ENERGY AND URBAN FORM
The Need for Energy Conscious Urban Planning

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It is now generally known that the world is in the grip of an environmental crisis. The potential outcome of the crisis is widely recognized: the self-destruction of human civilization. Its basic meaning is increasingly apparent: something is radically wrong with the way in which we use the earth's resources. The kind of action that survival demands is becoming painfully clear: equally radical reorganization of human society to bring it into harmony with the ecological imperative.

Barry Commoner

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I. INTRODUCTION

Since the beginning of this century, several significant changes have occurred in the urban land use patterns of western countries as a result of the development of new transport technologies. One of the major physical manifestations of this evolution has been the increasing geographical size of urban areas. Urban growth mainly took place in very low densities outside traditional urban centers. This phenomenon, which became known as urban sprawl, is one of the most important characteristics of modern urbanization.

However, there is a widespread concern that this present pattern of urban development is rather wasteful of limited resources such as energy, water, farmland, and open space. It is also said that to a great extent the suburbanizing trend has contributed to the economic and social problems of central cities. Until recently, there was no urban policy reaction to stop these trends. Instead, the suburban trend was directly or indirectly stimulated through new highway infrastructure and governmental housing and fiscal policies.

Only recently, some severe cases of central city decay have called for more public attention to the problem of declining central areas and its relation to suburban sprawl. In addition, the energy crisis of 1973-1974 and the subsequent precipitous increases in energy costs brought a new sensitivity to the importance of minimizing energy requirements in all sectors. Furthermore, there is a growing concern for energy conservation, as current use rates threaten to exhaust these fuel supplies within a relatively short period of time. At the current rate of use, all known petroleum resources would be exhausted within the next two decades, according to the forecasts in the first report of the Club of Rome (1). The methods used for this forecast have been questioned and there is also still a big discussion on the length of the period (2) but apparently while reserves may still be waiting for discovery, new discoveries and more intensive exploitation in the future will merely delay the inevitable crisis. In their current state of development, alternative sources are not the answer, as they are environmentally risky, such as nuclear energy, or still technologically and economically unavailable for widespread use, such as solar and wind energy.

During recent years, the energy shortage problem was seriously debated and in some countries a conservation policy was developed to moderate growing energy demands. But up to now, energy conservation was primarily concerned with altering construction and transportation techniques to save energy (3). Much less attention was given to better land development practices, although research has shown that also in this way energy could be saved. The growing energy consumption is a result, not only of what we do and how much we use in our homes, offices, factories, and shopping centers, but also of where these activities are located and how they are linked by transport systems. So it is my intent in this paper to look more closely at this particular aspect of energy conservation.

First of all, I will comment on the link between urban form (defined in this study as the general spatial system) and resource utilization and, in particular, energy resource utilization. In fact, the whole suburban movement was made possible by an increasing use of decentralized energy sources in combination with new technology. Besides the important social and economic consequences of spread urban development, it also determines to a great extent the amount of energy consumption. In a third chapter, an analysis will be made of various urban forms in terms of their energy consumption. Basic information for this analysis was found in some empirical studies which directly or indirectly dealt with energy consumption and urban form aspects. Here, I will focus on residential and transportation energy use, as mainly these two are affected by land use patterns. Chapter four gives an idea of how today's situation should develop in future by analysing three scenarios based on different objectives. The next chapter deals with the question of whether or not urban policy should react by correcting current land use patterns to meet energy and other environmental, sociological, and economical goals. Important here is the still unanswered question of whether future technological developments can change our heavy dependency on the traditional energy resources. This chapter will also examine the different ways in which urban policy can influence energy use. Here some planning directions will be summed up, for both local and regional/national levels which, according to previously mentioned research results, offer potential energy savings. Finally the ways in which this planning action should be accompanied by a policy strategy and implementation programs will be discussed. In the last chapter, a comparative analysis of energy consumption patterns in the U.S. and Western European countries will be set up to test the value of the energy saving land use policy in different socio-economic and political settings, as these variables determine to a great extent their possible effect. Besides having a closer look at current conservation policies in the U.S.A. and E.E.C. countries, some prerequisites for future energy saving land use policies in these countries will be discussed.

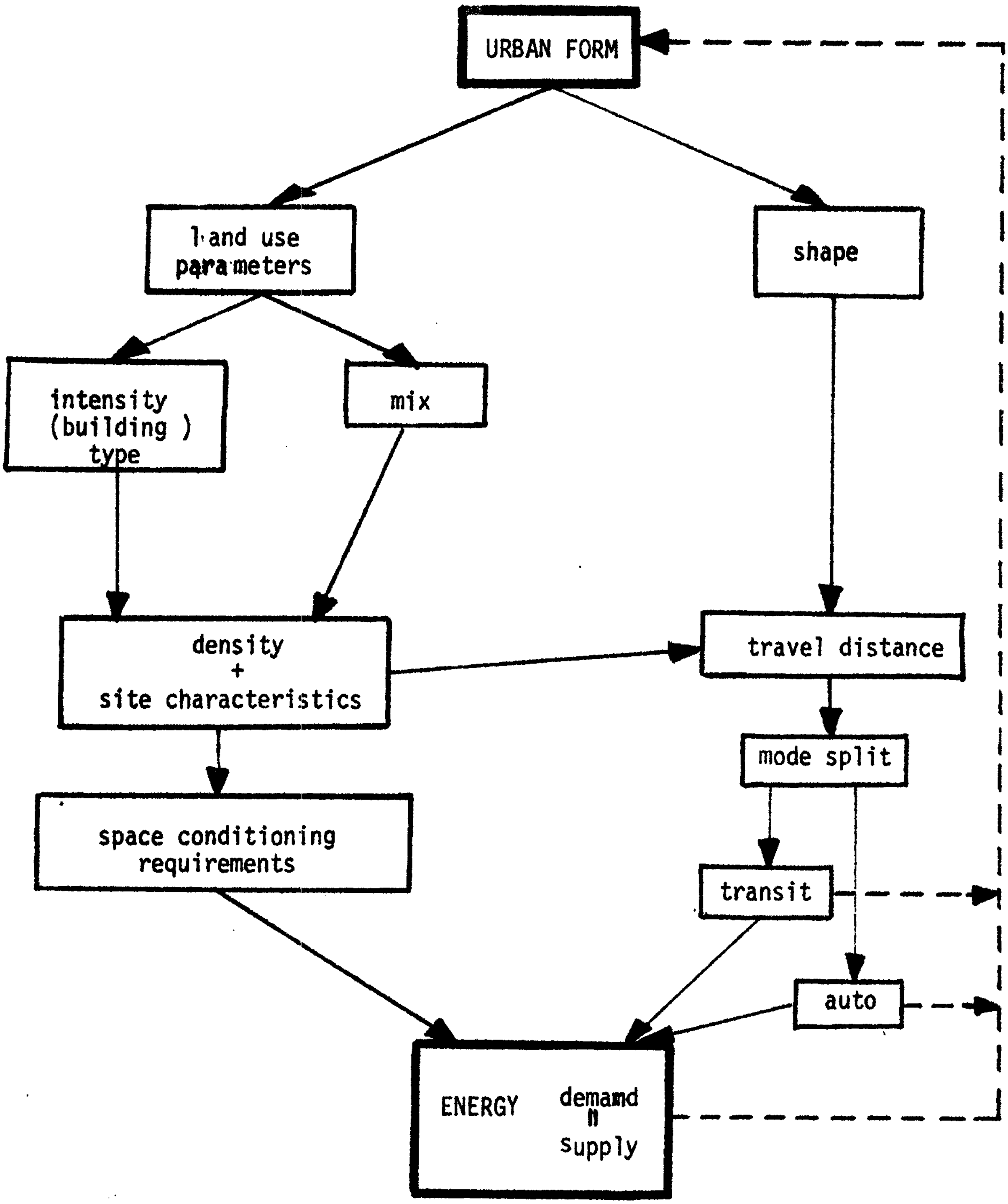
2. RELATIONSHIP BETWEEN URBAN FORM AND ENERGY

The relation between urban form and energy is defined by energy requirements for space conditioning and transportation energy needs (Figure 1).

Energy consumption for heating and cooling is indirectly influenced by urban form via land use parameters such as building types and the way different land uses are mixed. Both determine the potential density and the site arrangement, which are related to the total space conditioning requirements and how these can be met. Theoretically, where densities are high, residential and commercial units are frequently smaller and often share common walls or are located in larger structures providing up to some limit, economies for space heating and cooling.

However, the major influence of urban form on energy consumption has been through the development of a transportation network. Both land use parameters and shape of the urban area influence travel behavior via the distance factor. Where employment and commercial centers are located close to residential areas, travel distances will be reduced. When urban development follows certain patterns based upon major transportation corridors, and at sufficient densities, people and goods can be transported by more energy efficient modes. This part of the relationship between urban form and energy works in two directions. A spread urban pattern requires a high level of energy consumption because of the preference for private transport. This has allowed and promoted further development of remote areas.

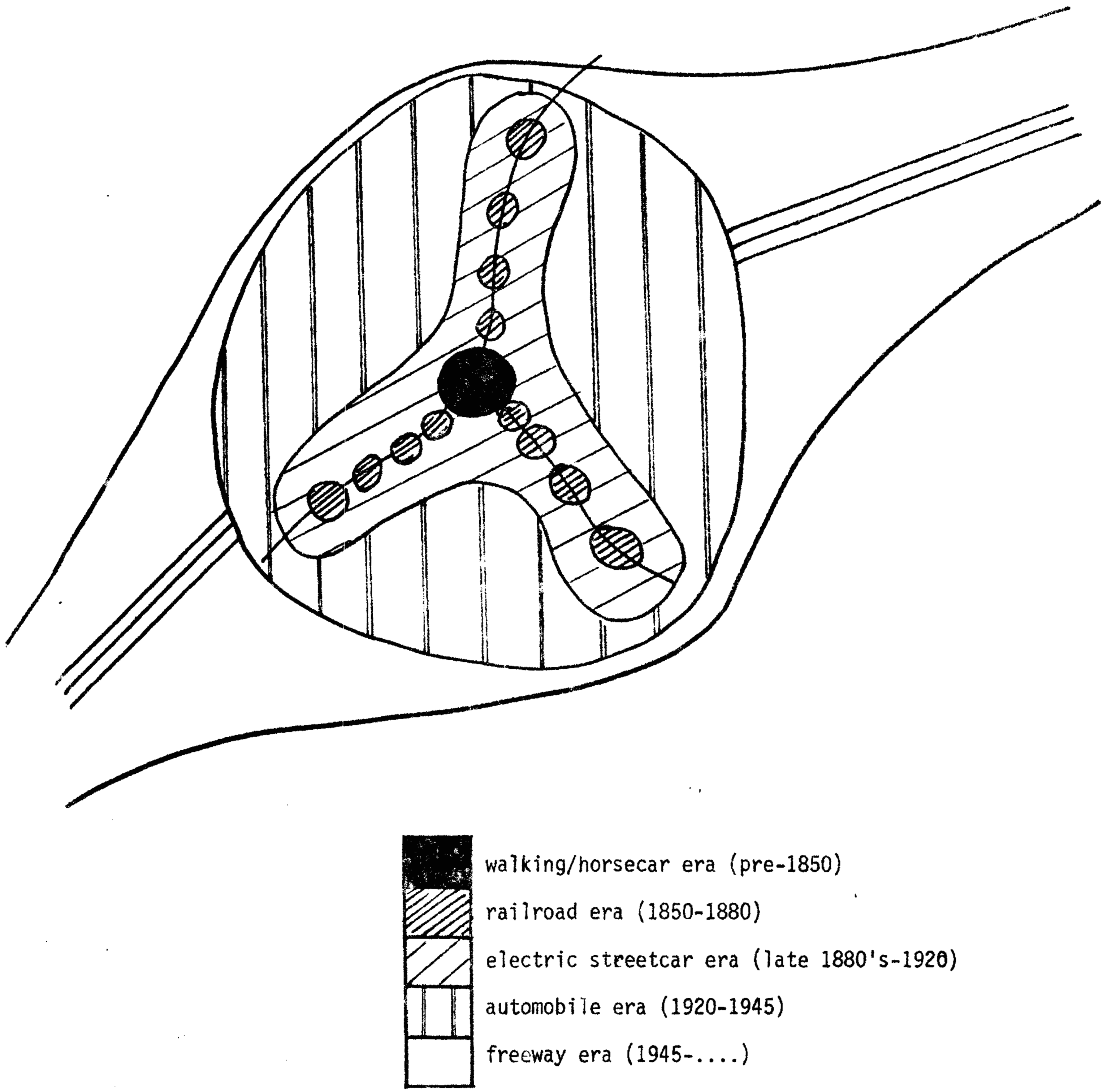
fig. 1. Relationship between urban form and energy



With every change in the means of transport, the urban pattern has been affected (see Figure 2) (4). Up to the middle of the 19th Century, urban areas stayed rather dense and compact. The only way to move from one place in town to another was to walk or, in the best case, using a carriage. With the construction of the railroad, urban growth became possible farther out from the dense core and developed in a star-shaped form along the main lines. But still, the first suburbs were fairly dense settlements built around the stations, as people still had to walk to the station. The late 19th Century streetcar lines opened up new wedges of developed land, but urban growth was still bound in narrow strips defined by these transit lines. It was only after the automobile became widely used in the 20th Century that the land between the wedges became developed. Especially after World War II, when new roads and highways were constructed, suburban growth continuously expanded farther into the country, and it was characterized by far lower densities than before. Gradually the distinction between urban areas and countryside became blurred as the characteristics of both city and country were found in most urban districts.

This new physical pattern for urban growth also had an important impact on urban life itself. Suburban development consisted mainly of new single family housing built on large lots of land and with plenty of green spaces. Thus higher and upper-middle class people were attracted as they could afford an automobile to commute. All the suburban housing being new and expensive, there was little chance that low to moderate-income families would be able to buy outside the city. Since central cities increasingly held only the

Fig. 2 Transport innovations and urban pattern.



less skilled and the less affluent who could not leave, there was little incentive for business to stay. So the second downward cycle started working, as manufacturing and office employment also moved out of the central city to scattered locations in the suburbs.

Suburban settlements usually are composed of large and specialized segments of housing, industry, commerce, and recreation areas. Access to all these basic functions requires that people migrate daily, often over great distances. In this scattered pattern, public transportation systems are economically inefficient. Every trip must be made by car and therefore living some miles farther or near it makes little difference. The progressive trend towards individualized transport systems is indicative of the whole individualized lifestyle in the suburbs. The large suburban lot offers ample space for the whole family to create as nearly total a recreational and leisure time environment as possible. So, social activity outside the home is not that essential anymore. Some people fear that such a development "...tends to decrease the prospects for the human contact so important to the socialization processes of a person." (5)

This highly individualized settlement pattern is also known to be highly consumptive of limited resources. Large areas of the best farmland and open spaces of high environmental value have been reshaped into homogeneous suburban lawns. The desire for unspoiled places defeats its own end; those places are rapidly spoiled as more and more people move into them. The act of building construction is by definition an act of land destruction (6). In addition, a spread urban pattern requires a costly layout of roads for private transport and billions have to be spent to provide the remote areas with sewer and water lines. Urban sprawl also requires a flexible transportation system and, up to now, only the private car could give such flexibility. Consequently, this private transportation system has developed high levels of energy consumption. The use of petroleum products in particular has expanded very fast since it became available as a decentralized energy source useful for private transport.

Hence, the relation between energy and urban form seems to be reciprocal. Because of present land use patterns, certain levels of energy consumption are required for the operation of urban systems and facilities. The above historical overview, on the other hand, has shown that, because of changes in energy sources and transportation, changes in land use patterns have occurred and probably will occur in future. Typical of the current stage of the process is that it has a cumulative effect. The individualized energy supply system which facilitated the spread pattern is now accelerated by the nature of the pattern itself. This rising trend in energy consumption seems to be irreversible as long as urban growth continues to follow the same pattern.

3. ANALYSIS OF URBAN FORMS IN TERMS OF ENERGY CONSUMPTION: EMPIRICAL STUDIES AND RESULTS

In order to get an idea of the differences among energy uses as a result of variations in urban form, this chapter will examine a number of recent studies on energy consumption in urban areas. Here again, we will focus on the residential and transportation sectors, particularly on the aspects affected by land use parameters. Data on energy use in existing urban areas is almost totally lacking so that most of the following studies are based on simulations of both hypothetical and real urban structures.

3.1. How is residential energy consumption affected by different land use patterns?

A variety of research approaches has been used to answer this question. One of these examines actual energy consumption on a regional scale in the New York region, an area which included nearly 20 million people in 1970, spread over 31 counties (including New York City). This study undertaken by the Regional Plan Association (7), presented some very interesting findings: the region has both a lower per capita rate of energy use and a different sectoral pattern of use than the nation as a whole.

Residential energy use accounts for 31.5% of total energy use compared to the U.S. average of 18.4%. The per capita residential consumption is 22% greater in the New York area (8) than the average for the country although the area has the highest density of all S.M.S.A.'s in the country. This rather puzzling observation may be partially due to the relatively higher per capita income level in the New York area, and, to a certain extent, also to the climate differences. The study did a further examination of the relationship between urban and spatial structure and residential energy use by looking at intra-regional variations (Table 1). Here it was found that the per capita energy consumption in the residential sector was nearly constant, although densities differed considerably (densities ranged from 53 persons per square mile in Sullivan County to almost 70,000 in Manhattan). However, the residential energy consumption measured per dollar of income does show an increase with a decline of density (Figure 3). This latter increase is only caused by residential use of electricity. There is also an increase in residential energy consumption per square foot as density declines from central New York City towards Richmond, Westchester, Nassau and Suffolk. However, this does not hold up in the other parts of the region. An explanation for this phenomenon was not given. Although it is very difficult to analyze these figures because of the interrelation of density - income - floor space - residential energy consumption, we can guess that it has something to do with the lower insulation capacity in single family detached houses, which results in higher heating and cooling needs (9).

Another approach for examining the relationship between energy and land use is to consider various development scenarios for accommodating specific needs, and then to relate the alternative land use patterns to energy use. An important study using this methodology was The Costs of Sprawl (10). Detailed cost estimates were made of 6 hypothetical neighborhood prototypes (each accommodating 1,000 dwelling units) and 6 community prototypes (each containing 10,000 dwelling units) Table 2). The neighborhood prototypes were based on housing types ranging from single-family detached houses to high-

Table 1:

Selected Indicators of Energy Consumption Related to Density, 1970.

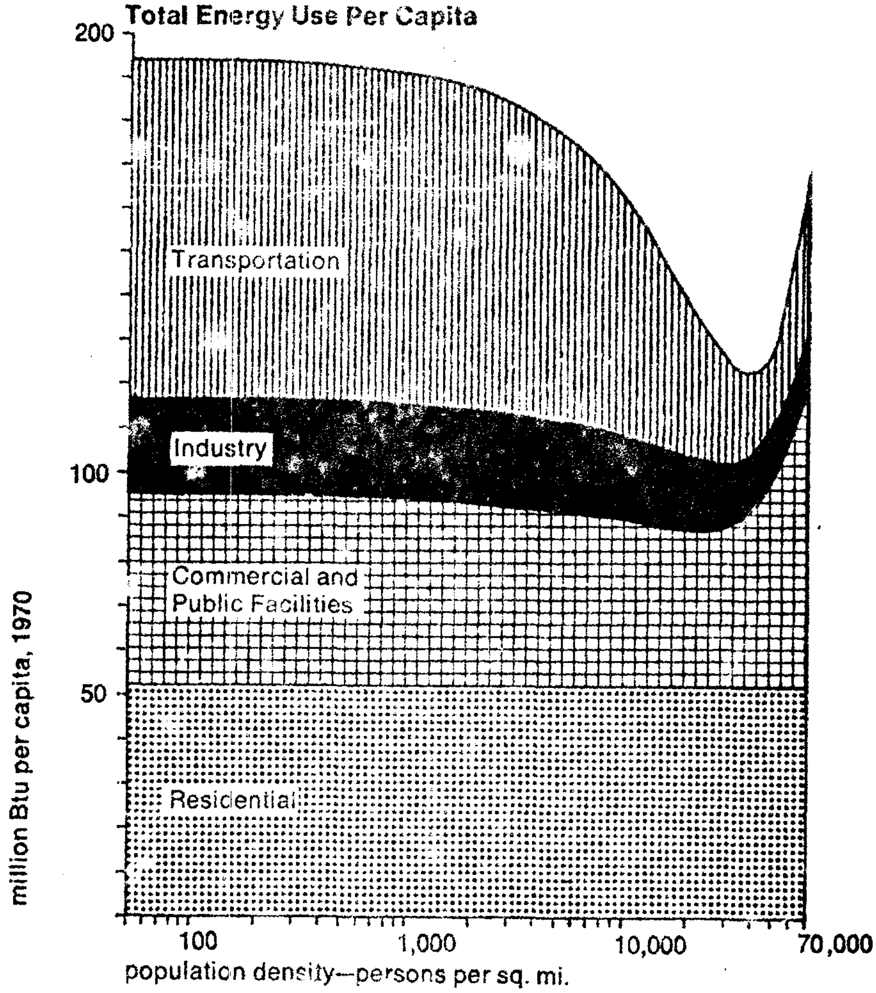
	Gross population density pers./sq. mi.	Total net energy use million Btu per capita (average)	Total net energy use million Btu per capita (actual)	Residential use thousand Btu per $ All energy (average)	Residential use thousand Btu per $ Electricity (actual)	Transportation use thousand Btu per $ (actual)	Residential use thousand Btu per sq. ft. of residential floorspace (actual)	Comm., Publ. & Industrial thousand Btu per sq. ft. of nonresidential floorspace (actual)
1 Manhattan	69,965	175	178	13.4	0.73	5.[illegible] + 3.7 (unallocated)	138	190
2 Brooklyn	37,531	126	124	13.5	1.08	5.6 + 3.7	176	359
3 Bronx	35,066	127	103	13.5	1.06	5.8 + 3.7	134	327
4 Queens	18,293	147	151	13.6	1.02	9.1 + 3.7	191	408
5 Hudson	13,479	157	121	13.6	1.05	8.9 + 3.7	115	254
6 Essex	7,291	174	167	13.7	1.14	8.6 + 3.7	135	291
7 Union	5,273	180	191	13.7	1.32	11.3 + 3.7	144	248
8 Richmond	5,120	181	151	13.8	1.38	9.0 + 3.7	200	405
9 Nassau	4,790	182	190	13.8	1.25	11.3 + 3.7	229	346
10 Bergen	3,845	185	200	13.8	1.25	13.8 + 3.7	158	275
11 Passaic	2,467	190	176	13.9	1.45	11.3 + 3.7	148	243
12 Westchester	2,058	191	202	13.9	1.07	10.5 + 3.7	206	365
13 Middlesex	1,866	192	253	13.9	1.65	17.5 + 3.7	150	428
14 Mercer	1,366	194	130	14.0	1.43	15.0 + 3.7	146	313
15 Rockland	1,288	194	213	14.0	1.40	18.3 + 3.7	191	391
16 Suffolk	1,256	194	208	14.0	1.76	19.3 + 3.7	157	430
17 Fairfield	1,253	194	177	14.0	1.56	13.3 + 3.7	182	203
18 New Haven	1,224	194	198	14.0	1.95	19.9 + 3.7	179	220
19 Monmouth	[illegible]	195	166	14.1	1.71	14.4 + 3.7	146	272
20 Morris	[illegible]	196	197	14.1	1.69	17.3 + 3.7	153	311
21 Somerset	646	196	205	14.2	1.53	17.0 + 3.7	148	350
22 Ocean	326	197	201	14.4	2.40	22.8 + 3.7	122	663
23 Dutchess	272	198	209	14.4	1.98	22.0 + 3.7	148	446
24 Orange	267	198	232	14.5	2.11	25.0 + 3.7	153	556
25 Putnam	241	198	172	14.6	2.22	24.2 + 3.7	118	357
26 Warren	205	198	160	14.6	2.52	22.8 + 3.7	112	323
27 Hunterdon	160	198	183	14.7	2.19	20.8 + 3.7	119	405
28 Litchfield	153	198	181	14.7	2.34	22.3 + 3.7	165	280
29 Sussex	147	198	153	14.7	2.00	21.9 + 3.7	107	336
30 Ulster	124	198	214	14.8	2.[illegible]	24.7 + 3.7	167	450
31 Sullivan	53	198	221	15.3	3.11	29.7 + 3.7	83	167

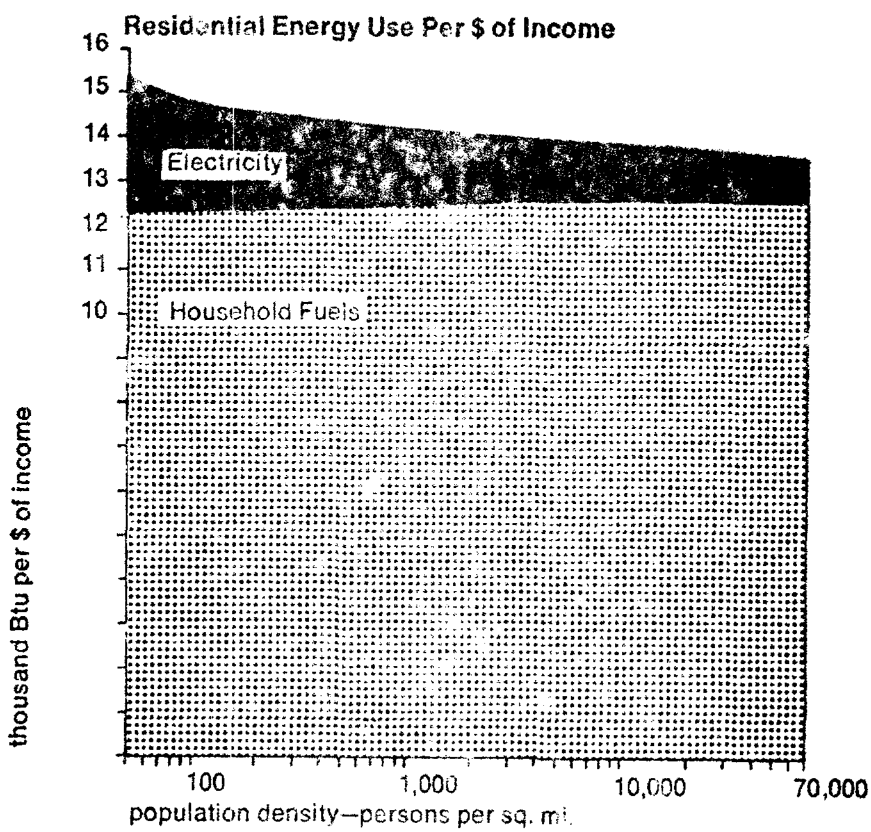
[illegible]

Source:Regional Plan Association

Fig: 3

THE EFFECT OF DENSITY





Source: Regional Plan Association, op.cit.

TABLE 2. SUMMARY OF PROTOTYPES

	Neighborhood	Community
Population	Varies according to housing type; three populations ranging from 2,825 to 3,520 used	Population of 33,000, same for all communities
Dwelling Units	1,000 for each neighborhood	10,000 for each community
Acreage	Varies from 100 to 500 acres, depending on assumed densities and housing types	6,000 acres for each community
Development Pattern	Conventional and clustered	Planned, sprawl, and combination
Housing Types	(A) Single-family, conventional (B) Single-family, clustered (C) Townhouses, clustered (D) Walk-up apartments (E) High-rise apartments (F) 20% mix of each type (A)-(E)	(I) 20% mix; planned (II) 20% mix; combination (III) 20% mix; sprawl (IV) 75% single-family conventional; planned (V) 75% single-family conventional, 25% single-family clustered; sprawl (VI) 10% single-family clustered, 20% townhouses, 30% walk-ups, 40% high-rise apartments; planned
Environments	"Undistinguished" site with typical environmental features; not site specific	Same as neighborhood
Commercial	Convenience center, 7,500 square feet of building area, 21,780 square feet of land area	(a) Strip commercial development, 200,000 square feet of building area, 1,056,000 square feet of land area (b) Center commercial development, 240,000 square feet of building area, 740,000 square feet of land area

SOURCE: Real Estate Corporation, op. cit.

rise multi-family housing. Each of the 6 community types contained a mixture of the various neighborhood housing types and differed in the amount of community planning (11): single family conventional land use patterns (or suburban sprawl); clustered single family homes; clustered townhouses; walkup apartments; high rises; and a planned mix of building types. Although only a minor aspect in the total cost evaluation of different development patterns, energy consumption was analyzed on both the neighborhood and the community levels.

On the neighborhood level, residential energy consumption was disaggregated into the different housing types. However, no differentiation was made to identify the space conditioning requirements (space heating, cooling, air conditioning) of these different housing types from other residential energy uses (lighting, appliances, etc.). However, these factors do not differ that much with housing type. In Table 3, it can be seen that gas and electricity use, although the same for detached and attached single family housing, was less than half that amount for higher density neighborhood (high-rise apartments). However, this difference again is partly related to the dimensions of the dwelling unit. Denser housing uses much less energy for space heating and cooling because the floor area is smaller and because less heat is lost through outside walls and roofs (12).

On the community level, the difference in heating and cooling needs showed a similar dependence on housing type through the variety in its composition (Table 4). A high density planned community would use only half as much energy for heating and cooling as a low density sprawl community.

Table 3: Neigbourhood cost analysis: gas and electricity.

	housing pattern					
	single-family conventional	single-family clustered	townhouse clustered	walk-up apartment	high-rise apartment	housing mix (20% of each)
annual gas consumption per unit (in therms)	1,872	1,872	1,248	948	792	1,344
annual electricity consumption per unit (in KWH)	61,166	61,166	39,734	29,759	25,524	-

1 KWH=3,413 BTUs 1 therm=100,000 BTUs

Source: Real Estate Corporation

Table 4: Community Cost analysis: gas, electricity and gasoline.

	community development pattern (10,000 units)					
	planned mix	combination mix:50% PUD 50% sprawl	sprawl mix	low density planned	low density sprawl	high density planned
natural gas (therms per year)	9,994,180	9,994,180	9,994,180	13,470,900	13,470,900	7,951,770
electricity (KWH per year)	220,046,750	220,046,750	220,046,750	295,227,080	295,227,080	177,251,577
gasoline (gallons per year)	8,200,333	9,879,333	11,777,333	10,658,000	13,115,667	6,594,333

Source: Real Estate Corporation: op.cit.

A more recent study, based on development scenarios for the Metropolitan Washington area (13) showed similar results. Six different development scenarios were presented to meet the region's future growth. They include: (a) dense center - higher density, more concentrated development focused on the metropolitan center; (b) transit-oriented - growth tied to the transit points of the planned METRO-systems; (c) wedges and corridors - all new development located in a radial configuration along rapid rail transit routes and concentrated near stations; (d) beltway-oriented - all new development located along a circumferential highway; (e) sprawl - low density, non-contiguous residential growth at the fringe with new employment primarily at the metropolitan center; and (f) wedges and corridors with income balance - the household and employment allocations derived under the regular "wedges and corridors" were maintained, but the differences in average household income in different parts of the metropolitan area were reduced. For each of these, the energy consumption attributable to the various patterns is measured in increments - from the present base, assuming total population and employment do not vary by scenario. The project concluded that, for the forecast year (1992) a savings of respectively 8% and 7% of residential energy use (which accounted in 1973 for 31% of total consumption) would be realized by "dense" and "transit-oriented" development rather than "sprawl." (Table 5)

Table 5:

ENERGY CONSUMPTION BY ALTERNATIVE DEVELOPMENT SCENARIOS

(In 10^{12} Btu/Yr.)

Consumption by Sector	1973 Base	"Wedges and Corridors"	"Dense Center"	"Transit-Oriented"	"Wedges & Corridors with Income Balance"	"Sprawl"	"Beltway-Oriented"
Residential	265.3						
Increment		109.9	91.0	95.8	109.9	122.6	112.4
Total, Forecast Year		375.2	356.3	361.1	375.2	387.6	377.7
Commercial/Industrial Institutional	176.6						
Increment		78.9	78.9	78.9	78.9	78.9	78.9
Total, Forecast Year		255.5	255.5	255.5	255.5	255.5	255.5
Transportation, Automobile	117.9						
Increment		59.5	35.1	33.1	46.8	70.6	52.2
Total, Forecast Year		177.4	153.0	151.0	164.7	188.5	170.1
Transportation, METRO	2.5						
Increment		12.4	12.4	12.4	12.4	12.4	12.4
Total, Forecast Year		14.9	14.9	14.9	14.9	14.9	14.9
Total	562.3						
Increment		260.7	217.4	220.2	248.0	284.5	255.9
Total, Forecast Year		823.0	779.7	782.5	810.3	846.8	818.2

SOURCE: Real Estate Research Corporation.

The Portland Energy Conservation Project was one of three demonstration projects funded by the U.S. Department of Housing and Urban Development to explore ways for local governments to improve their overall management of energy. Residential energy consumption accounts for 21% of the total Portland S.M.S.A. energy use. Of this residential energy use, approximately 70% is used for space conditioning. There again it was found that energy needs can be reduced in a considerable way by building homes which have more common walls and floors (town-houses, duplexes, semi-detached houses and apartments). These lower energy requirements would result from a reduced amount of exposed surface which loses heat (Table 6).

TABLE 6. ENERGY EFFICIENCY OF ALTERNATIVE HOUSING TYPES (New Units)

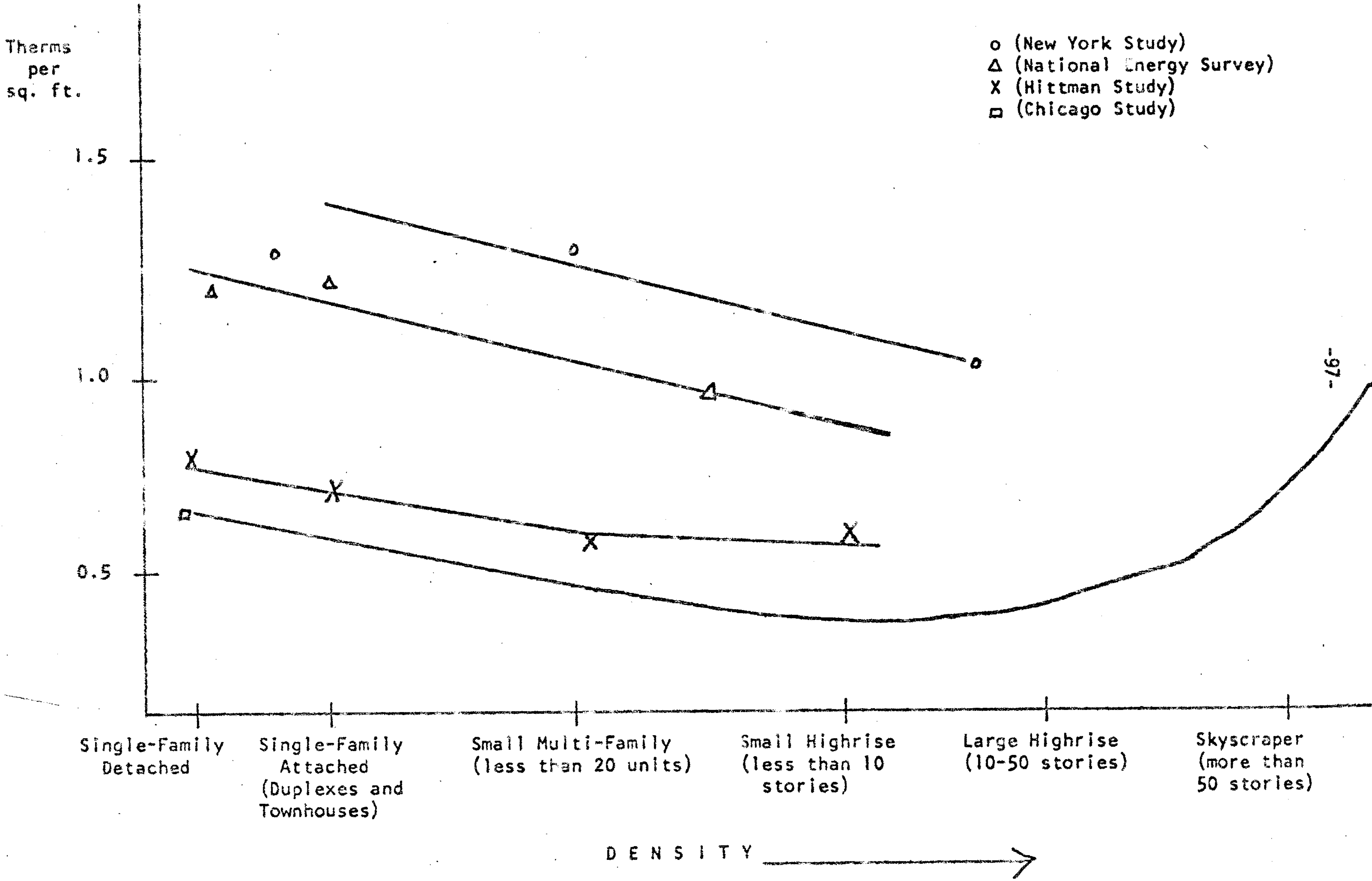
Type of Unit and Zoning*	Million Btu's Used Per Year for Space Heat	Energy Savings
One-story single family home (R10, R7, R5 zoning)	64	Base
Two-story single family home (R10, R7, R5 zoning)	59	8%
Two-story duplex (A2.5 zoning)	45	30%
Two-story triplex (A1 zoning)	42	35%
Low-rise condominium or apartment with the same living space as all of the above units (A1 zoning)	38	40%
Typical low-rise apartment with less space than the above units (A1 zoning)	21	67%

*All units are 3-bedroom homes except the last unit, which is a typical small 2-bedroom apartment.

D. Heyes summarized some recent research in the comparative chart in Figure 4 (15). The horizontal axis indicates building density - from single-family detached through small multi-family, to skyscraper. The vertical axis indicates therms consumed per square foot (a therm is equal to 100,000 Btu's). The influence of structure size on consumption is removed by expressing energy consumption on a square foot basis. The methodology used ranges from pure empirical analysis using data from individual structures to simulation analyses based on engineering principles. In the chart, it can be seen that there is a fairly wide range of consumption per square foot figures for any building type. This is not surprising considering the various methodological approaches that were used, and also the different parts of the country from which the data were taken. However, there is consistency in the slope of the curves which indicate an increase in energy efficiency (of about 30 to 40%) as one changes from single-family detached dwellings to units in small high-rise buildings. The data also suggest that, beyond some threshold number of floors in a multi-family structure, the amount of energy that is needed to run the elevators, to light and heat the common areas, and to transport water and waste material vertically outweighs the thermal efficiency advantages of the individual units (16). Although it is not really proved by these curves (not enough data on higher densities), one can at least conclude that medium densities have a relative low energy consumption level. Heyes also cited figures of some national U.S. - energy consumption data of 1968 where the total residential energy consumption accounted for 19% of the total energy consumption. Residential space heating and cooling represented 60%

FIGURE 4

RELATIVE ENERGY EFFICIENCY BY TYPE OF DWELLING



of that, and 45% of the space conditioning energy needs represented only 8 to 9% of total energy consumption which makes savings potentialities relatively low.

It is still not known to what extent new technologies (e.g. heat pumps, solar and wind energy, etc.) will replace or reduce the need for traditional energy resources for residential space conditioning requirements. There is only one thing one can say for sure, and that is that they will become increasingly important as they become technically more perfect. This may also have a considerable impact on the land use pattern. E.g. in the case of the use of individual solar collectors, exterior surface area becomes an agent for energy input, thereby encouraging single family housing units. In addition, a lower population density would reduce the potential sight line conflicts (17). However, collective community solar systems have the advantage of relatively lower capital costs, more efficient operation and lower space requirements. Furthermore they are more appropriate for application in existing urban areas. The same applies to other systems such as wind energy and heat pumps. Most of these systems are potentially decentralizing, but not necessarily. Whether or not this will happen depends on the economical and sociological trade-offs.

3.2. How is transportation energy affected by different land use patterns?

I will now turn to travel patterns and hence the transportation energy use generated by alternative spatial structures. Besides land use parameters such as building type and land use mix the broader spatial configuration of the area also must be taken into consideration. This is related to the assumption about the impact of density and shape on the choice of mode of transportation. As people live closer together and closer to their jobs, it is assumed that there are fewer and shorter automobile trips, more biking and walking and greater use of transit or other forms of collective transport which are much more energy-efficient than the private automobile (19). Support for these assumptions can be found in several recent theoretical and practical studies (20). Most of the following research reports touching the transportation energy effects of various land use patterns, are more unanimous in their conclusions and, in addition, show higher energy savings in the transportation sector than was the case for residential energy consumption.

In a Dutch study called "Space Consumption on Building Consumption" (21), an extensive analysis was made of direct and indirect transportation costs, both for private and public transport, in relation to two possible future density patterns: 6 dwellings per acre (15 dwellings/ha), which was considered as low density development (space consumption); and 12 dwellings per acre (30 dwellings/ha), which was considered moderate density (building consumption). Both densities were chosen in terms of consistency with current residential preferences. In a 12 dwellings/acre pattern a lot more travelling would be done by walking, biking, or public transport, so that the average distance driven by car would only be one third of the number of miles traveled in a 6 dwellings/acre pattern. Obviously, transportation energy use would be proportionate.

Keyes cited figures of the 1968 U.S. statistics (22) where the transportion sector represented 25% of total energy consumption. About 60% of that amount is consumed by passenger travel; of that, another 60% is consumed by urban passenger travel (8 or 9% of total energy consumption). The Portland Energy Conservation Project study estimated the transportation energy use in 1975 on 27% of the total energy use in the Portland S.M.S.A. 75% of the S.M.S.A. transportation energy is accounted for by privately owned automobiles, 11% is used for trucking, and only 1% is used for transit. The other 13% was used by air, rail, and other transport. The annual number of miles traveled by residents of the Portland S.M.S.A. differs not only with their location inside the area but also with the density of the area, caused by the type of housing (Table 7).

TABLE 7. ANNUAL VEHICLE TRAVEL
Number of Vehicle Miles Traveled per Household in the Region

	1975		1995	
Type of Household	Living Inside the City	Living Outside the City	Living Inside the City	Living Outside the City
Single Family	12,228 miles	15,100 miles	14,918 miles	18,422 miles
Multi-Family	9,782 miles	12,080 miles	11,934 miles	14,738 miles

SOURCE: Skidmore, Owings & Merril, op. cit., In 1975, the typical single family house occupant living in the city traveled about 3,000 miles (20%) less than a person living in the outlying areas. About the same difference could be seen when comparing the annual vehicle travel of the two density patterns. The estimates for 1995 show an even further increase in these differences.

In The Costs of Sprawl, gasoline use was also clearly related to the spatial pattern of the community via transportation demand. In a low density sprawl pattern, twice as much gasoline was used for transportation as in a high density planned pattern, a result of the differences in total annual vehicle miles traveled (Table 4).

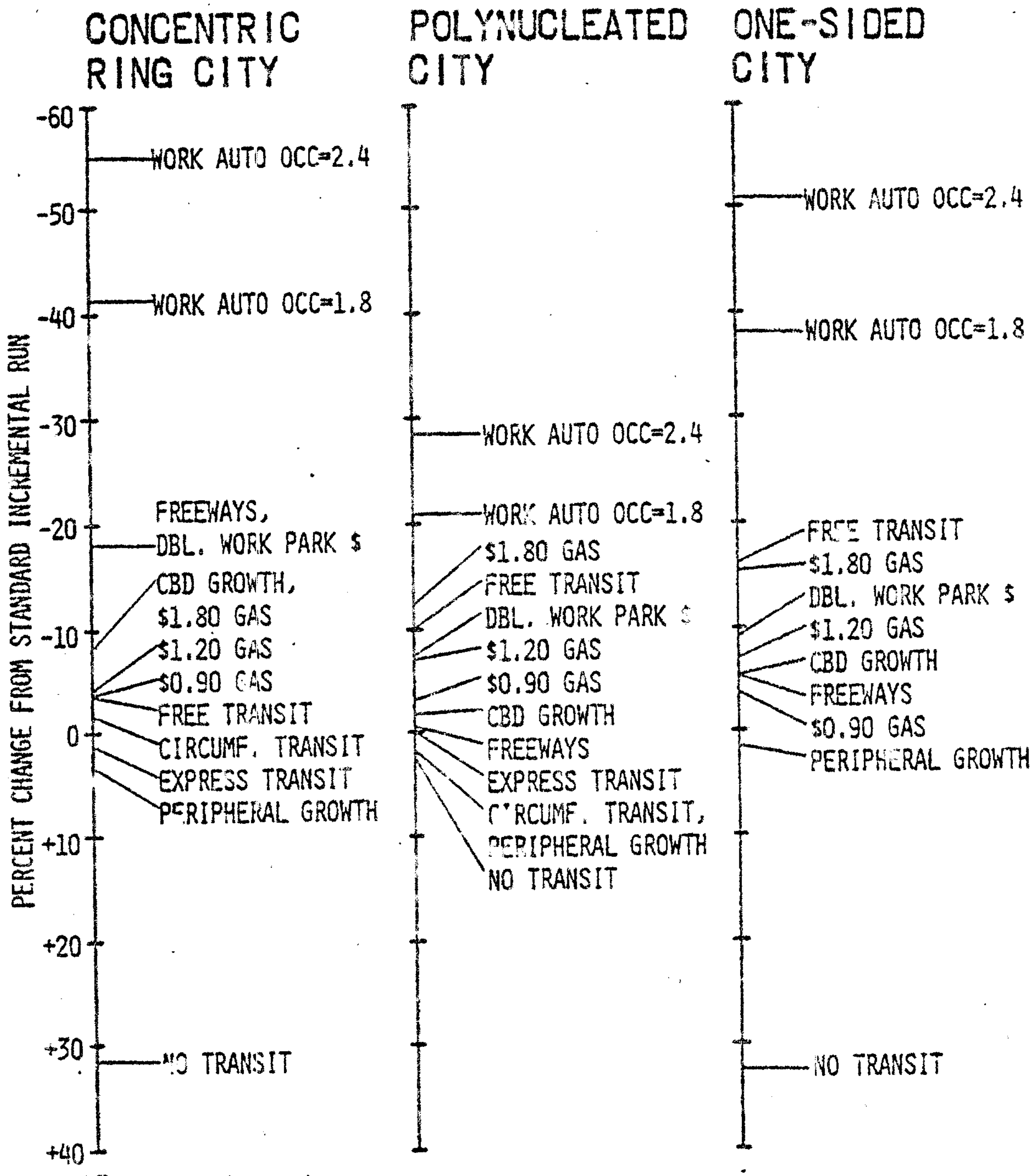
Transportation energy use was directly correlated with density in the Regional Energy Consumption Study of the New York Region. Of all sections, the transportation sector seems to be most subject to variations with density changes. The transportation energy consumption measured per capita shows a relatively sharp drop (from 80 to 30 million Btu per capita) in the range between 1,000 and 40,000 persons per square mile (resp. 386 and 15,000 inhabitants per square km.) and then rises sharply again in Manhattan. This can be explained by the fact that travel goes up with income and Manhattan has the highest income per capita in the region. Measured per dollar of income, energy consumption for transportation rises steeply and continuously with declining density, from a low of 9,000 Btu per dollar income in the central high density areas to about 33,000 Btu at the edge of the region. This pattern is in part a result of more trips on foot and by public transportation and fewer and shorter trips by car in the city area.

However, density is not the only factor in explaining these differences. In addition, the general land use pattern plays a decisive role in the consumption pattern. There is a new urban pattern that is pervading the nation, which the R.P.A. has called "spread city." (23) It differs from traditional cities and suburbs because jobs and services are no longer located in the center of the urban area or close to the residential area. Now, they are more and more scattered on the edges along the main expressways and highway interchange, totally separated from the residential areas. Although the average density may be similar to some more traditional urban areas, transportation energy use is much higher because almost all trips must be done by car.

Also, the metropolitan Washington area study showed considerable savings in the energy sector when the dense or transit oriented scenario was followed. Almost 20% of transportation energy use could be saved by exchanging the "sprawl" pattern for a "transit-oriented" urban structure.

A recent study undertaken at Northwestern University (U.S.A.) analyzed the impacts of various urban transportation and land use policies on transportation energy consumption. This research was based on the simulation of different energy-conserving transportation and land use policies on three hypothetical urban structures: a concentric-ring city, a one-sided or shoreline city, and a more radical polynucleated city. Each of these cities would grow from a population of 100,000 to 125,000 under the application of the particular policies to be tested. These experiments produced some very interesting results on the way cities would respond to the implementation of energy-conserving policies. Figure 5 presents the results of these experiments.

Fig. 5



Source: Peskin, R.L. and Schofer, F.L., op.cit.

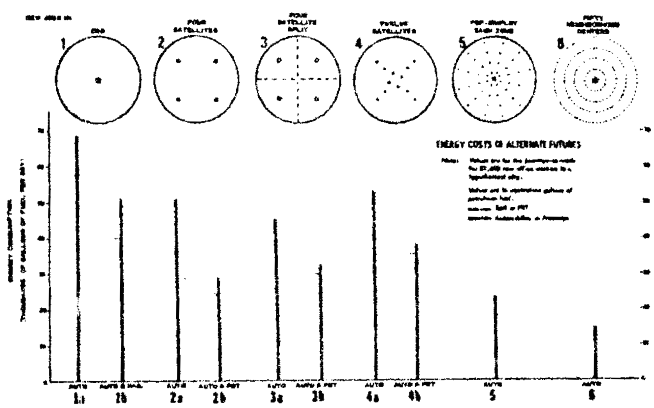
The most obvious finding is the similarity in the ordering of effectiveness of the alternative policy changes across the test cities, which makes the authors conclude that the results are generalizable to real-world situations (25). Also remarkable is the lower sensitivity of the polynucleated city to policy changes, which is probably due to its clustered distribution of land use, which results in shorter trips and lower total energy consumption. Encouraging increased average work-trip automobile occupancy seems to be the most effective policy change in reducing energy consumption. Surprisingly, eliminating transit would result in the greatest increase in energy consumption. On the other hand, simply adding more transit did little to improve the transit usage and thus had little impact on improvement of energy consumption. Contrary to intuition, freeways seem to be an important means of reducing energy consumption, especially by relieving congested arterials. In particular, the structure of the highway network would be most important in this respect. Furthermore, transportation pricing actions are not as effective as other policy changes. Increases in the price of gasoline are not too influential until exceedingly high prices are reached. The doubling of commuter parking prices and supply of free transit services are not that effective either, but that varies among the different structures. The study concluded that directed urban growth, particularly when coordinated with the existing transportation network or improvements to that network, would result in more energy-efficient urban forms than uncontrolled sprawled growth.

Transportation energy consumption may also be influenced by new technologies. This is possible in a direct way via new telecommunication systems which replace the need to travel. Innovations in the field of two-way cable-television systems seem in this respect quite promising. Examples such as remote shopping, using teleconferencing systems in office decentralization, and distributing utility services, etc., can all have a large influence on the travel patterns (26). There may also be an indirect influence via the land use pattern generated by such telecommunication innovations, as they have strong decentralizing dynamics. Mainly because of the rather speculative nature of the issue, at this moment there are almost no quantitative data available on the transportation energy effect of such innovations. However, there is a study by R. Harkness (27) which investigated the energy cost of alternative future transport relations dependent on the land use pattern. Of the six alternatives (presented in Figure 6), the neighborhood center concept, based mainly on highly decentralized job opportunities (facilitated through telecommunication systems), clearly had the lowest transportation energy consumption level.

Fig.t

FIGURE 2.20

Energy Costs of Alternate Future Transport



Source: R. C. Harkness, Telecommunications Substitutes for Travel (Springfield, Va.: National Technical Information Service, 1973), p. 471. and Golany, G., op. cit.

3.3. Conclusions and remarks

On the whole, the previous overview of research results confirm our intuition that there are significant opportunities to save energy by more conscious land use planning. Although comparison of the findings of the various studies is difficult because of the use of different methods of analysis, and not withstanding criticism of the rough estimates and of the use of some "non realistic" theoretical concepts and practical methods (28), it seems safe to make the following conclusions (adding some critical remarks):

- Space conditioning energy requirements seem to be lower in higher density clustered housing areas because the units are better insulated through common walls or ceiling. However, the research findings show considerable differences in their consumption figures and, in addition, some indicate a threshold in the potential savings. As the current research in this field is still in a pioneering stage, further analysis is needed to substantiate this relationship in a quantitative and qualitative sense.
- The prospect of energy savings through land use planning is much greater in the area of transportation. All the studies agree that by locating land uses so that people can travel shorter distances for each trip and so that using transit, bicycling, or walking can be acceptable alternatives for using the automobile, a lot of transportation energy can be saved. Therefore, land uses should become more compact and mixed and development should be fixed along major transit lines. Not only density but also the planning input

seems to be determinant for potential savings.

- As most of the energy saving land use patterns require complete reorganization of current patterns, it is clear that this can only be pursued as a part of a long-range strategy. In the short run, however, substantial energy savings can be obtained by other conservation policies.
- At the current stage, it is practically unknown what the exact impact would be of future technological innovations such as solar and wind energy and telecommunications on both residential and transportation energy consumption. Technology may not only help to solve the shortage problem but in addition may induce new spatial patterns.
- Given all the uncertainties, desirable land use patterns should be judged on many criteria. Hence, energy use is an important, but not the sole, consideration.

4. ALTERNATIVE SCENARIOS FOR FUTURE URBAN DEVELOPMENT

Having seen some technical evidence of the real link between urban form and energy use in the empirical studies mentioned above, we can start seriously considering what can be done in this field to conserve energy. Before considering whether or not urban planning policy changes are necessary to encourage desirable land use patterns, it is important to know which land use trends are moving in the direction of energy conservation and which are not.

To explore this, I will use the scenario method. In a scenario, a description is made of a future situation and of all the developments which lead to this situation. In this way, we may become more aware of some of the consequences of certain developments and their mutual relations. In addition, with this method, it is easier to detect possible conflict situations in the future. Three possible <u>urbanization scenarios</u> will be analyzed based on a different fundamental concern:

a) a scenario based on the maximum freedom for each individual;

b) a scenario based on a collective welfare view; and

c) a scenario based on a general environmental quality concern.

For each scenario, the most important social and economic implications will be mentioned, together with the spatial framework which is generated. Furthermore, special attention will be given to its energy consumption characteristics. It should be stressed that these scenarios are not policy alternatives. Many things in the scenarios are still uncertain and speculative. They can only be interpreted as touchstones on which more elaborated policy alternatives can be built.

4.1. Scenario based on the maximal freedom for each individual

basic trend: future urban growth will follow a rather random settlement pattern with as little planning input as possible.

economic and social implications:

the general preference for single-family detached housing parallel with technological innovations described above will generate a spread urban pattern, along with high individual and public social, economic and environmental costs (larger distance commuting, expensive infrastructure, loss of valuable agriculture land).

spatial framework:

current trends of suburbanization will continue, probably resulting in a spatial pattern similar to that suggested by Scott Greer (The Emerging City) or by Doxiadis (Ecumenopolis) based on a highly individualized transport system.

energy considerations:

besides market price adjustments of fuel costs (taking into account the growing scarcity) which will only have a minor short term effect, no conservation measures will be taken and energy consumption will grow even faster with the generalization of the spread urban pattern.

4.2. Scenario based on a collective welfare view

basic trend: future urban growth will pursue a settlement pattern which maximizes the quality of life (measured in terms of material conditions) from a collective point of view (including an equal distribution of income).

economic and social implications:

further economic growth is necessary to remove the inter- and intra-regional welfare differences and to stimulate research and development of new technologies; because of the general solidarity collective costs will be minimized.

spatial framework:

suburbanization will continue on a moderated way, particularly because of the strong decentralizing dynamics of new technologies which provide a substitute for physical movement (telework, teleshopping, telemed, etc.).

energy considerations:

energy supply will increase by means of new resources while on the demand side two counteracting forces are at work: on one hand there will be considerable savings in the transportation sector (telecommunications) while on the other hand demand will increase because of the nivellation of the consumption levels.

4.3. Scenario based on a general environmental concern.

basic trend: a future urban growth will develop a settlement pattern that at the same time tries to maximize the quality of life from a collective point of view and meet environmental constraints (such as scarcity of land and energy).

economic and social implications:

selective economic growth will be pursued together with a reorientation of the economy towards smaller self-supporting communities with low mobility needs; therefore drastic changes have to occur in current value systems to induce the necessary changes in lifestyles.

spatial framework:

taking into account the environmental damage associated with a spread urban pattern, urban policy will react to promote a more dense and planned spatial framework based on the integration of collective transport and energy system.

energy considerations:

energy consumption will be cut strongly because of integrated energy systems, higher energy prices (including community costs), denser housing, and lower mobility levels.

4.4. Evaluation of the scenarios.

The first scenario would certainly have an important impact on society and environment. As suburban sprawl would continue far outside the central city limits, the mobility needs would increase enormously. Even when sub-centers would grow, because of the lack of planning and coordination of housing, services, and employment locations, travel distances would not decrease. Shopping and commuter trips would be extended over even larger areas and all trips would be made by car as no public transport system can work efficiently in such a spread pattern. Higher market prices of fuel would not have a major influence on the mobility pattern as was demonstrated in the former chapter. In addition, reference can be made in this respect to the European situation where, despite much higher fuel prices, the relative scarcity of land, and the stronger policy influence, the same suburbanization trends seem to continue.

The sprawl pattern would also include continuous areas of single family houses on large lots, with high capital and operating costs for utility systems and municipal services. Social life would not necessarily decrease but real community life would become more difficult because of the physical distance barrier. The central city, with all its capital investment in buildings and infrastructure, would be lost as a potential living space. Because environmental quality is only a subordinate goal here, the waste of large areas of valuable agriculture land and open spaces would be accepted as a price to be paid. Furthermore, this option would demand continuously increasing energy utilization levels as this is embodied in such an urban pattern. As most observers recognize, a long-term reliance on this option would cause environmental dangers and can only be ruled out as being inconsistent with the goal of future well-being (29).

In the second scenario, these severe consequences would be minimized as there would be a general solidarity in society to pay for the negative consequences while in the first scenario, this is a matter of the individuals. However, as material conditions are still determinant for measuring the quality of life for the collectivity, some negative environmental consequences would be inevitable. Technological innovations would be further developed because of the collective backing. This would open new perspectives for solving problems such as urban congestion and auto-dominated environments, energy shortages, time intensive travelling, etc. It can be expected that the strong decentralizing dynamics of these innovations would push the urban growth to outlying areas although the important social, economic and environmental consequences would be kept within controlled channels.

It is no secret that our environmental problems would become more manageable at lower rates of economic growth. However, this simply transfers the problems to the socio-economic sector, where it would be even more difficult to reverse the growth in unemployment, to narrow the interregional differences in prosperity, and to remain competitive on the world markets. As the third scenario would also include a very tight urban policy to counteract current suburbanization trends, it seems difficult to realize. Not only would an appropriate zoning policy be needed to implement higher densities, mixed land uses, and so, but also a redefinition of property rights seems necessary, as we would have to deal with issues such as clustered housing, integrated energy systems, and reshaping existing cities and sprawl areas. Besides these institutional reforms, this scenario would also include some changes in life style which would be hard to realize.

Although a more dense and planned urban pattern may be most energy efficient and consumes less land, it is not necessarily the best solution for other environmental problems such as air and water quality. However, these problems can be more easily solved. Other benefits of this opposition are more clear. A denser pattern is consistent with the proposals for setting up a more active social and political structure on a neighborhood level. Furthermore, it offers more room for experimenting with technological innovations, particularly in the field of transportation (city buses, people movers, etc.). We can imagine the urban areas as a poly-nuclear complex with rather dense corridors of development along electric transit lines and with major centers of employment, and retail and business activities at the points of junction of these lines. Residential areas would again take the pattern of the old streetcar suburbs. High to moderate densities would evolve around the transit stops, the houses within walking distance or within the range of battery-driven electrical vehicles (golf cart culture) (30). Daily commuting would mainly use the public transit facilities while the use of gasoline powered vehicles would be limited to recreational trips into the countryside because then long distance energy sources would be needed. This would be consistent with the trend towards reduced work time and larger weekends. With more leisure time, second home and weekend camping trips would become more popular. So the automobile commuter trip would be only a once weekly event instead of the daily scene it is today.

It seems that neither one of these three scenarios leads to an ideal situation. It is also apparent that they cannot be followed independently because of some common features and various interactions in the real world. Hence, a compromise scenario would offer a more realistic base for a long term goal. In addition, such a compromise scenario as a basis offers more flexibility for switching to a more radical policy goal at a further stage if necessary.

5. ENERGY CONSTRAINTS AND URBAN PLANNING POLICY

The future conditions of energy supply to urban settlements are at least uncertain: traditional energy resources are expected to become exhausted before the year 2000 and alternative energy resources are either environmentally risky (such as nuclear energy) or at the current stage still technologically and economically unavailable for widespread use (solar, wind, and so on). There are also doubts as to whether these new resources will be sufficient to meet the fast growing needs. Meanwhile, new settlements are being constructed and many existing cities are undergoing revitalization. Therefore, it would be desirable that new settlements and existing cities would immediately be adapted as well as possible to meet the future energy conditions.

In the previous chapter, the compromise scenario was considered as more realistic, both in a short term and long term perspective. However, the question remains to what extent the reorganization of the spatial framework there included should be guided or encouraged by a broader urban policy action and what are the strategies that should be followed?

5.1. The need for a new urban planning policy

There is a lot to say on the question of government intervention as well as for and against urban policy action for energy conservation (31). It is clear that suburbia will not expand as rapidly as in the past if gasoline prices continue to increase and if long-term shortages materialize. High gasoline prices will urge more people to live in rather dense settlements again and make more use of public transport. Allowing in this way the price of energy to rise to a value reflecting its real scarscity and the cost to society energy producers would be confronted directly with the consumers and the demand would be adjusted to the supply. So there is absolutely no need for government intervention in land use opponents say. In addition they assert that it is not possible to predict to what extent future technology, i.e., in communications systems, will change the urban lifestyle so that distant movement is no longer required. And if, by some magical means, a new and inexpensive source of energy would be found in the very near future, then all these conservation measures would have been superfluous.

The market force argument has been refuted by showing that the price mechanism does not always reflect real market conditions and if it does, people may not be aware of it. For the individual, the increased gasoline costs per month may be just another six-pack of beer less and may not have that much impact on the driving habits of an individual. In most cases, people just don't realize what the cost differentials are, i.e., what it costs to drive from here to there versus taking the bus. So the point is that, until the market reflects the true value of our energy fuel resources, it can be too late already because land use patterns now laid out lock us into energy consumption requirements for decades.

From a social point of view, the market dependence strategy is less desirable because the price rises will fall most heavily on the lower paid segments of society, via higher costs of housing, or commuting. A general conservation policy, and in particular a more rational land use policy, is less discriminating in this respect.

However, there are some other important arguments which make urban policy measures really necessary. First of all, it is said that the only way to achieve substantial savings in energy through land use planning is in large-scale developments (at least on a neighborhood level). The development of new communities and large-scale projects make higher-density housing more appealing to the market and these larger higher-density areas are in turn more easily made efficient in terms of utility systems such as district heating and public transport (31). In the cases where it is desirable to get more moderate-density and high-density housing or maybe to mix uses within the development projects, it may be necessary to change zoning ordinances and in some cases expropriations may be inevitable. So it looks like, in general, some government action is indispensible to guide and coordinate large projects and to provide the legal framework and even some financial means to realize them. Government action should not replace initiatives but only complement and encourage them. Furthermore, urban policy action on the national and local levels should reinforce each other in this respect.

Opponents of public intervention also wonder how these energy conservation objectives can be reconciled with non-economic considerations which are important to the maintenance and improvement of the quality of life, i.e., at this time there is still an overwhelming majority of the people who prefer to live in energy inefficient suburban single family houses. Here two counter-arguments can be presented. First of all, it should be made clear whether or not the private interest of the improvement of the quality of life conflicts with the collective interest. That is, in the case of suburban sprawl, next to the individual advantages of having a single-family home in the countryside should be set the high capital and operating costs (i.e. for providing public transport for the young, old, and poor) and the environmental damage which must be paid by the whole community. Secondly, it is agreed that energy costs and economic costs cannot be the sole criteria for the planning of our urban environment. But even those who would take a more directly social approach to community development still need a physical framework which, if sufficiently diversified, can meet an array of human needs now and in the future (33). An energy conserving approach to urban design would provide such diversity. The steps for energy saving land use mesh nicely with other land use, environmental, and some social and economic goals. The adoption of energy-efficient land use policies (via alterations in land development patterns) offers the potential for a cleaner and healthier environment (decrease in traffic congestion noise and stress, walking distances, etc.), preservation of prime agricultural land and open spaces (now being consumed by sprawling development), increased leisure time, lower public expenditure (no more expenditure to cope with problems of urban decay), and considerable financial savings for consumers. All of these are very important social benefits which complement energy conservation.

5.2. The ways for urban policy to react.

As seen in chapter 3, the magnitude of the effect of urban form factors on energy use is still somewhat unclear. In addition, the research work is unbalanced as certain factors such as density and shape have been studied to a greater extent than, for instance, population size, land use arrangements, and national and regional settlement patterns. Nonetheless the current state of knowledge has broadened enough to offer some sense of directions for influencing urban form to achieve energy conservation. The set of directions for urban planning policy can be classified into two sections according to the level of operation:

1. local planning directions
2. regional planning directions

5.2.1. Local planning directions

Urban planning has traditionally been one of the important policy actions of local governments. Because of this well established role on the local level, energy saving land use changes may only be successfully guided and shaped by the action of local governments. There are three factors which offer somewhat clear directions for urban planning actions on the local level: density, land use arrangements, and site design.

Density is the urban form factor most frequently advanced as providing the opportunity for reducing energy consumption through adequate urban planning. In planning usage, density means the ratio of persons, households, or volume of buildings or development to some unit of land area. The concept of "residential density" used on the local level is expressed in number of dwellings per acre or hectare.

Most empirical studies are supportive of the view that higher density conditions tend to be more energy conserving. As seen in Chapter 3, the energy conserving nature of density is reflected in the per capita requirements for space conditioning, utility systems, and transportation. Space conditioning requirements are reduced in high density settlements because the houses are more likely to be clustered, sharing common walls (as in row houses or town houses) or common floors and ceilings (as in high-rise or garden apartments), and hence provide better insulation. Residential units then also tend to be smaller than in lower densities. Promoting higher densities does not mean that every one has to be put into high-rises. As was noted in Chapter 3, moderate densities of town houses and low-rise multi-family houses are more economical in terms of energy consumption. Higher densities should not only be stimulated in new development but also re-use, infilling and redevelopment of existing neighborhoods would be energy saving. However, it is clear that this will require added pressure on the local governments to permit infilling of development or even denser development.

Furthermore, higher density structures are more easily served by common integrated heating and cooling systems. Clustering housing and other buildings also reduces the need for streets, pavements, and utility systems. So, shorter streets and public utility lines mean that energy is saved in both the manufacture and the maintenance of these materials. Energy savings are also obtained through shorter transmission lines and larger conversion or production plants to serve the large number of consumers in high density settlements. In addition, higher densities reduce the need to travel because employment and shopping areas are located close to residential areas. Some minimum density is also a precondition for the formation and maintenance of a viable mass transportation system or for organizing car-pools on the local level.

A second factor which is important in terms of energy consumption is the land use arrangement. The general view is that land-use mixing and integration is more energy conserving than segregation and large-scale land use specialization. This latter became very popular in urban planning after the C.I.A.M. publication of "The Charter of Athens" (1933) as a way to separate conflicting land uses. But today light industry and advances in environmental protection have all reduced the need for a strict separation of land uses. Instead, a mixed use development where residences are closer to working, shopping, and recreational places (and in some cases even in the same building) can contribute to transportation energy savings as in such areas people are more likely to walk, bike, or take a bus (34). In general, mixed use development cannot guarantee less travel but it does encourage less travel (35). Land use mixing and integration can also facilitate the sharing of common services to minimize the energy waste e.g. waste heat from power stations or from other industries can provide space conditioning for residential, commercial, and other activities in the surroundings.

Site design elements relating to the physical characteristics of the site, the building shape, size, orientation and arrangement, and landscaping can also to a great extent affect energy demand (36). Although these aspects are rather technical and sometimes refer to the construction characteristics themselves they should nevertheless be evaluated in the planning process. The state of knowledge with regard to this factor is less developed than that which is available on the other factors. However, it is sure that a proper orientation and siting of the streets and buildings can save on their heating and cooling needs (protection from winds, advantage of solar radiation, shade from landscaping, etc.). Furthermore, shading and landscaping may often be the determining factors when an individual makes a decision to walk or bike in the summer or ride in an air conditioned car (37).

On the basis of the existing state of knowledge as to the ways urban form can be influenced to become more energy efficient, some guidelines for a planning policy at the local level can be advanced. In general, it can be said that urban form should be developed at higher densities and mixed to a greater extent than has been done up to now. In addition, some regulations should be worked out to realize more energy efficient site planning. More specifically, this would mean that:

- higher densities should be encouraged through clustering and infilling in residential building
- site plan requirements should be set up to assure site design taking energy advantage of topography, vegetation, and climate
- land uses should be less segregated and specialized and increased use should be made of multi-functional or mixed-use buildings
- the application of total integrated energy systems should be promoted
- policies which deemphasize private automobile use and give preferential treatment to public transit, car pools, bicyclists, and pedestrians should be promoted

5.2.2. Regional planning directions

The planning of urban settlements on a macro and meso level also includes some important energy considerations. Here, we must think of the different energy requirements of alternative macro-spatial arrangements, mainly on the scale of a metropolitan area or a city region, and the factors that influence this spatial configuration, such as migration, transportation network, regional economic incentives, etc.

There are a lot of studies which have dealt with urban patterns and spatial configurations and their effect upon energy consumption. Among the different urban growth alternatives such as redevelopment, new towns, peripheral growth of concentric ring types, regional cities, linear cities, scattered towns, and dispersed growth, the sprawl pattern was found to be less energy-efficient than other patterns although there is no clear consensus as to the most efficient pattern and shape. Much depends on the existing situation. On the basis of different studies, some authors conclude that, because of the size and the spatial inertia of some activities, when reshaping metropolitan areas a multi-nodal organization would be desirable (38). Energy savings in this respect are also explained in terms of transportation and utility networks. By reducing the distances for transporting goods and services, and also the extent of transmitting and infrastructure networks, an urban settlement pattern can achieve certain economic and energy savings by requiring less energy per capita for transportation and network operations. This is not only a consequence of operating in a more compact urban settlement (shorter distances and lines) but also of the more intensive use of the infrastructure facilitated by the pattern itself (development is more concentrated around the transportation and infrastructure systems). It is clear that, within this context, redevelopment tends to offer more possibilities for energy savings because of the increased compactness and contiguity of urban development.

The location of an urban settlement in relation to other urban areas and economic activity centers also affects energy demand in terms of transportation of goods and people. The regional economic development policy, the infrastructure policy, and even the fiscal policy all influence where people and economic activity want to locate and whether they will have to be transported over long distances. Indirectly this also influences the shape of the urban area via the different growth rates in various locations.

The planning direction here is that urban policy should encourage the establishment of a well-balanced national and regional system of urban areas, each of them being developed in planned patterns. Therefore, some particular guidelines should be followed, such as:

- the deconcentration of overcongested urban areas into a more balanced network of smaller urban settlements,
- the discouragement of sprawl patterns by imputing the real social costs based on a macro-approach to scattered and spread development,
- the provision of impetus for renewal of central cities and the upgrading of low-density areas (where costly public facilities are already provided) before creating new outlaying centers,
- the reorganization and coordination of public transportation networks on the regional level to complement local transit systems and to support regional planning objectives,

- the adjustment of government policy measures in other fields than urban planning (ranging from tax regulations to regional economic incentives) to realize previous objectives,

- the reorganization of the administrative framework to facilitate realization of this regional approach.

An important consideration after this summing up of the planning directions is that it should be emphasized that most urban form factors are interdependent; i.e., attempting to change the shape without using appropriate land use arrangements would not turn out to be very beneficial in terms of energy consumption. The same applies to improving and expanding public transport systems in low density areas. Simply providing transit and expecting people to use it instead of an automobile doesn't work. Some parallel traffic constraints and land use measures are necessary. It is clear that the need for coordinated planning is imperative. The national, regional, and local government policy measures should reinforce each other and become integrated in a general urban policy. Although all government levels have important roles to play, especially local governments have the obligation to see that new developments are planned and executed so as to minimize disruption of essential natural systems (39).

5.3. Urban policy strategies

Both the nature of the problem (which is based on future potential energy constraints) and also the fact that the energy saving possibility of land measures is only a long-term pay-off (and ought to be thought of in that way when compared with more short-term opportunities) require an appropriate policy strategy. Such a strategy should be based on immediate action, but, in addition, should include the flexibility for revision of policy action as time progresses. A. Dutt and F. Costa suggested two forms of strategy in this respect (40).

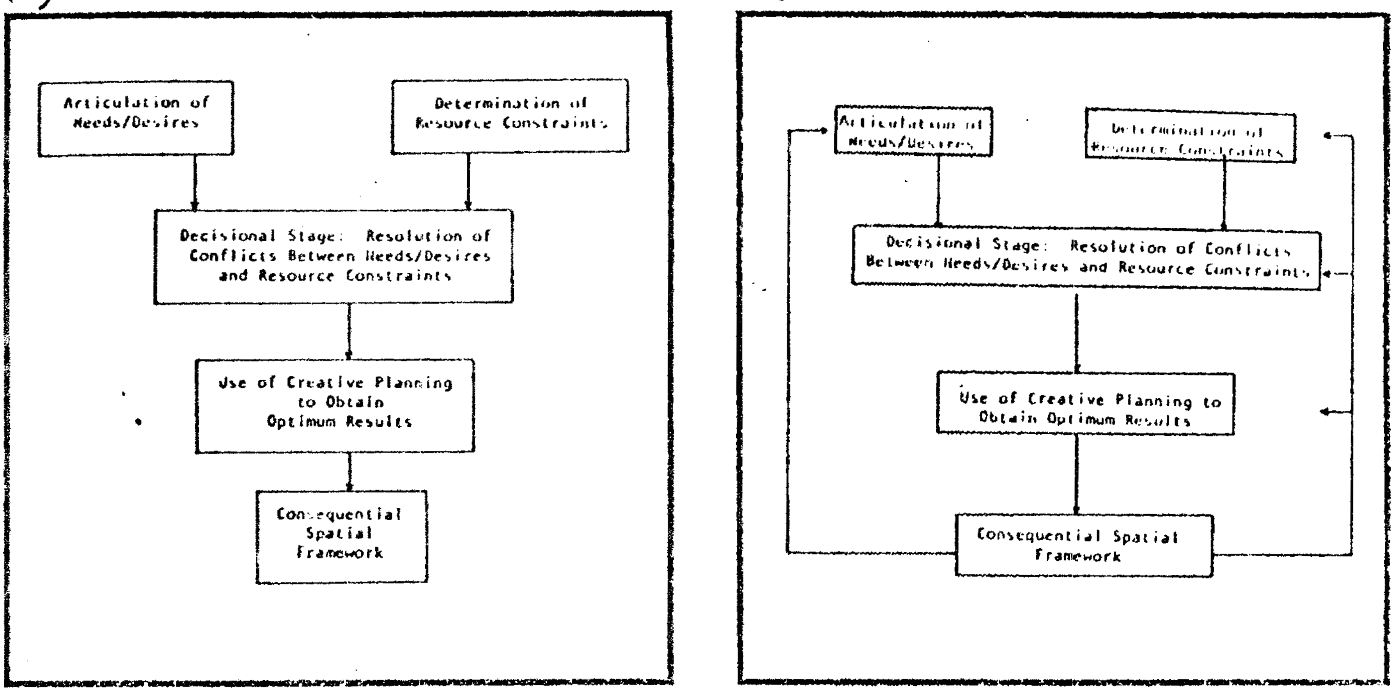
The first one is the sequential approach in which a continuous and uninterrupted process, beginning with the identification of needs and desires, is made subject to constraints imposed by economic and social realities (Figure 7(a)). At this point creative planning should be introduced to facilitate the harmonious meshing of perceived needs and desires with actual constraints or conflicting value systems. The result would be the spatial configuration that contributes to optimum living conditions within the city's area for the maximum number of people.

The second approach (Figure 7(b)) is based on a feedback mechanism at each important step in the decision-making process. So the information obtained in each of these subsequent phases of the process would be utilized to modify or reformulate objectives associated with earlier steps. The advantage of this dynamic approach is the built-in capacity to reshape planning with the advancement of knowledge and changing technology which is especially important in the case of planning for future urban settlements. Therefore, this dynamic approach in particular seems quite appropriate for energy saving land use planning.

Once an agreement is made on what exact measures should be taken for energy conservation inside the creative planning stage, some additional measures may be taken to encourage the adoption of conserving actions by residents and developers. Three kinds of such implementation programs can be used (41).

Fig. 7.

(a) (b)



Sequential approach to urban spatial planning — *Dynamic approach to urban spatial planning*

Source: Costa, F.J. and Dutt, A.K.: op.cit.

First of all, there is a need for educational programs to persuade people that they will benefit from conserving energy and from accepting (unpopular) land use policy and tell them how they themselves can help. As C. C. Harwood puts it: "...the real problem lies in convincing the public that it is better to make necessary lifestyle changes now to deal with the energy shortage than to wait until we must react hastily in a full-blown crisis for which we are ill-prepared." (42) Such efforts have shown to be ineffective because people do not perceive a crisis until it is real (43). However, these educational programs should go on, focused not only on the public, but on planners and decision makers as well.

Secondly, (dis)incentive programs should be set up to encourage energy savings either through money saving or through governmental zoning, budgeting, and administrative actions which make it easier for citizens to ride transit, for instance, or for developers to use land more efficiently (44). At the same time, the government should get rid of some incentives that still discourage investment in conserving types of developments such as apartments, i.e., the government housing policy in most countries still encourages the construction of single family housing via its credit policy and fiscal incentives. Indirectly this is stimulating suburban movement. Furthermore, it must be said that disincentives only seem to be effective if all jurisdictions within a certain region act in the same way to discourage inefficient development.

A third set of programs should be mandatory programs which legislate energy efficiently through the establishment of requirements and standards. This would include regulations such as speed limits, gas rationing, insulation standards and so on. Because all users covered by this program must comply with the established standards, such programs are extremely effective.

6. COMPARISON OF THE POSSIBILITIES FOR ENERGY CONSERVATION VIA LAND USE PLANNING IN THE UNITED STATES

Up to this point our analysis has mainly been kept on a general theoretical level. Where empirical evidence was given on the assumed relationship between urban form and energy consumption, most of the basic material was situated in a North American context. In this chapter, I will look at the practical possibilities for energy conservation through more conscious land use planning, in both a North American and a Western European perspective. At first I will analyze to what extent current energy consumption patterns in both parts of the world differ, and why. Besides having a look to current conservation policies, we will also discuss the prerequisites for future energy saving land use policy in these countries. Mainly we will be looking at the U.S. situation and the Common Market countries, but just as it is difficult to see the E.E.C. as a whole, we cannot neglect the regions inside the United States. Therefore, some reservations will be made on the total aggregated figures.

6.1. Market characteristics

Energy consumption shows a remarkable geographical distribution over the world. The U.S., E.E.C. countries and Japan, with about 15% of the world population, account for 56% of the world energy consumption. Calculated per capita, energy consumption shows large differences between the U.S. and the E.E.C., and even between the E.E.C. countries, energy consumption levels differ considerably. In 1975, U.S. energy use per capita was about three times the average E.E.C. level. Within the E.E.C. however, per capita consumption levels range from 6.835 kg. coal equivalent (kg.c.e.)

in Germany to 3.012 kg. c.e. for Italy.

Parallel with their economic growth, the demand for energy in all industrialized countries increased sharply over the last two decades. Between 1960 and 1974, the nine member states of the E.E.C. (45) had an increase of 79% in their total combined energy consumption. The growth of energy consumption in the United States was of a similar degree (+78%). With the energy crisis of 1973-1974 and the effects of the worldwide recession caused by it, there was an overall reduction of energy use in 1974 and later. Recent trends, however, show that the upward trend has been restored, although with a smaller growth rate.

This postwar boom in energy consumption was accompanied by some important changes, both in the use of various sources as well as in the distribution by consuming sectors. Just after World War II, 80% of the total energy requirements of the E.E.C. (52% in the U.S.) were met by solid fuels (coal and lignite) while oil accounted 10% of the total (31% in the U.S.). Now, this situation has changed completely (Table 7). Solid fuels cover only one-fifth of the total requirements both in the E.E.C. and U.S.A., whereas oil and natural gas account for about three-quarters of the total (natural gas being far more important in the U.S.A.). This switch in energy sources had very important economic and political consequences. With the growing dependence on crude petroleum as an energy source, oil imports appeared as a heavy burden on the balance of payments of most of the importing countries. In addition, with an average degree of dependence on foreign supplies of more than 80% (only Germany, the

Netherlands, and the United Kingdom have a lower percentage). European countries became extremely vulnerable in terms of economic growth (46). The U.S. economy seems much stronger in this respect as only 19% of its total energy needs have to be imported (Table 8). However, in the U.S., as well as in Europe, the degree of dependence on foreign supplies doubled over the last two decades.

The distribution by consuming sector shows some very interesting trends over time as well. It looks like both the transportation sector and the residential + commercial sectors are continuously enlarging their share in the total energy consumption at the expense of the industrial sector. While the energy consumption level of the industrial sector dropped both in absolute and relative terms between 1970 and 1974, there were significant increases in transportation and residential commercial energy consumption levels, both in the E.E.C. and the U.S.A. Notwithstanding the rapid growth in the E.E.C. the transportation sector in the U.S.A. is clearly still a much larger consumer than in Europe. This is mainly due to an increase in private passenger transport as this generally accounts for almost 3/4 of total transport energy consumption.

6.2. Explaining the differences

As has been noted in the former chapters, there is a clear relation between urban form and both residential and transportation energy consumption. These two sectors especially have increased their share in total energy consumption during recent years. Therefore, I will focus on the residential and transportation sectors in the analysis of the differences in consumption levels between the United States and Western Europe. Besides some general

TABLE 7. SHARE OF VARIOUS SOURCES OF PRIMARY ENERGY IN INLAND CONSUMPTION, 1973.

	E.E.C.		U.S.A.	
	mio. t.c.e.	%	mio. t.c.e.	%
coal and lignite	317.3	23.7	508.2	19.6
crude petroleum	792.8	59.3	1109.1	42.8
natural gas	168.4	12.6	839.0	34.4
primary electricity	57.2	4.3	131.2	5.0
TOTAL ENERGY	1337.4	100.0	2587.5	100.0

Source: Eurostat.

TABLE 8. ENERGY BALANCE OF E.E.C. AND U.S.A., 1960-1974
(in million ton oil equivalents: is defined as 10^7 kcal)

		1960	1970	1974
E.E.C.:	total energy requirements	519.4	838.1	927.9
	of which imports	243.9 (47%)	677.3 (81%)	774.6 (83%)
	final cons. of	357.5	575.3	626.6
	which indust.	162.4 (45%)	264.6 (45%)	263.8 (42%)
	transp.	62.7 (17%)	107.9 (18%)	123.4 (20%)
	res. and comm. and miscell.	138.4 (38%)	220.8 (37%)	238.4 (38%)
U.S.A.:	total energy requirements	965.0	1570.3	1713.7
	of which imports	94.1 (10%)	193.6 (12%)	326.8 (19%)
	final cons. of			
	which indust.	272.2 (35%)	401.0 (35%)	399.4 (33%)
	transp.	234.2 (30%)	348.6 (30%)	395.4 (32%)
	res. and comm. and miscell.	266.1 (35%)	409.6 (35%)	428.4 (35%)

Source: Energy Balances of O.C.D.E. countries.

factors, special attention will be given to the land use characteristics which are responsible for the differences in energy consumption levels.

6.2.1. General factors

It is remarkable that some European countries, with almost the same standard of living as the United States (i.e. West Germany, Denmark, Belgium) consume only half as much energy per capita (see Table 9). This U.S.-E.E.C.-difference is even larger on the sectoral level, particularly for residential and transportation energy use. In West Germany, for instance, the per capita energy use for transportation and for residential purposes is respectively 27% and 48% of the U.S. level (Tables 10 and 11).

Space conditioning is by far the largest use of energy in the residential sector, accounting for 70 to 80% of total energy consumed in this sector. The amount of energy used for space conditioning depends on a number of factors such as: climate, the characteristics of the housing stock, the amount and effectiveness of insulation, the efficiency of heating systems, and differing heating habits. However, it was found that climatic factors were not (47) that important in explaining the differences nor were insulation and efficiency of heating systems. Mainly the characteristics of the housing stock (floor space per dwelling, type of dwelling) and heating habits (proportion of the available space to be heated, indoor temperature) are responsible for the relatively high space conditioning energy use in the United States compared to Western European countries (48). As far as the rest of the residential energy consumption is concerned, that which is used for all kinds of home equipment and appliances other than heating and cooling installations, some significant

TABLE 9. E.E.C. - U.S. COMPARISON

	G.N.P. per capita in constant $ (1976)	Total energy consumption per capita kg.c.e. (1975)	Passenger cars in use per 1000 pop. (1975)	Gasoline retail price in U.S. cent per gal. (1977)
U.S.	7,864	10,999	503	60
E.E.C.	5,355	4,549	266	1.62 (a)
Belgium	6,927	5,584	259	169
Luxemb	6,417	-	357	139
Denmark	7,379	5,268	248	175
France	6,543	3,944	288	167
Germany	7,336	6,835	280	151
Ireland	2,524	3,097	164	150
Italy	2,905	3,013	257	209
Netherlands	5,331	5,784	257	177
United Kingdom	3,871	5,264	251	125

(a) average
Source: Eurostat and Statistical Abstract U.S.A.

Table 10.

RESIDENTIAL ENERGY USE PER CAPITA IN THE UNITED STATES AND WEST GERMANY--1972
(10^6 Btu)

	Electric		Other Energy		Total		
	United States	West Germany	United States	West Germany	United States	West Germany	West Germany as a Percent of United States
Space heating	4.23	3.03	32.11	21.41	36.34	24.44	67
Hot water	3.92	2.53	6.34	1.30	10.26	3.82	37
Cooking	1.61	1.52	1.73	0.49	3.34	2.01	60
Air conditioning	3.22	--	0.02	--	3.25	--	--
Clothes drying	1.11	--	0.46	--	1.57	--	--
Other	13.03	2.32	0.01	--	13.04	2.32	18
Total	27.12	9.40	40.67	23.19	67.80	32.59	
All uses							48

Source: Stanford Research Institute, op. cit.
and Reigeluth, G. op.cit.

Table 11.

ENERGY USE FOR TRANSPORTATION IN THE UNITED STATES AND WEST GERMANY--1972

	Per Capita Use (10^6 Btu)		West Germany per Capita Use as Percent of United States
	United States	West Germany	
Air transport	7.20	1.46	20.2%
Railroads	2.73	2.04	74.7
Road transport	63.22	18.28	28.9
Inland and coastal shipping	1.98	0.65	32.7
Pipelines	3.79	n.a.	n.a.
Military	5.42	0.71	13.2
Foreign shipping	1.46	n.a.	n.a.
Total	85.81	23.14	
All transportation			27.0

Source: Stanford Research Institute, op. cit.
And Reigeluth, G.: op. cit.

differences can be observed between the United States and Western Europe. Looking at U.S. and Western German consumption data (Table 10), although these countries are quite comparable in terms of living standards, appliances such as dishwashers, refrigerators, and so on, which use large amounts of energy, are still less frequently used in Germany than in the U.S. (49). However, this is changing rather quickly.

The greatest differences can be seen to exist in the transportation sector, where the United States consumes more than three times as much energy as in West Germany and some other countries (Table 11). Obviously, these differences are mainly situated in the road transport sector. The fuel savings in this sector are partly due to the much greater fuel economy of European cars (which are smaller, lighter in weight and more efficiently designed). Besides that, there are also some policy measures which have largely influenced this sector. The explosion of oil prices which has led to deficits in the balance of payments, has had its positive side in some European countries, as some of the them have taken steps to curtail the consumption of gasoline and restrict the use of automobiles by higher taxes and by improving public transit. As can be seen in Table 9 the degree of car-ownership in Europe is half as high as in the United States - and fuel prices are at least twice as high as in the U.S. In addition, most E.E.C. countries have adopted policies favoring fuel-efficient public transportation over private autos. However the potential effect of such measures clearly relates to the dominating land use characteristics.

6.2.2. Land use factors

According to a common stereotype, U.S.-cities are sprawling, inefficient, polluted, and in fiscal trouble, while European cities are dense, compact, charming, and well-managed. Although basically true, these contrasts are easily exaggerated. In addition they are mainly based on post-war contrasts which fail to take into account the current decentralizing trends in European cities.

The density level is generally believed to provide one of the strongest contrasts between U.S. and European cities. Although the average densities for the entire urban region are more or less the same (Table 12), the central city densities of European cities (with the exception of the north east) are higher. The low suburban densities of England, West Germany, and Holland are misleading, as the figures are gross densities in which greenbelts and planned open spaces are included (50). Residential density is a much more meaningful measure than gross population density. Then it is found that, dependent on the time period in which the suburb was built, European suburban densities are ranging between 10 and 40 people per acre. Comparable suburban residential densities for the U.S. are between 5 and 15 people per acre. As noted before, these density differences explain to a large degree the differences in space conditioning requirements.

These differences can be explained in a historical perspective. Up to the 1920's, American central cities were almost as dense as European cities, mainly developed on a basic rail pattern. The widespread use of the automobile, after World War II, permitted the mass flight out of the central

Table 12.

Comparative International Metropolitan Densities
1960 and 1970

	Year	Total Urban Region Density	Central City Density	Suburbs Density
United States	1960	3,837	5,502	2,622
	1970	3,376	4,463	2,627
North East Region	1960	4,840	10,088	2,914
	1970	4,429	9,309	2,946
North Central Region	1960	3,906	6,638	2,321
	1970	3,261	4,818	2,348
Southern Region	1960	2,940	3,391	2,246
	1970	2,617	2,904	2,243
Western Region	1960	3,699	4,550	3,032
	1970	3,577	4,121	3,169
England & Whales	1960	3,813	9,425	776
	1970			
West Germany	1960	2,514	6,205	1,074
	1970	2,623	5,569	1,396
France	1960	5,059	11,612	3,067
	1970			
Holland	1960	3,159	8,681	1,139
	1970			

Source: Country Censuses.
Reigeluth, G.: op. cit.

cities to the suburbs. This became a very typical characteristic of modern American urbanization. In the United States, this outward movement was further encouraged by some typical phenomena which created an anti-urban attitude: the child oriented family, the mass influx of poor blacks in the cities after 1940, and the extensive highway construction (51). In European countries, automobiles became widespread only in the sixties, and even then, far fewer Europeans could afford to own a car. As a consequence, European towns stayed focused on public transit much longer. Partly because of its historical growth conditions, the European cities were more people oriented, with public spaces, neighborhoods, parks, etc. Because of their stronger tradition of autonomy and independence, and even control over the adjacent countryside, many European cities have prevented suburban sprawl from spreading into the countryside by restricting the use of utilities in the nearby undeveloped areas. Generally most of the European states have a longer tradition of land use planning which gave both national and local governments more effective devices to control the location and type of urban growth.

However, during the sixties and the early seventies, European cities were experiencing strong decentralizing trends as well, and it is feared that Europeans are going to imitate the wasteful American pattern. The economic expansion during this period generally made a lot of people better off so that they could afford a house in the suburbs. Despite the relatively high prices for acquiring the land and building a house, suburban areas expanded rapidly (see Table 13). The number of cars in use is growing

Table 13

Comparative International Metropolitan Development Characteristics - 1960 and 1970

	Year	Total Urban Region		Central City		Suburbs	
		Population	Percent Growth	Population	Percent Growth	Population	Percent Growth
United States	1960	95,834,251		57,966,093		37,868,158	
	1970	118,446,566	24%	63,921,684	10%	54,524,882	44%
North East Region	1960	30,888,369		17,280,859		13,607,510	
	1970	35,144,675	14%	17,212,608	-4%	17,932,067	32%
North Central Region	1960	26,646,760		16,627,237		10,019,523	
	1970	31,551,632	18%	17,262,078	4%	14,280,554	43%
Southern Region	1960	21,452,196		15,019,040		6,433,1[illegible]	
	1970	28,395,411	32%	17,804,039	19%	10,591,372	65%
Western Region	1960	17,200,910		9,297,383		7,903,527	
	1970	23,696,763	38%	11,709,991	26%	11,986,772	57%
England & Wales	1960	35,719,463		22,270,400		13,440,100	
	1970	37,087,300	4%	21,911,600	-2%	15,175,700	13%
West Germany	1960	28,720,463		19,888,783		8,831,680	
	1970	33,773,719	18%	21,079,136	6%	12,694,583	44%
France	1960	19,615,491		10,497,195		9,118,295	
	1970	23,724,125	21%	12,059,550	15%	11,664,575	28%
Holland	1960	6,002,392		4,418,618		1,583,774	
	1970	6,611,280	10%	4,484,394	1%	2,126,886	34%

Source: Country Censuses.

Reigeluth, G.: op.cit.

very fast and highways are being built on a large scale. The general environmental concern growing in the seventies was an additional promotion for the home in the countryside. Furthermore, government policy indirectly subsidized new housing in the suburbs via semi-public housing companies who looked for cheaper land outside the city. A lot of European industrial conurbations also experienced a large inward movement of foreign workers into their older core neighborhoods. This created some social tensions and ended up in an exodus of higher and middle class people, as noted in U.S. cities after the black influx.

Despite the decentralizing trends of industrial and commercial activities, European cities still display a greater integration of land uses than in the U.S. Generally European planning policies, unlike U.S. zoning regulations, have permitted and sometimes encouraged the mixing of small service industries and retail shops in residential areas. Differences in the structures of retail commercial activity partly explain why decentralization of commercial activity has not occurred on the scale encountered in the U.S. In the cases where functional zoning has been applied in European cities, industrial zones seem to be smaller, closer to residential neighborhoods, and generally serviced by public transit.

The higher densities, more compact urban development patterns, and greater integration of land uses in European cities are likely to be related with the differences in travel patterns that can be observed between European and U.S. cities. Europeans clearly make a greater use of mass transit especially for the journey to work. Data shown in Tables 14, 15, and 16 illustrate this. The compact configuration of European cities and the

Table 14.

JOURNEYS TO WORK: BRITISH SMLA - U.S. URBANIZED AREA COMPARISONS

Proportion by Private Transport - 1966

SMLA	Central City Density (pop./sq. mi.)	Population	Originating Journeys to Work		Arriving Journeys to Work	
			Central City	Suburbs	Central City	Suburbs
1) London	19,709	8,634,200	25%	40%	25%	45%
2) Birmingham	11,618	2,818,000	30%	50%	35%	45%
3) Manchester	12,504	1,991,300	25%	40%	30%	35%
4) Bristol	10,470	718,100	30%	60%	35%	55%
5) Nottingham	9,433	673,900	10%	45%	30%	45%
6) Leicester	10,129	533,600	30%	55%	35%	50%
7) Reading	8,890	313,600	40%	55%	45%	55%
8) Southend	5,239	278,500	40%	45%	40%	45%
9) Northampton	12,931	167,400	45%	60%	45%	60%
10) Stevenage	7,256	133,100	60%	60%	60%	60%
11) Turnbridge	4,744	116,100	35%	45%	45%	50%
12) Burnley	10,422	112,300	25%	30%	25%	30%

Percent of Work Trips by Mode - 1970

Urbanized Area	Central City Density (population/sq. mi.)	Population	Private Auto	Mass Transit	Other
1) Los Angeles	6,135	8,351,266	87%	5%	8%
2) Boston	13,936	2,652,575	66%	20%	14%
3) Cleveland	9,893	1,959,880	78%	14%	8%
4) Louisville	6,025	739,396	85%	7%	8%
5) Fort Worth	1,919	676,944	91%	3%	6%
6) Akron	5,082	542,775	89%	2%	9%
7) New Haven	7,984	348,341	79%	9%	11%
8) Charlotte	3,173	279,530	84%	9%	7%
9) Reading	8,853	167,932	74%	11%	15%
10) New Bedford	5,219	133,667	78%	4%	12%
11) Port Arthur	1,190	116,474	90%	2%	8%
12) Waterloo	1,636	112,881	84%	2%	14%

Source: Edward Weiner and Brian Poole, "Some Urbanized Area Journey to Work Statistics," Department of Transportation, Census of the Population 1966, HMSO, 1970.

Table 15.

Comparative Passenger Miles by Mode of Travel (1972)

Mode	United States		United Kingdom		West Germany		Sweden	
	Pass. Miles/Capita	Percent	Pass. Mi./Cap.	Percent	Pass. Mi/Cap.	Percent	Pass. Miles/Capita	Percent
Cars	10,389	92.1	3,968	79.7	4,807	82.0	5,050	81.0
Buses & Transit	234	2.1	611	12.3	632	10.8	485	7.8
Trains	85	0.8	377	7.6	399	6.8	441	7.1
Airplanes	571	5.1	23	0.5			246	3.9

Sources:

Joel Darmstadter, Joy Dunkerley and Jack Alterman, "Progress Report on ERPI Project RP 384-1: Analysis of Variations in Energy/GNP Ratios between Selected Countries," Resources for the Future, Washington, D.C., July 15, 1975.

Richard L. Goen and Ronald K. White, Comparison of Energy Consumption between West Germany and the United States, prepared for Federal Energy Administration, contract 14-01-001-1885, Stanford Research Institute, Menlo Park, California, June 1975.

Lee Schipper and A. J. Lichtenberg, Efficient Energy Use and Well Being: the Swedish Example, report prepared for U.S. Energy Research and Development Administration, under contract W-7405-ENG-48, Washington, D.C., April 1976.

Reigeluth, G.: op. cit.

Table 16.

Road Transport Comparison - 1972
U.S. and West Germany

	Per Capita: United States	Per Capita: West Germany	West Germany per Capita Use as Percent of United States
Cars* and motorcycles			
Vehicles	0.54	0.27	50%
Vehicles-miles	5548	2656	48
Passenger-miles	11,536	4807	42
Energy (Btu)	52.5 x 10^6	11.3 x 10^6	22
Btu per PM	(4549)	(2357)	
Buses and transit			
Passenger-miles	415	632	152
Trucks†			
Vehicles			
Local	0.020	0.020 (Local and Intercity combined)	80 (Local and Intercity combined)
Intercity	0.005		
Vehicle-miles			
Local	199	307 (Local and Intercity combined)	72 (Local and Intercity combined)
Intercity	227		
Ton-miles			
Local	n.a.	470	n.a.
Intercity	2257	546	24
Total energy for road transport (Btu)	63.2 x 10^6	18.3 x 10^6	29

*For United States includes pickups and panel trucks, 14.4 x 10^3; for West Germany includes combination passenger and cargo vehicles, 1.2 x 10^3.

†Excludes pickups and panels, or combination passenger and cargo vehicles.

Source: Stanford Research Institute, *op. cit.*

Reigeluth, G.: op. cit.

greater integration of land uses seem to encourage shorter trips of all kinds and may partly explain the far lower per capita passenger car miles. However, the lack of comparative data makes it difficult to tell exactly how the distance of European journeys to work compares with that in the U.S. (52). The high levels of mass transit usage in European cities can not prevent them from having some serious traffic congestion problems. These problems are to a large extent due to the fact that the old physical structure of these cities, with high densities and narrow streets, is ill-suited for the automobile. However, European cities have not responded to their traffic congestion problems by changing the physical structure to accommodate more automobiles. Most of them have tried to preserve the existing urban structure and manage travel behavior by banning automobile traffic from parts of the city, creating pedestrian malls, restricting parking, and encouraging higher use of mass transit.

6.3. Current conservation policies

Most of the current energy conservation policies in use in the United States and E.E.C. countries are concerned with retail prices for energy, thermal efficiency standards, retrofitting, district heating, solar heating, automobile and transportation efficiency standards, progressive vehicle taxes, carpooling, etc. (53). Neither the recent Carter energy legislation nor the recommendations on energy conservation adopted by the European community, include any direct land use measures to influence residential and transportation energy consumption. State and federal urban policy levels in the United States are still not fully aware of what can be done in this field to save energy. In the European community on the other hand, as there is still no such thing as a common urban policy on a federal level, there is a great diversity of national measures and differences in priorities for urban development. Each member state has a number of policy instruments that could be used to influence land use patterns, but few use them as part of an energy conserving action.

However, most of the current conservation measures are indirectly related to the urban pattern as their success is to a large extent dependent on support by urban form conditions. That is, the use of district heating systems, retrofitting programs, solar heating systems, transit use, car pooling are all in a certain way linked with urban form through elements such as density, land use mix, and shape. If the appropriate urban form conditions are not present, it is less likely that the energy conservation measures will succeed. So, it seems that there is a need for a more comprehensive approach which includes land use policy measures as an integral part of a general energy policy.

6.4. Prerequisite for energy conservation through land use planning

The fact that the most industrialized countries (U.S., Western Europe, and Japan) with 15% of the world population use 56% of the world's energy resources should in itself be important enough to curb energy use in these countries. It is clear that, as the less industrialized countries develop, they will increase their energy consumption, which will definitely result in international conflicts over the dwindling energy supplies. As seen in the former chapter, there will be some automatic adjustment via the market mechanism, but this, however, is not sufficient. A general policy for conservation is necessary and this implies a new model of growth in the industrialized countries. This applies particularly to Western Europe, "...which has for too long blindly followed the U.S. growth model without having the domestic energy resources to support it." (54) But the U.S. which currently imports the equivalent of the total Saudi-Arabian oil production, should also revise its energy consumption behavior.

Since this paper deals with conservation action via land use planning, I will examine first of all the current institutional frameworks in the U.S. and the E.E.C. and see whether they are suitable for land use energy conservation action. Secondly, the social and psychological context of such a conservation policy must be considered as the attitude of the public is extremely important, both for accepting the restrictions in energy use themselves and for helping to bring about the institutional changes to promote them.

6.4.1. Institutional changes

It seems that, from a political, economical, and technical viewpoint, it is easier to find ways to conserve energy by improving the performance characteristics of motor vehicles, developing various forms of public transport, and adopting more stringent insulation standards, than to change the institutional framework to set up an energy saving urban policy. By urban policy, I understand not only the specified land use regulations to increase higher densities and promote mixed land uses but comprehensive planning including the whole set of issues such as housing, employment, recreation, and transportation activities and taking into account the environmental considerations of their location.

Most of the E.E.C. countries have a long tradition of planned urban growth and, in that time, have been able to set up an elaborate institutional framework for land use planning. Most of them regulate their land use via local development plans and comprehensive master plans, in some countries subordinated to covering regional and national plans. Local development plans either include or are complemented by zoning regulations and building regulations. So in these countries, the institutional framework for energy saving land use policy exists. However, up to now, it was simply not used for this particular goal. In addition, much remains to be done to include the energy perspective in the planning system and to strengthen and coordinate the action with other institutional levels, either within the nation itself or on the E.E.C.-federal level.

The current legislative framework in the U.S.A. is not that promising in this respect. Up to now, zoning ordinances are almost the only land use planning tools in use in the United States. With the exception of some states which have set up growth management schemes or require local development plans for each municipality, there is no general hierarchical planning structure which is part of the legislative framework. Even the new form of land use control promulgated under the authority of the Clean Air Act (1970), by which the location of facilities, buildings, structures, and installations which would attract or generate motor vehicle traffic (emission of pollutants), could be controlled, is expected to encounter technical and operational difficulties. "To become an effective policy for energy conservation, land use management in the U.S.A. would have to be capable of using more drastic measures than are possible in the current situation." (55) Various policies should be coordinated to fit into a comprehensive local development plan which would have mandatory power in each municipality. This of course comes to the "taking issue" and the problem of compensation. Although techniques can be worked out to minimize government expenditures for this purpose, such strong measures do not seem politically plausible at this moment. The political climate, however, is changing rather quickly, as was shown in the states which adopted stringent growth management laws. E. Bacon thinks a more general reform of the land use planning framework in the U.S. should be based only on three jurisdictions: (56)

- <u>local</u>: which would continue to exercise almost complete control within its own territory; there is every reason to leave local zoning in the hands of local jurisdictions: urban planning should be based on community planning where information and participation can be provided in the best way
- <u>metropolitan-wide</u>: which should deal with such extra-local concerns as power, sewage, transportation and the environment, because only on this broader level can provision be made for the basic elements of growth and change
- <u>federal</u>: which should underwrite and encourage the metropolitan planning jurisdictions, provide the equalizers that will compensate for some of the deficiencies of both nature and man, and provide the infrastructure that will make a wide choice of life styles possible.

6.4.2. Public acceptance

Much of what has been discussed above is dependent on one crucial question: how will the public react? Legislative measures and institutional measures, to be effective- need public acceptance and support. The public must become aware of the necessity and economic reasonableness. But even if that is the case, there is still a lot of inertia to be dealt with. It is very difficult to change current energy inefficient habits once one was used to the comfort they offered. Even more difficult is it to give up some of its property sovereignty in favor of the community. The feasibility of all this, again, differs with the geographical, cultural and socio-economic context.

In both the U.S. and Western Europe, strong forces are at work which will, to a certain extent, foster public acceptance of energy saving land use measures. First of all, the population growth rate will continue to slow down (the U.S. had still a somewhat faster growth rate than the E.E.C. average). However, housing needs will not decrease particularly because of the declining ratio of the amount of occupants per dwelling. More and more, people will be living on their own, and furthermore, the growing importance of adult-oriented households (less children) will mean a further decline of freestanding single family homes as the basic form of new housing, and a higher willingness of people to live in multi-family units. This slower growth rate means that the emphasis of the housing programs will increasingly be laid upon rehabilitation programs instead of new development. This will also make it easier to promote higher density development.
Another factor is that the rate of real income growth per worker will slow

down as world wide competition increases for limited amounts of food, raw materials, and other resources. With such external pressure, together with higher energy prices and land prices, the climate is right for public acceptance of conservation policies. This is particularly true for European counties which are more dependent on foreign supplies and therefore will experience even stronger pressure.

As far as counteractive forces are concerned, these are partly related to the physical structure and partly to the more sociological and psychological aspects of changing attitudes and habits. Existing lower densities in the U.S. will make it not only institutionally and technically more difficult, but also harder for the public to accept such things as infilling in suburban neighborhoods. Another factor is that people's habits and attitudes will not change overnight, and some will not change at all. As luxuries of the past have become the necessities of the present, they are not likely to be abandoned for less energy consumptive practices. It also requires a lot of courage to switch from a comfortable private car to a "crowded" transit vehicle. And what to do about the American myth that a man can use his land as he wants.[9] To change this fundamental idea will take a lot more discussion and debate. However, as has been said, the growing impact of government on land use matters in different states of the U.S.A. is inducing a mentality change and will create the necessary "pro" planning atmosphere. European countries have the advantages of having had a stronger planning tradition. The difference between energy efficient and inefficient transport modes are also not high in terms of comfort as in the U.S. So, it is expected that changing transport habits can be more successfully promoted in Europe.

Because of the complexity of such matters as cultural background and psychological behavior, much of what has been said above remains uncertain. It is clear that the problems of public acceptance of energy conservation measures should be subject to further, more specialized research for which this paper may give some rough ideas.

7. CONCLUSIONS

This paper gave a review of some of the aspects of the relationship between urban form and residential and transportation energy consumption and commented on the issue how this link could possibly be used as an additional tool for energy conservation. In the third chapter, has been shown that urban form influence energy consumption in various ways. Dwelling units in higher density structure consume less energy for space conditioning (only up to a certain density threshold) than do single family detached homes because of better insulation through common walls and ceilings. A compact spatial structure with more mixing of land uses may show a lower demand for travel as well and in addition may increase the feasibility of energy saving transit and carpools. Nevertheless, there is still a lot of reluctance (or is it ignorance or lack of long term view?) among policymakers to set up a more energy conscious land use planning policy.

There are some unsolved issues which support politicians in their passivity. On one hand, some controversy exists on the potential benefits of such land use action (nl. on the amount of energy that can be saved) and on the other hand it is difficult to evaluate the costs (what would be the costs at the expense of which energy could be saved?). In addition, this cost-benefit problem has to deal with the general uncertainty on the energy future: how long will it take before current resources will be exhausted? What about new resources and their possible effect on land use structure and the energy balance? Hopefully these information gaps can be filled by additional research.

Despite these uncertainties, policymakers should begin to apply what is known about energy efficient land use planning, and that for the following important reasons:

- Many of the proposed energy-efficient land use patterns are quite familiar and have already been advocated because of the opportunities they offer in other areas than energy i.e. preservation of prime agricultural land and open spaces, lowering public service costs, revitalization of central cities, political and social organization on the neighborhood level, and so on. Energy constraints are just one more argument to do something in the development problems facing local governments. Therefore, energy saving land use measures should be a part of a comprehensive policy in which energy efficiency is only one consideration and which is a result of a trade off between all the advantages and possible negative consequences seen from different perspectives.
- Another important point in this evaluation of costs and benefits is the fact that saving energy through land use planning is clearly a long range strategy. It cannot compete with immediate pay-offs of improving the gasoline mileage of automobiles and of retrofitting homes. However, its impact in the long run is significant. The energy wasted by inefficient land development patterns will continue for decades to come. The sooner the community begins with energy efficient planning, the sooner the energy servings can be realized. In the more industrialized countries, it is also extremely unlikely that the existing spatial pattern will be dismantled in favor of a more energy saving one. This pattern can only change very slowly. This

was even true in the post-war growth period, but even now that we have more stable demographic trends, it would require strong political pressure and take a long time before an increase in density by infilling by-passed land or by rearrangement of already developed areas can be realized. So, every occasion from now on has to be used to the utmost.

However, not only the existing physical structure contains strong inertia. It may even be more difficult to pursue land use change that include a reversal of attitudes and style of living. This is true especially in the U.S.A. where the cost of such action will be evaluated from a different perspective than in the European countries, taken in account the life style differences already in existence. However, the feasibility of these changes in both institutional framework and public attitude is a very complicated matter and should be subject to further research.

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