READING
THE ENERGY METER ON DEVELOPMENT

THE INTERACTION OF LAND USE AND ENERGY CONSERVATION

a technical study for the FEDERAL ENERGY ADMINISTRATION

a joint venture

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES continued

LIST OF TABLES

LIST OF TABLES continued

LIST OF TABLES continued

LIST OF TABLES continued

LIST OF TABLES continued

Appendix

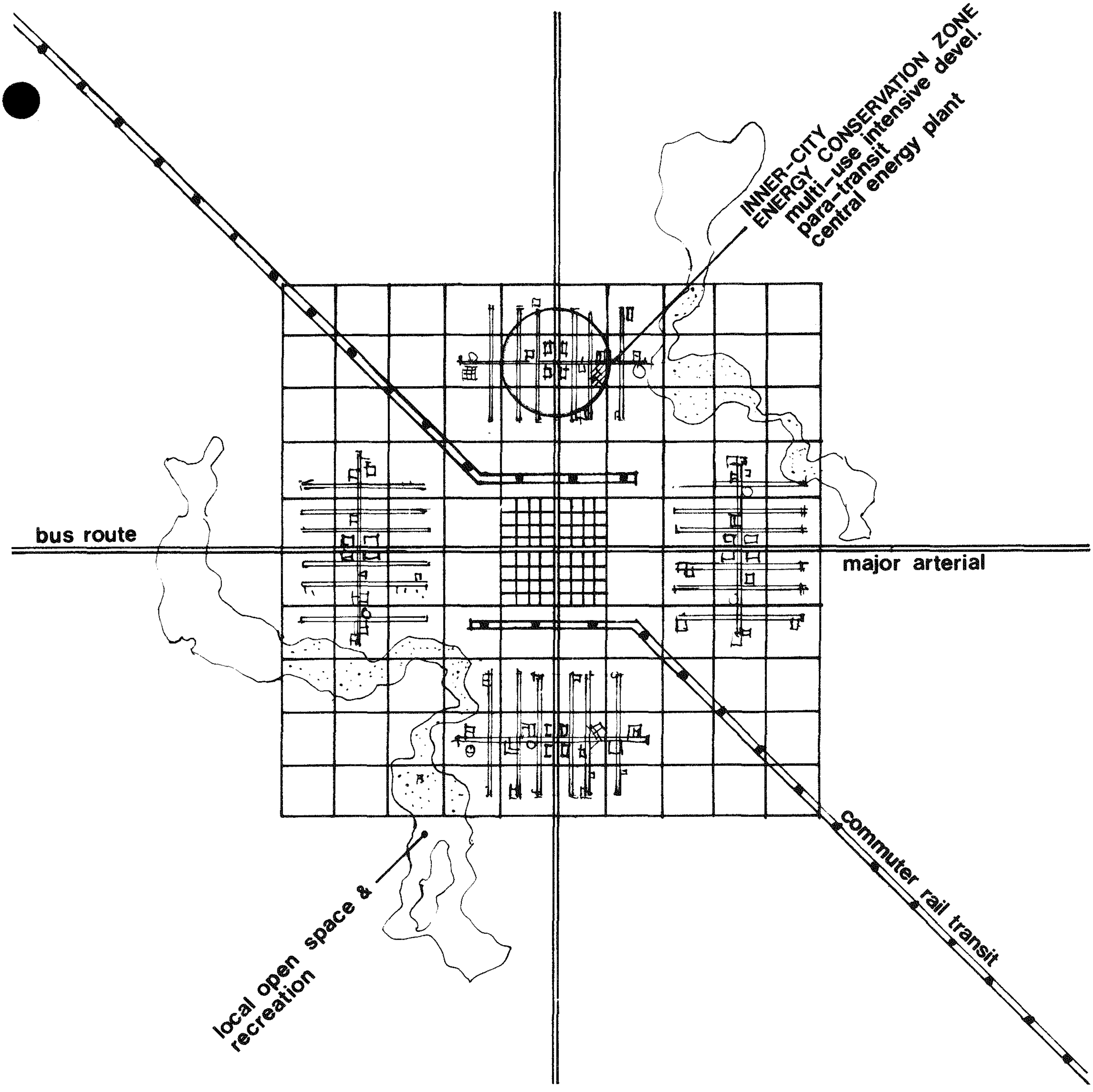
SUMMARY OF FINDINGS

This study through a case study approach has documented on a national basis the crucial role that urban design and land use planning have towards achieving meaningful energy conservation. With a set of study areas representative of present and future development patterns, and a variety of climatic, transportation, and market conditions, the major energy saving sectors within feasibile design actions are identified as:

- land use mix and configuration
- spatial arrangement affecting transportation requirements
- energy system technology

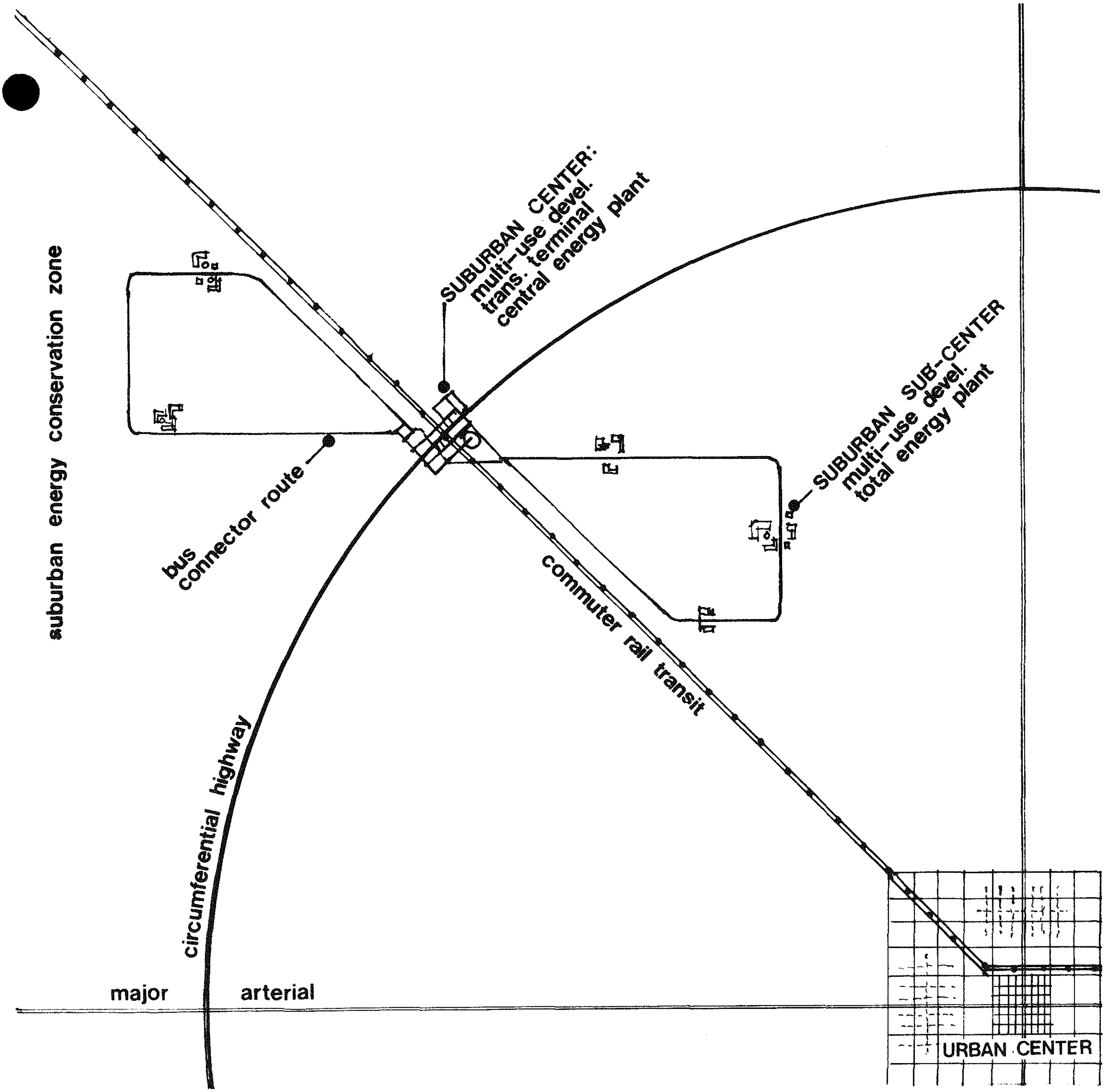
Within each of these sectors a list of energy conserving design measures is tested in two of the study areas: in Tucson, Arizona and Mt. Pleasant, New York, typical of national suburban and urban growth patterns, these two sites are considered prototypical of forecasted growth areas in the next decades given an energy conserving approach to land development and urban renewal. Their development patterns and energy conserving measures have been generalized in the following Figures 1 and 2; an urban and suburban context respectively.

Inasmuch as the generalized patterns diagrammed represent the majority of the prototypes found in metropolitan areas and that 86% of the projected national population for the Year 2020 is estimated to be located within metropolitan areas, these design approaches and their resultant savings noted below merit significant consideration in the formulation of both a national land use and energy policy.



GENERALIZED URBAN CONTEXT: ENERGY CONSERVING MEASURES

FIG 1



GENERALIZED SUBURBAN CONTEXT: ENERGY CONSERVING MEASURES

FIG 2

Section F of the study presents the findings in detail correlating the existing and future energy consumption under an unplanned laissez-faire and planned energy sensitive development scenario with population, density, number of dwelling units and land area. However, the most meaningful measure of energy conservation effectiveness of these sectors and their design measures is what we have termed "energy elasticity" the ratio of energy consumption change to development change. Here the effectiveness of the interaction of the above three energy saving design sectors is measured against the following three energy consuming development categories:

- the four basic land uses of residential, commercial, institutional, and industrial looked at separately
- all land uses looked at together
- transportation

Within the urban context (case study: Tucson), the effect of innovative energy systems in conjunction with good planning measures can conservatively produce a declining rate of energy utilization approaching 60% for each additional square foot or dwelling unit of land use. Transportation planning measures which reduce travel can result in a declining rate of energy consumption of 20% for each additional increment of passenger miles travelled. These are the two most significant measures followed by residential and commercial land use mix design actions related primarily to configuration and density which can result in 60% slower rates of energy consumption when compared to the rate of development.

Likewise for the suburban context (case study: Mt. Pleasant), the most significant savings is the declining rate of over 170% for institutional energy consumption with innovative systems per increment in development. Energy systems for re-designed commercial complexes can provide 75% slower rates of consumption compared to the rate of development. This is followed by land use mix and transportation design actions resulting in 70% slower rates in consumption compared to the development rate.

Given the high score of innovative energy systems with necessary urban design measures of density and configurations, these savings are further classified according to type. Highest savings of up to 25% of BTU consumption are achieved by use of selective energy and solid waste heat recovery systems; followed by the use of total energy and solar systems, resulting in savings of up to 20%; and by the use of central heating and cooling plants with savings of up to 15% of the specific land use category that benefits from the energy system.

A. INTRODUCTION

The primary purpose of this study was to explore the applicability of broad land use energy conservation guidelines to the planning and design of large scale developments and communities. These guidelines are derived from a number of analyses on the interdependence of the arrangement of land use activities and the resulting energy expenditure patterns. It is worth emphasizing that design rather than analysis is highlighted in this work, and that the scale is that of a community population unit of between 3,000 and 13,000 inhabitants. Analyses of existing community energy consumption data are utilized as a means of verifying the existing character of energy consumption and the differences in the energy use efficiencies between planned and unplanned communities. The major concern, however, is ascertaining the compatibility between energy conserving land use practices and local design programs. While no significant efforts were devoted to collecting new data on energy intensity factors associated with specific land use activities in the case areas, the intensity factors derived from other analyses and the methodologies employed in deriving these factors were verified, where possible, for the specific case communities dealt with and modified accordingly.

The design "programs" adopted for each of the two communities for which energy conserving designs were prepared - one an inner city mixed use area adjacent to downtown Tuscon, Arizona, and the other a suburban community of Mt. Pleasant outside of New York City were based on discussions with local planning groups and various master planning efforts for achieving areawide goals. In this sense, they represent targeted population and general mixes of land use activities which are seen as realistic future alternatives. In the case of the other two communities considered, the Near North Side of Chicago, Illinois, and Cedar-Riverside in Minneapolis, Minnesota, although no designs were attempted, the conclusions reached on the basis of the study of existing energy consumption patterns, namely that relatively small increases in energy efficiencies vis a vis land use are possible in communities of this type, represents a negative finding of importance. It establishes the fact that although community energy conserving guidelines can be applied to a large representative group of communities in the country, there are many others for which existing patterns of land use already serve to severly limit the opportunities to effect long term increases in efficiency of energy use. Part of our findings deal with a set of land use descriptors which might be used to pre-judge such communities.

Although the study concentrates on specific community designs, the process itself revealed a number of basic difficulties associated with attempts to apply broad land use energy conservation guidelines on a community scale. These findings could be of importance to certain Federal programs in ERDA and FEA which are aimed at effecting energy conservation practices and the employment of decentralized energy supply, waste heat, and conversion technologies on a community level. In part, these difficulties derive from the flow of energy consuming services and goods in and out of the community. Not only are the control of these activity levels within the community which determined external energy flows limited by what can be done within the community, but the activities displacement may result in an unknown (and possibly unknowable) net drop or gain, in overall energy use efficiency for the region and/or the country. For example, displacing commercial or industrial land with residential dwelling units may result in increases in work trips and therefore transportation energy expenditures, or a lowered potential for the use of industrial waste heat. Somewhat related are the difficulties associated with characterizing the concepts of energy savings or energy efficiency when these are applied on a community scale. In comparing planned and unplanned community growth, for example, one deals with two scenarios whose development parameters can differ in population and basic mix and growth of residential, commercial, and industrial activity levels.

To describe one development scenario as being more consistant with an energy conservation objective than another, requires an acceptable common basis of comparison of relative energy consumption. We discuss one comparative approach referred to as "energy elasticity" in the "Findings" section of this report which attempts to avoid some of the common difficulties.

Like all studies which are based on a case study approach, the task of delineating the generalizability and transferability of the results is far from straightforward. We deliberately focussed throughout our study on those questions which bear on relevant FEA and ERDA conservation programs and policies related to community land use practices and their underlying strategies. These have been postulated in part on a long-term shift to the eventual insitutionalization of energy conservation practices on a community level - either directly through an overt modification in land use activities, or indirectly through resultant alterations in land use activities which will follow revised transportation patterns and mode shifts, building construction practices, and household use expenditures. In attempting to come to grips with the design of specific communities under realistic conditions, we gain valuable insight into the barriers and the resultant energy savings assoicated with the realization of the postulated objectives.

Background

Over the past several years, a number of studies have been carried out dealing with the relationship between patterns of land use activities and energy utilization characteristics. These studies have ranged from a preliminary analysis of energy expenditures associated with urban sprawl in the report of the Real Estate Research Corporation, The Cost of Sprawl to data collection and analysis efforts on land use density and energy consumption such as that in the report of the Regional Plan Assocation, Inc., and Resources for the Future, Regional Energy Consumption; to modeling and simulation efforts of land use-energy consumption relationships such as the BNL/SUNY study of Land Use and Energy Utilization. The substance of all of these and related studies suggests that:

- It is the mix and spatial arrangement of land use activities which provides one of the underlying structural elements in the character of energy expenditures by householders. The specific demand sectors more effected by land use considerations are net energy consumption per dwelling unit, energy consumption in the transportation sector, and utilization of waste heat and both centralized and decentralized supply and conversion technologies.

- The increase in energy efficiencies which are potentially achievable, are significant both in terms of their magnitudes relative to other energy conservation measures and their usefulness in bringing about a long-term reduction (non-reversable reduction) in per capita energy consumption in the United States. Although the magnitudes of the estimated potential energy savings vary widely from study to study, depending on the savings attributable to land use as a result of the varying assumptions used in the calculations, the importance of land use as a parameter in determining overall energy demand seems to be beyond dispute.

- Insofar as the pattern of growth and development of land use represents one of the most obvious physical manifestations of the United States' life-style, the likelihood of achieving or bringing about wholesale changes in the current land use patterns to accommodate national energy goals on a broad scale by direct policies of federal intervention does not seem feasible, unless such interventions happen to be compatible with regional and related federal price incentives.

- Land use configurations not only influence energy consumption patterns but are effected by and effect the use of particular energy supply, conversion and end use technologies, as well as other technological innovations in communication of information, transportation of goods and service, delivery systems, and materials. Trends in the development of these technologies can either have a negative or positive effect on the energy consumption per capita as it is tied to the mix and spatial elements of land use.

Case studies which analyze and compare the component elements in the use of energy and different fuel forms in Sweden and the United States by the Energy and Environmental Division of the Lawrence Berkeley Laboratory (LBL) and the Engineering and Systems Division at Brookhaven National Laboratory (BNL) lend credence to these basic land-use/energy consumption relationships. For example, seeking to rationalize the fact that Sweden used approximately 33% of the energy consumption per capita of that of the United States in 1971 in the transportation sector, 75% in the residential sector as compared with the United States' average figures, and that district heating supplied fully 20% of total residential needs in Sweden compared to only a few percent in the U. S., the authors of the LBL report conclude:

> "Higher energy prices alone, however, do not account for the more efficient energy use in Sweden. In our report and elsewhere, it has been stressed that while a given set of energy prices determines a mix of energy and other economic factors that allow production for the least cost, institutional and social factors determine how close individual consumers, firms and society as a whole come to this most economic energy use.". . . . . . ."These factors also encourage important synergistic effects. Good intercity transport, and high costs of operating an automobile, tend to keep the population more concentrated. In addition to maintaining the viability of the public transport system itself, this situation also affects housing and living patterns in energy saving ways. With increased population densities apartment living is more common, allowing potential energy savings through fewer external walls, better insulation and more efficient heating systems. Shopping also becomes easier, with more neighborhood stores; trips are shorter, often on foot, and smaller storage facilities are required, resulting in smaller capacity refrigerators with consequent electricity savings."

It is erroneous, of course, to infer from these and other country-specific comparative studies, that the U. S. can achieve the same increases in energy efficiencies as are found in Sweden. These studies do provide, however, insights into understanding the potential role of land use design in both achieving a reduced level of energy expenditure and a high level of amenities derived from the careful use of energy. They also serve as examples of real-world alternative life styles. Together with the types of analysis and data collection cited above, they offer a plausible rationale for undertaking design studies which seek to apply the guidelines obtained from such efforts to specific community situations.

The decision to concentrate on a community scale design rather than on a regional or national one is justified on two accounts. As noted above, from a policy viewpoint, there are very involved problems associated with direct governmental interventions designed to bring about a major restructuring of land use patterns in the United States. On an individual community basis, however, this idea of intervention through governmental initiatives is more tractable. Alterations in the land use configurations within existing communities and municipalities are taking place on a recurring basis, new large scale developments are being constructed throughout the country. Changes in community designs incorporating energy efficiency measures and land use guidelines can become an important element in affecting the form of such alterations and new developments. We can expect them to be reflected in state and local land use regulatory legislation, environmental and building codes, and transportation network plans. Also, by illustrating their compatibility with non-energy related "good" design criteria, these designs can exert an influence on both the politcal decision maker and the land use and community planners in the public and private sectors.

A second justification for a community level focus lies in its usefulness in permitting a detailed examination of a limited set of realistic alternative land use designs. Not only can the constraints on existing energy expenditures be explicitly identified - both those related to land use and those arising out of local institutional factors and social preferences - but the final designs can be integrated with known design program objectives. Under these kinds of conditions, the knotty problems and issues raised in seeking to impose a new design on an existing municipality cannot be overlooked.

Study Approach

Design studies directed toward the types of issues and questions discussed above can employ a variety of approaches. Given our objective of exploring the applicability of broad land use energy conservation to specific community situtations, and to educe findings that would bear on related federal and local programs, the decision was made to concentrate on an in-depth generation and appraisal of site-specific designs in a few selected representative communities. This case study approach rather than one that would examine general design parameters appropriate to large groups of communities or types of metropolitan growth patterns was chosen as being more consistent with current needs to access the plausibility and practicalities of using land use as a mechanism for achieving energy conservation. This choice of the case study approach makes the choice of the selected sites particularly important. They should be representative of the patterns of existing community development in the United States, while at the same time affording the possibility of gathering data and information on the "energy sensitivity" of the constraining influences on their options for future growth.

The site selection process used, as described in Section C, was based on a preliminary nation-wide synthesis of the historical development of pertinent land use configuration descriptors such as density, mix, relative location and resulting linkages to the surrounding areas using the concept of the Planned Population Unit (PPU). The "energy sensitivity" of future development trends were also examined in terms of the historical planning and design models or images used by professionals to define overall design objectives. These design models which have up to now ignored energy as a design parameter, strongly effected the final forms of community design. Several other practical considerations affected the choice of specific sites. The availability of data sources on local energy consumption is obviously necessary. The same is true for information from local planning groups delineating the possibilities for future community development which is required for setting the non-energy design program objectives. Finally the cooperation and support of local planning groups is clearly needed to allow an exchange of both background non-quatitative information on the character of the community and ideas as to its future development.

The process of arriving at site-specific designs for achieving energy conservation within the context of a set of overall community design objectives is, itself, a revealing part of this study. One is faced with the situation of reconciling community development goals with so-called "good" design standards and with energy conserving land use mixes. Creating compatible land use configurations involves an analysis of the trade-offs and the dimensions of the overlapping congruities. An important additional difficulty that is exposed in the evaluation of the final designs is related to the characterization of measures for assessing the energy associated benefits of the designed plans which was noted above.

Our approach to these problems was to search for design configurations which had the potential for matching the overlap of energy and non-energy related interests. The process employed, which is spelled out in Section B, begins with the formulation of guidelines, derived from the regional and national studies alluded to above. *

These guidelines are cast in language and terms applicable to the community design process. These guidelines presume an important role for the employment of existing and new waste heat, solar and advanced utility system technologies. The interspersion of industrial, commercial, and residential land uses is considered to represent a major opportunity for achieving an early

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* Use was also made in our analysis of energy comsumption of the energy intensity factors derived in these other studies. Although we were not able to get independent energy intensity factors for each case study area, the general factors used were verified locally and revised to take into account local conditions where no independent information sources existed. The values given in these other studies were used as default estimates.

utilization of these more efficient supply and end use technologies. Although not directly a part of the guidelines, the use of a proper set of measures for calculating and comparing planned and unplanned energy expenditures forms an essential part of the energy related input into the design process. Such established measures as that of a total energy budget, resource use efficiencies, and energy consumption per community inhabitant turn out not only to be inapplicable to the community scale situation, but if used, can produce a misleading picture. We found it necessary to utilize a variety of measures depending on the demand sector and specific community situation.

Juxtaposed with these energy based guidelines and energy use "efficiency" measures are the non-energy design programs for the specific communities. These affect the use of land within the communities and the relationships of such land use to activities in neighboring areas which indirectly bear on the welfare of the community - the targeted populations, open spaces, employment location, etc. These basic elements in the design process are combined in the less explicit, but highly important activity interplay associated with the creation of what planners refer to as good land use designs.

While in practice much of the actual design process represents a creative synthesizing and welding of these basic elements, we have attempted to present a systematic description of the process in order to spell out both the inherent problems and issues and the opportunities afforded by this design procedure. These findings though qualitative are relevant to the efforts of Federal agencies such as FEA, ERDA, HUD, DOT, and EPA and local planners to assess the possibilities of seeking to configure land use activities to achieve energy conservation.

The design process includes considerations of implementability in its statement of a community specific design program. It does not, however, deal explicitly with mechanisms and incentives necessary for ensuring their realization. Nor does it deal with the problems surrounding Federal, state and local policy interactions in the area of land use management. Because these problems and interactions can depend to a large extent on local conditions, our approach to the discussion of these issues is based on 1) a country-wide assessment, and 2) the exploration of new planning concepts, the Energy Conservation Zone (ECZ) which would be applicable to a wide range of communities possessing the potential for adopting energy conserving designs. The exposition of this concept and what it means in terms of the specific community area studies is discussed in Section G.

In presenting our results we have tried to satisfy the needs of two disparate groups, Federal decision-makers who are responsible for both energy programs and those bearing on local land use management, and community planners whose need is for information on the design elements as they relate to energy considerations. For the former, we discuss the tentative implications of our findings in terms of on-going programs. For the latter, we have prepared a description of the methodologies used to calculate energy parameters of alternative designs, the design process itself, and graphic material illustrating the physical features of our own particular design choices. These are given in Section E.

We should emphasize that this study represents the first attempt in the United States to generate site-specific community designs based on the interplay of energy and traditional community planning objectives. As such, they represent the first step in an area that is bound to see increased activity should current energy supply shortages and increases in energy prices continue. We believe our results provide an initial basis for those developing more elaborate and specific designs.

The Planned Population Unit (PPU)

The selection of the PPU and its size is based upon the development forecast that within the near-term the opportunity for larger new community scaled projects will be small and that the emphasis of future land use planning policy should be on "super neighborhoods" and "planned unit developments" within the selected growing development contexts. New communities of themselves offer highly positive aspects such as a land use mix often including business, industrial and recreational components providing efficient energy utilization and reduced trip generation. Likewise, the opportunities of new community siting adjacent to under-utilized or more readily available energy resources and a community-scale testing of energy systems and conservation measures makes them seemingly desirable objectives for future urbanization. However, the past experience of Federal involvement in new community development along with the future projections of limited available financing, large land requirements and high infrastructure costs for their development has tarnished the panacea of Federally funded new communities. This policy shift has been seen in the planning approach of many of the nation's largest metropolitan areas, including New York, in the U.S. Department of Housing and Urban Development and in several recent academic studies.

For example, this recommendation is found in the National Science Foundation study by the Center for Urban and Regional Studies of the University of North Carolina. Their public opinion survey included some 15 private and publicly developed new communities along with samplings from traditional suburban developments built at about the same time. Problems in financing, community services' delivery, and available quality shopping and schools were leading reasons in favoring smaller scale developments. In summary, as urbanization does not occur in discrete increments, the smaller the scale without eliminating potential energy system benefits, the more feasible the energy sensitive PPU devised.

The Renewal Approach

This study focuses on redevelopment within various existing urban contexts as preferable to the conversion of a single tract of raw land to achieve the PPU, this being synonymous to a new community approach discussed above. The renewal approach can combine in-fill development with large scale new construction within an overall urban design which fully utilizes the existing investment in both transportation and utility infrastructure. The sizable "sunk costs" represented in this investment result in most cases in a higher energy efficiency of the renewal approach over the independent new development approach.

B. ENERGY CONSERVING MEASURES

Energy conserving design measures relate to a series of techniques described in this section as being appropriate in various development contexts. These become the basis for the general design process described in section D. The design measures themselves are presented here as structured to achieve energy savings in three sectors:

- land use mix
- spatial arrangement affecting transportation
- energy technology

The final sector provides the opportunity to utilize a variety of new systems summarized also in this section. This is followed by a brief historical perspective of planning and design images as having had a positive or negative effect on energy conservation as a design parameter.

Land Use Planning Techniques for Achieving Energy Conservation

All reasonable techniques for achieving energy conservation within land use configurations appear able to be grouped with the following four headings:

- land use change: the conversion from one land use to another, normally considered redevelopment or renewal and not raw land conversion in those cases where the land use designation does not remain the same.
- new development: the conversion of raw land with physical structures and infrastructure.
- land use densification: the increasing of the densities of the existing land uses maintaining their existing confirguration.

It can be achieved by in-fill new development or renewal or redevelopment in those cases where the existing land use designation is maintained. It may be found that the reverse (density dilution) is the energy conserving technique at extremely high densities due to possible higher per capita energy consumption from the rich mix of services provided and frictional losses.

- land use patterning: the alteration of the mix, relative location and resulting linkages of the various land use components which constitute the configuration. The overall gross density may or may not be altered.

It is possible to establish a probability rating for the likely implementation of these techniques in three generalized development contexts.

Table 1: Probability Rating of Energy Conserving Techniques for Three Development Context Locations

Techniques	Location		
	In-town	Edge	Independent
Land Use Change	±	+	+
Land Use Densification	±	+	+
New Development	-	±	+
Land Use Patterning	-	±	+

Rating: - unlikely
± possible
+ likely

The primary limitations on land use change are institutional constraints which are more significant in an "in-town" context than on the developing edge. The opportunities for land use densification, new development and land use patterning are all a function of redevelopment and new development market potentials and available land; the latter two being more constrained by the larger gross densities of existing land use patterns.

As background analysis for determining the efficiency and appropriateness of these techniques in a given development context, individual land uses and activities are examined for energy conserving aspects. These specifically include the following patterns:

- recreation (nearby versus long distance activities)
- shopping (regional shopping centers versus strip commercial; their energy and transportation requirements)
- transportation (densities necessary to support various modes)
- residential location (cluster versus sprawl)
- industrial and commercial location (relative to availability of land, labor, transporation and energy)

Preliminary studies in these individual land uses are noted in the Bibliography. Their conclusions become the basis of the thirteen proposed energy conserving measures which follow.

Energy Conserving Design Measures

On the simplest level, in order to conserve energy, future planning should be directed toward reducing transportation requirements, increasing the energy consumption efficiency of building configurations and promoting shared energy-utility systems among various land uses to maximize mutually compatible heating, cooling, electrical and waste product disposal needs.

From previous studies, a few key phrases are appropriate guides:

> "higher density housing requires less energy"
>
> "higher densities reduce both heating and cooling requirements in residential buildings"
>
> "mixed land uses reduce travel"
>
> "dense land uses reduce travel and promote modal shifts"

Energy savings in future development will be derived through some of the following measures. They are grouped according to the specific objective to be achieved and general energy savings sector:

Home-to-Work Travel Reduction/Spatial Arrangement

1. Development of new multi-family housing units adjacent to places of existing employment and services.
2. Improvement of the proximity of housing at related income levels to nearby employment opportunities.

Land Use Densification and Revitalization/Land Use Mix

3. Redevelopment and increased densification of older housing communities.

4. Revitalization of existing town centers and increased multi-use aspects.

5. Intensification of industrial land uses within prescribed areas.

Local Auto Travel Reduction/Spatial Arrangement

6. Reduction of quantity of urban streets devoted to automobile use.

7. Initiation of alternative transportation modes to individual automobile travel.

Energy System Integration Into Mixed Land Uses/Energy Technology

8. Introduction of energy efficient utility systems and infra-structures.

9. Development of new multi-use complexes of residential and business functions.

10. Integration of residential, commercial, and industrial energy uses.

Regional Growth Management to Achieve Trip Reduction/Spatial Arrangement

11. Preservation of open space and containment of sprawl.

12. Revitalization of existing recreation facilities in proximity to residential units.

13. Development of new local recreation facilities available to residential units.

These measures are arrayed in the following matrix against the land use planning techniques necessary for their implementation.

Table 2: Matrix of Energy Savings Measures versus Land Use Planning Techniques

Measures: / Techniques:	Land Use Change	New Development	Land Use Densification	Land Use Patterning
1. Multi-Family Housing/ Employment and Services		X		
2. Housing Income/Employment		X		X
3. Older Housing Communities			X	
4. Multi-use Town Centers	X		X	
5. Industrial Intensification			X	
6. Street Network Reduction	X			X
7. Alternative Transportation Modes				X
8. Energy Efficient Infrastructures				X
9. New Multi-Use Complexes		X		
10. Residential/Industrial Energy Uses				X
11. Preserved Open Space/ Growth Management			X	X
12. Local Recreation Revitalization			X	
13. New Local Recreation	X			

Energy Conserving Technology

There are several scales of energy conservation technology application, only some of which are of concern to this urban and community design analysis. The most immediate effort is concerned with retrofitting existing buildings or projects by the application of operational changes, or through minor capital improvements. Another short-term potential means of energy conservation lies in improved design for new buildings with reduced glazing, added insulation, etc. Neither of these levels of concern are directly connected with the design of energy conserving land use configuration. However, there are land use configurations which affect energy consumption in that they facilitate the application of energy conserving technology through clustering of development and through mixed land use. These are listed as design measures 8, 9, and 10 under the objective "energy system integration into mixed land uses/energy technology."

The land-use related technologies are the following:

- central heating and cooling plants
- total energy systems
- selective energy systems
- solid waste heat recovery
- integrated utility systems
- solar energy
- wind and water power

While conventional development is gernally served by individual heating and cooling plants for each home, all the above methods are predicated on having a central utility service. The potential application of any of these technologies is determined by a number of factors peculiar to each location. A tabulation of technical factors affecting these applications in a qualitative way is shown in Figure 3 which follows this discussion.

Central Heating and Cooling Plants:

The use of central heating and cooling plants contributes to reduced energy requirements for an area through the diversity of load requirements of the different types and building uses served. When central plants are used, reduced sizes of major equipment installed, and lower operating and maintenance expenses markedly reduce infrastructure costs. Density of settlement is crucial with any type of central plant because the cost of pipeline distribution radiating from the central plant can easily exceed the potential savings.

Total Energy Systems:

On-site energy generation can be provided by means of gas turbines, utilizing natural gas or fuel oil, as available, or by means of gas or diesel engines. The choice of equipment is based on sizes available to meet a project specific requirement of electric power and heat energy. Considerable energy savings can be realized through the utilization of waste heat with such an installation because the basic fuel is used twice, for electric generation and for heat energy.

Selective Energy Systems:

The balance of load requirements, as between electric and heating/cooling demands, is crucial to the economic feasibility of on-site generation systems. Under the selective energy concept, connections to the local electric utility company are retained, and electric power is generated on-site only to the extent that waste heat can be utilized. Alternately, such a system may feed power to the utility grid at certain times of the year. Institutional issues such as rate structures and franchise adjustments must be considered in such an application.

Solid Waste Heat Recovery:

Incineration for the purpose of volume reduction of solid wastes has been practiced for many years, but the utilization of the heat generated thereby has only been used infrequently. Size of operation is crucial to the feasibility of such a system; an increase in the solid waste stream from 30 tons per day to 100 tons per day can reduce the first cost of a heat recovery facility from $110 to $20 per pound of steam produced in one system tested, because certain system components such as size reduction equipment and air pollution controls did not vary considerably from one size of operation to another. Greater density of settlement would minimize traffic requirements of solid waste collection and could justify the use of automated collection.

Integrated Utility Systems (IUS):

In addition to the integrated facilities described above (electric power, heating/cooling, solid waste management), the IUS concept includes the treatment and re-use of liquid wastes. The sludge generated by sewage treatment processes can be incinerated together with other solid wastes. However, the heat content of this material is not significant because of its high moisture content. The reclamation of sewage gas for use as a fuel becomes practical only in plants of one million gallons per day or larger. This implies a population of approximately 10,000 people. The process of converting the basic gas into pipeline quality gas is still very costly. However, certain dense land use configurations should be adaptable to this energy conserving reclamation process.

Solar Energy:

The utilization of solar energy in the form of heat is technically possible; the actual use of currently available solar technology is constrained by its relatively high cost. Although solar collection is somewhat dependent on climatological factors, present-day economic feasibility is more closely related to local fuel costs. Proper application to uses that can utilize available solar heat most effectively (year-round hot water service) is an added consideration. Seasonal energy savings of approximately 50% appear to be possible, depending on location, method of utilization and collector efficiency.

The use of solar energy in dense urban settings may be limited by shading from adjacent buildings. Three-dimensional, or air rights zoning may have to be developed further for this purpose. However, as one of several energy conservation strategies, it can be useful in high structures also.

Photovoltaic solar energy conversion (solar/chemical reactions) has been proven to be practical; reduction in size of cells and increases in efficiency are being announced daily. Costs are still in the $15,000/kw range and must be reduced by at least one order of magnitude before utilization for other than small-scale uses becomes economically feasible. There appears to be no land use implication in this technology as yet.

The use of solar concentrators to generate steam to drive turbines or engines for power production is entirely practical. Electricity could be generated anywhere that space is available for a solar furnace and could then be distributed through existing electric grids. The location of such a system would be related to land use in the same manner that any other power plant is constrained. Commercial systems of this type are not avialable at this time.

Passive solar collection can be combined with a transparent plastic bubble covering large portions of the project site. Sunlight can be technically excluded when not wanted. Considerable heating energy economies are possible with the use of such an approach. Fairly dense land use would be implied by such a scheme, central business districts would be an ideal location.

Wind and Water Power:

Windmills have been used as power sources for centuries. Modern prototypes in sizes up to 30 KW are commercially available, sizes up to 100 KW are under active design. Collection by means of commercially avialable storage batteries is practical. Water power can be produced even on a small scale with com-

ENERGY TECHNOLOGIES

TECHNICAL FACTORS	central heating cooling plant	solid waste heat recovery	selective energy	total energy	integrated utility systems	solar energy	wind & water power
site & access dependent		●				●	●
climate dependent	●			●		●	●
fuel cost dependent	●		●	●	●	●	
density dependent	●	●			●		
load & land use density	●	●	●	●	●		
load balance				●	●		
o & m cost savings	●					●	●
fuel savings	●	●	●	●	●	●	●
life-cycle costing	●	●	●	●	●	●	●

● = related

QUALITATIVE TECHNICAL FACTOR EVALUATION MATRIX FIG 3

mercially available turbines. Both wind and water power are location dependent, in that they would be more readily applicable to lower density development.

<u>Basic Relationships of Energy Conserving Tehnologiy to the PPU</u>

The above systems are based on a balance of on-site and off-site energy generation with the critical factor of PPU land use density thresholds, mix and location determining the internal balance.

Energy generation utilizes commonly the initial natural resources of sun, wind, water, wood, coal, natural gas and oil in a variety of energy conversion techniques. The choice of technique and its operation is the major factor in achieving conservation potentials. Initial findings indicate that the first two resources can be utilized for on-site generation in low density configurations while the last five require significantly larger thresholds if utilized in a total energy context.

The following basic relationships between the PPU and various energy generation systems are noted:

- <u>Solar energy</u> generation requires one square foot of collector for two square feet of floor area heated and can satisy from 50 to 90 percent of a residential heating requirement. At a yet to be defined density threshold one would have to shift from on-site collection to off-site collection and to "solar farms" in which distribution distances from a central collection point become critical.
- <u>Wind power</u> generation appears more of a function of the wind rating of a location rather than the land use mix or density.

- Total energy systems have a direct relationship to land use mix and density. This has become a subject of much recent study, in particular the HUD/MIUS by NASA, AEC and others.
- Selective energy systems have great potentials for the PPU by balancing utilities' load factors, relieving peaks by the on-site generation of some power. This would appear viable in both an in-town and metropolitan edge context for the PPU. For meeting peak demands, either a fixed amount can be generated on-site with variable amounts purchased from the external utility or the reverse. The minimum threshold required appears to be of the order of 5,000 people in multi-family housing with both industrial and commercial components.

An Historical Perspective: Planning and Design Images Related to Energy Conservation

Energy conservation, until recently, has not been a major factor in the planning of influential models of what we have labeled as PPU's except as one of several infrastructure cost components. As an initial step in this analysis it is valuable to examine certain historical planning and design images or models which can provide potential design objectives. Many present land development patterns and types of building complexes have been near duplications of intellectual models established at various points of our planning history. Past physical planning models can be grouped into energy wasteful and energy conserving physical and social images.

The following are conserving physical images. Le Corbusier, the French architect and city planner, respected energy conservation objectives in his design philosophy of a city as a "machine for living". An admirer of the ocean-liner as an example of a compact structure which provides for total living and support systems, he transposed many of its achievements into various of his projects. A leading example is the Unité d'Habitation in Marseille which layers the major living functions of housing, recreation, school, and shopping in a single vertical structure. The building achieves high density activities in a suburban setting and internal energy savings with its bio-climatic approach to orientation, its brise soleil and ventilation. A vivid example of the "oceanliner compactness" is the renovated Queen Mary, itself now permanently anchored adjacent to Long Beach, California. It provides a dense configuration of hotel, convention, commercial and entertainment facilities within the ship's tight centralized utility system.

Paulo Soleri's underground cities of the 1960's and Frank Lloyd Wright's berm housing provide energy conserving solutions to two different density configurations. Both minimize heat loss and gain by limiting the amount of exposed building surfaces and by utilizing the natural insulation characteristics of earth. Costs of additional structural support might be compensated for by the reduction in required exterior materials.

Societal organization is directly reflected in physical land use configuration. Alterations in the former can have significant ramifications. For example, energy conserving social structures include the commune or kibbutz with its social ideology of job and habitation and institutions at a single location, greatly reducing induced travel. Certain vernacular land use patterns, such as the Pueblo Indian's Mesa Verde settlements, the Sind District in Pakistan and the Shimane Prefecture in Japan, achieved energy conservation through bio-climatic locations, siting, orientation and building design.

The following energy wasteful land use images are presented as illustrative of future issues area which can be remedied through policy changes and incentives. The "mobile home city" which although it provides relatively high density housing (10-12 du/acre) functions as and energy radiator with its thin walls and significant perimeter surface area. Both its high life-cycle costs and lack of other integrated services and land uses contribute to its energy inefficiency. For similar reasons, the typical suburban sprawl with meandering road networks rates poorly as indicated in The Cost of Sprawl. The habitat housing project in Montreal although innovative in its production concepts is wasteful by virtue of its high exterior surface area to dwelling unit ratio and its single use plan. All of the above are components of what might be called "single land use or segregated zoned city" which is energy consumptive at both the community and regional scale due to the significant number of vehicle trips generated. Finally, the ultimate example of the travel inducive land use are second home communities and vacation/resort developments which by their nature and location establish long distance trip patterns. Changes in this pattern would have significant life style consequences.

C. SITE SELECTION PROCESS FOR CASE STUDIES

The most significant future energy savings are achievable only by first focusing on those development contexts of likely future growth and then concentrating efforts on implementable energy conserving recommendations for them. Historically, growth has occurred as outward expansions of urban cores in relatively concentric rings constrained by topograpic and infrastructure factors. Also with time, new centers develop in formerly rural areas as a result of these migration patterns and begin again this incremental process. The morphology of the process has been for the population of the core and more centrally located rings in the metropolitan region to peak, stablize and then experience a subsequent decline. These rings can be characterized at a given moment by their degree of urbanization as indicated by their gross density.

Land Use and Energy Descriptors

For the purposes of this study, gross density is defined in terms of residential people per square mile (psm) as provided in Census tract data (640 psm equals one person per acre). For conversion purposes, the following psm of gross density to dwelling units (du) per residential acre equivalents have been approximated from 1970 Census data and for various numbers of persons per household to reflect existing density patterns.

20,000+ psm	40+ du/acre
10,000 - 20,000 psm	18 - 40 du/acre
5,000 - 10,000 psm	10 - 18 du/acre
1,000 - 5,000 psm	3 - 10 du/acre
100 - 1,000 psm	1.5 - 3 du/acre
50 - 100 psm	0 - 1.5 du/acre

A consensus of a range of density/land use definitional criteria results in the following standards to be followed. An urban area has a total population of 100,000 or more versus a non-urban area and contains a center with a least contiguous towns or cities with 1,000 psm or two seperate towns or cities of 2,000 psm linked by a contiguous pattern of at least 200 psm. Non-urban areas have a total population level below 100,000 and are characterized by a density generally below 200 psm. A further breakdown of the above two categories into development intensities follows:

Urban:	high intensity/urban	Over 10,000 psm
	medium intensity/urban	1,000 - 9,999 psm
	low intensity/urban	200 - 999 psm
Non-Urban Rural:	settled rural	100 - 199 psm
	sparsely settled rural	0 - 99 psm

Census data defines urban areas as standard metropolitan statistical areas (SMSA's) which contain at least one central city of 50,000 and a contiguous integrated metropolitan area defined by county lines, usually with densities exceeding 100 psm. For this study, land use configuration descriptors include: density, mix and relative location and resulting linkages. Those defined energy users in relation to land use include: residential, commercial, institutional, industrial, and transportation as major categories. Energy use categories examined include the operation of a PPU in terms of its transportation energy (with major trip purposes of home to work, shopping and others) and it utilities (heating, cooling, lighting, cooking, etc.), but not the construction of a PPU in terms of its embodied energy in the production of materials or transportation energy in the delivery of materials.

With respect to the general land use/energy relationship, the study's major area of concern is energy consumption within urbanization patterns and not energy resource development when defined as the land use implications of power plant location, coal, oil and gas exploration and development, etc. However, this area of study does include energy systems and their application to the PPU and the other major energy conservation measures within the PPU.

All energy comparisons of existing and energy sensitive PPU's will be in BTU's. Energy consumption is calculated as gross consumption defined as at the point of power generation (energy source) and net consumption defined as at the point of use.

Development Trends

A preliminary analysis of the leading research of existing and projected development patterns based on national population analysis and forecasting focused on the recent work of the following organizations:

Bureau of Census; U. S. Department of Commerce

Regional Plan Association; New York

Commission on Population and America's Future; Washington, D. C.

Economic Research Service; U. S. Department of Agriculture

Committee on Community Development, The Domestic Council; Washington, D. C.

Historical Growth Trends:

In summary, the following historical population migration and resultant growth trends are noted to set the framework for site selection:

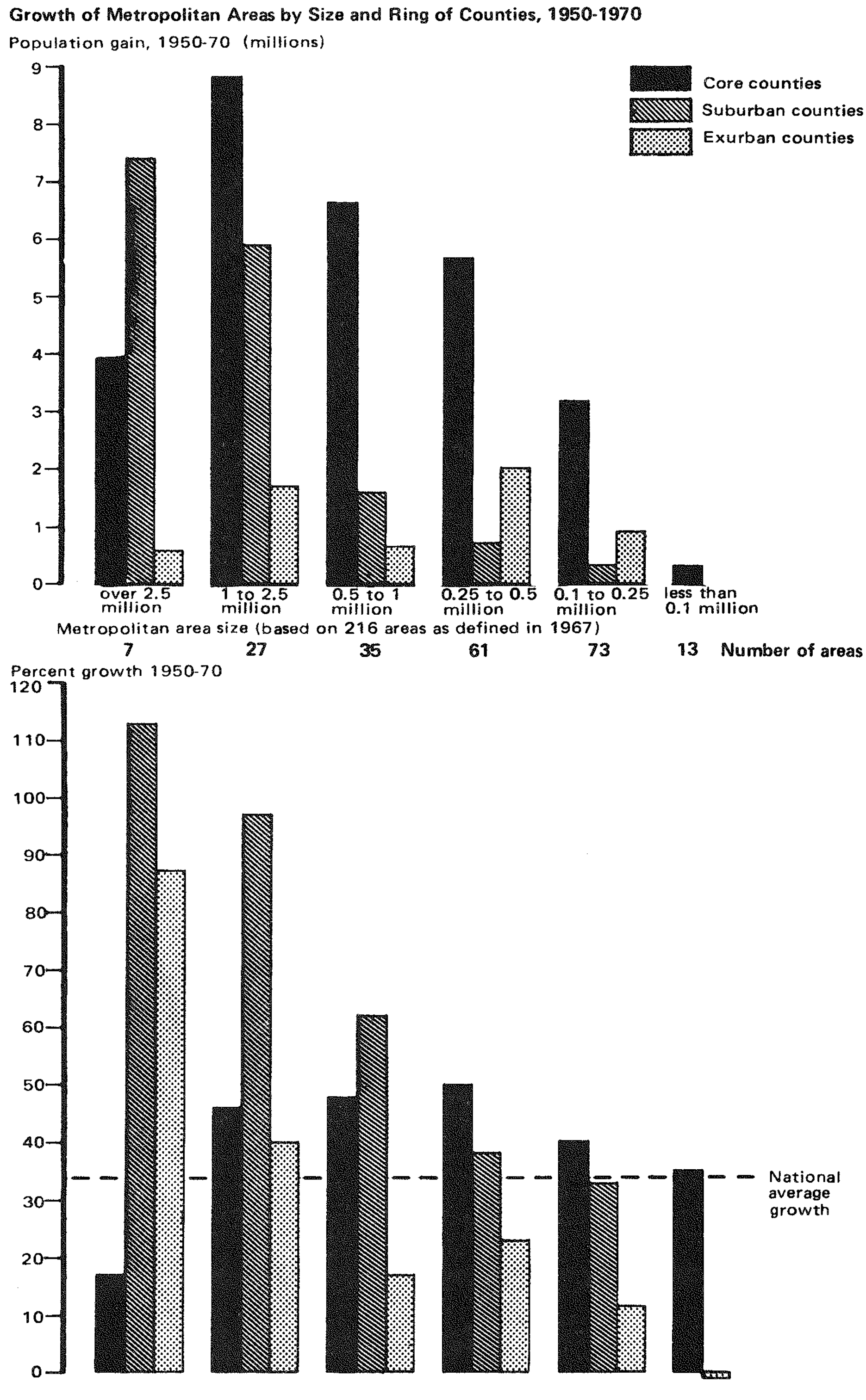
- the rural depopulation occurring after 1940 with a rural/farming population stabilizing at about 10,000,000.
- the corresponding migration to urban areas, a trend occurring since 1920. As indicated in the following table, the decrease of the nation's growth locating outside of SMSA's is due to the increase in SMSA growth most of which is located in the suburban rings.
- the development of metropolitan areas as the suburbanization of initially compact cities continues.
- the recent (1950-1970) out-migration from the central cities, primarily those over one million to adjacent suburbs or smaller cities. If it were not for territorial annexation, central cities would have grown by only two million for this time period.
- the decentralization within urban areas seen as the growth of suburban areas within SMSA's in the following Table 3.

Table 3: Population in 000's by 1960 SMSA's, Except Last Row (Percent of Total) (+/- increase/decrease over previous Census)

	Central Cities	Suburban Rings	Outside SMSA's	Total
1920	34,641 (33%)	17,866 (17%)	53,203 (50%)	105,711
1940	45,473 (34%) (+)	27,103 (21%) (+)	59,093 (45%) (-)	131,669
1950	52,138 (35%) (+)	36,826 (24%) (+)	61,252 (41%) (-)	150,216
1960	57,710 (32%) (-)	54,675 (31%) (+)	66,082 (37%) (-)	178,467
1970	61,452 (30%) (-)	68,805 (35%) (+)	71,886 (35%) (-)	202,143
1970 SMSA's	63,797 (31%) (-)	75,622 (37%) (+)	63,793 (31%) (-)	203,121

Source: U.S. Census and Regional Plan Association

- the fastest growing metropolitan areas are in the category of 1 - 2.5 million for 1950 - 1970, see following Figure 4.
- the fastest growing component of SMSA's nationally are the suburban rings around the largest metropolitan areas (115% for 1950 - 1970) with growth rates declining with the corresponding decline in metropolitan size, see following Figure 4.



Source: New York Regional Plan Association

GROWTH OF METROPOLITAN AREAS 1950 TO 1970

FIG 4

- However, recent mid-decade counts (1970 - 1973) indicate a possible reversal of past trends with non-metropolitan county growth of 4.2% developing at rural densities of less than 200 psm as compared to metropolitan county growth of 2.9%. This supposed reveral is generally explained both by the overspill of growth from metropolitan areas into counties not yet included within SMSA boundaries (Regional Plan Association includes some of these as exurban) and by the growth of some independent rural areas.

The following points attempt to summarize the salient trents in development densities over time:

- the increase in all developed land densities by 100% for each decade from 1900 - 1940 to be followed by a national decrease in the developed land densities of all urban places. In 1950, each urban resident on the average occupied 0.2 acres of urban land; each additional resident from 1950 to 1960 an additional 0.35 acres; and from 1960 to 1970, 0.4 acres.
- on the average, metropolitan areas with more than 1.5 million inhabitants and densities of more than about 800 psm declined in density over time, while smaller ones increased.
- densities of core counties have recently declined, the greatest change having occurred from 1950 to 1960, while the density of suburban counties has increased.

Table 4: Relationship of Size of Metropolitan Area to Density for 1970

Size of SMSA:	10 million	1 million	.1 million
Density of:			
Core County	20,000 psm	2,000 psm	200 psm
Suburban County	1,000 psm	200 psm	

Source: Regional Plan Association

Future Growth Trends:

The following future trends are noted as having achieved a certain consensus among those source noted above:

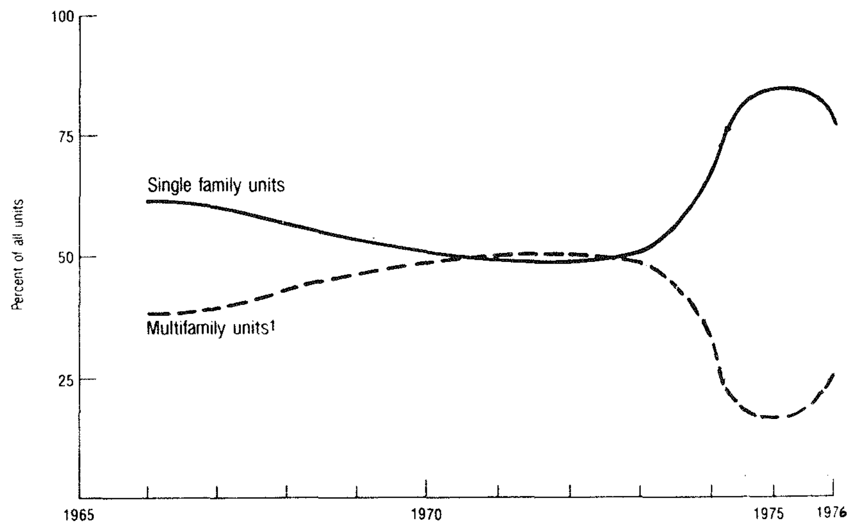
- the likely decline in rural out-migration.
- the likely decline in the rate of growth of the number of metropolitan areas.
- the growth within metropolitan areas will be dominated by natural population increase and inter-metropolitan migration.
- a greater dispersal will occur within urban regions although a larger percentage of the nation's population will locate within urban regions (Jerome Pickard).

However, the following "unknowns" may have a significant effect on future projections:

- the impact of higher future energy prices on development patterns.

- the future relationship of the number of units of single family to multi-family housing given recent trends, see the following chart.

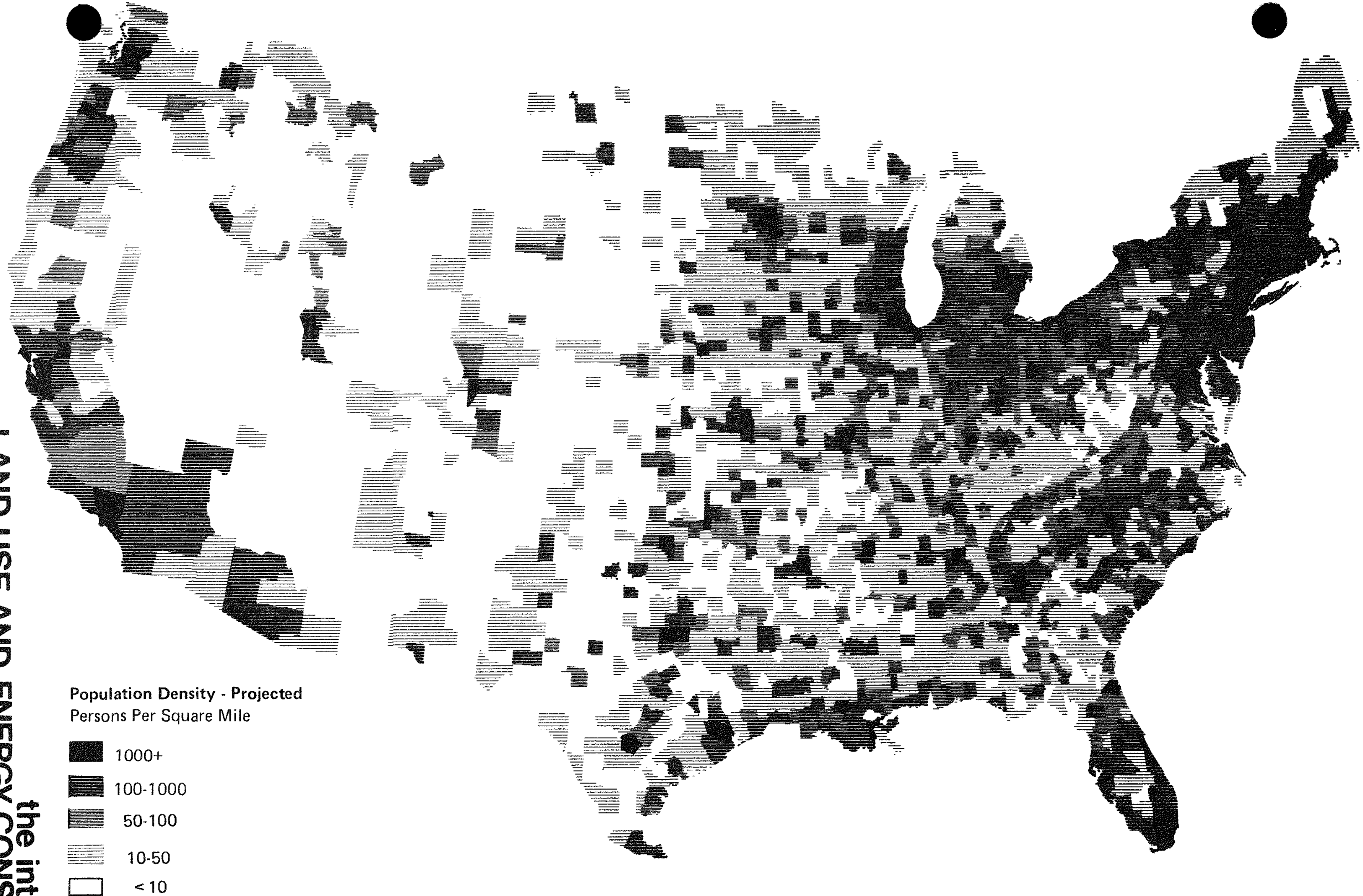
Housing Starts in Metropolitan Areas Outside Central Cities



[1]Multifamily units have two or more dwelling units per building.

Sources: U. S. Bureau of Census, Housing Authorized by Building Permits and Public Contracts; Council for Environmental Quality (1965-1973); Wall Street Journal (1974-1975); National Assoc. of Home Builders (1976 Projection)

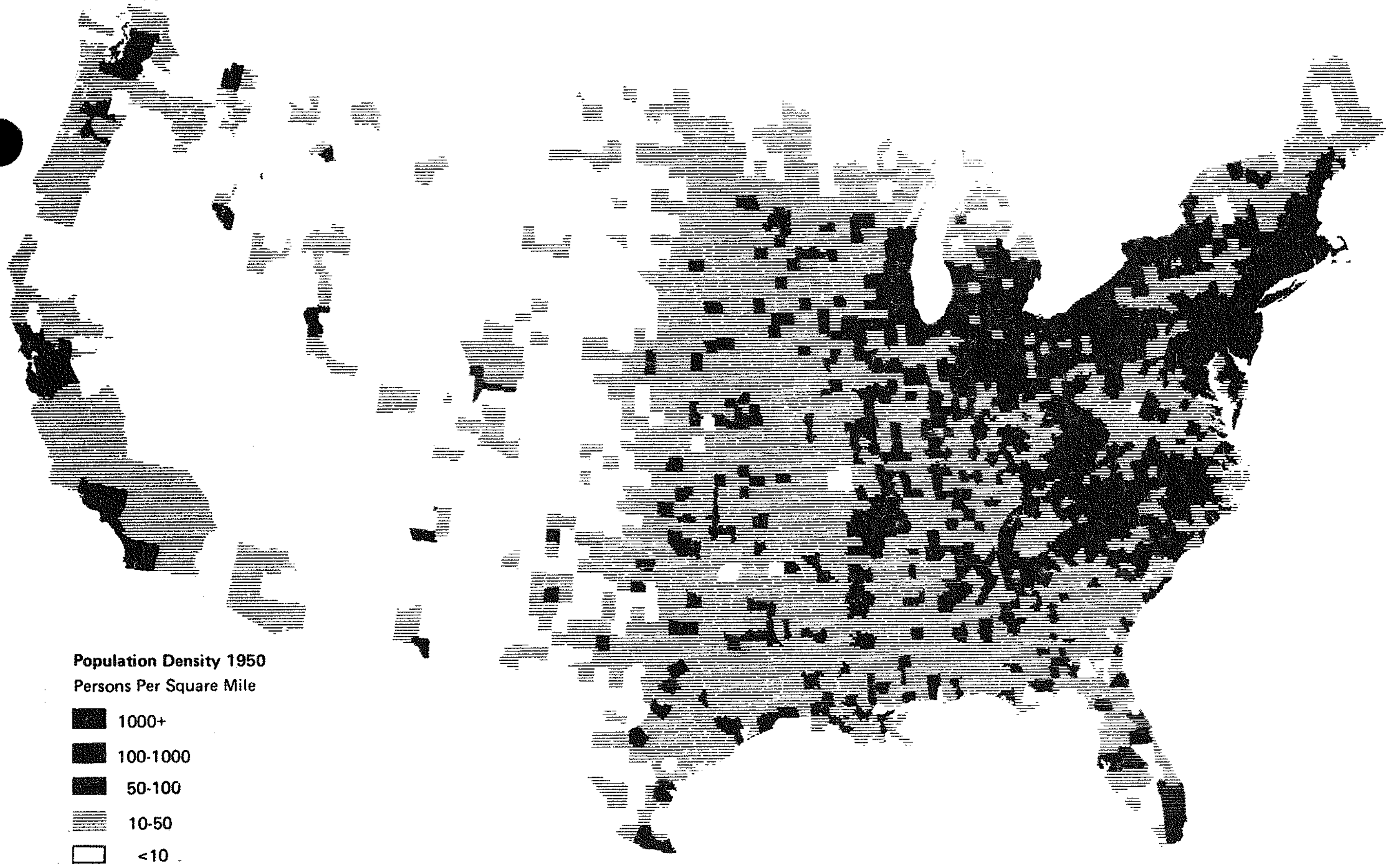
Various efforts have been made at projecting future growth usually in terms of the size of SMSA's likely to be major recipients. Most work has been an extension of 1950 - 1970 trends as a full analysis of the 1970 - 73 reversals appears to be difficult until more time has passed and data collected. Density allocations are made taking the Census Series E projections for maximum probable growth for the year 2020 of approximately an additional 100 million. These are distributed on a county basis on the following Figure 5, which can be compared to existing density patterns for 1950 and 1970, Figure 6. As for the last two decades, the fastest growing SMSA's would be in the 1 million range and the fastest suburban growth in the multi-million SMSA's. Core counties are generally projected to capture less growth than during 1950 - 1970. Eighty-five percent of the growth is projected for the existing 1970 SMSA's. Figures 4 and 6 have documented 1950 to 1970 density changes. The following Table 5 indicates the 1970 to 1973 trends including the reversals previously mentioned. One sees that the significant growth areas for this period (1970 - 1973) are in SMSA's of 1.0 - 2.0 million, .25 - .50 million, and below .25 million. Comparing these trends with those for 1950 - 1970 indicated in Figure 4, there is a continuance of the 1.0 - 2.0 million SMSA growth but a potentially dramatic increase in the growth rates of the smaller SMSA's (under .5 million).

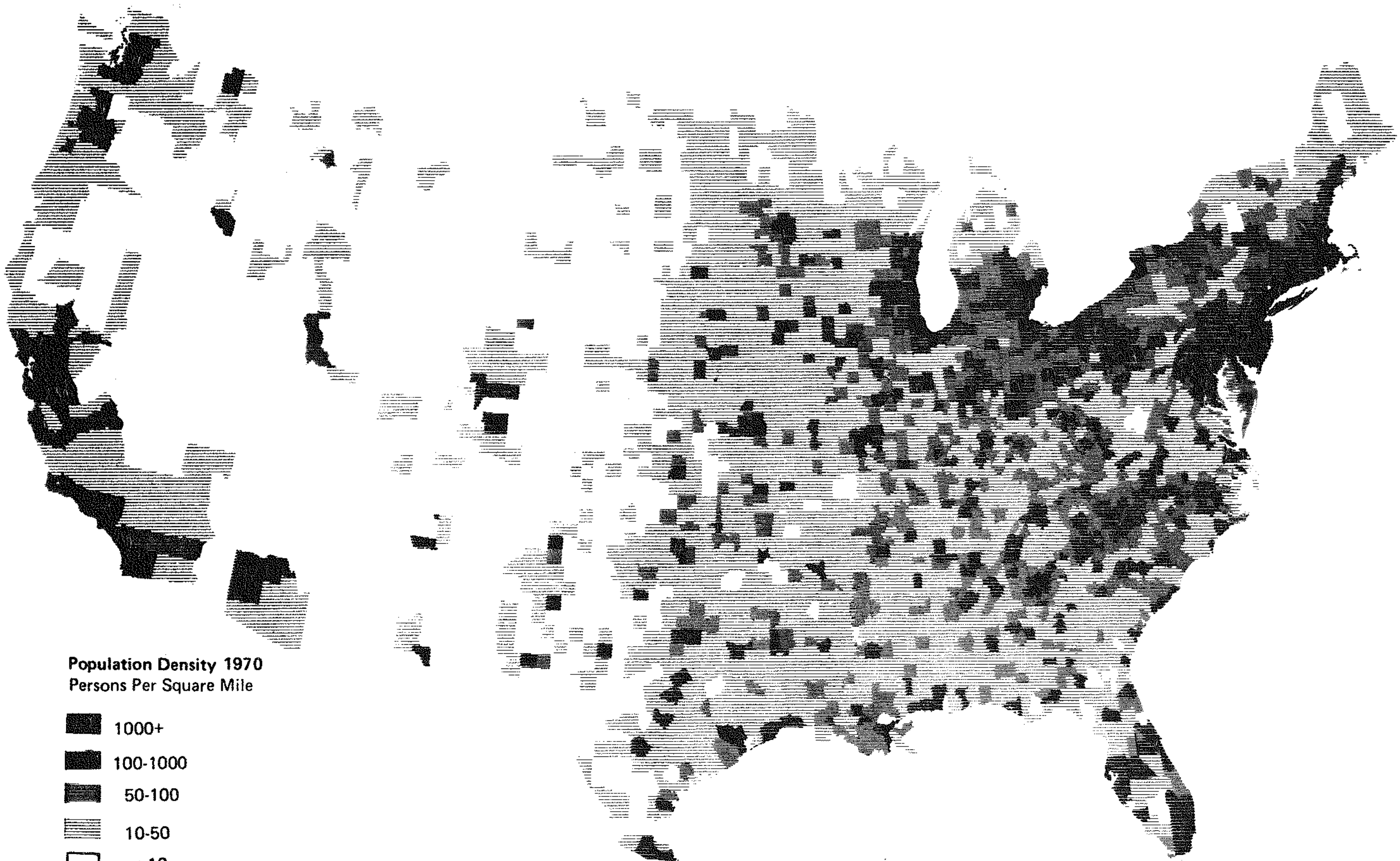


Source: New York Regional Plan Association

PROJECTED NATIONAL POPULATION DENSITY PATTERNS

FIG 5





Source:
New York Regional Plan Association

POPULATION DENSITY PATTERNS

FIG 6

the interaction of
LAND USE AND ENERGY CONSERVATION
a study for the FEDERAL ENERGY ADMINISTRATION by CONKLIN & ROSSANT/FLACK+KURTZ

Table 5: Population Change 1970 - 1973 for all SMSA's by Category and Non-Metropolitan Areas

Categories	Number of Areas	Population July 1973	Population April 1970	Changes 1970 - 1973 Number	Changes 1970 - 1973 Percent	Net Migration Number	Net Migration Percent
All SMSA's	253	152, 749, 200	148, 532, 886	4, 216, 300	2. 8	465, 300	0. 3
SMSA's of 2 million or more	15	58, 650, 500	58, 585, 221	65, 300	0. 1	-1, 161, 300	-2. 0
SMSA's of 1. 0-2. 0 million	19	26, 466, 100	25, 161, 277	1, 304, 800	5. 2	615, 800	2. 4
SMSA's of . 5-1. 0 million	38	27, 388, 700	26, 396, 061	992, 600	3. 8	290, 200	1. 1
SMSA's of . 25-. 50 million	63	22, 185, 300	21, 208, 311	977, 000	4. 6	363, 100	1. 7
SMSA's under . 25 million	118	18, 058, 600	17, 182, 016	876, 600	5. 1	357, 600	2. 1
Non-Metropolitan Areas	N. A.	57, 101, 800	54, 768, 370	2, 333, 400	4. 3	1, 199, 400	2. 2

Source: U. S. Census

Development Contexts of Future Growth

A selection of development contexts is made based on both these 1950 - 1970 trends and a consideration of recent trend reversals. These include:

(a) the suburban counties within the present multi-million SMSA's (2.5 million or more).

(b) the core counties within the present million plus SMSA's (1.0 - 2.5 million).

(c) the core cities and counties within the smaller SMSA's (under .5 million).

The next step is to extrapolate the likely gross densities of these selected development contexts. For present purposes this is considered to be a continuance of the existing density patterns. Calculations from Census data provides gross residential densities for the various categories of SMSA's selected above as future growth areas. This is presented in Table A-1 in the Appendix for the overall SMSA, its core city, core county and one or more selected suburban counties. For the largest two categories of SMSA's (1.0 million or more) all 34 SMSA's are listed. For the smaller SMSA's (under .5 million) 14 illustrative SMSA's are listed.

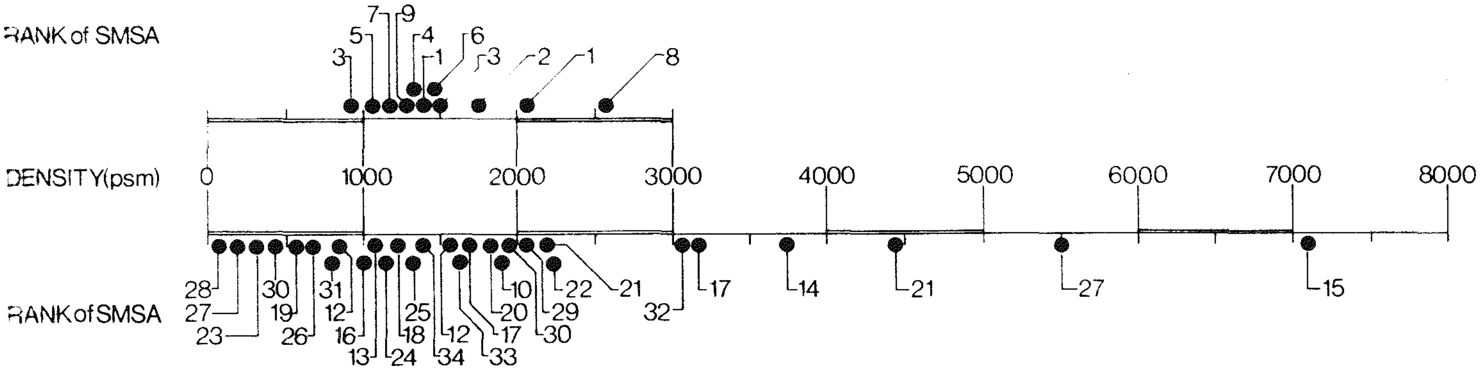
Gross density is a difficult measurement variable to deal with as it is more dependent upon the vagaries of the locations of county boundaries which define its size rather than providing an accurate comparative measure of different settlement patterns. However, the gross densities for each significant component of the selected SMSA's can be arrayed on a spectrum to determine its distribution and provide a range (see Figure 7 which follows). Clustering occurs in development context (a) in the 1,000 - 2,000 psm range, labeled medium intensity/urban. For context (b) clustering occurs at a broader range up to 2,000 psm or a low and medium intensity/urban class. Context (c) includes small SMSA's in the .25 - .50 million and less than .25 million category both of which have core counties clustering in the 25 - 1000 psm range or rural and low intensity/urban class. Within context (c) the larger SMSA's have core cities in a broader range of 3000 - 9000 psm while the smaller SMSA's core cities fall in the smaller range of 2000 - 5000 psm. Both ranges are labled medium intensity/urban.

What results from this analysis is an alarming concentration at the lower end of the density spectrum due to a projected continuance of the decline in gross density over time. This is disturbing in that the national consequences of instituting energy conserving measures decline rapidly with decreases in gross density. Perhaps, more important would be the adopting of policy measures which assured development at densities meaningful to energy measures. This is the subject of further institutional analysis in this study. But as an initial step a high intensity/urban "in town" context is added to the above three contexts for analysis for the following reasons:

- it provides a significant level of infrastructure needed for redevelopment opportunities.

(a)

DENSITY DISTRIBUTION OF SUBURBAN COUNTIES WITHIN NINE PRESENT MULTI-MILLION SMSA's (2.5million or more)

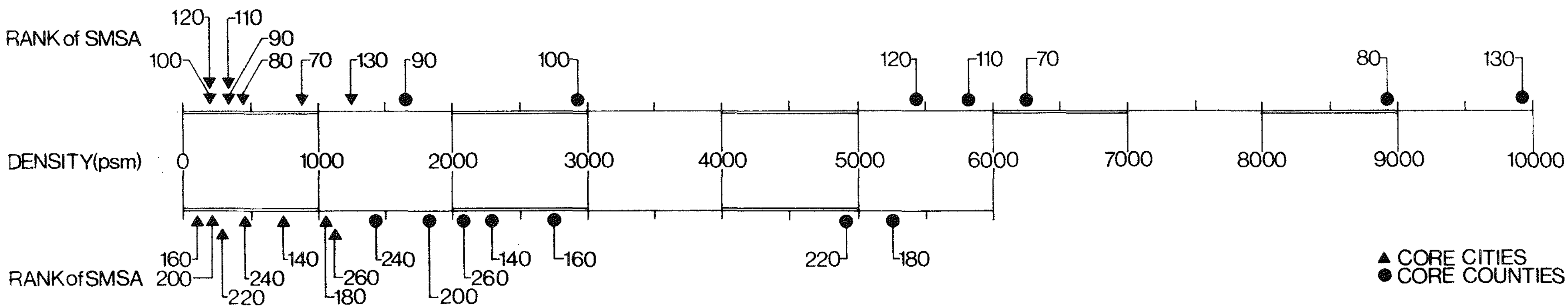


(b)

DENSITY DISTRIBUTION OF CORE COUNTIES WITHIN 24 PRESENT MILLION-PLUS SMSA's (1.0million to 2.5 million)

(c)

DENSITY DISTRIBUTION OF CORE CITIES AND COUNTIES WITHIN THE 64 SMALLER SMSA's FROM SEVEN ILLUSTRATIVE EXAMPLES (.25million to .50 million)



(c)

DENSITY DISTRIBUTION OF CORE CITIES AND COUNTIES WITHIN THE 128 SMALLEST SMSA's FROM SEVEN ILLUSTRATIVE EXAMPLES (less than .25million)

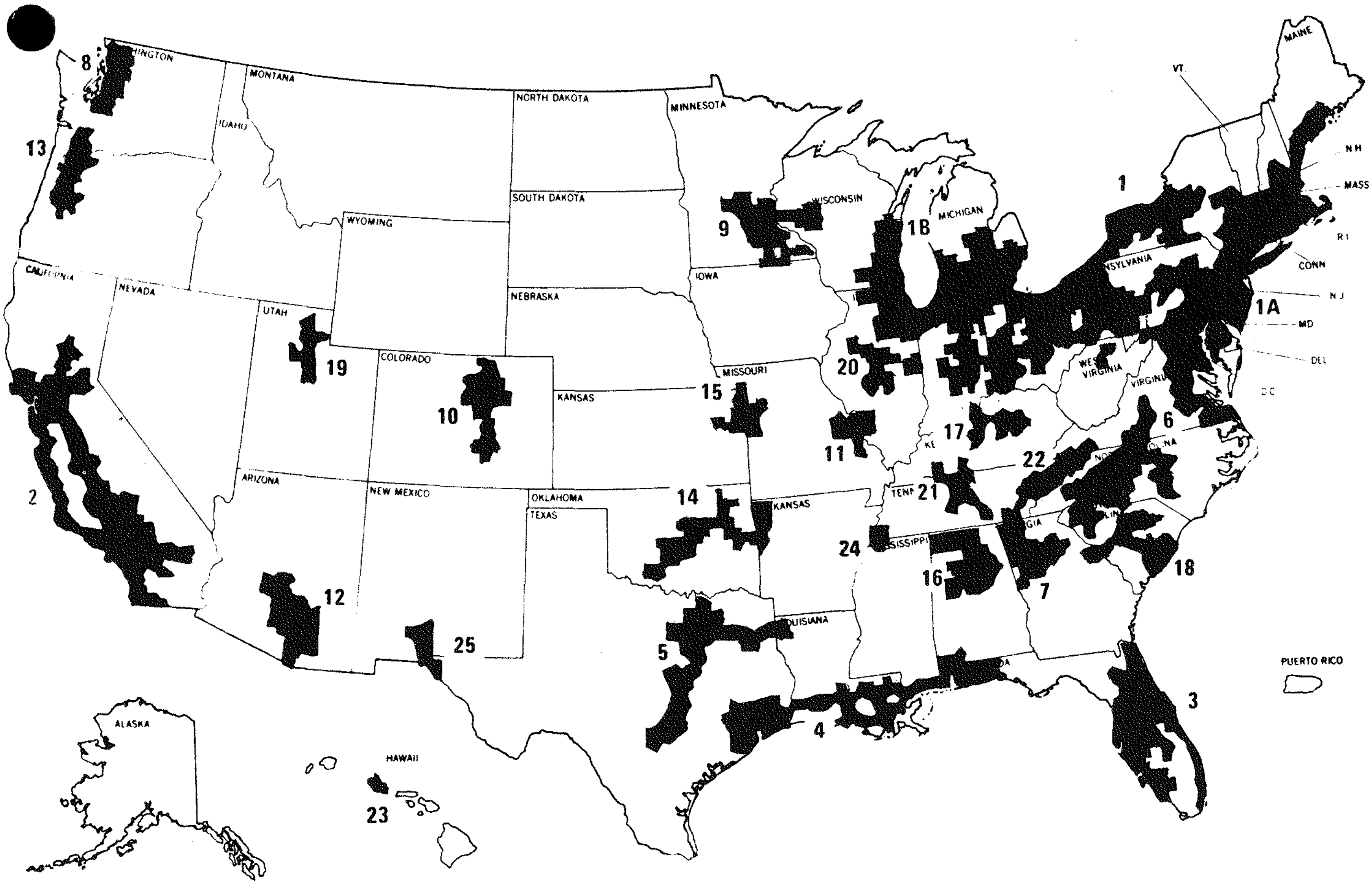
POPULATION DENSITY DISTRIBUTION BY SIZE OF SMSA

FIG 7

- it can provide the limited opportunities for reducing transportation energy consumption by utilizing various existing transit alternatives.
- energy system opportunities would be limited without the consideration of high intensity contexts.
- economic development opportunities which allow for energy conserving land use conbinations would be limited without considering the inner-city context.

Much recent regional development policy appears aimed at the premise of decongesting our large metropolitan areas and inducing growth in smaller independent metropolitan areas to rid larger segments of our population of so-called "urban ills". The 1970 - 73 trends appear to bear this out. However, it should be noted that although percent change appears significant, actual numbers are not large as these smaller areas are growing from a small base. As Jerome Pickard points out,

> "to obtain substantial effects, these smaller places would have to grow 50 percent per decade. Moreover, most of the smaller areas which are capable of attracting many people are in urban regions, or would be by the year 2000. Thus, stimulating their growth would have the useful effect of decongesting settlements in urban regions, but would do little to retard urban region growth. See Figure 8 which follows.



1. Metropolitan Belt
   1.a. Atlantic Seabord
   1.b. Lower Great Lakes
2. California Region
3. Florida Peninsula
4. Gulf Coast
5. East Central Texas—Red River
6. Southern Piedmont
7. North Georgia—South East Tennessee
8. Puget Sound
9. Twin Cities Region
10. Colorado Piedmont
11. Saint Louis
12. Metropolitan Arizona
13. Willamette Valley
14. Central Oklahoma—Arkansas Valley
15. Missouri—Kaw Valley
16. North Alabama
17. Blue Grass
18. Southern Coastal Plain
19. Salt Lake Valley
20. Central Illinois
21. Nashville Region
22. East Tennessee
23. Oahu Island
24. Memphis
25. El Paso Ciudad Juarez

Based on 2-child family projection

Source: Jerome P. Pickard, "U.S. Metropolitan Growth and Expansion, 1970-2000, with Population Projections" (prepared for the Commission, 1972).

PROJECTED URBAN REGIONS FOR THE YEAR 2000 FIG 8

Selection of Case Study Areas

Three development contexts of future growth have been identified as defined by 1950-1970 trends and a consideration of recent trend reversals and a fourth inner-city context added. PPU/study areas were then selected as representative of these contexts according to the PPU size requirements described in Section A. Selection criteria were described as ranges providing a proper diversity of examples within land use, transportation, demographic, physical and locational considerations. They are listed below:

Transportation

- variation in modal split (car/transit)

Land Use Composition

- variation in degree of self-sufficiency versus dependency on a city core
- variation in land use mix (residential, commercial, institutional, industrial)

Setting

- variation in climate
- variation in topography

Potentials for Renewal/New Construction

- variation in amount of vacant land
- variation in age of housing stock
- variation in growth rate

Population

- satisfy the established PPU

Prototypical Quality

- exemplary of its regional urbanization pattern and typical of a national pattern

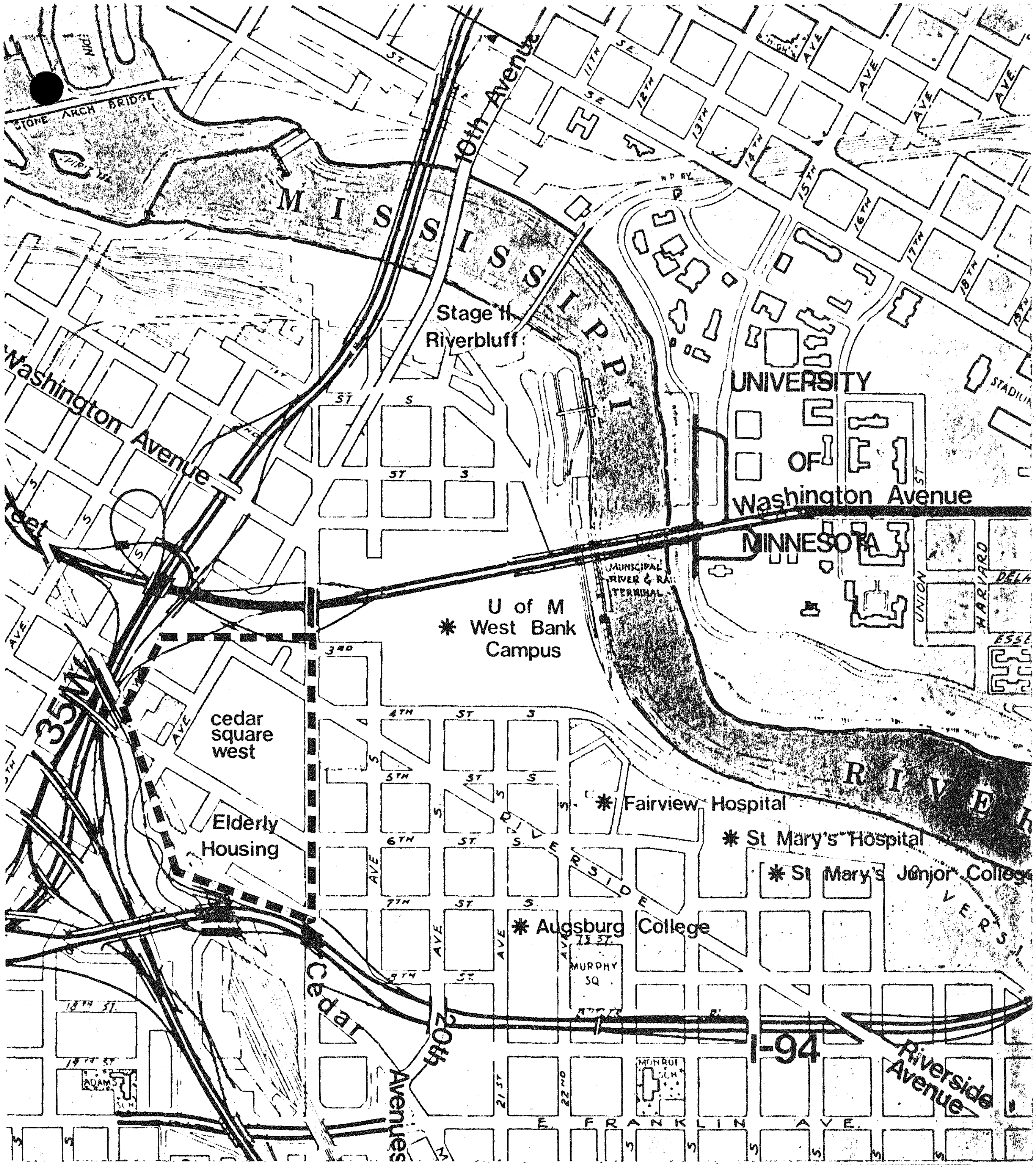
A major constraining factor in the utlimate selection was the availability of comprehensive transportation data and utility consumption figures by sector. The selected PPU/study areas approved by FEA are as follows:

- Cedar West, Cedar-Riverside, Minneapolis; a PPU within a core county within a million plus SMSA (1.0-2.5 million); an innovative high density inner-city community; the first phase of the larger Cedar-Riverside proposed new town intown.
- The Magnificent Mile of Chicago's Near North Side; a PPU within a high intensity urban context; a high level retail, office and hotel center with a greatly fluctuating day-night population.
- Census Tracts 6 and 7, Tucson, Arizona; a PPU within a core city and county within a smaller SMSA (less tha .5 million); an older mixed neighborhood adjacent to the downtown and university.
- Mt. Pleasant, Westchester County, New York; a PPU within a suburban county within a present multi-million SMSA (2.5 million or more); a residential community dependent on a metropolitan core.

The boundaries of the study areas are established by existing data collection formats or development patterns as follows:

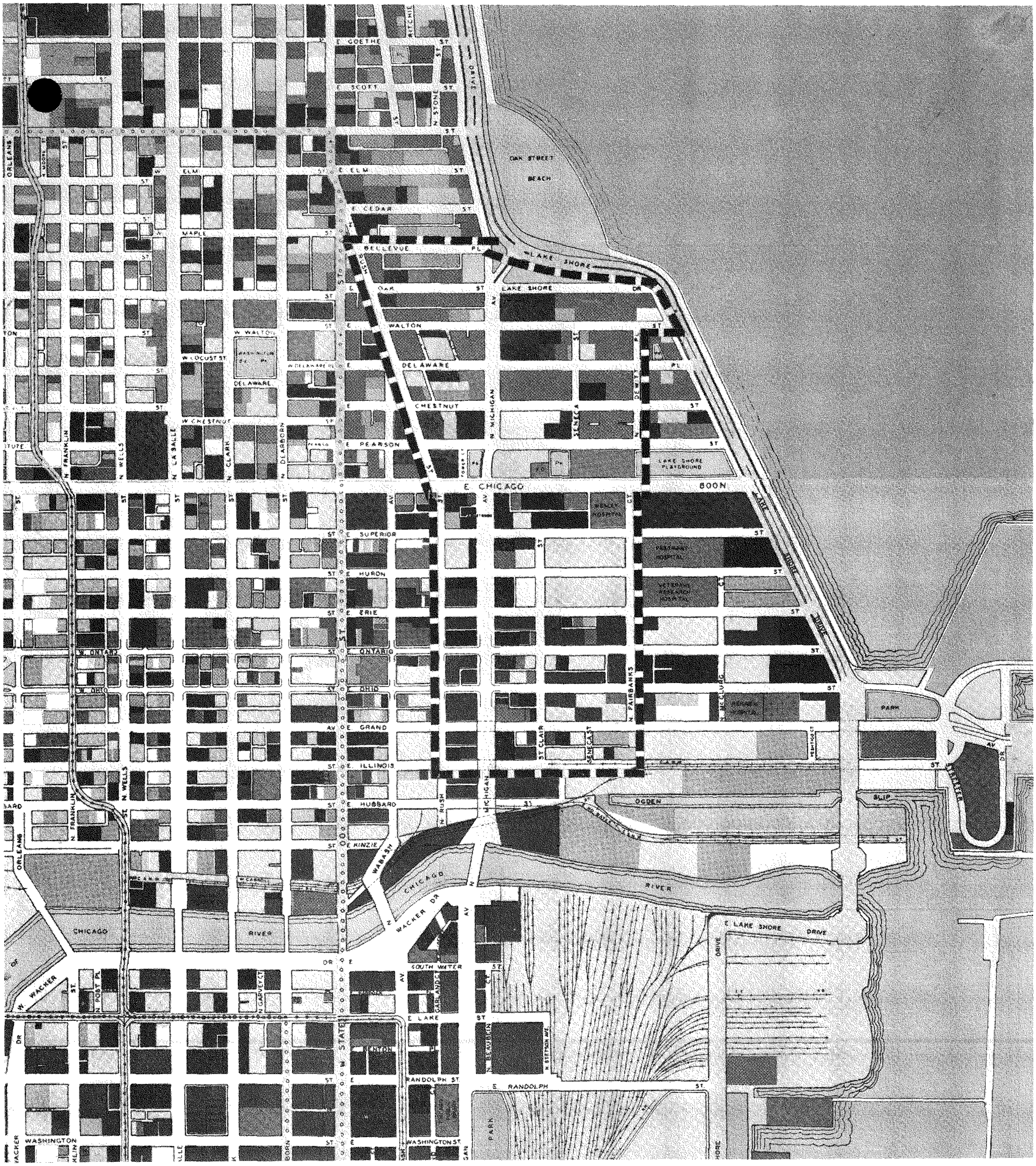
- Cedar-Riverside: the first completed phase of the proposed large scale complex plus earlier development within an identifiable community bounded by highways.
- Chicago: a cohesive development band extending one or two blocks east and west of North Michigan Avenue. The study area is portions of four Census tracts.
- Tucson: A diverse community typical of the region's one mile grid development pattern described only by two Census tracts.
- Mt. Pleasant: 12 irregular square miles utilizing Tri-State's transportation analysis zones.

The four PPU/study area boundaries are approximated on the following four Figures (9-12).



CEDAR RIVERSIDE STUDY AREA
MINNEAPOLIS, MINN.

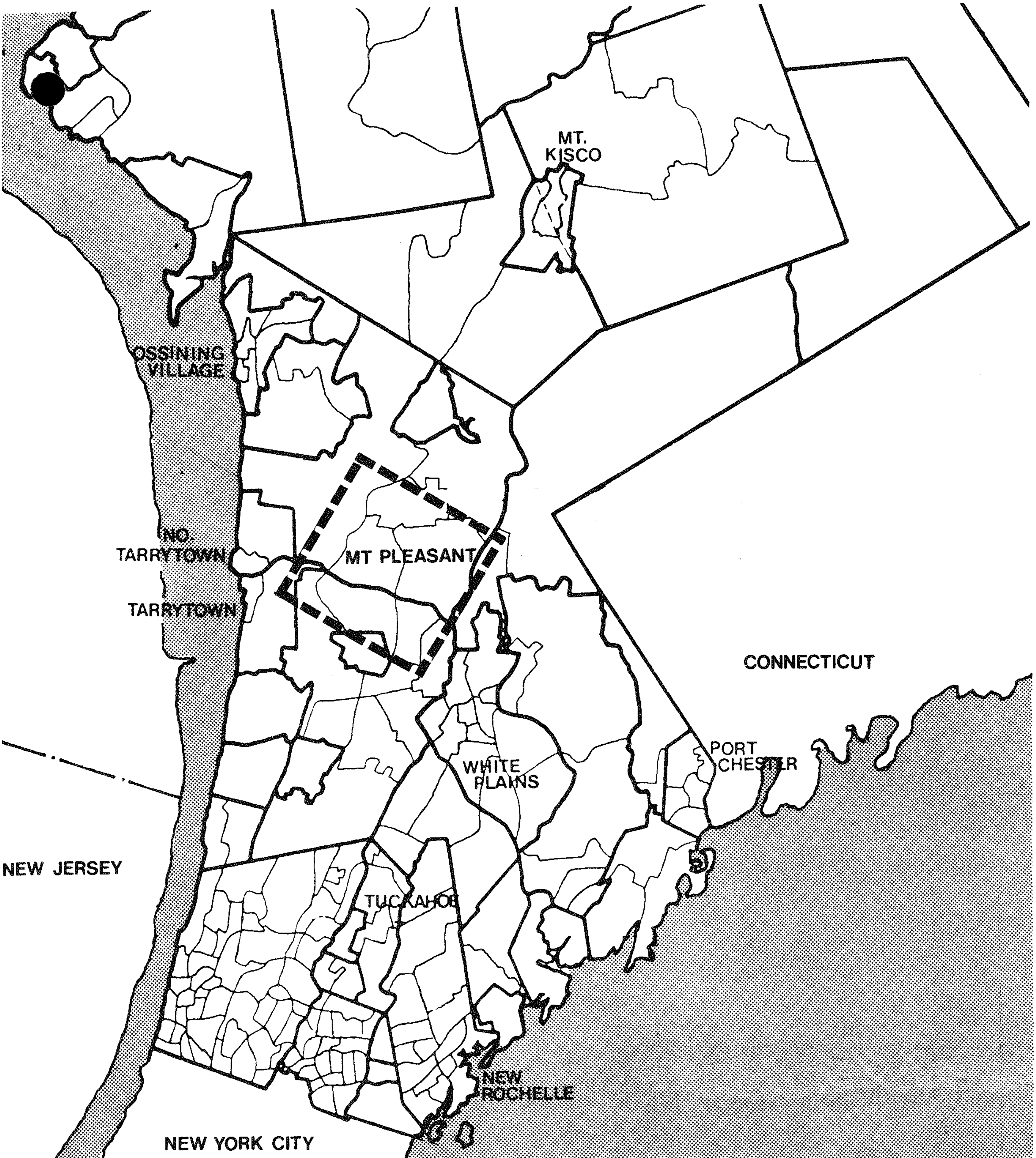
FIG 9



NEAR NORTH SIDE STUDY AREA
CHICAGO, ILLINOIS

FIG 10

TRACT 6 & 7 STUDY AREA TUCSON, ARIZONA FIG 11



MT. PLEASANT STUDY AREA WESTCHESTER CO., NEW YORK FIG 12

D. GENERAL DESIGN AND EVALUATION PROCESS

Four development contexts as described by density and basic relationship to urban centers have been selected in which future new growth and re-development is projected to occur. Within each context a "planned population unit" (PPU) of 3,000 - 13,000 has been selected. Its present energy consumption and conservation characteristics are to be calculated and analyzed. Then an "energy sensitive" PPU is developed within each context to accommodate growth projected for the year 1995 as one scenario. The final step is to compare the resultant energy comsumption in BTU's of two scenarios: the future "energy sensitive" PPU with the energy characteristics projected for a laissez-faire PPU. For both scenarios, the percent growth in energy consumption for the years 1975-1995 is compared to the growth in each land-use sector (residential, commercial, institutional and industrial) as it is affected by the basic planning measures of land use mix, the spatial configuration of development and its transportation implications, and the relationships between both mix and configuration to new energy technologies. This basis of comparison is referred to as "energy elasticity" and appears in Section F on findings from the case studies.

Approaches for Developing Energy Sensitive Land Use Plans

The comparative existing consumption analysis of the four study areas which follows in Section F indicates that major energy conserving aspects are achieved by density, self-sufficency, mass transit, available energy systems, and land use patterning; not surprising findings as they are all basic "good planning principles". From these findings, various alternative approaches are possible for developing "energy sensitive" land use plans prototypical of the development conditions found in each of the selected population units (PPU's) or study areas. These are categorized according to the following four groupings and description:

1. Redesign/Fixed Program

The various elements of the existing land use (number of residential units and square footage of commercial, institutional and industrial facilities) are held constant and become the program for a complete redesign which provides an energy sensitive solution.

2. Growth Expansion/Land Conservation

Available trends to population growth and decline are subdivided and allocated to each of the selected PPU's. These growth or decline factors become the program basis for expansion of development in new energy sensitive patterns maintaining major segments of existing urbanization.

3. Controlled Growth/Community Retrofit

A program for growth developed as described in Technique #2 above is used for the densification of existing communities within the PPU's. Raw land conversion is limited and the design emphasis is placed on infilling and achieving community self-sufficency in terms of jobs, shopping, recreation, etc.

4. Idealized Solution/Flexible Program

For each PPU an idealized solution is provided including the prototypical program necessary for achieving maximized energy conservation. The constraints of a fixed program in Technique #1 are not applicable here. The present level of infrastructure and development are likewise not considered as a constraint.

It was felt that all of the above approaches were not equally valid nor would result in significant energy savings. Budget limitations also indicated the need for a selection. The following evaluation matrix was the basis for a discussion by the consultant group. Not all cells were filled in. However, Techniques 2 and 3 were selected as being the most meaningful to the study, having the greatest likelihood of public acceptance and implementation and the least dependent on unquantifiable life-style and behavorial factors.

Table 6: Evaluation Matrix for Alternative Approaches

TECHNIQUES / EVALUATION CRITERIA	Ease of Quantification of Energy Characteristics and Comparison to Existing Conditions	Likely Energy Conservative Effectiveness of Design Measures	Likely Change in Resultant Life-style	Appropriateness to the Selected PPU's
1. Redesign/Fixed Program	directly comparable with fixed program	least potential	least	
2. Growth Expansion/ Land Conversion	dependent on validity of growth projections			Mt. Pleasant/available raw land Tuscon/minimal raw land Minneapolis/little raw land Chicago/no raw land
3. Controlled Growth/ Community Retrofit	dependent on validity of growth projections			
4. Idealized Solution/ Flexible Program	more difficult with program change	greatest potential	most	

Study Area Refinement

In conjunction with this selected approach a further evaluation of the four PPU study areas was made. A review of the selection criteria listed in Section C indicated that Tucson and Mt. Pleasant were the most suitable contexts for utilizing Techniques 2 and 3; Tucson providing opportunities for "community retrofit" and internalized travel solutions and Mt. Pleasant providing opportunities for new development and reduced dependency on its external automobile network. The following analysis of Cedar West, the first built phase of Cedar-Riverside in Minneapolis, as an example of an innovative high density inner-city community has documented some effective energy conserving land use planning techniques. But despite this, too few locational opportunities exist for more high density communities of this form in order for it to become a general development prototype. The following analysis of existing energy consumption in Chicago's "Magnificient Mile" a segment of North Michigan Avenue on the City's Near North Side ranks the highest in terms of millions of BTU's (MMB) per capita consumption. This is largely due to the large number of dwelling units and commercial space and relatively low residential population. However, given this present ranking within a high density context, remedial energy conserving planning measures as presently understood would appear difficult and relatively ineffective.

E. CASE STUDIES

Energy Analysis Factors

In order to assess the energy consumption for a planning area it is first necessary to establish the land use and population base, either present or future, or both, depending on the time frame of interest. Generally, quantification for both present and future land uses and population are of interest in order to assess the impact of proposed development. Sources and methods for obtaining information on present and future land use vary somewhat with each case study and hence, are described within each example.

Energy is measured in BTU's, or British Thermal Units, and all forms of energy can be converted to this unit. One BTU is the energy needed to raise 1lb. of water $1^{o}F$. from and at $60^{o}F$.

$$\text{MBTU} = 1,000 \text{ BTU} = \text{BTU} \times 10^3$$

$$\text{MMB} = 1,000,000 \text{ BTU} = \text{BTU} \times 10^6$$

The MBTU is a useful unit because it is approximately equal to the energy content of one cubic foot of natural gas, and also approximately equal to the energy content (latent heat) of one pound of steam (depending on pressure and temperature). In relation to land use studies, these equivalencies are considered accurate. The MMB is useful for making factors and totals more manageable in tables and other references where large number of BTU's would otherwise result.

Other conversion factors utilized are as follows:

1 KW = 3,413 BTU

1 HP = 2,545 BTU

Where the use of metric units is described the following conversion factors apply:

BTU x .252 = 1 KG calorie

1 KG calorie = 3.969 BTU

Other factors used in this study are:

MMB/d. u.	=	BTU x 10^6 per dwelling unit
MMB/CAP	=	BTU x 10^6 per capita of population
MMB/sq. ft.	=	BTU x 10^6 per sq. ft. of building space
Average VMT	=	Average Vehicle Miles per Trip

Factors used for analyzing energy consumption were obtained from various sources which are referenced below. Residential consumption factors vary with dwelling unit type; commercial, institutional and industrial uses were matched with the most appropriate factors available.

All factors should be ajusted for local climatic conditions, based on degree-days. Information on degree days is available from local units of the U. S. Weather Service, or from the cental data source in Ashville, N. C. Useful weather data for Air Force bases, which are located throughout the U. S. can be obtained from Air Force technical manual TM 5-785. Also, the ASHRAE Guide, and "Handbook of HVAC" by Strock & Koral contain necessary weather data.

A distinction should be made between demand and consumption. Demand is the <u>highest</u> use of energy in a facility during any hour of a month or year, measured in BTU/hr. or KW. Consumption is the total use of energy for that facility over a given time period (month or year) and expressed in BTU or KW - hr.

Energy Analysis Methodology

For each case study area a table, in the following format (see Table 7), was prepared. Land use information as developed for each case study, was grouped in the following categories:

- Residential
- Commercial
- Institutional
- Industry
- Transportation

Average energy consumption factors were taken from the following references:

Ref. No. 1: "Land Use and Energy Utilization"
Brookhaven National Laboratory (BNL)
and The State University of New York
at Stony Brook October 1975.

Ref. No. 2: "Analysis of Factors Related to Energy
Use in the Commercial Sector"
by Bernstein and McCarthy, American Institute of Planners
Conference, October 1975.

Ref. No. 3: "Public School Energy Conservation Study" (PSECS)
Educational Facilities Labratories with
Flack + Kurtz for FEA, Contract C-04-5004700
October 1975.

Table 7: Format for Annual Energy Consumption Estimates

Place:

Test Area Population:

Land Use	UNITS D. U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family				
2- Family				
Low Rise M. F.				
High Rise M. F.				
SUBTOTAL				
	Sq. Ft.			
COMMERCIAL				
Office				
Retail				
Mall/Large				
Attached/Small				
Strip				
Hotel				
Food Service				
Recreation				
Theatres				
SUBTOTAL				
INSTITUTIONAL				
Schools				
Hospitals				
Public Service				
Dormitory Type				
SUBTOTAL				
INDUSTRY				
Light Industrial				
Warehouse				
SUBTOTAL				
TOTAL (Less Transportation)				
Transportation				
GRAND TOTAL				

Ref. No. 4: "Low Energy Utilization School"
R. G. Stein, NSF-RANN G139612
(with Flack + Kurtz input)

Ref. No. 5: "Regional Energy Consumption"
Regional Plan Association Bulletin #121
by Resources for the Future and Regional
Plan Association, January 1974.

Residential utilization factors were modified for the following:

- prevalence of electric heating in area.
- prevalence of room air conditioning versus central air conditioning in the case study area.

This information is available from the appropriate tables in "Detailed Housing Characteristics", 1970 Census. Industrial energy consumption factors per area were adjusted for an assumed building coverage of 20% of the industrial land area. Degree day adjustments for all factors were made as per Table IV-6 and Figure No. IV-1 of reference #1.

Transportation energy is a major part of an area's requirements. The factors are dependent on:

- the number of average daily trips made
- the mode by which the trips were made
- the purpose of the trip
- the average trip length

This data can be converted into energy consumption as will be demonstrated within each case study analysis.

The general procedure used is as follows. In order to quantify annual transportation energy, total annual passenger miles as a product of daily trips by mode, daily trip length and 365 days/year is converted into BTU's consumed. The primary assumptions are the trip generation rates which are based on the number of dwelling units and are available from a variety of sources. The consultant has utilized "The Planner's Energy Workbook" by Palmedo, Nathans and Carrol, Brookhaven National Laboratory, October, 1976 (Ref. No. 6). These rates will produce a total number of daily trips by trip purpose: to work, for shopping and other trips, the major categories. "Modal split" or the percentage of various modes utilized for the total trips were generally available from the local or regional transportation planning groups; the major modes being: auto, bus, rail and walking. The average trip length for each of the three purposes was also provided by "The Planner's Energy Workbook" (Ref. No. 6) and validated where possible from local data developed by transportation planning groups. Annual passenger miles are a product of the number of daily trips, the modal split, the trip length and 365 days/year. These are converted into annual BTU's by multiplying by a factor of BTU's/passenger mile which varies according to mode. These factors are found both in Ref. No. 6 and the "Source Book for Energy Assessment", by Morris Beller, Brookhaven National Laboratory, January, 1976 (Ref. No. 7).

Validation of Energy Consumption Estimates

The best method for validating the results obtained with the use of average factors is to get actual consumption data from the local utility companies for each case study area. This information is to be incorporated as part of Task 2, Phase III of the overall FEA study effort. However, this task was not assigned to the Conklin & Rossant/Flack + Kurtz team, and the report by the other consultant was not available prior to the end of the overall study effort.

It was, therefore, attempted to develop this information by contacting the local utility companies with varying results as is described under the case studies. The case study areas were selected, in part, on the basis of the availability of transportation data. The quality of the sources and the results vary widely, as will be shown under the case studies below.

If accurate utility and transporation data are available for an area under study, it is, of course, preferable to use that rather than average factors. Part of the effort of this study was to validate the applicability of the BNL factors of Reference No. 1 and 6.

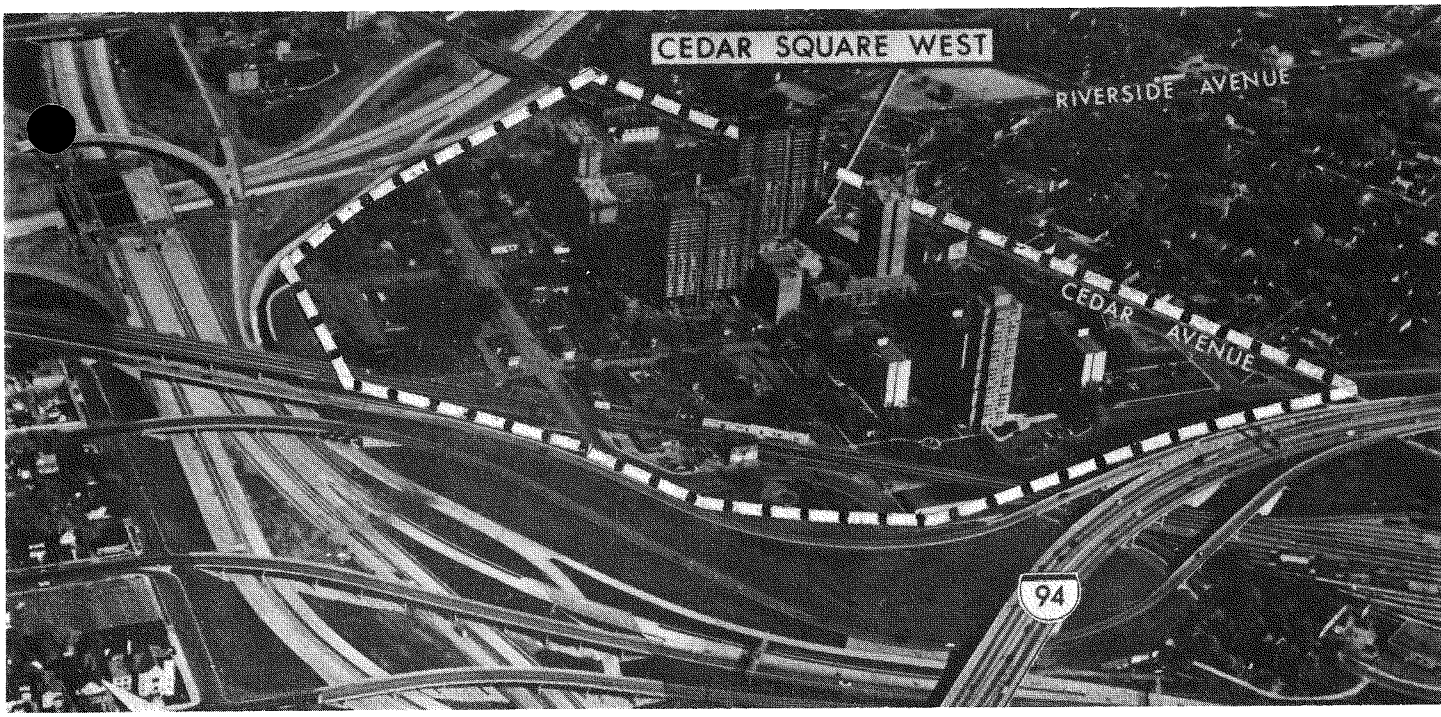
CASE STUDY: Cedar-Riverside, Minneapolis, Minnesota

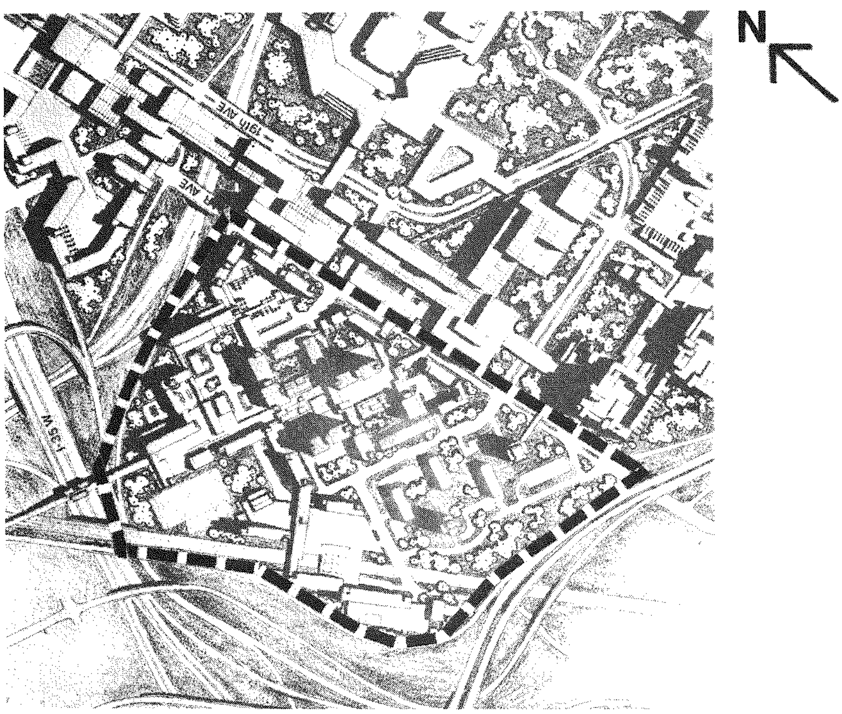
Existing Character:

Cedar-Riverside, a Title VII new town in town was intended to be a full service urban community. An environmental law suit stopped its planned growth at the first phase called Cedar West, the selected study area. Cedar West is primarily a high-rise residential complex with a component of community functions including social services and recreation. Office and retail elements are also included. This mixed use complex incorporates several energy conserving measures (centralized heating and cooling, and solid waste collection). Its location adjacent to downtown Minneapolis along with a high level of inner-city mass transit makes Cedar-Riverside a model suitable for analyzing these positive aspects. An aerial and graphic depiction of Cedar West appears in Figure 13, which follows.

The study area is made up of five sub-areas. The Cedar West Development described above is already built. Adjacent is a pre-existing complex of apartments for the elderly. The final three areas are presently deteriorating areas of low density housing and commercial uses, and are proposed for expansion in a similar fashion to the development of Cedar West.

All land use and population data for the Cedar-Riverside study area was provided by Cedar-Riverside Associates, the developer of the existing and proposed mixed use facilities.





EXISTING CEDAR-WEST DEVELOPMENT

FIG 13

Existing Energy Requirements:

The development of basic residential energy consumption factors is shown in Table 8. All factors must be modified for the higher degree days in Minneapolis, 8382 as compared to 5500 used in Ref. No. 1. Table IV-6, of the BNL report shows climatic variation factors for high rise multi-family of 7 MMB/ 1000^{o}days per year.

Base hi-rise factor	89
Add 7MMB (8.382 - 5.5)	20.2
Minneapolis	109.2 MMB/d.u./yr.

Similarly, a graph in Figure IV-1 of Ref. 1, shows an addition of .28 MMB/sq.ft. of space for land uses other than residential, and this was added to all factors used in the energy consumption summary (Table 9).

Annual energy consumption is summarized in Table 9, and the transportation energy consumption total is developed in Table 10.

Table 8: Energy Consumption Factors Per Dwelling Unit Per Year Cedar-Riverside

		MF High Rise
1.	Heating Oil/Gas MMB	47
2.	Heating Elec. MKWH	11
3.	Heating Elec. MMB	37.4
4.	Other Elec. MKWH	5.3
5.	Other Elect. MMB	18.0
6.	2% of (3)/100% Eff.	.75
7.	98% of (1)/65% Eff.	70.86
8.	Comb. Factor (5) + (6) + (7)	89.21
	Use	89

Notes:

- Basic factors are from Ref. No. 1, Table IV-8.
- Heating includes space and domestic hot water heating.
- "Other Electric" includes cooking, lighting, miscellaneous appliances, refrigeration and air conditioning.
- Breakdown into electric and gas/oil heating from 1970 Census.

Table 9: Summary of Existing Annual Energy Consumption
Cedar Riverside
(Test Area Population: 3305)

Land Use	UNITS	ENERGY CONSUMPTION PER YEAR		
	D. U.	REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family				
2-Family				
Low Rise M. F.				
High Rise M. F.	1,863	1	109.2	203,440
SUBTOTAL				203,440
	Sq. Ft.			
COMMERCIAL				
Office	13,100	1	.246	3,222
Retail				
Mall/Large				
Attached/Small				
Strip	36,600	1	.201	7,356
Hotel				
Food Service				
Recreation	17,200	1	.170	2,924
Theatres	19,000	2	.170	3,230
SUBTOTAL				16,732
INSTITUTIONAL				
Schools				
Hospitals				
Public Service	7,050	1	.246	1,734
Dormitory Type				
SUBTOTAL				1,734
INDUSTRY				
Light Industrial	40,800	1	.413	16,850
Warehouse				
SUBTOTAL				16,850
TOTAL (Less Transportation)				238,756
Transportation: See Table 10		1		35,000
GRAND TOTAL				273,756

Table 10: Existing Transporation Energy
Cedar-Riverside
(1863 d. u.)

	Trip Generation Rate (person trip/ d. u.)	Daily Trips (number)	Modal Split		Trip Length (miles)	Passenger Miles (000, 000)	BTU per Pass. Miles	Annual BTU's (000, 000, 000)
WORK	2. 20	4, 100			5. 1			
			auto	30%		2. 3	6, 600	15
			bus	10%		. 8	1, 150	1
			rail					
			walk	60%		4. 6		
SHOP	1. 75	3, 300			2. 8			. 007
			auto	30%		1. 0	6, 600	
			bus	10%		. 3	1, 550	
			rail			2. 0		
			walk	60%				
OTHER	1. 88	3, 500			4. 9			
			auto	30%		1. 9	5, 750	11
			bus	10%		. 6	1, 550	1
			rail					
			walk	60%		3. 7		
TOTAL	5. 83	10, 900			4. 4	17. 2		35
(actual)		(10, 500)					BTU/pass. mi. = 2, 000	

Validation:

For validating transportation energy consumption, the Metropolitan Regional Council had available the number of home based trips in the area, but there was little information on modes, and none on trip purposes. Factors for trip generation in the area as developed by Barton-Aschman Associates, Inc. were utilized to check the number of daily trips, as follows:

Table 11: Validation for Total Number of Daily Trips, Cedar-Riverside

	Size	Factor	Total Trips
Residential:	1,863 d.u.	4.4/d.u.	8,197.20
Office:	13,100 sq. ft.	8/1,000 sq. ft.	104.
Retail/Commercial	36,600 sq. ft.	22.5/1,000 sq. ft.	823.5
Recreation:	25,700 sq. ft.	19.5/1,000 sq. ft.	501.15
Industrial:	40,800 sq. ft.	22.5/1,000 sq. ft.	918.00
		Total	10,544.65

This compares very closely with the 10,900 average daily trips obtained with the BNL factors. It should be noted that the precentage of pedestrian trips in this community is unusually high, and the energy requirement of 2,000 BTU/pass. mi. is unusually low.

For validating the other energy requirements, the Minneapolis utility companies, Minnegasco and Northern States Power Co., were very helpful in that they made electricity, gas, and fuel oil data available to the study team. These quantities are summarized as follows:

Table 12: Existing Utility Consumption and Equivalent MMB's; Cedar-Riverside

Electric Power			
	11,560,655 KW hrs./yr. =	39,306	MMB
Natural Gas			
	116,035.3 MCF/yr.	116,035.3	MMB
Fuel Oil			
	418,052 gals. x .14 MMB/gal.	58,527.3	MMB
	Total	213,868.6	MMB

This is 10.42% lower than the total less transporation of Table 9. This reflects the energy efficiency of the central plant which services several buildings and is the largest user in this test area.

CASE STUDY: Near North Side, Chicago, Illinois

Existing Character:

The Chicago Near North Side is a high density diversified inner-city community whose commercial office, retail and residential components are growing rapidly to the extent that some of the original magnets of Chicago's Loop are shifting into the study area. It is also characterized by a number of large institutions including hospitals and university buildings and hotels and parking structures. An aerial view of the study area in its immediate context appears in Figure 14.

Because of the recent major building construction in Chicago's Near North Side, more recent population estimates had to be developed from the 1970 Census data. Increase factors for 1974 were available from the Chicago Area Geographic Information System and were also derived from data on residential telephone hook-ups from the Illinois Bell Telephone Company. The following indicates the population changes in the four Census Tracts since 1970:

Table 13: Population Change by Tract; Chicago

Tract	Total Population	% Change from 1970 Census
812	6911	+17%
813	8149	+17%
814	4789	- 2%
815	1342	+7.5%

The following assumptions were made for calculating Chicago/North Side Study Area Population:

- The portions of tracts 812, 813 and 815 within the study area were assumed to grow at the same rate as the entire tract.
- The population of the portion of tract 814 within the study area was assumed to have remained constant with the 1970 estimate and that the 2% decline occurred outside of the study area in the two block band adjacent to the waterfront.

Table 14: 1974 Population Calculations; Chicago

Tract	1970 Population of Study Area Portion of Tract	Increase Factor (base + increase)	1974 Estimate of Study Area Portion of Tract
812	1941	1.17	2271
813	4031	1.17	4716
814	2492	1.00	2492
814	40	1.075	43
		TOTAL	9522

In addition to the base residential population, the daily transient population in the area is estimated at 95,000, according to the Greater North Michigan Avenue Association. Land use data for Chicago was based upon information from the Greater North Michigan Avenue Assocation on hotel rooms, apartment hotels, retail square footage, rental apartment units, condominiums and coops, and office buildings. This data was supplemented by information on Water Tower Place and the John Hancock Building. Detailed maps of the Chicago study area were then analyzed at the Sanborn Map Company in Pelham, New York to provide the remaining information which was calculated on a block by block basis.

Existing Energy Requirements:

The development of basic residential energy consumption factors is shown in Table 15. Degree day modification is not required for Chicago because the Ref. No. 1 factors assumed the same average degree-days as those which are characteristic for Chicago.

The estimated existing energy consumption for the Chicago test area is summarized in Table 16 and the details of existing transportation energy consumption are shown in Table 17.

Table 15: Energy Consumption Factors Per Dwelling Unit Per Year, Chicago

		MF Low Rise	MF High Rise
1.	Heating Oil/Gas MMB	60	47
2.	Heating Elec. MKwh	14	11
3.	Heating Elec. MMB	47.6	37.4
4.	Other Elec. MKwh	5.3	5.3
5.	Other Elec. MMB	18	18
6.	97% of (1) x 65% eff.	89.53	70.14
7.	3% of (3) x 100% eff.	1.43	1.43
8.	Comb. Factor (5) + (6) + (7)	108.96	89.57
	use MMB/d.u.	109	90

Notes:

- Basic factors from Ref. No. 1 Table IV-8, Existing D.U.'s
- Heating includes space and domestic hot water heating.
- "Other Electric" includes cooking, lighting, miscellaneous appliances, refrigeration and air conditioning.
- Breakdown into electric and gas/oil heating from 1970 Census.

Table 16: Summary of Existing Annual Energy Consumption
Chicago
(Test Area Population: 9522)

Land Use	UNITS D. U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family				
2-Family				
Low Rise M. F.	365	1	109	39,785
High Rise M. F.	5,688	1	90	511,920
SUBTOTAL	6,053			551,705
	Sq. Ft.			
COMMERCIAL				
Office	4,382,200	1	.218	955,319
Retail				
Mall/Large	1,718,600	1	.1644	282,537
Attached/Small Strip	180,000	1	.0954	17,172
Hotel	1,862,400	1	.1466	273,151
Food Service	18,500	2	.300	5,550
Recreation	86,800	2	.142	12,326
Theatres	82,600	2	.142	11,729
SUBTOTAL				1,557,784
INSTITUTIONAL				
Schools	295,200	3&4	.15	44,280
Hospitals	443,500	1	.362	160,547
Public Service	168,700	2	.1446	24,394
Dormitory Type				
SUBTOTAL				229,221
INDUSTRY				
Light Industrial				
Warehouse	227,600	2	.062	14,111
SUBTOTAL				14,111
TOTAL (Less Transportation)				2,352,821
Transportation: See Table 17		1		392,000
GRAND TOTAL				2,744,821

Table 17: Existing Transportation Energy
Chicago
(6460 d. u.)

	Trip Generation Rate (person trip/ d. u.)	Daily Trips (number)	Modal Split		Trip Length (miles)	Passenger Miles (000, 000)	BTU per Pass. Miles	Annual BTU's (000, 000, 000)
WORK	2. 54	16, 400			5. 1			
			auto	65%		19. 8	6, 600	131
			bus	15%		4. 6	1, 150	5
			rail	20%		6. 1	4, 430	27
			walk					
SHOP	2. 20	14, 200			2. 8			
			auto	85%		12. 3	6, 600	81
			bus	15%		2. 2	1, 550	3
			rail					
			walk					
OTHER	2. 44	15, 700			4. 9			
			auto	85%		24. 0	5, 750	138
			bus	15%		4. 2	1, 550	7
			rail					
			walk					
TOTAL	7. 18	46, 300			4. 4	73. 2		392
(actual)		(20, 436)						BTU/pass. mi. = 5, 300

Validation:

The Chicago Area Transportation Study (CATS) made available the number of trips originating in the test area by trip purpose and mode. The resulting number of average daily trips were found to be as follows:

Table 18: Average Number of Daily Trips by Mode Chicago

Auto Driver	3,818
Taxi	8,234
Rapid Transit	1,117
Bus	2,408
Other	4,859
	20,436

The "Other" category includes auto passengers, pedestrians, and miscellaneous unassigned trips. This total is 55% lower than the total derived from Ref. No. 1 factors. As the CATS trip count is based on on-site survey techniques, it appears that the Ref. No. 1 BNL factors should be used with great caution in a high density inner-city situation, and that they appear more appropriate to suburban development patterns.

Since no utility company data of any kind were obtained for Chicago, no validation of the other energy consumption totals was possible. Comparisons can be made with the other Chicago test areas utilized by the Part I, FEA consultant: Booz, Allen and Hamilton.

CASE STUDY: Census Tracts 6 and 7, Tucson, Arizona

Existing Character:

The existing character of Tucson appears in the existing land use diagram (Figure 15), which has been superimposed over a 1974 aerial photograph and is statistically described in the following section. There are significant physical differences between Census Tracts 6 and 7. (See Figure 11 also).

Tract 6, closer to the University of Arizona, is basically a single family housing community. Homes are 5 du's per acre and multi-family units are scattered randomly throughout. Commercial development follows major east-west mile grids in nodes of greater concentration at intersections with the major north-south streets. There are two public elementary schools serving these neighborhoods. The street pattern rectangular grid has frequent intersections and rear alley access to most lots. Himmel Park is a large public park with tennis courts, swimming pool and a public library.

Tract 7 retains a small remnant of the Tract 6 pattern, but has two significant variations. There is a large quadrant of single family residential, fully built-up in long suburban subdivision blocks. There is also a significant area of business-industrial development. This Tract is also served by two elementary schools and by strip commercial along Broadway. A dry-river arroyo runs diagonally across the bottom of the Tract with other drainage ways also defined through the neighborhood. The Tucson High School athletic fields are in this area and some lots

LEGEND

- SINGLE FAMILY HOUSING
- MULTI-FAMILY HOUSING
- COMMERCIAL
- INSTITUTIONAL
- INDUSTRIAL

TUCSON EXISTING LAND USE

FIG 15

of vacant land are designed as government housing.

There are no significant parcels of vacant buildable property in either Tract, but there is a scattering of vacant lots throughout the residential neighborhoods. Existing street patterns and land uses are illustrated in Figure 15.

Tucson land use information was obtained from the City of Tucson, Department of Planning through whom the special Census data was also made available. Commercial, industrial, and institutional building areas were obtained and tabulated by a planning graduate student at the University of Arizona. These were available from Tucson tax assessment records. Reference was also made to aerial photography flown in 1974 and provided by the Planning Department.

Summary values for existing population and land use are tabulated along with the yearly energy consumption in Table 20. Work sheets through which these values were derived are available from the Consultant's files.

Existing Energy Requirements:

Energy consumption factors for residential uses were developed as shown in Table 19. Degree-day correction factors are shown in the same table. These factors are then used to determine the 1975 energy consumption of each of the land use categories in Table 20. The total transportation energy consumption estimate for 1975 is developed in Table 21.

Table 19: Energy Consumption Factors Per Dwelling Unit Per Year, Tucson

		MF Low Rise	MF High Rise
1.	Heating, Oil/Gas MMB	98	60
2.	Heating, Elec. MKWH	23	14
3.	Heating, Elec. MMB	78	47.6
4.	Other, Elec. MKWH	7.33	6.8
5.	Other, Elec. MMB	25.	23.
6.	4.34% of (3) x 100% eff.	3.38	2.06
7.	95.66% of (1) x .65% eff.	144.22	88.30
8.	Comb. Factor (6) + (7) + (5)	172.60	113.36
	degree day correction	(-) 52.14	(-) 37.24
	use factor MMB/D.U.	120.46	76.12

Degree Day Correction, Tucson

BNL degree days	5,500
Tucson degree days	1,776
diff.: degree days	3,724

S.F. residential 14 MMB/1000^{o} d x 3.724 = (-) 52.14

Low rise MF 20 " " x 3.724 = (-) 37.24
to be subtracted from above

All other factors:

5,500^{o} d - 5.3 MMB/100 sq.ft.

1,775^{o} d - 1.7 " "

difference: 3.6 " "
to be subtracted from all basic factors

Table 20: Summary of Existing Annual Energy Consumption
Tucson
(Test Area Population: 9758)

Land Use	UNITS D. U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family	3,520	1	120.46	424,019
2-Family				
Low Rise M. F.	900	1	76.12	68,508
High Rise M. F.				
SUBTOTAL	4,420			492,527
	Sq. Ft.			
COMMERCIAL	848,053	1	.182	154,346
Office				
Retail				
Mall/Large				
Attached/Small				
Strip				
Hotel				
Food Service				
Recreation				
Theatres				
SUBTOTAL				154,346
INSTITUTIONAL	21,630	2	.114	2,465
Schools				
Hospitals				
Public Service				
Dormitory Type				
SUBTOTAL				2,466
INDUSTRY				
Light Industrial	183,338	1	.349	69,384
Warehouse				
SUBTOTAL				69,384
TOTAL (Less Transportation)				718,723
Transportation: See Table 21		1		246,000
GRAND TOTAL				964,723

Table 21: Existing Transportation Energy
Tucson
(4420 d. u.)

	Trip Generation Rate (person trip/ d. u.)	Daily Trips (number)	Modal Split		Trip Length (miles)	Passenger Miles (000, 000)	BTU per Pass. Miles	Annual BTU's (000, 000, 000)
WORK	2.20	9,700			5.1			
			auto	97%		17	6,600	112
			bus	3%		1	1,150	1
			rail				4,430	
			walk					
SHOP	1.75	7,700			2.8			
			auto	97%		8	6,600	53
			bus	3%		–	1,550	
			rail					
			walk					
OTHER	1.88	8,300			4.9			
			auto	97%		14	5,750	80
			bus	3%		1	1,550	–
			rail					
			walk					
TOTAL	5.83	25,700			4.4	41		246
(Actual)		(31,000)						

BTU/pass. mi. = 6,000

Validation:

Total vehicle trips originating in Census Tracts 6 and 7, the study area, were 31,107 according to Census data. This is 17.36% higher than the total derived from Ref. No. 1 data (Table 21).

No utility company data were available for the area, so no comparison was possible for the other energy consumption components.

Growth Projection Scenarios:

The following discussion provides the basis for developing the land use and population projections for two growth scenarios:

- planned "energy sensitive" growth
- unplanned "laissez-faire" growth

The energy consequences of these two approaches are then calculated based on a feasible urban design proposal for the former and then evaluated against each other and the existing level of consumption.

The City of Tucson and its metropolitan area constitute a growing region. According to the draft of "The Comprehensive Plan" prepared for community review in 1975,

> "it is obvious that the Tucson area has not been growing in harmony with national demographic trends, but at a much more rapid rate."

Statistics from the 1970 Census show Pima County with a population of 351,667. This has grown to 448,926 according to the 1975 Special Census, a five year increase of almost 28% and very close to the projected 1975 figure in "The Comprehensive Plan" report.

In the Population Growth section of the Plan, a regional population forecast for the year 2000 has been set at 800,000. A study of the costs of alternative growth patterns to accommodate the population increase to 800,000 or 1,000,000 was prepared for the Comprehensive Planning Process by Booz, Allen & Hamilton, Inc. in July 1974. Their conclusions support a policy of contained growth for preservation of the land, economies of capital expenditure, and "improving the quality of life for Tucson residents."

The present population trend in our study area, Census Tracts 6 and 7, is one of decline in contrast to the overall Pima County growth which is presently occurring in an expansionary pattern but primarily on the outskirts of the urban area.

Table 22: Present Population Trends/Census Tracts 6 and 7

	1970	1975	% decrease
Census Tract 6	5402	4896	9.4
Census Tract 7	5598	4862	13.1

A reversal of the downtown population decline is a necessary component of the adoption of a contained growth policy for the urban region. Development of new housing units in inner-city areas will have to offer amenities and advantages competitive with those features currently attracting residents to new low density single family homes outside the downtown area.

The search for such solutions creates an equal opportunity for energy savings in building systems and design and in land use planning. The goals of contained growth and of energy conservation are highly compatible.

The selection of this portion of Tucson, a presently declining inner-city section of a small and expanding metropolitan area is an excellent opportunity to explore solutions for urban revitalization while analyzing the energy saving components.

For the purpose of this study we have referred to certain projections provided to the consultant by the Pima Association of Governments (PAG). These were developed for use in transportation planning programs. Two different studies were undertaken. The first, prepared in 1962, projected land use, population and dwelling units for the year 1995. This study showed optimistic population growth for the area and in land use development favored multi-family housing. The second projection, for the year 2000, was done in 1975 for use in the Alternate Modes study and reflects the actual declining population trend. In spite of the total population decline, the projections also note increasing acreage for multi and single family housing units, favoring the latter.

In the table below, the existing conditions' data devised for Traffic Assignment Zones (TAZ), which corresponds to the Tracts, is presented along with the two sets of PAG projections.

Table 23: Pima Association of Governments, Existing and Projected Population, Dwelling Units and Land Use Acreage

	1973 _/1	1995 _/2	2000 _/3
Census Tract 6			
Acres:			
Single Family Residential	309	294	389
Multi-Family Residential	71	135	106
Business	29	44	40
Industrial	1	2	2
Vacant	27	22	2
Population:	5739	6987	6057
Dwelling Units:	2528	2777	2019
Census Tract 7			
Acres:			
Single Family Residential	277	246	286
Multi-Family Residential	29	97	44
Business	73	63	93
Industrial	14	31	47
Vacant	129	61	12
Population:	5723	7182	3198
Dwelling Units:	2008	2394	1066

Sources:
_/1. TAZ estimates
_/2. PAG transportation planning projections
_/3. PAG alternate mode study projections

Whereas the projections for the year 2000 may represent current trends extended to the end of the century, the goal of both this energy study and contained growth policy requires the trend's reveral. We have, therefore, selected the projected number of dwelling units derived in the projections for 1995 and compared this to the existing number of units from the 1975 Special Census. This produces an increase of 363 dwelling units in Census Tract 6 and 387 in Tract 7. These will be used as our basis for planning the new housing units in each of these areas.

Table 24 describes the program which this study utilizes, comparing consequences of an energy conserving planned growth scenario with projected continuation of present unplanned "laissez-faire" trends.

For the planned growth scenario dwelling units are assumed to increase as indicated above. Population for this projection is modified to add an increment of 3 people per added dwelling unit to the Special Census 1975 population. Commercial acreage in each tract is increased in direct proportion to the present relationship of commercial acres to number of dwelling units: the square footage of commercial building is assumed at a Floor Area Ratio (FAR) of .5. Industrial acreage is increased by the definition of a proposed commercial-industrial zone and the calculation of available presently non-industrial land within those confines. The industrial FAR is assumed at .2.

For the unplanned growth scenario, Census Tract 6 can be assumed to follow the same growth but developing in unplanned patterns. Census Tract 7 shall be assumed to decline in population according to the PAG year 2000 projection. This anticipates the same industrial development as in the planned proposal, but at the expense of lost dwelling units without the amenities for multi-family housing and recreation incorporated in the planned proposal. Commercial growth is assumed to be negligible and remain unchanged from the existing level as much of the Tract 7 commercial is business related rather than retail. The population decline in Tract 7 will mean that the overall Tucson growth will be housing this number of units elsewhere.

Table 24: Census Tract 6 and 7 Study Area Program

Census Tract 6	Existing 1975	Energy Sensitive Planned 1995	Laissez-Faire Unplanned 2000
Population	4896_/1	5986	6057 _/4
Dwelling Units	2414_/1	2777_/3	2019_/4
Commercial	26.86 acres 259,489 s.f._/2	30.9 349,489	30.9 349,389
Industrial		Negligible	
Institutional	22.46 acres	24.46	24.46

Planned & Unplanned
Scenario:
- 363 additional dwelling units
- (assume 420 new multi-family units to allow for some replacement of existing single family)
- 4.01 acres or 90,000 sq. ft. additional commercial
- 2 acres of 50,000 sq. ft. additional community facilities

Table 24: Census Tracts 6 and 7 Study Area Program (con't)

Census Tract 7

Population	4862 _/1	6023	3198_/4
Dwelling Units	2007_/1	2394_/3	1066_/4
Commercial	66.53 acres 588,564 s.f._/2	79.36 868,564	66.53 588,564
Industrial	32.68 acres 182,012 s.f._/2	62.09 432,012	62.09 432,012
Institutional	60.63 acres	62.63	60.63

Planned Scenario:

- 387 additional dwelling units
- (assumed 500 new multi-family units to allow for some replacement of existing single family by both multi-family and industrial
- 12.83 acres or 280,000 additional sq. ft. of commercial uses
- 29.41 acres or 250,000 additional sq. ft. of industrial uses
- 2 acres or 50,000 additiona sq. ft. of community facilities

Unplanned Scenario:

- 941 decrease in dwelling units
- commercial and institutional uses unchanged from existing
- industrial uses increase same as above

Sources:
_/1 1975 Special Census
_/2 Robert Blau, Tucson Land Use Data Compiler
_/3 PAG transportation planning year 1995 projections
_/4 PAG alternate modes study year 2000 projections

Tucson Tract 6 Energy Sensitive Urban Design Proposals:

The Tucson urban design proposals are graphically depicted in Figure 16-19, with the first diagram, an area-wide plan view serving as a locational diagram for the Tract 6 Speedway Center seen in Figure 18, and Tract 7 Broadway Center seen in Figure 19.

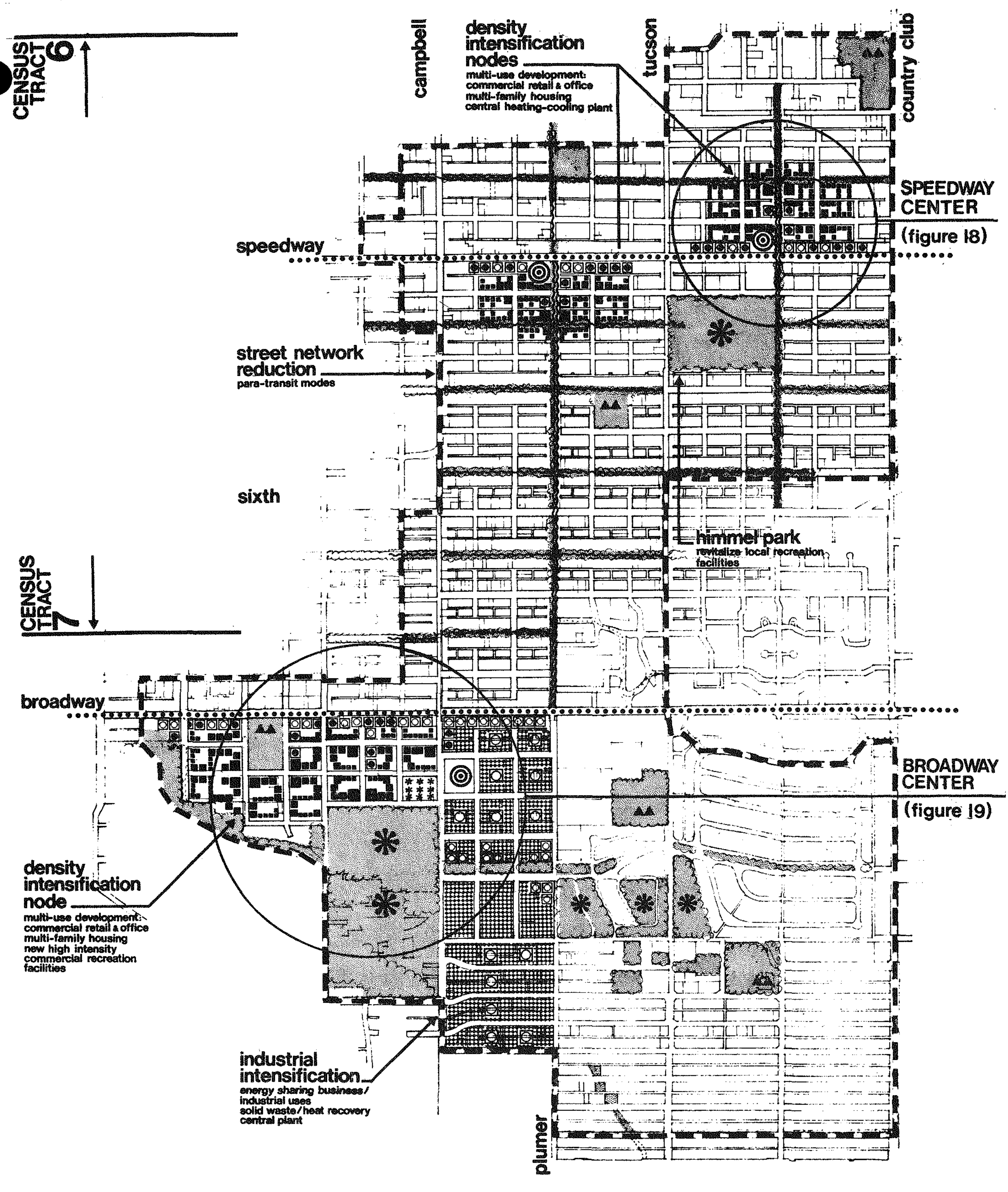
Most new housing to occur in inner-city areas shall be multi-family groupings. It is proposed that these be at densities ranging from 12 du/acre in town houses to 25 du/acre in garden apartment and mid-rise units. New construction, in order to take advantage of potential energy system sharing and efficiency, shall be concentrated in density intensification nodes. The program of 420 units in Tract 6 shall be divided into two groups of 210 dwelling units each with a common cental heating and cooling plant serving the new development. Design of these housing units shall be arrived at so as to provide unit sizes, open space, views and facilities competitive with single family homes. The housing program is summarized as follows:

150 du @ 25 du/acre = 6 acres

60 du @ 12 du/acre = 5 acres

11 acres/each node

Nodes are to be located on either side of the shopping street, in this case Speedway, and new commercial uses shall be developed in available parcels within the node's spine as seen in Figure 16. The nodes are situated at the ends of north-south pdestrian bike-ways developed within this tract area and described



LEGEND

- MULTI-FAMILY HOUSING
- COMMERCIAL RETAIL
- COMMERCIAL OFFICE
- INSTITUTIONAL
- INDUSTRIAL
- OPEN SPACE FOR RECREATION
- LOCAL SCHOOL
- NEW ENERGY SYSTEMS
- COMMERCIAL RECREATION
- MASS TRANSIT
- PARA-TRANSIT
- STUDY AREA BOUNDARY

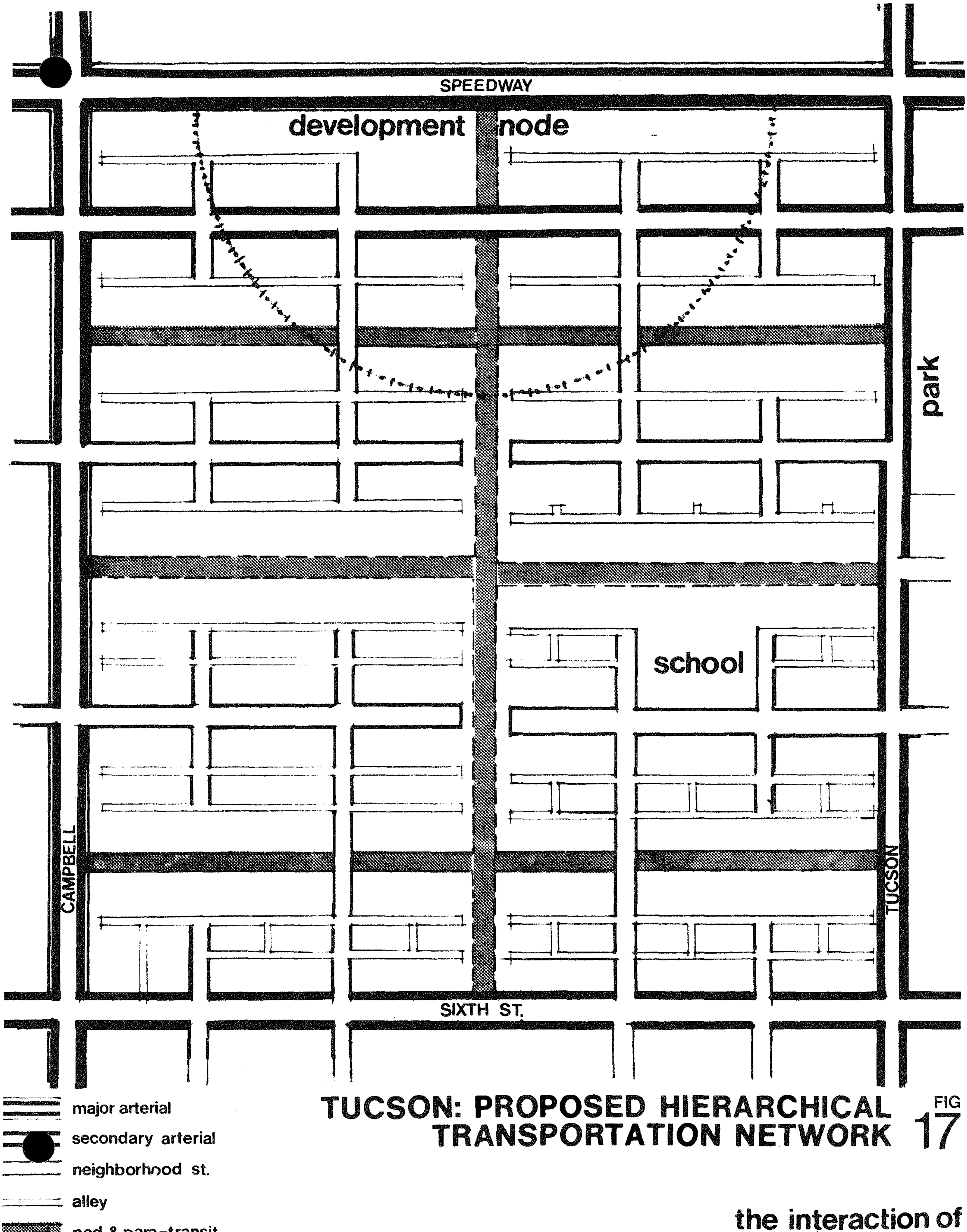
TUCSON: 1995 PLANNED ENERGY CONSERVING DEVELOPMENT FIG 16

in detail below. A small additional number of single family units may be built on the remaining scattered vacant properties and in some lots created by street closings.

In an effort to reduce reliance on individual automobiles and enhance energy-saving transporation via walking, biking, and public para-transit systems, the street pattern in this Tract is to be revised to reduce the total amount of paved roadway, reduce the amount of through east-west and north-south thoroughfares and create a series of limited or no automobile greenways through the community.

The proposed heirarchical pattern of raodways is based on the mile-grid of thoroughfares here bounded by Broadway, Speedway, Campbell and Country Club. These remain as principal through traffic routes, and by cross street closings, the number of interruptions by lights and turning cars has been greatly reduced. Each square mile is also bisected in both directions by secondary through streets, here Sixth Avenue and Tucson Boulevard.

The square mile thus divided into four quadrant neighborhoods is served by fewer existing streets giving auto access to each house via some streets and all back alleys. The north-south streets of Plumer and Treat become pedestrian bikeways which collect from several east-west similarly closed streets and feed the new multi-family nodes and intensified neighborhood retail centers. A typical quadrant pattern is shown in Figure 17, which follows.



TUCSON: PROPOSED HIERARCHICAL TRANSPORTATION NETWORK FIG 17

In order to discourage travel to distance recreation centers and to encourage living in central city locations, city recreation areas such as Himmel Park shall be reinforced with added facilities and activity programs. Parking shall be replaced with bicycle racks and new recreation uses such as tennis, swimming, nature centers, fairs, theatre and dance, art and food activities.

All areas of existing commercial shall remain on principal automobile through routes. Additional commercial growth to accommodate planned population increases shall be limited to development in these existing areas and integrated into the higher density nodes of new residential units. The commercial program is summarized as follows:

90,000 sq. ft. of building

FAR = .5

4.04 acres

Institutional land uses are limited to schools and community facilities. It is assumed that the school sites are sufficient to handle the population changes, but pedestrian access to these sites shall be improved and developed. New community facilities shall also be integrated into the radially developing nodes. The institutional program is summarized as follows:

50,000 sq. ft. of building

2 acres

If in the future beyond the projected development, greater quantities of new multi-family housing and related activities are needed, similar nodes may develop on opposite sides of the major avenues from the presently proposed clusters.

By the proposed development combination of new construction concentration and street pattern change, a new neighborhood identity should develop. Commercial areas will be reinforced with greater numbers of residents in walking range of shopping. Bikeways and walkways will encourage this. New development nodes will also be located at bus stops for public transit on major thoroughfares to distant work or other destinations. Para-transit systems may also be developed to move along the non-automobile routes connecting neighborhood retail, educational, recreation and public functions with the housing units. A conceptual sketch of a typical density intensification node, Speedway Center, follows as Figure 18.

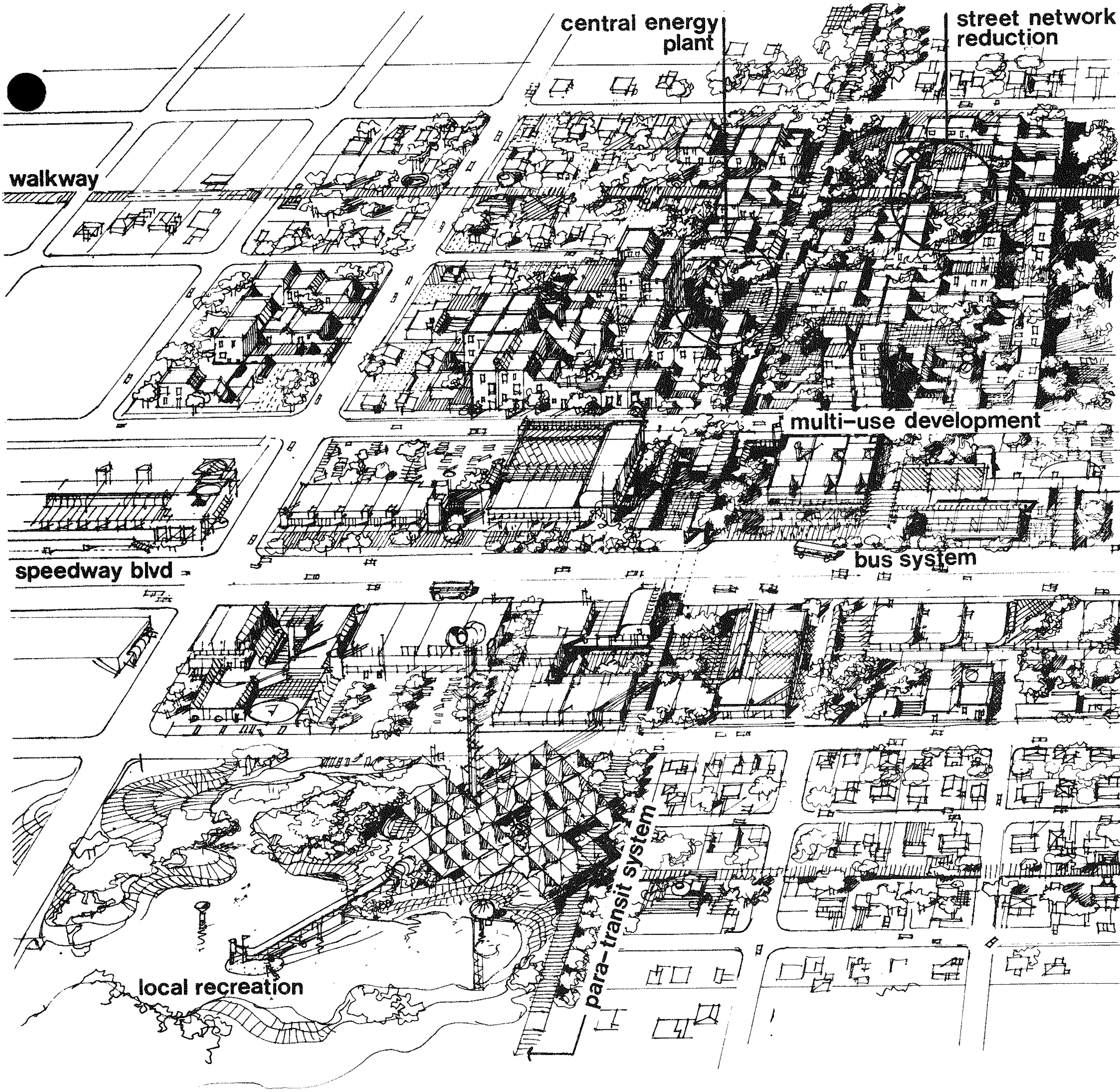
Of the thirteen energy conserving design measures described in Section B, the following have been employed in Census Tract 6:

Land Use Densification and Revitalization

3. Older housing communities
4. Multi-use centers

Local Auto Travel Reducation

6. Street network reduction
7. Alternate transportation modes



SPEEDWAY CENTER (TRACT 6)
PROPOSED PHYSICAL CONCEPT

FIG 18

Energy System Integration into Mixed Land Uses

8. Energy efficient infrastructure

Regional Growth Management to Achieve Trip Reduction

12. Local recreation revitalization

Tucson Tract 7 Energy Sensitive Urban Design Proposals:

Business and commercial land uses are presently found in Tract 7 in several locations between Cherry Avenue and Tucson Boulevard. Some parcels are adjacent to the arroyo at the south-western edge of the Tract and are separated from existing residential to the north by high school athletic fields. In the blocks south of Broadway and bounded by Campbell and Plumer, present business and industrial uses are mixed with mobile homes, single family houses, and vacant properties. This entire band is proposed for commercial business and industrial uses, creating an intensified industrial use in a coordinated, energy efficient and system sharing concentration. Within this band is located a new solid waste incinerator - central energy plant which will serve not only the new industrial facilities, but adjacent new commercial uses developed along Broadway and the new multi-family housing complex to the west. The projected program is summarized as follows:

Additional commercial uses	280,000 sq. ft. of building
	12.83 acres
Additional industrial uses	250,000 sq. ft. of building
	29.41 acres

The program of 500 new multi-family housing units for Tract 7 shall be developed in a single major cluster labelled the Broadway Center surrounding the Miles Elementary School. This area was selected for several reasons. It is presently isolated geographically by the arroyo to the south and by Broadway to the north. The proposed industrial intensification will eliminate some remaining single family homes to the east. The entire south-eastern portion of the Tract will remain a homogenous single family neighborhood. The several blocks surrounding the Miles School hence become an isolated pocket of remaining single family housing with some scattered multi-family units and vacant lots ideally suited to density intensification. Single family units will be replaced with new multi-family units. The school serves as the nucleus of the renewed neighborhood with easy access for families with children. The location adjacent to Broadway allows continuance of existing commercial uses and new retail construction related to the new development.

The new housing as already noted will also tie into the incinerator - central plant located in the adjacent industrial/business area. The proposed program is as follows:

350 dwelling units @ 25 du/acre =	14 acres
150 dwelling units @ 12 du/acre =	12. 5 acres
Total	26. 5 acres

Presently there is no public recreation facility in this neighborhood of Tucson. With redevelopment of the Broadway Center in the Miles neighborhood, a linear park development is proposed along the arroyo bed as an inner-city recreation park linking with Tucson High School playing fields and connecting to a future.

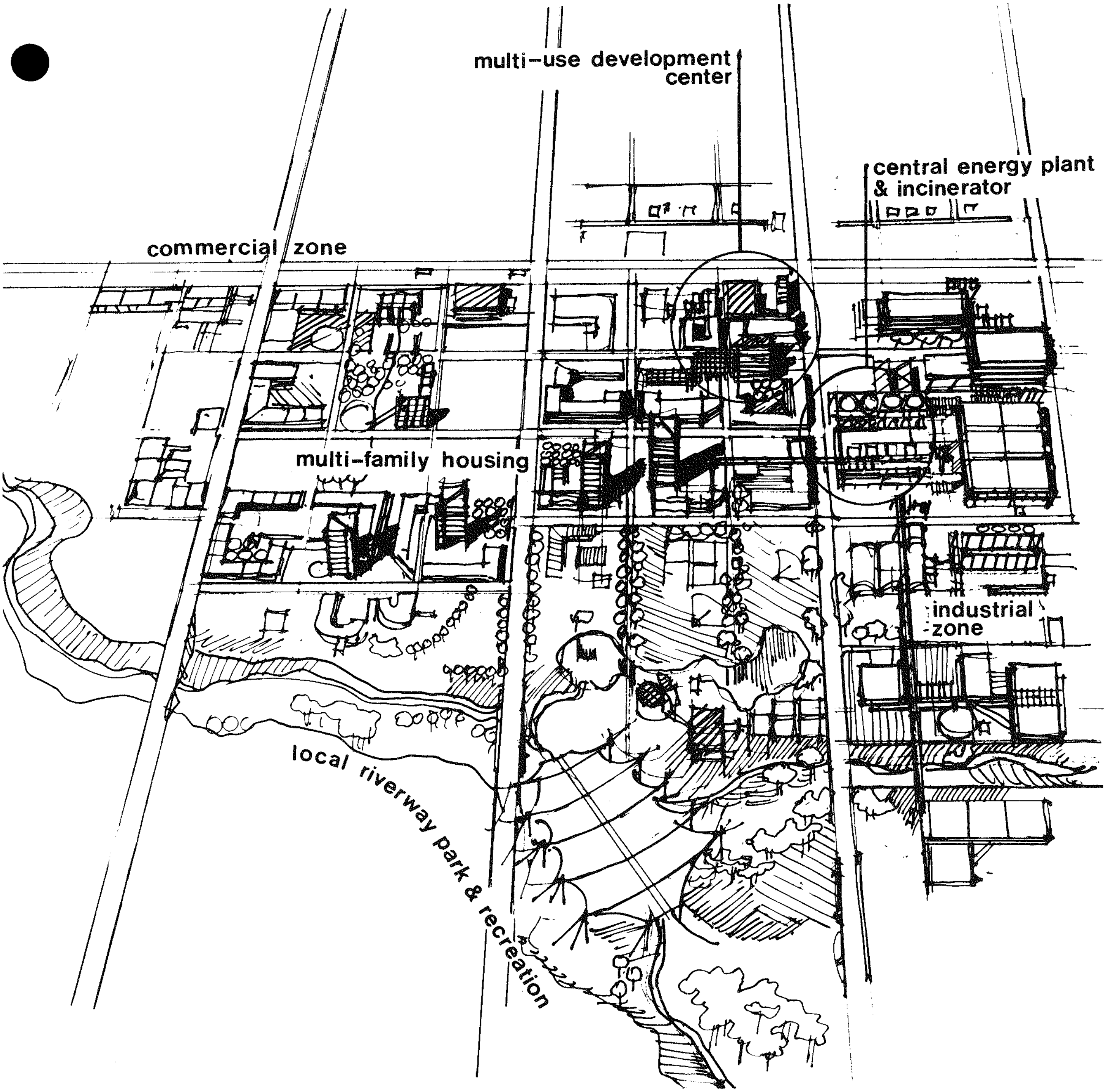
recreation development in the government housing vacant lands to the east of the industrial zone. This will also serve as recreation focus for the present single family homes in that sector. (See Figure 16).

No specific transportation changes are proposed for this area except the elimination of through streets in the industrial park. Proximity of new housing to commercial, recreation, new business and industrial job sources as well as major bus stops will reduce automobile trip travel.

The Tract 7 plan for an energy conserving future takes advantage of a variety of land use mixes, particularly in this case, the combination of new and existing industry sharing energy systems with new multi-family housing through the waste incineration central plant system, described in full in the following section on technology related energy conservation.

Attracting new housing to what otherwise might be a declining area will be accomplished partially through development of an adjacent major new recreational facility. New housing in town-house and higher density units clustered around the school and combined with new shopping and community facilities in the Broadway Center is also close to employment opportunities within the adjacent business/industrial zone.

An overall plan view diagram of the Tract 7 proposal appears in Figure 16. A conceptual sketch of the Broadway Center, its major density intensification node with the adjacent business industrial zone follows as Figure 19.



BROADWAY CENTER (TRACT 7)
PROPOSED PHYSICAL CONCEPT

FIG 19

Of the thirteen energy conserving design measures described in Section B, the following have been employed in Census Tract 7:

Home-to-Work Travel Reduction

1. Multi-family housing/employment and services

2. Housing income/employment

Land Use Densification and Revitalization

4. Multi-use town centers

5. Industrial intensification

Energy System Integration Into Mixed Land Uses

8. Energy efficient infrastructures

10. Residential/industrial energy uses

Regional Growth Management to Achieve Trip Reduction

13. New location recreation

Tucson, Arizona/Growth Patterns and Energy Proposals:

Growth races on at the periphery of Tucson while older areas nearer the central business district flounder and even decline. Despite the appeal to the pocketbook of "inner-suburb" living, the periphery will continue to grow faster. New population centers along Speedway and Broadway can only be proposed if a total approach to their re-planning takes place; by total we mean a comprehensive approach to the design of housing, recreation, shopping centers, and the interaction between them. Most assuredly, the parks, shopping and residential areas should be planned as one. Schools also should be incorporated and worked into the new dense activity centers. Each component must be made to feed off the total so that energy savings in all work, shopping and home bound trips will occur. It has been characteristic of areas like Speedway and Broadway in Tucson to disperse all these activities.

Tucson's peripheral areas take the lion's share of growth because the inner-city areas have few appealing recreational, free-and-easy life mode and newness and prestige qualities characteristic of these growth areas. It is our strong conclusion that areas like Speedway and Broadway can only attract the needed growth if, in addition to the built-in locational advantages and economies (including energy economies), they also are given the prestige and amenities to appeal to a broad market.

The land development pattern of Tucson is essentially a copy or adaptation of the type of land development in areas in the East and Mid-Western Plains: St. Louis, Chicago, Toledo, Cleveland, back to Nassau County, New York. That is green lawns, rich deciduous shade trees, relatively plentiful water, a more of less cool moist climate. In Tucson, not one of these natural elements is present, yet the land development style is all too familiar. Nowhere in the historic development of cities is clustering, dense development and economy in the use of space more evident than in population centers in desert areas, for example in North Africa, where city dwellers huddle together in a seeming effort to save every precious drop of moisture and every step of movement in the dry searing heat.

Not true in Tucson where the single family bungalow with its parched yard, the suburban roads and the parking lots baking in the sun reach endlessly to the horizon.

Future Energy Requirements 1995:

Energy requirements as related to the projected land uses for the 1995 unplanned and energy conserving planned scenarios for Census Tract 6 and 7 in Tucson are shown in Tables 25 and 27. Factors were adjusted to reflect changes in density and composition in the land use configureations, such as the shift from strip to centralized commercial retail facilities.

Related transportation energy requirement estimates are calculated on Tables 26 and 28 for the 1995 unplanned and planned scenarios, respectively. Transportation consumption for the two scenarios was influenced by the following considerations:

Unplanned:

- Simple extrapolation of present trends (but including improved gasoline mileage for vehicles).

Planned:

- Doubling of the industrial floor space increases industrial employment opportunities to 6,000 jobs. It is assumed that 10% of jobs (commercial plus industrial) are available to local residents. The resultant work mode shift becomes:

Auto	97%	to	80%
Bus	3%	to	10%
Walk	-	to	10%

- Closing half the streets in the area to vehicles provides better access to shopping opportunities. It is assumed that there is no change in the trip lengths as trips are already short in the inner-city area. The resultant mode shifts for shopping becomes:

Auto	97%	to	60%
Bus	3%	to	10%
Walk	-	to	30%

As the "other" trips are considered to be longer and less amenable to shifts toward walking, the resultant shifts are:

Auto	97%	to	80%
Bus	3%	to	10%
Walk	-	to	10%

Table 25: **Summary of Projected Annual Energy Consumption**
1995 Unplanned Growth Scenario
Tucson
(Test Area Population: 9,255)

Land Use	UNITS D.U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family	2,522	1	120.46	303,800
2-Family				
Low Rise M. F.	1,320	1	76.12	100,478
High Rise M. F.				
SUBTOTAL	3,842			404,278
	Sq. Ft.			
COMMERCIAL	938,053	1	.182	170,725
Office				
Retail				
Mall/Large				
Attached/Small				
Strip				
Hotel				
Food Service				
Recreation				
Theatres				
SUBTOTAL				170,725
INSTITUTIONAL				
Schools	71,630	2	.114	8,165
Hospitals				
Public Service				
Dormitory Type				
SUBTOTAL				8,165
INDUSTRY				
Light Industrial	432,000	1	.349	123,800
Warehouse				
SUBTOTAL				123,800
TOTAL (Less Transportation)				706,968
Transportation: See Table 26				150,000
GRAND TOTAL				856,968

Table 26: Projected Transporation Energy
1995 Unplanned Growth Scenario
Tucson
(3842 d. u.)

	Trip Generation Rate	Daily Trips	Modal Split		Trip Length	Passenger Miles	BTU per Pass. Miles	Annual BTU's
	(person trip/ d. u.)	(number)			(miles)	(000, 000)		(000, 000, 000)
WORK	2. 20	8, 400			5. 1			
			auto	97%		15. 1	4, 600	69
			bus	3		7. 3	800	
			rail					
			walk					
SHOP	1. 75	6, 700			2. 8			
			auto	97%		6. 7	4, 600	31
			bus	3		. 1	1, 100	
			rail					
			walk					
OTHER	1. 88	7, 200			4. 9			
			auto	97%		12. 5	4, 000	50
			bus	3%		. 3	1, 100	
			rail					
			walk					
TOTAL	5. 83	22, 300				35		150

BTU/pass. mi. = 4, 300

Table 27: Summary of Projected Annual Energy
1995 Planned Energy Conserving Development Scenario
Tucson
(Test Area Population 12,000)

Land Use	UNITS D. U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family	3,350	1	120.46	403,541
2-Family				
Low Rise M. F.	1,820	1	76.12	138,538
High Rise M. F.				
SUBTOTAL	5,170			542,079
	Sq. Ft.			
COMMERCIAL	1,218,600		.162	197,413
Office				
Retail				
Mall/Large				
Attached/Small				
Strip				
Hotel				
Food Service				
Recreation				
Theatres				
SUBTOTAL				197,413
INSTITUTIONAL				
Schools	121,630		.114	13,866
Hospitals				
Public Service				
Dormitory Type				
SUBTOTAL				13,866
INDUSTRY				
Light Industrial	432,000		.349	123,900
Warehouse		2		
SUBTOTAL				123,900
TOTAL (Less Transportation)				877,258
Transportation: See Table 28		1		166,000
GRAND TOTAL				1,043,258

Table 28: Projected Transportation Energy
1995 Planned Energy Conserving Development Scenario
Tucson
(5170 d. u.)

	Trip Generation Rate (person trip/ d. u.)	Daily Trips (number)	Modal Split		Trip Length (miles)	Passenger Miles (000, 000)	BTU per Pass. Miles	Annual BTU's (000, 000, 000)
WORK	2. 20	11, 400			5. 1			
			auto	80%		12. 0	4, 600	78
			bus	10%		2. 1	800	2
			rail					
			walk	10%		2. 1		
SHOP	1. 75	9, 200			2. 8			
			auto	60%		5. 7	4, 600	26
			bus	10%		. 9	1, 100	1
			rail					
			walk	30%		2. 8		
OTHER	1. 88	9, 900			4. 9			
			auto	80%		14. 3	4, 000	57
			bus	10%		1. 8	1, 100	2
			rail			1. 8		
			walk	10%				
TOTAL						48. 4		166

BTU/pass. mi. = 3, 500

Technology Related Energy Conservation:

The configuration of land uses in the planned energy conserving development proposals for Tucson were arranged to make it possible to utilize technology that will influence energy consumption. These potential savings are additive to those resulting from only the optimized land use design itself.

It is proposed to use two central plants in Census Tract 6 in conjunction with the two new density intensification nodes (see Figure 16). Solid waste heat recovery does not appear to be practical because of locational problems. Solar energy for domestic hot water will be tested.

In Census Tract 7 one central plant together with a heat recovery incineration system is proposed to be located in the industrial zone. The possible balance of energy requirements with supplies is shown in Figures 20 and 21. In the case of both Tract 6 and 7, the summer cooling requirement (which does not include existing commercial uses) is larger than the winter requirement. If it could be arranged to have existing commercial uses heated (but not cooled) from the central plant, better utilization of the primary equipment would result (see heating totals in parentheses in Table 29 and 30).

Solid waste generated on-site produces one-quarter of the total peak requirements; there is no reason why the incinerator could not be sized to serve the solid waste generated by an area broader than Tracts 6 and 7, if the economics and the institutional arrangements make it feasible.

Table 29: Summary of Demands
Census Tract 6, Tucson
1995 Planned Energy Conserving Development Scenario

Land Use	Solid Waste lbs/day	Electric KW	Heating MBH	D H W MBH	Cooling TR
Residential					
New		630	10,500	1,680	700
Total	24,000				
Commercial					
New		360	1,800	135	300
Total	10,500		(7,000)		
Institutional					
New	1,000	125	1,250	100	167
Totals	35,000	2,155	13,550	1,895	1,167
			(18,750)		

Solid Wastes:

35,500 lbs. sw/day = 17.75 tons per day

$$35,500 \times 3 \text{ MB/lb sw} = \frac{106,500 \text{ MB/day}}{16 \text{ hrs.}} = 6,656 \text{ MBH}$$

Cooling:

1,167 TR x 16 lbs. steam/TR/hr. = 18,670 lbs. steam/hr.

or 18,670 MBH

Table 30: Summary of Demands
Census Tract 7, Tucson
1995 Planned Energy Conserving Development Scenario

Land Use	Solid Waste lbs/day	Electric KW	Heating MBH	D H W MBH	Cooling TR
Residential					
New		750	12,500	2,000	835
Total	24,000				
Commercial					
New		1,120	5,600	420	935
Total	26,000		(17,376)		
Institutional					
New	1,000	125	1,250	100	167
Industrial					
Total	3,200	2,000	10,625	2,800	1,440
	83,000	3,995	29,975	5,320	3,377
Use	83,000	4,000	30,000 (47,345)	5,320	3,400

Solid Wastes:

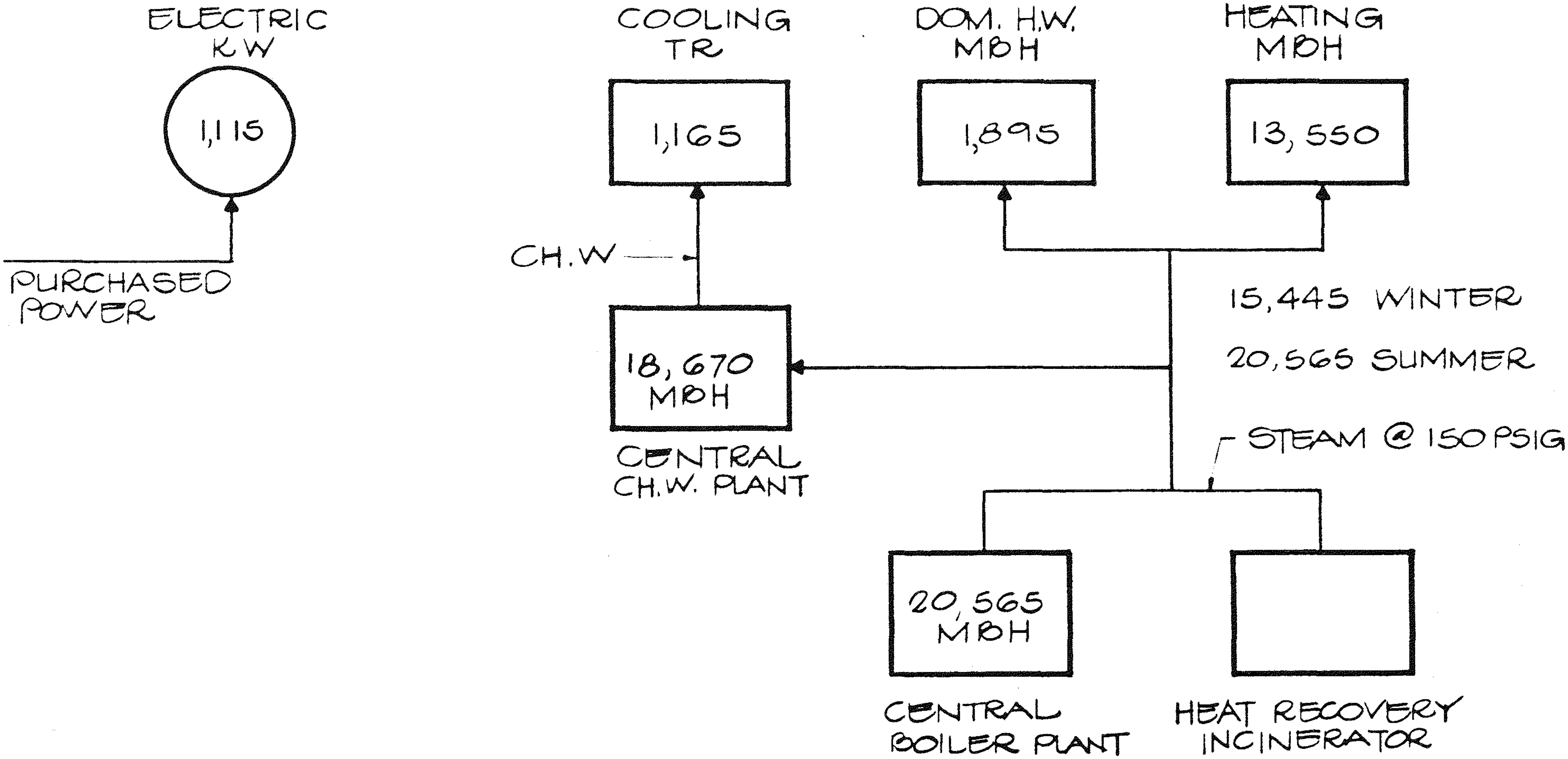
83,000 lbs/day = 41.5 tons per day

83,000 x 3 MB/lbs. S.W. = 249,000 MB/day

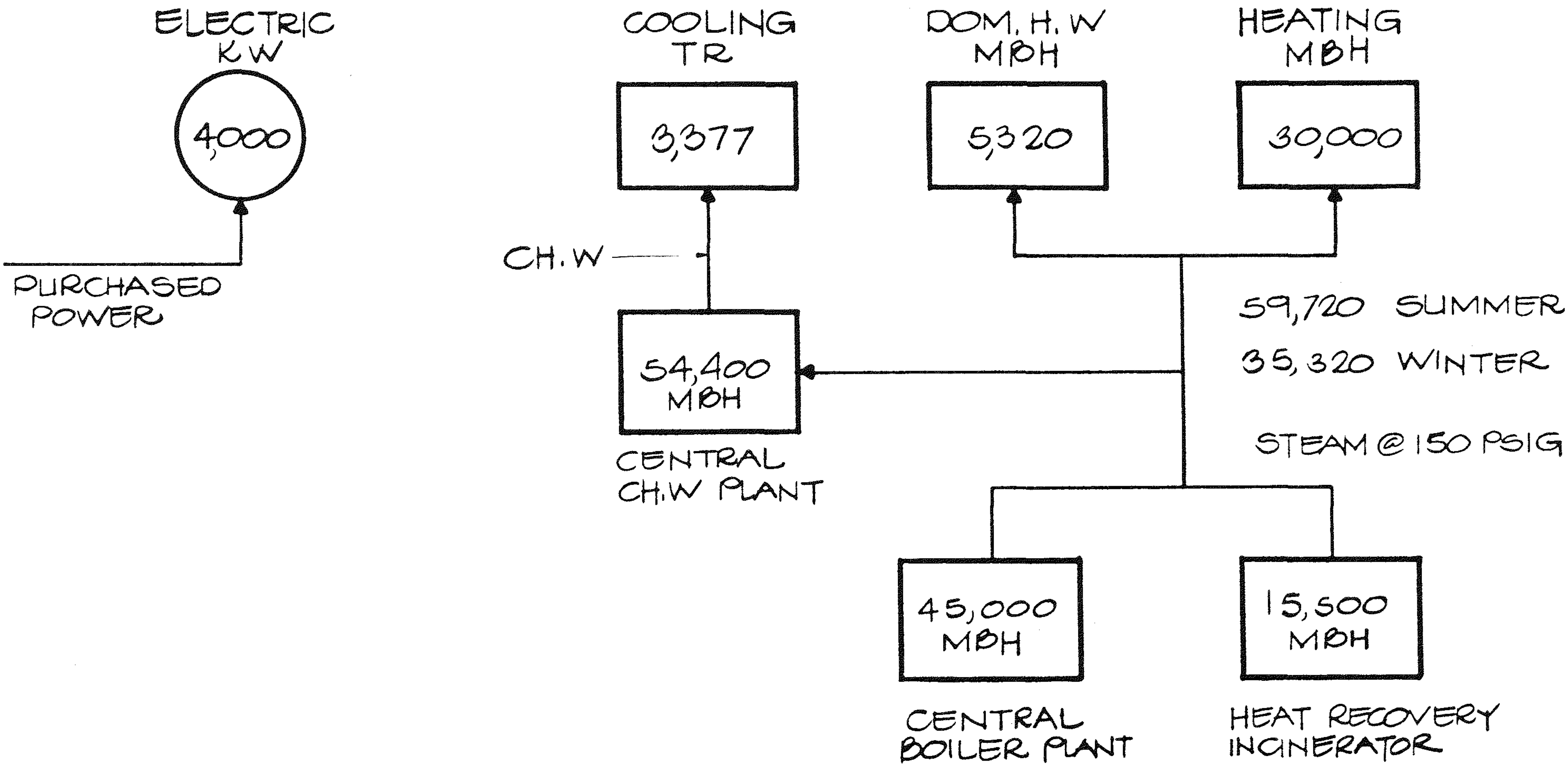
249,000/16 hrs. = 15,562 lbs. steam/hr. = 15,562 MBH

Cooling:

3,400 TR x 16 lbs. steam/hr./TR = 54,400 lbs steam/hr.



TUCSON TRACT 6: 1995 PLANNED DEVELOPMENT
CENTRAL PLANT FIG 20



TUCSON TRACT 7: 1995 PLANNED DEVELOPMENT
CENTRAL PLANT WITH INCINERATOR

FIG
21

Energy savings with the use of central plants are generally in the range of from 5% to 10%. Inasmuch as some of the development in year 1995 will not be connected to the central plant, a savings of 5% is estimated. The comparison is made to the total (without transportation) in Table 27.

CASE STUDY: Mt. Pleasant, Westchester County, New York

Existing Character:

The Mt. Pleasant study area is characterized by two declining village centers, Valhalla and Hawthorne which provide some service to its surrounding bedroom communities, several large institutions, and a major regional transportation network. The village centers provide minimal convenience retail shopping facilities necessitating extensive automobile travel to regional shopping centers in White Plains and in and around New York City. The housing is characteristic of the spectrum provided by most older middle class suburbs to large cities. It is predominantly single family and its physical land planning configuration is of two types:

- rectilinear street grid with older lower priced housing on quarter acre lots adjacent to the village centers.
- curvilinear street pattern with newer higher priced subdivision housing on half acre and one acre lots at greater distances from the village centers.

The study area has a perhaps larger than typical component of institutions. These are private and public health and educational facilities with large land holdings far from fully utilized. A major energy related planning issue is the inability of non-resident staff, students and employees to find nearby adequate housing within their income range. Tri-State Regional Planning Commission data and employee interview surveys carried out by the Westchester Department of

Planning indicate that average trip length is up to 45 minutes and that from no zone of origin is bus travel time competitive with automobile travel time. The major institutions are the Grasslands Reservation which includes hospital, rehabilitation, medical education, child care and penal facilities and Cedar Knolls, a private child treatment center, both are low density campus design facilities of many buildings unified only by central heating systems.

The study area is subdivided into sub-areas by the transportation network located within the valleys of the topography. A major interchange connects the Taconic, Saw Mill and Sprain Brook Parkways. The Harlem Division of the Penn Central Railroad provides stops at both village centers for its commuter service. The north-south orientation of the highways and railroad allow for a majority of commutation traffic to and from New York City and its broader employment base.

Other than the small commercial retail within the village centers, a major commercial office, motel, warehousing and sports corridor is developing along Saw Mill River Road (9A) providing a substantial local employment base. This corridor, along with the institutions, provides an opportunity for providing employment related local housing (energy conserving design measure 2).

The Mt. Pleasant study area has major and minor tracts of vacant or underutilized lands as defined by the present zoning ordinance. Some tracts are held by large corporations and the above noted institutions and are suitable for the following major planning proposals, others are within large estates and cemeteries and may soon be subject to subdivision development pressures. The energy sensitive design proposals outlined below are considered logical extensions of the land development policies upon which the local zoning ordinance is based.

Population statistics for the Mt. Pleasant study areas were taken from statistics developed by the Tri-State Regional Planning Commission for their transportation analysis zones. These are the square mile quadrants, distorted to conform to land ownership patterns, which were selected for the study because of the availability of data. The 12,593 figure is also reasonably close to the extrapolated population check which was made from Census Tracts which do not coincide with the study area limits.

Existing land use data for Westchester was derived initially from land use plans prepared for the Town of Mt. Pleasant by Frederick P. Clarke Associates, Rye, New York and from aerial photography counts of single family housing units and identification of other non-residential land uses. Photography was provided by the Tri-State Regional Planning Commission from photos flown in 1969-70. Field research confirmed these land uses and building coverage was extracted from tax assessor's records for the Town of Mt. Pleasant. The aerial photography with the distorted quadrants became the final data base for diagramming the existing land use patterns on a street map of the study area. See the following Figure 22.

LEGEND

- SINGLE FAMILY HOUSING
- MULTI-FAMILY HOUSING
- COMMERCIAL
- INSTITUTIONAL
- INDUSTRIAL
- OPEN SPACE

MT. PLEASANT EXISTING LAND USE

FIG 22

the interaction of
LAND USE AND ENERGY CONSERVATION
a study for the FEDERAL ENERGY ADMINISTRATION by CONKLIN & ROSSANT/FLACK+KURTZ

Dwelling unit counts were confirmed by extrapolation from the 1970 Census. Institutional data regarding the Westchester County Grasslands Complex was obtained from the Westchester County Planning Commission.

Existing Energy Requirements - 1975

Energy consumption factors for residential uses were developed as shown in Table 32. The factors are then used to translate the land uses aggregated into four categories: residential, commercial, institutional and industry into their existing energy consumption levels as shown on Table 33.

Transportation energy requirements were calculated as shown in Table 34.

Table 32: Energy Consumption Factors Per Dwelling Unit Per Year Mt. Pleasant

	Single Family	Two Family	Low Rise M. F.	High Rise M. F.
1. Heating, Oil/Gas MMB	98	69	60	47
2. Heating, Elec. MKWh	23	16.2	14	11
3. Heating, Elec. MMB	78	55	47.6	37.4
4. Other, Elec. MKwh	6	5.6	5.3	5.3
5. Other, Elec. MMB	20.6	19	18	18
6. 2% of (3)/100% eff.	1.56	1.1	.95	175
7. 98% of (1)/65% eff.	147.75	104.03	90.46	70.86
8. Comb. Factor (6)+ (7)+ (5)	169.91	125.23	109.41	89.21
USE MMB/d. u.	170	124	109	89

Notes:

- Basic factors are from Ref. No. 1, Table IV-8.
- Heating includes Space and Dom. H. W. Heating.
- "Other Electric" includes cooking, lighting, miscellaneous appliances, refrigeration, air conditioning.
- Breakdown into electric and gas/oil heating, from 1970 Census

Table 33: Summary of Existing Annual Energy Consumption
Mt. Pleasant
(Test Area Population: 12,593)

Land Use	UNITS D. U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family	3,320	1	170	564,400
2-Family	120	1	124	14,850
Low Rise M. F.	250	1	109	27,250
High Rise M. F.				
SUBTOTAL	3,690			606,500
	Sq. Ft.			
COMMERCIAL				
Office	702,652	1	.218	153,178
Retail				
Mall/Large				
Attached/Small				
Strip	98,006	1	.173	16,955
Hotel	22,748		.1446	3,289
Food Service	33,938	2	.300	10,181
Recreation	113,826	1	.084	9,561
Theatres				
SUBTOTAL	971,170			193,164
INSTITUTIONAL				
Schools	746,854	3&4	.150	112,028
Hospitals	1,151,502	1	.362	416,843
Public Service	241,199	2	.1446	34,877
Dormitory Type	1,961,758	2	.1446	283,670
SUBTOTAL	4,101,313			847,418
INDUSTRY				
Light Industrial	52,941	1	.385	20,382
Warehouse	451,526	2	.062	27,994
SUBTOTAL	504,467			48,376
TOTAL (Less Transportation)				1,695,458
Transportation: See Table 34				551,000
GRAND TOTAL				2,246,458

Table 34: Existing Transportation Energy
Mt. Pleasant
(3690 d. u.)

	Trip Generation Rate (person trip/ d. u.)	Daily Trips (number)	Modal Split		Trip Length (miles)	Passenger Miles (000, 000)	BTU per Pass. Miles	Annual BTU's (000, 000, 000)
WORK	2. 54	9, 400			11. 5			
			auto	70%		27.	6, 600	178
			bus	13%		1.	1, 150	1
			rail	27%		11.	4, 430	49
			walk					
SHOP	2. 20	8, 100			6. 3			
			auto	97%		18.	6, 600	118
			bus	3%		1.	1, 550	2
			rail					
			walk					
OTHER	2. 44	9, 000			11. 1			
			auto	97%		30.	5, 750	201
			bus	3%		35.	1, 550	2
			rail			1.		
			walk					
TOTAL	7. 18	26, 500				94		551
(actual)		(31, 500)					BTU/pass. mi. = 5, 900	

Validation:

The energy consumption data excluding transportation for Mt. Pleasant were tested as follows. From Consolidated Edison Company reports to the N. Y. S. Public Service Commission could only be obtained for the entire Town of Mt. Pleasant. As the study area was a portion of the town, totals were prorated based on population.

Table 35: Prorated Existing Energy Consumption for the Mt. Pleasant Study Area

	Mount Pleasant	Study Area
Population	20,411	12,593
Electric Consumption	123,387,500 KW hrs./yr.	76,126,533 KW hrs./yr.
Gas Consumption	775,121 MCF/yr.	478,227 MCF/yr.

From Ref. No. 5 the oil consumption was obtained per household in Westchester County, in which the study area is located. There are 3,690 dwelling units in the study area, and from the Census data for Westchester County the following distribution of residential heating sources is found:

	D. U.'s	%
Gas Heating	80,078	28.82
Fuel Oil Heating	191,863	69.05
Electric Heating	5,890	2.13
	277,831	100.00

From this distribution, oil consumption for the study area is estimated as follows:

3,690 d.u.'s x .69 (%oil) x 258.3 MMB/d.u. = 667,657 MMB

Gas consumption for the study area from Table 35 is 478,227 MCF or 478,227 MMB. Electric consumption for the study area from Table 35 is 76,126,533 KW hrs. x .0034 MMB/KW hr. = 158,830 MMB. The total oil, gas and electric consumption is 1,404,714 MMB. This is in fair agreement with the total without transportation energy consumption of 1,695,458 (+17.1% from Table 33).

Transportation energy was validated by using data from Ref. No. 5 as follows:

Table 36: Annual Per Capita Westchester County Transportation Energy Consumption by Mode

Cars	42.25 MMB/capita
Bus	.29 " "
Taxi	.73 " "
Truck	11.19 " "
	54.47 MMB/capita

Source: Regional Plan Association, Westchester (Ref. No. 5).

If the truck item is omitted (since there is little truck traffic in the study area), the resulting number of 43.27 MMB/capita is very similar to the result from Table 33, of 551,000 MMB/12,493 person or 43.75 MMB/capita.

Growth Projection Scenarios:

The Mt. Pleasant study area boundaries were selected primarily due to the availability of detailed transportation and land use data prepared by the Tri-State Regional Planning Commission. Conforming to Tri-State mile square cells, the data and projections do not conform to Census Tracts or political boundaries. Hence, the availability of projections are limited. Within those which overlap the study area, a divergence of growth rates are apparant.

Table 37: Range of Projected Growth Rates

	Growth Rate For Time Period Noted
Consultants to Town Planning Board (1970 - 1990; for entire township of Mt. Pleasant)	43%
Regional Plan Association (1970 - 1985; for entire township of Mt. Pleasant)	33%
Building Permits/Straight Line Projection (1970 - 1990; for entire township of Mt. Pleasant)	33%
Tri-State Regional Planning Commission (1970 - 1995; for study area)	32%
Tri-State Regional Planning Commission (1963* - 1995; for study area)	24%

* Population in study area declined by 807 persons from 1963 to 1970, hence the different rates, and 1963 is the survey year for the transportation data utilized in the existing energy consumption analysis.

The benchmark year for 1995 has been taken for both the Tucson and Mt. Pleasant energy conserving proposals. As only the Tri-State projections extend over this time period and include only the study area, they were selected for analysis purposes.

Table 38: Mt. Pleasant Study Area/Existing Development 1975

Population	12,592 _/1
Dwelling Units	3,690 _/3
Commercial	1,228,393 s.f. _/2
Industrial	52,941 s.f. _/2
Institutional	4,411,307 s.f. _/2

_/1 Tri-State estimates for 1963
_/2 C&R/F+K totals from Mt. Pleasant Tax Assessors Records
_/3 Extrapolation from Census Tract Data, Aerial Photography, and Tax Assessor Records

Developing projections of commercial, industrial and institutional land uses are extremely difficult and depend on many undefined trends. As part of Tri-State's studies, land use projections were made based on a sophisticated model of its entire metropolitan region and its growth pattern. Their 1970 base line figures, however, appear to not account for the large amount of institutional space within the study area that was evident in the consultant's aggregation of tax assessor's building files as noted above. Tri-State's factors were useful in projecting 1995 growth increments discussed below.

In Westchester County's past, population growth has generated employment growth, and commercial and public construction. Specifically, commercial development has been ultimately dependent on population growth, often with time lags involved. Population growth has slowed and in some locations within the County stopped. Present housing starts have provided for both the decrease in household size and the demolition and other loss of existing housing. It is likely that employment growth will also slow due to this housing downtrend. Due to the energy situation, it is also likely that the commercial and industrial growth which does occur will favor mid-County locations similar to Mt. Pleasant where public transportation exists over north-County isolated highway oriented sites where public transportation is unavailable. With these factors in mind along with the availability of land, adequate zoning, compatibility with existing master plans and other factors, projections were made. These are based on two different sets of land development goals. The first is trendlike "conservative" estimate based on the 1995 Tri-State population projections for the unplanned scenario. The second is a higher growth estimate based on the additional development stimulus which would be achieved through an energy conserving land use design proposed in the following section, and for which implementation strategies are recommended in Section G of this study. This is the planned growth scenario. These pairs of projections are to be considered synonymous with the unplanned and planned growth projections prepared for the Tucson study area. The former becomes the baseline for the determination of the energy savings achieved in the latter. These calculations follow the presentation of energy sensitive design proposals.

The following table presents two sets of projections for 1995. For the trendline projection, the Tri-State population estimate was taken and the dwelling unit number and mix projected based on a continuation of the present 3.5 persons per household (which has remained unchanged from 1960 to 1970) and the present construction mix of 90% single family and 10% multi-family (mostly two-family homes) is maintained. Commercial and industrial floor space increases are based on planning factors considered appropriate for the urbanization pattern which presently characterizes Mt. Pleasant. As there is sufficient underutilized capacity in most of the public facilities (schools, hospitals, etc.) no additional space is forecasted within this projection.

Table 39: Mt. Pleasant Study Area Program

	Existing 1975	Unplanned, Laissez-Faire Trendline Projection		Planned, Energy Conserving Higher Growth Projection	
		Increment	Total	Increment	Total
Population	12,593	3,020	15,612	4,610	17,202
Dwelling Units Total	3,690	863	4,553	3,100	6,790
Single Family	3,320	777		100	
Multi-Family	370	86		3,000	
Commercial (square feet)	971,170	295,000	1,266,170	450,000	1,421,170
Retail		118,000		180,000	
Office		177,000		270,000	
Light Industrial (square feet)	52,941	12,700	65,641	19,400	72,341
Institutional (square feet)	4,101,313	negligible	4,101,313	100,000	4,201,313

Source: Tri-State Regional Planning Commission
C&R/F+K

The higher growth estimate is based upon several proposals for actual projects within the area due to significant market pressures for higher density and/or lower cost housing developments than is presently provided. To date, these proposals have been defeated by local planning boards on the issue of inordinate increases on community services, primarily schools. The issue of resultant energy and land resource consumption of the two land development policies has not been considered as of yet. Mt. Pleasant, like most suburban communities in large metropolitan regions, still consideres itself to be "land wealthy" and "energy cheap". However, with the recent downtrend in growth, many communities are feeling the high costs of underutilized community services and are looking to increase their tax ratables. Proposals such as those noted here may be reviewed with greater local acceptance.

These proposals are essentially of two types:

- providing housing for staff and residents of large scale public insitutions, specifically the county and regional medical college, penal, public works, and hospital facilities.
- providing market rent higher density housing and community facilities on large tracts of available land.

Aggregating their dwelling unit counts, their mix and their projected number of persons per household and estimating an absorpiton factor for the benchmark year of 1995, the dwelling unit total and resultant population is projected for the higher growth policy. Although the 1975 - 1995 housing unit increment for the higher growth projection is over three times the increment for the trendline projection, the resultant population increment is only one and one half times the trendline population increment as the number of persons per dwelling unit for most of the multi-family housing ranges from 1.1 to 2.0. The major difference between the two 1995 projections is the shift in housing mix as shown below:

Table 40: Housing Mix Comparison

	Unplanned, Laissez-Faire Trendline Projection	Planned, Energy Conserving Higher Growth Projection
Single Family	90%	4%
Multi-Family	10%	96%

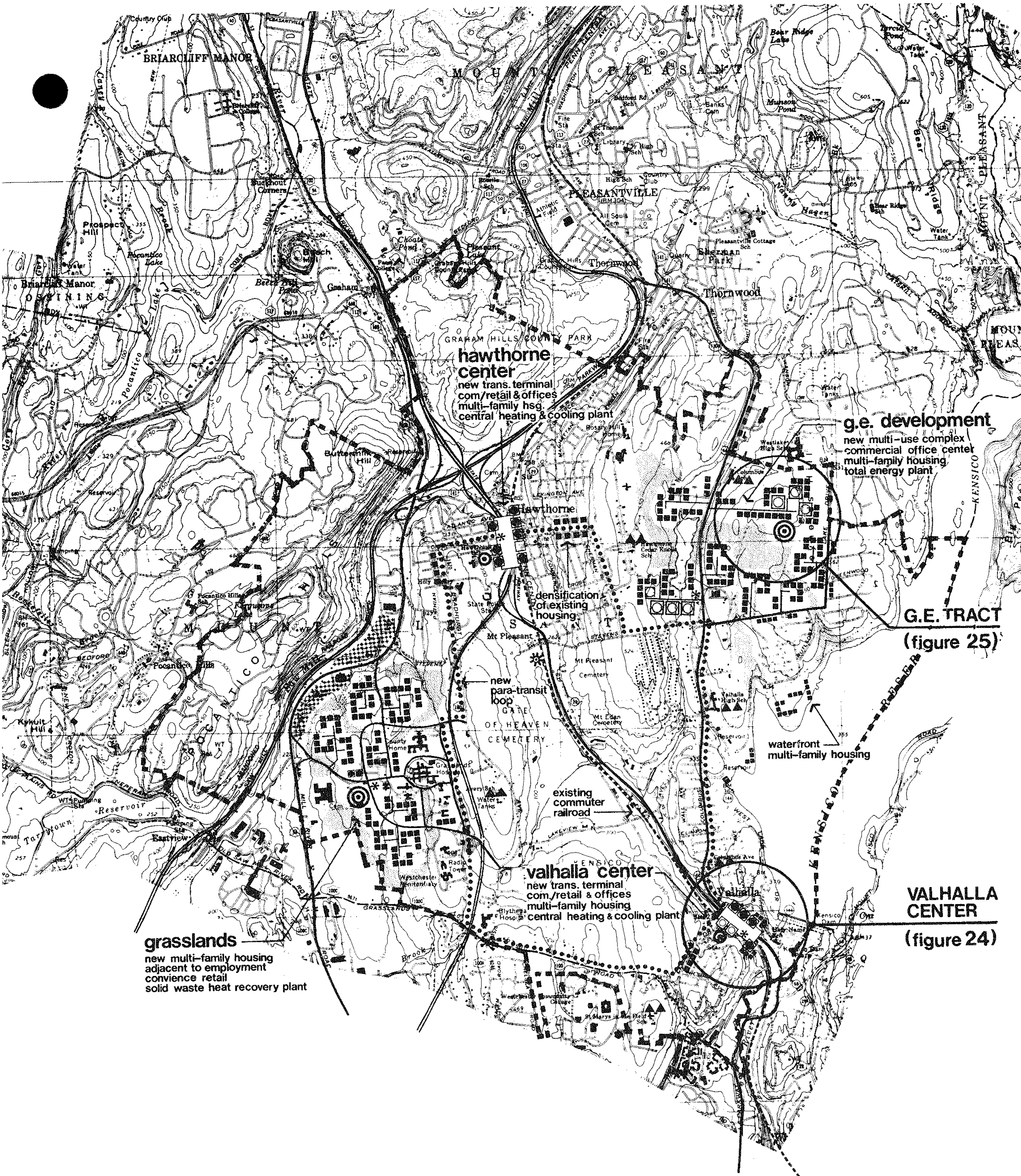
The increment in commercial and industrial development for the higher growth estimate is based on job opportunities and service market demands generated by the size of population forecasted. The additional institutional space is seen as the public facilities required by the additional 2200 persons over the trendline projection, its incremental population having consumed most of the underutilized capacity within the existing facilities.

Energy Sensitive Urban Design Proposals:

The Mt. Pleasant proposals are graphically depicted in Figures 23-25. The first diagram is an area-wide plan view serving as a locational diagram for the various measures utilized, including two prototypical developments, the Valhalla and General Electric (G. E.) Centers, sketched in Figures 24 and 25 respectively.

The existing village centers of Hawthorne and Valhalla as the core of most suburban region's development patterns become the basis for a series of energy conserving design and planning measures. As these centers can provide automobile free access to existing shopping, housing, schools and employment, their revitalization and densification is considered primary. Full range shopping, along with an infilling of new multi-family housing and densified existing housing within the existing rectilinear street grid will achieve the objective of reducing total vehicle transportation by all trip purposes, the major energy conserving component being within the home-to-work trip. Figure 24, the Valhalla Center, indicates the physical concept resulting from these measures.

Achieving the same principal are major higher density housing proposals on the fringe areas of the large institutional land holdings. The major cluster would exist between the Saw Mill River commercial corridor and the Grasslands complex providing housing at affordable levels related to the wage scale of the local jobs (see Figure 23). This complex, with its existing employment, becomes a new energy conserving development node similar in its achievements to the

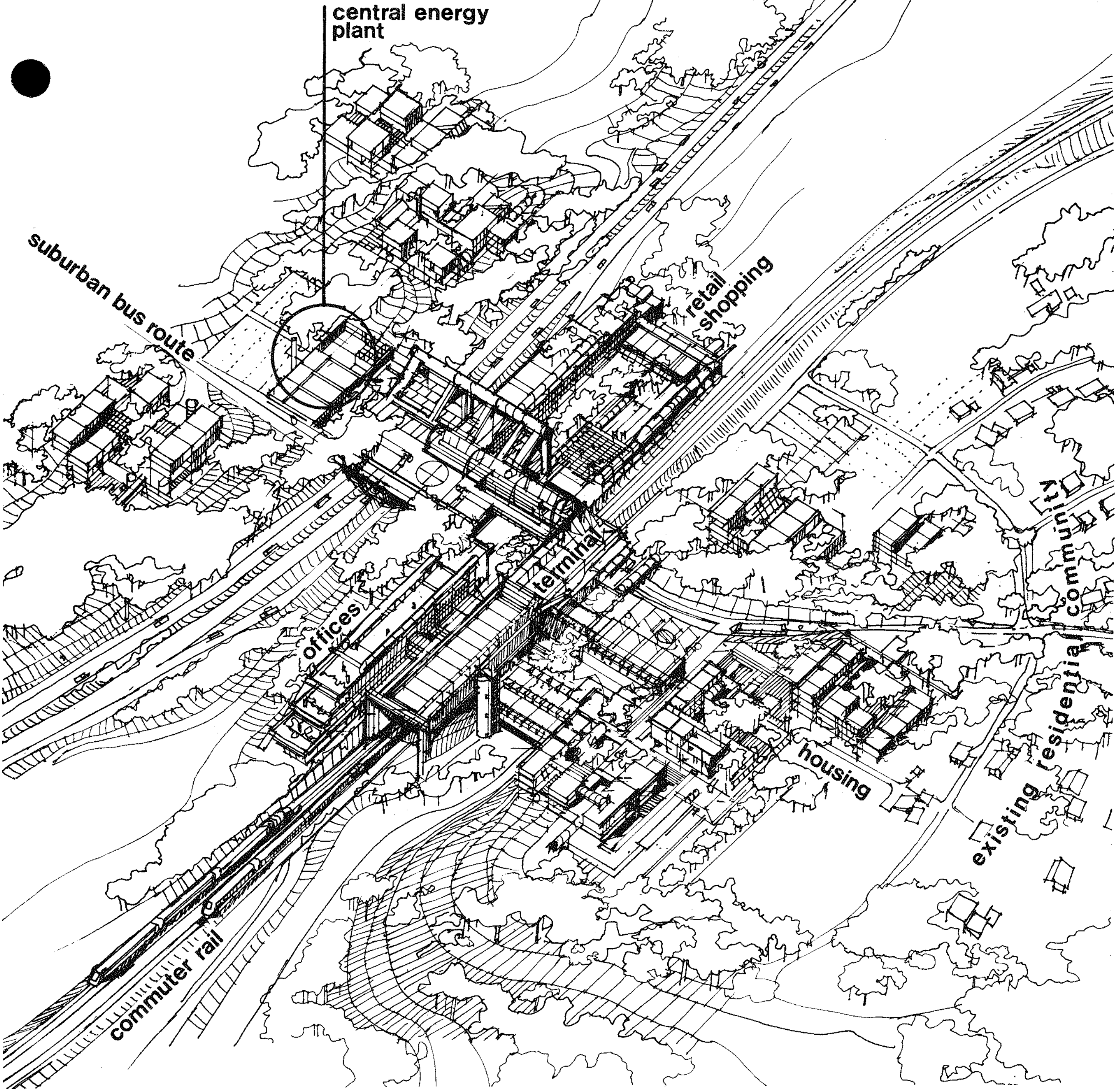


LEGEND

- MULTI-FAMILY HOUSING
- COMMERCIAL RETAIL
- COMMERCIAL OFFICE
- INSTITUTIONAL
- INDUSTRIAL
- OPEN SPACE FOR RECREATION
- LOCAL SCHOOL
- NEW ENERGY SYSTEMS
- COMMERCIAL RECREATION
- PARA-TRANSIT
- STUDY AREA BOUNDARY

MT. PLEASANT: 1995 PLANNED ENERGY CONSERVING DEVELOPMENT

FIG 23



VALHALLA CENTER PROPOSED PHYSICAL CONCEPT

FIG 24

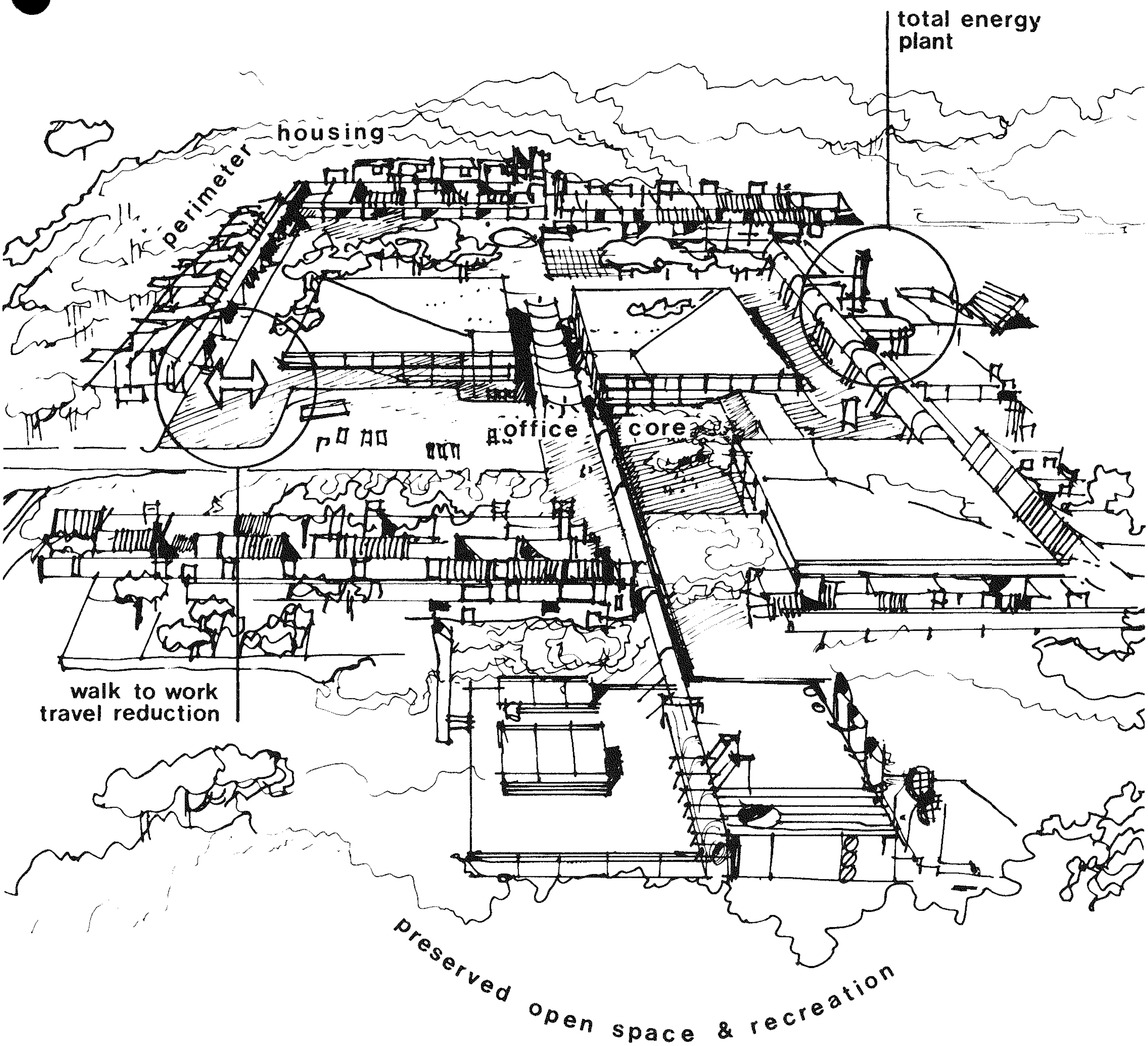
new multi-use complex of residential and business functions proposed for the so-called General Electric tract. In this instance, a suburban headquarter center is integrated in design with on-site housing aimed at local employees. Its physical concept is presented in Figure 25. Additional new multi-family units are considered appropriate on available vacant land at the periphery of the older village centers (see Figure 23).

The 1995 higher growth projection of 3000 additional mult-family units are allocated among the above locational proposals as follows:

Table 41: Mt. Pleasant/Proposed Multi-Family Housing

	Dwelling Units
New Village Center Housing (Hawthorne and Valhalla)	250
Periphery of Village Centers	150
Major New Development Nodes:	
Grasslands	1000
General Electric	1600
	3000

To facilitate the non-automobile transit potentials provided by these four nodes (two existing village centers; two proposed development nodes), a loop bus system or para-transit route is proposed connecting the nodes, the locations of the peripheral housing, existing transfer points to the commuter railroad and the multi-use functions (shopping and schools) within the revitalized nodes. Although a detailed



G.E. TRACT
PROPOSED PHYSICAL CONCEPT

FIG 25

analysis of development densitites necessary to support a specific transit mode is not undertaken, the planning principle of node concentrations has a greater likelihood of supporting a future non-automobile system (see Figure 23).

The residential, office and institutional components of the two new development modes are scaled to allow for the incorporation of a centralized and balanced energy system described in the following section. Achieving this balance is the major objective of these proposals and would necessitate the concentration of the study area's higher growth potential within these nodes. This objective would be achieved by keeping most of the existing open space free of scattered development through growth management controls discussed in Section G of this study. This objective is also reflected in the higher growth projection's high percent of multi-family units. Single family construction is not prohibited, but is severely constrained over the trendline projection.

Of the thirteen energy conserving design measures described in Section B, the following have been employed in the Mt. Pleasant study area:

Home-to-Work

1. Multi-family housing/employment and services
2. Housing income/employment

Land Use Densification and Revitalization

3. Older Housing Communities
4. Multi-use town centers

Local Automobile Travel Reduction

7. Alternative transportation modes

Energy System Integration into Mixed Land Uses

8. Energy Efficient Infrastructures

9. New Multi-Use Complexes

Regional Growth Management to Achieve Trip Reduction

11. Preserved Open Space

Future Energy Requirements - 1995:

Energy requirements as related to the projected land uses for the 1995 unplanned and energy conserving planned scenarios for the Mount Pleasant study area are shown in Tables 42 and 44. Factors were adjusted, as appropriate, to reflect changes in density and composition in land use configurations.

Related transportation energy requirement estimates for both scenarios are calculated on Tables 43 and 45. Transportation consumption was influenced by the following considerations:

Unplanned: (Trendline) — Simple extrapolation of present trends (but including improved gasoline mileage for vehicles).

Planned: (Higher Growth) — The addition of the mini-bus loop improves access to rail, resulting in an assumed mode split for work shifts as follows:

	Shop	Other
Auto	97% to 70%	97% to 70%
Mini-Bus Loop	3% to 10%	3% to 20%
Walk	- to 20%	- to 10%

Note: "Other" trips are longer and are less likely to be walk trips. The 20% walk-to-shop is quite reasonable in light of an estimated 60% walk trips in the Cedar Riverside planned community.

If auto utilization for shopping and other trips can be reduced from 70% t0 50%, the overall elasticity of energy consumption with respect to passenger miles drops from .71 to .35.

Table 42: Summary of Projected Annual Energy Consumption
1995 Unplanned Trendline Growth Scenario
Mt. Pleasant
(Test Area Population: 15,612)

Land Use	UNITS D.U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family	4,099	1	170	696,830
2-Family	152	1	124	18,848
Low Rise M. F.	304	1	109	33,136
High Rise M. F.				
SUBTOTAL	4,555			748,814
	Sq. Ft.			
COMMERCIAL				
Office	879,652	1	.218	191,874
Retail				
Mall/Large				
Attached/Small	118,000	1	.161	18,998
Strip	98,006	1	.173	16,955
Hotel	22,748		.1446	3,289
Food Service	33,938	2	.300	10,181
Recreation	113,826		.084	9,561
Theatres				
SUBTOTAL	1,266,170			250,748
INSTITUTIONAL				
Schools				
Hospitals				
Public Service				
Dormitory Type				
SUBTOTAL	Same as for 1975			847,714
INDUSTRY				
Light Industrial	65,641	1	.385	25,271
Warehouse	451,526	2	.062	27,994
SUBTOTAL	517,167			53,265
TOTAL (Less Transportation)				1,900,541
Transportation: See Table 43		1		493,000
GRAND TOTAL				2,393,541

Table 43: Projected Transportation Energy
1995 Unplanned Trendline Growth Scenario
Mt. Pleasant
(4,555 d.u.)

	Trip Generation Rate (person trip/ d.u.)	Daily Trips (number)	Modal Split		Trip Length (miles)	Passenger Miles (000,000)	BTU per Pass. Miles	Annual BTU's (000,000,000)
WORK	2.54	11,500			11.5			
			auto	70%		34	4,600	156
			bus	3%		1	800	1
			rail	27%		13	4,430	57
			walk					
SHOP	2.20	10,000			6.3			
			auto	97%		22	4,600	101
			bus	3%			1,800	1
			rail					
			walk					
OTHER	2.44	11,100			11.1			
			auto	97%		44	4,600	176
			bus	3%		1	1,100	1
			rail					
			walk					
TOTAL	7.18	32,600			9.9	116		493

BTU/pass. mi. = 4,300

Table 44: Summary of Projected Annual Energy Consumption
1995 Planned Higher Growth Energy Conserving Development Scenario
Mt. Pleasant
(Test Area Population: 17, 202)

Land Use	UNITS D. U.	ENERGY CONSUMPTION PER YEAR REF.	MMB/UNIT	TOTAL MMB
RESIDENTIAL				
Single Family	3,420	1	170	581,400
2-Family	1,120	1	124	138,880
Low Rise M. F.	2,250	1	109	245,250
High Rise M. F.				
SUBTOTAL	6,790			965,530
	Sq. Ft.			
COMMERCIAL				
Office	972,652	1	.218	212,032
Retail				
Mall/Large	180,000	1	.142	25,560
Attached/Small				
Strip	98,006	1	.173	16,955
Hotel	22,748	2	.1446	3,289
Food Service	33,938	2	.300	10,181
Recreation	113,826	1	.084	9,561
Theatres				
SUBTOTAL	1,421,170			277,584
INSTITUTIONAL				
Schools	846,854	3&4	.150	127,028
Hospitals	1,151,502	1	.362	416,843
Public Service	241,199	2	.1446	34,877
Dormitory Type	1,961,758	2	.1446	283,670
SUBTOTAL	4,201,313			862,418
INDUSTRY				
Light Industrial	72,341	1	.385	27,851
Warehouse	451,526	2	.062	27,994
SUBTOTAL	523,867			55,845
TOTAL (Less Transportation)				2,161,377
Transportation: See Table 45		1		564,000
GRAND TOTAL				2,725,377

Table 45: Projected Transportation Energy
1995 Planned Higher Growth Energy Conserving Development Scenario
Mt. Pleasant
(6790 d. u.)

	Trip Generation Rate (person trip/ d. u.)	Daily Trips (number)	Modal Split		Trip Length (miles)	Passenger Miles (000, 000)	BTU per Pass. Miles	Annual BTU's (000, 000, 000)
WORK	2. 54	17, 200			11. 5			
			auto	63%		45. 5	4, 600	209
			bus				800	
			rail	37%		26. 8	4, 430	119
			walk					
SHOP	2. 20	14, 900			4. 7			
			auto	70%		17. 8	4, 600	82
			bus	10%		2. 5	1, 100	3
			rail					
			walk	20%		5. 1		
OTHER	2. 44	16, 600			8. 3			
			auto	70%		35. 0	4, 000	140
			bus	20%		10. 0	1, 100	11
			rail					
			walk	10%		5. 0		
TOTAL						14. 8		564

BTU/pass. mi. = 3, 800

Technology Related Energy Conservation:

In order to test technological systems capable of energy reduction suitable for the study area is proposed development on the G. E. Tract, the following programmed land uses were considered:

Residential:	500 d.u.	in townhouses
	1,100 d.u.	in garden apartments
	250 d.u.	in garden apartments in supporting areas
Office Commercial:	200,000 sq. ft.	
Industrial:	25,000 sq. ft.	

The summary of demands are calculated in Table 47, and these are then translated into the proposed total energy scheme in Figure 26. All the waste heat from the gas turbine driven electric generator can be utilized for heating or cooling at the central plant.

The auxiliary boiler shown in Figure 26 could be replaced by a heat recovery incinerator. However, a solid waste heat recovery installation on a much larger scale is under design for the Grasslands Reservation nearby, and an additional local unit may not be acceptable environmentally.

A total energy system is very efficient, but savings resulting from it cannot be related to the energy consumption estimates as they have been used in this study so far. Energy consumption throughout has been considered at the building or project boundary, regardless of how it was generated. In the case of electric power, the energy required to produce one KW or 3,414 BTU's of electricity requires approximately three times the energy input, or 11,000 BTU/KW. The savings with the total energy system accrue from the reuse of the waste heat associated with electricity production. It will be assumed that half of the waste heat available is the savings:

From Figure 26: $\dfrac{15{,}000 \text{ MBH} = (\frac{1}{2}) \text{ waste heat}}{80{,}000 \text{ MBH} = \text{Total Requirement}} = .1875$ (18.75% saving)

Comparing the totals less transportation from the following:

Table 44:	2,161,377 MMB
Table 33:	1,695,458 "
Attributable to new development:	465,919 MMB

If half of the new development is served by total energy, then:

$$\frac{465{,}919 \times .1875}{2} = 43{,}680 \text{ MMB}$$

Another major part of the proposed development is related to the Grasslands Reservation, where it is proposed that this development be served from the proposed Grasslands solid waste heat recovery installation. According to the discussion under the Tucson proposal a $12\frac{1}{2}\%$ savings is estimated with the reclamation of solid waste heat. For Mt. Pleasant this results in a savings of:

$$\frac{465{,}919 \times .125}{2} = 29{,}120 \text{ MMB}$$

Solar energy collection used to make domestic hot water in building clusters in Westchester County should save approximately 50% of the yearly energy requirement. Domestic hot water at 25% of residential sub-total from Table 44 is 241,382 MMB. A saving of 50% would amount to 120,690 MMB.

A summary of potential savings in energy required due to applied technology is shown in Table 48 and amounts to a reduction of 41.52% in energy increase due to growth.

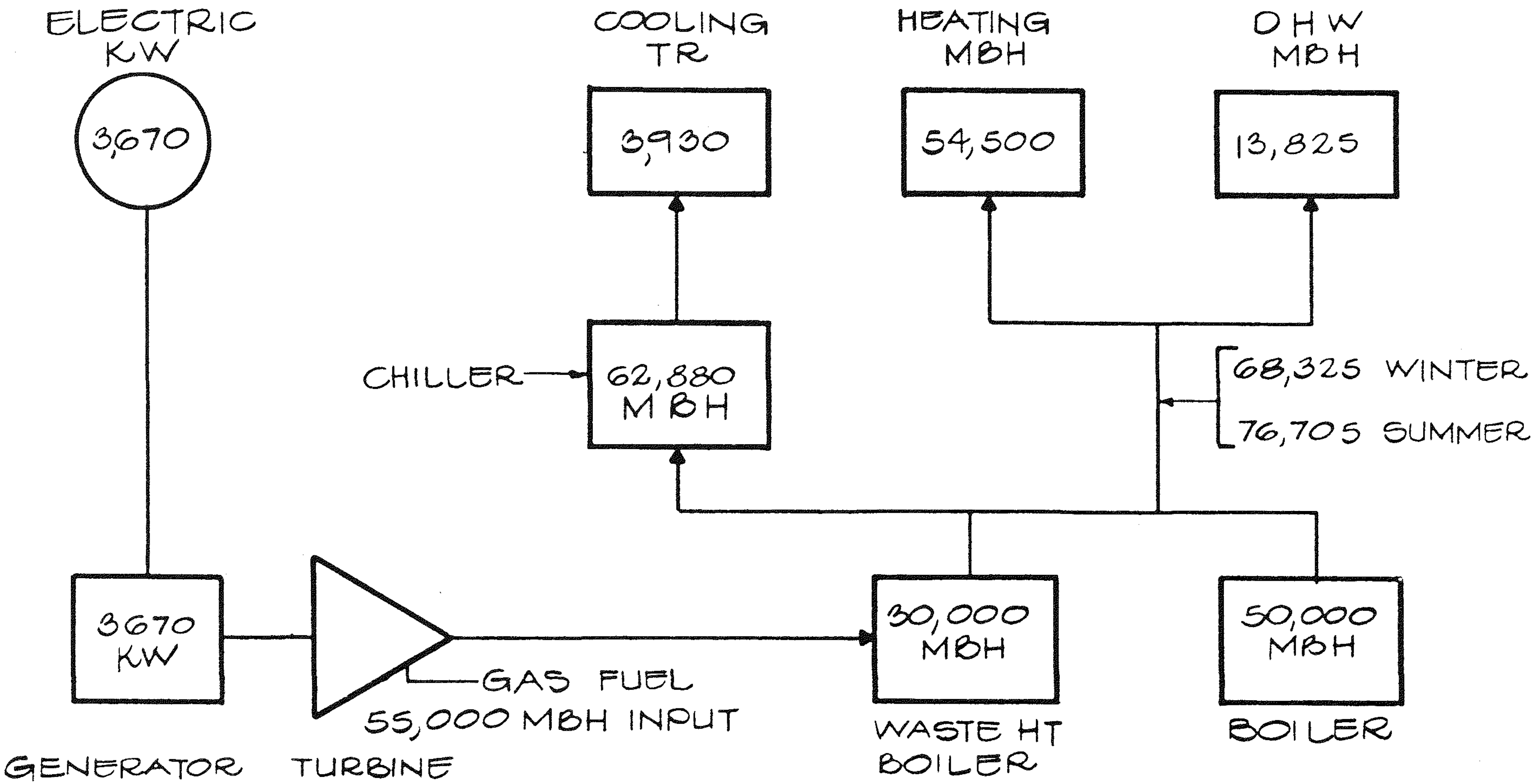
Energy saving due to technology application when compared to total energy consumption for the study area (less transportation) is only about 9%.

Table 46: Summary of Demands
Mt. Pleasant Study Area
1995 Planned Higher Growth Energy Conserving Development Scenario

Land Use	Solid Waste	Electric	Heating	DHW	Cooling
	lbs/day	KW	MBH	MBH	TR
Residential					
New	26,800	5,055	84,500	16,750	5,650
Existing	50,000				
Commercial					
New	13,500	1,598	10,350	900	1,430
Existing	37,000				
Industrial					
		375	3,000	300	250
New	3,000	375	3,000	300	250
Existing	8,800				
Light Industry					
New	815	50	485	70	65
Existing	2,240				
Totals	221,355	7,078	98,335	18,020	7,395

Table 47: Summary of Demands
G.E. Tract, Mt. Pleasant
1995 Planned Higher Growth Energy Conservation Development Scenario

Land Use	Solid Wastes lbs/day	Electric KW	Heating MBH	DHW MBH	Cooling TR
Residential	22,200	2,925	48,750	9,750	3,250
Commercial	5,000	650	5,000	4,000	615
Institutional	500	95	750	75	65
Total	27,700	3,670	54,500	13,825	3,930



G.E. TRACT 1995 PLANNED DEVELOPMENT
TOTAL ENERGY PLANT

FIG 26

Table 48: Energy Reductions Through Technology
Mt. Pleasant Study Area
1995 Planned Higher Growth Energy Conserving Develop Scenario

Line		MMB/yr.
1	Increase due to planned growth	465,191
2	Total Energy Plant	(-) 43,680
3		422,239
4	Solid Waste Heat (-) $12\frac{1}{2}$%	(-) 29,120
5		393,119
6	Residential Sub-Total	965,530
7	Domestic Hot Water at 25%	241,380
8	Solar Savings at 50%	120,690
9	Line (5) - Line (8)	272,429
10	Total Saving: Line (2), (4), and (6)	193,490
11	Total Savings Re: Line (1)	41,52%
12	Total without transportation energy consumption (Table 44)	2,161,377
13	Savings Re: Line (12)	8.95%

F. FINDINGS

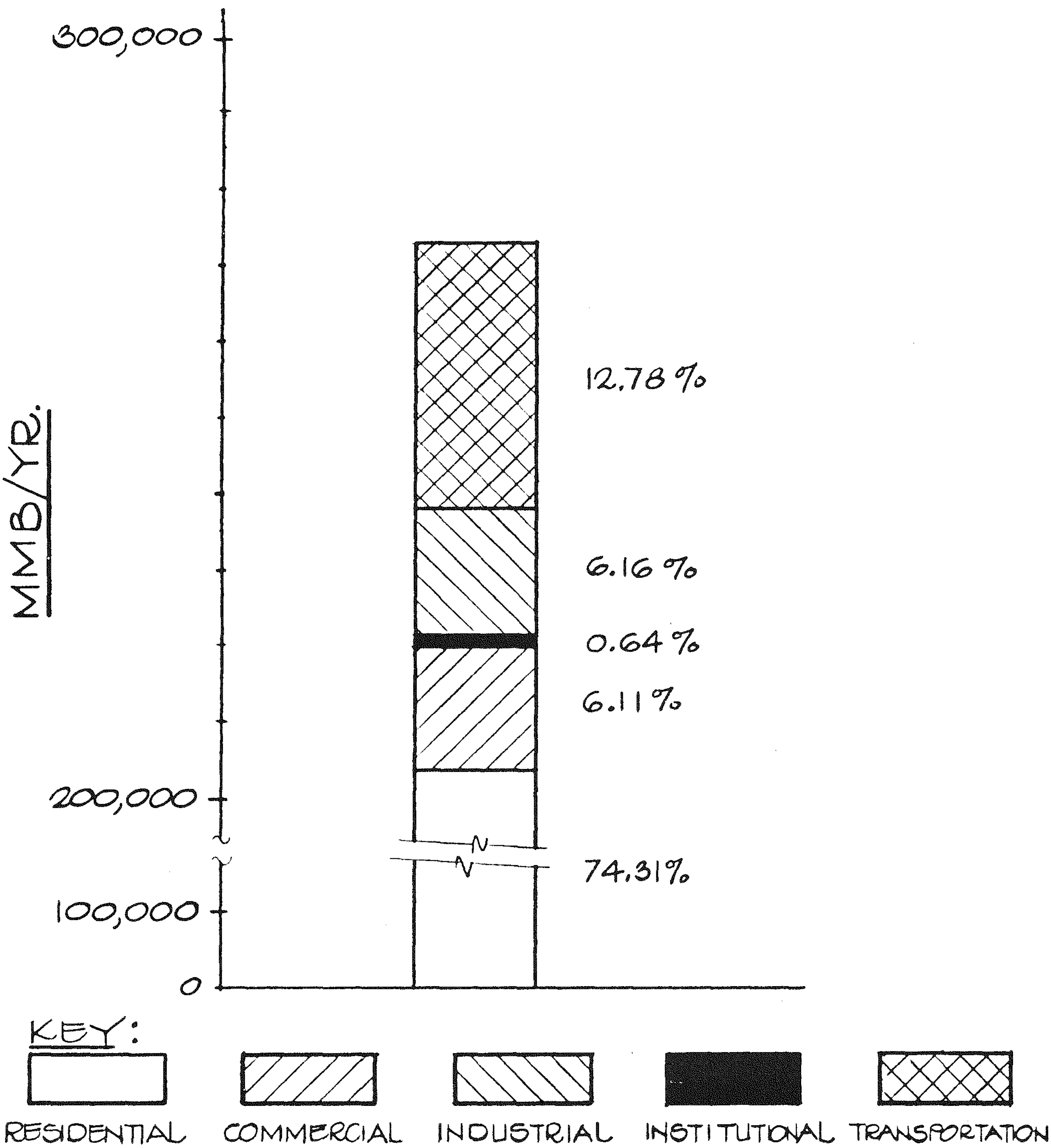
Energy savings have been demonstrated through the application of energy conservative land use mixes, through spatial arrangements affecting transportation requirements and through innovative applications of known technology.

Summary Bar Charts

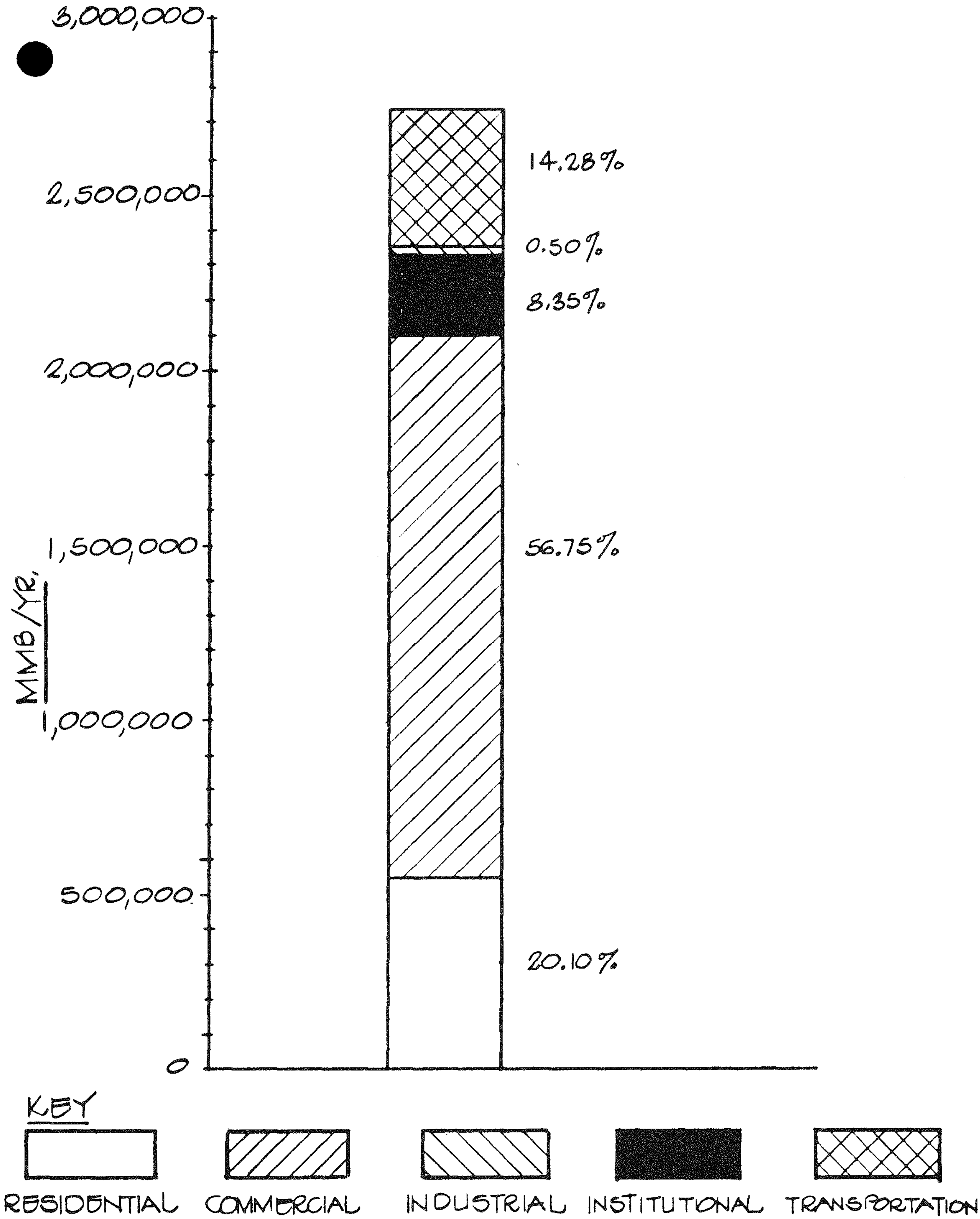
A graphical representation of energy utilization comparisons in absolute terms is shown in Figures 27 through 30. The Tucson graph (Figure 29) clearly shows the reduction in energy consumption due to unplanned 1995 growth, caused by an expected reduction in population. Under the planned 1995 growth option the reduction in transportation energy requirements is seen to be very important. However, the application of energy system technology to more efficiently planned areas is seen to have the most important influence. Per capita existing energy consumption of 98.86 MMB/capita/year drops 12.05% to 86.94 MMB/capita/year under the planned 1995 scenario without energy conserving technology, and with the technology a total reduction of 32.5%, a significant savings.

The Mt. Pleasant bar graph (Figure 30) does not show any dramatic reductions in the use categories due only to planned growth. However, with the application of energy system technology the total energy consumption is reduced by approximately 10%. When tested on a per capita basis, the 1975 consumption is 178.40 MMB/capita/year, and the total per capita consumption under the planned 1995 option is 158.43 MMB/capita/year, or a reduction in energy consumption of

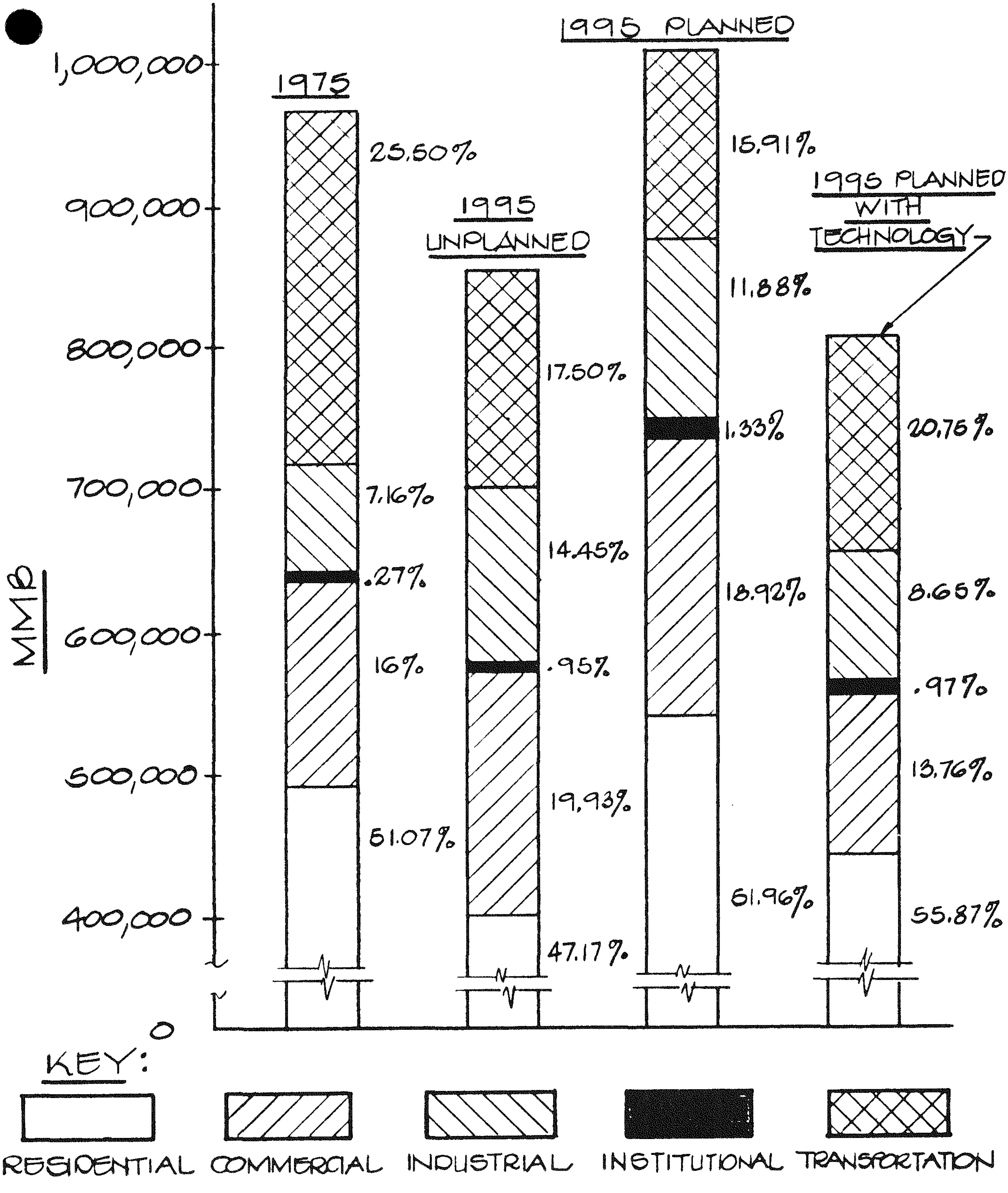
11.21%, while the reduction for the 1995 planned option with energy conserving technology to 147.18 MMB/capita/year is 17.5%, a dramatic savings.



CEDAR RIVERSIDE
ENERGY CONSUMPTION BY END USE FIG 27

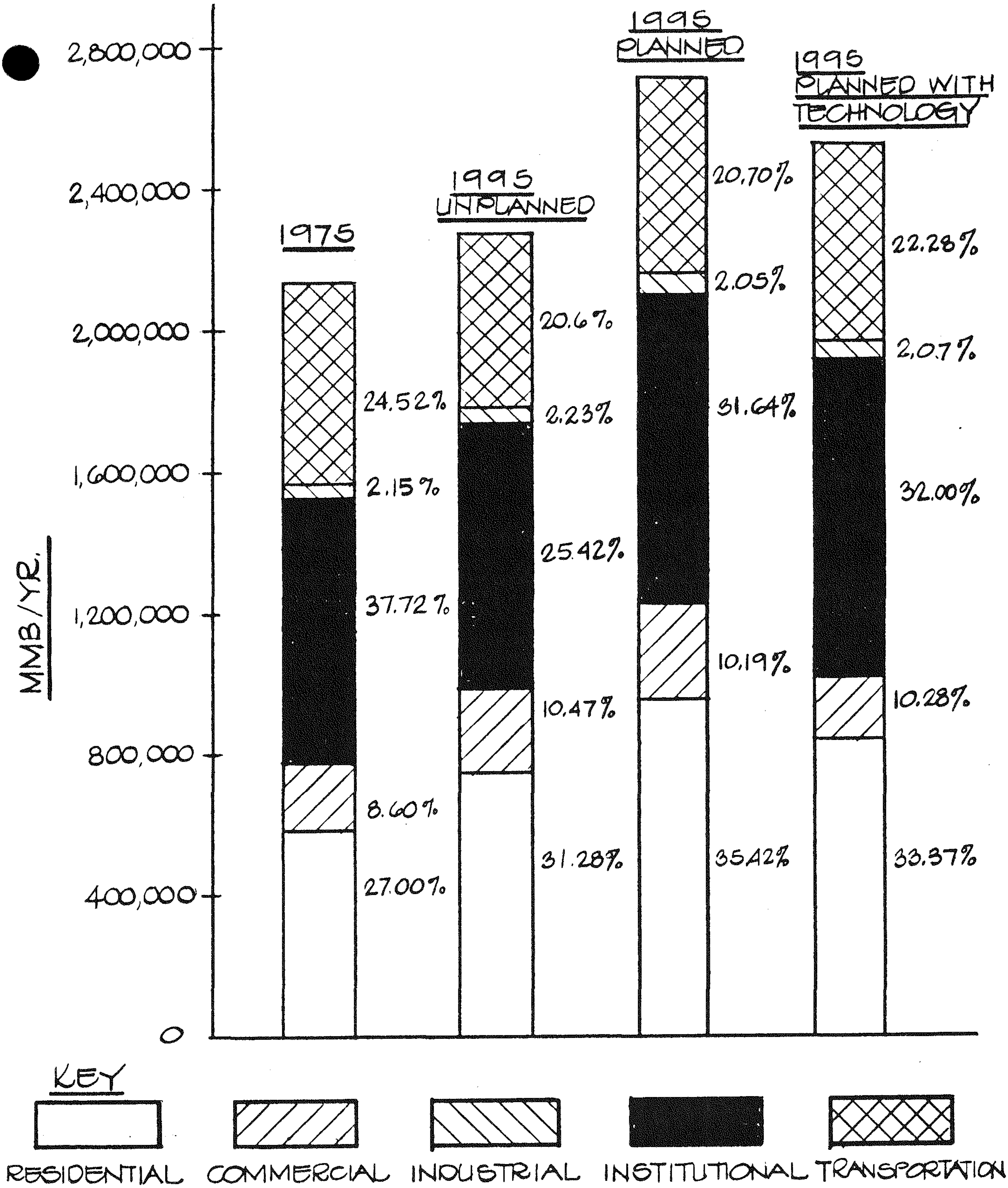


CHICAGO
ENERGY CONSUMPTION BY END USE FIG 28



TUCSON
COMPARATIVE ENERGY CONSUMPTION BY END USE

FIG 29



MT. PLEASANT
COMPARATIVE ENERGY CONSUMPTION BY END USE

FIG 30

Energy Elasticity

A more effective method of evaluation of these energy conserving design measures is in the form of a ratio of energy consumption change to development change , or

$$\frac{\%\text{ energy consumption growth or decline}}{\%\text{ development increase or decrease}} = \text{energy elasticity}$$

where the unit for development change is that appropriate for the given land use. The resultant ratio indicates the following rating of that particular energy conserving design measure:

- A ratio larger than one is unfavorable, because it indicates energy consumption is growing faster than development.
- A ratio of unity indicates that energy is growing at the same rate as development.
- A ratio smaller than unity is favorable because energy is growing at a slower rate than development.
- A negative ratio indicates that energy utilization is declining despite development increase, and is the most favorable of all.

The desirability of this ratio, termed energy elasticity, is that as a comparative tool it can disect the effectiveness of individual energy conserving design measures. Those considered most important and calculated below are the design measures presented in section B and grouped according to three energy saving sectors:

- land use mix
- spatial arrangement affecting transportation requirements
- energy system technology

as they interact with:

- the four land use categories separately
- all land uses together
- transportation

Table 49 shows the derivation of the transportation ratios for both the Tucson and Mt. Pleasant Study Areas.

In Table 50 for Tucson, energy reduction through technological innovation is shown to be the most effective. The two unfavorable ratios under the "unplanned" column are the result of the expected decrease in population with some increase in energy use. Residential and commercial use show improvement under the planned growth column related to land use mix factors. This is caused by the increase in multi-family housing and the trend to shopping nodes, both of which are favorable to energy consumption. Transportation related improvements through urban design are shown to be highly effective.

In Table 51 for Mt. Pleasant, energy reduction due to application of technology again is shown to be highly effective under the residential and commercial land use categories. However, improvements in energy elasticity are shown in all categories. It is misleading to assume that only the planned land use mix contributed to the unfavorable energy elasticity rating indicated for commercial and industrial uses. In fact, they result more from programmatic requirements rather than mix. For example, the bulk of the commercial increase in both the planned and unplanned scenario is in the office sector which has a higher than average energy consumption factor for the commercial land use category. This factor is, of course, unaffected by the planned land use mix, and the additional office space in the planned high growth scenario negates the positive land use mix effect of clustering the planned commercial retail facilities. It is only the utilization of energy conserving technology which shows marked savings in the office sector and additional savings in the retail sector. In the industrial category, all programmatic increases are in the light industry component, again having a higher than average energy consumption factor and as the increases are so small, the energy elasticity calculations are not meaningful. As indicated in Table 44, the 1995 planned scenario alters the mix only in the density of housing and commercial retail components shifting to multi-family units and larger concentrated facilities, respectively. No energy factor adjustments were made in the planned scenario.

Table 49: Transportation Energy Elasticity
(% change in BTU/% change in Pass. Mi.)

	Mt. Pleasant			Tucson		
	Present	Unplanned	Planned	Present	Unplanned	Planned
BTU (billions)	400	493	564	172	150	166
		+23%	+41%		-13%	-3.5%
Pass. Mi. (millions)	94	116	148	41	35	48
		+23%	+58%		-13%	+17%
Elasticity		1.0	0.7		1.0	-.2
Avg. BTU/Pass. Mi.		4200	3800		4300	3500

Table 50: Ratio of Energy Growth to Development Increase
Tucson

	Unplanned	Planned			
		Due to Land Use Mix	Due to Spatial Arrangement	Due to Technology	Reference Units
Residential	1.37	.593	-	(-) .597	Dwelling Units
Commercial	1	.638	-		Square Feet
Institutional	1	1	-	(-) .525	" "
Industrial	1	1	-		" "
Overall Consumption Less Transportation	2.45	.96	-	(-) .578	Population
Transportation	1	-	(-) .2		Passenger Miles

Table 51: Ratio of Energy Growth to Development Increase
Mt. Pleasant

	Unplanned	Planned			
		Due to Land Use Mix	Due to Spatial Arrangement	Due to Technology	Reference Units
Residential	1.09	.71	-	.47	Dwelling Units
Commercial	1.02	1.06	-	.75	Square Feet
Office	1	1	-	*	" "
Retail	.933	.819	-	*	" "
Institutional	1	.73	-	-1.78	" "
Industrial	3.96	4.0**	-	+2.13**	" "
Overall Consumption Less Transportation	.50	.75	-	.394	Population
Transportation	1	-	.7	-	Passenger Miles

* See energy elasticity ratio for all commercial (.75)
** Not meaningful for this study area, due to small incidence of industry

The Savings Potential of Energy System Technology

Due to the importance indicated here of energy system technology to efficient energy utilization, a range of potential savings of the systems described in Section B is summarized in Table 52. It should be noted that these energy reductions must be related to the cost of additional equipment needed, and that complete life-cycle cost calculations are required to establish economic feasibility.

The critical factor in the utilization of each system as determined from this analysis and the Consultant's experience is as follows:

- In the case of central plants the cost of distribution piping is considerable.
- With the use of Total Energy, land use mix is crucial.
- Selective Energy requires the cooperation of the local utility.
- Solid Waste Heat Recovery must consider the storage and handling of solid wastes, as well as the air pollution control requirements.
- Solar energy feasibility is largely governed by the local cost of fuel.

Table 52: Range of Potential Savings of Various Energy System Technologies

Central Heating & Cooling Plant	5% - 15%
Solid Waste Heat Recovery	10% - 25%
Selective Energy	15% - 25%
Total Energy	10% - 20%
Solar Energy (DHW)	10% - 20%

Notes:

The percentages shown refer to energy reductions only without system cost considerations.

Percentage reductions are to be applied only to the specific use category that benefits from the technology application.

Energy Consumption Related to Land Use Density

Since previous studies have found a relation between energy consumption and urbanization density, a comparison was attempted, as shown in Table 53. Except for Chicago, which does not fit the pattern, total energy consumption and transportation energy consumption is inversely proportional to population density. There is some correlation of the Chicago findings with the Regional Plan Association study in that energy consumption declined by 50% from the periphery to near the center, only to increase again by 38% above the low point at the center.

As there is considerable difficulty in finding average study areas, the density comparison between study areas in different regions is not an appropriate indicator of energy consumption.

Table 53: 1975 Energy Consumption Per Capita Versus Land Use Density for the Four Study Areas

	Cedar Riverside	Chicago	Tucson	Mt. Pleasant
1. Total Consumption MMB	273,756	2,744,821	964,723	2,246,458
2. Transportation Energy Consumption MMB	35,000	392,000	246,000	551,000
3. Population, p	3,305	9,522[1]	9,758	12,592
4. Total MMB/Capita	82.83	288.2[2]	98.86	178.40
5. Transportation MMB/Capita	10.59	41.16[3]	25.21	43.75
6. Study Area Acreage, ac	27.5	131.2	1,490	7,502
7. Density, p/ac	120	72.52	6.54	1.68
8. No. of D.U.	1,863	6,456	4,420	3,690
9. D.U./Acre (development intensities)	67.7 (high intensity/ urban)	49.1 (high intensity/urban)	2.96 medium intensity/urban	.491 (medium t low intens urban)

1. Resident population; daytime population is usually ten times this number.

2. It must be remembered, however, that many of the land uses in the study area are related to daytime population, rather than only to resident population, on which this factor is based. The following modification may therefore, be in order: since daytime population for the study area is estimated at ten times the resident population by a local planning group, the "Commercial" item only of the tabulation is reduced by 90% - this gives the following:

Notes: (continued)

Residential	57.94	MMB/Capita/Yr.
Commercial	16.35	
Institutional	24.07	
Industry	1.48	
Sub Total	99.84	
Transportation	41.16	
	141.00	MMB/Capita/Yr.

This modified total compares well with the Ref. No. 5 energy consumption factor for Manhattan, New York of 138.9 MMB/Capita/Yr. and alters its rank relative to the Mt. Pleasant Study Area.

3. If the CATS average daily trips are utilized (see Table 18), the 45% reduction results in 18.52 MMB/Capita, a comparative figure which places Chicago in the proper rank order according to population and housing density.

G. LOCAL LAND USE CONTROL STRATEGIES TO SUPPORT ENERGY CONSERVING LAND USE PLANNING AND DESIGN

Introduction

The strategies and concepts discussed in this section are meant to be applicable throughout the country, though a wide span of local variation must be anticipated. The focus throughout is exclusively on those aspects of land use regulation and control which generally remain the purview of local government. For the purposes of this report local government is defined as towns, cities and villages to whom certain planning powers in most instances are delegated by State statute.

This focus has been derived as a result of the history of this study. It was initially anticipated that a broad review of Federal, State, Regional, County and local public authority as well as incentives to the private sector would be considered. Refinement of the study in subsequent stages of client and project review as well as the evolving parallel work of Technology + Economics, Inc. now indicate that opportunities to implement energy conserving land planning strategies by means of existing local public government power and authority should be stressed.

It will of course, be recognized that the local implementation strategies presented here should be reasonably supplemented, if a very high degree of achievement is to be anticipated, by support from a number of existing and proposed State and Federal procedures and programs. In this regard appropriate Federal programs and potential policies are reviewed in The Energy Vista: Policy Perspectives on Energy Conservation Through Land Use Management, Interim Draft, June 1976, by Technology + Economics, Inc., Cambridge, Massachusetts.

Our more specific focus in this report is to propose a new concept which might be integrated into local planning options in order to promote new development and redevelopment which is energy conserving. This concept we call the Energy Conservation Zone (ECZ). It is believed that the adoption of such a concept at the local level would help to accomplish many of the most critical energy conserving design and planning interventions, such as those presented in this study, in the near term using conventional and generally available administrative tools and incentives.

The Energy Conservation Zone

The descriptive outline presented below is intended to describe boundary characteristics and objectives of the ECZ. A detailed discussion of ECZ implementation approaches follows this outline.

Boundaries:

The Energy Conservation Zone is envisioned as a designated area within a local community. Unlike an historic district or a coastal zone or an agricultural district, it is not necessarily distinguished or defined by existing natural or man-made physical features. And unlike a Planned Unit Development it is not necessarily distinguished as a zone which must be predominantly planned and initiated by a single developing entity on generally undeveloped land. Also, unlike a PUD, the perimeter of an ECZ need not be restricted to an area for which development appears economically defensible in a specifically planned development campaign by a single entity or amalgam of private real estate interests. Like the PUD, however, the Energy Conservation Zone is imagined as an area whose boundaries may be determined at the local level; but these boundaries might very well include terrain which is partially developed or even rather fully developed and entering a stage of in-fill and redevelopment.

Objectives:

As will be elaborated in more detail below, the objective of the ECZ is to establish an area in which a high degree of energy conserving planning and development may be reasonably expected. The ECZ, as proposed, would also have a priority claim on local resources in recognition of the local, state and national interest served through creating energy sensitive settlement and development patterns. It suggests then a site specific area in which special incentives are offered the private sector for energy efficient building and planning. It is intended to balance recognized additional costs of providing energy conserving utility systems, transportation, structures and settlement patterns with off-setting long and short term economic benefits to individuals and to the public. To be optimally effective, as stated above, the presence of the ECZ as a new planning and development tool should also be reflected in various State and Federal procedures and statutes which are not discussed in this report.

In addition, another objective of the Energy Conservation Zone is to inaugurate a first testing ground for the practical realization of energy sensitive design and planning. A number of ECZ's, established throughout the country in various physical, ecological, climatological, and energy demand and supply diverse areas, if properly utilized and monitored, could form the basis for a well conceived national experiment directed toward the evolution of a new option for local area planning wherever energy conservation is a prime objective.

The implementation recommendations here proposed, in addition to being administratively feasible in a near term time frame, are calculated to be capital conserving. Thus, new public expenditures are minimized while the preferential allocation of resources and specialized use of established public rights are suggested.

Local Planning Authority for the Implementation of the Energy Conservation Zone

The following segment of this report outlines an approach to the implementation of an Energy Conservation Zone focused on local planning tools and procedures which would stimulate the realization of design and planning proposals such as those presented in section B. It will be noted that a number of specialized provisions which would benefit the realization of an ECZ are also suggested.

Within existing local government there generally exists the power to prepare a comprehensive plan, adopt subdivision controls and regulations, establish an official map, create a zoning ordinance and zoning descriptors, adopt a capital improvement program and enforce building codes. Among these there is adequate authority to establish effective Energy Conservation Zones. Some of the potential approaches are as follows:

Comprehensive Plan and ECZ Schematic Plan:

In the preparation of comprehensive plans by Town Planning Boards or their consultants, the inclusion of one or more ECZ's should be established. The ECZ should be located wherever opportunities for energy conservative residential, commercial and/or industrial development appears feasible. The location of such zones should reflect awareness of optimal energy sensitive transportation planning, utility siting and delivery as well as urbanization patterns. This planning element would be assured if such a requirement were truly reflected and enforced in revised regulations governing U.S. Department of Housing and Urban Development "701" planning grants administered by the States for assistance in the preparation of comprehensive master plans. Vague language presently exists in Article 600.55(b) of the regulations.

The Comprehensive Plan, once prepared, provides a specific basis for a local zoning ordinance. It should be remembered that Town Planning Boards have the authority to change the Comprehensive Plan when conditions call for its amendment.

As part of each community's Comprehensive Plan it is suggested that any designated Energy Conservation Zone be subject to intensive schematic planning by community planning officials and/or their designated professional consultants. Through such a process, a schematic land use plan for the ECZ could be presented to the local governing body, following public hearings, for approval. The existence of this plan, more refined than a zoning description, and more specific than the majority of the Comprehensive Plan itself, would indicate a synthetic means to coordinate energy conserving planning and design objectives over the term of anticipated growth and development of the Energy Conservation Zone. Such a planning procedure would offer a means to achieve the coordinated results in general adherence with a combination of local planning tools including the Comprehensive Plan, Official Map, Capital Improvements Program, Subdivision Regulations, and Zoning, as well as any special local provisions such as development or energy rights utilization and transfer. In addition, this schematic plan should be subject to variation and modification by approval of the local planning board or of the local review and appeals boards. The plan would suggest a cohesive means for numerous development and redevelopment schemes, perhaps undertaken incrementally by many parties over a relatively long time period, to be linked and coherent in terms of their overall energy conserving characteristics. As the Schematic Plan would be a part of the Comprehensive Plan, it should receive 701 review as well as A-95 clearance, both significant in terms of overall coordination to achieve energy conservation. Environmental Impact Statements would be filed, in addition, for any proposed major facility to be funded or administered by the Federal government within the ECZ, as required by the National Environmental Policy Act.

Subdivision Controls and Regulations:

Special Subdivision Controls and Regulations should be enacted for the ECZ. These regulations might require that open space, road networks, transit access, utility services are all designated and delivered in a manner that is optimally energy conserving by specific recognized standards given reasonable options and expectations for the region and for the specific ECZ area. As subdivision regulations define the design parameters for the street network and building parcel layout, they offer significant opportunity to induce energy sensitive planning. Examples are permission and inducements to reduce the amount of street network, as well as the average and minimum size of a permitted building parcel. Offsetting these development capital and operating cost savings might be regulations which more strictly control the location of parks and recreation areas to assure proximity to residential areas in a meaningful quantity with reasonable and usable improvements and facilities. There should also be a set of requirements which ensure that a proposed subdivision will be coordinated with adjacent developments with respect to street connections, utility services and open space reserves. Utility installation requirements for both generating and distribution systems should be directed toward sound energy conserving standards. Their cost, however, should, if economically infeasible to the public sector, be offset by an appropriate compensatory program of federal and local tax and finance policies.

Official Map:

An official map should be established for areas lying outside of any incorporated village or city. This map should show the layout of existing streets, highways, parks, and drainage systems. To make the official map an effective reinforcing tool for energy conserving planning it should also indicate the location and character of proposed public improvements such as roads, utility and drainage systems and additional parks and open space. These should be planned by public officials and their consultants as model, energy conserving prototypes. It should be noted that though short term capital expenditures are encountered in the planning and development of green space, utility systems and recreation areas need not represent a long term community financial loss. High land and improvement values in the vicinity of such areas generally generate a long term stream of tax revenue that can more than pay for their initial and operating costs, as has been noted in a number of analytical studies. In addition, these should be supplemented by indications from the public sector of proposals for improving existing facilities such as schools and creating new public facilities. A high proportion of these proposed improvements and expenditures of public resources should be within an area designated as an Energy Conservation Zone.

The Official Map should become an important and dependable source of forecast information concerning the allocation of resources within the local Capital Improvement Program. Once the official map is adopted by the local governing body after public hearings and referral to the planning board, no building permit should be issued within an ECZ for a proposal which does not conform to the allocation of land for development, open space and infrastructure rights-of-way. In short, the official map is a basic tool which delineates where development may take place and where it may not. It also functions as a dependable guide as to where public improvements will take place, and suggests the character of these improvements.

Capital Improvement Program:

The community establishes a Capital Improvement Program. This program, which should be revised annually, details all major public projects to be undertaken for a five to ten year period. These projects include proposed acquisition of park lands and open space, construction and major reconstruction of municipal buildings including schools, development of sewage and water lines, treatment and disposal facilities, road extensions and improvements. A tentative budget should be included in the Capital Improvement Program; a development timing schedule should be presented; and priorities established.

This Capital Improvement Program is a means by which local government is able to give well considered priority allocation of resources received from a wide variety of Local, County, State and Federal sources and programs to the implementation of an Energy Conservation Zone. The signal of significant concentration of effort and resources into an Energy Conservation Zone through the Capital Improvement Program is likely to stimulate private concentration of capital and development and redevelopment resources in the same area thus facilitating the realization of relative energy conservation as a concomitant aspect of community development.

A concentrated focus within the Capital Improvement Program on a designated Energy Conservation Zone is also likely to permit the introduction of energy efficient and energy conserving utility systems and infrastructure through the stimulation of relatively rapid development under conditions which give a priority consideration to these matters. Special provisions which might further increase the likelihood of the realization of this objective are discussed below under "Special Provisions."

The Capital Improvement Program, and the designation of one or more Energy Conservation Zones within it, should be coordinated for maximum effectiveness with areawide and even state level planning agencies. Such a procedure, cleared through the A-95 review process, would maximize the potential for the coherent and judicious utilization of a wide array of Federal program monies which are distributed ultimately to local jurisdictions or spent within them. Each State Energy Office or parallel agency could assist in the planning, coordination and distribution of Energy Conservation Zones throughout its area of jurisdiction in consultation with other State and Federal agencies and perhaps in an advisory capacity to local government. Such a program would help produce a locally responsive mechanism for energy focused planning and coordination mindful of other significant and relevant planning activities being undertaken by a wide array of Federal and State offices and programs ranging from the EPA and HUD through DOT, and including many others.

In recognition of the potential for a disproportionate share of local public funds allocated through the Capital Improvement Program to designated ECZ's, a variety of offsetting local measures might be introduced including variable assessment and real estate tax practices, development rights or energy rights programs and others as suggested below. In addition, extra burdens may be placed on a private developer in terms of required capital facility improvements for development within the ECZ as a match or partial match to the public expenditures exerted within the district which in general would be expected to raise the value and desirability of many types of projects within the ECZ.

A significant impediment to the orderly and appropriate establishment of energy conserving planning and infrastructure development is their potential effect on housing maintenance costs. However, if savings for clustering, reduced street network and common utility facilities are passed along to the end user, these may be largely offset. In addition, if financing incentives are offered by public programs and local lending institutions, as suggested below (see "Special Provisions") user costs for housing within the ECZ are likely to be favorably compared to similar annual expenditures elsewhere in a given community.

Alternatively, it would be possible to direct energy conserving community development and growth through required development timing related to completed stages of the Capital Improvement Program which might itself focus on one or several designated Energy Conservation Zones. A relevant example is of course, Ramapo, New York. There the town planning board prepared a comprehensive master plan for the town's future growth. The town then amended its zoning ordinance to prevent the development of land for new housing unless the developer of such housing received a "special permit," regardless of the existing residential zoning of his land. The permit is granted only if the land to be developed is located in an area of the town that will be served by a minimum proscribed level of certain public facilities which are detailed and scheduled in the town's Capital Improvements Program. This CIP established an eighteen year capital improvement program involving three six-year phases for the construction of municipal services. Thus, no land in the town can be developed for residential purposes unless the developer can show that certain capital improvements -- whether constructed by the town or by the developer himself -- will be available by the time the proposed project is completed. Such an approach ties residential development to the provision of adequate and appropriate infrastructure and utility systems. This link provides an opportunity for the enactment of energy observant planning and phased development and could be extended to cover commercial and industrial development as well.

As in Ramapo, should such a development timing program be instituted, it is important to recognize the manipulation of land values implied. This can be done through a real estate taxation policy geared to an established development timing sequence. Thus, the owners of property with deferred development potential should be able to apply for a tax reduction in recognition of the induced holding period and reduced development value. Within the ECZ, which would be presumably scheduled for first priority capital improvements, real estate taxes would be based on a highest and best use formula.

Zoning Ordinance:

A zoning ordinance should be adopted in accordance with the Comprehensive Plan, as recommended by the Town Planning Board or other suitable body. In addition to other zoning areas designated, one or more Energy Conservation Zones should be created and mapped in a proscribed location. These should not be floating zones as are permitted in some ordinances which include Planned Unit Development and related zoning concepts.

Special provisions to include within the zoning ordinance which apply specifically to the Energy Conservation Zone are the following:

1. Mixed use zoning for the intermingling of residential and commercial uses is a permitted option.
2. Mixed use zoning for the intermingling of certain industrial land uses with commercial residential and recreational uses is permitted within proscribed areas.

3. Higher densities for residential development are permitted than is the case in other areas incorporated in the comprehensive plan.

4. Cluster development is permitted.

5. Introduction of density bonus provisions for the ECZ, which might include:

   - Increase density bonus in exchange for planning and development of para-transit, bikeways and improved pedestrian paths and routes or for contributions toward an escrow fund reserved for these same objectives.
   - Increase density bonus for provision of specified types of energy conserving utility systems.
   - Increase density bonus for planning and development of local recreation facilities in open space areas designated in the Comprehensive Plan, particularly for in-town Energy Conservation Zones.

The provisions of the zoning ordinance, its attendant land use map and the suggested schematic plan for the ECZ together offer a significant means to establish energy conservative planning and development in a community. Through them the relationship of land use configurations, densities, new public improvements, parking requirements and transportation facilities siting may be effectively coordinated.

As a result of knowledge gained in recent years as to the impact of automobile travel on energy utilization, the need to reduce automobile trips through the zoning ordinance is focused upon. Toward this end the potential for increasing density is outlined above while several other options to reduce automobile travel in selected situations are suggested below. These include:

1. Reduce conventional requirements for the provision of off-street parking facilities particularly in commercial and industrial areas of the ECZ. Where this practice is introduced, transit and para-transit service should be made available, at best throughout the community.
2. Reduce the conventional dispersion of residential areas away from commercial, industrial and institutional job centers.
3. Reduce the conventional dispersal of residential buildings from one another by reducing lot sizes. At the same time maintain community-wide densities at an appropriate level through the increase of open space and recreation areas close to housing.

Building Code:

Local governments are authorized to adopt standards which control building construction. These may include building codes and housing codes. Through this regulatory right it is possible for local government to stimulate energy conservation through special emphasis on material requirements such as insulation, etc. It would be possible, in addition, to establish special provisions which pertained as an option within Energy Conservation Zones which could simultaneously foster even greater energy conservation without penalty to the builder or redeveloper. Among the possibilities are:

1. Permitted increased density in exchange for construction technique

and/or system utilization which contains energy conserving characteristics in excess of traditional building code requirements.

2. Tax abatement or assessment considerations for particular costs attributable to energy conserving construction and/or system utilization.

In addition, a number of states including California, Florida, Oregon, Pennsylvania, Texas and Virginia have already placed considerable emphasis on building codes as a means to pursue energy conservation practices in the development process. While building codes are not land use controls and thus not emphasized in this study, they do offer an effective means by which local officials may take action to reduce energy consumption in new buildings and in the redevelopment process.

Special Provisions for the Implementation of The Energy Conservation Zone

There are a number of special provisions already in limited use which might be employed at the local level to strengthen the attractiveness and implementability of the ECZ. Among these are:

Transferable Development Rights:

Within the proposed comprehensive plan it is possible to define and allocate development rights as a substitute for zoning rights as has been provided for or is being considered in one form or another in several states including New Jersey, Oregon, Alaska, New York and Virginia. Though there are many potential complexities to the whole concept of Development Rights and their potential transfer, and already a burgeoning literature exists on the subject, some particular suggestions relative to their use in an Energy Conservation Zone are as follows:

The ECZ's could be described as the only areas within a designated Comprehensive Plan into which development rights could be transferred and purchased. At the same time, commercial, residential, and industrial development building potential would be allocated to the ECZ in excess of the development rights distributed to it. Such an approach could be a useful device to assure a market for development rights, the concentration of desired development within an ECZ and simultaneously avoid the windfall/wipeout phenomenon which could occur with ECZ planning and traditional zoning without a development rights program. In addition, the use of a transferrable development rights concept is likely to be of community-wide benefit as regards energy conservation development for the following reasons:

- rights utilized in the ECZ, (if sale of all rights for any given parcel were required to sell at all) would assure increased amounts of open space outside of the ECZ boundary.
- a means to induce residential, commercial and industrial population distribution and jobs according to energy conserving principles would be established without inequitable land use controls.

Energy Rights:

A more elaborate and sophisticated approach closer to the specific concerns and objectives of this study but based on the development rights concepts would be the introduction throughout a community of "energy rights" as a replacement for either conventional zoning rights or development rights. Such rights could be allocated to all land covered by the Comprehensive Plan and might be defined by an acceptable standard such as BTU of consumption per square foot of construction factored for land use type. This factor would establish a required energy consumption performance standard for redevelopment and new building. Existing structures would be granted a pre-existing non-conforming status as is the practice in present conventional zoning. Energy rights, thus allocated, could be transferred. Once again the ECZ, along with its other special characteristics, would be able to accept a high proportion of underutilized energy rights. This procedure would focus development where it was planned for in terms of energy considerations. It would also assure energy utilization throughout the whole area covered by the Comprehensive Plan on a basis that could be anticipated, and thus more efficiently served in terms of energy systems and infrastructure. Like zoning, energy rights allocations could be periodically reviewed and modified to adjust to evolving community planning and regional changes in terms of energy consumption requirements.

Local Public Incentives to the Private Sector

As is well known, many actions which profoundly affect land development patterns result directly from financial incentives offered by the public sector. The more powerful of these are probably special provisions contained within Federal tax laws and regulations. Nevertheless, through the control of real estate assessment and tax levies, local government is in possession of a reasonably powerful tool that could be used to foster the concept of the Energy Conservation Zone, or energy conservation through its entire area of jurisdiction. The options available fall into the categories of assessment practices and real estate tax policy. It would be possible, on an energy selective basis, for instance, for local government to:

- Forego increased assessment on real property improved in an acceptable manner for the particular purpose of achieving approved energy conserving objectives.
- For development in conformance with energy conserving objectives offer tax abatement for a specific time period, or a phased below market tax program in the private sector for all development within the ECZ as proscribed by the ECZ Schematic Plan. Justification for such a preferential act might be found in communities in which energy conservation was of critical importance to the health and welfare of the community at large. Long term, public funds might be more than recovered as a result of (1) acceleration of development through the device of the ECZ; or (2) augmentation of value due to sound planning and coordinated public-private development within the ECZ which will justify higher eventual assessment and taxes than would otherwise be the case.
- Undeveloped land within the ECZ is assessed and taxed at highest and best use while undeveloped land outside of the

ECZ is assessed and taxed based upon current use. Such a program, though subject to charges of preferential tax policy, would be commensurate with other aspects of proposed ECZ regulatory legislation and would, in fact, balance proposed municipal resource allocations in a more equitable manner. Thus, real property ownership beneficiaries of disproportionate public expenditures for municipally sponsored improvements within the ECZ would also be expected to contribute a higher share of public tax revenue. Simultaneously, the policy could assist in the maintenance of existing natural areas, scenic vistas, historic zones, ecologically critical lands, open space, forests, and agricultural lands in their existing condition. Such a result would contribute to sound and balanced community growth as well as further the cause of energy conservation during the process.

Whenever a program of preferential assessment is considered, as proposed here, recapture provisions or conversion penalties must be associated with the program to reinforce the incentive to preserve land in its current use. These penalties which discourage "checkering" and leapfrog development most commonly take the form of a "rollback" or a "deferred payment" beneficially assessed if the land is developed. A step beyond such penalty provisions is a requirement that any landowner deriving preferential assessment sign a contract to keep his land undeveloped for a specified number of years. Currently, over 15 states with preferential assessment programs have coupled a penalty provision of some sort for the sale of such property. Where necessary under unusual circumstances to accomplish objectives set for the ECZ in the Comprehensive Plan and Schematic Plan, local powers of eminent domain could be exercised with perhaps even concomitant traditional features of land write down.

Local Private Incentives to the Private Sector:

Though consideration of private action which might be taken to strengthen the implementation of energy conserving planning and development is of only tangential importance within a study which is concerned with public policy and authority, a number of outline observations can be made as follows:

- If energy conservation in the building and development process were considered in terms of conventional real estate economics, it is clear that for any given structure or group of structures, those which were energy conserving would carry a less burdensome annual operating cost statement and thus display higher earnings for income producing property and lower operating costs for owner-occupied residential property. Both may be translated into higher capitalized value. This higher value might then quite reasonably be expected to be translated into a higher ratio of loan to actual cost at the time of permanent financing. Such a consideration could make the financing of energy conserving structures sufficiently attractive to overcome any experienced first cost penalties and indeed promote energy conserving construction and planning. A policy such as this, though ideally applied on a national level, might very well be articulated by locally oriented financial institutions in an effort to promote energy conservation in the community while attracting business to the institution.

- A second and rather often considered option which is outside of but related to land development controls falls to the utility industry. It is possible to consider the economic justification of differential utility rate charges within a local community based on an analysis of the actual cost of utility service delivery including original capital costs of plant and infrastructure as well as the relatively uniform cost of fuel, power, labor, etc. In such a system of rate structuring, energy conserving planning and design such as one would expect in an ECZ should be the recipient of utility user charges below those sustained elsewhere in the community. Such a program would be of great benefit in attracting residential, commercial and particularly industrial activities to the ECZ without overall cost penalty to the utility. This would in turn enforce community development which was mindful of energy and capital conserving infrastructure planning of delivery systems as well as use control. Such an attitude would effectively promote the cause of energy conservation and stimulate interest in construction within the ECZ as a beneficiary of such a policy.

Outline of Planning Proposals

The following outline repeats the energy conserving design proposals more fully discussed and described in section B, Energy Conserving Design Proposals, and section F, Energy Savings Calculations and Findings.

Home-to-Work Travel Reduction

1. Development of new multi-family housing units adjacent to places of existing employment and services.
2. Relation of housing income levels to adjacent employment opportunities.

Land Use Densification and Revitalization

3. Redevelopment and increased densification of older housing communities.
4. Revitalization of existing town centers and increased multi-use aspects.

5. Intensification of industrial land uses within prescribed areas.

Local Auto Travel Reduction

6. Reduction of quantity of urban streets devoted to automobile use.

7. Initiation of alternative transportation modes to individual automobile travel.

Energy System Integration Into Mixed Land Uses

8. Introduction of energy efficient utility systems and infrastructure.

9. Development of new multi-use complexes of residential and business functions.

10. Integration of residential and industrial energy uses.

Regional Growth Management to Achieve Trip Reduction

11. Preservation of open space and containment of sprawl.

12. Revitalization of existing recreation facilities in proximity to residential units.

13. Development of new local recreation facilities available to residential units.

Application of Implementation Recommendations to Planning Proposals

The Planning and design proposals suggested for energy conserving new construction and redevelopment in Mt. Pleasant, Westchester County, New York and Tucson, Arizona, incorporate opportunities for building found through research and analysis of those communities and then supplemented by energy conserving land development patterns, attributes and opportunities for utility delivery system design, transportation proposals and suggestions for the arrangement of open and recreational spaces. In short, the physical development proposals encounter the full range of building and design potential as they would be in a typical situation.

On the other hand, implementation strategies for the realization of these project due to the history of this study as outlined above, are here restricted to local regulation, practice and incentive. In a typical situation, these proposals could be further reinforced by county, state and federal initiatives. Nevertheless, the Energy Conservation Zone, as proposed, might reasonably be considered an appropriate focus of activity which could stimulate and enhance the chance for realization of the planning and development recommendations proposed here. Particular ways which various aspects of the proposed local implementation strategies might be refined to promote those design and building interventions recommended within this study are detailed as the various implementation strategies discussed above. Through a review of these, one is able to conclude that the local level potential for the realization of energy conservation planning and design through the agency of a device such as the Energy Conservation Zone is quite extensive. This is in large measure because the ECZ is conceived of as an area for specialized activities, a part of the physical domain of a community intended to service the multifaceted complex objectives associated with energy conservation in the land development and redevelopment process through selected land use control.

Conclusion

It is our conviction that the focus on local and realizable strategies must remain central to considerations for near term realization of energy conservation in the land development process. At the same time, the potential for introducing the concept of the Energy Conservation Zone or a rather close counterpart as a means of assuring rapid use of local authority is compelling. Without such a concept which initially describes special physical areas for priority consideration, it is unlikely that energy conservation will become an effective determinant of land use considerations at the local level where so many other competing forces must be considered. Furthermore, many of the greatest gains in energy conservation susceptible to planning and design intervention under the guidance of land use controls are realized when a particular physical terrain of some limited size, with all of its interrelated activities and land uses, is considered as a manageable ensemble. Since it is in the domain of control of the land and its uses that local authority in planning primarily resides, it is strongly recommended that a physically based concept such as the Energy Conservation Zone be employed to incorporate the power and interest of local government if energy conservation objectives are to be pursued through the planning process at the local level.

APPENDIX

Table A-1: Gross Density, Population in Rank Size Order of SMSA's in Four Categories Designated as Future Growth Areas

Rank	I. 2. 5 Million and Over (inclusive)	Population (persons)	Gross Density (psm)	1970-1990 Growth Projection
1.	New York, N. Y. - N. J.			
	Total SMSA	9,973,577	7,206	15%
	Core City (Manhattan)	1,539,233	66,923	
	Core County (five boroughs)	7,894,862	26,316	
	Suburban County (Westchester)	894,104	2,018	
	(Rockland)	229,903	1,306	
2.	Los Angeles, Long Beach, Calif.			20%
	Total SMSA	7,032,075	1,728	
	Core City (Los Angeles)	2,816,111	6,060	
	Core City (Long Beach)	358,673	7,369	
	Core County	7,032,075	1,728	
	Suburban County (None)	-	-	
3.	Chicago, Ill.			19%
	Total SMSA	6,978,947	1,876	
	Core City	3,362,825	15,136	
	Core County (Cook)	5,492,369	5,757	
	Suburban County (DuPage)	491,882	1,486	
	(Lake)	382,638	837	
4.	Philadelphia, Pa. - N. J.			18%
	Total SMSA	4,817,914	1,356	
	Core City	1,948,609	15,175	
	Core County	1,948,609	15,175	
	Suburban County (Montgomery)	623,799	1,258	
5.	Detroit, Mich.			19%
	Total SMSA	4,431,390	1,132	
	Core City	1,511,336	10,968	
	Core County (Wayne)	2,666,751	4,408	
	Suburban County (Oakland)	907,871	1,047	
6.	San Francisco, Oakland, Calif.			24%
	Total SMSA	3,109,519	1,254	
	Core City (San Francisco)	715,674	15,764	
	(Oakland)	361,613	6,771	
	Core County	715,674	15,764	
	Suburban County (Alameda	1,073,184	1,464	

Rank	I. 2.5 Million and Over (inclusive)	Population (persons)	Gross Density (psm)	1970-19[illegible] G[illegible]th Projecti[illegible]
7.	Washington, D. C.			53%
	Total SMSA	2,908,801	1,034	
	Core City	756,510	12,321	
	Core County	756,510	12,321	
	Suburban County (Fairfax)	455,021	1,140	
8.	Boston, Mass.			66%
	Total SMSA	2,899,101	2,351	
	Core City	641,053	13,936	
	Core County (Suffolk)	735,190	13,128	
	Suburban County (part Middlesex)	1,083,188	2,579	
9.	Nassau-Suffolk, N. Y.			-
	Total SMSA	2,553,030	4,941	
	Core City (Levittown)	65,399	9,484	
	Core County (Nassau)	1,428,080	4,941	
	Suburban County (Suffolk)	1,124,950	1,211	

Rank	II. 1.0 Million to 2.5 Million (inclusive)	Population (persons)	Gross Density (psm)	
10.	St. Louis, Mo. - Ill.			15%
	Total SMSA	2,410,163	488	
	Core City	622,236	10,167	
	Core County	951,353	1,906	
	Suburban County (Madison)	250,934	342	
	(St. Charles)	92,954	169	
11.	Pittsburgh, Pa.			5%
	Total SMSA	2,401,245	788	
	Core City	520,167	9,422	
	Core County (Allegheny)	1,605,016	2,205	
	Suburban County (Westmoreland)	376,935	368	
12.	Dallas - Ft.Worth, Tex.			41%
	Total SMSA	2,377,979	284	
	Core City (Dallas)	844,189	3,179	
	(Ft. Worth)	393,463	1,919	
	Core County (Dallas)	1,327,321	1,545	
	(Tarrant)	716,317	832	
	Suburban County (Collin	66,920	80	

Rank	II. 1.0 Million to 2.5 Million (inclusive)	Population (persons)	Gross Density (psm)	1970-1990 Growth Projection
13.	Baltimore, Md.			14%
	Total SMSA	2,070,670	917	
	Core City	905,759	11,568	
	Core County	621,077	1,038	
	Suburban County (Harford)	115,378	255	
14.	Cleveland, Ohio			14%
	Total SMSA	2,064,194	1,359	
	Core City	751,046	9,893	
	Core County (Cuyahoga)	1,721,300	3,774	
	Suburban County (Lake)	197,200	854	
15.	Newark, N.J.			24%
	Total SMSA	2,054,928	2,039	
	Core City	382,377	16,252	
	Core County (Essex)	929,986	7,153	
	Suburban County (Morris)	383,454	819	
16.	Houston, Texas			45%
	Total SMSA	1,999,316	294	
	Core City	1,232,407	2,841	
	Core County (Harris)	1,741,912	1,011	
	Suburban County (Brazaria)	108,312	76	
17.	Minneapolis - St.Paul, Minn. - Wis.			35%
	Total SMSA	1,965,159	423	
	Core City (Minneapolis)	434,381	7,884	
	(St. Paul)	309,940	5,933	
	Core County (Hennepin)	960,080	1,693	
	(Ramsey)	476,255	3,072	
	Suburban County (Anoka)	154,556	364	
	(Dakota)	139,808	243	
18.	Atlanta, Ga.			52%
	Total SMSA	1,597,816	369	
	Core City	497,024	3,783	
	Core County (Fulton)	607,592	1,146	
	Suburban County (DeKalb)	415,387	1,544	
	(Clayton)	98,043	658	

Rank	II. 1.0 Million to 2.5 Million (inclusive)	Population (persons)	Gross Density (psm)	19 -19 Growth Projecti
19.	Seattle-Everett, Wash.			19%
	Total SMSA	1,421,869	336	
	Core City (Seattle)	530,890	6,350	
	(Everett)	53,732	1,830	
	Core County (King)	1,156,633	543	
	Suburban County (Snohomish)	265,236	126	
20.	Anaheim-Santa Ana-Garden Grove, Calif.			43%
	Total SMSA	1,420,386	1,816	
	Core City (Anaheim)	166,188	4,997	
	(Santa Ana)	156,520	6,997	
	(Garden Grove)	122,560	5,769	
	Core County (Orange)	1,420,386	1,816	
	Suburban County (None)	-	-	
21.	Milwaukee, Wis.			9%
	Total SMSA	1,403,688	964	
	Core City	717,124	7,551	
	Core County	1,054,063	4,448	
	Suburban County (Wankesha)	231,365	418	
22.	Cincinati, Ohio, Ky., Ind.			18%
	Total SMSA	1,384,851	644	
	Core City	452,550	5,780	
	Core County (Hamilton)	924,018	2,232	
	Subruban County (Clermont)	95,725	209	
23.	San Diego, Calif.			30%
	Total SMSA	1,357,854	318	
	Core City	696,566	2,200	
	Core County	1,357,854	318	
	Suburban County (None)	-	-	
24.	Buffalo, N.Y.			2%
	Total SMSA	1,349,211	849	
	Core City	462,783	11,205	
	Core County (Erie)	1,113,491	1,052	
	Suburban County (Niagara)	235,720	443	

Rank	II. 1.0 Million to 2.5 Million (inclusive)	Population (persons)	Gross Density (psm)	1970-1990 Growth Projection
25.	Kansas City, Mo.-Kan.			30%
	Total SMSA	1,271,515	381	
	Core City	168,149	2,961	
	Core County (Wyandotte)	186,845	1,229	
	Suburban County (Jackson)	654,558	1,085	
	(Clay)	123,322	299	
26.	Miami, Fla.			84%
	Total SMSA	1,267,792	621	
	Core City	335,075	9,763	
	Core County	1,267,792	621	
	Suburban County (None)	-	-	
27.	Denver-Boulder, Colo.			83%
	Total SMSA	1,237,208	266	
	Core City (Denver)	514,678	5,418	
	(Boulder)	66,870	5,144	
	Core County (Denver)	514,678	5,418	
	(Boulder)	131,889	176	
	Suburban County (Jefferson)	233,031	298	
28.	Riverside-San Bernadino, Calif.			30%
	Total SMSA	1,143,146	42	
	Core City (Riverside)	139,769	1,959	
	(San Bernadino)	104,394	2,407	
	Core County (Riverside)	459,074	64	
	Suburban County (San Bernadino)	684,072	34	
29.	Indianapolis, Ind.			30%
	Total SMSA	1,109,882	361	
	Core City	744,570	1,967	
	Core County (Marion)	792,299	2,021	
	Suburban County (Johnson)	61,138	194	
30.	Tampa-St. Petersburg, Fla.			68%
	Total SMSA	1,088,549	532	
	Core City (Tampa)	277,736	3,287	
	(St. Petersburg)	216,067	3,902	
	Core County (Hillsborough)	490,265	472	
	(Pinellas)	522,329	1,917	
	Suburban County (Pasco)	75,955	102	

Rank	II. 1.0 Million to 2.5 Million (inclusive)	Population (persons)	Gross Density (psm)	970- Grow Proj
31.	San Jose, Calf.			83
	Total SMSA	1,064,714	819	
	Core City	446,504	3,279	
	Core County (Santa Clara)	1,064,714	819	
	Suburban County (None)	-	-	
32.	New Orleans, La.			13
	Total SMSA	1,045,809	532	
	Core City	593,471	3,011	
	Core County (Orleans)	593,471	3,011	
	Suburban County (Jefferson)	337,568	915	
33.	Columbus, Ohio			43
	Total SMSA	1,017,847	414	
	Core City	539,377	4,012	
	Core County (Franklin)	833,249	1,549	
	Suburban County (Fairfield)	73,301	145	
34.	Portland, Oregon, Wash.			28
	Total SMSA	1,009,129	276	
	Core City	381,877	4,265	
	Core County (Multnomah)	556,667	1,316	
	Suburban County (Washington)	157,920	221	

Rank	III. .25 Million to .50 Million (illustrative examples, every tenth rank)	Population (persons)	Gross Density (psm)	
70.	Wilmington, Del.-N.J.-Md.			29
	Total SMSA	499,493	429	
	Core City	80,386	6,231	
	Core County (New Castle)	385,856	881	
	Suburban County (Cecil)	60,346	167	
80.	Harrisburg, Pa.			26
	Total SMSA	410,626	253	
	Core City	67,880	8,955	
	Core County (Dauphin)	223,834	432	
	Suburban County (Cumberland)	158,177	285	

Rank	III. .25 Million to .50 Million (illustrative examples every tenth rank)	Population (persons)	Gross Density (psm)	1970-1990 Growth Projection
90.	Davenport, Rock Island Moline, Iowa - Ill.			8%
	Total SMSA	362,638	213	
	Core City (Davenport)	98,477	1,666	
	Core County (Rock Island)	166,734	393	
	Suburban County (Scott)	142,687	314	
	(Henry)	53,217	64	
100.	Albuquerque, N. Mex.			34%
	Total SMSA	333,266	75	
	Core City	243,751	2,965	
	Core County (Bernalillo	315,774	270	
	Suburban County (Sandoval)	27,492	5	
110.	Binghampton, N. Y. -Pa.			8%
	Total SMSA	302,672	146	
	Core City	64,123	5,829	
	Core County (Broome)	221,815	311	
	Suburban County (Tioga)	46,513	89	
120.	Appleton-Oshkosh, Wis.			21%
	Total SMSA	276,891	197	
	Core City (Oshlcosh)	53,155	5,417	
	Core County (Winnebago)	129,931	290	
	Suburban County (Outagamie)	119,356	188	
130.	Lawrence-Haverhill, Mass. -N. H.			
	Total SMSA	258,564	859	
	Core City (Lawrence)	66,915	9,840	
	Core County (Part Essex)	221,208	1,170	
	Suburban County (Part Rockingham)	37,356	334	

Rank	IV. Less Than .25 Million (illustrative examples every twentieth rank)	Population (persons)	Gross Density (psm)
140.	Columbus, Ga. -Ala.		
	Total SMSA	238,584	217
	Core City	154,098	2,231
	Core County (Muscogee)	167,377	760
	Suburban County (Chattahoochee)	25,813	102

Rank	IV. Less than .25 Million (illustrative examples, every twenthieth rank)	Population (persons)	Gross Density (psm)
160.	Salem, Oregon		
	Total SMSA	186,658	98
	Core City	68,249	2,784
	Core County (Marion)	151,309	130
	Suburban County (Polk)	35,349	48
180.	New Bedford, Mass.		
	Total SMSA	161,288	787
	Core City	101,759	5,219
	Core County (part Bristol)	148,946	1,027
	Suburban County (part Plymouth)	12,342	205
200.	Waterloo-Cedar Falls, Iowa		
	Total SMSA	132,916	234
	Core City (Cedar Falls)	29,504	1,838
	Core County (Black Hawk)	132,916	234
	Suburban County (None)	-	-
220.	Bay City, Michigan		
	Total SMSA	117,339	263
	Core City	49,449	4,945
	Core County (Bay)	117,339	263
	Suburban County (None)	-	-
240.	Pittsfield, Mass.		
	Total SMSA	96,817	461
	Core City	57,124	1,411
	Core County	96,817	461
	Suburban County (None)	-	-
260.	Bristol, Conn.		
	Total SMSA	69,878	885
	Core City	55,487	2,086
	Core County (part Hartford)	59,557	1,045
	Suburban County (part Litchfield)	10,321	469

Source: U. S. Census, 1970
County and City Data Book, 1972
New York Regional Plan Association, 1975
OBERS 1990 Growth Projections for Category I

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