THE CONSERVING COMMUNITY
by
Carol J. Mancke

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Chairman, Departmental Committee on Theses
ABSTRACT

THE CONSERVING COMMUNITY

by

Carol J. Mancke

Submitted to the Department of Urban Studies and Planning on May 27, 1975 in partial fulfillment of the requirements for the degree of Bachelor of Science.

Inexpensive energy has resulted in uncontrolled growth which is both damaging to the natural environment and wasteful of an important natural resource. And yet, current policies and monies are directed toward the development of new energy sources and thus continuing the tradition. The need for policy revision is, therefore, indicated. While the development of new sources is necessary and inevitable, consideration must be given to curbing energy demand. Local governments have the tools to affect energy demand and begin movement toward energy conservation.

This paper is concerned with the future of the community as a part of a national and world eco-system. There are three parts: 1) a discussion of energy wasteful practices which are prevalent in American communities; 2) a discussion of the possibilities for improvement offered by existing technologies in conjunction with community energy management; and 3) recommendations for the use of municipal regulating tools for bridging the gap which exists between existing patterns and conserving patterns.

Thesis supervisor: Gary Hack

Title: Assistant Professor of Architecture and Urban Design
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INTRODUCTION

There has been serious neglect of facts in the formulation of current energy policy in the United States. Although contemporary sources of energy are non-renewable and in limited supply, energy has been very inexpensive in this country. The patterns of energy consumption which have developed are extremely wasteful. If the U.S. wishes to reduce its energy consumption, it must develop vastly different patterns of use.

Human beings as individuals are marvelously adaptive, but the rituals and institutions of human society are often slow to adjust to new circumstance. In a "free" society, institutional change requires the collective action of individuals. Collective action requires leadership and/or guidance. Government can be an instrument of collective action. Local government can provide the necessary initiative and guidance for the transition from wasteful patterns to conserving patterns.

The profit system is the motivating factor behind the capitalist economy. Unfortunately, Profit maximizing often works contrary to energy conservation. Dollar costs often do not reflect true energy costs. Minimizing dollar costs can and does in many cases result in wasting BTUs. This is true in industry, building construction, and transportation systems. Lack of energy planning has resulted in the inefficient or ineffective use of land. The American economic philosophy of unplanned markets has not encouraged coordination of energy consumption between users which could result in energy savings over
"The energy gap in 1985 will be greater or lesser than current projections depending in decisions by government on all levels." The gap referred to in this statement is the gap between immediate demand and the immediate supply. The kinds of decisions which are being made at the national level reflect the goal of filling in the gap, i.e., increasing the supply to meet the demand of 1985. Policy makers are asking questions like: How much of the demand can be met by light water nuclear reactors? by new breeder reactors? What other energy sources can be tapped?

Most of these solutions are frightening to the layman and terrifying to anyone with any environmental sensitivity. Visions of an earth divided between radioactive wastelands and unending urban sprawl are brought to mind. The time has come to look at the tradeoffs once again. This paper is written in the belief that there is an alternative which is being overlooked by policy makers. As the government pours money into the research of alternative energy sources, very little indeed is funneled into researching methods of reducing the demand to the level of supply. Governments at all levels should work to reduce demand.

Energy management must be instituted to see that the available energy is used efficiently, without waste and to coordinate the use of energy. Management at the national level would determine what sources are to be tapped. The federal government would also be concerned with the allocation of the available energy both geographically and sectorally across the country. Local energy management would involve the

It is unlikely that such a system could be made workable in the immediate future. However, there are many tools available to the municipality which can be used to begin to move toward such a system. One such tool is education. Communities can launch educational programs to teach background information (facts on the energy situation, concepts in ecology, etc.) as well as methods of conservation in the home and office. Tax incentives for energy conserving systems and innovations and penalties for wasteful consumption are effective and implementable at the local level. The community can legislate building codes and standards which regulate energy use and encourage individual users to seek higher efficiencies. Zoning can be used to encourage conserving land use patterns. Public funds can be invested in upgrading public services in terms of energy efficiency. Life cycle and/or energy costing can be required in all new developments. The use of these tools within the broader framework of the goal of future comprehensive management can ease the transition which could otherwise have serious economic and political implications.

This paper is addressed to the contemporary community. It is concerned with the future of the community as a part of a national and world ecosystem. There are three parts: 1) a discussion of energy wasteful practices which are prevalent in American communities; 2) a discussion of the possibilities for improvement offered by existing technologies in conjunction with community energy management; and 3) recommendations for the use of municipal regulating tools in bridging the gap between existing patterns and conserving patterns.
PROBLEMS

Overview

The national system of energy consumption is made up of many wasteful local systems. Figure 1 on the page following shows the uses of energy in 1968 by end uses. The tools of the local government can be used to directly affect consumption in three of the four sectors which make up the total consumption: commercial, residential, and transportation. Local regulation can affect more than 28% of the total energy consumption of the U.S. (residential and commercial space heating and cooling, 21%, plus water heating, 4%, plus urban transportation, at least 3%).

Every year, the demand for energy rises. Every year the rate of consumption rises. A Vice President of Consolidated Edison Co. of N.Y. Inc. summed up the problem facing American cities today:

When you consider the whole energy picture, the big loads are caused by space heating, space cooling, water heating, automobiles, mass transit, sewage disposal, water pumping. We have tremendous growth in these areas going on in New York City.

Table 1 lists the annual growth rate of energy consumption in the U.S. during the years 1960 to 1968.

Inefficient utilization at the point of consumption contributes to waste and, therefore, tends to augment the growth rates. Inexpensive energy has led to inefficient utilization and high growth rates. A discussion of those problem areas which the local authority can affect follows. The problem has two hosts: indoor spaces or Architecture and community spaces or Townscape.

2. see figure 1 p. 8.
Figure 1.
End Uses of Energy
United States, 1968*

Table 1.

Annual Growth Rate of Energy Consumption by End Use from 1960-1968. 4

<table>
<thead>
<tr>
<th>End Use</th>
<th>Annual rate of growth (%)</th>
<th>Percent of national total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1960</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>space heating</td>
<td>4.1</td>
<td>11.3</td>
</tr>
<tr>
<td>water heating</td>
<td>5.2</td>
<td>2.7</td>
</tr>
<tr>
<td>cooking</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>clothes drying</td>
<td>10.6</td>
<td>0.2</td>
</tr>
<tr>
<td>refrigeration</td>
<td>8.2</td>
<td>0.9</td>
</tr>
<tr>
<td>air conditioning</td>
<td>15.6</td>
<td>0.3</td>
</tr>
<tr>
<td>other</td>
<td>5.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Total</td>
<td>4.8</td>
<td>18.6</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>space heating</td>
<td>3.8</td>
<td>11.2</td>
</tr>
<tr>
<td>water heating</td>
<td>2.3</td>
<td>1.3</td>
</tr>
<tr>
<td>cooking</td>
<td>4.5</td>
<td>0.2</td>
</tr>
<tr>
<td>refrigeration</td>
<td>2.9</td>
<td>1.2</td>
</tr>
<tr>
<td>air conditioning</td>
<td>8.6</td>
<td>1.3</td>
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<tr>
<td>feedstock</td>
<td>3.7</td>
<td>1.7</td>
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<tr>
<td>other</td>
<td>28.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>5.4</td>
<td>13.2</td>
</tr>
<tr>
<td>Industrial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3.9</td>
<td>42.7</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fuel</td>
<td>4.1</td>
<td>25.2</td>
</tr>
<tr>
<td>raw materials</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>4.1</td>
<td>25.5</td>
</tr>
<tr>
<td>National Total</td>
<td>4.3</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Architecture

The major use of energy in architecture is in climate modification. Twenty-one percent of the energy consumed in the U.S. in 1968 was used to condition indoor spaces, i.e., to create spaces with climatological conditions which allow the human body to function in comfort. There are a number of conventions which have developed in building conditioning which are wasteful of energy. One of these is the twentieth century tendency to prefer imported resources (fossil fuels) to natural resources which may be available on the site (solar energy, wind energy).

The regional climate (sun, winds, humidity, precipitation) interacts with the local environmental characteristics to create unique local climate conditions. Local environmental characteristics such as topography and vegetation can capture or reflect solar radiation, increase or decrease winds, and/or cause changes in humidity. These effects combine to form the local climate or "microclimate".

Early man learned to use natural microclimates for sheltering. At first, he used natural shelters like caves. Upon moving into his own shelters, early man learned to locate and shape his shelters to maximize the advantages afforded him by the local conditions and minimize the effects of the disadvantages. Where importable energy is not so readily available as in the United States, the art of using microclimatic advantages is still practiced.

5. see figure 1. p. 8.
Any man-made intervention into the natural environment, architectural or other, becomes a local characteristic and begins to affect the microclimate. Where importable energy is not available, a shelter must be designed to create an indoor climate which will support and foster human activity. Intuitively, it is understood that this must involve the creation of a "climatological sheath around each ...[shelter which is characterized by the most favorable components in the outdoor climate." The form, materials, and the resultant effects these have on the microclimate all become important in energy conservation considerations.

The igloo is an elegant example of the use of natural resources in a climate which affords little advantages to sheltering. The hemispherical form maximizes volume while minimizing surface area. This results in the least possible heat loss. The outside form of the igloo also causes little wind resistance which also cuts down on heat loss. The hemispherical indoor space is one which is most efficiently heated by a central point source. The entrance is stepped down from the living area thus allowing the cold air to drain out of the igloo. Snow and ice are excellent insulators. In toto, the igloo is designed for indoor climate amidst the harshest of climates with a minimal use of imported energy.

Although examples of environmental integration or the use of natural resources and advantages which avail themselves can be found on the U.S., the American vernacular has drifted far from the use of the beneficial interaction of structure with environmental factors. The release of naturally stored energies has made it possible to solve climatic problems irregardless of local conditions.

Today, mechanical heating, ventilating, and air conditioning systems (HVAC systems) create and maintain favorable indoor climates regardless of location, orientation, form, and/or choice of materials.

The glass curtain wall office tower epitomizes contemporary American commercial architecture. It is interesting and informative to look at the kinds of obstacles such a building places in the way of efficient and conservative space conditioning. The height of a skyscraper puts much of it right out in the regional climate and eliminates the possibilities of favorable modification by topography or vegetation. Tall buildings affect local wind conditions in very striking ways. The rectangular form tends to increase wind resistance along the surfaces thus increasing heat loss from the building and the heating load in the winter. The huge amounts of surface area which are exposed to radiation cause an overall increase of heat gain during the warm months and localized heat gain at all times during the year. This might mean that certain [8] Gosta Carlestan, "Climatological Data for Regional and Town Planning" in C.I.B. p. 40.
areas in the building have to be cooled even during the heating season. Regional winds hitting the building make a sealed shell necessary. The lack of natural ventilation which openable windows make possible creates a need for mechanical ventilation during all seasons. As a rule glass has a very low thermal resistance. This means that more heat is allowed out during the winter and in during the summer, when glass is used, than when some other material is used. The use of glass can, however cut down on the amount of lighting needed on the perimeter of the building. Thermal glass is often used to offset the heat loss/gain problem. Unfortunately, thermal glass transmits little natural light.

More conserving buildings would be designed for a specific climate. In temperate and cool climates where heating makes up the largest energy expenditure, a conserving building would take full advantage of climate sheltering devices. The building would be low. Trees and shrubs would be used to break cold winds. Trees and facade elements would be used to control radiation. Windows would be openable to allow natural ventilation whenever possible. The building would not be made out of glass and all windows would be protected from surficial air movement which facilitates heat loss. Since the walls each have different orientations, each one might well be different in form and materials to optimize advantages at that orientation. The building would be placed on the land to
take full advantage of the sheltering effects of different landforms. These and other alternatives for conserving design will be discussed in more detail in later sections.

It is easy to see why the glass skyscraper requires an excessive amount of energy to condition. This example brings to mind two points of importance. The first is that if an excessively large amount of energy is needed to maintain a pleasant indoor climate in a building, imagine the waste multiplied by the hundreds of buildings in a community! This excessive consumption also affects the outdoor air in terms of temperature, pollution, and noise.

In other words, excessive consumption has a disturbing effect on the ecosystem. The disturbance creates "a completely new environment against which we must provide protection." The second point is the more important within the context of this paper. The example illustrates the many ways such a building wastes energy. At the same time, it shows how much room there is for improvement and conservation.

Many energy-wasteful practices in building conditioning have been institutionalized in standards and building codes. Human comfort is based on thermal balance, i.e., the ability of the body to exchange heat with the surroundings. The bioclimatic building chart illustrates that thermal balance can be achieved through a variety of means.

of combinations of air temperatures, wind velocities, humidity levels, and radiation levels. Comfort is also affected by the level of activity and the amount of clothing worn. Standard practice today is to maintain all the climatic elements at a constant level when variation within bounds could save energy and provide a more stimulating working or living atmosphere. Often, these levels are maintained even when the building is not in use.

It has been said that the major impact of codes and standards on energy consumption is in the requirements for ventilation and illumination. According to Dubin-Mindell-Bloome Associates (hereafter DMBA), the necessary oxygen can be supplied by ventilation of 1-2 CFM/person and that an additional 1-4 CFM/person is sufficient for the control of odors and light smoking. According to the 1970 Boston building code, ventilation as low as 5 CFM/person is only allowable in spaces where smoking is not allowed which have at least 600 cubic feet per person in volume.

There are basically two ways in which lighting standards are excessive: high lighting levels are often maintained where they are not needed and when they are not needed. Standards often require whole rooms to be lit at levels which facilitate intricate work when such work is done only in a small part of the room. Much more energy is required to light the entire room to this level than to maintain the room at a lower level and light only the portion used for intricate work to the higher level. Areas are often maintained at high levels.

12. Ibid. p. 54.
when the room is used for work requiring those levels for only a short time during the day or night. Corridors and rooms often remain lit even they are not being used (weekends, nights).

A combination of task lighting and lighting controls which allow lighting in areas to be shut off or reduce when they are not being used, or are being used for tasks which do not require so much light. Tools for work can be chosen to allow performance in reduced lighting situations. For example, switching from #2 pencils on white paper to black flairs on tinted paper for tasks of more than one hour duration could reduce lighting level requirements by as much as 40% without any loss in visual Performance.

Prescription building codes and predetermined standards often have requirements which either lead to wasteful energy use or prohibit innovation which could conserve. An extreme example is one which was still on the books in a Texas community as late as the early 1950's. It stated that no part of a class room should be further from a window that twice the height of the top of the window from the floor. This means that to have a reasonably shaped classroom of 30 ft. across the ceilings would have to be at least 15 ft. high! This creates huge useless volumes that have to be conditioned. Many codes still have restrictions on minimum window areas for light and air that do not include skylights which can be more efficient at providing light.

Standards which are set outside the municipality are often set by associations which are biased towards excessive consumption. Often such associations are dominated by representatives of firms which manufacture the materials and equipment involved in the standard.

For example, lighting standards are set by an association whose members

are associated with firms that manufacture lighting equipment!

Minimum requirements for insulation are common and are often too low and encourage wasteful energy consumption. Minimum requirements for window areas are often stated as a percentage of the floor area, regardless of compass exposure. Interior climate and lighting standards are set without regard for specific needs. Energy saving solutions, however, require close attention to the specific site characteristics and user needs. Codes and standards often restrict the designer from the optimal energy conserving solution.

Modern commercial and large residential buildings require a range of mechanical support systems from elevators and escalators to HVAC systems. All of these consume power for operation and maintenance. The materials necessary for these systems such as duct work and piping cost energy to manufacture. Decisions affecting the choice of systems are usually made on the basis of initial dollar costs. Future operation and maintenance dollar and energy costs are rarely taken into account. Unfortunately, the system with a low initial dollar cost is likely to have poor operating efficiency and a high operation and maintenance cost. Since dollar costs are not always in proportion with energy costs, even choices made on the basis of dollar costs over time may not be energy saving choices. These factors combine to make tradeoffs between initial costs, life cycle costs, and energy life cycle costs obscure, and to make energy conserving decisions even more difficult to optimize.

17. from conversation with G. Hack May 1975.
The American dream of a house on a plot of land, unfortunately, causes most of the waste of energy in residential consumption patterns. The usual procedure for subdivision development is to first clear and rework the land, then to place upon individual lots identical homes which face the road. The roads are placed to fit the most house lots on the site. This type of development is a prime example of poor climatic planning and energy utilization. Decisions which involve energy consumption/conservation are made by the profit maximizing developer on the basis of initial costs. This usually results in 1) little consideration of the natural resources on the site for favorable microclimate creation, 2) the lowest allowable investment in materials (e.g., minimum insulation), 3) the lowest possible investment in heating and cooling apparatus, and 4) the lowest investment in quality of construction. Mortgaging policies reinforce these practices by granting loans on the basis of first costs. This makes it virtually impossible for the home buyer to demand higher initial investments which would result in energy savings over time.

There is room for improvement in the single family house; one may assume that most of the residential buildings in use today may consume 40% more energy than they would had they been insulated and sealed in accordance with present day minimum property standards.

However, the waste which is caused by one single family home is multiplied by the number of single family homes. Subdivision development results in wasteful energy consumption above and beyond that of the individual homes. It is apparent that is energy conservation is to become a habit in America, the American dream must shift away from the traditional single family house.

Out of this discussion of the problems which lie behind the failure of contemporary architecture to conserve energy come three target areas for community energy policy.

I. The financial situation which; a) does not encourage life cycle costing of any sort, dollar or energy, b) barely allows the developer to cover the costs of poor repetitive design and precludes the possibility of energy conserving design.

II. The codes and standards which in some instances actually require wasteful expenditure of energy and often restrict the designer from an energy conserving solution.

III. Societal attitudes which; a) regard energy as a cheap and easy substitute for old fashioned environmental integration, b) cause a demand for energy wasteful products.
The energy waste which becomes apparent at the community level is not simply the waste in individual buildings multiplied by the number of buildings which make up the community. Inexpensive energy has had its effect on towns above and beyond the individual structures. In many ways, the effect on communities has been the most devastating. The community is made up of numerous networks which serve individuals, institutions, and buildings. Transportation systems, waste disposal systems, and communication networks use energy for operation. The energy utilities, electric, gas, coal, fuel oil, ... consume energy in production and distribution.

The community is a mosaic of energy uses which differs from its natural counterpart, the ecosystem, in its dependence on imported materials and energy. In the stable, natural ecosystem, the amount of possible production is determined by the limiting factor. In the human ecosystem created by the widespread use of fossil fuels and materials imported from outside the system, the effect of the limiting factor has been removed. Materials are imported from all over the world to subsidize systems which may otherwise have been limited by the lack of that material. Fossil fuels supply this "industrial ecosystem" with unlimited energy. Energy subsidies in the form of machinery, and materials in the form of fertilizers cause the high farm yields common in industrialized

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societies. Essentially, energy flow has become the lim-
20
iting or unlimiting factor in the economy.

The removal of natural limiting factors which controlled
production has resulted in an uncontrolled pattern of growth
at the national and local levels. Just as "work expands
to fill the time available", production expands to use the
energy available. This uncontrolled growth has resulted
in extreme misuse of the environment. Environmental and
energy problems agree that the system must be stabilized.
Government at all levels must apply limits to the indus-
trial ecosystem in a way which would ease it into a stea-
dy-state system without inflicting irreparable damage to
social institutions.

The patterns of land use which have become prevalent
in American communities are rarely determined by overall
community energy efficiency considerations. Only in the
most severe climates and where imported energy is not
available do land use patterns respond directly to energy
considerations. A very simplified example is a self-suf-
ficient farm. The farm is located near the fields and near
the woods which supply the farm with fuel. In this system
the only energy expenditure is the farmer's own; and his
farm buildings are located with respect to the existing
conditions in such a way that minimizes his energy expen-
diture. The efficient working of the farm depends on the

relative locations of the components. In the modern U.S.

20. Howard T. Odum, "Terminating Fallacies in National Policy on
Energy Economics, and Environment" in Energy: Today's Choices, Tomorrow's
community, work, shops, the bank, ... are not necessarily located anywhere near each other, or anywhere near home. The car and inexpensive imported energy have replaced rational land use for people.

Most cities in plan reflect a variety of social elements; "mixtures of dynastic, military, transportation, real estate, and occasionally philanthropic considerations." The industrial city depends on the import of necessary materials and energy for its survival. In light of this, it is not surprising that most American towns and cities betray transportation as having the major impact on land use patterns. Indeed, it has been suggested that the spread of single family homes into the U.S.'e countryside has been largely encouraged by the expansion of the roadway system. The "American dream" house provided the incentive and the roads provided the means.

As different modes of transportation have come into existence, different patterns of land use have developed. It is easy to recognize a railroad or canal town by their linear growth patterns. The automobile, with its flexibility and speed, has caused a shift away from nodal and linear development toward the more uniform sprawling patterns. When there is a demand for any new development, the less expensive land on the outskirts of town becomes prime land for low density development. Subdivisions, garden apartments, and low density commercial establishments begin coming in at the edges of the higher density town.

These areas are designed for the automobile. Signs are large and garish so as to be readable from a moving car, the distances between establishments are discouraging even if there are sidewalks (often there are none), and roads are dangerous to would-be bicyclists. Above and beyond the objectionable landscape created by auto-oriented development, it is extremely wasteful of energy.

In a study done for H.U.D., the Real Estate Research Corporation compares different community types by their estimated costs. For the purposes of the study, characteristics of six prototype communities of equal size were determined. Among the costs compared is energy consumption. Table 2 shows their results.

According to the Costs of Sprawl, planning alone can result in energy savings of 14% in communities with mixed densities and 8% in low density communities. A combination of planning and increased density can result in savings of as much as 44% over low density sprawling communities.

Decreased energy expended on auto transportation accounts for much of the savings connected with planned communities. Higher density planned communities save energy consumed for heating and cooling as well as energy consumed by automobile travel. Higher density development results in less space to condition and possibility higher efficiency conditioning.

Sprawling communities require more extensive, hence more energy consuming services. As the physical size of the community increases due to low density sprawl, more garbage trucks are required.

24. Ibid.
25. Ibid.
## Table 2.
Community Cost Analysis:
Energy Consumption

<table>
<thead>
<tr>
<th>Annual Consumption of Energy</th>
<th>Planned Mix</th>
<th>Combination Mix</th>
<th>Sprawl Mix</th>
<th>Low Density Planned</th>
<th>Low Density Sprawl</th>
<th>High Density Sprawl</th>
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<tbody>
<tr>
<td>Natural Gas**</td>
<td>999.418</td>
<td>999.418</td>
<td>999.418</td>
<td>1,347.090</td>
<td>1,347.090</td>
<td>795.177</td>
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<tr>
<td>Electricity**</td>
<td>751.020</td>
<td>751.020</td>
<td>751.020</td>
<td>1,007.610</td>
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<td>604.960</td>
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<td>Gasoline**</td>
<td>1,066.043</td>
<td>1,284.313</td>
<td>1,531.053</td>
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<td>1,705.037</td>
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<td>Total**</td>
<td>2,816.481</td>
<td>3,034.751</td>
<td>3,281.491</td>
<td>3,740.240</td>
<td>4,059.737</td>
<td>2,257.400</td>
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</table>

*Real Estate Research Corp.; p. 147
**Billion BTUs per year
to cover more miles in order to service the community. As the amount of necessary power line increases, transmission losses increase. Similarly, as the distances increase, the energy requirements for water pumping increase.

Haphazard development often requires more roads, more sewer pipes, more water mains,...All of which cost energy to manufacture and install. A developer is concerned with minimizing the use of expensive materials within his site, he is not concerned with how efficiently his development fits in with the overall system. Sprawling, unmanaged development often results in the inefficient use of energy expensive material.

Transportation is a problem in and of itself. Table 3 shows the relative energy efficiencies of various modes of transportation.

<table>
<thead>
<tr>
<th>Intercity mode</th>
<th>energy (BTU/pas.-mi.)</th>
<th>Urban mode</th>
<th>energy (BTU/pas.-mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>bus</td>
<td>1600</td>
<td>bicycle</td>
<td>200</td>
</tr>
<tr>
<td>railroad</td>
<td>2900</td>
<td>walking</td>
<td>300</td>
</tr>
<tr>
<td>car</td>
<td>3400</td>
<td>mass trans.</td>
<td>3800</td>
</tr>
<tr>
<td>airplane</td>
<td>8400</td>
<td>car</td>
<td>8100</td>
</tr>
</tbody>
</table>

Although the automobile is the most inefficient mode of urban transportation, it is the most often used. When a would-be cyclists drives because s/he finds the roads to dangerous, s/he uses 12.6 times the energy. When someone drives because there is no available mode, s/he

27. See Real Estate Research.
consumes over twice the energy. The amount of wasted becomes very large very quickly when the actual numbers of car-miles which are driven in a day are added up.

The problems concerning energy consumption/conservation which face the community are complex. Three generalized targets for local governmental strategies come out of the preceding discussion.

I. The problem of uncontrolled growth. Local governments are in the position to play a decisive part in easing the necessary transitions and in raising the consciousness of individuals who will be affected by change.

II. Land use patterns. Recent development has been geared toward the car. The resultant "sprawl" is extremely wasteful of energy.

III. Transportation systems. The automobile is the most widely used mode of transportation yet it is the most inefficient mode of urban transportation. Transportation networks affect land use patterns.
NEW PATTERNS AND POSSIBILITIES

Overview

It is the planner's vocation to be critical of the complex movement of goods, services, and people which make up the dynamic community and the structures, resources, and places which make up the static community. S/he must be and become aware of the faults and inefficiencies in the system.

It is the planner's vocation to imagine an ideal community, to visualize how things can be better. S/he must decide, extrapolate, guess, or in some other way come to an understanding of what S/he believes to be an appropriate goal for the community.

It is the planner's vocation to act on his criticisms and goals in the belief that improvement is possible and that the future can house a more just, a more beautiful, a more hospitable, or, in other words a more liveable community.

Part one of this paper represents stage one in the planning process: problem recognition. This part represents stage two in the planning process: the study of alternatives.
Architecture

In its attempt to meet the physical and aesthetic needs of clients and potential users, architecture must reflect contemporary attitudes and concepts. In many ways, the architecture of the last forty years has reflected inexpensive energy and the disregard for the environment which has characterized American society. New patterns in building design and construction will come into existence in response to the "energy crisis" and a new concern for the physical environment.

The architecture of excessiveness must be replaced with an architecture of economy.... We're due for another revolution in architecture which responds to the additional changes of all people about fuel shortages as well as the total environment, conservation picture.

Builder-designers, whether they be architects or not, have been relying to heavily on the use of imported energy to cover deficiencies in design. This is the fault of a system which barely gives the designer funds to cover repetitive design and at times pre-empts the designer altogether.

The art of low energy design must be rediscovered and renewed with the aid of new technologies. Architects and engineers should slip into a new role which this kind of change requires. They should become "modifiers" of the environment (or environmental integraters). The new architecture should use natural resources and existing and future technology in an innovative manner to create energy efficient, physically comfortable, and aesthetically pleasing indoor and outdoor spaces.

The future offers this new challenge to designers. But, in order for architects and engineers to answer to the challenge, they must be free to exercise their full range of imagination and inventiveness.

Prescriptive codes describe exactly what materials and dimensions are to be used for certain building components. If the codes are followed, the building will be reasonably protected in the case of fire and the indoor spaces will have adequate light and air. The codes are general enough to allow this to be true for any building regardless of site characteristics and use patterns. As a result, the requirements are at times excessive. The system is highly inflexible to specific cases and changes in available materials and societal attitudes. Innovation is discouraged, and the only avenue for reform is dollar savings.

An alternative system is performance standards. These specify what a component must be able to do but not exactly how it is to do it. Performance codes can also be applied directly to the issue of energy conservation through energy performance standards or energy budgets. These will be discussed in more detail in the third part of this paper.

Whether applied directly to the energy issue or simply adopted in place of prescriptive codes, performance codes can lead to energy conservation. Performance standards allow the designer much more freedom to find solutions to the specific site conditions and user criteria. Less expensive and less energy consumptive designs which are keyed closer to the site and client can result. Technical innovations are encouraged and the incentives for innovation can be created and directed by the code. (for example, energy budgets provide freedom
and incentive for innovative energy conserving solutions.)

The high initial cost of energy conserving buildings has discouraged the wider use of technology which is available today. Conventional patterns have been subsidized to such a degree by artificially low energy prices that it is difficult to build alternative systems which conserve over time. New patterns must be based on life cycle costing. The practice of costing over time brings long term costs and savings into the design decision process. As dollar cost/savings are made to vary more closely to energy costs/savings, life cycle costing can result in more energy conserving decisions. Long term costing can also encourage the building of what are initially expensive innovative prototypes which, if successful, could be mass produced more cheaply.

One key to energy conservation is the manipulation of the environment to make it work toward the ends desired. Environmental integration is the process of using the positive environmental components while reducing the effect of the negative components. Environmental integration requires asking the questions: How can I make this better? or How can I use what this site already has to offer? rather than: How can I protect my client against these elements? The local authority must exemplify and encourage the positive approach.

Energy is consumed in overcoming the differential of climatic elements which exists between the outside of a building and the inside. Energy can be conserved if the design is able to use the positive site characteristics to create a climatic sheath. A useful sheath is one which minimizes the differential through the passive manipulation of climatic elements. Location, orientation, building geometry,
materials, shading, wind control, and planting are the tools for energy conserving climate manipulation. If climatic elements can be manipulated to result in an increase of three degrees along one wall of a house during the winter months, up to 6% of that house's annual energy consumption can be saved.

An understanding of the movement of the sun across the sky is essential to the passive use of the sun's energy. Each outside wall of a building faces a different direction. Each exposed to different patterns of insolation during a day. In order to take the best advantage of each exposure and to properly control the heat and light received by interior spaces, each wall may be physically different from the others. Conventional buildings are usually identical on all sides. Sometimes this leads to the need for cooling in one part of the building while the rest of the building is being heated. The architecture of energy conservation may well be characterized by asymmetrical facades.

In Design with Climate, Victor Olgyay includes comparative analyses of matched "orthodox" and "balanced houses in terms of heat gain and loss in different climates in the U.S." The results of his analysis of houses in temperate climates (N.Y.) are illustrated in Figure 2. The orthodox house was balanced through changes in orientation, building geometry, materials in the roof and certain walls.

2. C. McGinn based on his work in conjunction with the Housing for Newark's Watershed study. Spring 1975.
NEW YORK
ORTHODOX HOUSE

WINTER

BALANCED HOUSE

WINTER

SUMMER

SUMMER

Victor Olgyay p. 136.
window sizes, and the addition of plantings and shading devices.

Shading devices are useful solar heat/light controls which can be added to any design or existing building. Problems of excessive heat gains which necessitate cooling can be completely or partially remedied through the use of shading devices. Deciduous trees are useful as shading devices in temperate climates where solar heat is desired during the winter and deplored during the summer. Building appendages and facade elements (eaves shields, etc.) can be designed to allow light and radiation at certain times of the day or year and not at others.

Sun and wind are "the two main influences in physical orientation." In southern latitudes, wind is the more important factor, but throughout most of the U.S., the optimum orientation is dictated by solar considerations. Figure 3 shows Olgyay's optimum orientations for most of the U.S.

In hot, humid climates, increased wind can result in energy conservation. Throughout most of the U.S., however, increased winds result in increased heat loss and heating loads. Winds can be manipulated and modified in a number of ways. Structural and natural forms can be used to increase or decrease winds through an area. Buildings, hedges, and trees can be used to shield other buildings or spaces. Facade elements can be designed to direct

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4. Victor Olgyay chapter VII.
5. Ibid. p. 55.
Figure 3.
Orientation

Cool Region
(Novato, California)

Temperate Region
(New York-New Jersey)

Hot-Arid Region
(Phoenix)

Hot-Humid Region
(Miami)

Olgyay, p. 61.
breezes into interior spaces. Different facade elements can be used to protect materials with high thermal conductance from surficial air movement. Pressure walls can be designed to ventilate leeward spaces or to direct air into low energy consuming cooling units like the evaporative cooler. The wind tunnel and/or water table can be used to test wind effects during the design process.

The form of the building affects the amount of energy it requires. In climates where energy is used primarily to counteract heat loss and gain, a low surface area to volume ratio is best. Where energy can be saved by using natural lighting or by facilitating heat loss from the interior spaces, the surface area to volume ratio should be high. Since different walls receive different amounts of solar radiation, building geometry further affects indoor climate by exposing more or less external surface area to the sun. In northern latitudes, a rectangular plan with the long axis aligned nearly East-West allows radiation in the winter and summer through the southern exposure but allows little of the morning and afternoon summer radiation through the East and West exposures. Olgyey has combined the criteria of surface to volume and building plan geometry to arrive at the optimum building configurations for different American climates. His results are shown in Figure 4.

7. see Victor Olgyey chapter IX. 
The energy conserving architecture of the future should be characterized by the thoughtful use of materials. Every material has different thermal, reflective, and aesthetic properties. Each building component can be chosen with an eye to its specific role in passive energy conserving design.

- In hot climates, walls can be designed to delay transmission of heat until the evening when it would be desirable.

- Composite walls have been developed which store heat through the melting of parafin.

- Shawn Buckley of MIT has developed a "thermic diode" which stores heat and allows transfer of heat in only one direction.

- NASA has developed paints with controlled ratios of solar absorptivity to gray body emissivity which can control the temperature of structures passively.

- Zomeworks has developed the bead wall which is a double glass wall with space between the plates. When more insulating wall is needed or desired the space is filled with beads of styrofoam or other insulative material.

- Burying parts of the building makes use of the earth's natural insulating qualities.

9. Victor Olgyay
Burying parts of the building makes use of the earth's natural insulating qualities. Collecting snow on the roof makes use of the insulative properties of snow. Using insulation properly (enough, kept dry, not cramped, etc.) can result in tremendous energy savings.

Passively conditioned outdoor spaces designed with an understanding of desirable microclimate creation and maintenance could in some climates be used in place of interior spaces. Classes, dining, and conferences could all be easily adapted to outdoor spaces. Where precipitation presents a problem to the use of outdoor spaces, semi-enclosed spaces such as greenhouses and/or tents could be used. The use of conditioned outdoor spaces can reduce energy consumption by reducing the amount of interior space which must be artificially conditioned and lit.

The same materials and practices of environmental integration will not result in energy conservation across the country. Climatic conditions define regions. The architecture of conservation will be characterized by regional differentiation. The common practice of putting identical structures throughout the U.S. will end and be replaced by a new regionalism in building aesthetic. Each region will have its own vernacular architecture born out of its unique environmental characteristics.
In most cases, passive design will not eliminate the need for imported energy powered mechanical systems. Imported energy will still be used to heat, cool, and illuminate indoor spaces but with much improved efficiency of use.

An efficient plan reduces energy consumption by reducing the amount of space which needs to be conditioned. The open plan is the most efficient way to achieve cross ventilation and natural lighting. The open plan can also be heated and cooled using simpler systems with higher energy efficiencies.

The redefinition of comfort standards can result in tremendous energy savings. Under most circumstances, there is no need to maintain each element at the optimum. Systems can be smaller and operated more efficiently if sizing was based on slightly worse than average rather than on extreme conditions. Systems should be designed to condition to the edge of comfort. Clothing can be added or removed to provide comfort when extreme conditions occur.

The recognition of specific climate requirements for different tasks and activities allows the conservation of energy through the localization of energy expenditures. Large interior spaces can be maintained at sub optimal levels while local areas can be brought up to optimal levels. Designing for specific task requirements is especially applicable to lighting. The same concept applied to heating and cooling should be explored to determine the circumstances under which energy can be saved.

Efficiency in HVAC systems can be improved through a variety of means. Operating efficiency can be improved by using equipment sized to handle average rather than extreme loads, designing at the edge of comfort, and task recognition. Life cycle or energy

costing of equipment can result in the installation of systems which conserve energy over time. Tradeoffs between decentralized versus centralized systems can be judged with energy consumption/conservation as a criterion. Flexibility of control which allows areas to be shut off when not in use can result in substantial energy savings.

There is much room for conserving technical innovation in HVAC systems. Many have already been developed. The heat pump which works much like a refrigerator in reverse was available during the fifties. They have been improved and the "energy crisis" has made them more attractive in the market than they had been. The heat pump can deliver as much as two units of heat energy for unit of electrical energy it consumes. Heat exchangers can recapture for reuse (or initial use) heat energy which remains in the exhausted air or which results from the lighting system. Two types of exchangers have been designed. The rotary wheel exchanger transfers both sensible and latent heat but requires that the supply and exhaust ducts be in one location. The coil exchanger transfers only sensible heat but allows the supply and exhaust to be separated. The coil exchanger is especially suited to retrofitting existing buildings.

The heat transfer concept has been applied in the U.S. A study was conducted for the first large building to use the concept in a combined lighting and air conditioning troffer: the San Diego Home Tower building. The quantity of air needed per floor was reduced by 11% which was reflected in reduced power for fans and in duct sizes. Illumination was increased by 10%. In all, $50,000 extra was spent on double glazing and $20,000 extra for special lighting fixtures. But $100,000 was saved in installation.

15. Citizens' Advisory Comm. on Envir. Quality p. 27.
16. Progressive Architecture p. 17
17. Ibid.
costs through reduced air conditioning tonnage and in air handling equipment.

The heat pipe is a different kind of heat transfer device with different kinds of applications. It is a pipe filled with a working fluid which evaporates near one end and condenses near the other. It can double as a structural member. Since it can remove heat very quickly in case of fire, use of the heat pipe can result in the relaxing of fireproofing requirements for steel frame buildings. NASA has perfected a reversible pipe which can remove heat from the building and reverse to process in the fall. It is of less use in the winter except in the control of overheated spaces.

Of utmost importance is that each innovation provide explicitly for operation and maintenance. "[11] All energy conservation methods are dependent in the final analysis upon proper operation and maintenance." Even the most efficient equipment will not save energy unless it is properly operated and maintained.

Other technical innovations which, if applied, can save energy are in the development process or will be developed in the future. The problems with financing and rigid codes obstruct the application of these new technologies. The more flexible, energy responsive patterns which will be created in the future must provide incentives for innovation and constant improvements in the efficient use of energy.

19. Ibid. p. 34.
20. Ibid.
Future development patterns which conserve may facilitate the use of alternative energy systems for individual buildings. The possibilities and new technology which have been discussed all presuppose the basic utility system which exists today. Large utility companies produce electricity which is sold to a local utility or transmitted directly to the building-user. Heating fuel is obtained by the user from a separate source and fed into the building's own HVAC system. This pattern may well become obsolete as new energy conserving technology and patterns are developed. Solar energy and total energy systems are conserving alternatives which are less dependent on the existing utility structure.

Solar energy

There are many circumstances under which the use of solar energy for space heating and cooling can result in imported energy savings. The literature on solar energy is extensive and will not be discussed here in detail. Solar energy utilization will play a part in the energy use patterns of the future. Flat plate collectors can cover the heating load over most of the heating season in warm and temperate climates. Solar cooling systems have also been developed but with less overall success than heating systems. Water storage flat plate collector system with a wood burning back up would take care of all the heating requirements comfortably in low density rural areas. At higher densities, there is less room for solar collectors and wood burning is impractical and dangerous. The protection of investments in solar energy utilization devices requires a system of legal or purchased "sun rights".

Photovoltaic cells which are currently being tested are very expensive to manufacture (both in terms of dollar costs and energy costs).
The day may come, however, when photovoltaic cells can be make inexpensively enough or when their efficiency is improved to such a degree that the energy cost of production can be returned in energy savings over a few years. When and if this day ever arrives, the widespread use of photovoltaic cells will have a tremendous impact on patterns of energy use. Without careful planning, however, this kind of technical breakthrough could result in the same kind of uncontrolled growth and environmental degradation which has occurred during this century in the U.S.

"Total energy"

"Total energy" is the name given to the on-site generation of electricity and the use of the waste heat for building conditioning.

The idea of total energy is deceptively simple, its ramifications fascinating. A building contains its own electric generating system, then captures the system's waste heat, converts it into steam or hot water and uses this by-product for heating, air conditioning (with absorption chillers), and domestic hot water. In appropriate situations, fuel costs to power the generating system are less than the cost of electricity from a public utility. Plus, the heat supplied by the recovery system represents fuel that would otherwise be purchased.

Figure 5 is a diagrammatic sketch of a total energy system.


As a rule, large electrical generating stations are able to attain much high efficiencies in converting fuel into electrical energy than small on site generators. Since the waste heat is used in a total energy system, the overall efficiency of energy use can be as high as 65% (other sources predict efficiencies as high as 70-80%). Electric companies generally operate with an overall efficiency of 20-40% since the waste heat is generally discarded.

Total energy at the scale of the individual building may not ever be any more feasible than it is right now. With energy management, however, the optimum size for total energy installations can be determined and encouraged. The concepts of district heating, cooling and power generation will be discussed in the next section.

26. Ibid.
The economists of the Public Service Commission have studied the growth rate problem. Their study resulted in the statement that a reduction of the growth rate by 4.2% compounded to 3.7% by 1980 is possible without significantly reducing the standard of living or causing widespread unemployment. In order to estimate these figures, they made certain assumptions about the energy conserving changes which would be made.

- reduce the average miles per gallon of automobiles from the 1069 average of 13.75 to 20.
- increase the average efficiency of electrical generation in fossil fuel plants to 35-37%.
- halve the energy requirements for new buildings through the use of "superior insulation and other energy conserving features.

All but the last of these is outside the control of the local government. They are relatively short range changes which grow out of the goal to reduce energy consumption "across the board" of the country. The community can conserve energy beyond that required by national policies. Communities can improve efficiency of energy use and distribution within each of its service networks. Each of these consumes energy in ways which can be improved. Energy is also expended in interactions among networks. The community can conserve energy through the more efficient coordination of all of its networks.

Energy can be saved by integrating all of the individual energy systems into a master complex, each subsystem consuming less energy than would be required without the interfaces between subsystems.

28. Ibid.
29. Progressive Architecture p.3.
Immediately following is a discussion of improvements possible in the energy consumption efficiencies of community networks. Then, a projection of long range energy conservation possibilities brought about by planning and urban design in conjunction with energy management issues. A descriptive scenario of an imagined energy conserving community is also included.

The transportation network (passenger transportation) is one of the most extensive network in the community. Community transportation based on the privately owned automobile causes waste of energy directly by discouraging the use of more energy efficient modes of transportation. It causes waste indirectly by encouraging wasteful sprawling development.

The direct waste caused by the use of automobiles can be effected in four ways:

a) increase vehicle efficiency; b) increase the occupancy of vehicles; c) shift the demand from less to more energy efficient modes; and d) reduce overall demand. Of these, b), c), and d) are implementable at the local level. Only demand shifting can alleviate the detrimental effects of the automobile based transportation network on development patterns.

In the short run, car pooling can increase the occupancy of vehicles. Malliaris and Strombotne have estimated that persuading fifty percent of urban commuters to car pool can result in the conservation of 3.1% of the total U.S. energy consumed by transportation (1970). Persuading other urban passenger trip takers, shopper, school goers, etc., to car pool can reduce transportation energy consumption even more.

31. Ibid. p. 433.
Shifting the demand to more efficient modes is a mid range policy. At the present time, there are two obstacles to shifting the demand to more efficient modes. One is that gasoline and automobile prices have been held artificially low. Another is the spiralling self-reinforcing effect which auto-oriented development creates. Extended roadway systems plus cars plus the American dream lead to sprawling development. Sprawling development encourages the further extension of the roadway system. Since everyone owns a car, there is no need for a public transportation network. Since there is no public transit everyone needs a car. In a sprawling community, the distances are such to discourage walking or cycling. Any design that goes into sprawl community is for the travelling speeds and size of the automobile and is often unpleasantly garish to the slower moving traveller.

Making alternatives available is not sufficient to shift demand over to the more efficient modes. If automobile manufacture and operation prices are brought more closely into line with their true energy costs, then, the availability of other modes can shift demand. Unfortunately, it is beyond the scope of the community to affect the automobile industry.

Reducing overall demand requires drastic changes in lifestyles and development patterns. These kinds of changes are long range and require careful planning by policy makers.

Fuel rationing, travel rationing, four-day week, television links to replace some travel, urban and community design to minimize travel, and walking and bicycling instead of driving have all been suggested as possible ways to reduce demand.

An energy conserving network would include only the most efficient of the urban modes. Walking and cycling supplemented by buses.

32. A. C. Malliaris and Strmbotne p. 431.
dial-a-buses, or some other form of "people movers" for longer distances or for steep hills or other difficult topography. A rapid transit system would provide transportation to other centers where, again, walking and cycling supplemented by people movers would handle all the local transportation needs. All mass transit vehicles would have facilities for users with bicycles and carts for carrying children and/or packages. This "carless" transportation system requires more physical effort from the users and is probably feasible only in high density communities. In addition to conserving energy, such a system can contribute to the increased vitality and health of the community through lowering noise and pollution levels and increasing physical activity of the residents.

The National Commission on Materials Policy recently included the following statement in one of their reports.

A consumption-oriented economy and incentive policies appropriate to a young nation with an abundance of high grade resources have made virgin materials cheaper than secondary ones....

The future holds the possibility of setting up a recycling system. It has been estimated that the recycling of just the available steel, aluminum, and paper could save 2% of the U.S. energy consumption.

The lack of recycling results in tremendous waste of materials. Since manufacturers have not had to internalize the external costs which wasteful products inflict upon society, they have had no incentive to reduce the amount of waste a product produces. Traditionally, it has been the consumer's problem to deal with waste. Since consumers live in communities, waste collection and disposal has become a municipal service (the problem of the municipality).

34. Ibid. p. 40.
Unfortunately, waste disposal technology is primitive. Mostly, it is concerned with getting wastes out of site: dumps, fills, dumping in the sea,.... In the future, waste disposal will have to be dealt with on a more sophisticated level; this will cost energy. Requiring manufacturers to externalize the external costs of waste disposal could cut down on the volume of wastes produced and lead to more conserving use of materials and product packaging.

An often suggested way of dealing with waste disposal is using waste materials for fuel. In 1903, two heat-recovery incinerators were built on Manhattan. The waste heat was used to heat the city. The plants were eventually abandoned because of operating difficulties, air pollution, and undependability of waste heat. A more modern development in waste disposal technology is pyrolysis. Pyrolysis is the destructive distillation of wastes under pressure and heat in a low oxygen atmosphere. The process can be energy conserving since the volatile gases which are siphoned off during the process can be used to heat the chamber. A prototype plant in St. Louis boasts that it can salvage waste heat, metal, oil from tires, charcoal, acetic acid, tar, methanol, combustible gas of low heating value, and a char which can be used as a water filter material.

Many college campuses in the U.S. have centralized heating plants which distribute steam or hot water to the buildings to be used for space conditioning and water heating. Since 1882, the Consolidated Edison Co. of N.Y. have been producing and selling steam to building owners in N.Y.C. who find it more economical than maintaining their...
own heating plant. The city of Hartford, Connecticut recently installed the first district cooling system. Many buildings in downtown Hartford now receive both steam and chilled water in addition to water and electricity. Centralized heating and cooling plants with distribution systems throughout a community can result in large energy savings. Advantage can be taken of the favorable economies of scale and the increased energy efficiencies associated with larger heating plants.

Large, centralized plants can be professionally maintained and operated while smaller plants are often poorly maintained.

Total energy systems which are not always feasible or conserving when applied to individual buildings can be used to provide electricity and heat for a complex of buildings. There are two ways in which the district heating/cooling concept might be extended for further conservation. One district total energy. The mix of uses served by a district total energy plant can be chosen to insure optimal operating conditions for the system; constant demand for electricity and heat. In order to work most efficiently, district total energy would need fairly high densities of development and a carefully chosen mix of users (to provide the right balance of electric and heat demand).

Another extension of the district heating/cooling concept is a community heat sink-source system. In this system a closed loop of working fluid would be circulated through the community. Any waste heat from electrical production or industrial processes or virgin heat from solar collectors or concentrators or any other heat source could be pumped into the working fluid by means of a heat pump or other heat exchanger. Homes, commercial establishments and other buildings

40. Ibid. p. 425.
41. Currently being developed by Peter Griffith at MIT (source: Shawn W. Miller in course lecture fall 1974).
can tap heat out of the system as needed. During the summer, the heat sink-source can store heat which is exhausted into it from individual homes as well as from industries and utility companies. During the heating season, a heat utility company can supplement and maintain the heat content of the sink-source at the level of demand by producing heat. Tappers would pay for the amount of energy they tap and a proportion of the proceeds would be divided among contributors to the heat sink-source in proportion to the amount contributed. The remainder of the proceeds would go to the managing utility.

If such a system is made technologically feasible, it could cut down enormously on the amount of waste heat which is presently discarded and feed it back into the system for reuse. In the ecological model of energy flow through natural ecosystems, energy is cascaded. As the sun's energy seek its way to the lowest entropy state, it passes through a number of intermediary states. At each of the states, the energy is used by different agents and transformed into a new form. (sun—radian energy—green plants—cows—human paper writers—) In the community, energy flow is not continuous. Coordination of sectoral energy consumption within the community can help to make the community energy cascade more continuous and therefore less wasteful.

Power generation, incineration, central space heating, sewage disposal, industrial steam production, water and air purification, and parts of the transportation network can be combined into a comprehensive master energy system. The establishment of master energy 42, this discussion of heat sink-source is based on lecture by S. W. Miller to class 4.45 MIT fall 1974 supplemented with the authors conjectures. 43, concept developed by DMBA in Progressive Architecture p. 19.
systems in already existing communities is impossible except in the very long range. It is possible to implement energy planning with the long range goal of a working master energy system. Some of the strategies for energy planning will be discussed in the next section. New towns offer the ideal circumstances for the development of workable master energy systems. Here different systems can be designed, instituted, and monitored for problems; possible improvements; advantages; and political, social, or environmental implications.

In a previous section, the possibilities for energy conservation in buildings through the proper use of climate conditions were discussed. An obstacle in the way of the optimal location-orientation of a building is the location and size of the site itself. If a four acre lot has poor orientation and exposure with respect to cold winds, for example, there is little the designer can do to create a useful climatological sheath. A community which is located and laid out in accordance with climatological considerations can create the possibility of more conserving building design.

Variations in topography result in temperature differences. Some of the possible effects are illustrated in figure 6. Cold drainage winds often exist in hilly terrain. At night the cold air settles causing severe inversions, low temperatures, and fog and pollution stagnation. Slopes tend to be the warmest areas in a hill and valley situation. South slopes receive far more radiation than north facing slopes. A climatological study of an area can show the areas of minimum stress, i.e., areas which have climate conditions nearest to

H. E. Landsberg in WHO p. 369.
Figure 6.
Effects of Topography

- Cold Air Pool

- Warm Slope Zone

Ogyay, p. 45.
human comfort conditions. The pueblos in Southwestern U.S. are elegant examples of the passive use of environmental characteristics in the creation of a more comfortable community climate.

Large scale and/or high density development has a major effect on the local climate. More solar radiation is converted into heat in urban areas than in rural areas. The materials of streets and buildings tend to store more heat than do natural landforms and vegetation. The community itself produces heat. The result of these and other factors is a phenomenon generally referred to as the urban heat dome. A town lies in a pool of warm air and can have a minimum winter temperature of 5-10 degrees higher than the surrounding areas.

An understanding of these effects can aid in energy conserving planning. Streets can be oriented to increase or decrease winds or to block or intercept radiation. Roof heights can be varied to facilitate natural ventilation through increased turbulence or uniform to avoid turbulence. Open construction and thoughtful location of open space can help alleviate the heat dome phenomenon in climates where cooling is the major energy use.

-environmental analysis

A combined environmental analysis and climatological analysis of either a natural area or previously

46. Harriet Ryd in C.L.B. p. 68.
47. see Ian L. McHarg, Design with Nature. Doubleday / Natural History Press Doubleday & Co., Inc. (Garden City, NJ; 1971).
48. Ibid.
developed areas can yield information pertinent to energy conserving planning and design. Areas where development would have the least affect on the existing ecosystem or areas with conditions favorable to reduced energy consuming design can easily be seen. An analysis of an already developed can result in a rational land use plan which encourages energy conserving development. An analysis of undeveloped or underdeveloped areas can aid greatly in the formulation of a development control plan which is sensitive to environmental and energy issues.

- size, density, and patterns

Both conserving transportation systems and energy systems impose constraints on the size and density of communities or centers. If the transportation system is to be successful, daily destinations should be local. Necessities should be within walking or cycling distance. Higher densities can assure that goods and services will be closer to the consumer. If three miles is the furthest a person will ride a slow bus, bicycle, or walk, rapid transit will be needed for trips longer than three miles. But, distances of six miles on rapid transit seems not much longer than distances of three miles. This points to a landuse pattern of nodes of high density development connected by connected by rapid transit and perhaps roads. The intervening landuses could be rural or urban open space.(parks, victory gardens, ...).

Centralized heating and cooling plants, total energy, and heat sink-source systems are not compatible with low
density development. Each requires mixed high density landuse. The sink-source system requires industry, power generation, housing, and commercial establishments all in close proximity. Total energy and district heating/cooling must be limited in size by the distances steam or hot water can be transported without exorbitant losses. These systems are compatible with the conserving transportation network in that they too dictate nodal development patterns. Centralized energy systems are also compatible with the separation of high density nodes by health giving open space.
COMMUNITY ACTIONS

Goals

A system which uses energy only when and where it is essential and uses it efficiently must replace the present system of often innecessary and usually wasteful energy consumption. Policy makers, consumers (includes all citizens), and the research community must guide, push, lead,... each other through a process of change. Local governments can initiate the process by giving it a broad flexible definition.

The formulation of explicit goals begins to define the process. The first two parts of this paper brought out certain specific goals: encourage climatic design, discourage wasteful modes of transportation, discourage sprawl development, etc. It is important to recognize the more basic which lie under these specific goals. It is these broad aims which form the framework for policy which facilitates change in the desired direction.

The broadly defined goals are listed here:

REDUCE THE DEMAND FOR ENERGY IN THE COMMUNITY;

IMPROVE THE EFFICIENCY OF UTILIZATION OF ENERGY:

and DEVELOP SELF-SUSTAINING, CONSERVING PATTERNS OF USE.

The general goal of consumption (or demand) reduction can gain wide acceptance in the community. The next goal of improved efficiency of use follows logically out of the first. Inherent in the last goal is the true hope for the future. The self-sustaining, self-reinforcing patterns prevalent today are wasteful. The superimposing of energy conserving goals over this system cannot work alone! The shortage of energy should not be thought of as a temporary
situation which requires the temporary intervention of governments until large power plants can be built. Uncontrolled growth and environmental degradation bring out the need for fundamental change in energy use patterns.

These goals are interrelated and cannot be isolated. Consumption reduction is implicit in efficiency improvement and vice versa. Both consumption reduction and efficiency improvement are necessary to the generation of conserving patterns.
Strategies

To be useful, an exposition of policy alternatives must be explicit. In order to be as explicit as possible within the scope of this paper, the strategies have been described and elucidated briefly in tabular form. The table affords the easy comparison of strategies. The information thus presented is meaningless without some explanation of assumptions which underly the criteria and terminology.

-guide to table 4: "Description of strategies"

"STRATEGY"

The strategies discussed were chosen because they can be implemented and effective at the local level. The list is not meant to be inclusive of all the options open to the community. It is hoped that it does include representatives of different kinds of tools the community can use to work toward its goals. The strategies were chosen from many which were suggested in the literature.

"WHAT"

This is an explanation of what exactly the strategy is to do. Educational programs are to teach facts about the energy situation, tips on energy conservation which are applicable in the home or office, and a sense of the role of the human being and human communities in the larger environmental system (environmental studies).

"GOALS"

Under this heading are listed the broad process defining goals toward which the strategy is geared. The goals are listed in order of magnitude of effect of the strategy has on movement toward those goals. Educational programs are geared primarily toward the generation of conserving patterns and has less effect on movement toward the
other goals.

"TARGET"

In the problems section, certain target areas were brought out in discussion. These are areas which are in need of improvement and can be reached by the local authority. Under the target heading, is the specific focus of the strategy: what exactly is to be affected. Educational programs are designed to affect societal attitudes.

-explanation of table 5: "Implementation"

"MEANS"

This is a brief description of how the strategy would be implemented. Educational programs would be implemented through the already existing public school system, adult education classes, and community lecture series.

"REQUIREMENTS"

The implementation of each strategy requires different kinds of information and personnel. The most pertinent of these are listed under this heading. Knowledgeable instructors are needed in order to implement educational programs.

"PROBLEMS"

Each strategy has inherent problems which may hinder implementation. For example, educational programs for adults are effective only if adults participate. In this society it would be difficult and wrong to require adults to participate in educational programs. This sort of problem must be considered in the implementation process.
Under these two headings are the major advantages and disadvantages of the strategy respectively. Educational programs are especially important for the efficient implementation of future strategies. The disadvantages of educational programs is that they do not motivate change by themself.

"EFFICIENCY"

Here the word is used in the economic sense of benefit achieved versus time and dollar costs accrued. Educational programs are the most efficient strategy at affecting consumer attitudes.

"EFFECTIVENESS"

Under this heading is a brief statement of the strategies effectiveness based on the criteria discussed. Educational programs effectively provide the basis for future strategies.
Table 4.

Description of Strategies

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>WHAT</th>
<th>GOALS</th>
<th>TARGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Teach facts about energy situation, tips on conservation, environmental studies.</td>
<td>Conserving pattern generation.</td>
<td>Consumer attitudes.</td>
</tr>
<tr>
<td>Educational Programs</td>
<td>Require developers to make decisions involving energy consumption on the basis of life cycle costs.</td>
<td>Efficiency; Reduce Consumption.</td>
<td>Force market to consider long range costs; force financers to finance high initial costs.</td>
</tr>
<tr>
<td>II. Required Life cycle</td>
<td>Inspect and monitor new uses; avenues for public input into policy.</td>
<td>Conserving pattern generation.</td>
<td>Coordination of uses; consumer attitudes.</td>
</tr>
<tr>
<td>Costing</td>
<td>Replace prescriptive codes with performance standards; reevaluate standards for lighting and ventilation.</td>
<td>Efficiency; Codes and standards which require unnecessary energy use.</td>
<td>Reduce consumption; efficiencies in conserving buildings and equipment.</td>
</tr>
<tr>
<td>IV. Performance Codes</td>
<td>Tax incentives for conserving design; help balance high initial costs.</td>
<td>Conserving pattern generation.</td>
<td>Improve efficiency of transportation.</td>
</tr>
<tr>
<td>Tax Incentives and penalties.</td>
<td>Zone for conserving land use patterns; higher densities, multi-use, etc.</td>
<td>Conserving pattern generation.</td>
<td>Improve coordination of uses; improve efficiency of transportation.</td>
</tr>
<tr>
<td>VI. Upgrade mass transit, biking, and pleasant to wouldbe cyclists.</td>
<td>Reduce energy use.</td>
<td>Conserving pattern generation.</td>
<td>Reduce consumption; Efficiency.</td>
</tr>
<tr>
<td>V.</td>
<td>Enforced Disclosure of buildings showing expected energy requirements.</td>
<td>Consumer attitudes; market by bring energy consumption in as an issue in sales.</td>
<td>Reduce consumption; Efficiency.</td>
</tr>
<tr>
<td>Energy budgets</td>
<td>Limit the amount of energy a building can use.</td>
<td>Eliminate wasteful energy consumption by buildings; Coordination of uses.</td>
<td>Reduce consumption; Efficiency.</td>
</tr>
<tr>
<td>VIII. Zoning</td>
<td>Zone for conserving land use patterns; higher densities, multi-use, etc.</td>
<td>Improve coordination of uses; improve efficiency of transportation.</td>
<td>Improve coordination of uses; improve efficiency of transportation.</td>
</tr>
<tr>
<td>IX. Restrict cars</td>
<td>Reduce consumption; Conserving pattern generation.</td>
<td>Improve efficiency in transportation.</td>
<td>Reduce consumption; Conserving pattern generation.</td>
</tr>
</tbody>
</table>
Table 5.

Implementation

<table>
<thead>
<tr>
<th>MEANS</th>
<th>REQUIREMENTS</th>
<th>PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Curriculum of energy and environmental studies added in public schools; start adult night classes; lecture series.</td>
<td>Knowledgeable instructors; educational framework already exists.</td>
<td>Adults may not be motivated to participate; education can lubricate change but cannot motivate it; knowledge useless if no alternatives are available.</td>
</tr>
<tr>
<td>II. Pass legislation requiring life cycle costing; records to be inspected for building permit.</td>
<td>Trained personnel to inspect records.</td>
<td>Bog down construction process; building permit considerably slowed down; may not be enforced.</td>
</tr>
<tr>
<td>III. Pass legislation requiring all innovations, life cycle costed buildings, other products of strategies to be inspected and some monitored. Open up public discussion of community actions.</td>
<td>Trained inspectors; criteria for inspection and monitoring.</td>
<td>Takes time and money.</td>
</tr>
<tr>
<td>IV. Reform building codes to performance standards; proof of performance quality presented for permit.</td>
<td>Information for setting performance standards; information for guidelines and collection time and dollar expensive.</td>
<td>Liabilities in case of failure; information collection time and dollar expensive.</td>
</tr>
<tr>
<td>V. Property taxed relative to energy consumed.</td>
<td>Information to set tax levels properly for positive results.</td>
<td>Regressive tax; high for low income owners and renters who do not have capital for improvements.</td>
</tr>
<tr>
<td>VI. Use public funds plus local gasoline tax to upgrade transportation system.</td>
<td>Planning personnel to do transportation planning and urban design for bike and walkways.</td>
<td>Expensive; making system available will not alone induce people to use it in place of wasteful modes.</td>
</tr>
<tr>
<td>VII. Pass legislation requiring energy impact statement listing materials and projected energy requirements; presented for permit.</td>
<td>Information to describe circumstance of builder liability.</td>
<td>Cost of statement passed on to consumer.</td>
</tr>
<tr>
<td>VIII. Pass ordinance which designates limits to the amount of energy a building may use beyond which must pay a premium.</td>
<td>Information setting up criteria: size of allotments, units of allotment (by sq ft or building type,..) and level of premium.</td>
<td>Collection and compilation of materials and determining levels expensive to community.</td>
</tr>
<tr>
<td>IX. Reform zoning ordinances to comply with future master energy systems, heat sink-source, district heating/cooling, or conserving transportation system.</td>
<td>Research to determine public protest of movement away from traditional systems; planners for energy/environmental planning.</td>
<td>Public protest movement away from traditional patterns (lifestyle).</td>
</tr>
<tr>
<td>X. Restrict cars from high density centers.</td>
<td>Alternative transportation must be available.</td>
<td>Public protest movement away from traditional patterns (lifestyle).</td>
</tr>
<tr>
<td>PRO</td>
<td>CON</td>
<td>EFFICIENCY</td>
</tr>
<tr>
<td>-----</td>
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<td>------------</td>
</tr>
<tr>
<td>II. Force developers to consider long range costs; may be unenforceable; works against market.</td>
<td>Regulates market from outside rather than through market mechanisms.</td>
<td>Effectively forces consideration of long range costs.</td>
</tr>
<tr>
<td>III. Necessary for maintaining fit of strategies to needs.</td>
<td>Expensive; does not directly affect goals.</td>
<td>In concept, works very efficiently through market mechanisms.</td>
</tr>
<tr>
<td>IV. Allows the designer freedom to design fully conserving systems.</td>
<td>Difficult to formulate and test; liabilities compounded.</td>
<td>Obstacle to efficiency is liability problem.</td>
</tr>
<tr>
<td>V. Provide incentives for owners to conserve.</td>
<td>Regressive tax; does not affect renters.</td>
<td>In concept, works very efficiently through market mechanisms.</td>
</tr>
<tr>
<td>VI. Necessary for long range goal: conserving pattern generation.</td>
<td>Does not by itself provide incentive to abandon wasteful modes.</td>
<td>Most efficient tool.</td>
</tr>
<tr>
<td>VII. Brings long range costs into marketing; allows market to find own equilibrium.</td>
<td>Costs passed on to consumers; does not force financier demand.</td>
<td>Very effective at eliminating wasteful use in buildings.</td>
</tr>
<tr>
<td>VIII. Cuts down on consumption and improves efficiency immediately! leads to management.</td>
<td>Determining budgets expensive to community; may cause consumer protest.</td>
<td>Very efficient if allotments set carefully and correctly.</td>
</tr>
<tr>
<td>IX. Necessary for conserving pattern generation; create efficient energy cascades.</td>
<td>Calls for the destruction of 20th century land use patterns,</td>
<td>Very effective at elimination of wasteful land energy systems, use patterns.</td>
</tr>
<tr>
<td>X. Forces consumers to use energy efficient transportation modes.</td>
<td>Impinges on freedom of individual.</td>
<td>If energy conserving alternatives are available, transition can be made efficiently.</td>
</tr>
</tbody>
</table>
Implementation schedule

The implementation schedule is the plan of action. The strategies are tied to a time frame. A strategy's position in the plan is based on the relative ease of implementation in terms of costs and impact on life styles; its relationship to the overall goals; and its relationship to the other strategies. A schedule has been developed from the discussions of strategies and criteria in tables 4, 5, and 6. It is made with reference to the traditional time divisions: short term, implementable within five years; mid term, within ten years; and long term, after ten years.

SHORT TERM
- Implement educational programs.
- Begin developing energy management plan.
- Require life cycle costing in all new municipal buildings.
- Set up evaluation and feedback mechanisms.
- Implement enforced disclosure strategy.
- Begin research and information collection for future implementation of performance standards and tax incentives.
- Design bikeway and pedestrian system.

MID TERM
- Set up guidelines for new development consistent with energy management plan.
- Implement performance codes.
- Implement tax incentives.
- Upgrade mass transit.
- Implement energy budgets strategy.
- Continue work on energy management plan.
LONG TERM

- Implement energy management plan.
- Restrict cars from districts where they are unnecessary.
- Use zoning strategy.
- Begin setting up master energy system.

The long range goal is the development of self-sustaining, conserving patterns. As progress is made along the schedule, it must be revised to remain true to this goal. The plan should include the most detailed description as possible of these "conserving patterns" which are the goal, the contemporary problems, and the immediate implementation schedule proposed to deal with these problems. A plan which is drawn up today cannot deal adequately with the problems of 4 or 10 years from today. For this reason, only the short term strategies will be discussed in more detail.

Changes in societal attitudes forms the foundation for change. The strategies will work only if the consumer and/or designer understand energy issues and tradeoffs. It is therefore important that educational programs be the first strategy implemented.

The importance of an on-going planning process is outlined above. At the same time that educational programs are implemented, an energy management board should be formed. It should include professionals from the area, elected officials, and possibly an energy expert as a consultant. During the first five years, the board would coordinate the implementation strategies, provide for public input and responses to strategies, collect the data needed for future strategies, and clarify future policy and strategies.

Enforced life cycle costing in new public buildings can be publicized as an example of what can be done to conserve. This would
bring life cycle costing to the attention of financers. They may see it as a preview of future regulations. This might encourage them to develop alternative finance mechanisms for initially expensive conserving buildings and homes.

Evaluation mechanisms such as inspection and public discussion are essential to insure consistency between intended and actual effects of strategies. They are also essential to maintain a match between public directives (strategies) and the kind of guidance the community requires.

All the short term actions discussed thus far are long range in orientation and preparatory in nature. None immediately cause reduction in consumption or improvement in efficiency of use. Requiring builders to disclose the expected energy consumption of the building after occupation can result in a rise in demand for energy conserving buildings. If buyers are sufficiently educated to see tradeoffs clearly, they will demand more energy conserving solutions.

Many of the strategies require much information and study before can be implemented. Performance codes and tax incentives are in this category. The benefits which a strategy can produce must be weighed against the costs of making the strategy implementable. Performance codes are important enough to energy conserving design that they will probably remain in the implementation schedule. In order to be useful, they must be implemented as quickly as possible. Data collection, research, etc. should be begun during the first five years.

The first five year period in the process of change is devoted primarily to public conscious raising. Once the individuals are aware of the problems and more importantly, have an idea of what the energy conserving patterns will be like, s/he will be much less likely to
support the process. The major obstacle that stands in the way of the transition to conserving patterns is an unwillingness to give up something known for something unknown. If the public and the local government can together work out a clear picture of the future conserving patterns, both the good and the bad aspects, the transition will be made easily and intelligently.

Unfortunately, in many communities, even those strategies which are immediately implementable seem years in the future. A motivation gap lies between today and the day the first move toward energy management is made. At the root of this hesitancy to act are the two questions: Why should government at the local level be an instrument of change? and Why should local governments work to reduce future demand while national government is working to meet future demand?

Policy makers at the national level depend on polls, surveys, and projections for the basis for policy. This distance from all but very large consumers has resulted in very broad internal energy policy which is markedly biased toward large consumers. Local government is close to consumers of all amounts of energy. Local government is in the position to raise consumer consciousness and ease the transition. It is in the position to guide and be guided.

Many communities have unified over the issue of nuclear power plants. Few have been pleased at the possibility of their town being the home of a new nuclear power plant. Nearly every community when threatened with this possibility has fought it. The general feeling is that nuclear plants are OK but not in "our town". Communities should work for future demand reduction to make the statement that if nuclear plants are no good in "our town", they are not good in ANY TOWN.
What can be done today to "get this show on the road"?

I. BEGIN EDUCATIONAL PROCESS BY EDUCATING OTHER MEMBERS OF THE LOCAL GOVERNMENT OF THE IMPORTANCE OF COMMUNITY ENERGY PLANNING.

II. DECLARE AN ENERGY CONSCIOUS WEEK WHICH INCLUDES CONSCIOUSNESS RAISING ACTIVITIES.

III. PERSUADE SCHOOLS OF THE IMPORTANCE OF AN ENVIRONMENTAL STUDIES, ENERGY CONSERVATION CURRICULUM.

IV. DISTRIBUTE PAMPHLETS ON: A) THE ROLE OF THE INDIVIDUAL IN COMMUNITY ENERGY CONSERVATION; B) THE IMPORTANCE OF COMMUNITY ENERGY CONSERVATION; C) ENERGY FACTS AND FIGURES.

V. INVITE SPEAKERS ON THE ENERGY SITUATION.

VI. INITIATE PUBLIC DEBATE OF ENERGY ISSUES.
AFTERWORD

A friend who was visiting me while I was working on this paper spoke of his plans for next year: "Well, I'll be living in this tremendous apartment complex that has tennis courts and a swimming pool! ...It is kind of far from campus, but, Scott and the other guy both have cars, and,...I guess I'll be getting one too..."

When I began this paper, I had tremendous faith in the willingness of individuals to conserve if they were only given the conserving alternatives. Though I still support energy demand reduction over increasing supply, I now see that it will take more guidance than simply making options available. Policy who also believe in demand reduction must first raise the public consciousness of energy tradeoffs, beginning with their colleagues.

This paper was intended as an exercise in consciousness raising. It is directed to community policy makers because I believe that their role in future decisions concerning energy is an important one. It was written in the hopes that fifteen years from now, three people who live in the same apartment and commute to the same place will not feel the need to have three different cars and that those three people will be no worse off than they are today in spite of this difference.
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