lack of understanding about the properties of indigenous materials among local building code officials, resulting in difficulty in incorporating their use in building projects requiring code approval. This is particularly true when operating under stringent time and/or budget constraints.

While these obstacles seem formidable, they should be evaluated as to their bases and addressed in an organized fashion to bring about a code and market condition that is consistent with the sustainability objectives highlighted through the City of Austin's Sustainable Star Rating Program and associated Green Builder Program.

CALICHE

Caliche is derived from calcium carbonate-based soils and limestone bedrock, of which there are abundant supplies in the Austin area. Perhaps best known as a road-bed material and primarily marketed as such, caliche can be processed into low-cost unfired building block, stabilized with 5% to 10% cement, depending on the purity of the source. Though there are no known suppliers of caliche block locally, it is possible that blocks can be manufactured on-site by a small crew or by owner-builders. Because caliche block are derived from a regional material and can be manufactured into unfired block, they can provide a low-cost alternative to purchased block with a significant reduction in energy requirements in the manufacturing process. The resulting unfired caliche blocks can easily pass Unified Building Code standards for compression with and average p.s.i. of 960 p.s.i.

Source:

• Nine caliche and lime pits operate in the region, and can be purchased from:

- Austin White Lime
  5014 McNeil Road
  Austin, Texas
  255-3646
- Capitol Aggregates
  Bolm Road
  Austin, Texas
  385-3211
- Centex Materials
  901 S. Mopac
  Austin, Texas
  327-3652
- Southwest Materials (also Georgetown & Bastrop)
  4200 Todd Lane
  Austin, Texas
  444-2213
- Texas Crushed Stone
  5300 N. IH 35
  Round Rock, Texas
  255-4405
- M. E. Ruby, Jr.
  Lime Creek Road
  Austin, Texas
  258-1601
- Boorhem Field Highway Letting
  208 Barton Springs Road
  Austin, Texas
  477-8111
- Colorado Materials Co.
  6 Mi Hunter Road
  San Marcos, Texas
  385-4844

Quantity:

• Approximately 14% of the Austin area is covered with caliche, also described as a soft limestone composed mostly of light gray to white and tan, thin- to thick bedded, fine-grained chalk, marl, and marly limestone. The thickness of chalk in this zone is about 350 feet.

Use:

- Mass
- Road Base
- Structural Walls (interior/exterior)
- Permeable Paving
- Stucco

By-products:

- No inherent waste materials in unfired process; excess materials can be used in subsequent manufacturing processes

Advantages:

- Locally available
- Low-energy requirements
- No additional finishes required for exterior/interior surfaces
- No known negative environmental impacts
- Provides mass in building for interior climate control

Disadvantages:

- May require variance if used structurally
- Unit costs may be higher than conventional masonry materials
- Commercially unavailable in finished block form

RAMMED EARTH

Rammed earth walls are made from a moist, sandy soil which is tamped into forms with a minimum thickness of 12". Soils for rammed earth should contain about 30 percent clay and 70 percent sand.

Source: Travis County and surrounding counties have high percentage of soils suitable for ramming.

Quantity: According to the U.S. Department of Agriculture, Soil Conservation Service, Travis County has approximately 19,610 acres of sandy soils suitable for ramming. By using only the top one foot of soil from these 19,610 acres, approximately 529,470 two-bedroom rammed earth houses, or houses for the entire projected population of Travis County through 2025, could be built. (McIntyre, 1983.)

Use: Rammed earth is suitable for use as walls and floors, and introduces mass into the building to passively stabilize interior comfort zones. Walls are generally built with a minimum thickness of12".

By-Product: Unused soil can be used in later building projects.

Advantages:

- Locally available
- Provides mass for comfort control

Disadvantages:

- Requires minimum crew size of 3 and mechanical equipment
- May require building code variance
- Generally unfamiliar to local builders

FIRED BRICK

Central Texas has clay soils suitable for manufacturing fired brick, a conventional building material derived from indigenous materials. Fired brick are recognized for their consistency in color and form, and therefore lend themselves to quality control. However, they do rely on an energy-intensive firing process, which also has negative environmental ramifications. Two brick companies operate out of Austin, and derive a portion of their brick from regionally-located operations south and east of Austin.

Source: Brick operations are located in McQueeny (near New Braunfels) and in Elgin, east of Austin. It should be noted that not all bricks sold by the local brick companies are manufactured in the local region; local companies are:

- Elgin-Butler Brick
  4000 N. IH 35
  Austin, Texas
  453-7368
- Acme Brick
  631 Round Rock West Drive
  Round Rock, Texas
  244-7600

Quantity: Over 75,000,000 brick produced each year in the Austin area

Use:
- Exterior Walls
- Interior Walls
- Walkways/Paths
- Retaining Walls
- Fireplaces

By-Products:
- Waste heat from firing process
- Cracked bricks, seconds

Advantages:
- Locally available
- Consistency in size and color
- Skilled labor force for construction

Disadvantages:
- Use fossil fuels for firing process

FLY ASH

Fly ash from coal-burning plants (not to be confused with fly ash from municipal or hazardous waste incinerators) is a well-proven cement and nearly identical in chemical structure to pozzolan--the same materials that built Roman aqueducts and buildings of the Roman Empire, many of which are standing today.

Due to fly ash's ability to replace cement, the U.S. federal government has funded several states, including Texas, to test the fly ash from each of the state's coal-burning power plants. At this time, it is an accepted practice by the Texas Sate Highway Department to replace 35% of the cement used in construction with fly ash, while still achieving 100% to 125% of the compression strength of 100% portland cement. However, acording to many authorities, 100% fly ash can easily be used to totally displace the concrete (Dr. Ramon Carrisquillo, Professor of Structural Engineering, University of Texas, Austin.)

There is particular appeal for fly ash in Central Texas since it is compatible with the alkaline soils present. Thus, if introduced as an accepted building material among the region's construction trades, fly ash represents a viable new industry for central Texas and could replace part of the energy- and water-intensive cement industry. Additionally, recent research has found that cement also contributes to global warming, since the firing of calcium carbonate-based substances releases carbon dioxide into the atmosphere, which makes fly ash an even better option from an environmental viewpoint.

Source:	There are five coal-fired power plants within the seven county central Texas region.
Quantity:	Texas produces approximately 5 million tons of fly ash each year, with only about 20% of this amount used as a cement substitute or additive.
Use:	Can be used in place of poured concrete for slabs, foundations, walls, structural members, etc.
By-Products:	Surplus fly ash mix should be properly disposed
Advantages:	• replaces cement which is energy and water intensive, and which is considered a major contributor to global warming • uses an industrial by-product with considerable quantities of available local supplies • has greater p.s.i. than its typical cement equivalent • has a natural light tan color which may eliminate need for any interior or exterior stain or color additive • some local ready-mix companies have familiarity with fly ash
Disadvantages:	• sets up more quickly than standard cement so may require addition of retardants • requires custom engineering to determine proper mix with specific fly ash samples

LIMESTONE

The Austin area has large reserves of limestone suitable for crushed stone, high-purity uses, and dimension stone. The Edwards limestone, located in the Jollyville Plateau and in the southwest part of Austin just east of the Mount Bonnell fault, is a source of high-purity limestone used in producing lime, fluxstone, agricultural limestone, and crushed stone. Much of the limestone in these formations exceeds 97% $CaCO3$.

Source: Jollyville Plateau, east of Mount Bonnell fault, and along Onion Creek upstream from Highway 183.

- Baker Stone Supply
11213 N. Highway 620
Austin, Texas
335-0178
- Billy Cooper Stone Co.
11331 Highway 71 W
Austin, Texas
263-5116
- Don E. Cooper Stone Co.
6107 Nuckols Crossing Road
Austin, Texas
444-1116
- James Daugherty Stone Co.
7704 Williamson Creek Drive
Austin, Texas
288-2712
- Featherlite, Texas Quarries Division
FM 1431
Austin, Texas
258-1474
- Howard Pierce & Son Stone Co.
1303 Georgian Street
Austin, Texas
452-6516
- Leander Cut Stone Plant
401 Brushy Creek Road
Austin, Texas
258-4440
- Marx Building Stone
1310 Chisholm Trail
Austin, Texas
255-3796
- Howard Ken Pierce
1402 Pecan Street
Austin, Texas
258-3065
- T&R Stone Company
4409 Gamett Street
Austin, Texas
441-8858

Quantity: Hard limestone accounts for about 10% of the Austin area; soft limestone comprises almost 14% of the Austin area.

Use:

- Flagstone
- Exterior/Interior walls
- Fences
- Retaining Walls

By-Products: Scrap materials can be used in other building projects

Advantages:

- Locally available in abundant quantities
- Relatively inexpensive
- Highly durable
- Requires no treatment other than cutting
- Skilled labor locally available familiar with the material

Disadvantages:

- Heavy weight requires large truck for transporting

SAND AND GRAVEL

Colorado River and Onion Creek fluvial deposits are extracted as aggregate, though many of the existing deposits are unavailable due to urbanization which has covered their access points. There are, however, substantial deposits which remain in undeveloped areas.

Source: Many sand and gravel pits operate in the Austin area.

- Austin Sand & Gravel
809 Dalton Lane
Austin, Texas 385-5379
- Austin White Lime
5014 McNeil Road
Austin, Texas
255-3646
- Capitol Aggregates
W. Highway 29
Georgetown, Texas
255-2126
- Centex Materials
Falwell Lane
Buda, Texas
247-2304
- Joe Cook Hauling
Bastrop Highway
Austin, Texas
247-4290
- 4G Materials Inc.
FM Rd. 967
Dripping Springs, Texas
473-2516
- Marcelo's Dirt & Loam
800 Dalton Lane
Austin, Texas
385-5205
- Naumann's Pit
8800 Ramirez Lane
Austin, Texas
385-0690
- Pioneer Concrete of Texas Inc.
8900 Ramirez Lane
Austin, Texas
385-6920
- M.E. Ruby, Jr.
Lime Creek Road
Austin, Texas
258-1601
- Southwest Materials
4200 Todd Lane
Austin, Texas
444-2213
- Texas Crushed Stone Co.
5300 S IH 35
Georgetown, Texas
255-4405

- Texas Industries Inc.
Harold Green Road
Austin, Texas
276-7986
- Texas Readymix Inc.
(See Southwest Materials above)

Quantity: There are over 75 operating sand and gravelpits in the Austin area.

Use:
- walkways
- aggregate
- earth block amendments

By-products:
- re-use potential for future building projects

Advantages:
- Abundant local supplies
- Non-toxic

Disadvantages:
- May result in run-off and erosion problems when not placed within confinement curbing

COMPRESSED EARTH BLOCK

Source:	Similar soil types as with adobe and rammedearth. In addition, one can use caliche based soils with high calcium carbonate, requiring a small percentage of cement for stabilization.
Quantity:	See rammed earth and caliche quantities.
Use:	• walls • walkway paving • landscape retaining walls
By-Products:	Surplus materials should not flow into water courses; implement erosion control
Advantages:	• Locally available • Low energy • Low water using • Dimensional quality control • Massive for climatic purposes
Disadvantages:	• Mix design must be carefully administered • Improper placement on certain orientations can result in high radiant temperatures • Requires overhang and foundation water precautions • May require building code variance

CONCRETE BLOCK

Source: Available at most every building supply center, concrete block are manufactured in the Austin area:

- Barrett Industries
6889 Evans Road
Austin, Texas
651-6550
- Featherlite Block
508 McNeil Road
Austin, Texas
255-2573
- Masonry Products
835 Kramer Lane
Austin, Texas
837-7940

Quantity:

Use:

- exterior load-bearing walls and columns
- retaining walls
- may be reinforced for use in other purposes (i.e. filling bar and concrete)
- foundations

By-Products:

- High CO2 production resulting from manufacture
- waste heat resulting from manufacture

Advantages:

- predictable structural integrity
- uniformity
- locally available
- code compliant

Disadvantages:

- neither highly insulative nor highly massive
- difficult to shape for custom conditions

AGRICULTURAL PRODUCTS (Straw & Straw Bales)

Structures comprising over 300 million square feet have been built in Canada, over 1 billion square feet world wide, and over 50,000 homes have been built in Sweden over the last ten years all using waste from wheat and oat harvests as the principal wall building materials. When combined with a plentiful fireproofing and binding agent, this building material is used as the wall infill insulation and lateral support for post and beam building. The materials proposed supply ample fire rating, and have an insulating capacity of k = .78 (R value for 16 inch wall = 20.5.)

This material combination has been used in buildings within humid (temperate) European climates since 1834, with many structures still standing in good condition. This historically-proven technology has been highlighted in a demonstration sustainable housing program near Grenoble, France, with 178 units under construction.

Straw bales also have a history of precedents throughout the world in grassland prairies.

Source:	Travis County and the adjacent region all produce agricultural cellulose waste and straw bales suitable for construction.
Quantity:	Our data indicate agricultural waste in Travis County alone of approximately 43,050 tons from wheat and 10,050 tons from oats. These figures suggest that approximately 256,558 1000 square foot homes could be constructed each year using wheat chaff as the wall in-fill material.
Use:	• Wall in-fill (exterior/interior) • insulative walls • structural bales when wound tightly • roof insulation when properly applied
By-Products:	• When overharvested, erosion/water run-off • When overfertilized, groundwater pollution
Advantages:	• Locally available bales can promote a sustainable building practice and maintain agricultural activities on local arable soils • Takes advantage of agricultural waste material • Combines wall in-fill with insulative performance
Disadvantages:	• May promote mold growth if improperly applied, to which some may be allergic • May require variance from local building codes • Requires interior and exterior finish work • Fire hazards if improperly applied

BAMBOO

Bamboo is one of nature's phenomenal plant species, with a legacy of uses in cultures spanning the globe attesting to its unique attributes of extraordinary strength and delicacy.

Source:	Bamboo grows throughout Travis County often in unmanaged groves and is subject to chemical destruction if not controlled to fulfill some useful purpose such as wind break, visual barrier, or property demarcation.
Quantity:	Quantified data unavailable for this region
Use:	Bamboo is traditionally used in a number of construction applications including scaffolding, trellises, water pipes, rebar, fences, visual barriers.
By-Product:	Rhizome infestation into other plant species
Advantages:	• low-energy • renewable • locally available • naturally resistant to decay when properly harvested
Disadvantages:	• not an appropriate substitute for re-bar for all structural purposes • does not have the durability of rebar • invasive to other plant species • requires building code variance for structural applications when used in buildings

CELLULOSE INSULATION

Cellulose insulation can be manufactured almost entirely from recycled newsprint, and thus is an ideal material to spawn both a waste-based industry and an energy-conservation industry. Austin current recycles an estimated 50,000 tons of newsprint each year, some of which could be directed for local manufacture of cellulose insulation. According to studies conducted at the National Bureau of Standards on the performance of several insulating materials, cellulose, with an R-value of 3.6, was given top rating in the area of overall lasting, with no discernible settling over an eighteen-month period. Properly treated cellulose is insect- and fire-resistant, meeting all required safety standards. However, there is some concern about treatment chemicals that are borate substitutes which may have some negative health impacts. Moreover, the establishment of a cellulose manufacturing facility in Austin could create many local jobs.

Source:	The principal raw material for cellulose insulation are recycled newspapers.
Quantity:	Austin generates approximately 50,000 tons of used newsprint each year
Use:	Insulation
By-Products:	No signficant by-products; problems withoutgassing associated with borate substitutes
Advantages:	Local waste material converted to importantbuilding material, providing local jobs andoffering an additional market opportunity for the newsprint recycling industry
Disadvantages:	May be treated with toxic chemicals for fire and insect retardants, resulting in potentially hazardous outgassing

COTTON

Cotton lint has been determined to be a suitable material for insulation, with studies currently underway in Texas funded by the Texas Agricultural Diversification Fund.

Source:	Travis and Hays counties
Quantity:	7,900 bales produced in 1990
Use:	One of the by-products of cotton ginning is lint, which can be used for insulation after appropriate treatment for fire retardancy and bug control. Lint is generally stored in an approved warehouse to await favorable market conditions, or forfeited to government.
By-Products:	• The lint used is an industrial by-product and therefore generates no significant waste materials. • When cotton grown using chemicals, crop can be deleterious to groundwater
Advantages:	• locally available • insulative
Disadvantages:	• The cotton may have been treated with chemicals during its growth cycle which may result in toxic emissions • Growing cotton can result in soil quality depletion

MESQUITE

Mesquite (*Prosopis glandulosa)*, a native Texas tree with over 55,000,000 acres of growth throughout the State, is prolific throughout many parts of the state, including the Austin area. It is an undervalued species, known more for its invasive characteristics than for its many functional attributes, including as a highly durable flooring material.

Source: Native growth throughout the Austin area

Quantity: Information unavailable

Use:

- Flooring material, milled as 3"x3"x1/2" tile (end grain); random length 3"x1/2" up to 5" in length; round cuts with bark and sapwood left on with 3" average diameters and planks 3" x 1/2" x random lengths from 8" to 14".

- A high Btu fuel source for wood heating
- A rot resistant wood for fence posts or other exterior uses

By-Products: Since mesquite wood is a well known flavor-enhancing additive for barbeques any scrap mesquite can be directed to the grill for food preparation.

Advantages:

- A durable, even-grained hardwood which withstands heavy traffic with little or no sign of wear
- Abundant, renewable, regional supplies to meet demand
- Distinctive, rich tones requiring no staining for finishing and minimal maintenance
- Three times as stable as oak

Disadvantages:

- Limited shapes and sizes available due to growth patterns
- Higher front end prices due to current low production
- Dark natural color may make it incompatible with some interior color schemes
- Milling process may be more demanding on equipment than softer wood species
- Currently marketed as expensive "exotic" wood

Many different designs can be developed within the basic outline given here. These guidelines are general in nature and it is important for the developer and builder to be familiar with their own region and specific site location. Their task is to know how these general guidelines may be applicable to their site planning, building design, and construction process.

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Section Three: Climatic Design Guidelines/Energy

CLIMATIC DESIGN GUIDELINES/ENERGY

OVERVIEW : Integration approach
Quality of life
Site analysis criteria
Site planning and building orientation

SOURCES : Solar radiation (heating, electric power generation)
Daylight (natural lighting)
Wind (cooling, electric power generation)
Water (heating, cooling, electric power)
Land features and vegetation (heating, cooling)

TRANSPORT : Access to renewable energy sources
Design and construction

TOOLS : Glazing, windows, and skylights
Thermal mass
Vents
Shading devices
Controls
Water heaters
Photovoltaic panels
Wind generators
Building materials
Landscaping

USES : Heating
Cooling
Ventilation
Natural lighting
Electric power generation
Food production
Water supply

INTEGRATION: Heating, cooling, ventilation, natural lighting (e.g., a window)

AUDIT : Occupant feedback
Performance monitoring

> "Climatic design is the one approach by which to reduce the energy cost of a building comprehensively : the building design is the first 'line of defense' against the stress of the outside climate. In all climates, buildings built according to heating and cooling by using 'natural energy' available from savings that result make climatic design the best financial investment for any building owner. Many are 'no cost' techniques requiring only climatic design knowledge. Other techniques are easily incorporated into conventional construction...."
>
> **Climatic Design**, Watson and Labs

An Integration Approach

Climatic design methods utilize on-site energy sources to achieve human health and comfort conditions with minimal reliance on external resources and centralized utility grids. These "natural energy" sources include solar radiation, daylight, wind, precipitation, groundwater, vegetation, and land features that can reduce the non-renewable energy requirements of a building. Some, if not all, of these energy design concepts can and must be incorporated into building practices if the full potential for energy savings is to be achieved in new homes in Texas.

Site planning and building orientation are the first steps in this design process. They can assure access to the sun for heating and daylighting and to the wind for cooling and natural ventilation. They can preserve the water, vegetation, and land features of the site that enhance winter heating and summer cooling. It is at this stage that developers and builders must layout roads, locate buildings, and plant landscaping so that access to renewable energy sources, whether implemented now or in the future, can be planned into the project.

Reduction of heating and cooling energy involves the control of the indoor environment with the least use of energy possible. This means that the total building envelope must allow the least heat flow into or out of the home according to the season. The building envelope must have adequate insulation to resist heat flow through the walls, roof, ceiling and floor. Air leakage through the home must also be controlled. In most climates, the potential energy savings through good infiltration control is much greater than that afforded by the best insulation practices.

The equipment required for heating and cooling is the major energy user in the home. It must be specified for its efficiency, appropriateness to the design, and proper match to available utility service or fuel source. In the past, the selection of this equipment was generally made on the basis of performance and first cost. Energy economics today has introducred the concept of life cycle costing. This takes into account such factors as efficiency, maintenance costs, life expectancy, and the increasing cost of fuel. All these factors are important to a design process characterized by sustainability.

In a sustainable design approach, most, if not all, of these potential energy saving measures are integrated into the design and construction of the home. It is a characteristic of sustainable design to integrate as many of these concepts as possible into the design and construction process. Each of these measures, when implemented separately, will result in a small fraction of the energy savingsd that can be attained when implemented together. For example, high efficiency heating and cooling equipment mnay result in energy savings of 10 percent, but when coupled with proper building siting and orietation the energy savings may be as much as 30 percent. Both of these measures are low or no cost options that can be easily implemented to every design project.

When all these measures are included in a comprehensive design and construction approach, the energy savings can amount to as much as 65 to 75 percent over "standard" construction practices. Greater results can be achieved by having systems working together than as disparate measures implemented for a single specialized purpose. [In fact, there is now on-going research in many countries (U.S., Germany, Sweden) to design and build a "zero energy" house - one that would not require any energy input from non-renewable sources.] Rather than implementing stop gap measures that are "added on" to the building to conserve energy, the sustainable design approach maximizes potentials by integrating these measures into the initial stages of the planning process.

Each developer and builder must ascertain for each project to what extent all of the energy saving features can be `designed and built into the home. To achieve the most savings possible, the builder should address all five elements of planning and construction mentioned here. Their share of the potential energy savings applied to a new home are:

Orientation	16.67%
Design	21.33%
Thermal	12.0 %
Infiltration	33.33%
Equipment	16.67%
	100.00%

Note that 38 percent of potential savings occur during design and planning stages. Only 45 percent is attributed to the building envelope itself. These elements of planning and construction are the major concerns for the design of the energy efficient home.

There is an awareness of the added value to a home created by energy efficiency and sustainable design among the home-buying public. Professional Builder reports that 91 percent of prospective homebuyers in Texas will be willing to spend more for energy efficient homes. Energy efficiency will be the most important consideration of 86 percent of consumers if they move again.

Quality of Life

Climatic design can address the issue of sustainability by going beyond the perception that "natural energy" sources are simply replacements for unreliable and expensive fossil fuel supplies. Utilizing solar energy, for example, as a replacement for artificial light, fuel fired heat, and photovoltaic powered electric systems as an alternative to centralized power grids is part of, but not all of, the climatic design approach. This approach extends the concept of access to renewable energy sources as simply necessary for energy supply uses. It states that access to and utilization of these sources is important to the overall quality of life. If our energy supply problems were suddenly solved by some economic or technical breakthrough, we would still need to confront the basic issue of life quality.

Our present day buildings do not follow the principles of working with "natural energy" sources. They are undifferentiated by orientation to the sun and are the same from city to city, region to region, without regard for climate. They employ inefficient mechanical systems and often include unhealthy building materials. In an era of rapid development we did not take the time to fit our development to a varied environment. Instead, we modified the environment to fit repeated units of construction.

Several issues concerning improved quality of life are addressed by the climatic design approach. Regarding the human occupant, the goal of any design is to provide for the user's comfort and physical and mental health. This goal may be the easiest to attain. It is generally accomplished by controlling temperature, humidity, air movement, light and sound levels, and other aspects of the physical environment that impinge on our bodies. Access to renewable energy sources has a direct impact on most of these conditions and a secondary impact on the rest.

Sustainable design methods however, try to fulfill this function without undue expense to the environment. Its goal is not only to fulfill our needs but to also maintain, preserve, and sometimes regenerate the life of the surrounding environment in which we live, locally, regionally, and even globally. Its purpose is to assure that the resources available for our use today will also be available for the use of future generations tomorrow. It proposes that the quality of our lives is dependent upon the quality of the environment surrounding us.

Site Analysis Criteria

The climatic design process begins with the selection and analysis of a particular site. This involves many decisions already familiar to developers and builders, and some procedures that will be new, but not necessarily complex or difficult. These procedures include the assessment of the following site characteristics:

The availibility of renewable energy sources.
The influence of land and vegetation features.
The effects of this project on adjacent sites.

An assessment of available energy sources usually includes solar (heating, electric power generation) and wind (ventilation, cooling, electric power generation) energy. Their availability is dependent upon the site's latitude, topography, local land and vegetative features, and local atmospheric conditions. The developer or builder will need to asssemble information from local climatic data, aerial photos, and site surveys necessary for the site analysis process.

The latitude of the site determines the position of the sun in the sky relative to the particular site. At higher latitudes, the sun is lower in the sky, casting longer shadows than at lower latitudes. The hours of daylight during different seasons of the year vary with latitude.

Changes in topography influence both solar and wind availability. The angle at which the sun strikes the earth's surface changes with slope. South slopes for example, capture more direct solar radiation during the winter months athan other slopes or flat surfaces. They tend to be warmer than other places on the site, moderating temperatures during the winter months. East and west slopes receive more direct sunlight in summer and less in winter than south slopes causing potential overheating problems even in northern climates. North slopes receive direct sunlight only during the early mornings and late afternoons of summer. Horizonrtal surfaces receive most direct solar radiation during the summer when the sun is more directly overhead.

Wind is influenced by valleys and hills, with more wind usually available at the top of unobstructed hilltops and peaks. However, wind can be channelled into small ravines and valleys by vegetation and local land features. Coastal and lake areas are also sites with good access to wind. Access to the wind is not always desirable. For some sites, during the winter months blocking and redirecting of wind may be required.

Local atmospheric conditions that affect the availability of sunlight are fog, air quality, and cloud cover. Local fog conditions can change the availability of sunlight from one site to the next. Air quality can be affected by agriculture and industry in rural areas, and by smog in urban areas. Cloudy climates receive less sun than clear climates and high altitudes are usually clearer than low altitudes.

Obstructions to solar and wind energy must be assessed during the site analysis process. Shadows cast by natural (trees, hills) and man-made objects (existing buildings) on or near the site must be measured and plotted. Winter shadow patterns will be longer than summer patterns because of the difference in solar altitude during the different months of the year. Planning for solar access during the winter months will assure solar access for the summer moinths as well. Where summer overheating is a problem, trees and existing structures can be used to provide shading for summer cooling.

Wind obstructions can cause similar problems. Cooling and ventilating breezes can be blocked by trees, structures, hills, etc. However, unlike sunlight, wind can be directed over and around objects. In most climates for example, it is desirable to block winter winds from the north and allow cooling and ventilation breezes during the summer to enter the building.

Land and vegetative features will alter the microclimate of a site and influence the amount and type of energy used for heating and cooling. Besides the effects of topography, other factors such as bodies of water and types of vegetation must be assessed in the design and location of future buildings. Each of these features can reduce energy requirements when properly considered during the site analysis stage of the project.

Solar and wind access should also be left unobstructed for sites adjacent to the proposed project. Development on site can take place only within certain limits that do not shadow surroundings during critical periods of the day. This volume has been defined as the site's "solar envelope." The envelope limits on site building heights and the casting of unwanted shadows on the property surrounding a given site. It defines the largest container of space that would not cast shadows off site at specified times of the day. The solar envelope performs the dual function of asssuring asolar access to surrounding sites while defining the largest appropriate developable volume.

Developers and builders are familiar with site plans that indicate topography, existing buildings, significant natural features, soil conditions,and available utilities. In addtion to this information, the climatic design approach outlined above requires a site plan to indicate obstructions to solar and wind access, energy related features of the site and vicinity, local climatic data, local atmospheric conditions and limits on development that will assure for adjacent sites future access to energy sources.

Site Planning and Building Orientation

Critical to site planning and building orientation is the degree of access to renewable energy sources. For solar energy, the level of solar access can be described as roof top access, wall access, and whole site access.

Roof top access guarantees solar access to the roofs of buildings. The sun's direct energy is provided only to the roof, and shading of the rest of the building is allowed to occur. This access is appropriate in high density areas and provides the most possible development.

Wall access allows the whole building to utilize and store solar heat and have access to daylight. The potential uses of solar energy are increased. The whole building structure and form can be adapted to conditions of light and heat for improved energy performance and quality of life.

Site acccess provides direct solar gain to the ground surface of the site . This allows yards, gardens, and outdoor living spaces access to direct sunlight. This type of access would be appropriate for low to middle density housing.

Planning efforts must be directed toward the type of of energy access desired. Developments have generally been planned without regard to energy access and building orientation. At present, shadows cast on our neighbor's house and land prevent their use of solar energy.

Orientation is the positioning of the building on its site in relation to the seasonal changes of the sun, access to wind, and proximity to land and vegetation features that influence energy requirements. Proper orientation allows some heat gain in winter and minimizes heat gain in summer. Orientation towards prevailing summer winds is also important. In Texas, orientation alone has the potential for reducing energy demands by 17 percent over another home without proper orientation.

The solar heat gain on walls and roofs with vary from summer to winter according to orientation and time of day. The east and west walls should be designed to be as small as possible to avoid summer heat gain. Minimize glass on these walls or provide means of shading in the summer mornings and afternoons. Face the house north or south with its roof running east-west. Provide additional west shade by locating the garage and other outbuildings on that side of the home.

Using traditional layout patterns, streets running east-west make this orientation easier than streets running north-south. The most number of buildings can then face north or south and minimize east and west exposures.

Orientation with respect to prevailing wind direction will influence the ventilation and cooling of the building. A principal requirement for satisfasctory ventilation is the placement of openings on both the windward and leeward sides of the building. Additionally, if the wind changes direction in the building or within a room, a larger volume of the interior is affected by the airflow and average air velocities are higher. Thus, it is not necessary to orient the building so that the main walls allow the wind to enter perpindicular to the windows. Good ventilation can be achieved by orienting the building at an angle to the prevailing winds. Thus,with both windward and leeward openings, good cross ventilation can be achieved with a wide range of building orientations with respect to the wind. In hot humid climates, orientation to the wind may be more critical than orientation to the sun.