An Assessment Of Energy-Efficient Land-Use Planning In Prairie Cities

by

Raymond Yei Cheung

A thesis
presented to the University of Manitoba
in partial fulfillment of the
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ABSTRACT

The intention of this thesis is to assess the extent to which the five Census Metropolitan Areas (i.e. Calgary, Edmonton, Saskatoon, Regina, and Winnipeg) in the Prairie region have integrated energy-related objectives, policies and evaluation criteria into their land-use planning process.

The general apathetic attitude of city officials towards the implementation of energy-efficient land-use planning is evident in the studied cities. This attitude is reflected in the absence of explicit energy-related goals, policies and evaluation criteria in respective development plans, which, in turn, is mainly attributable to the following constraints: (1) other issues take precedence; (2) lack of interest in the community; and, (3) lack of clear direction from senior levels of government. In order to overcome these perceived barriers, city planners should assume responsibility in the area of energy-efficient land-use planning, since every decision made by them influences spatial structure. To this end, the thesis offers an action plan for them.

ACKNOWLEDGEMENTS

I am thankful to my advisor, Professor Basil Rotoff, for his invaluable comments and enduring patience in guiding the writing of the thesis, and, of course, to my two readers, Professor Geoff Bargh and Professor Leon Feduniw, for their wise words of critique which have given me insights into the ramifications of problems.

More importantly, I would like to express my heart-felt gratitude to my parents and Chun-Pui for supporting me in my every pursuit. To them I am ever grateful.

Finally, to my Lord, who can, and does, I dedicate this thesis.

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Chapter I

INTRODUCTION

The intent of this thesis is to assess the extent to which the five Census Metropolitan Areas (i.e. Calgary, Edmonton, Saskatoon, Regina, and Winnipeg) in the Prairie region have integrated energy-related objectives, policies and evaluation criteria into their land-use planning process.

1.1 SETTING THE SCENE

Few issues have captured public and political attention to quite the same extent as energy did since the early 1970s. Since that time, the world has been faced not merely with an adjustment to higher energy prices, but with a period of absolute shortages of energy resources. The most common response to the energy crisis in many countries, including Canada, has been massive investment, and plans for more, in energy resources to open up new supplies and reduce dependence on imported oil (National Energy Board 1986). These are clearly of great economic importance, with considerable effects on society, politics and the environment. On the other hand, in order to ameliorate the uncertain supplies and the fluctuations in prices of energy resources (especially petroleum/oil), urban researchers, academics and planners have stressed the saving of energy at the community level. Specifically, many city planners have recognized the potential contribution of land-use planning to energy conservation and energy efficiency. In view of this, a shift in focus from a dominant concern with energy supply strategies, to strategies which, at least to an extent, consider the options which demand management and conservation may offer.

In the past years, more and more North American planners and related professionals have realized the need to improve energy efficiency through changes in lot orientation, building design, dwelling densities and the arrangement of land-uses. Until now, these changes have been researched and documented to some extent. Rather than mainly focussing on these changes again, it is appropriate now to assess in practice the degree of integration of energy considerations into the land-use planning process.

Within this context, several questions arise: have all these changes mentioned previously been explicitly manifested in urban land-use planning? Why is it that most Canadian planners in the Prairie cities remain largely unaware of energy and land-use relationships and ways in which energy considerations might be incorporated into the planning process? Why is it that, in spite of an extensive body of theoretical information, and in spite of existing practice elsewhere (e.g. United States), this knowledges has largely not been applied on the Canadian Prairie? Only as such information becomes available, can the gap between theoretical possibility and practical reality in the area of energy-efficient land-use planning be significantly narrowed. In addition, recognizing the perceived barriers to the inclusion of energy considerations into city land-use planning process can enable planners or policy makers to make institutional aids to the implementation of measures of saving energy more effective and the obstacles less of a hindrance.

1.2 STATEMENT OF OBJECTIVES

Based on the foregoing questions, five major objectives will be pursued by this thesis. They are as follows:

1. to present the needs for energy-efficient land-use planning;

2. to identify elements which constitute an energy-efficient land-use pattern;

3. to evaluate the extent to which the studied cities have integrated energy considerations into the land-use planning process;

4. to identify major constraints or barriers to such integration; and

5. to suggest means of overcoming perceived constraints or barriers.

1.3 THE SCOPE OF THE STUDY

- The study covers the five major cities with population of 100,000 and over within the Prairie region. They include Calgary, Edmonton, Regina, Saskatoon, and Winnipeg.

- The study limits itself to the city level in the analysis of energy-efficient land-use planning (e.g. the arrangement of land-uses). Special design of individual buildings vis-a-vis energy conservation will not be considered.

- The study is limited to the discussion of spatial structure variables affecting energy use (e.g. size, shape, density and interspersion of land-uses of the city) as opposed to nonspatial variables (e.g. the tendency to travel, personal preference on choice of jobs and services and the extent to which cars are used).

- The study concerns itself with direct energy savings (e.g. savings on motor fuel, space heating, etc.), whereas indirect use of energy, such as those used for constructing buildings, will not be thoroughly analyzed.

- The study primarily touches up on the normative side of the procedural questions. What constitutes a good energy-efficient land-use pattern? What should planners do to be effective practitioners in diffusing and bolstering the concept of energy conservation and energy efficiency through land-use planning at the city level?

1.4 METHODOLOGY

Two category of sources were utilized in conducting the study: primary and secondary.

1.4.1 Primary Sources

In terms of the primary category, sources like questionnaire surveys and personal interviews were undertaken to obtain some first hand information concerning the extent to which the land-use planning of each studied city has included energy-related objectives, policies and evaluation criteria. Particularly, these primary sources were used to pinpoint some major constraints or barriers to the integration of energy considerations into the land-use planning process.

Questionnaires with stamped and self-addressed envelope were mailed directly to five city planning departments, together with a cover letter explaining the nature of the research and welcoming any other comments. To assure a high response rate, a second letter, attached to another questionnaire, was sent out to those city planning departments who did not respond to the first questionnaire. Moreover, in terms of the content of the questionnaire, it contained questions (both open-ended and specific) concerning the general attitudes of city planners towards the importance of energy issues in relation to land-use planning (see Appendix A). Specifically, the questionnaire comprised questions regarding energy considerations (i.e. energy-related objectives, policies and evaluation criteria) in city land-use plans, ways in which energy considerations might be incorporated into the planning process and the identification of constraints or barriers to the integration of energy considerations into the land-use planning.

To complement the techniques of questionnaire design, personal interviews were conducted. Interviewees were all city planners. Generally, they were asked to give their opinions on the importance of having energy-related policies in city land-use plans and some perceived barriers to the inclusion of such policies in the plans.

1.4.2 Secondary Sources

Literature review was undertaken to identify the characteristics of the land-use patterns compatible with energy-efficient of energy sources, were planners to incorporate energy considerations successfully into their policies. One broad approach to identify the above characteristics was the deductive approach, in which the energy implications of alternative spatial structures were investigated and an attempt made to identify the characteristics to a form with low energy requirements. Both empirical and theoretical studies have employed this technique. As well, a review of existing planning documents was conducted not only to examine the present practice of energy-efficient land-use planning in the five cities studied, but also to review some North American cities with records showing successful integration of energy-saving objectives and policies into their land-use planning. This suggested some of the means of overcoming perceived constraints or barriers to the inclusion of energy considerations into the land-use planning process in the studied cities.

1.5 ORGANIZATION OF THE STUDY

This thesis consists of seven chapters. The stated objectives of each chapter are summarized as follows:

Chapter I: Introduction

This chapter enunciates the problem and objectives, the scope, the methodology used, and the overall organization of the thesis.

Chapter II: Energy: Problems And Planning

This chapter probes the nature of energy problems by understanding the relationships among energy, economy and environment. Also it demonstrates a strong case for energy-efficient land- use planning by depicting primarily the interrelationship between energy and spatial structure.

Chapter III: Energy And City Form

This chapter discusses some basic concepts of city form in an attempt to help the reader to comprehend and appreciate the principal elements of city form and the nature and characteristics of their relationships. Furthermore, this chapter also describes some likely impacts of energy constraints on the metropolitan spatial structure.

Chapter IV: Energy-Efficient Spatial Structures

This chapters examines the elements which constitute to the "best" city spatial structures or patterns from the standpoint of energy efficiency and energy conservation.

Chapter V: Energy-Efficient Land-Use Planning In Selected North American Cities

This chapter provides a review of experience in energy conservation through land-use planning in selected North American cities which this had had a high profile.

Chapter VI: Energy-Efficient Land-Use Planning In Prairie Cities

This chapter assesses the extent to which the studied cities have integrated energy considerations into the land-use planning process and the perceived barriers to such integration. Also, this chapter endeavors to unveil certain variables which may be important preconditions associated with successful community energy conservation.

Chapter VII: Summary And Concluding Comments

This chapter not only summarizes the major findings pertaining to the context of energy-efficient land-use planning and its present practice in the Prairie cities, but also recommends an action-plan for planners in the promotion of energy-efficient land-use planning in their respective jurisdictions. Further areas for research are suggested.

Chapter II

ENERGY: PROBLEMS AND PLANNING

2.1 INTRODUCTION

Energy issues have received much attention in Canada since the massive increase of oil price which occurred between 1973 and 1980 (National Energy Board 1986). In response, a burgeoning literature concerning the present and future energy supply and demand in Canada has emerged (e.g., Energy, Mines and Resources 1987; National Energy Board 1986; Environment Canada 1982). On the one hand, this literature places a relatively heavy emphasis on the supply side of the energy problem --- the generation of alternative renewable energy resources. On the other hand, however, they also mention the importance of energy conservation in light of future uncertain supply of oil (for social and political reasons if not because of the size of the resource base itself). To this end, under the sponsorship of government, several major studies concerning the promotion of energy conservation through planning were conducted (e.g., Lang and Armour 1982; Sewell and Foster 1980a,b; Jackson 1977), all of which shared the same concern, that is, to encourage and facilitate energy efficient land-use planning in Canada.[1] These studies were undertaken to provide further information and understanding of the significant value of land-use planning as a mechanism for improving energy use efficiency at the city level. Emphasis was placed on the relationship between energy considerations and the planning of spatial structure.

But times have changed. Energy prices have declined during the first half of the 1980s, and since then, public interest in the "energy crisis" of the 1970s has been subsiding. The energy problem has gradually become less serious over the years. Nevertheless, in the long run, the need for energy conservation is still compelling. This need can only be met by setting up sound, effective policies. To achieve this, policy maker requires to have a knowledgeable grasp of the subject of energy in terms of its nature and its relationship with surrounding environments. Viewed from this perspective, the purport of this chapter, therefore, is twofold: (1) to probe the nature of energy problems by understanding the relationships among energy, economy and environment; and, (2) to demonstrate a strong case for energy efficient land-use planning by depicting primarily the interrelationship between energy and spatial structure. Before all these, a short discussion on the present and future energy scene of Canada vis-a-vis energy conservation

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[1] Energy-efficient land-use planning can be defined as the arrangement and design of land use and circulation in such a way that energy consumed by all users, the energy cost to average households as well as other taxpayers is as small as it can reasonably be (Regenstreif 1983).

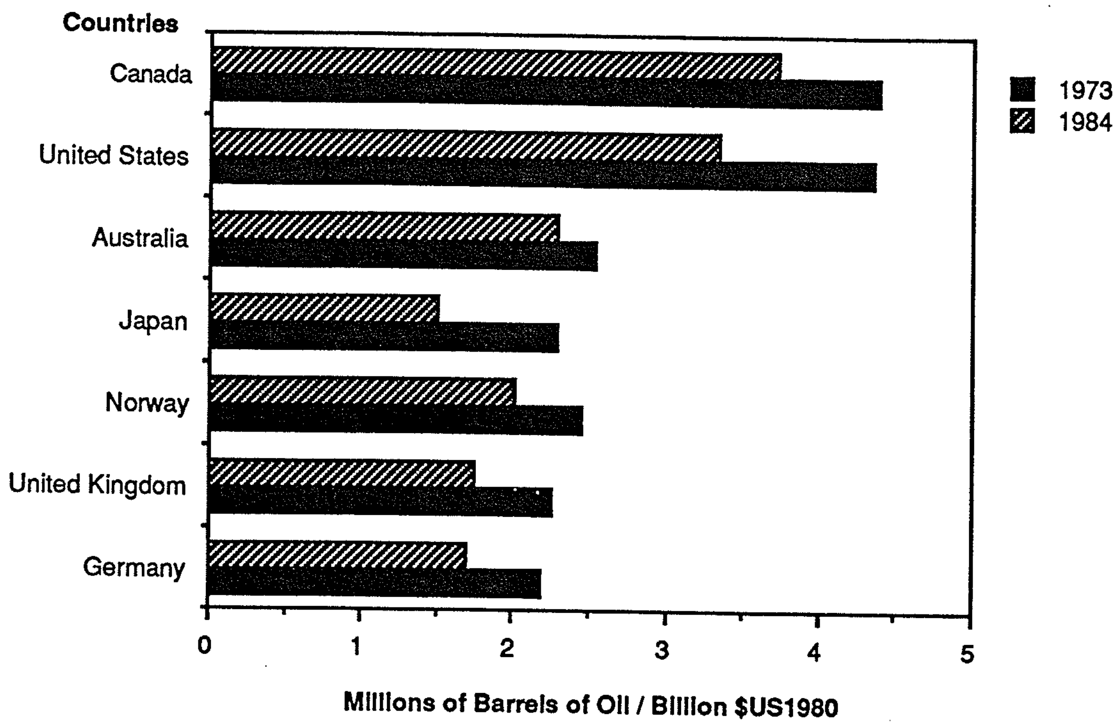
is deemed to be appropriate.

2.2 THE ENERGY SCENE

Canada is a country of sparse population with a vast area and natural-resource potential. It is referred to be the most energy-intensive industrialized country in the world (Energy, Mines and Resource 1987). This stems in part from its cold climate and its long distances. It reflects, as well, the influence Canada's rich energy resource endowment has had on the evolution of its industrial sector. In short, it is believed that the diversity and abundance of Canada's energy endowment account largely for the apathetic reaction to the first oil shock in 1973 (Energy, Mines and Resource 1987).

As in other industrialized countries, the energy consumption patterns of Canada have changed greatly since the 1973 oil embargo. The general promotion and availability of substitutes for oil (e.g. natural gas) led both consumers and governments to put relatively more emphasis on substitution than on conservation in responding to the oil crisis (Energy, Mines and Resources 1987). As a consequence, reductions in overall energy consumption have somewhat lagged behind other Organization for Economic Cooperation and Development (OECD) countries (see Figure 1).

Figure 1: Final Energy Consumption/GDP, 1973 and 1984



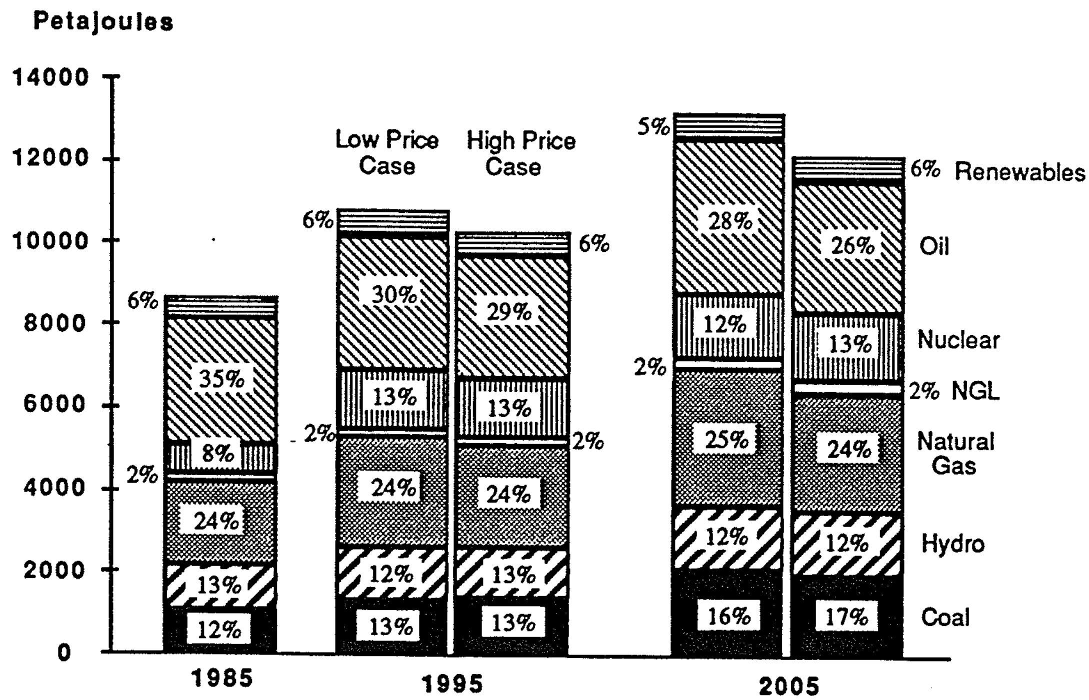
Source: Energy, Mines and Resource 1987, p.121.

Putting the quoted statistic in a positive light, if conservation and efficiency gains are seen as a resource to be tapped, the comparison of countries indicates that Canadian economy is blessed with the richest deposits in the world! They represent clear evidence of the vast potential contribution of conservation still available to the Canadian economy.

Looking at the future projections of Canadian primary energy demand and production, several highlights are noteworthy (National Energy Board 1986). Regarding the distribution of primary energy demand (see Figure 2), it is projected that, by 2005, the share of oil in overall energy use will drop substantially, whereas the share of nuclear-generated electricity and coal are projected to rise concomitantly. Figure 2 also suggests that, if the current relatively low price levels of conventional energy prevail, alternative energy forms (e.g. solar, wind, municipal solid waste, etc.) are unlikely to comprise a greater share of the energy market in 2005 than they do now. The change in the distribution is broadly similar for both price cases.

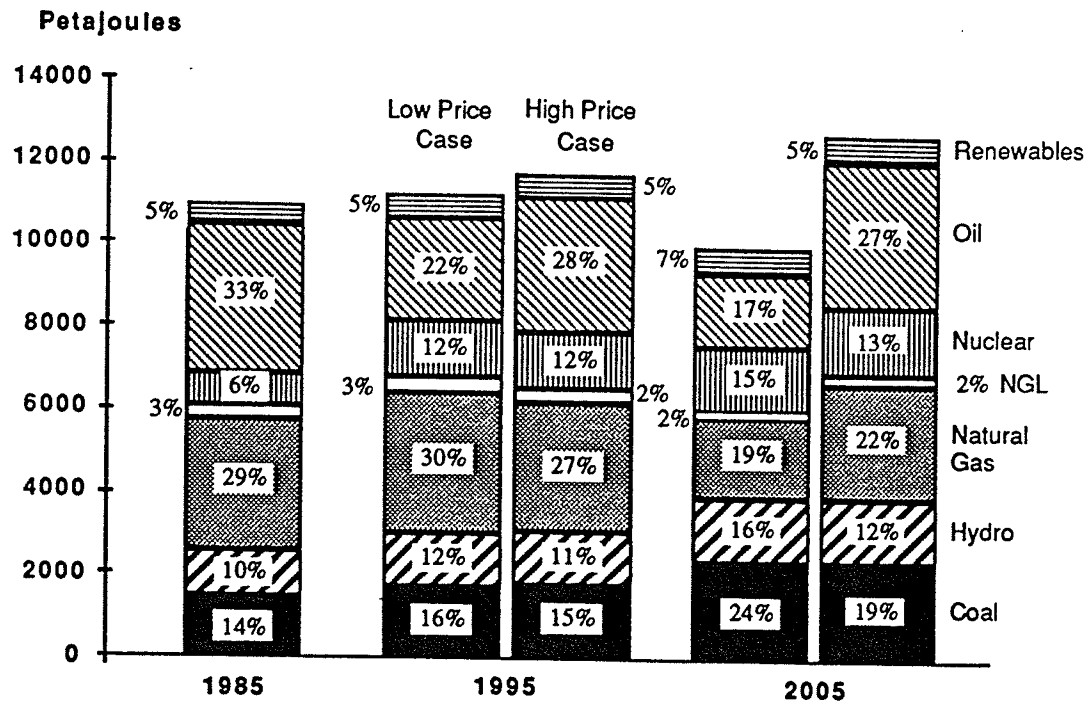
The future projections for primary energy production, furthermore, are shown in Figure 3. In the low price case, the shares of oil and gas in overall energy production are projected to be considerably smaller in 2005, and shares for other energy forms (except Natural Gas Liquids--NGL) larger, than are the corresponding shares for primary energy demand.

Figure 2: Comparison Of Primary Energy Demand Projections



Source: National Energy Board 1986, p.113.

Figure 3: Comparison Of Primary Energy Production



Source: National Energy Board 1986, p.115.

This indicates the projected declines in gas and oil over the period. In the high price case, the differences between the shares of energy demand and production projected to be held by each energy source are small.

In short, the above analysis does not suggest that renewable energy forms do not have a role to play in the future; but, more importantly, it implies that, in a given time, there is scope for continuing substitution among energy forms as a means of securing future energy supply.

2.3 ENERGY, ECONOMY AND ENVIRONMENT

In the last two decades, some developed countries of the world, including Canada, have been confronted by a series of seemingly intractable crises. First, there was the threat to environmental survival; then, there was the outcry of energy shortage; and, now there is the gradual decline of the economy. In trying to ameliorate these issues, fragmented policies, unfortunately, have been pursued within sectors (e.g. energy, trade, and environment), and within broad areas of concerns (e.g. social, economic, and environmental), by government officials. To this effect, issues are usually regarded as separate distress, each to be solved in its own terms: environmental degradation by implementing pollution controls; the energy crisis by finding new sources of energy and new ways of conserving it; the economic crisis by manipulating prices, taxes, and interest rates.

But the fact is that each effort to solve one crisis seems to clash with the solution of the others (one person's "source" is another's "sink"): pollution control decreases energy supplies; energy conservation costs jobs. Inevitably, proponents of one solution become opponents of the others. As a result, policies or remedial actions, to some extent, become ineffective.

This phenomenon is not surprising, for the tangled knot of problems is poorly understood. The recent report of the United Nations World Commission on the Environment and Development, known as the Bruntland Report (1987), also criticizes the inadequacy of the compartmentalized approach of policy setting to various crises. It asserts that "various crises are not separate crises: an environmental crisis, a development crisis, an energy crisis. They are all one" (p.4). Under the chapter "From One Earth to One World", the report, as this author sees it, implicitly demonstrates that each crisis involves complex interactions among the three basic systems --- the ecosystem, the production system, and the economic system --- that, together with the social or political order, govern all human activity.

As it is understood, the ecosystem --- the great, natural ecological cycles that comprise the planet's surface and the minerals that lie beneath it --- provides all the resources that support human life and activity. The production system --- the agricultural and industrial processes --- converts these resources into goods and services; the real wealth that sustain society: food, manufactured goods, transportation, infrastructures, and communication. And, finally, the economic system --- the recipient of the real wealth created by the production system --- transforms that wealth into earnings, profit, savings, taxes; and governs how the wealth is distributed.

The relationships among these systems are comprehensible: the economic system on the wealth is yielded by the production system and the production system on the resources is provided by the ecosystem. Logically speaking, given these dependencies, the governing influence should flow from the ecosystem through the production system to the economic system. In actual fact, however, the relations among the three systems are the other way around. The environmental crisis tells us that the ecosystem has been disastrously affected by the production system, which, the author would argue, has been developed with almost no regard for the compatibility with the environment or the efficient use of energy: the widespread use of automobiles induced by the continuous separation of various land-use activities pollutes the environment with smog. In turn, the bad design of the production system has been imposed upon it by the economic system, which invests in factories that emphasize increased profits rather than environmental compatibility or efficient use of resources. In essence, the relationships among the systems on which society depends are upside down. The constant strive for successful economic growth is now achieved at the expense of the natural environment. As a result, this has prompted a recent global concern (Bruntland Report 1987, p.5):

> We have in the past been concerned about the impacts of economic growth upon the environment. We are now forced to concern ourselves with the impacts of ecological stress --- degradation of soils, water regimes, atmosphere, and forests --- upon our economic prospects.

A shift in emphasis from economic to ecological interdependence among nations is now underway in an effort to preclude any further degradation of the fragile environment.

In its broadest sense, energy plays a decisive role in the interactions among the systems. Energy, radiated from the sun, drives the great ecological cycles. Energy, derived from fuels, powers nearly every production process. Most of the recent increases in the output of the production system and in the rate of economic growth are due to the intensive use of energy to power new, more productive machinery. The intensified use of energy is responsible for the rapid drain on fuel supplies and for much of present environmental pollution. In view of this, controversial questions between energy supply and environmental quality arise. Some of them have been questioned by Kelley (1977, p.237):

> What remains unknown is how to calculate just where the energy consumption and environmental survival points converge. What combinations of energy consumption and environmental protection are possible without threatening the survival of both the social system and the environment? How much can energy consumption patterns be altered without causing fundamental economic and social changes, and how far can the environment be permitted to deteriorate before irreplaceable natural cycles and food chains are disrupted?

There are no easy answers to these questions. But there is one way to begin to look for them, that is, to recognize that energy problems will not be solved by technological advances alone. The energy crisis and the knot of environmental, economic, and social issues in which it is embedded call for a holistic approach --- the concept of "sustainable development"[2] (Brundtland Report 1987). Again, the Brundtland Report sees the possibility for a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base in order to ensure human progress and human survival (a better life). To be sustainable, development must be based on conservation of living resources and associated life-support systems, especially agricultural, forest, coastal and fresh water. Conservation and development become mutually reinforcing activities. In short, sustainable development, as depicted:

> is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs. We do not pretend that the process is easy or straightforward. Painful choices have to be made. Thus, in the final analysis, sustainable development must rest on political will (p.9).

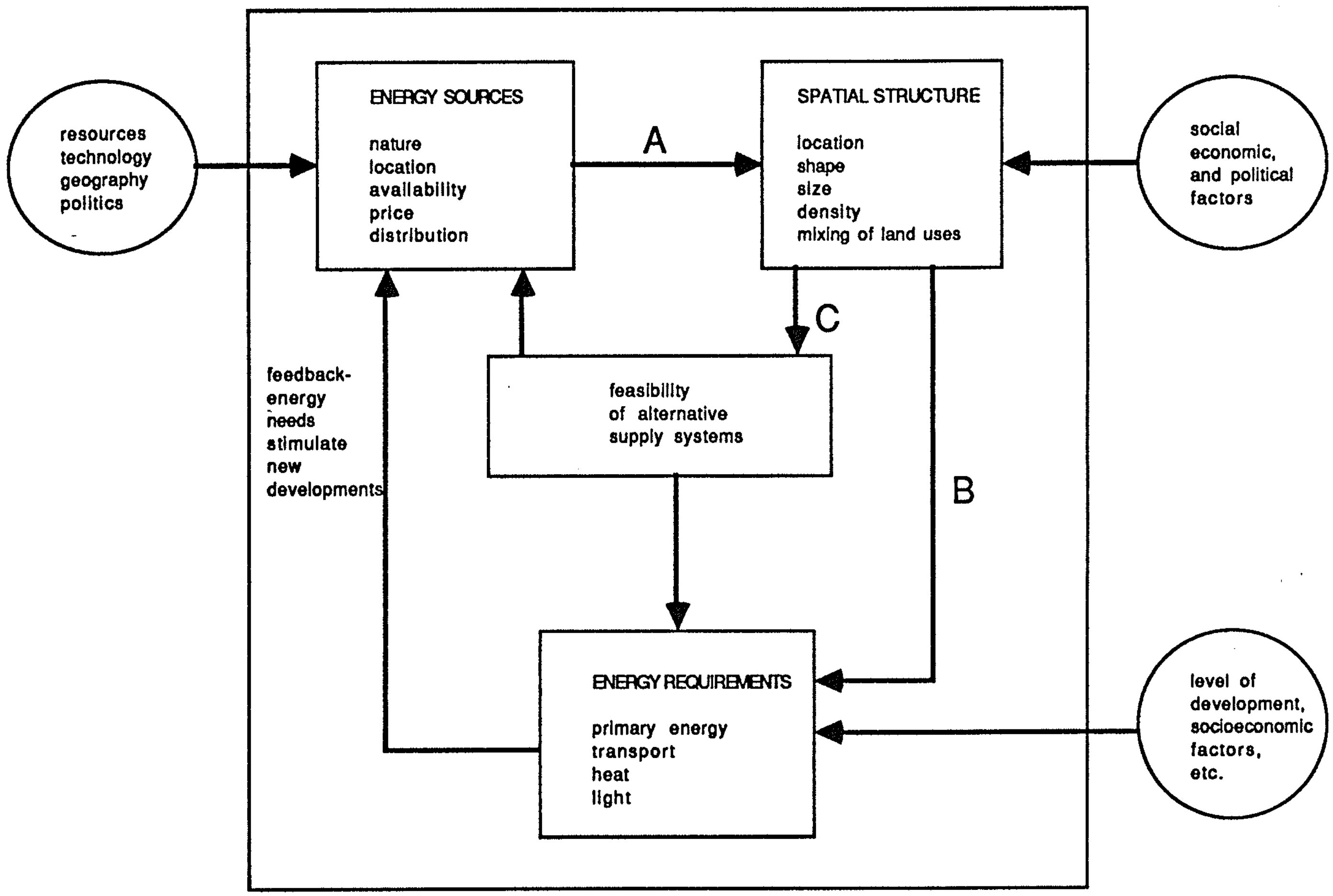
[2] Due to the limited scope of this thesis, it is not the intention of the author to expand on this concept. The reader is referred to chapter two of the Brundtland Report for detail.

2.4 RATIONALE FOR ENERGY-EFFICIENT LAND-USE PLANNING

2.4.1 Energy and Land Use

There has been a growing concern for the energy-land use relationship since the oil crises of the 1970s (e.g., Owens 1986b, 1985; Owens and Rickaby 1983; Burchell and Listokin 1982). The interrelatedness of this relationship has long been recognized. As commented by Steadman (1980, p.27), "the spatial organization of society is fundamental to the way in which it uses energy." Energy is a basic resource on earth, use of which both affects and is affected by the spatial structure of the city (Owens 1986a). One major implication arising from this relationship is that land use policies, those influence the development of land use patterns, may have significant consequences for future energy consumption. Thus, land use planners should be aware of the energy implications of the policies they proposed and be able to implement plans which are conducive to energy conservation in the longer term. To this end, a thorough understanding of the energy-land use relationship by planners is warranted if integration of energy considerations into the land-use planning process is thought to be successful.

In her recent book, (1986b), Owens has succinctly illustrated in a diagram the nature of the energy-land use relationship. In her model (see Figure 4), she indicates that the availability and use of different forms of energy



Source: Owens 1986b, p.3.

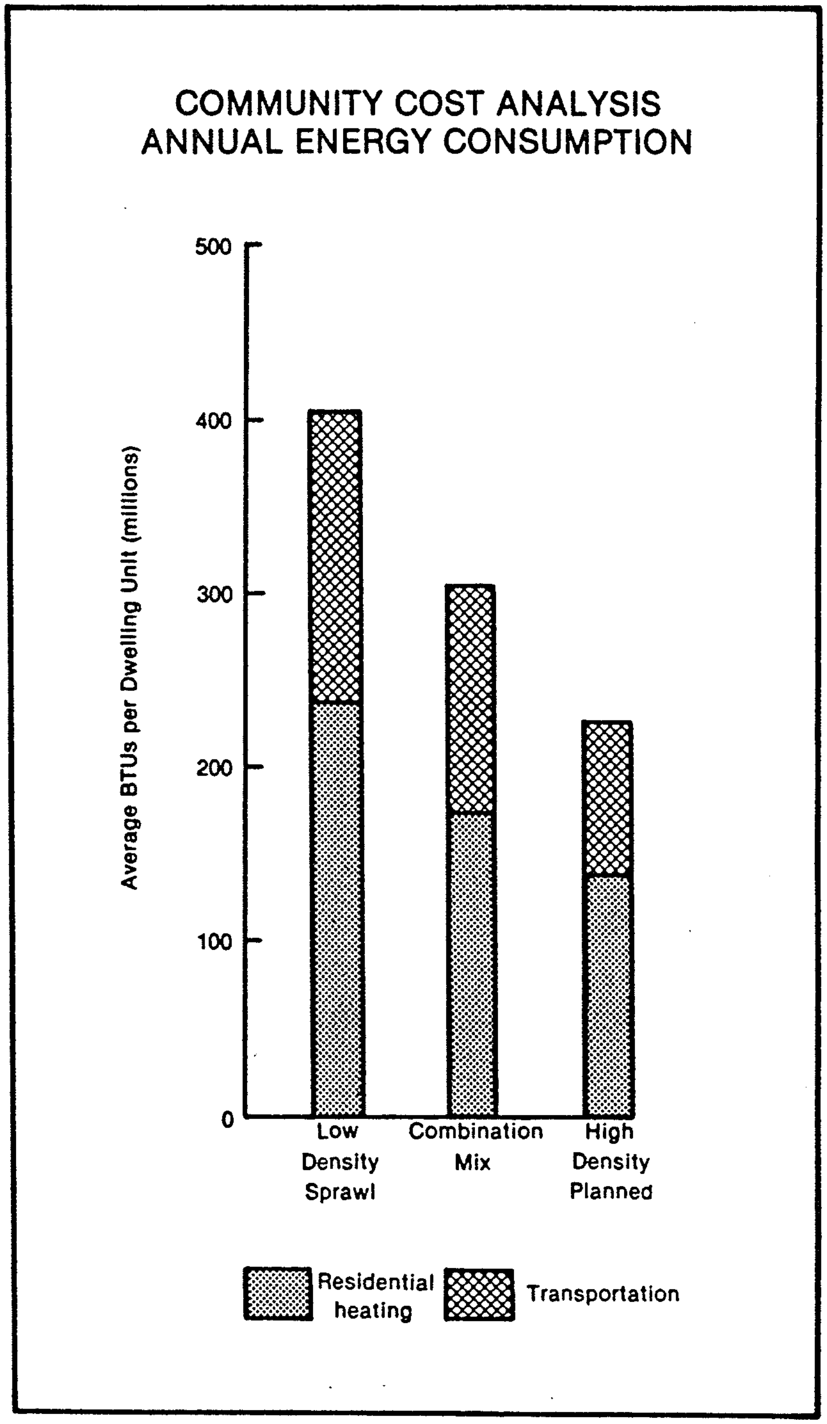
Figure 4: The Relationship Between The Energy System And Spatial Structure

have always exerted a profound influence on the location, shape, size and density of the spatial structure of society (Link A). Historically, the location of human settlements was strongly influenced by the limited capacities of natural energy sources (e.g., water, wood, coal, etc.). In those days, settlements appeared in relatively small, uniform and compact units; places of work, living and service were all arranged in close proximity. The physical layout was conceived very much in relation to natural conditions and resources such as topography, climate, fertility of soil, availability of water and natural sources of energy. Later, as the economy of society shifted its base from agriculture to an industrial base, energy development has become more intensified. With the development of industry, new manufacturing and transportation facilities were developed. This, as a consequence, led to fundamental changes in both regional and local land-use patterns. On the regional level, one obvious change was the separation of places of energy extraction (e.g., coal, oil and gas) and places of energy use. As mentioned earlier, historically, the development and use of energy resources took place in the same general location as their consumption. As industrialization has continued and cities have become larger and more complex, the distance between energy development and utilization has increased. This spatial separation of distance was a crucial factor in affecting the location and structure of human settlements. Further, on the community level, the industrial development led to a distinct separation of urban functions, requiring more and longer trips between places of work, living, recreation and other service functions. The detachment of different urban functions was further exacerbated by the availability of cheap energy during the 1950s and 1960s. Thus, the urban sprawl and increasing separation of activities experienced by most of the Western World reflected the relative lack of energy constraints in the transport system and the absence of much concern for space heating efficiency in low density, dispersed residential development. Urbanization, indeed, is a resource-expensive process (Newcombe, Kalma and Aston 1978). It requires a large supply of energy and materials per capita to satisfy basic human needs. In short, based on the foregoing discussion, it is obvious that both the physical and economic development of society have been closely associated with the increased use of energy and to changes in the predominant form of energy supplies.

Energy sources influence land use patterns and the built environment which, in turn, determine the level and pattern of energy demand. As reflected in the model, once constructed, the built environment and land use patterns interact with the energy system in two major ways. First, they constrain the level and pattern of energy demand (Link B). This is incorporated in the model as the influence of spatial structure on energy requirements for various activities. For instance, the prevalence of low density, dispersed suburbs is energy-intensive. The suburbs generally have lower densities than their big city counterparts, which, in itself, causes higher energy consumption. This is because of higher heating and related home costs. When this turns out to be "sprawl", as it is often the case, the problem is compounded. Many of the relationships between sprawl and energy have been documented in a study by Real Estate Research Corporation (1974). It reported that "low-density sprawl" consumed 80 percent more energy than "high-density planned" development (4,059,787 vs 2,257,400 billion Btu/year). Intermediate densities such as "combination mix" (i.e., 50 percent Planned Unit Development, 50 percent sprawl) consumed intermediate amounts of energy. These relationships are graphically portrayed in Figure 5.

Sprawl a is huge waste of energy for two major reasons (Compact Cities 1980, pp.5-12). First, leapfroging and overextended growth waste energy by leaving urban capital underused. This applies to schools, parks and playgrounds, roads and bridges, libraries and museums, as well as gas, sewer and water lines. Sprawl also means that more energy must be expended in maintaining these facilities and utilities --- more highways to patrol, more utilities to service, more schools and recreation centers to light and heat, etc. Furthermore, sprawl causes higher energy

Figure 5: Community Cost Analysis: Annual Energy Consumption



Source: Real Estate Research Corp. 1974.

consumption in that there are greater distances for people to travel to work, to school, to shop, to eat out, to meet with friends, to attend meetings --- all these extra miles mean extra energy.

Not only does the spatial structure of city influences the level and pattern of energy demand, but also it determines the feasible aspect of future alternative energy supply and distribution systems (Link C). For example, district heating is a technology designed to improve efficiency in energy utilization (Environment Canada 1982, p.88). This term refers to a central heating plant supply space heating and domestic hot water to all residential, commercial and institutional users through a system of underground, low-temperature hot water pipes.[3] However, to be feasible, district heating requires relatively low physical separation of existing activities which could be achieved by moderately high densities and by some decentralization and clustering of employment and services. In short, the potential for introducing district heating depends on the density of development and on the degree of mixing of various land uses.

A final aspect of the energy system and spatial structure model is the feedback loop. "Feedback" is allowed in the model to account for the difficulties experienced because of the inelasticities of energy demand in spatial systems,

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[3] For more information on district heating, see McLaren.

would themselves stimulate new developments and adjustments in the energy system. For instance, ways of meeting district heating requirements may be explored.

2.4.2 Inflexibility of Land-Use Patterns

An implicit aspect of the energy and land-use model is the ability for parts of the energy system to change much more rapidly than it is possible for spatial structure to respond. Generally speaking, 1950s and 1960s were the period of abundant energy availability, and the built environment, during that period, was able to respond gradually to the increase of energy supply. When the price of oil soared abruptly in 1973, it was quite impossible for the spatial structure of the built environment to adjust, because its form had developed under the 'given' assumption of abundant, cheap energy supply. The problem, further, has been aggravated by a lower rate of growth and development in the following decade. As a result, people, especially in the lower income bracket, had, and still have, been locked into an energy-intensive lifestyle without any choice.[4] In light of this, planners should assume their role in promoting quality of life in cities by providing alternative living for people of all walks of life. Specifically, they should be able to ensure that land-use patterns will not lock people into lifestyles of high energy consumption.[5]

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[4] A recent study was undertaken to investigate the travel behavior and transportation energy use by minority and poor households. See Millar et al (1986).

[5] Apart from this, there is another difficult issue planners have to take into account when promoting energy-efficient land uses, that is, the equity consideration. If changes in spatial patterns occur in order to conserve energy, and if present trends in growth and development are altered by whatever means (government policy, for example), then the question arises as to who bears the cost. Land use and

Given the existence of a close relationship between society's energy system and its spatial structure and the inherent inflexibility of existing land-use patterns, it is irresponsible for planners to ignore energy considerations in land-use planning if their ultimate goal is to plan a "better" city for all people, especially in the light of the documented finiteness of our non-renewable energy resources.

2.4.3 A Tradition in City Design

Energy conservation through land-use planning in itself is not a new, an innovative concept. Its inception can be traced back to more than two thousand years ago.[6] For centuries, city designers have exploited nature to promote human purposes (e.g. health and safety). For instance, in the 5th century B.C., Hippocrates described the effects of air, water, and places upon human society, including the health of both individuals and the community at large (Glacken 1967). He constrasted the ill health plaguing cities that occupy damp ground or windy slopes with the

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settlement changes mean that private rights might have to be sacrificed for the wider public interest. Or the impacts of energy conservation might fall more heavily on lower-income families, who may have less capability to change consuming habits to adjust to energy conservation, land use, and settlement changes.

[6] Besides ancient cities, the majority of people in the industrially developing countries, where the conventional energy sources of the industrialized world are not readily available at affordable prices, still devise ways to warm or cool their houses with natural sources of energy and physical phenomena. For more information, see chapter two of Richard Stein's book (1978).

benefits enjoyed by cities located to exploit sun and breezes. Subsequent writers suggested how cities might be sited and designed to avoid such problems. The Roman architect Vitruvius, for example, specified how the layout of streets and the orientation and arrangement of buildings should respond to seasonal patterns of sun and wind (Morgan 1960, pp.24-25,27):

> The town being fortified, the next step is the apportionment of house lots within the walls and the layout of streets and alleys with regard to climatic conditions. They will be properly laid out if foresight is employed to exclude the winds from the alleys. Cold winds are disagreeable, hot winds enervating, moist winds unhealthy. We must, therefore, avoid mistakes in this matter and beware of the common experience of many communities. For example, Mylitene in the island of Lesbos is a town built with magnificence and good taste, but its position shows a lack of foresight. In that community when the wind is south, the people fall ill; when it is northwest, it sets them coughing; with a north wind they do indeed recover but cannot stand about in the alleys and streets, owing to the severe cold .... If the streets run full in the face of the winds, their constant blasts rushing in from the open country, and then confined by narrow alleys, will sweep through them with great violence. The lines of houses must therefore be directed away from the quarters from which the winds blow, so that as they come in they may strike against the angles of the blocks and their force thus be broken and dispersed.

In the 15th century, the Italian architect Alberti distilled the knowledge of ancient Greeks and Romans on the subject, and added some observations of his own (Rykwert 1966). Alberti advocated that the siting of cities and the design of streets and buildings within them should be adapted to the character of their environment so that cities might promote health, safety, and pleasure. To Alberti, the forces of nature were powerful and deserved respect. Acknowledged, they represent a powerful resource for shaping a hospitable urban habitat. Ignored, they magnify problems that have plagued cities for centuries: poisoned air and water; depletion of scarce resources as well as increased energy demands and high construction and maintenance costs. Alberti underscored this warning by listing the disasters incurred by cities that had disregarded the power of nature.

Unfortunately, especially in this century, city planners and designers have mostly neglected and rarely exploited natural forces within cities. They seem to believe that the city is apart from, and even antithetical to, nature. Issues such as energy conservation, air and water pollution and waste disposal are treated as isolated problems, rather than as related phenomena arising from common human activities, a situation exacerbated by a disregard for the processes of nature (Hough 1984).

Chapter III

ENERGY AND CITY FORM

3.1 INTRODUCTION

Having mentioned the significance of the link between energy and land use, one related issue for land-use planners can be raised: how would the spatial distribution of population and economic activities within metropolitan areas (i.e. between suburbs and exurban communities and central cities) respond to changes in the energy system or what are the likely impacts of energy constraints on the spatial structure? Although these broad trends are attributed to forces or factors predominantly outside the control of land-use planners (e.g., technological innovations), they are, however, likely to have an influence on energy usages at the city level. Thus, if energy-efficient planning policies are to be formulated and implemented successfully at this level, it is important for land-use planners to recognize the anticipated regional trends of the late twentieth century prior to the development of any energy-efficient strategy This chapter will endeavour to respond to this issue. Before proceeding further, however, a discussion concerning some basic concepts of city form is appropriate, for it can help the reader to comprehend and appreciate the principal elements of city form and the nature and characteristics of their relationships. More importantly, it delineates the scope upon which later discussion on energy-efficient land-use planning will be based.

3.2 BASIC CONCEPTS OF CITY FORM

> (City) form is the spatial arrangement of persons doing things, the resulting spatial flows of persons, goods, and information, and the physical features which modify space in some way significant to those actions, including enclosures, surfaces, channels, ambiences, and objects. Further, the description must include the cyclical and secular changes in those spatial distributions, the control of space, and the perception of it (Lynch 1984, p.48).

This description of city form provided by Lynch encompasses three conceptual levels of generalization.[7] The most general of these distinguishes among different spatial configurations or patterns on the basis of the geometry of the developed area. In this way, city form is categorized according to its development patterns. The most common categories are the grid or network pattern, linear pattern, and centroidal pattern. These shapes, as if seen from the air, articulate the overall relationship between developed areas and surrounding undeveloped areas. They also reveal many of the relationships among parts ---- the internal structure of city areas.

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[7] Much of the ideas discussed here has been succinctly elaborated by Kevin Lynch in his book Good City Form (1984). See chapter 2 and appendix B of that book.

The second conceptual level of city form is its internal structure. It consists of the spatial organization of human activity systems. Activity systems are defined as patterns of behavior or interaction among individuals, families, institutions and firms (Chapin 1979, p.194). As McLoughlin (1969) and Chapin (1979) have argued, understanding city form in terms of these systems emphasizes the subtlety and complexity of the relationship between activities and form.

In general, there are two inter-related components to these patterns of interaction, that is, two basic types of activity systems (Chapin 1979; McLoughlin 1969; Webber 1964). Most involve "within place" activities, including the broad categories of industrial, recreational, residential or commercial activities. Second, the flows of information, people or goods that occur among place-related activities constitute "between place" activities. Whereas most activities in the first category occur in fixed locations, the second type consists of activities in motion. Activities of both types that occur repetitively in spatial patterns generate results in physical structure and form. The resultant physical framework consists of spaces adapted to accommodate various place-related activities and channels for movement-related activities that link adapted spaces (Chapin 1979; McLoughlin 1969).

Lastly, the third level of urban form description concerns spatial organization and design at the scale of a group of buildings or individual buildings. Issues of city form at this level are generally related to architectural designs. Planning, on the other hand, usually encompasses the total city physical system, and is essentially concerned with the more generalized levels of city form, that is, with the pattern and geometry of development and, particularly, with the characteristics of the internal structure.

As alluded to earlier, adapted spaces and movement channels are the principal elements of the urban physical system. The distributed patterns of these elements reflect the key organizational relationships that generate city form. We have spoken of city form in terms of the spatial organization of human activity systems which, in turn, forms the organizing concept of the urban system and its physical form.

Urban activity systems shape, and are shaped by, the physical structure of cities. All activity systems are the result of the behavior and interactions of people. Therefore, to understand how city form occurs, it is necessary to understand how people's values and motivations affect their behavior and interaction which, in turn, generate activity systems. Chapin (1974) provides one explanation: (i) the value held by people lead to (ii) needs and wants on the basis of which (iii) goals are formed; these goals, in turn, stimulate (iv) courses of actions or activities that require (v) modification of the environment to create specialized settings. Lynch (1984, p.36) summarizes it this way: "city forms, their actual functions, and the ideas and values that people attach to them make up a single phenomenon."

In short, energy costs, energy scarcities and energy policies can induce change at different scales of spatial structure: macro-scale (i.e. metropolitan, the first level of description of city form), meso-scale (i.e. city, the second level), and micro-scale(i.e. local, the third level). It is the meso-scale that will constitute the primary focus of our discussion on energy-efficient land-use planning in later chapters. However, in order to provide the reader a more complete picture of how energy factors can subtly influence the spatial structures of built environments, it is necessary to touch upon the extent to which the effect of energy factors (i.e. rising energy costs and/or uncertain supplies) have on the spatial structure of a larger scale --- the metropolitan scale.

3.3 THE EFFECT OF ENERGY CONSTRAINTS ON SPATIAL STRUCTURES

Although it is impossible to predict patterns of future development with any degree of certainty, it is likely that we can anticipate a future metropolitan pattern by simply studying the continuous forces at work in shaping it. These forces can be political, economic, social and technological in nature (Newton and Taylor 1985; Pressman 1985). This section focuses on the likely impact of the expected energy changes on the spatial distribution of population and economic activities within metropolitan areas.[8] In this regard, three schools of thought will be scrutinized: Centralization, Dispersal and Multinucleation.

3.3.1 Centralization

The first school of thought contends that the impending energy changes will lead to a more compact, energy-efficient metropolis, one characterized by more high-rise apartments than detached single family homes; higher density; more mixed residential and commercial developments to shorten journeys to work; and more growth around existing transportation modes. In brief, the argument here is that if fuel is costly or difficult to obtain, central locations and high residential densities will become more attractive as people seek to shorten trips, take advantage of mass transit, and reduce home heating costs. Indeed, some planners have perhaps inadvertently fostered this view by using such terms as "imploding metropolis" (Franklin 1974). Further, some energy experts subscribe to this view. Cook

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[8] An exploratory survey was conducted to 153 experts from 26 countries (37 per cent responded) in identifying trends that were considered likely to have marked influences on future urban form. A list of both exogenous and endogenous dimensions was suggested. Among them, the price of energy was ranked first in the list. The results of this content analysis are displayed in Appendix B. Consult Newton and Taylor (1985) for detailed information.

(1976), for example, has written:

> In the approach to the steady state, emphasis on the efficient use of energy will have brought about great changes in the structure of cities and in transport systems. Cities will be three-dimensional as well as smog free. Urban sprawl will be checked. The urban underground will developed for transport, storage, and manufacturing, and people will again want to live in cities (p.437).

The press and other popular means of communication espouse glowing stories about the coming revival of our central cities, reversing a trend that has been underway since the mid-1950s.[9] Many reasons are offered, ranging from the expected demographic changes (smaller household sizes, older population, end of the baby boom) to the lower property values in central cities and the increasing cost of single family housing. One of the reasons most frequently mentioned is the impending energy "crisis". The argument here is that if fuel is costly and/or difficult to obtain, households and businesses will seek central locations and high residential densities where their home heating costs will be less; travel costs will be less; two-worker families are more apt to find jobs in large cities with varied

[9] During the 1970s, there have been some notable shifts in the spatial distribution of population and economic activities in North America. These shifts have been basically of three kinds: (1) continued suburbanization --- that is, movement from central cities to suburban areas within metropolitan regions (this, of course, is not a new trend but one that began in the late fifties and early sixties); (2) the slowing down of growth of the metropolitan areas and the relatively more rapid growth of the metropolitan areas; and (3) interregional shifts of employment and population between the North and the South and West. For more information on these trends regarding Canada, see Robinson (1981).

employment opportunities; and alternative means of transportation are available.

There may, indeed, be some movement back to the city and a revival of central city viability and growth in the future, especially of particular segments of the population: the retired, the young, households without children, and those attracted to cultural and recreational facilities --- all of whom should contribute to the revitalization of older, central city neighborhoods. But, these persons are expected to populate the central cities irrespective of any rise in the price of personal transportation. Also, widespread recentralization of population of central cities is not possible unless significant numbers of manufacturing and other establishments return to the central city, and most observers do not expect this to happen. There is the question of access of industries to the highly skilled and educated part of the labor force, most of whom live in the suburbs and, given the low quality of central city schools and other infrastructure, is almost certain to remain there, despite any impending price rises in energy. Rather than suburbanites moving to be closer to sources of employment, it is more likely that industries will continue to move to the subrubs to be near their labor force ("jobs follow people" as opposed to "people follow job"). In light of this, widespread recentralization of our central cities is unlikely. Refer to Small (1980), who has examined analytically the possibility of residents of suburbs relocating to central cities in response to higher energy (particularly petroleum) prices and/or uncertain supplies, for further arguments.

3.3.2 <u>Dispersal</u>

However, not all students of energy agree that a smaller energy budget will or should lead to a more concentrated settlement pattern. Instead, they argue for dispersal of population and economic activities. One of them is Johnson (1978). An argument for dispersal is offered by him in his popular tract on the fast approaching era of scarcity, when the very large material and energy requirements of the American population will become harder and harder to satisfy. He foresees an improvement in our collective life if only we can train ourselves to live far simpler, more frugal lives. Thinking about the implications of such a life, Johnson foresees a dispersal of population away from large cities --- "large cities require more energy ... to move people about, more energy to bring in goods and to export manufactured goods, and more energy to process waste" (1978, p.114). Johnson bases his prediction of this emerging spatial pattern on the contention that we will be moving towards more labor-intensive industries, simpler lives closer to the land, and smaller enterprises --- in short, economic decentralization.

Howard Odum, a major contributor to the study of energy flows and energy efficiency in modern environmental systems, has also argued for the dispersal of population and economic activities. In one of his published textbooks, he makes the following comment:

> Although we do not yet see much evidence of it, the energy theories suggest that there will be a large shift of population back to the land, with more feedback of human work to the solar energy chain (Odum and Odum 1976, p.263).

Further, in their mammoth study of Florida, Odum and his colleagues make spatial dispersion and decentralization one of their prescriptions as well as one of their predictions:

> When energy and resources are abundant and cheap, it is frequently economical to concentrate activities, centralize authority, and undertake large-scale solutions to problems. Sometimes this trend is referred to as the "economy of scale". If, however, the proposed size or degree of centralization becomes too great or the energy and resource basis for development is diminishing (and becoming more expensive), large size can be a serious handicap. Greater efficiency, flexibility, and reduced costs can result from smaller, decentralized activities and solutions (Browder et al 1976, p.10).

The claim for the continuation of recent trends is not without drawback. Wardwell and Gilchrist (1980) contends that because nonmetropolitan areas have less dense population distribution, they are more sensitive to changes in energy availability and cost. Further, they argue that residents of suburbs and nonmetropolitan areas are likely to suffer disproportionately from rising energy costs and uncertain supplies, especially compared with the inhabitants of large cities and the larger metropolitan areas. This is because of the following: (1) the suburbs and nonmetropolitan areas are commonly characterized by low densities and "sprawls"; (2) rural and nonmetropolitan residents depend more heavily on the automobile and customarily travel the most miles by car, especially for commuting to work. They are also heavily dependent on the automobile for business and shopping and for access to social and health services, and to entertainment and culture; (3) rural and nonmetropolitan residents have a greater dependence on petroleum and other forms of energy than other residents and spend more on energy, especially for transportation, than other residents; and (4) the economy of small towns and rural areas is often based on industries with heavy dependence on petroleum. The suburbs, small towns and rural areas generally do not have alternative means of transportation available for either personal or goods travel. All these could certainly make nonmetropolitan areas less attracting as places to live and do business and also adversely affect their economies. From this standpoint alone, it is possible that the recent population deconcentration trends could, at a minimum, be dampened, if not reversed.

3.3.3 Multinucleation

The final school of thought concerning energy and spatial structure is actually a hybrid of the first two --- centralization plus dispersal. It has been assumed by many planners that the anticipated energy changes is one factor that will encourage growth of regional centers and a maturation of the multinucleated pattern of spatial organization. The emergence of these regional centers, generally located near transportation nodes, contain a mixture of retail, commercial, residential, and even light industrial activities and are generally imbedded in areas of moderate to low activity. There is ample evidence of this "claim" in the research (e.g., Small 1980; Romanos 1978; Anas and Moses 1978; Van Til 1980, 1982).

Small (1980) concludes that the evidence that energy shortages might foster a multinucleated pattern, though far from conclusive, is much stronger than that for a revival of central cities. He argues that greater nucleation of both suburban and city development is more likely because the relative energy-cost differences between high and low-density developments, between transit-oriented and highway-oriented developments, and between close in and outlying suburbs, are much greater than the average differences between central city and suburbs.

Ramanos (1978) comes to a similar conclusion. He notes the ongoing processes since the 1960s of households relocating to the suburban rings, at the same time with employment decentralization taking place in the same areas. Using utility analysis of the residential location decision by households he concludes that the effect of higher energy prices and/or uncertain supplies on housing and transportation costs is likely to produce residential areas located closer to employment locations and, consequently, creating building densities. He also anticipates a continuation of the trend towards suburban relocation and establishment of job opportunities in part as a response to higher energy prices. This suggests, he argued, that these more compact and dense future residential areas are likely to develop around semi-independent suburban centers of economic activity and employment. "The future metropolitan configuration could be one of compact urban clusters each consisting of a suburban employment center and a relatively dense residential area around it" (1978, p.102).

Anas and Moses (1978), moreover, draw up the same conclusion. They both envision the formation of distinct and quite dense centers, based on the development of a few major employment centers in the suburbs and exurban areas. This implies a great degree of centralization of jobs and household locations within these areas. It also implies a significant increase in public bus transportation and the number of multi-family, high-density dwellings in the vicinity of major suburban nuclei. They conclude that reconcentration of jobs and population within suburban and exurban areas, and the development of a multinucleated metropolitan region within which there are important employment centers in densely settled areas, is the most likely development pattern to emerge in the years to come (1978, p.165).

Among these three scenarios regarding possible settlement patterns (i.e., centralization, dispersal and multinucleation), which one is it more likely to emerge, if energy changes assumed in this thesis actually materialize? Besides the foregoing arguments, recently Haines (1986) has undertaken a fairly thorough research on land use studies concerning the most energy-efficient settlement pattern (see Table 1). She basically categorizes the study under two central frameworks: the Centralization and Sprawl configurations (CS) and the Centralization, Sprawl and Multinucleation alternatives (CMS). Under the CS framework, she identifies studies that compare centralization and sprawl configurations, whereas the CMS framework compares the centralization, sprawl and multinucleation alternatives. Each of these alternatives comprises four major events: predominant housing structure, principal mode of transportation to work, employment and population distribution. Forecasts were made for each of these alternatives and were then evaluated on the basis of current census and human ecological data. Haines concludes that the movement toward multinucleation has already begun, and that there will not be any fundamental spatial change in settlement pattern; but rather, the future energy constraints will intensify contemporary redistribution patterns. Multinucleation is occuring, as Haines claimed, not so much because of energy factors, but mainly resulting from fortuitous consequences of the location choices of households and firms governed by ecological laws. In other words, energy is not a major "determinant" factor of urban spatial structure, but rather, a "permissive" one (Owens 1986b, p.2).

TABLE 1

A Summary Of Land Use Studies Concerning The Most Energy-Efficient Urban Form

STUDY	CS- FRAMEWORK	CMS-FRAMEWORK
Bacon, 1973	centralization	
Franklin, 1974	centralization	
Real Estate Research, 1974	centralization	
Council on Envirn Qlty, 1975	centralization	
Hoben, 1975	centralization	
Nadler, 1975	centralization	
Kydes et al., 1976		multinucleation
Slayton, 1976		multinucleation
Cornehls, 1977	centralization	
Anas and Moses, 1978		multinucleation
Burby and Bell, 1978		multinucleation
Carroll, 1978	centralization	
Edwards, 1978		multinucleation
Roberts, 1978	centralization	
Romanos, 1978		multinucleation
Soot and Sen, 1979		multinucleation
Windsor, 1979		multinucleation
Small, 1980		multinucleation
Van Til, 1980, 1982		multinucleation
Keyes, 1981		multinucleation

source: Haines 1986, p.341.

Chapter IV

ENERGY-EFFICIENT SPATIAL STRUCTURES

4.1 INTRODUCTION

Having assessed what might happen on a metropolitan scale, it is now time to turn our attention to the question of how land-use planners might plan spatially for an energy uncertain future on an urban scale. This is the question to which the following chapters are devoted. Meanwhile, in order to plan efficiently and effectively, land-use planners must ponder over questions concerning the "best" city spatial structures or patterns from the standpoint of energy efficiency and energy conservation. What do they look like and what are their properties? To answer these, literature pertaining to two areas of research will be reviewed. The first deals with the effects of various spatial structure variables on energy consumption and use. Most of this research does not deal directly with energy consumption, but with the effects of different spatial variables on travel demand or the types of transportation mode, one can infer the implications for energy consumption. The second type of research examines directly the transportation energy implications of different spatial structures, both theoretically and empirically. Finally, a synthesis of energy-efficient environments will be put together in light of the foregoing literature review.

4.2 SPATIAL STRUCTURE VARIABLES AFFECTING ENERGY USE

Consumption and use of transportation energy is a function of several variables. These include frequency and use of available transportation modes, length of roads and highways required, vehicle distance traveled, frequency of travel, average length of trip, and the extent of automobile ownership (Brunso and Hartgen 1985; Desfor et al 1979). These factors interact with each other and with the spatial arrangement of the population and economic activities. A few researchers have attempted to categorize and measure the spatial structure variables (e.g., Desfor et al 1979). For the purpose of this thesis, the following spatial structure variables have been identified for analysis: (1) size of the city, in term of population and land area; (2) population density of the city; (3) length of roads of the city; (4) vehicle distance of travel of the city; (5) land-use pattern of community --- that is, the relationship between living, working, shopping and recreational areas; (6) type and density of housing, and (7) transportation network.[10] These different spatial variables affecting energy requirements

[10] There are, of course, nonspatial variables affecting energy: the tendency to travel, personal preference on choice of jobs and services, and the extent to which cars are used. It is certain that the relative performance of land-use patterns in energy efficiency depends, to some extent, on the values assumed by people for these nonspatial variables.

at various scales are shown in Table 2.

TABLE 2

Spatial Structure Variables At Different Scales

Scales of Spatial Structures	Spatial Variables
Macro (i.e. metropolitan)	- pattern (e.g. size and spacing of settlements) - shape (e.g. centralization, dispersal, multinucleation)
Meso (i.e. city)	- size (e.g. population and area of settlement) - shape (e.g. linear, circular, etc.) - density (e.g. built form) - interspersion of land-uses (e.g. mixed, clustering, etc.) - location and degree of dispersal of employments and services - layout and orientation of streets
Micro (i.e. local)	- orientation of a group of buildings or individual buildings - site planning - specific design of individual buildings

4.2.1 Population Size

The Nationwide Personal Transportation Study conducted for the Department of Transportation of the United States shows the variation in household automobile travel behavior as measured by daily miles per household and daily trips per household. Results indicate that household travel demands by automobile for work and work-related trips and non-work related trips are highest for cities in the 5,000-25,000 population range, with a steady decrease as population increase over 25,000. The result in itself is not too surprising, since the data are for auto travel only and there is a great tendency to take trips by public transit in larger cities, since there have better systems. The result provides evidence that city size is an important aspect of city form as it affects travel demand (Gilbert and Dajani 1974).

4.2.2 Developed Land Area

The amount of developed land area is directly related to energy consumption. There is a clear upward trend in energy consumed for transportation as the amount of developed land area in a city increases. In particular, expansive land use patterns characterized by low density consume large amounts of transportation energy compared, for example, with compact urban spatial structure (Edward and Schofer 1977; Kim and Schneider 1985).

4.2.3 Population Density

Density is considered to reduce average trip length by decreasing the distance between the origin and destination of trips. Where densities are higher, the work trip lengths are shorter, more workers ride public transit, buses and trains are fuller, and, therefore, transportation energy consumption is reduced (Lutin 1976, p.297; Keyes 1982; Kim and Schneider 1985). Where higher density is associated with reduced distances between employment and residential areas, transportation energy consumption is reduced. Although density and transport energy use is inversely related, it is not the case that energy efficiency can be attained only with very high densities.

There is some evidence presented by Lutin(1976) that higher density areas have higher vehicle occupancy levels for both automobiles and public transit. This will reduce the number of vehicle kilometers and energy requirements necessary to provide a given level of transportation services or passenger kilometers

There is also evidence that public transit is found more frequently in high rather than low density areas (Boyle 1982), and since higher rates of public transit usage tend to imply lower rates of automobile usage (Darmstader 1977, p.20), it would appear that high density areas have lower levels of energy consumption. Moreover, Darmstadter (1977) argues that high density is not sufficient by itself, but must be accompanied by a fairly large population in order to justify expensive transit facilities. Because of the closeness of land uses in higher density areas, there are also higher levels of pedestrian activity, which, by partially substituting for other travel modes, will also decrease transportation energy consumption on a per capita basis.

4.2.4 Length of Road

There is a direct relationship between number kilometers of road per unit of population and land area and population density of the community. The more area (in square kilometers) per unit of population a community has, the more kilometers of road per unit of population it requires. Another way of putting it is to say that the more spread out a city is, the more kilometers of road it will have, with more inhabitants in single family houses and these houses are on large lots. In short, length of road is really an indicator of how spread out a city is. Indeed, it is a better measure than land areas, because the inclusion of large areas of undeveloped land in parks, farms, etc. does not necessarily include an increase in corresponding length of road. Thus, given the relationship between kilometers of road and population density, and the afore-mentioned relationship between city size and population density, it is not surprising to find that there is a tendency for larger cities to have fewer length of road per capita (Miller 1978). The more length of road there are per unit of population, the more auto use there is. Thus, larger cities have less auto use because they have higher population densities and a lesser length of roads.

4.2.5 Vehicle Distance of Travel

Vehicle distance of travel is a function of a city's size, land area, population density, and number of kilometers of road. Miller (1978), again, argues that the larger a city in terms of population, the greater the number of vehicle distance of travel per year. There is a tendency for persons in larger cities to drive longer distances than those in smaller cities, probably because many activities are still centered downtown, and the fact that the average distance to downtown increases with city size. Furthermore, the higher the population density, the lower the number of vehicle distance travelled. In short, the lower the population density, the higher vehicle distance of travel per capita and the greater the need for more roads and highways.

4.2.6 Land Use Pattern

The relative locations of residential and employment patterns have been found to influence energy consumption (Fel 1975; Gilbert and Dajani 1974; Markovitz 1971). Markovitz (1971) compares trip generation rates for clustered and non-clustered residential and non-residential land uses in the New York Metropolitan Area.[11] For the residential situation, clustering reduced the average number of daily trips per household from 3.77 to 2.07, a decrease of 45 percent. For non-residential land use, the reduction is even much dramatic. Trips per thousand square feet of floor space fell from 12.99 to 4.57, a reduction of 65 percent. Commenting on these data, Gilbert and Dajani (1974) conclude that clustering commercial and industrial establishments leads to lower demand on travel facilities than if the same establishments were dispersed. In brief, clustering of land uses can help to reduce travel needs, by reducing physical separation and making multipurpose trips more feasible.

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[11] Clustering is one of the techniques for increasing the energy efficiency of new housing development by pooling or decreasing individual yards. Without any overall increase in gross density, clustering can reduce the length of streets and utility installations. Energy is saved in the construction and later in the maintenance of streets, transmission of electricity and water, and provision of services like garbage collection. Other energy savings can be attributed to increased walking or biking (shorter streets may be an incentive to this).

4.2.7 Type and Density of Housing

High residential densities are associated with relatively low rates of energy consumption on a per dwelling unit basis (e.g., Jackson 1977; Darmstadter et al 1977). Density determines energy consumption indirectly through an association with certain micro-technical factors, such as number of exposed surfaces, insulation levels, shelter from the wind, and economics in space and cooling systems. In general, the high density of attached housing will be associated with shared walls, they insulate each other on the common side from exterior cold and heat and therefore require less heating and cooling energy per square foot than a detached unit in the same climate. In this way, even at low densities, use of common-wall units such as town houses, duplexes, and low-rise, walk-up apartments will increase the per unit energy efficiency of new development. As alluded to earlier, clustered housing also results in more compact development and thus less travel.

4.2.8 Transit Usage

Transit usage depends on city size, the densities of residential and non-residential areas and their locations, and, of course, the extent of car ownership. It is obvious that conventional mass transit is not well suited for servicing people who live and work in dispersed locations. Spread suburb clusters of non-residential use can only occasionally support meager bus service. The higher density of the downtown (or other employment sub-center) and the larger its size, the more it will shift travel from auto to transit (Steadman 1980).

The location of residential, employment, commercial and institutional density levels also has effect on the potential role and the efficiency of public transit. Since high load factors improve transit energy efficiency, it is desirable to avoid the "peak" problem of high load factors for some portions of the route and low load factors for other portions of the route by locating both residential and commercial developments along transit corridors, thereby creating savings in energy consumption/use (Desfor et al 1979, p.2).

4.2.9 <u>Transportation Network</u>

Of importance in energy consumption is the degree of congestion and average speed of the vehicles in the transportation network. Automobiles are most efficient at speeds of 48-72 kms/hour (32-48 mph) (Desfor et al 1979, p.21; Stowers and Boyar 1985, p.7-11). Where there is a high degree of congestion, that is, where speeds are substantially below 48 kms/hour, as in most inner-city traffic, the efficiency of transportation is reduced and consumption increased.[12] This is due not only to the lower

[12] A very recent study was conducted to challenge the conventional wisdom that much fuel can be saved by

speeds, but also to the greater number of idle, stop and start cycles found in congested traffic (Desfor et al 1979).

4.3 EVALUATION OF TRANSPORTATION ENERGY IMPLICATIONS OF ALTERNATIVE SPATIAL PATTERNS

The interrelatedness of land use and transportation has long been recognized. Yet, in the traditional transportation planning process, land use patterns and projections of these patterns are normally treated as exogenous or given variables (Chapin and Kaiser 1979, p.620). Given expected land use patterns, the transportation planner typically alters the type and location of transportation facilities to meet the projected travel demands generated by and associated with the land use projections.[13]

During the past decade or so, a different approach has been taken in which land use patterns are viewed as an independent variable and the resulting travel demands are

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creating smoother flowing traffic with improved average speeds. However, the authors, Newman and Kenworthy (1988), argue that optimizing traffic for better fuel efficiency in vehicles is a trade-off with a less fuel-efficient city overall. A comparison of 32 world cities confirms this proposition. Conceptual models for understanding transport energy use in cities are illustrated in Appendix C.

[13] Chapin and Kaiser (1979) argue that institutional constraints have been a significant factor in the separation of land use and transportation planning and will continue to be a factor in the future. They also offer their view on the coordination of transportation and land-use planning. For more detailed discussion, see Urban Land Use Planning, Chapter 1 and 16.

estimated. This approach was given added attention in recent years by our concern for the impending energy crisis which has led some researchers to argue that by planning land use and settlement patterns it may be possible to minimize personal travel demands and thus energy consumption. The research in this area has been both empirical and theoretical. In brief, the empirical research includes valuable studies of the transportation and, in some cases, the energy implications of alternative spatial patterns in particular cities and metropolitan region (Foell et al 1981; Sargious and Szplett 1979). On the other hand, the theoretical work has focussed on modeling of the relationships between spatial patterns or structures, transportation, and energy efficiency or conservation and examining these relationships under a variety of energy scenarios (Kim and Schneider 1985; Van Til 1980, 1982; Edwards and Schofer 1974; Hemmens 1967; Jamieson et al 1967). Without actually generating the particular results of all of those studies, it is useful to summarize the general implications with appropriate examples cited.

Energy use and consumption relate to land use and settlement patterns in several ways. If more compact development occurs, there are potential saving in materials, installation, and construction.[14] With more compact and

[14] Construction costs were discussed thoroughly by the Urban Land Institute based on the five detailed case studies involved in the Site and Neighborhood Design for Energy Conservation Program in the States. See Crane and Steller, Jr. (1981) for more information.

contiguous development, there are potential saving in operating and maintenance requirements for energy. With shorter distances and more efficient coverage of an area, for example, police and fire patrols, school bus routes, and other urban services can be provided with less energy. The provision of private goods and services, such as service or delivery calls, can be less energy consuming as well. A study conducted in Oakville, Ontario concluded that a 33 per cent reduction in total energy costs could be realized in attached cluster housing compared to conventional detached dwelling patterns (Hix 1977, p.58). As well, the experience of Bedford in Nova Scotia with cluster housing showed that a community can trade-off lot size for open space (64% of the site), allow the use of compact development (in a 94 acre site, 405 units are planned, 72 of them single-family detached, 215 multifamily attached and 116 apartment units) and reduce servicing cost (Lang and Armour 1982, pp.101-102). These areas for potential savings assume two features of future development, that is, use of clustering techniques with somewhat higher densities for shorter distances, and elimination of haphazard development and "sprawl" in order to limit the amount of extra travel as well.

Further savings will result if land uses are organized in such a way that fewer trips are required and if the number of land uses are related so that multi-purpose trips are possible. This involves mixing residential, commercial, industrial and recreational uses of land which decreases transportation energy consumption and where increases the feasibility of district heating. By comparison, segregated land use patterns create many transportation problems: energy inefficiency, traffic jams and overinvestment in transportation infrastructure to meet peak travel demand.[15] Mixed land use in new developments, infilling on vacant land and conversion of existing uses of buildings in the inner city can alleviate these problems. Cited as examples of high density with mixed-use are the Pacific Center edifice in Vancouver, Eaton Centre in Toronto and Place Desjardins in Montreal (Lang and Lounds 1979, p.85). Multiple use buildings are also becoming increasingly popular in the United States. Examples of such buildings include the Penn Centre in Philadelphia, the Citicorp Centre in New York City, and the John Hancock Centre in Chicago (Ellis 1989). As compared to other mixed-used buildings, Hancock Centre (Ellis 1989) is somewhat of an exception,

> in that the building has become a neighborhood in itself. It offers residents a place to park their cars, to eat and sleep, even to vote in their own precinct and buy stamps in their own post office. On Halloween, the children go from floor to floor ... spooks in the elevator (p.162).

[15] To get a picture of the associated costs (time and energy) of transportation problems and their subtle influence on people's choice of living and working, the reader is referred to a recent article published by <u>Time</u> Magazine entitled "Gridlock" (Koepp 1988).

Furthermore, in his recent empirical analysis of 57 of the largest suburban employment centers in the United States, Cervero (1988) asserts that the degree of land-use variation does exert a significant influence on the modes that suburban workers choose. The analysis, using a series of stepwise regression models, indicates that mixed-use developments result in the shortening of motorized trips and the amelioration of local traffic congestion; and that they generally encourage more ridesharing, walking, and cycling. An even more striking example is the new community of Fermont, Quebec which is located in a subarctic region, about 800 kilometesr north-east of Montreal, with the use of only 77 hectares of land for a population of 5000 (Lang and Armour 1982, pp.93-95). Its gross density of 65 persons a hectare is about double that of an average northern town. Fermont has allocated roughly around 2.3 linear meters per person for rights-of-way, one fourth that of a conventional town, all of which translates into savings estimated at $8 million in capital expenditures alone.[16] The community may even be realizing additional savings from reduced expenses for snow clearance, the operation of public and private vehicles and police as well as fire service. All these savings resulted from the compact nature of the town's land-use pattern with the energy-conscious design of both street layout and building locations. Elsewhere, mixed land

[16] These capital expenditures include such items as paved roadways, curbs, sidewalks, sewers, street lighting, hydrants and power distribution.

use has opened the possibilities of the South March energy conserving community at Ottawa, Ontario to district heating (Lang and Armour 1982, pp.83-88). If major centers of activity, such as employment, shopping, education are located at the junction of public transit system, then even more efficient use of both land and transportation is possible. With higher densities, average trip lengths, especially work trips, are reduced; more workers ride public transits; there is higher vehicle occupancy level (for both automobile and public transit); and more pedestrian activity in place of other transport modes. All these conditions help to reduce transportation energy consumption.

Moreover, the design of circulation systems has certain effects on energy consumption. The layout and design of streets determine how far people must drive and how much material must be used to build and maintain the street system. Discouraging automobile use and encouraging walking and bicycling within a community can be accomplished by paying special attention to the design of the circulation system, increasing development density and integrating land uses so that destinations are closer together.

A study has indicated that there are chances for fuel saving to tip-makers travelling on energy-efficient street patterns against existing street pattern. In Bayridge subdivision in Kingston township (population 26,000) Ontario, Curtis and Pringle (1983) used the Residential Area

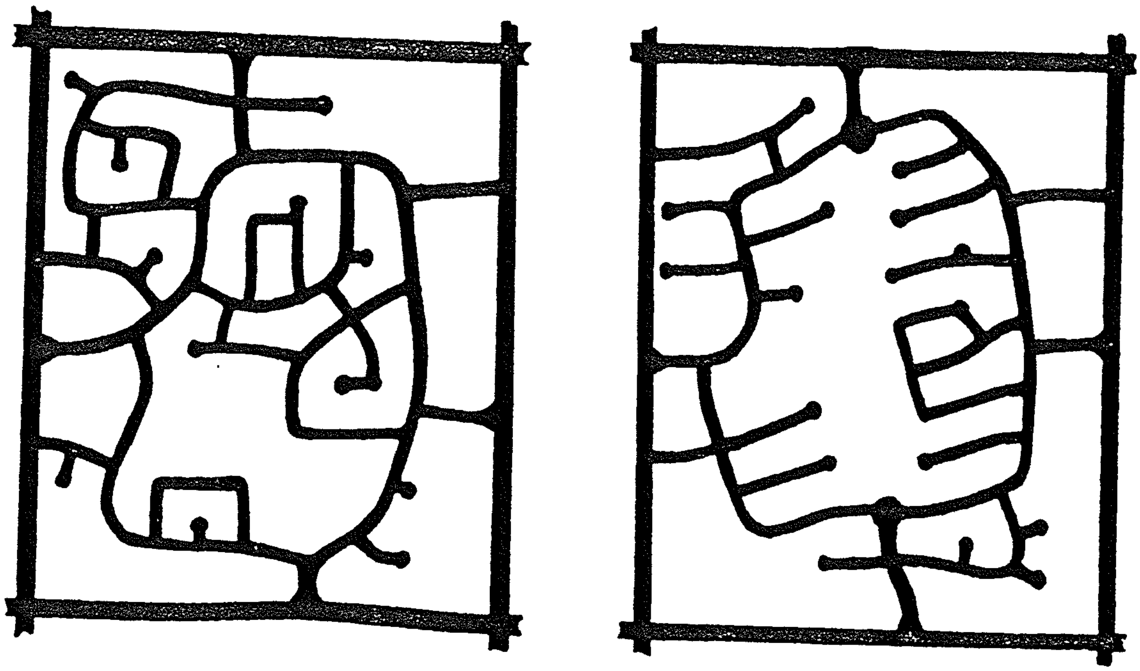
Traffic Analysis Model (RATAM) to calculate the amount of fuel consumed by work trip commuters on automobiles travelling through the subdivision to a major arterial. The model was applied to alternative street patterns to compare fuel consumed in the work trip. The findings indicated that the grid and solar super-block street patterns showed fuel energy savings compared to the existing ad hoc/conventional street pattern[17] (see Figure 6). About 30 per cent of total fuel consumption in the work trip occurred within the area of the subdivision.[18] Dollar and fuel saving estimate for all home-owners in subdivisions planned and designed for transportation energy conservation become significant at regional, provincial and federal levels.

The foregoing discussions can be given more concrete illustration by briefly describing an empirical study of one city, Washington, D.C., which has assessed the energy efficiency of alternative land use and transportation plans with density and urban forms as key variables. Five development scenarios were prepared for analysis of energy consumption by Roberts (1975). Each of the scenarios was

[17] Many recent residential subdivisions, planned or built, have been designed to use a complex pattern of curvilinear, loop and dead-end streets with the result that residents, travelling within the same subdivision, follow indirect paths.

[18] A similar analysis also was conducted for a residential subdivision in Regina, Saskatchewan and concluded with the same result, that is, both the solar superblock and grid street patterns do offer considerable fuel savings compared to conventional street patterns. See Curtis and Neilson and Bjornson (1984) for detailed information.

Figure 6: The Conventional And The Solar Super-Block Street Patterns



Conventional Street Pattern Super-Block Street Pattern

Source: Curtis and Schlosser 1987, p.284.

based on the same total population, total number of households, and total employments, but varying as to the arrangement of land uses, economic activities, and levels of transportation.

The five scenarios developed were termed Dense Center; Transit-oriented; Wedges and Corridors; Beltway-oriented; and Sprawl. The dense center scenario assumed that all additional households and employment would be concentrated in the metropolitan center, with somewhat higher-density residential development. The emphasis in the transit-oriented scenario was on the planned Metro system, with all new households and employment located in areas where transit stops on the rapid rail system are located. Densities are moderately higher. The wedges and corridors scenario, which conformed to the then-prevailing plan for development in metropolitan Washington, called for emphasis on rapid transportation routes from the Metropolitan Center and development in those corridors; wedges of open land without development would be reserved between the corridors. Since much of the then-recent growth in metropolitan Washington focused on the Capital Beltway, an expressway that rings the metropolitan center, the beltway-oriented alternative extrapolated that trend. All additional households and employment were concentrated in vacant areas adjacent to the beltway. In the sprawl scenario, additional households were located beyond the beltway in low-density, largely single-family units, with employment, on the other hand, concentrated in the metropolitan center or around the beltway.

Analysis of energy use based on these alternative scenarios focussed on the increment for residential and automobile uses (see Table 3). In the residential sector, the largest consuming alternative was "sprawl" and the least consuming was "dense center"; the degree of variation between them was 35 percent for the increment of development. This means that for the households added to the housing stock of the metropolitan area between 1973 and the forecast year 1992, about one-third of the energy used in the "sprawl" alternative could be saved by building at higher densities.

In the transportation sector, the amount of variation was much greater. The number of vehicle miles travelled, and therefore the amount of energy used, differed according to scenario. The largest amount of variation was between "sprawl" and "transit-oriented" development, with a difference of 113 percent for the increment of development. If the forecast year is compared to the base year, energy used by automobiles increased by 60 percent in the "sprawl" scenario, but only 28 percent with the "transit-oriented" development. The "dense center" alternative was close to "transit-oriented", with an increase over the base year of 30 percent. The potential for energy savings in the "dense center" pattern, then, was about one-half by the forecast year. This difference is attributable to three factors: shorter trip lengths, fewer trips, and a higher level of ridership on public transit.

Finally in his study, Roberts concluded that:

> the attributes of an energy-efficient land use pattern seem to include the following: development at somewhat higher densities, with clustering techniques as well as use of natural amenities on the site to reduce heating, cooling, and lighting loads; contiguous development with no leapfroging; orientation to public transportation and reduced, more efficient use of the automobile; use of certain technical options that require some reorganization of present land use patterns in order to be implemented; and general relationships among land uses that will result in less travel, less material requirements, and less land and structureal area per dwelling units

TABLE 3

Energy Consumption By Alternative Development Scenarios (in 10 Btu/Yr) In 1992

	Base	A Dense Center	B Transit Oriented	C Wedges & Corridors	D Beltway Oriented	E Sprawl
CONSUMPTION BY SECTOR						
Residential	265.3					
Increment		91.0	95.8	109.9	112.4	122.6
Total, Forecast Year		356.3	361.1	375.2	377.7	387.9
Commercial/Industrial Institutional	176.6					
Increment		78.9	78.9	78.9	78.9	78.9
Total, Forecast Year		255.5	255.5	255.5	255.5	255.5
Transportation, Automobile	117.9					
Increment		35.1	33.1	59.5	52.2	70.6
Total, Forecast Year		153.0	151.0	177.4	170.1	188.5
Transportation, METRO	2.5					
Increment		12.4	12.4	12.4	12.4	12.4
Total, Forecast Year		14.9	14.9	14.9	14.9	14.9
TOTAL	562.3					
Increment		217.4	220.2	260.7	255.9	284.5
Total, Forecast Year		779.7	782.5	823.0	818.2	846.8

Source: Roberts 1975.

4.4 A SYNTHESIS OF ENERGY-EFFICIENT ENVIRONMENTS

In the previous sections, Energy-efficient attributes have been identified from exploration of possible responses to fuel constraints. An obvious relationship between certain spatial variables and energy consumption is recorded. For the sake of brevity and convenience in formulating effective energy conservation policy, an interaction matrix is simply conceived as an overall guiding principle (see Table 4).

A considerable degree of consensus concerning the attributes of an energy-efficient form has been made apparent. City spatial structure under energy constraints suggests that reduced energy consumption would result not only from higher development density but also from mixing of different land uses. It is these characteristics of compactness and interspersion of land uses that further encourage nonmotorized transport and increase the feasibility of energy-efficient district heating system.

In summary, the characteristics of an energy-efficient form include compactness and integration of land uses with clustering of trip ends. More compact developments can be encouraged by increasing the overall density of the community, encouraging infilling and redevelopment, minimizing urban sprawl and encouraging large-scale integrated development. As well, vehicle trips also can be minimized by locating interrelated land uses in close

TABLE 4

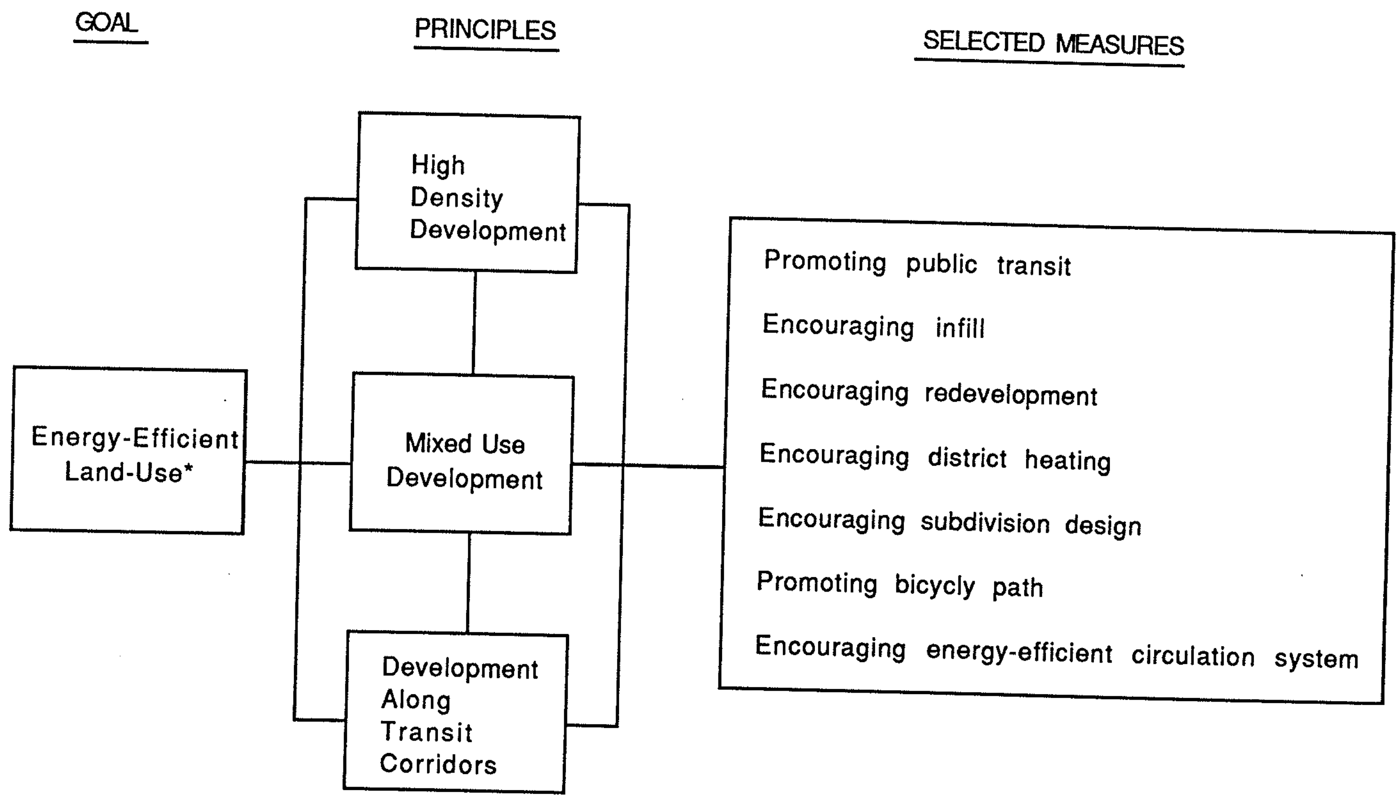
Relationships Between Spatial Variables And Energy Consumption

Variables / Consumption	Size, shape and density of development	Relative location and spread of residential development	Relatiave location and spread of commercial/ institutional activity	Relative location and spread of industrial activity	Design of circulation system	Form and orientation of building
Energy consumption for transport	●	●	●	●	●	○
Energy consumption for infrastructure maintenance	●	●	●	●	●	●
Energy consumption for buildings (space heating)	●	○	⊜	⊜	●	●
Potential for efficient district heating	●	●	●	●	●	○
Potential for efficient public transit system	●	●	●	●	●	○
Potential for efficient pedestrian system (walking, cycling)	●	●	●	●	●	○

● Interaction ⊜ Possible Interaction ○ No Interaction proximity, concentrating development in nodes and along transit corridors, encouraging greater mix of uses, and discouraging isolated commercial development. In theory, these attributes finally would lead to a reduction in energy requirements for travel and space heating/cooling, and would increase the potential for attaining an efficient public transport system as well as facilitating the introduction of energy supply technology (i.e., district heating). A display of some major principles and measures of energy-efficient land use planning is illustrated in Figure 7.

Moreover, the reader should recognize that the principles which have been identified could be applied to growth and incremental changes. For instance, in large cities continuing development might be channeled and directed gradually around already existing suburban centres and along major nodes and transit corridors. Development which would bring about greater interspersion of land uses as opposed to greater separation should be further encouraged. As well, it is essential to bear in mind that the identified conservation measures just provides a necessary but not a sufficient condition for energy savings thus far.

While the principle of greater land-use integration for more energy-efficient city design is clear, how to apply it in actual practice is a total different story. Relatively little is known about the multitude of complex factors that



* A land-use pattern that can help to faciliate energy saving in three main ways: (1) reducing transportation requirements within the development; (2) reducing the infrastructure (roads and utilities) required in the development; and (3) reducing the space conditioning (heating and cooling) requirements of buildings.

Figure 7: Principles And Measures Of Energy-Efficient Land-Use Planning At City Level

determine where people will choose to live in relation to their place of employment and their travel patterns for shopping and recreation. For instance, if a new industrial park is located close to a residential area, will the people living in that area work in that industrial park? If residential developments include more convenience commercial facilities, will the use of automobiles go down? Answers to these questions are not yet clear, and thus specific recommendations on how to guide land-use patterns are difficult to make. At this point, planners must take the general principles outlined above and apply them as a means of encouraging more energy-efficient city design.

Chapter V

ENERGY-EFFICIENT LAND-USE PLANNING IN SELECTED NORTH AMERICAN CITIES

5.1 INTRODUCTION

A repertoire of academic research concerning energy consumption and land-use planning has been explored and documented in preceding chapters. In spite of the deficiency in understanding the behavioral aspect of people in relation to energy use, there is unanimous agreement on the characteristics of energy-efficient city forms. To translate these identified characteristics into practice, appropriate planning policies and strategies need to be formulated and implemented. In North American cities, yet only few in number, positive steps have been undertaken to integrate energy considerations into the land-use planning process. However, these steps may vary from city to city, depending on a number of issues such as public awareness of energy problem, the concern of local government, and so on. In order to maintain an environment which is conducive to energy conservation, some cities have enacted energy-conscious legislation, whereas other urban centers have introduced conservation measures in development plans and land use by-laws.

Having identified what principles and measures are essential for effective energy-efficient land-use planning, it is now time to evaluate the extent to which they have been adopted or operated in the real world. Therefore, this chapter is to provide a review of experience in energy conservation through land use planning in selected North American cities which this have a high profile. During the review, a set of commonly adopted energy conservation strategies will be formulated, which, in turn, will serve as the framework for assessing the Prairie Cities' efforts in their planning of energy-sensitive environments in the later chapter.

5.2 A REVIEW OF SELECTED NORTH AMERICAN CITIES

A total of eight representative cities were chosen to illustrate how certain jurisdictions have implemented comprehensive policies for energy management and conservation. These cities comprise Davis, California; Portland, Oregon; San Diego, California; Seattle, Washington; Boulder, Colorado; Lincoln, Nebraska; Toronto, Ontario; and Brampton, Ontario, all of which are selected on the basis that those energy conservation measures or programs they adopted must be both sufficiently advanced to have resulted in practical, concrete information that can be shared and, to some degree, repeatable in other locations, providing a model and/or information base for similar activities elsewhere. A list of strategies which these cities have adopted to affect energy conservation within their own jurisdictions is summarized in Table 5.

TABLE 5

Energy Conservation Strategies Adopted By Selected North American Cities

Strategies \ Cities	Davis	Portland	San Diego	Seattle	Boulder	Lincoln	Toronto	Brampton
High density development	●	●	●	●		●	●	
Mixed use development	●	●	●	●		●	●	●
Development along transit corridor	●	●	●	●		●	●	
Promoting public transit	●	●	●	●			●	●
Infill		●	●	●			●	
Redevelopment		●		●	●		●	
Energy profile	●	●		●	●		●	
Encouraging bicycle path	●	●	●	●			●	●
Subdivision design	●	●	●			●		●
Development plan	●	●	●	●	●	●	●	●
Zoning by-laws	●	●	●	●	●	●		●
Development approval	●	●	●	●	●	●		●

5.2.1 Davis, California

The City of Davis is one of the best known examples which has integrated energy considerations into its physical planning. In the 1973 General Plan for the City (McGregor 1984), a goal was set for reducing energy consumption by the development of multimodal transport, new building and sitting regulations, a more compact city, and public education. This plan, according to the Community Development Director for Davis, resulted in "a shift from sprawling suburbia to a pleasantly planned and more efficient use of land ..." (McGregor 1984, p.195).

In brief, the City of Davis is trying to reduce energy usage in relation to work-related travel by encouraging people to live and work in the same neighborhood. A number of different ordinances have been passed to implement this objective including the encouragement of cottage industry by allowing home owners to operate small businesses (Ridgeway and Projansky, undated). As well, the General Plan for the City encourages various measures for energy conservation, including shading, drought-resistance vegetation, alternative transportation modes (bicycles and transit), recycling non-renewable materials, conservation of prime agricultural land, higher density development along transit corridors and energy conservation standards for buildings. The City enforces these planning policies through ordinances and development reviews.

5.2.2 Portland, Oregon

A second example of a city which has undertaken some positive steps towards energy conservation through land-use planning is Portland, Oregon. The City has taken a legal and regulatory approach to conservation by establishing a comprehensive energy plan that relies heavily on the city's power to shape growth and mandate conservation (Sewell and Foster 1980b and Hemphill 1980). Since 1984, homeowners have met mandatory weatherproofing requirements such as installing storm windows and insulation (Sewell and Foster 1980b). The Plan also has a land-use component encouraging compact growth and integration of new development with public transit systems (Hemphill 1980).

Portland was one of the first cities to attempt to quantify potential energy savings related to the application of particular land-use strategies. The main objective of the Portland Energy Conservation Management Demonstration Project was to develop a methodology that could be used to predict potential energy savings from changes in the urban form. In short, the project examined eighty-five possible energy conservation strategies and identified forty-two as being applicable to Portland (Sewell and Foster 1980b).

Specifically, Portland is also considering use of energy zones (Sewell and Foster 1980b). Simplified procedure for mapping areas of the City according to energy efficiency was established, resulting in an "energy zone map" which divides the City into five zones based on relative energy efficiency. The purpose was to guide new development to energy-efficient locations (see Table 6). Priority would be given to capital improvements and development proposals in zones well served by public transit, utilities, and services near the Central Business District and close to employment and shopping.

TABLE 6

Criteria For Establishing Portland's Energy Zones

Energy Zone		Efficiency Ranking
ZONE 1 Areas served by transit, shopping and jobs	Sewered areas in Portland that are: EITHER within 1/8 mile of 1995 transit routes or 1.3 mile of 1995 transit stations And within 1/3 mile of major shopping centres And within 1/2 mile of industrially or commercially zoned land. OR within 1 mile of the central business district.	Excellent
ZONE 2 Areas served by transit and shopping, or transit and job	Sewered areas in Portland that are: EITHER within 1/8 mile in 1995 transit routes or 1/3 mile of 1995 transit stations And within 1/3 mile of major shopping centers. OR within 1/8 mile of 1995 transit routes or 1/3 mile of 1995 transit stations And within 1/2 mile of industrially or commercially zoned land.	Good
ZONE 3 Areas served by transit, or shopping, or jobs	Sewered areas in Portland that are: EITHER within 1/8 mile of 1995 transit routes or 1/3 mile of 1995 transit stations. OR within 1/3 mile of major shopping centres. OR within 1/2 mile of industrially or commercially zoned land.	Fair
ZONE 4 Other sewered areas in Portland	Other sewered areas in the City of Portland that are not in zones 1, 2, or 3.	Poor
ZONE 5 Unsewered areas and areas outside city boundaries	Unsewered areas in Portland and all areas outside present city boundaries.	Very Poor

Source: Sewell and Foster 1980b, p.110

5.2.3 San Diego, California

Since 1973 the San Diego County has been an active proponent of energy conservation by bringing energy considerations into its land-use planning process. In 1977 the County General Plan was amended to incorporate an "Energy Element" whose purpose was to address energy demand and supply and the policies and implementation strategies required to reduce the rates of energy growth to desirable levels (Lang and Armour 1982, pp.167-169).

Included in the "Energy Element" of the County General Plan are policies which attempt to attenuate the energy consumption in areas such as transportation, general land uses, and housing through the discouragement of undesirable development. Increased development densities are encouraged by emphasizing on smaller average lot size and more multi-family developments in new areas and infilling in existing areas. A greater mix of residential of commercial land uses are promoted so as to minimize energy used in work trips. Moreover, the Plan recognizes that the transportation sector is major user of energy and that choices between modes of transportation will be the prime determinants of future energy needs. As a result, policies promoting public transit and bicycle routes are formulated in the Plan.

5.2.4 Seattle, Washington

In 1976 the City Council of Seattle passed five resolutions that together comprise a comprehensive municipal energy policy. The resolutions involve the following (Ridgeway and Projansky undated, pp.17-38):

(a) developing new building codes for energy efficiency aimed at improving construction in terms of thermal performance and increasing residential densities;

(b) forecasting electrical demand to project baseline levels of electrical energy demands;

(c) specifying energy conservation policies in the city's comprehensive policy plan;

(d) managing power generation with due consideration to resource use, energy conservation, sound economics, and environmental responsibility; and

(e) preparing a contingency planning program for energy use.

Furthermore, the Plan seeks to use land in downtown Seattle more efficiently: intermixing living working space in a denser pattern, and thus reducing energy otherwise consumed in commuting (Ridgeway and Projansky, undated).

5.2.5 Boulder, Colorado

The City Planning Department of Boulder, which also contains the City Energy Office, has come up with the

"Residential Allocation System" for energy conservation measures in new residential development (Lang and Armour 1982, pp.177-180). This system encourages new development to be located close to a variety of existing facilities and services and to incorporate design directed towards solar energy by granting bonus points to developers who must compete for a limited number of development permits annually. For instance, the maximum number of points is awarded for the following distance parameters:

- the project is within 1.6 km of three of the following facilities: library, recreational centre, day-care centre, neighborhood shopping facilities with at least one grocery store;
- the project is within 1.2 km of a developed neighborhood park;
- half the project is within 0.4 km of existing bus service; and
- the project is within four minutes of fire department response.

The distinctive features of the merit approach adopted by the City of Boulder, as Lang and Armour (1982) stated, include its ...

> explicit nature of the evaluation criteria and the use of a competitive rather than simply a regulatory mechanism ...its initial focus on energy-oriented development controls, through growth management, rather than on the comprehensive plan (p.179).

5.2.6 Lincoln, Nebraska

The City of Lincoln was one of the first regions in North America to develop a comprehensive plan which explicitly accentuated energy conservation as a major goal (Sewell and Foster 1980b; Lang and Armour 1982). In 1977 a new plan was adopted with three apparent energy-related themes: controlling urban sprawl, encouraging concentric growth, and maintaining and further strengthening the central business district (Lang and Armour 1982, pp.59-61). Specifically, the plan encompassed five noticeable energy-related goals with accompanying policies. They are listed in Table 7. Many such goals are set to address and promote energy-efficient land-use. They include the effort to minimize energy demand through urban design and land-use planning, in order to provide higher residential density facilities close to major activity centres.

In brief, the City's Comprehensive Plan embodies a variety of energy-efficient land-use strategies, including the prevention of further sprawl through the use of an urban growth boundary, the construction of multi-family housing in close proximity to proposed shopping centres, the promotion of multi-use centers to reduce travel, the encouragement of other modes of transportation besides automobile, the zoning for higher density development and close proximity to transportation networks, and the use of incentives for protecting solar access (Sewell and Foster 1980b).

TABLE 7

Energy-Related Goals Of The Lincoln City Comprehensive Plan

ENERGY SUB-GOAL 1: LAND USE

Regulate the use of land and encourage the use of urban design so as to minimize the demand for energy consumption and maximize the effectiveness of energy consumed.

Policies:

(1) Regulate the use of land so as to provide higher density residential facilities in proximity to the Lincoln Center and other major activity centers.

(2) Encourage the development of fewer and more intense multipurpose centers and their concentration as opposed to the scattering of such activities in order to provide opportunity to eliminate or substantially reduce auto travel.

(3) Encourage people to live in proximity to activity centers and particularly their place of employment.

(4) Emphasize the revitalization of the Lincoln Center and the rehabilitation or redevelopment of established neighborhoods near the Lincoln Center.

(5) Encourage radial or concentric growth about the Lincoln Center with new development to north, west, and south. When the objective establishing growth areas to the north, west, and south has been substantially developed, growth to the east into Stevens Creek watershed area may be pursued.

(6) Encourage land-use arrangements and densities that facilitate energy efficient public transit systems.

(7) Encourage existing and future industries to conserve energy and improve energy efficiency.

(8) Encourage site planning and designs which reduce demand for artificial heating, cooling, ventilation, and lighting.

(9) Encourage the investigation of energy conservation and improved energy efficiency possibilities of centralized heating and cooling facilities serving building complexes.

Table 7 continued

ENERGY SUB-GOAL 2: TRANSPORTATION

Plan, design, and manage a coordinated system of public and private transportation programs and facilities which maximize passenger and freight miles travelled per unit of energy consumed.

Policies:

(1) Provide the facilities and programs for increased utilization of public transit, car pooling, and bicycle and pedestrian systems.

(2) Reduce the need for and utilization of the private automobile.

(3) Continue to improve the effectiveness of existing and future roadways so as to minimize unnecessary energy consumption by improving circulation through engineering procedures and roadway improvements.

(4) Encourage a system of staggered work hours for major employment concentrations.

(5) Endorse efforts to develop energy efficient freight and passenger systems.

ENERGY SUB-GOAL 3: COMMUNITY FACILITIES

Exhibit governmental leadership and innovation related to the conservation and efficient utilization of energy for community facilities and services.

Policies:

(1) The location, design, and operation of community facilities such as schools, churches, libraries, recreational facilities, university facilities, and other public buildings should encourage energy conservation and efficient energy utilization by such means as multipurpose or joint uses.

(2) Public motor vehicle fleets should emphasize energy effectiveness.

(3) All public lighting systems should be designed and operated to utilize energy efficiently without sacrificing public safety.

(4) The disposal of wastes should permit the recycling of materials and the capture of energy from non-recyclable materials, including such processes as incineration and landfill gas production.

(5) Encourage the operation of all generating plants to incorporate the "total energy" concept, which utilizes energy by-products in addition to the primary power source.

Table 7 continued

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(6) Power-generating facilities should utilize technology which is consistent with the need to conserve exhaustible resources.

(7) Increase consumer awareness and knowledge to reduce energy consumption through educational efforts and rate structure incentives based on costs.

(8) Develop methods to provide financial relief to the low-income families from increasingly costly energy resources.

ENERGY SUB-GOAL 4: BUILDING DESIGN

Encourage the design and construction of buildings and building complexes so as to effectively utilize all energy sources.

Policies:

(1) Building design and orientation should utilize natural lighting effectively and reduce the effects of exposure to extreme weather conditions, thereby reducing the need for mechanical heating, cooling, and ventilation.

(2) Building codes should stress the requirement of adequate insulation in all types of structures.

(3) Building codes should promote the use of energy conserving building materials.

(4) Landscape materials should be utilized effectively to reduce the adverse effects of weather conditions.

(5) Building codes and other regulatory measures should encourage the utilization of new and alternate energy sources in order to reduce the demand for exhaustible energy sources.

(6) Buildings should be designed and built to utilize waste heat to reduce the demand on public utilities.

(7) Buildings should be designed and built to consider energy costs for the life of the building.

ENERGY SUB-GOAL 5: ENERGY PRODUCTION AND ENVIRONMENT

Encourage energy production from all sources which promote environmental quality.

Source: Sewell and Foster 1980b, pp.149-151.

5.2.7 Toronto, Ontario

In 1980 Toronto City Council passed a by-law to amend the Official Plan and incorporate statements on energy efficiency (Lang and Armour 1982, pp.63-65). Toronto is a fully developed inner city with a vital core area, a mixture of high-density residential complexes and mature, low-density residential neighborhoods, and a multi-modal transit system.

With the intent to attenuate energy consumption and encourage energy conservation, the goals of the by-law are to minimize energy use while improving quality of urban life (i.e. preserve and promote the attractiveness of the City both as a place to do business and live), to replace the consumption of non-renewable resources, particularly oil with renewable energy sources such as sun, wing and biomass, and to minimize inequities for residents caused by higher energy prices and possible shortages. Policies pertaining to energy conservation, urban form and public involvement are pursued and guided by the principle that all measures should be cost-effective.

Moreover, the City has completed a Municipal Energy Audit and is exploring such measures as the cogeneration of electricity and steam for district heating and the use of sewage for district heating, and is developing guidelines for assuring solar access in medium- and high-density developments. As well, a demonstration program in community retrofit has been started.

5.2.8 Brampton, Ontario

In 1979 Brampton became the first city in Canada to require the application of the principles of passive solar design to all new subdivision plans (Lang and Armour 1982, pp.157-159). The Brampton by-law is based on eight energy conservation criteria, including siting and designing buildings for solar orientation and solar access, designing for pedestrian access and use of public transit, and developing mixed-use centres. The criteria also formed the basis of the City's energy policy concerned with:

- promoting greater local self-reliance;
- reducing consumption of= non-renewable energy sources;
- sitting buildings for proper sun and wind orientation;
- protecting solar access;
- encouraging mixed-use developments and a comprehensive waste recycling program; and
- promoting public transit

In addition, the Brampton City Council approved the formation of an Energy Conservation Committee to analyze energy use by city-owned or operated facilities, to prescribe conservation measures, to monitor future energy use by municipal facilities, and to involve the general public in a program of public relations and information dissemination. Public understanding and involvement are deemed essential if passive solar and other design measures being applied to subdivisions are to achieve their potential energy savings.

5.3 SUMMARY AND COMMENTS

The major principles and measures of energy-efficient land-use planning which have been theoretically identified in the preceding chapter have been adopted by different North American cities. This is promising in that the gap between theoretical possibility and practical reality in the area of energy-efficient land-use planning at the city level is starting to narrow.

Specifically, it is noteworthy that cities which have been successful in energy-integrated planning usually possess effective strategies. As illustrated in Table 5, almost all cited cities have formulated, in one way or another, tough, comprehensive energy-related policies, zoning by-laws and development approval process. In these cities, development plans and policy statements provide a general framework for conservation actions, which, in turn, are regulated by zoning by-laws, codes, and development controls; and the process of development approval further encourages the understanding and application of energy conservation techniques in new developments.

On a whole, the review of experience in energy conservation through land-use planning in selected North American cities is encouraging in that some communities have addressed the issue and are adopting relevant policies and actions. Whether they will remain to be isolated examples of energy-sensitive communities or attract others to follow suit has yet to be determined.

Chapter VI

ENERGY-EFFICIENT LAND-USE PLANNING IN PRAIRIE CITIES

6.1 INTRODUCTION

The recapitulation in the preceding chapter of actual examples of energy-efficient land-use planning in selected North American cities is rather encouraging; especially because positive steps have been undertaken by some municipalities to integrate energy considerations into the land-use planning process. Nevertheless, as this chapter begins to assess the relative efforts of the five Prairie cities in the area of energy-conscious planning, the reader will soon realize that this promising sign is not ubiquitous. It is, therefore, interesting to consider why some cities have perceived the potential benefits of energy-efficient land-use planning and have positively pursued them, whereas in other areas, such as the studied cities, the energy issue is hardly recognized, or is afforded very low priority.

To explain this marked differences, responses to the questionnaire survey will be thoroughly analyzed both to assess the extent to which the studied cities have integrated energy considerations into the land-use planning process and to identify major perceived barriers to such integration. To further aid the analysis, this chapter will endeavor to point out certain variables which may be important preconditions associated with successful community energy conservation by examining the factors behind the success of some of the previously cited North American cities in their city-wide energy conservation efforts. Before proceeding further, however, an epitome of the present practice of energy-efficient land-use planning in the studied cities is provided in the following section.[19]

6.2 ENERGY CONSERVATION STRATEGIES ADOPTED BY THE STUDIED CITIES

In drawing on the wider North American experience in municipal energy conservation management, a set of commonly adopted conservation measures has been outlined. This ,in turn, will be used to assess energy conservation efforts in the five Prairie Cities (see Table 8).

[19] In helping planning agencies to fully appreciate the urban residential energy use in selected Canadian prairie cities (Edmonton, Saskatoon, and Winnipeg), a recent dissertation (Regenstreif 1987) has been prepared to show a method of organizing, processing and modelling data for that purpose. One of its objectives is to consider urban residential energy policies which can help to achieve a balance between energy production and useful urban consumption and, as a consequence, can result in increased urban energy system efficiency. Factors such as housing mix, dwelling age and condition, residential density, travel distance, and climate have been considered in the analysis.

TABLE 8

Energy Conservation Strategies Adopted By Prairie Cities

Strategies \ Cities	Winnipeg	Regina	Saskatoon	Edmonton	Calgary
High density development	●	●	●	●	●
Mixed use development	●	●		●	●
Development along transit corridors	●	●		●	●
Promoting public transit	●	●	●	●	●
Infill	●	●		●	●
Redevelopment	●	●		●	●
Encouraging bicycle path	●	●		●	●
Subdivision design	●	●	○	●	
Energy profile					
Development plan		○	●	●	
Zoning by-laws				●	
Development approval				●	
District heating			●	●	

● Adopted ○ Under consideration

When looking at the table, two issues can be raised regarding energy conservation efforts of the studied cities. Firstly, some noticeable weaknesses are recorded in areas such as the formulation of comprehensive energy development plans and policy statements, zoning by-laws, codes, development approval process, and energy profile compilation, all of which have been shown by previously cited North American cities to be rudimentary measures for accomplishing successful energy-efficient land-use planning. In view of this, one question arises as to what would be some of the predominant barriers to the integration of energy considerations into the planning process in the Prairie Cities.

Secondly, the five studied cities appear to perform satisfactorily in taking up some energy conservation measures such as encouraging and promoting high density and mixed use development along transit corridors, public transit, bicycle path, infill and redevelopment. And yet, energy considerations in these cities still receive a relatively low profile in the day-to-day planning, for the efficient use of energy resources has not been accepted as a legitimate goal of land use planning.

This seemingly conflicting situation gives rise to another question: if selected conservation measures were adopted by respective planning authorities, on what grounds were they justified? In other words, were they drafted with or without the notion of energy conservation in mind (e.g. promotion of public transit can be justified on grounds of equity)? These are the questions which will be discussed in the remainder of this chapter.

6.3 QUESTIONNAIRE RESULTS

The survey of five planning authorities in the Prairie region was conducted in the summer of 1988. In the survey, seven fairly straightforward questions were asked concerning the extent to which energy issues had been pondered over during the preparation of the city development plans or general municipal plans.[20] All questionnaire survey forms were mailed initially to planning directors, who, in turn, dispatched the forms to those planners who have adequate knowledge in answering the questions. Generally speaking, although not all planning authorities had dealt explicitly with energy issues, most made an appreciated attempt to answer the questions.

Responses to questions 1 to 4, which concern energy considerations, are displayed in Table 9 and Table 10. Table 11 provides some of the reasons cited for not giving greater attention to energy considerations in land-use planning.[21]

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[20] See Appendix A for the questionnaire.

[21] All given responses will be analyzed complementarily with existing planning documents.

TABLE 9

Responses To Questions Concerning Energy Considerations

Questions		Winnipeg	Regina	Saskatoon	Edmonton	Calgary
Q 1. Energy efficiency among goals	Y			●	●	
	N		●			●
	I	●				
Q 2. Energy profile information	Y					
	N	●	●	●	●	●
	I					
Q 3. Energy Efficiency criterion for evaluation	Y				●	
	N					
	I	●	●	●		●

Y: YES N: No I: Implicit

TABLE 10

Grounds For Energy Conservation Measures Adopted In Prairie Cities

Strategies \ Cities		Winnipeg	Regina	Saskatoon	Edmonton	Calgary
Higher density zoning	E				X	
	O	X	X	X		X
Mixed use zoning	E				X	
	O	X	X			X
Promotion of public transit	E				X	
	O	X	X	X		X
Setting energy-efficient standards for new developments	E	X	X			
	O					
Requirement of energy impact assessments from developers	E					
	O					
Construction of a district heating system	E			X	X	
	O					
Encouragement of subdivision design	E	X	X	X		
	O					X
Promotion of the use of car pool	E					
	O	X				X
Encouragement of bicycle path	E		X		X	
	O	X				X
Recycling of bottles, cans and paper	E				X	
	O					

E - with energy-efficiency/conservation in mind
O - with other reasons in mind

TABLE 11

Reasons Cited For Not Giving Greater Attention To Energy Issues In Prairie Cities(*)

1. Other issues take precedence

2. Lack of interest in the community

3. Lack of clear direction from senior levels of government

4. Energy Conservation not perceived to be important

5. Conflict with other municipal goals or policies

6. The rigidity of the existing municipal infrastructure, such as roads, sewers, and other utilities

7. Lack of jurisdiction over this issue

8. Lack of resources/information/education

9. Planning staff unfamiliar with the approach

(*) Listed in descreasing order of significance

6.3.1 Energy Considerations In The Plans

Three out of five of the Prairie cities still do not include energy efficiency among the goals and objectives of their development plans (see Table 9). For example, there is no mention, explicitly or implicitly, in the Calgary General Municipal Plan (GMP) of the need to consider energy efficiency and energy conservation; neither are they used as a criterion for the evaluation of alternative policies of city's land uses and development pattern (Calgary City Planning Department 1981). In Regina, since its Development Plan was prepared between 1976 and 1979, it does not contain policies or objectives related to energy efficiency. However, it is encouraging to learn that the City Council is now undertaking revisions to the Plan which do contain such policies and objectives. In aiding the revisions, two recent studies on "Energy Efficient Community Development" had been prepared by the City Planning Department for the Council to explore the opportunities available to improve the energy efficiency of the community, and develop appropriate standards and policies for inclusion in the Development Plan and other relevant by-laws (Regina City Planning Department 1985, 1986). Furthermore, in the area of policy development, the Greater Winnipeg Development Plan concerning Environmental Planning Component (1980) has examined energy impacts on Winnipeg economy.[22] As stated in

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[22] Concern over energy impacts on Winnipeg economy was the result of a study done by the Hildebrant-Young and Associates (1978) for the Department of Environmental

the Plan Winnipeg ...

> more than any other single factor, the energy question may dictate our economic future. Rising prices and possible shortages will retard economic performance and reduce personal disposable income4. In addition, they will most likely alter transportation patterns, the housing market and the future development direction of the city (p.1).

However, Plan Winnipeg does not explicitly propose energy related policies, but rather the concept of energy conservation and energy efficiency is woven through the entire document. For instance, under the section of "Suburban Residential Neighborhood" (Winnipeg Environmental Planning Department 1986), it is stated that:

> within suburban residential neighborhoods that the City shall direct all higher intensity residential development and ancillary land uses to sites adjacent to major traffic arteries or transit corridors as determined by Council. (p.5)

In the survey, only Saskatoon's and Edmonton's planning authorities indicated that they did include energy efficiency and energy conservation explicitly among the goals and objectives of their plans. In general, the Land Use Policy Plan of Saskatoon (Saskatoon City Planning Department 1987) deals with the promotion of orderly, rational and compact development. Specifically, the Plan enunciates "to achieve greater energy conservation and efficiency through appropriate community planning and design" (p.12). However, the author would tend to believe

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Planning. This study examines the possible impact of future energy price increases upon household income, and the implication for urban development.

that this sentence may serve only as a 'lip-service' statement in the Plan; the reason appears inherent in the grounds provided by the City for justifying its decision for adopting certain energy conservation strategies.

Whereas the Edmonton's 1980 General Municipal Plan (Edmonton City Planning Department), in setting the context for its strategy, recognizes the "changing energy situation", that of diminishing fossil fuel resources and rising energy costs. The Plan aims to pursue ...

> actions to develop a more energy-efficient city in concert with energy conservation measures so as to minimize the impact of diminishing fossil fuel resources and rising energy costs on the quality of life in Edmonton (p.13).

Thus, one of the growth strategies listed in the Plan is ...

> to promote energy-efficient design and opportunities for energy conservation in land use and transportation planning, municipal servicing and building design (p.13).

When it comes to the consideration of community energy profile,[23] all planning authorities reported that they do not engage in the gathering of information concerning energy flow in the planning area during survey stage. Virtually, no authorities had collected any information about the energy supply and demand in their communities as a whole.

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[23] An energy profile provides a picture of how energy is used in the community. It includes measures of the various energy sources (natural gas, electricity, gasoline) and the end use of the energy (transportation, industrial, commercial, residential). The profile's intention is to identify those areas where the greatest energy savings can be achieved and consequently, where the focus of attention should be directed. See Pferdehirt (1980) for detailed description.

Without such hard data, the author would argue that municipal officials cannot effectively assess their particular problems and vulnerabilities, pinpoint areas of greatest need and opportunity, set priorities for action, develop feasible solutions, make persuasive arguments to political decision-makers and community interests, and monitor and evaluate progress of their energy programs. In short, the development of an energy profile does provide the opportunity to integrate the proposals for the future physical layout of the community with the proposals for the future energy use pattern in the community.

A similar picture appears in relation to criteria for evaluation of alternative policies. All planning authorities, except that of Edmonton, do not explicitly employ energy efficiency as one of the criteria for evaluation of alternative policies of city's land uses and development pattern (see Table 9). The majority of planning authorities employed criteria which implicitly, if not explicitly, include energy efficiency, such as the travel distances from place of residence to work place, shopping and other major employment areas. In Edmonton, nevertheless, energy efficiency from a transportation perspective (i.e. journey to work and urban density vis-a-vis public transit efficiency and costs of extending roadways) was an explicit factor in evaluating different suburban growth strategies during the City's preparation of its General Municipal Plan in 1979. It is referred in the General Municipal Plan (Edmonton City Planning Department 1980) that one of the benefits of increased density of suburban development is the potential

> to reduce the amount of energy consumed in daily urban travel by generally reducing the distance between places of residence, work and shopping ... Higher densities will also improve the viability of providing public transit service ... Finally, energy savings will be realized through compact development because less extensive utility systems will have to be built and operated (p.9).

A question has been raised previously: on what grounds were those adopted energy conservation measures justified? It is not amazing to find that those cities (i.e. Edmonton) which explicitly include energy-related goals or objectives in their development plans, generally speaking, do adopt measures with energy conservation in mind, whereas those cities (i.e. Calgary, Regina and Winnipeg) which do not explicitly include energy efficiency among the goals or objectives of their plans do sometimes justify adopt strategies on other grounds besides energy conservation (see Table 10). For example, as far as the City of Edmonton is concerned, the purpose of promoting public transport is to curtail energy consumption by discouraging automobile ridership[24] but in Saskatoon and Calgary, the purpose is to

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[24] A recent article argues that the success of public transport service is not simply depended on large subsidies but also an indirect result of a range of complementary "pro-transit public policies" as well (e.g. heavy taxation on automobile use, compact urban development, strict land use controls, etc.). The reader is referred to Puncher (1988) for more information.

attain equity (i.e. all have right to mobility) and a balanced transportation, respectively. Besides promoting public transit, higher density zoning/development and mixed use zoning/development, other main criteria identified for a potentially energy-efficient environment, are often cited in the plans. In Calgary, higher density zoning is seen as a way of reducing infrastructure costs, and mixed use zoning is perceived as a useful implementation tool for increasing residential housing in the downtown area. In Regina, mixed use zoning is treated as one of the means to maintain neighborhood cohesiveness, whereas higher density zoning facilitates the efficient use of land and infrastructure. Moreover, encouraging bicycle path is also cited as an energy conservation measure; but, replies from Winnipeg and Calgary indicate that their primary function is recreational.

In summary, based on the foregoing discussion, it is interesting to notice that the majority of planning authorities have been 'unconsciously energy conscious' by including goals, policies, evaluation criteria, and measures which implicitly promote energy efficiency, but whose main purpose is primarily economic, social or environmental. This is encouraging for it lucidly demonstrates that energy-efficient land-use policies do not necessarily conflict with other municipal goals or objectives.

6.3.2 Perceived Barriers To Energy Considerations In The Plan

In order to identify potential barriers to the incorporation of energy considerations into the planning process, each of the studied cities was given in the survey a list of "forethought barriers" which had been prepared by the author on the basis of the literature review. The respondents were given a list of presently existing barriers to effective energy planning in their municipality, and asked to rank them according the degree of seriousness. The result is summarized in Table 11.

The major barriers to the acceptance of energy-efficient land-use planning are: (1) other issues take precedence; (2) lack of interest in the community; and (3) lack of clear direction from central governments. Of least importance are lack of resources, information and/or education and unfamiliarity with the approach by planner over the issue of energy-efficient land-use planning. Since the least important barriers are generally perceived by the planning authorities as either a minor constraint or not a constraint to the inclusion of energy considerations into the planning process, the discussion that follows will concentrate only on those major barriers. These can be dealt with under two broad headings: guidance from the senior levels of government and perceived significance of energy issues.

6.3.2.1 Guidance From Senior Levels of Government

All planning authorities intimated that, because of the lack of any clear direction from the senior levels of government, especially the provincial government,[25] they are uncertain about the legitimacy of integrating energy considerations into the land use planning process.

Take the provincial governments for example. As already noted, under the BNA Act provinces have the power to control land and land use and over the years they have delegated this legal power to local governments by enacting enabling legislation in the form of Planning Acts. However, the Planning Acts of Alberta, Saskatchewan, and Manitoba do not necessarily preclude the concept of energy conservation or energy efficiency, but nothing contained in them encourages it either. For instance, the

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[25] In Canada, the direct federal role in land-use issues is minimal. This is due to the fact that the powers relative to cities and urban development were delegated to the provinces under the British North American Act (BNA Act) of 1867. The Canadian federal government has not been able to undertake direct intervention in urban development or redevelopment. No direct revenue-sharing can take place without provincial approval, and the provinces tend to discourage city-federal linkages for fear of being by-passed and their role in municipal affairs reduced (Goldbergs and Mercer 1986; Plunkett and Betts 1979). In view of this constitutional constraint, all land-use related matters (e.g. energy-efficient land-use planning) considered to be of a purely local nature are areas of responsibility originally allocated to the provinces. As a result, the author would argue, the Provincial governments of the Prairie region should assume a more greater role to play than the federal in diffusing and promoting the idea of energy-efficient land-use planning at a city level.

Planning And Development Act of Saskatchewan (1984), section 73 states:[26]

> ... a zoning by-law ...contain provisions:
>
> (c) prescribing the uses of lands and buildings and forms of development that may be permitted in the district ...;
>
> (d) prescribing the minimum or maximum area and dimensions of lots ...;
>
> (e) prescribing the percentage area of a lot that a building may occupy and prescribing the size of yards, courts and other open spaces;
>
> (f) regulating the location, height, number of storeys, area, volume or dimensions of any building to be placed, constructed, reconstructed, altered or repaired;
>
> ....
>
> (l) prescribing the permissible density of population in any district of part of a district.

In permitting a discretionary use or a discretionary form of development, the Council may dictate specific development standards pursuant to the Planning Act And Development, section 74(3)(b)(i) and (ii), which states:

> (i) the nature of the proposed site, including its size and shape and the proposed size, shape and arrangement of buildings;
>
> (ii) the accessibility and traffic patterns for persons and vehicles ...

All these enabling clauses seem to appear to give sufficient legal power to allow the planning authorities to practise energy-efficient planning. Nevertheless, since the

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[26] A similar content can also be found in the Planning Act of Alberta (1988), 69(3) and 71(1) and the Planning Act of Manitoba (1987), 43(2).

Acts contain nowhere statements which explicitly encourage the inclusion of energy-conscious policies into the planning process, municipalities do not feel they can include them in the plans.

6.3.2.2 Perceived Significance Of Energy Issues

Continued delays in the introduction of energy considerations into the planning process are attributable to the fact that energy issues, when compared with other issues (i.e. social, economic and environmental), are still perceived to be relatively unimportant by the city officials. It is acknowledged that energy conservation and energy efficiency are essential objectives, but they are not the only ones, nor are they the only objectives relative to land-use planning. The need for economic growth, employment opportunities, community balance, or maintenance of the quality of life seems to be profoundly entrenched in many city officials' minds in the pursuit of their ultimate goal, that is, planning a "better" city for all people. However, as indicated already, energy conservation and energy efficiency are, indeed, compatible with other social, economic or environmental goals. For instance, high density development, one of the main attributes identified for an energy-efficient land-use pattern, is an objective of all plans, but primarily for nonenergy reasons (except the one in the Edmonton's plan). The point here to stress is that energy conservation is not an end in itself but rather a means to other goals. This notion is implicitly expressed by Goode and Sedgwick (1980, p.9):

> clearly, if the economic and social costs of allowing energy considerations to modify other areas of public policy exceed the economic and social benefits, then such modifications should not take place.

In short, all efforts to integrate energy considerations into the planning process should be based on the principle that energy conservation is not an end in itself but a means by which society can continue to operate effectively and efficiently without the social, economic and environmental costs of the abundant use of a scarce resource.

As alluded to earlier, energy prices have declined during the first half of the 1980s, and since then, public interest in energy-efficiency has been subsiding. In places that are secure in short-term energy supplies, the drop of energy prices means the inception of economic recession. This has some bearing to the Province of Alberta where its economy has been intensively depended on energy production. For example, one respondent, a senior planner from Calgary conceded that:

> energy-efficiency is no more a concern today than it was ten years age. Perhaps the heavy reliance of Alberta's (and Calgary's) economy on the energy sector is the key to this situation ... since Alberta's economy depends heavily on energy production, the Provincial government cannot reasonably be expected to promote conservation.

Similarly, the planning officer from Edmonton echoed the same response:

> the major fall in world oil prices and resulting recession in Alberta resulted in other economic issue taking precedence over energy conservation, both from an individual and corporate perspective.

Moreover, attitudinal factors are also a major reason why city officials have not yet made conservation a priority. The political constraint on action is real. For example, a senior planner from Regina replied that many councils resist suggestions for changing conventional planning because of public opposition to higher densities and associated land-use arrangements (B.G. Braitman, personal communication).[27] Undeniably, there is a degree of political risk in altering the traditional agenda.

Another reason for energy conservation through land-use planning is not commonly included as an aim or specific planning issue in the official policy documents is that the scope of land-use planning for influencing energy use is seen as marginal because it is incremental and long-term in implementation. To quote one response (B. Mohr, personal communication):

> some planners feel that there is little point in devoting much attention to energy considerations when only marginal changes can be effected by their policies.

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[27] All informal personal communication were taken place at the Canadian Institute of Planners' National Conference at Winnipeg, July 10-13, 1988.

Planners feel frustrated in evaluating any of the attempts at energy-efficient planning,[28] since substantial changes to spatial structure will not occur for a long time. Especially at a time of relative stagnation in development, in building and in the provision of facilities, there appears little potential for effecting a significant change in travel patterns through the planning and structuring of land use. Owens and Rickaby (1983), for instance, has commented that:

> there is considerable inertia in the built environment, exacerbated in periods of slow economic growth and change. When marginal adjustments do take place, there is inevitably pressure for them to conform with and reinforce existing land-use/activity patterns (p.154).

There would clearly be no dramatic short-term feedback, and so no urgency for initiating change foreseen. However, it is the author's opinion that the word "long-term" does not mean suitable only for future policy; it also means suitable for long-term action, or needing a very long time before the effects are felt. Thus, it is all the more important for such action to begin soon rather than in the future.[29]

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[28] Perhaps except at the very small scale, where the energy usage (i.e. fuel consumption) of individual houses can be evaluated and monitored.

[29] An example of the impact of gradual long-term action can, in fact, be seen in the effects of past policies and attitudes of the United States, and, to a lesser extent, of Canada, on residential and industrial development, on catering for personal motorized mobility, on meeting transport demand, and on seeing increases in travel as social benefits rather than also as costs. It has been seen that such policies and attitudes led to rising

In summary, the lack of clear direction from senior levels of government and the relatively unimportant perception of energy issues have been identified as the major barriers to energy considerations in the plans. There is no concrete statement, whatsoever, elicited from either the federal or provincial governments vis-a-vis the bolstering of energy-efficient land-use planning at the city level. Despite this fact, energy issues have often been excluded in that they were regarded insignificant by the city planning authorities, who have always viewed energy-related goals or policies as being subordinated to other goals and, to some extent, jeopardized the city's (provincial) economy. In addition, public opposition to the implications of energy-efficient land-use (i.e. higher densities) and the incremental nature of new development were other cited hindrances to the integration of energy considerations into the land-use planning process.

To further aid the foregoing analysis, the following section will present some variables or factors which have contributed to the successful formulation, adoption and implementation of energy-related planning policies in some North American cities. Concern over these variables is crucial if the practice of energy-efficient land-use planning is to be fostered effectively at the city level in

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energy consumption in personal travel in the 1960s and the early 1970s. For a quick overview of some of these policies and attitudes, the reader is referred to Robinson (1986).

the Prairie region.

6.4 VARIABLES ASSOCIATED WITH SUCCESSFUL COMMUNITY ENERGY CONSERVATION

Although communities have had over a decade to respond to the energy crisis, only a relative few have managed to organize city-wide conservation efforts effectively. An analysis of selected North American cities in chapter 5 indicates that the presence of certain variables may be important preconditions associated with their successful community energy conservation. These variables (see Table 12), to some extent, may contribute to the better understanding of the reason why energy considerations have received little attention in the planning process in the five Prairie Cities. Expanded examples are given below of how these variables operating in conjunction have acted as a catalyst to city-wide energy conservation.

TABLE 12

Variables Associated With Successful City-Wide Energy Conservation For Selected American Cities

City	Perceived Crisis	Community Values	Receptive Policical Representation	Community Participation	Resources
Davis, Ca.(a)	Out of control growth	Protection of farmland, preservation of small town values	City Council	Multiple citizens' committee	$86,000 federal grant, UC Davis Consultants
Portland, Or.(b)	Shortages of both natural gas and hydroelectricity and impact of Arab oil embargo	Preserving coastal environment and agricultural lands	Mayor and city officials	Energy Policy Steering Committee	$224,355 federal grant
Seattle, Wa.(c)	Impact of proposed nuclear power plants	Preserving agricultural lands	Mayor, city and county councils	Citizens' committees, Seattle 2000 Commission	$30 million county bond issue
Lincoln, Neb.(c)	Urban sprawl impact of Arab oil embargo	Protecting surrounding rural areas	Mayor and city officials	Neighborhood Associations, Goals and Policies Committee	
Boulder, Co.(d)	Unchecked city growth	Preserving critical natural areas and open space	city officials		$242,000 federal grant, continuing funding of $36,000/yr.

Sources: (a) McGregor 1984; (b) Sewell and Foster 1980b; (c) Ridgeway and Projansky; (d) Lang and Armour 1982.

6.4.1 <u>Perceived Crisis</u>

First, communities are motivated to effect change when their members perceive a crisis or an imminent threat of sufficient magnitude to challenge the communities' values. For instance, a study compared attitudes about the perceived seriousness of the energy problem in a city with community-wide conservation programs (Davis, California) and a nearby comparable city (Woodland, California) that did not emphasize energy conservation (Scheffler et al 1979). Davis residents, consistent with the community's response, believed there was a more serious energy problem than Woodland residents.

Furthermore, it is argued that a belief in the seriousness of the energy crisis or desirability of energy conservation practices may not be enough to result in increased conservation behaviors (Anderson and Lipsey 1978). Apparently, it takes a perception that the energy problem has direct personal consequences to stimulate conserving actions (Hass and Bagley 1975). In their research, Kahneman and Tversky (1979) conclude that people are more motivated to take action if it will avoid a loss than if it will achieve an equivalent gain.

6.4.2 <u>Community Values</u>

Second, successful community conservation usually occurs where there are cohesive community values related to the perceived crisis (Anderson and Lipsey 1978). this may mitigate the resistance of oppositions from the community as a whole as well as increase collective participation. For instance, the value espoused by the City of Lincoln, Nebraska, was primarily to protect existing rural areas from urban sprawl through planned development. As the City felt the negative influence of the Arab oil embargo during 1973 and 1974, citizen attitudes toward future transportation plans and energy conservation had experienced considerable change. As a result, energy turned out to be a strategic issue on the City political agenda, with strong public acceptance and relatively little opposition (Sewell and Foster 1980b).

Winett, a noted psychologist in the United States, supports the notion that community values are related to community conservation. In his article (1976), Winett reports on his futile attempts to obtain funding for a research program that used incentives to promote residential energy conservation. One of the major reasons cited for his failure to obtain local funding was the heavy dependence of the community's (Lexington, Kentucky) economy on energy production. This might create a community value structure that is indifferent to energy conservation proposals (this has been shown to be true in the Province of Alberta, especially the City of Calgary).

6.4.3 Receptive Political Representation

Third, receptive political representation is obviously an indispensable factor in implementing community conservation. The case of Seattle, Washington epitomizes the political role. The City Council, which oversees the city-owned electric utility, requested as option agreement with the Washington Public Power System (WPPS) to participate in the building of three nuclear power plants. An environmentally minded Citizens' Committee persuaded the City Council to let it first prepare an environmental impact study before the option was finalized. The report of the Citizens' Committee recommended a solution to future electrical demand that favored conservation. This conflicted with the new power plant approach favored by the utility. The City Council was swayed by the Citizens' Committee approach and then went on to use its political clout to turn the City of Seattle away from nuclear power and toward a comprehensive energy conservation policy. The result of this policy turned out to be doubly impressive in light of the eventual financial collapse of WPPS (Ridgeway and Projansky, undated).

Furthermore, the outstanding leadership role assumed by the city mayor of Portland, Oregon to advocate energy conservation is another example of receptive political representation. It was for his discerning vision of energy curtailment and the relentless efforts in lobbying the federal government that the City of Portland was finally designated to be used as a model to demonstrate how a community could identify and assess alternative strategies for energy conservation. As a result, despite some vigorous oppositions, a comprehensive land-use and energy conservation plan was formulated, and many of its energy conservation measures have been adopted (Sewell and Foster 1980b).

Again, Lee (1981) believes that, because officials face re-election every few years, most have a strong aversion to risk limited city resources on nontraditional programs like energy management. What differentiates cities with successful conservation programs like Seattle, San Diego, Portland, Davis and so on from other cities is their visionary senior elected officials willing to risk reallocating substantial resources into conservation efforts or to assure a degree of political risk in altering the traditional agenda.

6.4.4 Community Participation

Fourth, the participation of community groups seems to be an important component in municipal energy conservation. For example, in Portland, Oregon, 15 citizens were appointed to serve on the Energy Policy Steering Committee and 60 others to participate in technical advisory task force (Sewell and Foster 1980b); in Seattle, Washington, representatives from different organizations, who would question, voice opinions, listen and cooperate well with other members, were nominated to join the citizens' committees (Ridgeway and Projansky, undated); and, in Lincoln, Nebraska, a citizens' committee of 450 people was established (known as the Goals and Policies Committee) to formulate goals and policies to guide the planning of the metropolitan area (Sewell and Foster 1980b).

These cited examples of effective citizen participation help to produce better energy policies and increase significantly the chances of successfully implementing them in their respective jurisdictions. In short, a bottom-up (community involvement) approach to policy formulation is far better than a top-down (government control) approach in reducing citizen resistance (Howl 1985).

6.4.5 Resources

Fifth, it is unequivocal that a community requires the resources necessary to implement its conservation programs. The primary resource is usually grant money, as in the cases cited. For instance, in the early 1970s the City Council of Davis California adopted a new General Plan with a heavy emphasis on resource conservation (McGregor 1984). However, the plan could not be successful implemented until the necessary technical program backup work was financed. An $86,000 grant from the United States Department of Housing Community Development Innovative Grants Program made it possible to begin Implementation of the new Davis General Plan. In much the same way, Boulder, Colorado was offered $242,000 grant by the United States Comprehensive Community Energy Management Program for two years (completed in 1981) as well as $36,000 per year from then on to implement a comprehensive energy land-use plan (Lang and Armour 1982).

In summary, the potential for success in city-wide energy conservation efforts can be affected by various variables --- whether there is a significant environmental crisis to spur the community into action, how cohesive the community values are in relation to the perceived crisis, the receptiveness of political leaders to environmental change, how much input the community has had in the decision-making process and what resources are available to implement city-wide conservation.

Unfortunately, all these variables which have been identified as critical in determining the chances of successfully implementing community conservation programs have shown to be relatively lacking in the conservation efforts exerted by the five Prairie Cities. As a result, an important public policy implication is that the studied cities should be familiar with current evaluation findings and incorporate those variables associated with successful conservation into their programs. Public policy and planning implications of all the findings contained in this study will be explored in the coming up chapter.

Chapter VII

SUMMARY AND CONCLUDING COMMENTS

The following section summarizes the major findings pertaining to the context of energy-efficient land-use planning and its present practice in the Prairie Cities.

7.1 SUMMARY

- The nature of energy problems can never be solved without the understanding of the relationships among energy, economy and environment.
- The need for energy-efficient land-use planning is based on three salient facts:
  - the use of energy affects and is affected by the spatial structure of the city. The availability and use of different forms of energy have always exerted a tremendous influence on the location, shape, size and density of the spatial structure of society. Once constructed, the built environment and land-use patterns determine the level and pattern of energy demand and the feasible aspect of future alternative supply and distribution systems.
  - the inflexibility of land-use patterns locks people into an energy-intensive lifestyle without any choice.

  - energy conservation through land-use planning is a tradition in city design; its inception can be traced back to more than two thousand years ago.

- The main characteristics of an energy-efficient land-use pattern include compactness and integration of land uses with clustering of trip ends. More compact developments can be encouraged by increasing the overall density of the community, encouraging infilling and redevelopment, minimizing urban sprawl and encouraging large-scale integrated development. Vehicle trips can also be minimized by location interrelated land uses in close proximity, concentrating development in nodes and along transit corridors, and encouraging greater mix of land uses. All these principles are intricately interrelated.

- The review of experience in energy conservation through land-use planning in selected North American cities is encouraging in that major principles and measures of energy-efficient land-use planning which have been theoretically identified during the literature review are currently being adopted. This means that the gap between theoretical possibility and practical reality in the area of energy-conscious planning at a city level is starting to narrow.

- The review of experience in energy-efficient land-use planning in the five Prairie Cities discloses several facts:

- the studied cities show some noticeable weaknessess in areas such as the formulation of comprehensive energy-related goals or policies, zoning by-laws, codes, and other development controls, development approval process, and energy profile compilation.
- the majority of planning authorities of the studied cities have been 'unconsciously energy conscious' by including goals, policies, evaluation criteria and measures which implicitly promote energy efficiency, but whose main purpose is primarily economic, social or environmental.
- the lack of clear direction from senior levels of government and the relatively unimportant perception of energy issues have been pinpointed as the major barriers to the integration of energy considerations into the land-use planning process.
- the potential for success in city-wide energy conservation efforts can be affected by various variables --- whether there is a significant environmental crisis to spur the community into action, how cohesive the community values are in relation to the perceived crisis, the receptiveness of political leaders to environmental change, how much input the community has had in the decision-making process and what resources are available to implement city-wide conservation. All these have been shown to be relatively lacking in the conservation efforts of the studied cities.

7.2 CONCLUDING COMMENTS

7.2.1 Actions For Planners: Some Recommendations

As alluded to earlier, the implementation of energy conservation through land-use planning is not without hardship. The indifferent attitude of city officials towards energy considerations has often discouraged many practising planners and led them to believe that virtually they have no significant role to play in the area of energy-efficient land-use planning. Wright (1979) sums up this view when he claims that planners

> will have a minor interest in changes of appearance to buildings from conservation measures and in changes to the transportation system, (but can see) ... no key role for planners in energy conservation (p.6).

Despite the fact that planners will not precisely know the future values of the variables, whether spatial or non-spatial, which influence the relative performance of land-use patterns in energy efficiency, they need not be hindered by the seemingly limited potential to create an energy-efficient environment.

The author would argue that since every decision made by planners influences spatial structure, it is hard to accept, as we now enter an era in which energy is widely expected to become increasingly scarce and expensive, that they should keep on to pay scant attention to the energy implications of their plans and policies. Instead, as contended earlier, planners should aim for flexibility; they should ensure, for instance, that land-use patterns will not desperately lock people into lifestyles of high energy consumption but will provide an alternative, should energy become scarce and expensive.

One question arises as to what planners should/could do to achieve this end. One should know that responsibilities for promoting and managing energy conservation affect many local agencies, not just planning departments: transit, transportation, parks and recreation, hydro, civic properties, police, fire, hospital, waterworks, waste and disposal, for example.[30] By their perspective and institutional role, however, planners are arguably well equipped to take the lead in addressing those responsibilities and to provide necessary coordination among agencies that is needed to develop appropriate responses. Below are a few recommended steps:

- Policy Commitment

  Cities tend to address energy issues only after a 'crisis' arises --- a sudden curtailment in oil supply. To wait for such a crisis, however, risks consequences that may be costly. An essential first step, therefore is to make local elected officials aware that these issues affect every community and to seek their support in identifying what problems might arise locally. Those elected officials should also give strong, visible

[30] These are some of the major 'users' of energy within the civil administration.

support to the local conservation efforts. Taking conservation seriously at the official level demonstrates to the community that it needs to be practised at all levels in the community.

More importantly, support should also be sought from the senior levels of government to review the land use-related legislation and regulations in an attempt to identify areas of needed modifications and enunciate in a clear statement of realistic objectives. Legislative change (e.g. incorporation of energy concerns into the provincial Planning Act) should be made towards the conservation needs of the future. Money, moral and technical supports are needed from the senior levels of government if energy-efficient land-use planning is thought to be successful.

- Public Attitude Re-orientation

The bottom line to legislative change is the educational process necessary to educate the general public on the positive aspects of energy conservation and energy efficiency. If the public perceives a problem then the municipality or any level of government will make the changes necessary and provide the adequate resources to implement these changes. Some vigorous information programmes are needed to persuade people of the desirability and feasibility of a change of direction. Demonstration should be given to people that a conserver society can yield increased personal satisfaction rather than reducing the standard of living. In short, politicians will change legislation when they feel the electorate wants change.

- Policy Review

  There should be a concerted effort to feature how various goals or policies stated in the plans can be linked together in an effort to bolster the concept of energy conservation and energy efficiency. Thus, existing goals or policies related to land use should be under detailed scrutiny in order to understand their energy implications for energy-sensitive environment.

- Energy Information Bank

  What is the energy situation now in the city, and where and how much energy is being used? This inventory of energy usage is essential to planning. Without it, it is difficult to set priorities and develop a program; and, without a clear baseline to compare with, it is hard to measure the success of an energy management program. In any event, financial and logistical assistance should be sought from senior governments in establishing the data base and in its monitoring.

- Citizen Liaison Committee

  The most difficult aspect of energy conservation management is not technical feasibility, but public acceptance. One step toward increased legitimacy is to establish at the outset a citizen involvement committee that includes broad representation of businessess, civic leaders, environmental and other citizen groups, and local government, with staff support by local government. The key purpose of this group is to generate a common understanding of the community's energy situation and a broadened consensus on further steps and priorities. As well, it has been shown that resistance to change is reduced when the community has some control by contributing to the conservation program design: whatever program develops, ot is likely to be more responsive to local needs.

- Contingency Planning

  Finally, a more specialized but essential task is contingency planning to assure that the city is adequately prepared to respond to the uncertain supplies and the fluctuations in prices of energy resources. A well-prepared planner might serve an important coordinating role in promoting study and planning for emergency response.

7.2.2 Conclusions

In conclusion, it would be unfair and wrong to imply that energy considerations are totally being ignored in the development plans. They are mentioned here and there, and as the author has argued, they are even compatible with other identified goals or policies. If these various goals or policies (be it social, economic or environmental) are drawing roughly in the same direction, then coupled with a little more attention to detail concerning the energy issue, policies to attain an energy-efficient environment can be formulated. In fact, this proves that there are number of ways in which energy-sensitive policies may be pursued, whether explicitly or implicitly. Moreover, this also strengthens the view that there are opportunities for energy considerations to feature, and that it is perhaps only a matter of time and collaborative efforts before they permeate more generally into planning policy and analysis at the city level. These efforts will be sharply constrained, however, until much clearer signals come forward from provincial and federal levels concerning the nature and extent of the energy problem as well as the degree of urgency that it deserves.

On a whole, it can be said that the barriers to the implementation of energy-efficient land-use planning in the Prairie cities are not in themselves special nor insurmountable. Virtually, to overcome them does not require much effort. What it takes is the willingness or positive will on the part of city officials to proceed, and, of course, their acceptance of the fact that energy-efficient land-use planning at the city level needs a long time before the associated effects are felt. Afterall, both theoretical findings and practical experience point to the fact that there is little to lose by taking energy considerations as a legitimate concern of land-use planning, and there may be a lot to gain in return.

7.3 AREAS FOR FURTHER RESEARCH

This thesis implicitly serves as a catalyst for a re-evaluation of values which redirects our efforts and our plans from the pursuit of power and prestige (economic ends) to the pursuit of human development (i.e. to provide conditions which enable human beings to lead healthy, happy, and creative lives). In light of the foregoing, certain responsibilities have to be assumed by city planners in bolstering energy conservation and energy efficiency through land-use planning. To this end, this thesis has offered an action plan; however, some areas for research have emerged which are considered to be beneficial in further facilitating planners' role in the area of energy-efficient land-use planning. They are listed as follows:

- to study the impact of changes in spatial patterns resulting from actions concerning energy conservation on lower-income families, who may have less capability to change consuming habits to adjust to energy conservation, land use, and settlement changes.

- to undertake research regarding how political decisions are made vis-a-vis energy usage in the city and their impacts on other decisions (be it economic, social or environmental).

- to establish criteria (i.e. standards), that might be based on unit of some sorts (e.g. energy efficiency per capita or per hectare), which serve as guidelines for city planners to formulate appropriate policies in determining the level of energy use in the city.

- to develop a model which could help to map areas of the city according to relative energy efficiency, so that new developments can be guided to energy-efficient locations.

Appendix A

QUESTIONNAIRE

City: ____________________

Respondent's Position: ____________________________________

1. Do the goals or objectives of the General Municipal Plan include "the efficient use of energy resources" or something similar in relation to land use?

____

____

____

____

____

2. During the planning survey stage, was information gathered concerning patterns of energy demand in the General Municipal Plan area (e.g. proportion of total energy used by industry/transport/ domestic consumers etc., and information about spatial patterns of energy use)? If so, where was the information from and what kind?

____

____

____

____

____

____

3. During evaluation of alternative policies of city's land uses and development pattern, was energy efficiency one of the criteria (e.g., in comparing the transport energy requirements associated with different locations of services)?

____

____

____

____

.../continued

4. Below is a list of strategies which a municipality can adopt to affect energy conservation within its jurisdiction. Please indicate which of these have been adopted by your municipality and if so, on what grounds were they justified (e.g. promotion of public transport can be justified on grounds of equity, for the sake of people without cars)

		Justification
a. ( )	Promotion of public transport	__________
b. ( )	Higher density zoning/development	__________
c. ( )	Mixed use zoning/development	__________
d. ( )	Setting energy efficient standards	__________
e. ( )	Requirement of energy impact assessments from developers	__________
f. ( )	Construction of a district heating system	__________
g. ( )	Encouragement of subdivision design	__________
h. ( )	Promotion of the use of car pool	__________
i. ( )	Encouragement of bicycle paths	__________
j. ( )	Recycling of bottles, cans & paper	__________
k. ( )	Other strategy (please specify)	__________

____

____

.../continued

5. If energy considerations do not receive very much attention in the General Municipal Plan, what would you say are the main reasons for this? Below is a list of possible barriers and please rate each one regarding how serious a barrier you believe it to be at present in your own municipality, using the following scale:

0 Not a barrier
1 A minor barrier
2 A modest barrier
3 A major barrier but solvable
4 A major barrier and not readily solvable

___ a. energy conservation not perceived to be important by local planning authorities and politicians
___ b. lack of clear direction from senior governments
___ c. lack of interest in the community
___ d. planning staff unfamiliar with the approach
___ e. lack of resources/information/education
___ f. other issues take precedence
___ g. lack of jurisdiction over this issue
___ h. the rigidity of the existing municipal infrastructure, such as roads, sewers, and other utilities
___ i. conflict with other municipal goals/objectives
___ j. other (please specify) ______________________________

____

Of the barriers listed above, please indicate with an asterisk (*) the one which you believe is the most significant.

6. If energy-efficient land-use planning is perceived to be an important issue, what role would you think planners should have in the planning process?

____

____

____

____

7. Is there any further information about energy conservation in your municipality which you think it would be useful for me to have?

____

____

____

END

Appendix B

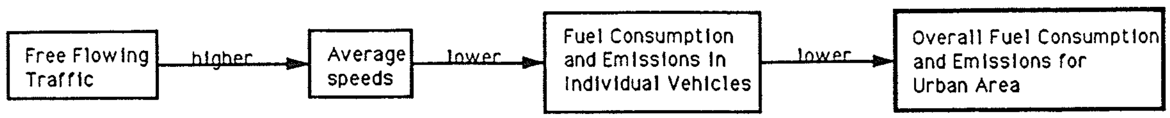
CONTENT ANALYSIS OF RESPONSES TO EXPLORATORY FUTURE SURVEY: TOP 25 RESPONSES

Rank	Subject	Per cent of respondents identifying subject
1	Real price of oil.	46
2	Unemployment.	28
3	Emphasis on environment and conservation of resources	25
4=	State of national economy.	23
4=	Diversity in, and substitution of, transport modes (ranging from low technology modes such as walk/cycle, through individual and mass transit systems to high technology modes such as pipelines/guideways).	23
6	Application of telecommunications technology (e.g. satellite communication) in productive processes and the organization of industry.	21
7=	Substitution of telecommunications for some forms of travel (e.g. shopping-at-a distance via videotex).	19
7=	Level of social disorganization (e.g. crime, violence).	19
9=	Polarization of the population, emergence of 'two nation syndrome', with a wealthy elite minority and an economically disadvantaged majority.	18
9=	Application of computer technology (e.g. micro processors) in productive processes and the organization of industry).	18
9=	Ageing of the population.	18
12=	Size of households.	16
12=	Shift to labour-displacing (rather than labour-complementing) technology.	16
14	Leisure time available to workers.	14
15=	Income differentials between skilled, semi-skilled and unskilled occupations.	12
15=	Real value of wages and salaries.	12
15=	Private vehicle ownership, availability and use.	12
15=	Diversity of life styles.	12
19=	Rate of household formation (net effect of divorce/separation rate, marriage-remarriage rate, youth leaving parental home).	11
19=	Real cost of housing and land.	11
19=	Improved vehicle design (cost, safety, efficiency, emissions).	11
19=	Education level among the population.	11
19=	Changes in structure and operation of firms and their human organization.	11
24=	Level of government spending on urban infrastructure (e.g. roads, utilities).	9
24=	Rate of population growth.	9

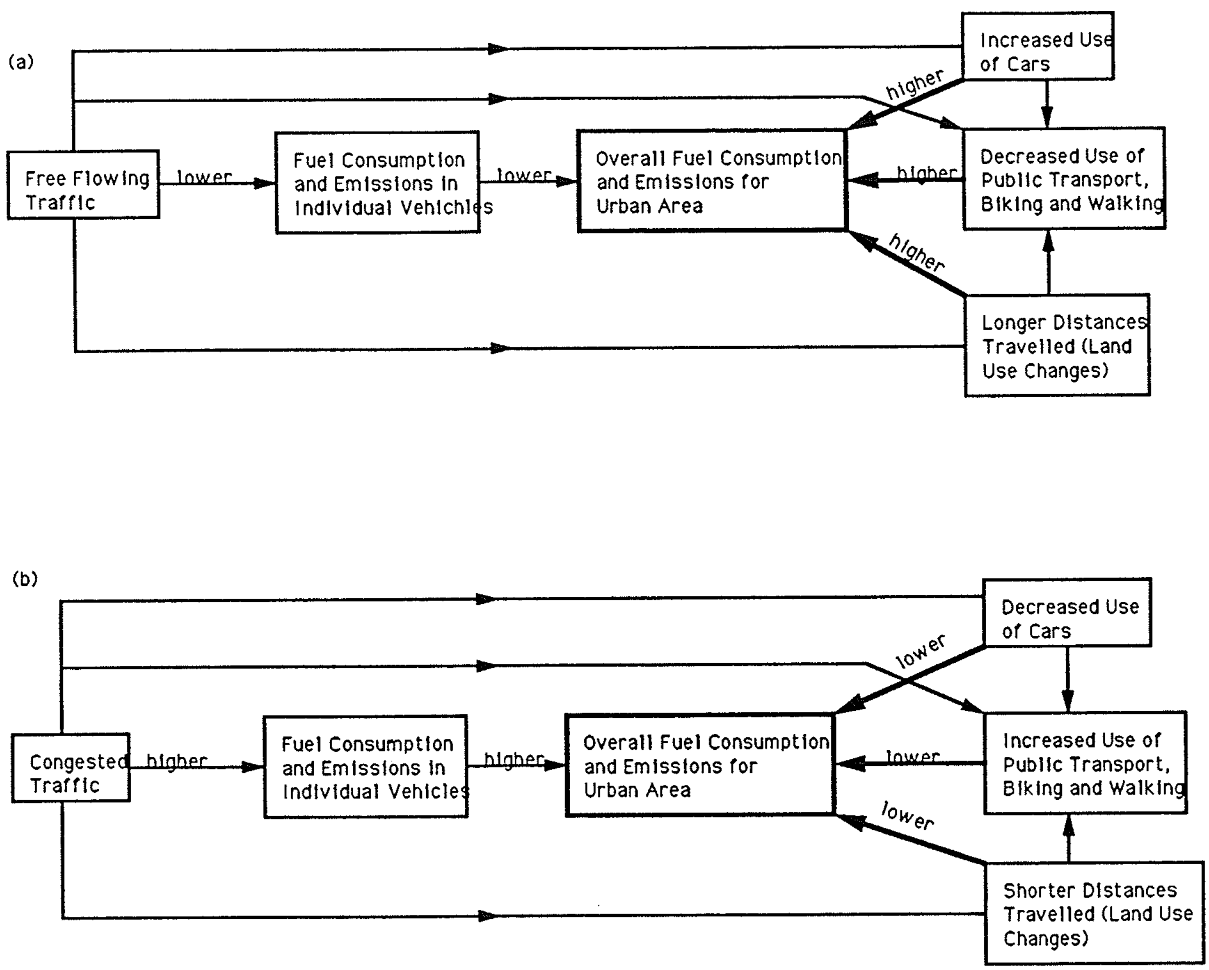
Source: Newton and Taylor 1985, p.319.

Appendix C

CONCEPTUAL MODELS FOR UNDERSTANDING TRANSPORT ENERGY USE IN CITIES



Model 1: Linear Assumptions



Model 2: Feedback Assumptions (a) Freeflowing Traffic, and
(b) Congested Traffic

Source: Newman and Kenworthy 1988, p.164.

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