SUSTAINABLE CITIES:
PROGRAMS & PROCEDURES

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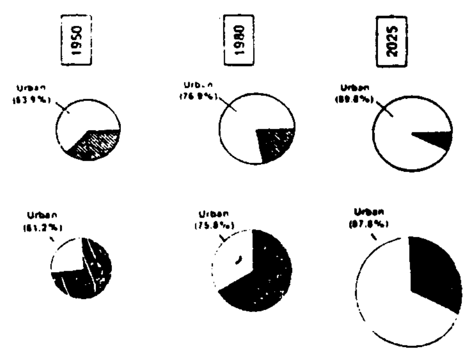
ABSTRACT

The unprecedented growth rate--existing and projected--of urban areas throughout the world requires a careful look at the degrees to which cities can be organized and coordinated to actually function as systems responsive to global resource issues as well as their internal needs. This paper summarizes some of the most pressing global urban problems, details individual success stories, suggests a sustainability indexing system for cities, and, finally, proposes a planning process. References to specific analytical planning techniques as well as renewable energy options within each life support use category are included.

1. INTRODUCTION: THE STATE OF THE CITY

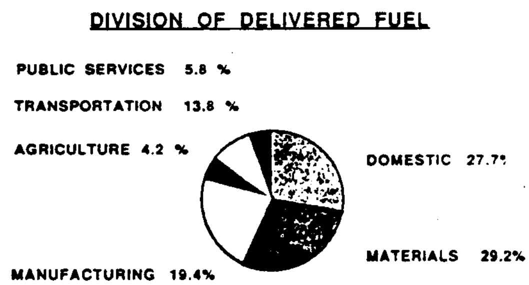
The trends towards **urbanization**, both around the world and in the U.S. are illustrated below. [1]



This trend towards urbanization brings with it an inherent inefficiency within the urban system and results in an enormously disproportionate percentage of the world's natural resources consumed by its urban population.[2] This inefficiency can be tracked in utility distribution of **electricity, gas, water, sewage** and **waste disposal networks,** as shown in a study done in England which demonstrated that in a large city, per person per annum transmission inefficiency accounts for 6.6%, distribution 21.4% and 14.78% connection. Together these account for 43% of the total utility costs, including losses, overheads, maintenance, and amortization.[3] With time, the maintenance costs become so high that total replacement of all systems becomes the only efficient way of continued use.[4]

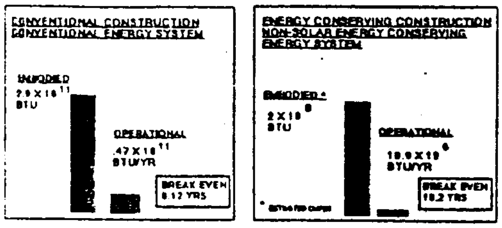
Similarly, agriculture exhibits equal degrees of inefficiency: in the U.S., for example, an average food product travels approximately 1,300 miles between its point of production and final destination,[5] accounting for 10% of agricultural energy use.[6] The amount of energy put into fertilizers on the farm itself is the next highest portion of food inefficiency this amounting to a total of 5.76%.

Perhaps the most misunderstood and underestimated portion of energy use is within the materials sector. In the U.S., for example, only the amount of energy used in the production of energy itself slightly exceeds the amount of energy used in the mining, production, and distribution of materials for construction, as illustrated by the pie chart below.[8]



That a misunderstanding of energy conserving strategies within the building sector exists is underscored by the fact that the predominate focus in building research since the 1972 oil embargo has been on the **operational costs** of buildings, not on their **embodied costs.** Although considerable energy use does occur at the operational level, as illustrated in the chart. It is important to note that even in analyzing a small energy conserving building, embodied and operational costs may not be equivalent for almost twenty years. Moreover, some projections estimate that the operational costs never equal the embodied costs within large buildings. The figures below compare a typical building and a well known energy conserving building in this light.

EMBODIED VERSES OPERATING
ENERGY COST IN THE BUILDING SECTOR



How physical resources are spatially allocated, where manufacturing occurs, what is manufactured and how energy is used at the domestic level together account for 90.1% of the national energy budget, much of which is determined by how we plan our physical and economic environments.[9]

Finally, we find that the size of cities has much to do with the way resources are used. Thirty-four cities around the world now have populations exceeding more than five million people, and an additional 93 cities are expected to be added to this list by 2025. The resultant manifestations of challenging a city's limits to growth include choked traffic arterials, rampant ghettos coupled with an overwhelming growth in homelessness, chronic unemployment, regular system failures in utility systems, including electricity, water, and waste services, and, in many instances, prohibitive increases in food and fuel costs.[10]

But even with an objective approach to global resource issues, probably the most insurmountable obstacles are political. Political jurisdictions by definition separate regions into what are often unworkable natural systems. The urban brother is divorced from its rural sister, and no longer has the means to feed its people or to actively participate in any number of productive alliances that could be the cornerstone of sustainable communities. Seldom do these jurisdictions reflect the natural profile of a region in planning and growth studies by taking into account the presence of a watershed, or by including the city in a regional resource assessment. Such a study should be one of the initial undertakings in any investigation into the potential for revitalization or economic development.

Another more glaring political obstacle is the arbitrary way in which energy prices are set. The enormous subsidies granted to the energy industry in the U.S.--totalling $44 billion in 1984--is of course reflected in many other sectors, resulting in an artificial price structure. Agriculture, for example, which for centuries was by definition a renewable energy industry, is now 97% dependent on fossil fuels.[11]

Although others have suggested that the city be the principal framework to address sustainability issues,[12] I propose that this framework be extended to include **the city and its immediate rural resource base.** In order to effectively address the potential for sustainability, one should explore it on various levels beginning with the individual housing unit to the neighborhood, the community, the city and, finally, the region. A Sustainability Index can then be devised for each of these levels, that could suggest that a city's vulnerability is lessened by even a small gesture such as supporting an integrated resource efficient house in which a household's resource needs are demonstrably reduced and which is officially sanctioned. The Sustainability Index can become a compilation of each scale--from home demonstrations to city and regional efforts--covering principal resource issues in addition to the broader concern of the city' s, immediate economic and align it with a long-term environmental carrying capacity.

2. DEVELOPING A STANDARD FOR SUSTAINABILITY INDEX - SOME SUCCESS STORIES

Having briefly outlined some of the urban problems confronting us, we switch gears to highlight some of the most compelling examples of how cities are successfully grappling with these challenges. Within the U.S., at least six cities are currently engaged in actively planning for sustainability; in Europe, particularly in France and Germany, many cities are pulling together different facets of their local and regional economies into a steady state, sustainable plan. In many instances, our neighbors overseas are approaching their endeavors with an unexpected daring flair! (For the purposes of this discussion, toxic wastes and air pollution are not included).

2.1 Solid Waste

- In Wijster, Netherlands, 125,000 tons per year of organic solid waste is recycled through composting.[13]

- The net energy difference per ton between anaerobic composting and landfilling is estimated at 13 million BTUs when methane gas is used during decomposition.[14]

- An estimated 70% to 85% of the U.S. municipal waste stream is recyclable.[15]

2.2 Liquid Waste

- The City of Seattle, Washington, "recycles every ounce of the 100,000 tons of sludge its 1.1 million residents produce each year." According to the U.S. Environmental Protection Agency, U.S. sludge contains at least 10% of the principal chemicals used in fertilizers, in addition to many other beneficial chemicals, enzymes, and micro-organisms not found in commercial fertilizers and has an equivalent value of $1 billion per year.[16]

• Solar waste treatment systems based on aquatic plants are found in about 40 towns in the northeastern U.S.[17] Some of these are producing food for adjacent restaurants in a commercial complex that some are calling "bioshelters." Such systems commonly reduce the amount of energy in waste treatment by about 60%.[18]

2.3 Food

• In an unexpected research finding, scientists at Rutgers University were surprised td find a higher mineral content in organic produce than in non-organic product, by a factor ranging from 1.4% to 1,938%, using a random sampling.[1]

• As city size increases, food production within the city can also increase if the city retains an open space plan and promotes community gardens. In Rio de Janeiro, for example, the government effectively solved a problem of squatter communities stealing utility service by building housing units for them. However, when the residents were unable to keep up with their mortgage payments, the government recognized their inadequate cash flow and provided each unit with 800 square feet of garden space and solar water heating units.[20]

2.4 Materials

• The City of Grendble, France has completed a public housing project using all indigenous materials, including some agriculture waste from the adjacent rural area.[21]

• Seven cities in Germany have similar building campaigns in both the public and private sectors underway.[22]

• The embodied energy cost in these construction projects is shown to be 1/50th that of conventional "advanced" building technologies.[23]

• The City of Milwaukee has established an integrated materials recycling campaign with an energy-saving goal of between 29% to 95%.[24]

2.5 Transportation

• By combining the efficiencies of bicycling and mass transportation, several successful systems around the world have effectively reduced air pollution, reinforced exercise regimens, and substantially cut back on energy use in the transportation sector.

• "Between 1975 and 1981 the number of bicycles parked daily at Japanese railroad stations more than quadrupled to 1,250,000 and continues to grow by 21% per year."[25] The Japanese example is particularly interesting because it demonstrates how an advanced technical society can relate to simple transport methods.

• In the U.S., even though it has remained untried in an actual urban setting, the Taxi 2000 Corporation has developed an electrically operated monorail system which depends totally on off-the-shelf technology. The low energy use, low maintenance, low land use, negligible noise and pollution, and low cost have been cited as major advantages over other mass transport systems.[26]

2.6 Size

Finally size itself and the degree to which all activity uses are included within a given area is an important criterion for reducing energy use.

• "In Athens, which has 287 'self-contained' neighborhoods, 51.2% of activities still occur entirely within the neighborhoods. This minimizes energy use. It has been suggested that a city with multiple self-contained centers uses 1/17 of the energy of a uniform spread settlement and 1/6 of the energy of a single-centered city.[27]

2.7 Creative Economic Development

In Italy, Denmark, and New York City, **flexible manufacturing networks** enable tiny employee and family-owned businesses to band together to produce major products in the metalworking, machinery, electrical, transportation, and farming industries; some of these products are as complex as entire buses and trucks. The strength behind these firms lies in the flexibility inherent in their multi-use automated machinery and their propensity to link together to perform complex manufacturing tasks. The foresight and imagination of so many artisans produces an extraordinary variety of products and a high degree of employment as well as worker satisfaction.[28] Many other economic development approaches provide different degrees of what we refer to as **"business necklacing."** These are referred to in the above footnote.

3. TOWARDS AN URBAN/RURAL PLANNING METHODOLOGY

Start where you are, with what you have, and where the power is! If you have a innovative housing department or economic development department, planning department, environmental or solid waste department, an innovative developer, university programs that don't shy away from working with its community in real and basic terms, or a state government with funds, look at these as potential allies. One state, for example, is investing most of its oil overcharge money into sustainable cities programs.[29] Once you have the inkling of something moving forward, the next big hurdle is overcoming the cities' building codes, which have a lot to do with why our cities are inherently unsustainable.

3.1 The Urban Metabolic Units

The next step should look towards integrating systems within the city; the key here is to forge an alliance with the business community. How the businesses within a community functionally relate to each other determines how the internal flow of energy, materials, and services functions within the city context. This flow is also determined by the type of businesses attracted into the community. There may or may not be an economic development commission asking this question. If not, go to your chamber of commerce and show them the results from some firms cited below performing this type of service around the country.

At some levels this can be easy. For example, to accomplish a modicum of integration of the business community requires knowing their inputs and outputs and showing how in perhaps 20% of the cases that needs usually satisfied with imported goods and services (exogenous) can be fulfilled from goods and services located within the city (endogenous). Your city's local job multipier effect will immediately jump.[30] Most of this data exists end several firms in the country specialize in the task of integrating one business to another on a city-wide scale.[31]

3.2 Dwelling Unit Scale

At the home scale, however, this integration is not such an easy task. It is not easy because we are, in general, not taught to think horizontally to help us solve problem, and are trained to segment our thinking into a single discipline. (This training pattern is also reflected in the city level, as departments are in most cases focused on a single discipline, and, of course in the academic world.)

When we broaden our vision of our home to ask how its basic elements could fulfill a number of functions, we discover, for example, that the amount of heat produced by the refrigerator is roughly equivalent to that used in many cooking processes, especially the slow-cook methods, or could supplement the energy required to heat water. Similarly, a household air conditioner produces enough waste heat to supply all the household's hot water needs. A household's annual vegetable needs can be provided by a 50' x 50' plot when using intensive production methods with raised beds. The garden's fertilizer needs can almost totally be fulfilled by wastes generated within the household when coupled with proper crop rotations. Add to this list the ability of the home's roof to catch rainwater, which can then be collected in a cistern and treated for potable use with a solar distillation unit or photovoltaic ozonator, and channel the greywater for commode flushing (if not using a compost privy) and, when properly filtered, for irrigation. Following these simple steps could result in at least six code violations in most cities, and depends on some equipment which is virtually non-existent on the marketplace!

The irony of this scenario is that it could represent greater overall energy savings than what are generally achieved by conventional "energy conservation strategies" in the energy, water, and food sectors. The type and number of products resulting from such a proposed integrated system could result in job multipliers many times over those of centralized systems.

But, so far, we have not even integrated the house with the community or the community with the region. The Center has designed and built a number of buildings using fly ash waste from coal burning plants as cement, agricultural waste as insulation, certain earth materials as a structural building material, etc. to give some hint of the potential relationship between the process of building and its relationship to the region.[32]

3.3 Developing a Simple, Descriptive Lexicon

When viewed in the manner described above, the home contains as many potential linkages that now appear as holes or gaps in its functioning as it has operable units; many more gaps could be discussed. Potential linkages abound, such as that between dehumidification by all refrigeration equipment and the resulting output of condensed potable water, or cisterns being used as heat sinks, or swimming pools used as solar ponds using Sokolov' s new solar pond technology, or compost as a heating medium. Our list could go on at the individual building scale.

If, however, we were to look more closely at the city and its capacity to functionally network together its business environment--one business to the next--you would find a proportionally equal number of gaps. We refer to this second condition as "gap necklacing," and apologize for our slightly silly semantic tendencies. Going one step further, when a regionally relevant technical breakthrough comes about or must be made, such as with the zeolite mineral down the road used as an absorption medium for an integrated solar cooling/cooking refrigerator/stove combination, we use an even sillier term: "trigger necklacing." This type of discovery brings to bear a whole new potential for urban-rural integration. The right combination of triggers may be what are necessary to elevate the urban environment to a next level of technical sophistication, just as certain industrial breakthroughs triggered the industrial revolution and, perhaps, the contemporary city as we know it.[33]

There are several other terms in our lexicon that we feel are equally good descriptors as those above. We use the term " metabolic unit" to describe any conversion process (a component of a necklace) that has been created by humans that have primary products but also produce waste or by-products that can be converted to useful products. This means that every business, household, or machine is a metabolite or metabolic unit with inputs, throughputs, and outputs of varying types.[34]

But thus far we have not actually linked the city to its region, perhaps the most important step in the development of the city as a sustainable system.

3.4 The Urban-Rural Necklace

The city exists as a system because it metabolites resources. However, there is virtually no discrimination used as to what resources or where they come from. The kinds of resources and where they derive from determine whether the city is at the mercy of a world economy, or at the mercy of itself and its region. When it places itself at its own mercy and becomes a responsible entity willing and able to steer its own future with its own resources, it has every incentive to become more creative, different, special and, just as with the flexible manufacturing networks of Italy, a dynamic, well-integrated and job saturated local economy. The creativity must be focused again on what it has and how the region can supply all its needs through a totally different set of technical mixes, and technologies that take advantage of abundant resources. It is slowly being shown that even fresh food can be supplied year round in remote, seemingly uninhabitable locales using renewable resources.[5] Exports to other regions become only those items that are truly special, many of which can be complemented by the indigenous artistry skills of a given region.

Thus, the link between the city and its region requires a creative and special inventory including all basic life support needs, and a particular focus on all types of renewable resources and abundant abiotic resources developed within an ecological land planning framework. There are few examples where this has even been partially attempted but one or two studies do exist, at least within the renewable energy field.[36]

4. CREATING THE CONDITIONS FOR A SUSTAINABLE URBAN FUTURE

Conditions, incentives, leaps of faith--whatever one might like to call them--are urgently needed before the urban condition so totally disintegrates that available fiscal resources don't even come close to approaching the enormous reconstruction effort required to sustain life as we know it. As we survey around the world, certain people are developing their terminology and the necessary imagary for this to take place. Dan Desmond, Deputy Director of Energy for the State of Pennsylvania, has a concept he calls sustainable enterprise parks."[37] Andy Euston, Director of Energy and Urban Design for U.S. Department of Housing and Urban Development has another which he calls "sustainable urban rural enterprises", or S.U.R.E..[38] (address) At the Center, we call them "City Gates."[39] Each of these point to a new type of enterprise zone, located on the frinne of any town or city or even university campus, that brings together businesses which in some way relate to one another, while, simultaneously, link the urban system with its rural resource counterpart. At the neighborhood scale, this could be looked at as a special demonstration home, store, or small commercial complex; a kind of " neighborhood gate." The businesses themselves often work together as small ecological units sharing certain inputs and outputs (equipment, energy, materials, skills) in exchange for others' resources. The linkage itself gives each entity strength and permanence due to the increased stability of belonging to a networked series of resources and people, such as described years ago in Richard Meier's Communication Theory of Urban Growth.

The Center is working on several examples of City Gates. In Laredo, Texas a demonstration farm complements traditional agricultural functions by recycling urban organic waste, reusing urban scrap and farm waste for building, and treating water.[40] Meanwhile, in Austin, an MIT graduate student, Knute Brinchmann, is exploring how a shift towards indigenous housing methodologies and various support requirements, such as research, training, innovative banking and living demonstrations, can be linked together in what he terms an "East Austin Housing Science and Resource Center."[41] Then, in conjunction with Milosav Cekic, AIA, an Austin architect, we are working with a college in Helena, Montana to design some major campus structures that reflect the college's commitment to resource efficiency and regional sustainability, and which highlight the region's vernacular architecture, indigenous resources, and skills. One complex that includes a miniconference center, a student union, stadium, support athletic facilities and open space contains wind, solar and large water catchment cisterns designed and built as part of the architecture. The complex is being viewed as the campus gateway into a more meaningful future for academia and the city of Helena. For this campus and the surrounding communities it will act as a trigger into the 21st century.

5. CONCLUSION

It is extremely difficult to include in this brief all that one must to help spur on the cause. The space left for really explaining our methodology at each scalar level discussed early on is lacking and will have to be taken up in another paper. But the basic message to integrate is brought out - the exciting part is to accomplish this at the city scale. To be very optimistic about changing something so monolithic as the city takes courage and hope that human evolution has actually approached the level of pre-empting the inevitable and is able to take action. Without the activities going on presently in the Eastern Block countries it is difficult to fathom how this change can ever take place within the time period that it must.

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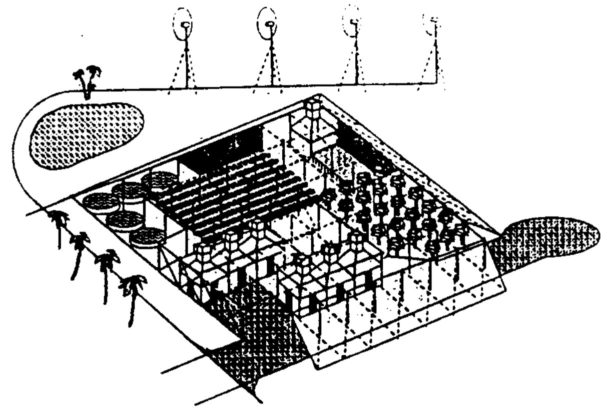
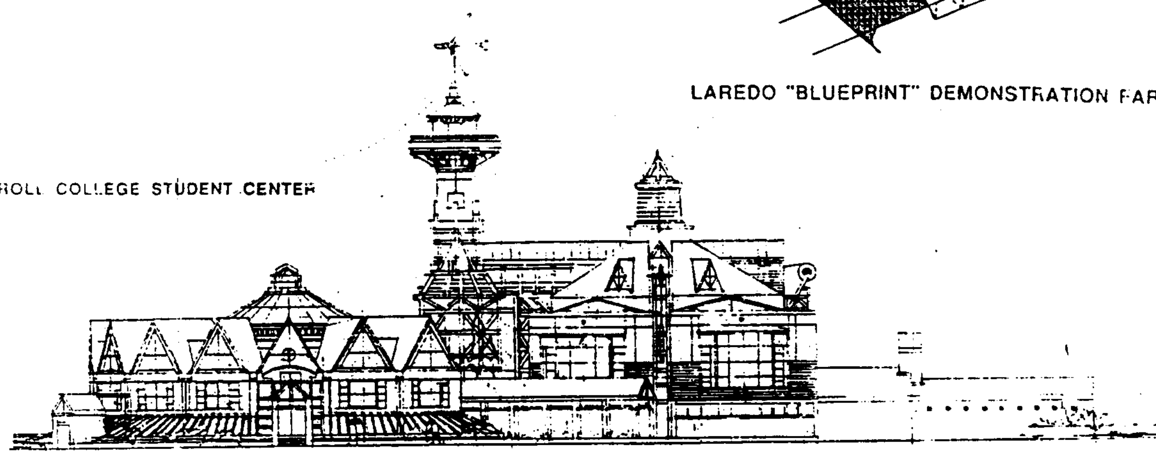


LAREDO "BLUEPRINT" DEMONSTRATION FARM

CARROLL COLLEGE STUDENT CENTER



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