A SOLAR ENERGY SUBDIVISION:

AN ASSESSMENT OF SELECTED INSTITUTIONAL BARRIERS TO SOLAR ENERGY IN WINNIPEG

By

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ABSTRACT

Solar energy cannot make an impact on energy consumption patterns in Canada until solar homes are available on the general housing market. Most housing is made available through an institutional framework involving the interactions of a private housebuilding industry and public planning and approval mechanisms. The study refers to this institutional framework as a subdivision delivery system.

A hypothetical solar energy subdivision is used to clarify the institutional implications of solar housing for the Winnipeg subdivision delivery system. One suitable subdivision plan is derived and submitted to officials of institutions in the subdivision delivery system. The response of the officials help identify which institutional considerations are likely to be a barrier for solar housing in Winnipeg, and which policy strategies would prove useful in eliminating the barriers.

It is concluded that a solar energy subdivision could be delivered to the housing market through the Winnipeg subdivision delivery system with only minor institutional changes: increased use of the R-PL Planned Residential District zoning bylaw to obtain the required subdivision flexibility; use of sunscape analysis, derived in the study, to determine the scope of solar access needs for each home; greater use of public open spaces to provide solar access protection for homes in the subdivision; and use of restrictive covenants and solar easements to legally guarantee solar access into the future.

It is suggested that the housebuilding industry could reduce risk and possible delays in approval and construction by modifying the existing subdivision delivery system so as to involve various public planning and approval administrators at the initial design stage of the project. It is further suggested that the City of Winnipeg and the local housebuilding industry give consideration to jointly undertaking an educational program to identify and evaluate potential energy-conserving planning and building practices.

It is also argued that a solar-heated home provides social benefits in terms of reduced consumption of conventional fuels. Estimates are made of the magnitude of such benefits, for an individual solar house and for a 72-unit subdivision. The calculations consider: a high cost and low cost version of a solar home; three different time horizons; three scenarios about future energy price increases; and three social discount rates to provide a sensitivity analysis of the calculations. It is concluded that a passive solar home obtaining seventy percent of its annual heating requirements from solar energy, and costing $3,500 more than a comparable conventional house, will yield net present value savings within six years even with conservative assumptions about future energy prices.

ACKNOWLEDGEMENTS

Researching and writing a practicum would be impossible without the kind assistance of many people. I would like to express sincere thanks to my advisory committee for their many useful suggestions, their time and their patience: Prof. Tom Henley, Natural Resource Institute; Mr. Bruce MacLeod, Land Manager, Castlewood Homes Ltd., Mr. Len Vopnfjord, Chief Planner, Department of Environmental Planning, City of Winnipeg; and Prof. John Welch, Faculty of Architecture, University of Manitoba.

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I am indebted to the many individuals who took time away from their work to share their knowledge about solar housing, the housebuilding industry and urban planning. Special acknowledgement must go to Doug Kalcsics and Irwin Torry of the Department of Environmental Planning, City of Winnipeg and to Keith Funk, of Concept Construction in Saskatoon. They provided important data and many helpful suggestions; their enthusiasm and support were a constant source of encouragement.

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All of these people have some rightful claim to whatever value this study may have. I alone am responsible for any of its errors in emphasis, judgement or calculations.

Tom Shillington
Natural Resource Institute
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CHAPTER I

THE PROBLEM AND ITS SETTING

1.1. Introduction

Canadians are building and buying 250,000 dwelling units every year.[1] The natural gas, oil and electricity used to heat the nation's housing account for nearly fifteen percent of annual energy consumption in Canada.[2] As conventional fuel prices increase and uncertainty prevails about future supplies, then many homes will be burdened with heating systems consuming increasing portions of household incomes.

Energy conservation practices and non-conventional home heating systems can decrease the reliance of the housing sector on conventional fuels. Solar energy is one promising non-conventional energy source.

But research must continue to analyse and identify possible solutions to the technical, economic and institutional barriers presented by alternative home heating technologies. It is to the final, and often neglected category of potential institutional barriers that the present study is directed.

Institutions are established organizations, patterns or procedures of decision-making: the private housebuilding industry; the zoning bylaws of a civic government; the lending codes of a bank or mortgage company; the work habits of a construction trade; the attitudes of prospective homebuyers.

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[1]Central Mortgage and Housing Corporation, Canadian Housing Statistics 1977 (CMHC, Ottawa, 1978) p. (viii).

[2]Energy, Mines and Resources, Energy: The Task Ahead (EMR, El 77-1, Ottawa, 1977) p.28, and Energy Conservation in Canada, (EMR, El 77-7, Ottawa, 1977) pp. 16-17.

Solar housing, like all innovations, can be expected to cause changes in the status quo of each institution involved in the housing sector. Anticipating the changes, and examining the probable institutional implications, may suggest policy strategies that will encourage an early and orderly adoption of the solar home heating innovation.

1.2 Problem Statement

Solar energy cannot make a significant impact on energy consumption patterns in Canada until solar housing is available in the general housing market. Solar housing will be delivered to the market through an established institutional framework involving primarily the interactions of the private housebuilding industry, civic governmental departments and financial institutions. The present study will refer to this institutional framework as the subdivision delivery system.

The unique design requirements of solar housing may confront institutional barriers within the subdivision delivery system. The main research problem is to determine the institutional implications of solar home heating for the existing Winnipeg subdivision delivery system. The problem has two components:

i) Can a solar energy subdivision be designed, approved, constructed and marketed within the institutional constraints of the Winnipeg subdivision delivery system? and,

ii) if not, then what institutional changes are required to accommodate solar housing?

1.3 Project Objectives

1. To identify the special requirements of solar housing at the planning, approval, construction and marketing stages of the Winnipeg subdivision delivery system.
2. To identify and assess how the Winnipeg subdivision delivery system would respond to and accommodate a solar energy subdivision.
3. To identify, develop and assess policy options for the private housebuilding industry and civic government in order to resolve conflicts between the requirements of solar housing and the Winnipeg subdivision delivery system.
4. To identify private and social consequences of a solar energy subdivision.
5. To create an increased awareness of solar housing, among members of the Winnipeg housebuilding industry and City of Winnipeg government staff.

1.4 Study Area

Winnipeg is located approximately on latitude 50 degrees North. It has a relatively high degree-day factor of approximately 10,900[1], and enjoys 2,200 hours of sunshine a year.[2]

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[1]A degree-day figure indicates the number of Fahrenheit degree variations below 65 F. of the daily mean outdoor temperature throughout the year; a day that averages 40 F. totals 25 degree-days. Environment Canada publishes climatic data, including degree-day values, for all major Canadian cities.

[2]Central Mortgage and Housing Corporation, The Conservation of Energy in Housing (CMHC, Ottawa, 1977) p. 12.

Figure 1-1 illustrates the physical setting for the hypothetical solar energy subdivision. It is a 14.1-acre site in the southwest area of Winnipeg known as Charleswood. Construction of a conventional subdivision was begun on this site in the spring of 1978.

The institutional setting of the study is restricted to the subdivision delivery system in the city of Winnipeg.

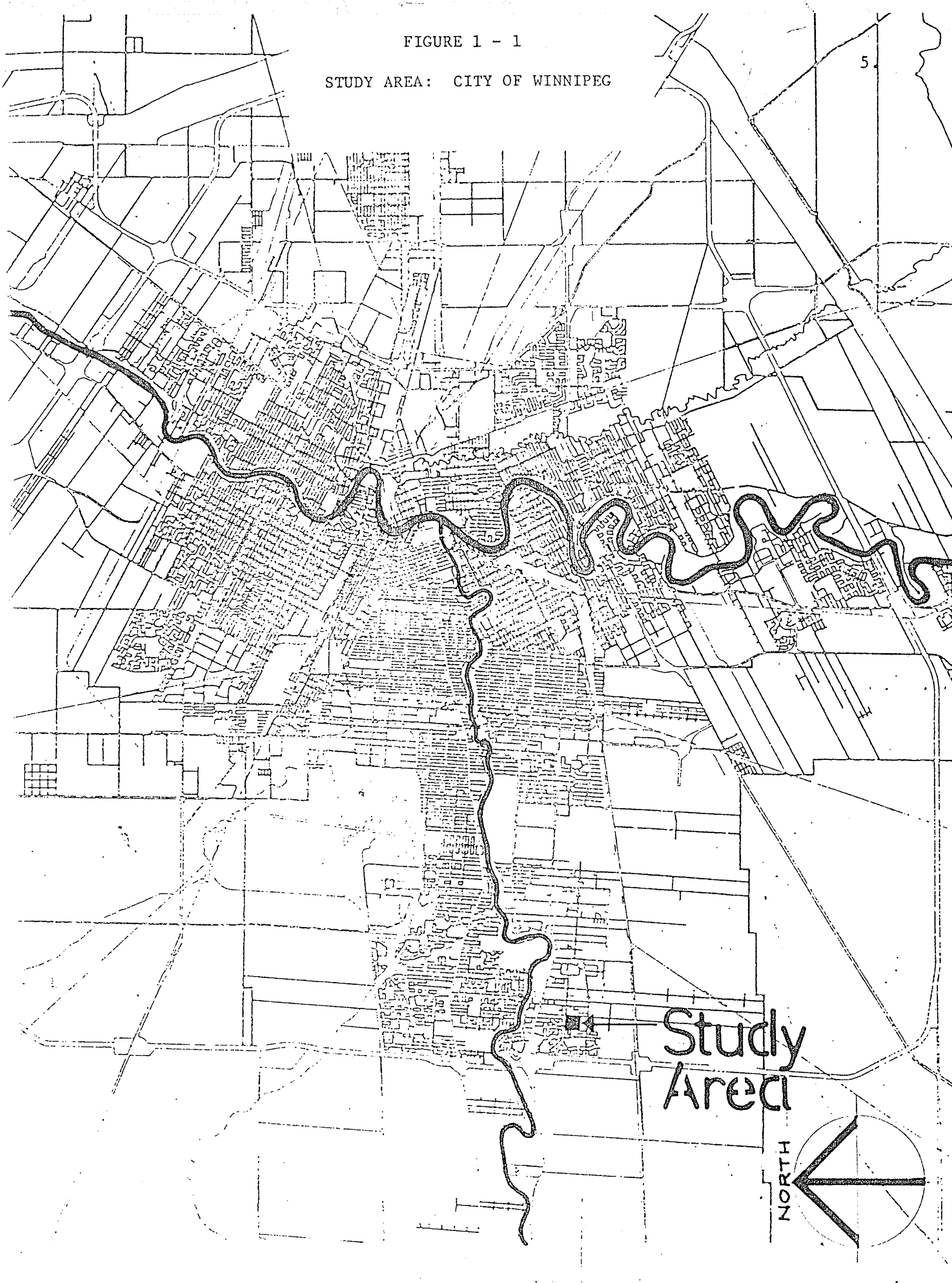
1.5 Definitions

The following definitions of important terms will assist in the understanding of the discussion in subsequent chapters:

1. Active solar heating systems: Mechanical systems designed to collect, store and distribute solar energy; characterized by a fluid mechanically pumped through a solar collector mounted on the wall or roof, and back into a storage tank.
2. Passive solar heating systems: Non-mechanical systems which incorporate certain building design features to collect, store and distribute solar energy; heat is distributed by natural means rather than mechanically.
3. Institutional: Relating to patterns of collective action, decision-making and organization.
4. Subdivision: A clustering of several dozen or more dwelling units planned and constructed as a unit.
5. Subdivision delivery system: An established institutional framework by which most housing in urban areas is designed by the private sector, formally approved by the civic government, constructed and marketed.

FIGURE 1 - 1

STUDY AREA: CITY OF WINNIPEG



6. Solar energy subdivision: A subdivision with the primary design constraint of providing adequate solar exposure[1] for all of its dwelling units.

7. Solar rights: Legalized, enforceable rights of a homeowner to a reasonable proportion of the natural, unobstructed flow of direct solar radiation;[2] also known as sun rights and solar access.

8. Sunscape: The energy-gathering zone of a solar heating system described in terms of distances and angles extending outward and upward from the south wall or solar collector of the home.

1.6 Assumptions:

1. That a market exists for the solar homes built in the solar energy subdivision. Although a recent Canadian study concluded that a market presently exists for cost-competitive solar housing,[3] more research is needed into future market potential.[4]

2. That the solar energy subdivision has received political approval. This is a reasonable assumption because the hypothetical solar subdivision assumed the density, lot size and housing mix of an actual conventional subdivision built on the 14.1-acre site.

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[1]Throughout the study "south exposure" will be substituted freely for "solar exposure". This gives the study a northern hemisphere bias. Designers of solar subdivisions in the southern hemisphere would, of course, be concerned with providing adequate northern exposure for the solar homes.

[2]Based on Ontario Ministry of Energy, Perspectives on Access to Sunlight, (Ontario Ministry of Energy, Toronto, 1978) p.2.

[3]Michael Berkowitz, Implementing Solar Technology in Canada (Energy, Mines and Resources, Ottawa, 1977)

[4]See the recommendations in Section 8.3.

1.7 Limitations of Study

1. The scope of the study is restricted to the Winnipeg subdivision delivery system, and conclusions from the research will not necessarily be applicable to other cities.
2. The study is concerned with development of a hypothetical solar energy subdivision on a specific site in Winnipeg within a given set of actual constraints. No attempt is made to develop an ideal energy-conserving subdivision regardless of actual economic and institutional constraints.[1]
3. The study is not an engineering or architectural examination of solar housing. The concern is with the institutional implications of solar housing designed by engineers and architects.
4. The study does not attempt an economic feasibility study of solar housing.
5. Only selected institutional barriers are examined in the study. Among the barriers not examined are the response of private sector financial institutions and the response of utility companies.

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[1]Such an idealized approach is the subject of a major research project to be undertaken over the winter of 1978-79 funded jointly by the Ontario Ministry of Energy and the Housing and Urban Development Association of Canada; see "Terms of Reference, Building Guide to Energy Efficiency in New Housing", (Ontario Ministry of Energy, Toronto, 1978).

1.8 Methodology

1.8.1 Institutional Assessment

The general approach of the study can be termed an institutional assessment. The institutional framework is the Winnipeg subdivision delivery system. To be assessed are the responses of various institutions within the subdivision delivery system to the introduction of solar housing.

Institutional assessment is similar to technology assessment, a policy analysis tool developed in the United States in the late 1960s out of a recognition that traditional project evaluation methods failed to include the full social and environmental impacts of a project. Institutional assessment can indicate the probable effects of an institutional setting when a new technology is introduced. It has three functions:[1]

i) To describe a likely future of the technology;

ii) To assess the institutional impacts of the described future; and,

iii) To identify key issues and policy options that emerge.

An institutional assessment can be an exercise to help decision-makers consider a possible future and clarify the implications to them of "the desirable, undesirable and uncertain consequences of the technology".[2]

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[1]Based on J. R. Reuyl et al, Solar Energy in America's Future (US ERDA, Washington, 1977 Second Edition) p. (vii).

[2]Stephen G. Burns, "Congress and the Office of Technology Assessment" pp. 1123-1150 in George Washington Law Review, August, 1977, p. 1124.

Increased awareness of the implications may allow decision-makers to make better use of present and future technologies.[1]

There are two general types of institutional assessments: model building and case study.[2] The former develops a model description of the issue, applicable to other settings. The case study considers the problem in a specific institutional setting. The present study combines the two types: a case study is made of the response of the Winnipeg subdivision delivery system to solar housing, and a hypothetical solar energy subdivision is used to describe a likely future of solar home heating.

1.8.2 Organizational Framework

The research was conducted in five stages:

i) Identification of Winnipeg's subdivision delivery system: The delivery system consists of the institutional practices, processes and constraints which govern the design, approval, construction and marketing of subdivision housing. Figure 1-2 illustrates the stages of the subdivision delivery system, and the participation of various institutions at different stages. Figure 1-2 provides an overview of the organizational framework of the study.

ii) Design of a hypothetical solar energy subdivision, called Sunnyvale: in order to provide a more realistic design, Sunnyvale assumed the primary site and economic constraints of an actual conventional subdivision built in the study area in 1978.

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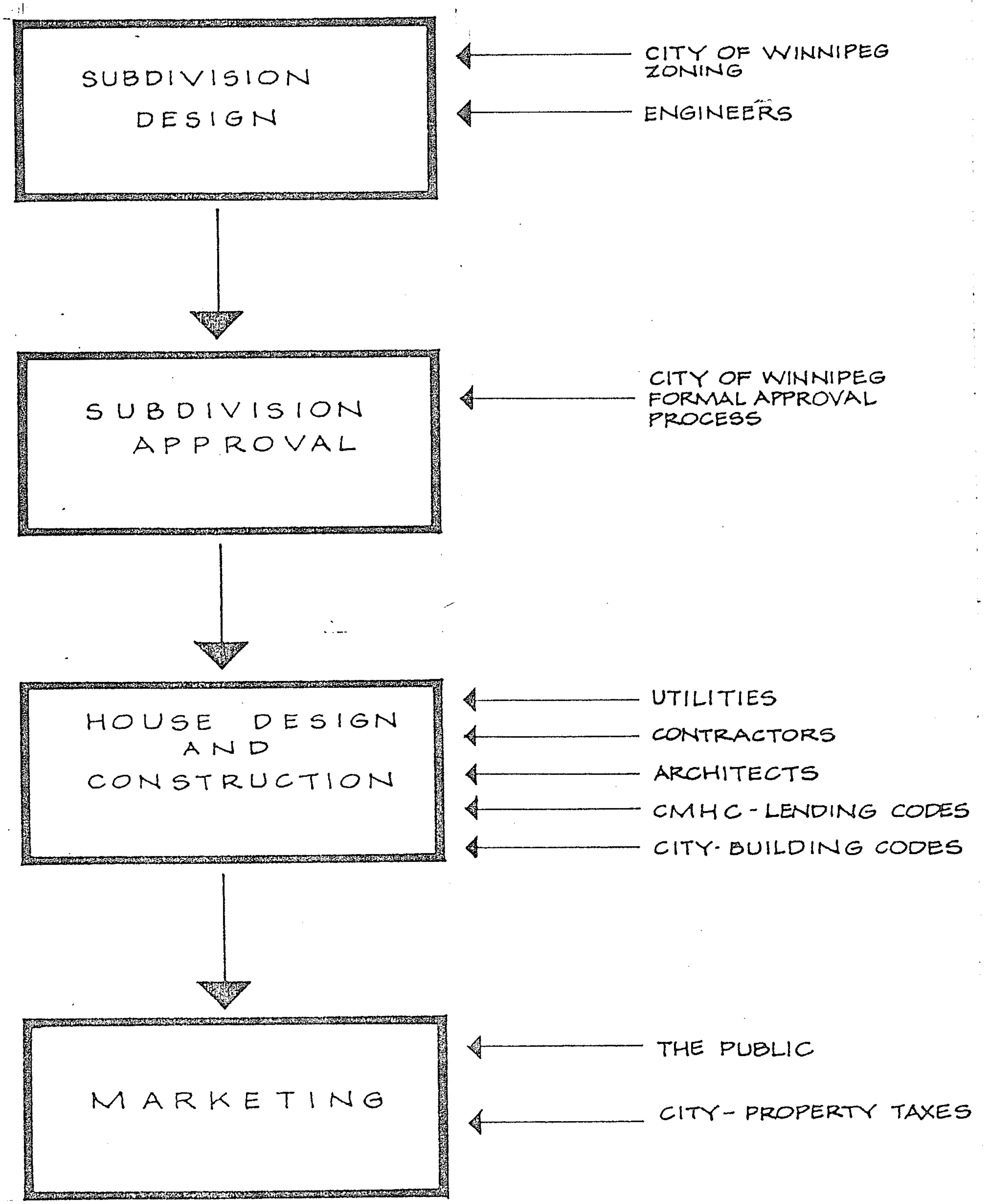
[1]Based on Dieter Schumacher, "Technology Assessment: The State of the Art", pp. 71-89 in Technology Assessment and Quality of Life (SAINT Project, 1976) p. 74.

[2]ibid., p. 78.

FIG. 1-2
SUBDIVISION DELIVERY SYSTEM:
CITY OF WINNIPEG



iii) Determination of the relevant solar energy requirements at each stage of the subdivision delivery system.

iv) Determination of the responses of the various institutions within the subdivision delivery system to the proposed Sunnyvale plan.

v) Development and assessment of policy options for the local housebuilding industry and the City of Winnipeg government for resolving conflicts between requirements of Sunnyvale and the subdivision delivery system.

The sources of information and data were:

i) Government documents;

ii) Personal interviews with private housebuilding company managers, and civic and federal government officials involved in subdivision design, approval and construction;

iii) Personal interviews with designers, architects and engineers who have had practical experience with solar housing in Manitoba, Saskatchewan and Ontario;

iv) Responses from approximately 20 Canadian manufacturers of solar products to requests for information on availability and costs of products; and

v) The literature.

Table 1-1 summarizes the institutional barriers selected for study. Selection was based on specific relevance to the subdivision delivery system. The selected barriers primarily involve interactions between the housebuilding industry and civic government departments, the industry and its contractors, and the industry and Central Mortgage and Housing Corporation.

Following a literature review and a summary of solar home heating principles and designs, subsequent chapters will examine each stage of the subdivision delivery system.

Table 1-1

Selected Institutional Barriers

Stage of Subdivision Delivery System	Selected Institutional Barriers
Subdivision design	Inadequate southern exposure for all lots Zoning bylaws inflexible
Subdivision Approval	Administrative inflexibility to special requirements of solar housing; General conservative attitude towards housing innovations;
Subdivision Construction	Building codes CMHC financing regulations; Lack of labour skills required for solar housing; Inter-union jurisdictional disputes over new work created by solar housing;
Subdivision Marketing	Protection of solar rights; Uncertainty over property tax assessment of solar housing

CHAPTER II

LITERATURE REVIEW

This chapter will briefly review the literature related to institutional barriers and incentives to solar energy utilization. Literature related to the more specific topics of passive solar energy in house design and site planning, and of solar rights protection will be reviewed separately, in Chapters III and VII respectively.

2.1 Institutional Aspects of Solar Energy

In recent years, several authors, including Amory Lovins, Ivan Illich and E.F. Schumacher[1], have argued that all energy technologies have important social and institutional implications. A theme of their work is that energy technologies are not neutral, ready to be used well or badly. Rather, technologies imply certain patterns of action and organization to initiate and sustain them. Lovins categorizes technologies into two broad and inherently conflicting types: "hard path" and "soft path" energy technologies. The former are characterized by: reliance on non-renewable energy sources such as oil and coal; their centralized, capital-intensive production; a rigidity in location or transmission facilities that make them vulnerable to accident or sabotage; and a high degree of adverse environmental impact. Conversely, soft path technologies are used and controlled on a smaller scale. They are characterized by use of renewable

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[1]Amory Lovins, "Energy Strategies: The Road Not Taken? Foreign Affairs (October, 1976) 65-96; Ivan Illich, Energy and Equity (London, Marion Boyars, 1976); E.F. Schumacher, Small is Beautiful (London, Abacus, 1974).

energy flows, relatively simple technologies matched to end-use needs, operated under decentralized control, and with relatively little environmental impact. Among the soft path technologies noted by Lovins is solar energy for space heating purposes. He argues that the "most important, neglected questions of energy strategy are not mainly technical or economic, but rather social and moral".[1] Lovins concludes that society must soon make difficult choices about which energy path to follow:

> "The pattern of commitment of resources and time required for the hard energy path and the pervasive infrastructure which it accretes gradually makes the soft path less and less attainable."[2]

Studies of potential institutional barriers to solar energy do not appear in the literature until 1976, with the publication of a series of papers from the 1976 joint meeting of the Solar Energy Society of Canada and the American Section of the International Solar Energy Society. One volume of the published proceedings contained several important early efforts at identifying social, economic and institutional aspects of solar energy utilization.[3]

Bezdeck and Maycock cite five general problem areas of solar energy utilization: high initial costs; interface with electrical

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[1]Lovins, ibid., p. 95.

[2]ibid., p. 86.

[3]K. W. Boer, ed., Sharing the Sun: Solar Technology in the Seventies 10 vols. (American Section, ISES, Cape Canaveral, Fl, 1976) vol. 9: Socio-Economic and Cultural; see R.H. Bezdeck and Paul D. Maycock, "Incentives and Barriers to the Development of Solar Energy" 65-73; H.D. Foster and W.R.D. Sewell, "Daedalophobia: Diagnosis and Prognosis" 84-89; Robert K. Swartman, "Solar Energy and Urban Settlements" 155-161; A.E. Small et al, "Solar Energy Application Considerations for Housing in Depressed Communities" 137-154; J.F. Blarr Jr. and J. O'Brien, "Some Institutional Problems of Solar Heating" 190-199; H. Lorsch, "Effects of Solar Home Heating on Electrical Utilities" 97-112.

utilities; legal and regulatory; public acceptance; and cultural. The third category, legal and regulatory barriers includes several of the institutional barriers examined in the present study; zoning ordinaces; building codes; and solar access or sun rights. The authors suggest solutions to the institutional barriers may include solar easements, solar zoning and solar land use planning. However, no detailed analysis is provided for the institutional barriers or possible institutional incentives. The authors conclude that institutional concerns over solar energy use are significant and deserve further research:

> "Even if the technological, economic and utility interface problems are solved, the legal barriers in many instances may be of such a nature that they could themselves severely constrain solar energy commercialization."[1]

Foster and Sewell question why less than 20 of the 3.3 million dwelling units built in Canada from 1946 to 1976 utilized solar heating systems. They argue that a series of institutional barriers are a major cause of the low level of solar energy use in Canada: a lack of federal and provincial funding for research and development; hindrance at the local level through "a multiplicity of building codes, regulations and restrictions"[2], and conservative manufacturing and construction industries. The authors conclude that if solar energy is to achieve widespread use in Canada, then it must be made to fit into the present institutional structure which delivers most housing to the national market. The present

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[1]Bezdeck and Maycock, ibid., p. 70.
[2]Foster and Sewell, ibid., p. 84.

study has adopted a similar argument, and called the institutional structure a subdivision delivery system. The Foster and Sewell paper is a useful identification of the potential problems of the subdivision delivery system. A useful next step would be an examination of the problems in the specific context of a real site.

Swartman suggests that "probably the greatest impact of solar energy on the urban settlement" will be the south-facing orientation of large numbers of solar collectors on houses.[1] Solar energy will also require awareness of energy concerns in housing design, and "homeowners will be more sensitive to the buildings between them and the sun."[2] Swartman also suggests that the diffuse nature of solar energy may permit increased decentralization and self-reliance in society:

> "It might encourage a re-introduction of mutual responsibility and cooperation, concepts which were introduced into the earliest villages."[3]

The broad nature of the articles in the 1976 SESCI volume provides a useful background to the attempt of the present study to clarify specific implications for the subdivision delivery system.

The importance of examining institutional barriers to solar energy has also been recognized by the federal government's National Research Council. In a 1977 paper, E.P. Cockshutt, coordinator of Energy Project of the NRC concludes that in addition to technical research, "work needs to proceed on the institutional barriers to solar heating."[4] Cockshutt

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[1]Swartman, ibid., p. 160.
[2]Ibid., p. 161.
[3]Ibid., p. 159.
[4]E.P. Cockshutt, "Solar Energy" (SCITEC Briefing, Renewable Energy Resources, Feb. 15, 1977, 14 pp.).

notes the problems of solar access, taxation policies and consumer protection. He also suggests that "the present (federal) research and development program is clearly not sufficient to elucidate these important non-technical issues."[1]

Recent American publications confirm the importance of the institutional aspects of solar energy use and in particular the role of the subdivision delivery system. A 1976 report prepared for the Department of Housing and Urban Development[2] lists five general constraints to solar energy use: economic; technical; political; institutional; and legal. The latter two are of direct concern to the present study. The report states that with respect to institutional constraints, the decision-makers of major importance are financial institutions, the construction industry and labour unions.[3] The importance of the institutional framework of the subdivision delivery system is specifically noted:

> "The most frequently cited institutional constraint is the nature of the building construction industry and the nature of the decision-making process that takes place within it."[4]

The report cites the fragmented nature of the housebuilding industry, its likely aversion to the high initial capital costs of solar housing and the failure of the industry to consider the marketability aspects of annual fuel savings:

"Design requirements of solar systems and the need to

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[1]Ibid., p. 11.

[2]Residential Solar Heating and Cooling Constraints and Incentives: A Review of the Literature (Prepared by Arthur D. Little Inc. for Division of Energy, Building Technology and Standards, Office of Policy Development and Research, Department of Housing and Urban Development, HUD-PDR-196, December, 1976).

[3]Ibid., p.2.

[4]Ibid., pp2-3.

integrate the systems into existing systems both in design and construction might pose additional difficulties for builders. Finally, the environment within which builders operate is typically viewed in the literature as not being conducive to technological innovation in building construction. This environment is characterized by features such as:

. skilled labour jurisdictional agreements;
. laws and regulations;
. professional practices and relationships; and,
. building department approval processes."[1]

With respect to legal constraints, the HUD report states that local zoning and land use ordinances are a widely recognized constraint because

"...the required location of buildings on lots in order to maximize exposure to the sun would result in patterns of building location that might be inconsistent with either the height, bulk or frontage requirements of local zoning ordinances."[2]

Solar rights, or guaranteed solar access, and a multiplicity of local building codes are also cited under the legal constraint category.

Finally, two recent Canadian studies have played an important role in the formulation of the present study: M.K. Berkowitz, Implementing Solar Technology in Canada and H.D. Foster and W.R.D. Sewell, Solar Home Heating in Canada.[3] Berkowitz attempts to quantify the net benefits to society of a large-scale shift to solar energy utilization. Benefits accrue in two forms; reduced consumption of non-renewable resources; and

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[1] Ibid., p.3.
[2] Ibid.
[3] M.K. Berkowitz, Implementing Solar Technology in Canada: The Costs, Benefits and Role of Government (Ottawa, Energy Mines and Resources, 1977); H.D. Foster and W.R.D. Sewell, Solar Home Heating in Canada, (Ottawa, Dept. of Fisheries and Environment, 1977).

decreased pollution costs. His calculations are possible only with a series of assumptions. Under one set of assumptions, he predicts social benefits of more than $1 billion by 1990.[1] A second contribution by Berkowitz is his survey of 1,200 Canadians. The results suggest a positive attitude among Canadians towards solar energy: 66 percent of the respondents stated they would buy a home partially heated by solar energy if all other costs were equal to a conventional home;[2] 73 percent favoured a government incentive program to encourage utilization of solar energy.[3] Among six possible incentive programs noted in the survey, two were institutional in nature: reduced property taxes for solar homes; and the legal protection of sun rights.

However, two aspects of the Berkowitz study suggest the need for further institutional research. Its estimates of social benefits are too broad in scope to be of significant use to individual role groups within the subdivision delivery system. More detailed analysis, under specific sets of circumstances, is required. Secondly, the discussion of institutional barriers is relatively simplistic. Berkowitz simply recommends that:

> "The government should actively seek to remove all institutional barriers to solar energy implementation."[4]

But the analysis does not describe these institutional barriers. He only adds:

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[1]Berkowitz, ibid., pp. 116-119.
[2]ibid., p. 163.
[3]ibid., p. 172.
[4]ibid., p. 217.

> "There exists an institutional infrastructure within Canada that presents major obstacles to a successful solar energy implementation program. Among these are insurance companies, mortgage companies, utilities and land developers. The barriers presented by these groups can only be overcome by government intervention."[1]

The nature of the government intervention is not specified. Berkowitz concludes on a simplistic and optimistic note: "The institutions presenting barriers must realize their social responsibility and act to eliminate these strawmen."[2]

Foster and Sewell examine the adoption of solar home heating technology as a case study in diffusion of innovation. They cite four key role groups in the process: creators, which include scientists, architects and the building industry; transmitters, which include the media and solar energy groups; influencers, which are politicians, government officials and unions; and adopters, the various segments of the market. The authors have performed a valuable role in drawing attention to the process of innovation adoption, the idea that at each stage of the process, different institutions will face different constraints. In particular, their study emphasizes the role of the housebuilding industry:

> "Dedicated proponents of solar home heating have constructed a small number of unconventional houses, mostly outside the auspices of the normal building industry. If this innovation is to have any significant impact on the use of oil or electricity, the Canadian building industry must become convinced of its potential, and confident that any perceived barriers to its acceptance by the financial institutions and the public will be removed."[3]

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[1]ibid., p. 217.
[2]ibid., p. 220.
[3]Foster and Sewell, Solar Home Heating in Canada, pp. 51-52.

Foster and Sewell note several important institutional barriers to solar energy: inflexible zoning bylaws and building codes; conservative lending policies of financial institutions; uncertainty of future protection of the solar rights of a homeowner; and a lack of solar equipment standards.[1] They conclude that there has been little attention given to these issues in Canada so far, and "it is clear that much more in-depth analysis is required".[2]

Finally, Foster and Sewell make several recommendations which directly relate to the present study:

. The establishment of solar zones in several Canadian cities to act as "catalyst areas where the innovation can be tested on a large enough scale to be generally convincing".[3]

. Federal assistance to local municipalities wishing to encourage solar energy through revision of building codes, protection of sun rights by means of zoning restrictions and property tax rebates;[4]

. Federal encouragement of the construction industry through the establishment of training courses designed to familiarize the industry with solar energy and by means of preferential borrowing rates from Central Mortgage and Housing Corporation.[5]

2.2 Solar Energy Subdivisions

There are only a small number of articles in the literature directly relating to the design or performance of solar energy subdivisions.

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[1]ibid., p. 131.
[2]ibid., p. 132.
[3]ibid., p. 143.
[4]ibid., pp. 153-154
[5]ibid., p. 151.

There is a general recognition that subdivision design must be altered in order to accomodate the needs of solar energy. An Ontario study into solar rights protection, for example, states:

> "Typical suburbs have not been planned with energy criteria in mind. In addition to features which impede conservation, the orientation of the houses varies and many lack suitable southern exposure for the collection of solar energy. In many cases, houses are so placed as to unnecessarily shade their neighbours. However, new subdivisions could be designed to permit sustantial use of solar energy by a large proportion of the homes."[1]

A CMHC publication, The Conservation of Energy in Housing, is more specific:

> "If a large residential development is being planned, buildings on either side of an east-west street may be placed a sufficient distance apart that those on the south side do not obstruct the sun for those on the north, particularly when it is at its maximum height during the heating season. Buildings on north-south streets may be staggered on their respective sites, so that adjacent structures do not fully obstruct the southern horizon."[2]

R. B. Pope and W. P. Schimmel Jr. made an early attempt to calculate the performance of a solar subdivision.[3] They assume a 20-house subdivision, active solar heating and cooling systems, centralized collection and storage of solar energy and cascaded energy which uses exhaust energy from a turbine to provide low quality energy needs, including space heating. The authors conclude that annual fuel savings of 60 to 70 percent are possible, and that the subdivision would be technically and economically feasible by 1990. However, the Pope and Schimmel study is only of limited use to the present study. It assumes centralized, rather than individual unit, collection of solar energy, so that subdivision

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[1]Ontario Ministry of Energy, Perspectives on Access to Sunlight (Toronto, 1978).

[2]CMHC, "The Conservation of Energy in Housing (Ottawa, 1977).

[3]R.B. Pope and W.P. Schimmel Jr., "The Solar Community and the Cascaded Energy Concept applied to a Single House and a Small Subdivision--A Status Report (Albuquerq... N Sandia Laboratories, 1973).

design considerations can be ignored. It assumes active solar systems are used, rather than less expensive passive design techniques which might otherwise make the subdivision feasible sooner than 1990. Finally, the study does not discuss any institutional aspects of the design, construction and marketing of the subdivision.

More ueeful to an examination of a solar subdivision in Winnipeg, are two articles discussing recent developments in Davis, Claifornia.[1]

Hunt and Bainbridge discuss how Davis became the first U.S. city to adopt a comprehensive energy-conserving building code. Davis also adopted solar-use planning policies, and approved a 289-unit, 70-acre solar subdivision. In 1972, a newly-elected Davis city council ordered an energy-use study of the climate and buildings of the city. The study concluded that "simple principles of climatic design were consistently ignored by the local building industry"; existing civic review policies were inadequate; building code changes were required; and neighborhood planning policies would also need revision.[2] A new code was adopted. It provided two alternatives for builders; a set of rules governing construction; and a minimum performance standards approach based on a series of calculations.

The City of Davis also adopted a set of planning policies to complement the new building code. Subdivision design is encouraged to provide maximum southern exposure for all lots. Setback flexibility and minimum lot size policies were introduced to permit proper orientation. Street widths are narrowed and pedestrian and bicycle paths encouraged. Landscaping policies which encourage the shading of streets and parking areas have been adopted.

Hunt and Bainbridge report that in 1978 the new code and planning

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[1]Marshall Hunt and David Bainbridge, "The Davis Experience", Solar Age, May, 1978, 20-23; and Robert DePrato, "The Village", Solar Age, May, 1978, 24-26.

[2]Hunt and Bainbridge, ibid., p. 21.

policies have been in effect for two years and one year respectively. "The majority of builders who opposed it (the code) initially have been convinced that it works and are now strong supporters."[1] Under the new planning policies, more than 90 percent of new lots are oriented for solar use, and street widths have been narrowed to 26 feet from 40 feet. Hunt and Bainbridge conclude that:

> "The energy savings have been even better than expected. Code and related education measures have caused a dramatic change in the trend of energy use in Davis..Most important, however, is the fact that the people of Davis have broken the myth that the energy problem is far beyond our control and can be handled only by far-away men of great power and expertise."[2]

In the second article about Davis, Robert DePrato provides details of the solar subdivision built in Davis, including a sketch of its general design. This sketch is reproduced in Figure 2-1. DePrato makes it clear that the subdivision is not conventional in many respects:

> "Streets are 30 percent narrower than elsewhere in the city; bicycle paths meander through. Drainage is through natural sand gullies rather than standard concrete and pipe systems. Land usually wasted as front yard space is fenced for private use while back yards open to face common gardening areas and green belts...Each cluster of eight houses collectively owns the common-cluster space adjacent to their individual property lines."[3]

Finally, DePrato briefly relates the institutional difficulties experienced by the developer of the subdivision; difficulty in obtaining capital financing; inflexible attitudes of building code inspectors; and union jurisdictional disputes in construction.

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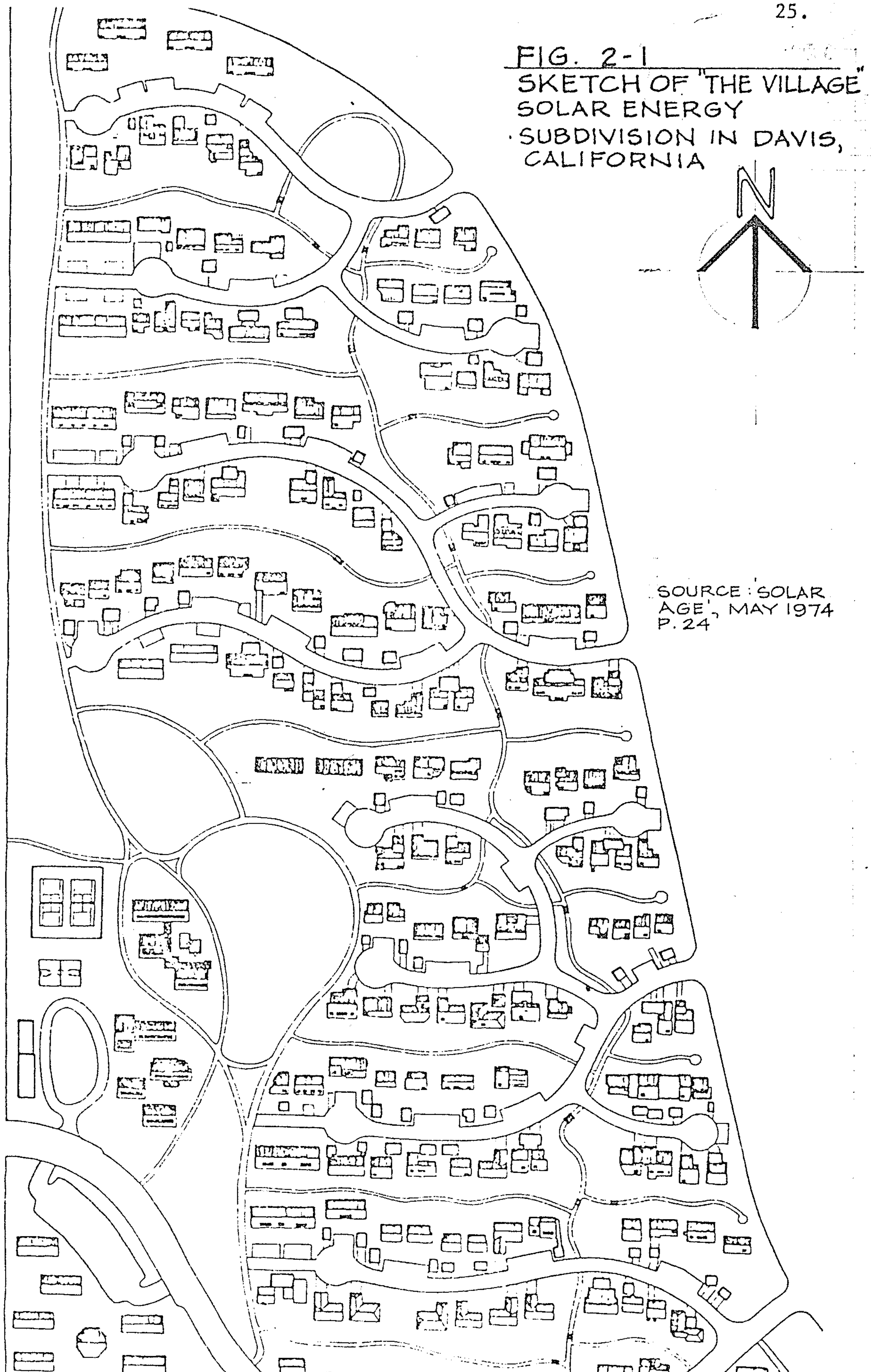
[1]ibid., p. 23.
[2]ibid.
[3]DePrato, ibid., p. 26.

FIG. 2-1
SKETCH OF "THE VILLAGE" SOLAR ENERGY SUBDIVISION IN DAVIS, CALIFORNIA



SOURCE: 'SOLAR AGE', MAY 1974 P. 24

A 1978 publication of the American Urban Land Institute[1] suggests the importance of flexible municipal zoning and planning regulations in accomodating solar energy subdivisions:

> "...the prospect of implementing passive solar design techniques on a large scale has raised two major land-use-related concerns. One is that it will result in rows of structures all facing the same direction with similar or identical roof configurations. The other is that it would require low-density development so that the potential energy savings from high-density development's reduced construction and heating costs and reduced transportation requirments could not be realized."[2]

However, the author argues that the use of performance standards in zoning and planning, rather than reliance on prescriptive regulations, can provide the flexibility to eliminate the concerns:

> "Necessary design flexibility can be provided by the decreased use of traditional lot subdivisions with setbacks and bulk and height restrictions, and the increased use of land use management tools such as planned unit developments coupled with energy performance standards. Proper building orientation and collector location, the protection of solar rights, and other potential constraints have been demonstrated to be surmountable within the context of these more flexible planning techniques...If buildings are designed in relationship to one another rather than relative to fixed lot lines, they can be located in order not to infringe on one another's solar rights..."[3]

2.3 Conclusion

The literature reviewed consistently identifies institutional barriers as an important, and often neglected area of solar energy utilization. In particular, the rôle of the housebuilding industry, and its interactions with various government agencies and departments within

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[1]"Solar Energy and Land Use", Environmental Comment (Urban Land Institute, Washington, D.C.) May, 1978.

[2]Pat Smith, Peter Pollock and Robert Twiss, "Residential Solar Energy Systems: On-Site Versus District", in Environmental Comment, ibid., p.4

[3]ibid.

the subdivision delivery system, are viewed as critical to the successful implementation of solar home heating. Limited experience with and study of solar energy subdivisions suggest that civic planning departments will need to examine present zoning and subdivision planning provisions with a view to providing the required design flexibility.

However, only rarely does the literature consider the institutional implications of a large number of solar homes planned and built as a unit. Furthermore, the generalized nature of most of the literature makes it difficult for groups within the subdivision delivery system to clarify implications of solar housing for actual institutional settings.

CHAPTER III

SOLAR ENERGY: AN OVERVIEW

3.1 The Resource and Technology

Solar energy strikes the earth primarily in the form of light, a short-wave radiation. When the radiation strikes a solid or liquid:

> "...it is absorbed and transformed into heat energy; the material becomes warm and stores the heat, conducts it to surrounding materials (air, water, other solids or liquids), or reradiates it to other materials of lower temperature. This reradiation is a long-wave radiation."[1]

Glass easily transmits short-wave radiation, and therefore allows most of the solar energy to pass through it. However, it is a poor transmitter of long-wave radiation:

> "Once the sun's energy has passed through the glass windows and has been absorbed by some material inside, the heat will not be radiated back outside. Glass therefore acts as a heat trap..this has come to be known..as the 'greenhouse effect'".[2]

The question becomes whether the resource is available in sufficient intensity and amount in Canada to meet a significant degree of the heating needs of a home. The intensity and levels of radiation experienced in a particular locale "depend upon latitude, cloud cover, clearness of atmosphere, degree of obstruction on the horizon, and time of year".[3] The greater the latitude, the lower the position of the sun in the sky during the winter heating season and the less intense the radiation. Local atmosphere conditions can:

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[1]Bruce Anderson, Solar Energy: Fundamentals in Building Design, (New York, McGraw-Hill, 1977) p.4.

[2]ibid., p.5.

[3]Central Mortgage and Housing Corporation, The Conservation of Energy in Housing, (CMHC, Ottawa, 1977) p. 8.

"...significantly influence the potential for solar heat. For a very clear, unpolluted atmosphere, normal radiation values can be increased by about five percent; for urban areas, they should be reduced by ten percent."[1]

The theoretical level of radiation outside the atmosphere of the earth is about 1,400 watts/square meter a year.[2]

"The radiation actually received on a horizontal surface at ground level in most of Canada amounts to about one-tenth of that theoretical value, or 150/watts/square meter. This latter value represents a year-round average -- night and day, overcast and clear; more than ninety percent of the country's population live where the solar radiation is within ten percent of that nominal value."[3]

The average Canadian value compares not unfavourably to a level of 250/watts/square meter a year for the world's sunniest locations of Israel, Northern Africa and Australia.[4]

Figure 3-1 shows the mean annual hours of sunshine received by various regions across Canada. The southern prairies receive the most, more than 2,200 hours a year. The east and west coasts receive the least, less than 1,400 hours in some locations.

Seasonal variations in radiation levels are the most significant technical consideration for solar home heating in Canada. "The problem with using solar energy for space heating is that it is most abundant when it is needed least."[5] The monthly average in June is nearly twice the yearly average; in December, typical values are less than one-third the yearly average.[6] Again, the southern prairies have the sunniest winters in Canada,

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[1]ibid., p. 11.

[2]E.P. Cockshutt, "Solar Energy" (National Research Council Energy Project, February, 1977) p.2.

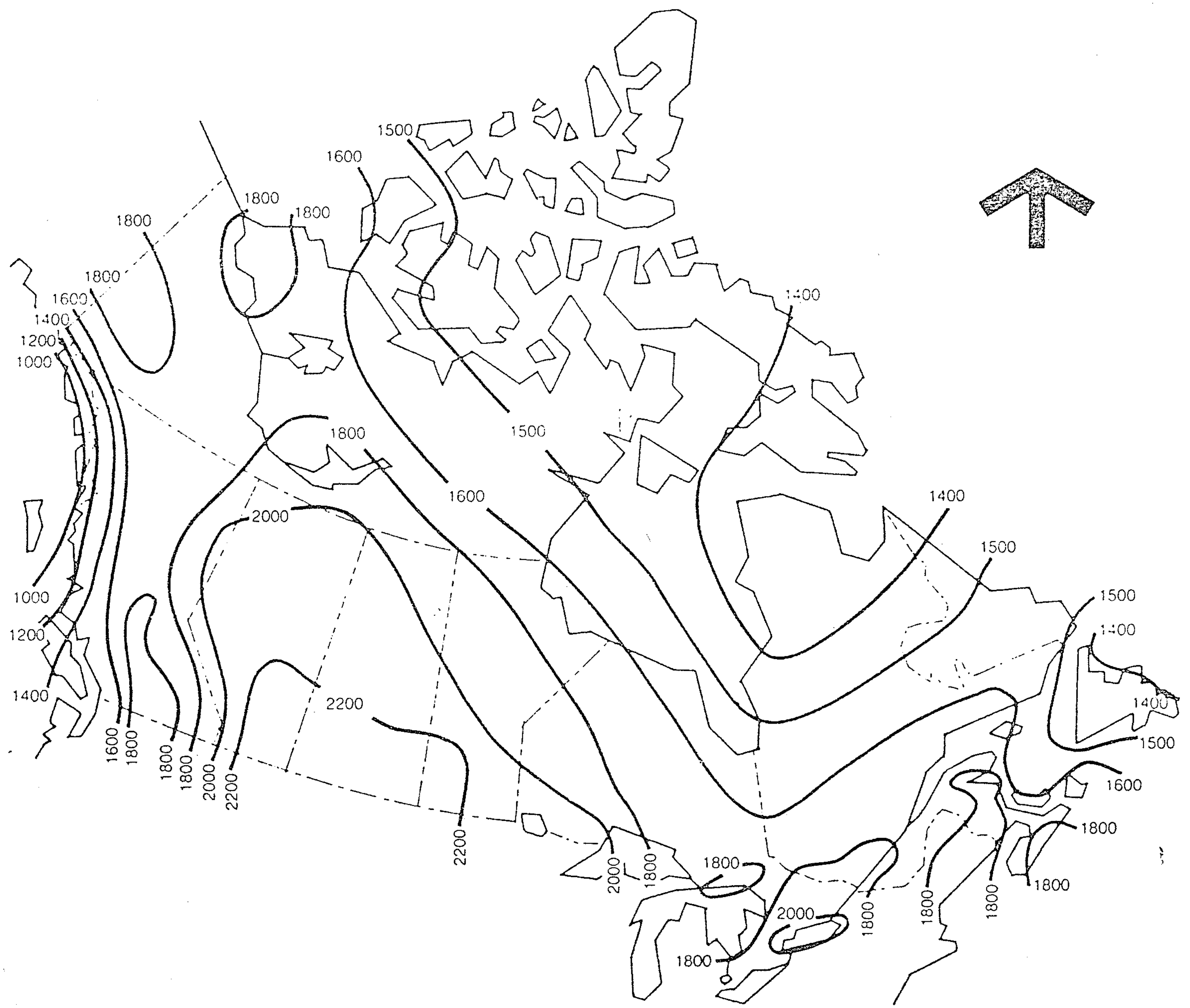
[3]ibid.

[4]ibid.

[5]ibid., p. 3.

[6]ibid.

FIG. 3-1 MEAN ANNUAL HOURS OF SUNSHINE IN CANADA



Source: *Climatological Atlas of Canada* (Ottawa: National Research Council of Canada and Department of Transport, 1953).

Mean annual hours of sunshine in Canada

REPRINTED FROM: THE CONSERVATION OF ENERGY IN HOUSING (CMHC 1977) P.12

and could rely more heavily on solar heating than a costal area such as Vancouver, which receives only fifteen percent of its annual sunshine hours in the winter months.[1]

Solar home heating technology is of two types; active systems and passive systems.

Active solar heating systems are characterized by an assembly of equipment arranged to collect, store and distribute heat from the sun. The transfer fluid, either air or water, which flows through the system is mechanically driven by pumps, or fans, rather than by natural forces. Figure 3-2 illustrates the major components of an active system:

i) Solar collector: a device placed on the south-facing roof or wall of the house to intercept incoming solar radiation and convert it to thermal energy in order to warm a fluid flowing through the system. Collectors are based on the greenhouse effect and are usually either flat-plate or evacuated-tube designs:

> "The flat-plate collector is simply a blackened metallic plate exposed to the sunlight, with integral tubes or other provision for carrying the circulating fluid; to prevent heat loss to the atmosphere, it is generally insulated on the back and double-glazed on the front. The evacuated-tube collector...resembles an oversize fluorescent light tube; it again incorporates a blackened absorbing surface, and it may also incorporate concentrating reflectors; it is sealed to hold a vacuum and thereby minimize heat loss."[2]

The collector area required depends on the size of the space to be heated. An approximate guide is that the collector area should be about one-half the area of the floor space to be heated. Collector efficiencies and costs

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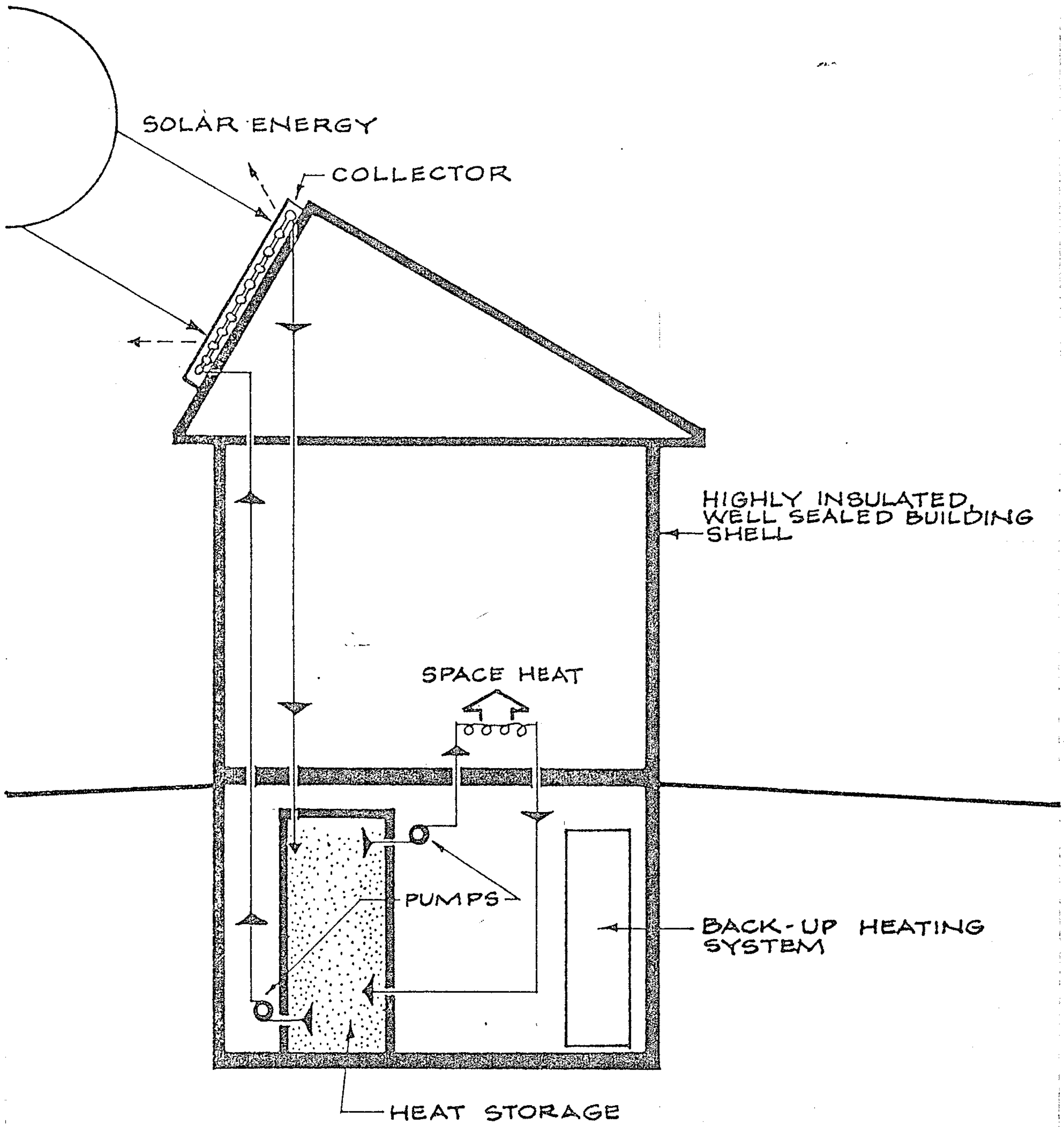
[1]CMHC, ibid., p. 11
[2]Cockshutt, ibid., p. 5.

FIG. 3-2
COMPONENTS OF AN ACTIVE SOLAR HOME HEATING SYSTEM



BASED ON: COCKSHUTT, P.4

vary with the design. Current uninstalled costs for collectors are estimated at about $10 a square foot.[1] One Winnipeg distributor sells a four by six feet flatplate liquid-fluid collector for $365, or about $15.21 a square foot. The distributor recommends ten to twelve collectors for a house, for a total collector cost of $3,650 to $4,380[2] (not installed).

ii) Storage system: Heat from the circulating fluid is stored in a tank, usually in the basement, and used when needed. Storage tanks may be simple: an insulated bed of rocks; or more complex: an insulated water tank. Short-term storage units, enough to cope with three or four consecutive cloudy days, maybe require only a few thousand gallons of liquid capacity. Seasonal storage units would need to be substantially larger.[3] Costs vary from only a few hundred dollars for a simple storage tank to several thousands of dollars.[4]

iii) A conventional heat distribution system of ducts, wiring, and heat exchanger: costs can vary from about $1,000 to more than $3,000, depending on the complexity of the system.[5]

iv) A backup heating system is an essential part of the active system:

> "The target with short-term storage is to meet at least fifty percent of the seasonal heating demand, leaving the rest to be met by fossil fuels or electricity...Long-term storage may be able to approach 100 percent of the seasonal demand, but both meteorological and mechanical exigencies suggest the need for some back-up."[6]

Total costs of an active solar system vary greatly, depending on

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[1]ibid., Berkowitz, ibid., p. 14.

[2]Personal communication, Jim Phimister, Mecanitec Ltd., Winnipeg, July 10, 1978; prices quoted as of July, 1978.

[3]Cockshutt, ibid., p.6.

[4]Berkowitz, ibid., p. 14.

[5]ibid.

[6]Cockshutt, ibid., p. 6.

the technology chosen and labour costs. Recent Canadian studies suggest that system costs vary from $5,000 to $20,000, with about $15,000 being an average figure.[1]

Passive solar heating systems, unlike active systems, are non-mechanical designs which incorporate the design and materials of a structure into an integrated system of solar energy collection, storage and distribution. Heat is distributed by natural means, rather than the mechanically-driven heat distribution of active systems. "The structure is usually shielded from excessive summer heat and winter cold, while capturing and storing solar warmth during the winter."[2] The feasibility of certain passive solar design techniques was known to ancient civilizations. About 400 B.C., the Greek writer Xenophon recorded some of the teachings of Socrates:

> "...Now in houses with a south aspect, the sun's rays penetrate into the porticoes in winter, but in summer the path of the sun is right over our heads and above the roof, so that there is shade. If, then, this is the best arrangement, we should build the south side loftier to get the winter sun and the north side lower to keep out the cold winds."[3]

The present study will assume that the homes in the hypothetical solar energy subdivision incorporate passive solar heating features. The following section examines the designs, costs and performance of passive solar homes being built in Canada.

3.2 Passive Solar Homes

3.2.1. Design Techniques

Figure 3-3 illustrates the three passive solar concepts relevant to

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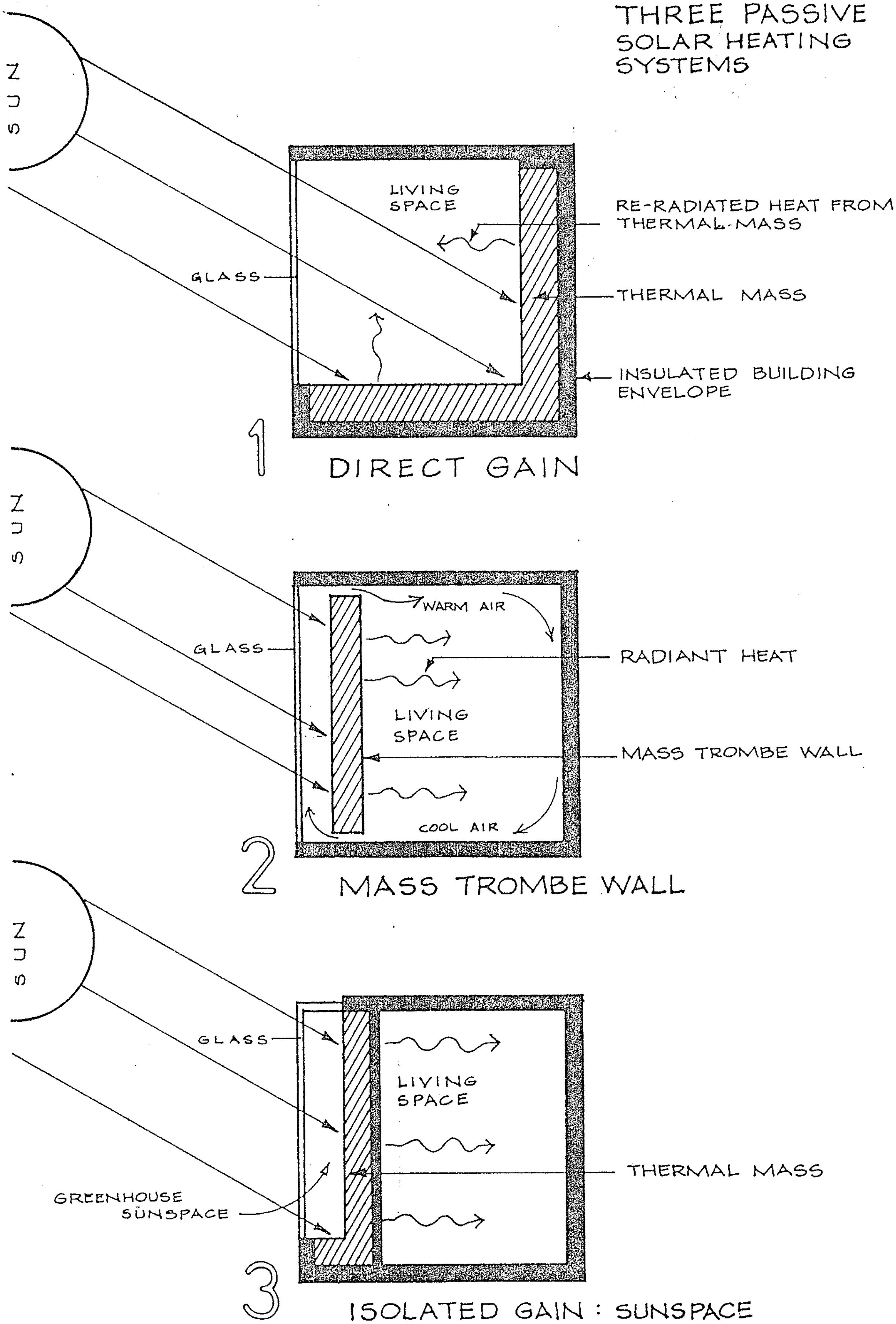
[1]Berkowitz, ibid., pp. 11-14.

[2]Environmental Comment (Urban Land Institute, Washington DC), May, 1978, p.2.

[3]Quoted in Anderson, ibid., p. 3.

FIG. 3-3

THREE PASSIVE SOLAR HEATING SYSTEMS



SOURCE: 'A SURVEY OF PASSIVE SOLAR BUILDINGS (A.I.A. RESEARCH CORP., H.U.D. WASHINGTON D.C. 1978)

Canadian housing.[1]

i) Direct Gain:[2] Direct gain is the most common passive solar design technique.

> "Simply diagrammed as sun to living space to storage mass, the solar radiation is collected in the living space and then stored in a thermal storage mass. Thus, the actual living space is directly heated by the sun and serves as a 'live-in' collector."[3]

The direct gain system requires: a large south-facing glazed area; the living space exposed directly behind the glazed area; thermal storage mass in terms of walls, floors or other structures such as stone fireplaces; and a method of protecting the living space from the exterior climate. "The absence of thermal storage mass in most conventional homes is what eliminates the possibility of storing the heat gained through large expanses of picture windows."[4] Placement of the thermal mass in the living space is important for the proper functioning of the system:

> "Care must be taken with thermal mass to ensure that it is directly irradiated by the sun during the period of interest. In the low sun angles experienced in the winter months, little sun will strike thermal mass in the floor in northern latitudes if the window does not extend almost to the floor."[5]

Storage materials, which reradiate heat to the living space, are usually concrete, brick, sand, ceramics or water.[6]

Two controls must be added to the direct gain system to increase its efficiency. To prevent heat loss through the south-facing glass at night

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[1]Other passive solar design concepts such as roof ponds and water Trombe walls are inappropriate for Canada's severe winter temperatures, and are used in warmer climates of the southwest United States; see AIA Research Corporation, A Survey of Passive Solar Buildings (U.S. Department of Housing and Urban Development, 1978).

[2]Based on ibid., pp. 25-27.

[3]ibid.

[4]ibid.

[5]Robert S. Dumont, et. al., "Passive Solar Heating: Results from Two Saskatchewan Residences", (Saskatoon, 1978) p. 18.

[6]AIA Survey, ibid., p. 26.

(or on cloudy days), the glazed area must be insulated. Several Canadian and American companies market forms of movable insulation panels, curtains and shutters that can cover the glazed area. To prevent unwanted heat gain in summer:

> "...sunshading is required for the large expanse of south facing glass. Due to the high location of the southern summer sun, overhangs can provide adequate protection for vertical southern glazing, but other solutions must be found for..east and west orientations (faced with low sun angles)."[1]

Without the controls designed into the system:

> "...the addition of a passive system with its large glazed exposure to the outside and adjacent masses with great heat storage potential can cause tremendous discomfort due to winter losses and summer overheating..."[2]

Dumont[3] reports that a direct gain solar house in Saskatoon, Sask., experienced a daily temperature fluctuation of about 14 degrees C on a clear winter day before blinds were installed.

ii) Indirect Gain: Mass Trombe Wall[4]

In the indirect gain system, the fabric of the house continues to collect and store incoming solar energy, but the solar radiation does not travel directly to the living space. Instead, "the sun's rays are intercepted directly behind the collector glazing by a massive wall which serves as heat storage."[5] In addition, the Trombe system induces a warm air flow behind the glass. The warm air is discharged upward near the ceiling and is replaced by cooler air flowing across the floor. The concept requires only a large glazed area facing south and a storage mass directly behind it. The

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[1]ibid.
[2]ibid., p. 27.
[3]Dumont, ibid., pp. 9-10.
[4]Based on AIA Survey, ibid., p. 69.
[5]ibid.

Trombe mass wall, named after the French scientist who developed it, can consist of a heavy building material such as concrete, stone, brick, block or sand:

> "The property to consider in deciding on storage construction is the method of distribution inherent in massing materials with different heat storage capacities and emission properties. Radiant distribution from a storage mass to a living space can be almost immediate, or it can be delayed up to 12 hours, depending on the depth and time lag property of the storage material chosen."[1]

Controls are important in the indirect gain system, as well. For optimum efficiency in winter,

> "...external movable insulation, or other insulation alternatives, should be included to protect the storage mass from wasteful heat loss to the overcast or night sky."[2]

In summer, overhangs, insulation and exterior vents can help prevent unwanted heating. A mass Trombe wall has the potential to provide ventilation for summer cooling, if exhaust vents are placed at the top of the south-facing glazed area:

> "Solar heated air (in the summer) in the collector air space will force its way outside, drawing air from the living space to replace it. Therefore, another opening must be provided within the living space for replacement air -- preferably from a shaded or cooler area. This continual air movement exhausts hot air from the house drawing in cooler air for ventilation."[3]

iii) Isolated Gain: Sunspace[4]

In the isolated gain passive design, solar collection and storage are thermally isolated from the living spaces of the home. The sunspace,

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[1]ibid.
[2]ibid.
[3]ibid., p. 70.
[4]Based on ibid., pp. 121-122.

often a greenhouse, sun porch, atrium or an indoor pond, collects and stores solar energy. Heat from the sunspace can be drawn into the living space when required. Size of the sunspace can vary from one small corner to the entire south side of the building. In addition to the south-facing glazed area, the sunspace requires thermal mass in the floors, walls, benches or pools in order to provide effective heat storage. The most important control of the isolated gain design is the link between the sunspace and the living space.[1] The wall or walls connecting the two spaces require flexibility so that the spaces may be thermally connected or separated as required.[2] The type of walls chosen will determine how the stored heat is distributed, whether by radiation, convection or conduction.

Humidity control in the sunspace is another important consideration. As in the other two passive design types, "shading should be provided to prevent overheating of glazed spaces during the summer; and some form of movable insulation would prevent unnecessary heat losses on winter nights or cloudy days."[3]

3.2.2. Performance

Relatively few studies have been made of the performance and cost-effectiveness of passive solar homes, particularly under the harsh Canadian winter conditions. Recent papers by Gilpin and by Jones and Tymura[4]

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[1]ibid., p. 122.
[2]ibid.
[3]ibid.
[4]R.R. Gilpin, "The Use of South Facing Windows for Solar Heating in a Northern Climate" and R. E. Jones and E. J. Tymura, "Passive Solar Heating Design for Canada" both in Proceedings, Solar Energy Update Conference (Solar Energy Society of Canada, Edmonton, Alberta, 1977).

present theoretical studies on the performance of south-facing windows and passive solar designs in Canada. Gilpin concludes that south-facing windows result in an energy saving of about 85,000 BTU a year for each square foot of window, compared to an energy loss of 20,000 BTU for each square foot of north-facing window:[1]

> "...it is clear that in the design of a house, north-facing windows should wherever possible be replaced by south-facing windows. For a house of standard construction, however, the maximum amount of south-facing window area that can be used without causing overheating in the house is about seven percent of the house floor area."[2]

Gilpin also emphasizes the importance of thermal mass and overhangs to control overheating and regulate temperature fluctuations. As well, an automatically controlled thermal shutter system is desirable in the house, reducing heat loss at night and overheating during the day, Gilpin concludes. "Unfortunately, a proven shutter system does not as yet exist. It is recommended the development of such a system be pursued."[3]

Jones and Tymura conclude that improved insulation and direct gain passive solar heating "appear to be economically attractive at present and anticipated energy costs...(whereas) current active solar heating systems do not appear to enjoy an economic advantage until quite high energy costs are reached."[4] Their study assumed three house models: a standard insulated house with no basement insulation; a model with improved insulation, costing $2,800 more than the standard model; and an energy-conserving house with high insulation values, costing $5,400 more than the standard model. To each of these models were added first a passive solar system costing either

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[1]Gilpin, ibid., p. 6.
[2]ibid.
[3]ibid., p. 7.
[4]Jones and Tymura, ibid., p.7.

$1,400 for the standard model, or $1,800 for models two and three and secondly, an active system costing $10,000 installed.[1] Calculated annual heating loads varied from nearly 173 million BTU for the standard model without solar heating, to only 16.9 million BTU for the energy-conserving model incorporating passive and active solar systems.[2] Annual net savings, defined as dollar fuel savings less increased mortgage payments, were achieved for all of the models incorporating passive solar heating when conventional energy costs increased about $5 per million BTU. Energy costs of $10 and more per million BTU were needed to result in annual savings for homes incorporating active solar systems.[3]

Dumont[4] presents results from two solar homes actually built in Saskatchewan. Based on the measured results of the two dwellings, it is concluded that:

> "Passive solar heating can contribute a large fraction of the heating requirements as inexpensive heat to well-insulated dwellings even in the harsh climatic area of Canada. For the Regina residence, the contribution of passive gains should amount to forty-four percent of the heating requirement during the heating months. Coupled with the 'free' gains from the use of electricity and heat from people in the dwelling, the passive gain can reduce the auxiliary heat requirement to a very low value. At present electricity costs of 2.2 cents/kwhr ($6.11 GJ) the auxiliary space heat requirement for the Regina house would amount to only $31 per year, assuming that it did not have an active solar system."[5]

Dumont also notes the importance of the size and placement of the thermal mass to the proper functioning of a passive solar system.

A 1978 survey of 96 passive solar homes in the United States [6] provides information on the performance of the three passive designs

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[1]ibid., p. 2, p. 8.
[2]ibid., p. 9.
[3]ibid., p. 11.
[4]Dumont, ibid.
[5]ibid., p. 18.
[6]AIA Survey, ibid.

discussed in section 3.2.1. In 34 direct gain houses, the passive system typically contributed 70 to 80 percent of the heating needs of the home. In the 13 Trombe wall houses surveyed, heating contributions of 60 to 100 percent were achieved. Contributions of 70 to 80 percent were also achieved in most of the 29 homes surveyed which used the sun-space design.

3.2.3. Cost-Effectiveness: A Hypothetical Example[1]

Too few passive solar homes have been built and monitored in Canada in order to provide significant data on the comparative heating costs of a typical conventional home and a passive solar home. Any economic analysis of comparative heating costs must rely on assumptions about capital costs, energy consumption patterns and rates of price increases for conventional home heating fuels. The simplified analysis presented in this section attempts to indicate the general magnitude of the cost-effectiveness of a passive solar home, under a set of specific and reasonable assumptions.

The assumptions of the analysis are:

i) Houses: Three houses are compared. One is assumed to be a well-insulated house heated by a conventional fuel such as natural gas or heating oil. Two houses are passive solar homes, solar home A and solar home B, differing only in their initial capital costs.

ii) Energy consumption; All three homes consume 150 million BTUs a year for space heating purposes.[2] This level remains constant from year to

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[1]Prof. John Gray, Department of Economics, University of Manitoba, made several useful suggestions that improved the analysis presented in this section.

[2]BTU - British Thermal Unit. One BTU is the amount of energy required to heat one pound of water one degree F.; one BTU=0.25 kilocalories.

year.

iii) Performance of passive solar heating system: Both solar homes obtain 70 percent, or 135 million BTUs a year, from passive solar energy. Therefore, 45 million BTUs a year must be obtained from a conventional heating source.[1]

iv) Energy costs: The cost of a conventional heating fuel is assumed, for simplicity, to be $3 a million BTU in year 1.[2]

v) Inflation: An annual inflation rate of 8 percent is assumed.

vi) Energy price increases:[3] Three scenarios are assumed for illustrative purposes. The first assumes a 15 percent a year increase for conventional heating fuels for the first five years, followed by annual increases that match the inflation rate of 8 percent. It is suggested such a price increase pattern is a reasonable one, given existing federal government energy pricing policies.[4] The second pattern projects a constant

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[1]Concept Construction in Saskatoon, Sask., has calculated that, in theory, a well-insulated passive solar home using a Trombe wall design could obtain 50 percent of its heating requirements from solar, and 32 percent from appliances and persons living in the dwelling. Conventional fuel requirements for such a house would only be 7.5 million BTUs a year. A practical, cost-competitive demonstration of this theoretical house has yet to be built. The calculations are based on the pioneering theoretical work of J.D. Balcomb in New Mexico. See J.D. Balcomb and R.D. McFarland, "A Simple Empirical Method for Estimating the Performance of a Passive Solar Heated Building of the Thermal Storage Wall Type," Proceedings, of the Second Annual National Passive Solar Conference, Philadelphia, Pa., March, 1978. Personal communication, Keith Funk, July 25, 1978.

[2]The $3 a million BTU figure is slightly high for natural gas costs in Winnipeg, slightly low for heating oil, and substantially lower than electric heating costs. See Hildebrandt-Young and Associates, The Energy Crisis and the City of Winnipeg (1978) p. 35, 45.

[3]Increases are dollar-of-the-year increases which include the inflationary factor; the analysis accounts for inflation by including the inflationary factor in the discount rate used to determine present value costs.

[4]The existing federal policy to increase domestic oil prices by $2 a year to approach world prices represents approximately 15 percent a year increases; natural gas prices, in turn, are to be gradually increased so as to approach equivalent oil prices.

10 percent a year increase in prices, slightly higher than the annual inflation rate. The third pattern is a 6 percent a year increase, below the inflation rate, and likely representing the lower range of energy price increases in Canada in the near future.

vii) Capital costs and mortgage rates: The conventional house costs $70,000. It has a $50,000, 25-year mortgage at 11 percent, with monthly payments of $481.27[1]. Solar Home A and B are assumed to cost, respectively, $3,500 and 6,000 more than the conventional house. It is suggested that the two figures represent the lower and upper range of additional capital costs that a private housebuilding company would be able and willing to undertake.[2] Sources of additional capital cost may include: $1,000 for increased south-facing glazing; $800 for an insulated shutter system; $800 for a Trombe wall; and increased insulation and vapour barrier.[3] The additional capital costs of the two solar homes are accounted for in larger mortgages, paid as additional monthly mortgage payments. Solar Home A, costing $73,500 has a $53,500, 25-year mortgage at 11 percent, for monthly payments of $514.95. Solar Home B, costing $76,000, has a $56,000 mortgage, with monthly payments of $539.02. The additional mortgage payments represent a passive solar system cost to the homeowner. The differences in yearly mortgage payments between the solar homes and the conventional home

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[1]Mortgage rates and payments obtained courtesy of property investments branch, Confederation Life Insurance Company, Winnipeg, March, 1979.

[2]Enercon Building Corporation of Regina, Sask., is reported to be offering an energy-conserving passive solar house for $3,500 more than a conventional house. The 1,500-square-foot house can be electrically-heated for $150 a year, according to the builder. See The Canadian Magazine (1979; date unknown) pp.19-21.

[3]Costs estimated by Concept Construction, Saskatoon, Sask.; personal communication, Keith Funk, Sept. 22, 1978, Winnipeg, Man.

are therefore treated as part of the annual "solar cost" to the homeowner.[1] Total "solar cost" is the sum of the mortgage payment differential and the cost of conventional fuel which must be used to supplement the contribution of the passive solar heating system.

The results of the analysis are summarized in Tables 3-1 and 3-2. Firstly, consider Table 3-1, which compares the annual space heating costs of the three homes under the three energy price scenarios in terms of current dollars[2], for the first six years of operation. Note that under the first scenario with 15 percent a year energy price increases, Solar Home A, compared to the conventional home, results in an annual fuel cost saving, from and including year 3. But even under the high energy cost assumption, it will take more than six years for the higher cost Solar Home B to produce an annual dollar saving for the homeowner. Under the assumption that fuel prices increase by 10 percent a year, Solar Home A has an annual fuel cost lower than the conventional home from and including year 4; again, Solar Home B does not provide an annual saving within six years under the 10 percent a year scenario. Finally, under the third energy price scenario of 6 percent, annual fuel savings are achieved for Solar Home A from and including year 6, and substantially later for Solar Home B.

The results listed in Table 3-1 may be misleading, because the comparison is between annual costs rather than costs incurred over a period of time such as the life of the mortgage or the life of the dwelling. Life-cycle costing analysis is a more appropriate approach. When considering

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[1]The "solar cost" approach, which includes the additional mortgage payments on the solar home, was suggested by Keith Funk, Concept Construction.

[2]Current dollars is used here to refer to dollars-of-the-day, which include inflation, as opposed to real dollars or constant dollars, which have taken into account inflationary effects.

costs and benefits incurred over time, it is necessary to relate the sum of the costs or benefits to their present value, that is, what the future costs or benefits are worth at the present time. Discounting future costs and benefits is a standard practice in economic cost-benefit analysis. Discounting reduces the stream of costs or benefits to a single amount, by using the method of compound interest.[1] The basic rationale for discounting is that most people:

> "...under almost any circumstances, would prefer $1 now to $1 a year from now. A sum of money in hand is worth more than a promise of the same sum at a specified time in the future, because the money may be invested so as to produce earnings in the intervening time...
> ...having to wait for payment means foregoing the income that could be earned on the money in the meantime. In other words, waiting carries a cost in the form of a lost opportunity."[2]

The choice of the discount rate obviously effects the calculation of present value. The smaller the rate, the more highly valued are costs incurred in the future; a higher discount rate will result in a reduced present value of the stream of costs. There is no agreement among economists as to the proper discount rate to use, and it is generally recommended that a range of discountrates be used to calculate the net present values.[3] As well, all future costs must be in terms of constant prices. That is, the discount rate must be a real rate rather than a nominal rate.

Table 3-2 presents a summary of the present value of heating costs of the three homes. Three different energy price scenarios are considered,

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[1]Edith Stokey and Richard Zeckhauser, A Primer for Policy Analysis (Norton and Co., New York, 1978) p. 160.

[2]ibid.

[3]Treasury Board, Benefit-Cost Analysis Guide (Ottawa, 1976) p. 26. This is usually referred to as a sensitivity analysis.

TABLE 3 - 1

COMPARISON OF ANNUAL SPACE HEATING COSTS:

THREE ENERGY PRICE SCENARIOS

(See Text for Assumptions)

(Current Dollars[1])

Year	Annual Energy Price Increases	Conventional Home: Annual Heating Bill	SOLAR HOME A				SOLAR HOME B			
			Annual Heating Bill	Additional Annual Mortgage Payments	Total Annual Solar Cost	Annual Savings	Annual Heating Bill	Additional Annual Mortgage Payments	Total Annual Solar Cost	Annual Savings
1		$ 450.00	$ 135.00	$404.16	$539.16	-$ 89.16	$135.00	$693.00	$828.00	-$ 378.00
2	15%/8%	517.50	155.25	404.16	559.41	- 41.91	155.25	693.00	848.25	- 330.75
	10%	495.00	148.50	404.16	552.66	- 57.66	148.50	693.00	841.50	- 346.50
	6%	477.00	143.10	404.16	547.26	- 70.26	143.10	693.00	836.10	- 359.10
3	15%/8%	595.13	178.54	404.16	582.70	+ 12.43	178.54	693.00	871.54	- 276.41
	10%	544.50	163.35	404.16	567.51	- 23.01	163.35	693.00	856.35	- 311.85
	6%	505.62	151.69	404.16	555.85	- 50.23	151.69	693.00	844.69	- 339.07

[1] Current dollars are dollars of the day, and include annual inflation rate of 8%.

(continued)

TABLE 3 - 1 (continued)

COMPARISON OF ANNUAL SPACE HEATING COSTS:

THREE ENERGY PRICE SCENARIOS

(Current Dollars)

Year	Annual Energy Price Increases	Conventional Home Annual Heating Bill	SOLAR HOME A Annual Heating Bill	SOLAR HOME A Additional Annual Mortgage Payments	SOLAR HOME A Total Annual Solar Cost	SOLAR HOME A Annual Savings	SOLAR HOME B Annual Heating Bills	SOLAR HOME B Additional Annual Mortgage Payments	SOLAR HOME B Total Annual Solar Cost	SOLAR HOME B Annual Savings
4	15%/8%	$ 684.39	$ 205.32	$404.16	$609.48	+$ 74.91	$205.32	$693.00	$898.32	-$213.9
	10%	598.95	179.69	404.16	583.85	+ 15.10	179.69	693.00	872.69	- 273.7
	6%	535.96	160.79	404.16	564.95	- 28.99	160.79	693.00	853.79	- 317.8
5	15%/8%	787.05	236.12	404.16	640.28	+ 146.77	236.12	693.00	929.12	- 142.0
	10%	658.85	197.65	404.16	601.81	+ 57.04	197.65	693.00	890.65	- 231.8
	6%	568.11	170.43	404.16	574.59	- 6.48	170.43	693.00	863.43	- 295.3
6	15%/8%	905.11	271.53	404.16	675.69	+ 229.42	271.53	693.00	964.53	- 59.4
	10%	724.73	217.42	404.16	621.58	+ 103.15	217.42	693.00	910.47	- 185.6
	6%	602.20	180.66	404.16	584.82	+ 17.38	180.66	693.00	873.66	- 271.4

TABLE 3 - 2

SUMMARY OF PRESENT VALUES OF SPACE HEATING:

FOR CONVENTIONAL AND PASSIVE SOLAR HOMES:

CALCULATED OVER PERIODS OF 5 YEARS, 25 YEARS AND 50 YEARS

FORMULAS:

i) for a stream of constant annual costs

$$PV = a \left[\frac{(1 + i)^n - 1}{i\,(1 + i)^n} \right]$$

where PV = present value of stream of costs
a = constant annual payments
i = social discount rate
n = number of years

eg. Solar Home A has additional mortgage payments of $404.16 a year for 25 years; at a discount rate of 14%, the present value of these costs is -

$$= 404.16 \left[\frac{(1.14)^{25} - 1}{.14\,(1.14)^{25}} \right]$$

= $2,277.76

ii) for a stream of growing costs

$$PV = r \left[\frac{1 + g}{i - g} \right] \left[1 - \frac{(1 + g)^n}{(1 + i)^n} \right]$$

where r = initial value of costs
g = growth rate

eg. Solar Home A has initial space heating costs of $135 a year; under the second energy price scenario, heating costs will increase by 10% a year; so g = .10 at a discount rate of 9%, the present value of the space heating costs over 50 years is -

$$= \$135 \left[\frac{1.10}{.09 - .10} \right] \left[1 - \frac{(1.10)^{50}}{(1.09)^{50}} \right]$$

= $8,594.22

TABLE 3 - 2 (continued)

SUMMARY OF PRESENT VALUES OF SPACE HEATING COSTS FOR

CONVENTIONAL AND PASSIVE SOLAR HOMES:

CALCULATED OVER A PERIOD OF 50 YEARS

(real dollars)

NNUAL NERGY RICE NCREASES (g)	SOCIAL DISCOUNT RATE (i)	CONVENTIONAL HOME	SOLAR HOME A PRESENT VALUE COSTS OF:				SOLAR HOME B PRESENT VALUE COSTS OF:			
		PVC OF SPACE HEATING COSTS	SPACE HEATING	ADDITIONAL MORTGAGE PAYMENTS	TOTAL SOLAR COSTS	P.V.[1] COSTS (-) OR SAVINGS(+)	SPACE HEATING	ADDITIONAL MORTGAGE PAYMENTS	TOTAL SOLAR COSTS	P.V. COSTS(-) OR SAVINGS(+
15%/8%	.09	$23,830.21	$7,148.99	$3,969.89	$11,118.88	+12,711.33	$7,148.99	$6,807.05	$13,956.04	+ 9874.1
	.14	9,987.51	2,996.22	2,777.76	5,773.98	+ 4,213.53	2,996.22	4,762.94	7,759.16	+ 2228.3
	.18	6,270.15	1,881.02	2,209.50	4,090.52	+ 2,179.63	1,881.02	3,788.57	5,669.59	+ 600.5
10%	.09	28,647.41	8,594.22	3,969.89	12,564.11	+16,083.30	8,594.22	6,807.05	15,401.27	+13246.1
	.14	10,300.39	3,090.17	2,777.76	5,867.93	+ 4,432.46	3,090.17	4,762.94	7,853.11	+ 2447.2
	.18	6,002.55	1,800.77	2,209.50	4,010.27	+ 1,992.28	1,800.77	3,788.57	5,589.34	+ 413.2
6%	.09	11,961.19	3,588.37	3,969.89	7,558.26	+4,402.93	3,588.37	6,807.05	10,395.42	+ 1565.7
	.14	5,805.65	1,741.70	2,777.76	4,519.46	+1,286.19	1,741.70	4,762.94	6,504.64	- 698.9
	.18	3,956.36	1,186.91	2,209.50	3,396.41	+ 559.95	1,186.91	3,788.57	4,975.48	- 1019.1

[1] "PVC Savings" lists the difference between total PVC of space heating for the Conventional Home and PVC of total solar costs of the solar home. A positive sign indicates savings for the solar home compared to the Conventional home.

TABLE 3 - 2

SUMMARY OF PRESENT VALUES OF SPACE HEATING COSTS FOR

CONVENTIONAL AND PASSIVE SOLAR HOMES:

CALCULATED OVER A PERIOD OF 25 YEARS

(real dollars)

ANNUAL ENERGY PRICE INCREASES (g)	SOCIAL DISCOUNT RATE (i)	CONVENTIONAL HOME	SOLAR HOME A PRESENT VALUE COSTS OF:				SOLAR HOME B PRESENT VALUE COSTS OF:			
		PVC OF SPACE HEATING COSTS	SPACE HEATING	ADDITIONAL MORTGAGE PAYMENTS	TOTAL SOLAR COSTS	P.V. COSTS (-) OR SAVINGS(+)	SPACE HEATING	ADDITIONAL MORTGAGE PAYMENTS	TOTAL SOLAR COSTS	P.V. COSTS(-) OR SAVINGS(+
15%/8%	.09	$12,855.82	$3,856.71	$3,969.89	$7,826.60	+$ 5,029.22	$3,856.71	$6,807.05	$10,663.76	+$2,192.0
	.14	7,742.38	2,322.70	2,777.76	5,100.46	+2,641.92	2,322.70	4,762.94	7,085.64	+ 656.7
	.18	5,562.58	1,043.53	2,209.50	3,253.03	+2,309.55	1,043.53	3,788.57	4,832.10	+ 730.4
10%	.09	12,695.63	3,808.64	3,969.89	7,778.58	+4,917.05	3,808.64	6,807.05	10,615.69	+ 2,079.9
	.14	7,308.11	2,192.43	2,777.76	4,970.19	+2,337.92	2,192.43	4,762.94	6,955.37	+ 352.7
	.18	5,117.75	1,535.33	2,209.50	3,744.83	+1,372.92	1,535.33	3,788.57	5,323.90	- 206.1
6%	.09	7,986.27	2,395.88	3,969.89	6,365.72	+1,620.55	2,395.88	6,807.05	9,202.93	- 1,216.6
	.14	4,995.44	1,498.63	2,777.76	4,276.39	+ 719.05	1,498.63	4,762.94	6,261.57	- 1,266.1
	.18	3,702.77	1,110.83	2,209.50	3,320.33	+ 382.44	1,110.83	3,788.57	4,899.40	- 1,196.6

(continued)

TABLE 3 - 2 (continued)

SUMMARY OF PRESENT VALUES OF SPACE HEATING COSTS FOR

CONVENTIONAL AND PASSIVE SOLAR HOMES:

CALCULATED OVER A PERIOD OF 5 YEARS

(real dollars)

ANNUAL ENERGY PRICE INCREASES (g)	SOCIAL DISCOUNT RATE (i)	CONVENTIONAL HOME	SOLAR HOME A PRESENT VALUE COSTS OF:				SOLAR HOME B PRESENT VALUE COSTS OF:			
		PVC OF SPACE HEATING COSTS	SPACE HEATING	ADDITIONAL MORTGAGE PAYMENTS	TOTAL SOLAR COSTS	P.V. COSTS(-) OR SAVINGS(+)	SPACE HEATING	ADDITIONAL MORTGAGE PAYMENTS	TOTAL SOLAR COSTS	P.V. COSTS(-) OR SAVINGS(+)
15%	.09	$2,649.98	$794.99	$1,572.04	$2,367.03	+$282.95	$794.99	$2,695.53	$3,490.52	-$ 840.54
	.14	2,309.90	692.97	1,387.51	2,080.48	+ 229.42	692.97	2,379.13	3,072.10	- 762.20
	.18	2,084.10	625.23	1,263.88	1,889.11	+ 194.99	625.23	2,167.13	2,792.36	- 708.26
10%	.09	2,312.69	693.38	1,572.04	2,265.42	+ 47.27	693.38	2,695.53	3,388.91	- 1,076.22
	.14	2,023.95	607.19	1,387.51	1,994.70	+ 29.25	607.19	2,379.13	2,986.32	- 962.37
	.18	1,831.69	549.51	1,263.88	1,813.39	+ 18.30	549.51	2,167.13	2,716.64	- 884.95
6%	.09	2,070.90	621.27	1,572.04	2,193.31	- 122.41	621.27	2,695.53	3,316.80	- 1,245.90
	.14	1,818.37	545.51	1,387.51	1,932.02	- 113.65	545.51	2,379.13	2,923.64	- 1,105.27
	.18	1,649.82	494.95	1,263.88	1,758.83	- 109.01	494.95	2,167.13	2,662.08	- 1,012.26

as in Table 3-1. Three discount rates 9, 14 and 18 percent are used to determine how sensitive the results are to the choice of the discount rate. The discount rates include the 8 percent inflation factor; thus the real discount factors in the rates are 1 percent, 6 percent and 10 percent respectively. Finally, in Table 3-2, note that three different time horizons have been considered. The first, over 25 years, represents the life of the mortgage; the second, 50 years, is the assumed life of the building. However, a 50-year, or even a 25-year timeframe is not likely to be of primary importance to a prospective homebuyer, who may be anticipating moving from the home in another five or six years. The third part of Table 3-2 indicates the calculations of the present value of heating costs over the initial five-year period.

Table 3-2 indicates that when considered over a 50-year or 25-year period, both Solar Homes A and B are profitable investments under the assumption that energy prices increase by 15 percent a year for the first five years, and 8 percent a year afterwards. Note that under this energy price scenario, the selection of a discount rate does not affect the results: both solar homes yield net present value savings in heating costs compared to the conventional home. The savings are, of course, larger for the lower cost solar home A than for the higher cost solar home B.

If energy prices instead increase more gradually, at 10 percent or 6 percent a year, then solar home A still yields a net present value saving over the life of the building and life of the mortgage. Note however, that solar home B does not provide net present value savings under the 6 percent a year price scenario, even over a 50- year period, unless the lowest discount rate is used. The higher cost solar home does provide net present value savings under the 10 percent a year price scenario, except under the highest discount rate over 25 years.

Life-cycle costing of the solar homes therefore suggests that even a relatively high-cost solar home can be a profitable investment for a homeowner over the long run with certain energy price increases. However, as noted previously, the time horizon of an individual is more likely to be five years or less, rather than 25 years. The reduced time horizon might be expected to eliminate any net present value savings for a solar home compared to a conventional home, because the solar home has not had enough time to pay back the original higher capital investment of the owner in the form of reduced fuel bills. The third part of Table 3-2, however, indicates that if prices for conventional fuel increase according to either of the first two energy price scenarios, then the lower cost solar home A will still yield net present value savings within the five-year period. The results for solar home A are not affected by the choice of a discount rate. However, the higher cost solar home B will not yield present value savings within five years, even under the high energy price increase scenario.

The results of the five-year analysis in Table 3-2 are important for two reasons: Firstly, their results indicate to the housebuilding company the importance of reducing the additional capital costs of a solar home to the lower range of $3,500. The lower the additional costs, the sooner the homeowner obtains a return on the investment. Secondly, the economic attractiveness of a solar home need not necessarily depend on a consideration of the entire life-cycle costs of home heating. If a solar house can be built according to the assumptions behind solar home A in the analysis, then net present value savings compared to the conventional house can accrue to the owner of a passive solar home within five years, under reasonable assumptions about future energy price increases.

TABLE 3 - 3

EQUIVALENT ENERGY SAVINGS
OF A PASSIVE SOLAR HOME[1]

ASSUMPTIONS ABOUT SOLAR HOME: Passive solar energy contributes 70 percent of annual space heating needs of 150 million BTUs ie-105 million BTUs/year

CONVENTIONAL FUEL	PASSIVE SOLAR HOME		
	1 YEAR	25 YEARS	50 YEARS
NATURAL GAS (Cubic Feet)	105,000	2,625,000	5,250,000
OIL (Barrels of oil equivalent)	17.85	446.25	892.5
COAL (Metric Tons)	3.78	94.5	189
ELECTRICITY (Kilowatthours)	30,765	769,125	1,538,250

[1]The following conversion ratios have been used to calculate equivalent energy savings:

1 million BTUs = 1,000 cubic feet of natural gas
= .17 barrels of oil equivalent
= 0.036 metric tons of coal
= 293 kilowatthours

Source: Carroll L. Wilson, ed. Energy: Global Prospects 1985-2000 (McGraw-Hill, New York, 1977) p.64.

Tables 3-1 and 3-2 indicate heating cost savings accruing to the individual homeowner. Finally, Table 3-3 provides an indication of the social benefits of the passive solar home. Social benefits arise because of the reduced consumption of conventional, and in most cases finite, heating fuels. A solar-heated home places a reduced demand on the resources of society, allowing, on a marginal basis, those resources to be conserved for future use. (A similar argument will be made in Chapter VIII, when the total space heating costs of a solar energy subdivision are compared to those of a conventional subdivision.) Table 3-3 illustrates that an individual passive solar home contributes substantial social benefits over the life of the mortgage, or the life of the building. For example, over a period of 50 years, a home obtaining 70 percent of its space heating requirements from passive solar energy will save society the energy equivalent of 5.25 million cubic feet of gas or 892.5 barrels of oil, or 189 metric tons of coal.

3.3 Energy Conservation in Site Planning

The physical site on which a house is built:

> "...is perhaps the most important factor affecting the design, construction and functioning of the building. The relationship between the site and the dwelling unit is, however, seldom accorded the attention it deserves, particularly with respect to the influence of site conditions on energy requirements and the potential for adapting the design and construction of the building to these conditions in order to minimize energy consumption."[1]

General principles of energy conservation in site planning are well established in the literature. The classic work is by Olgyay[2] who

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[1]CMHC, The Conservation of Energy in Housing, ibid. p. 20.

[2]Victor Olgyay, Design With Climate, (Princeton University Press, Princeton, N.J., 1963).

determined an optimal community layout, shelter design and building elements for a given site under four climatic regimes. The "cool region" examined by Olgyay corresponds closest to the Winnipeg climate.[1] The cool region is characterized by too much sun in summer, and too little in winter, and cold winds during a long winter. General design objectives are increased heat production, increased radiation absorption, decreased radiation loss and reduced conduction and evaporation loss. Table 3-4 presents several conclusions by Olgyay about the ideal community arrangement under the "cool region" climate.

Similar conclusions have been made in more recent studies of energy conservation in site planning. The American National Association of Home Builders suggests the following design features to meet the two major objectives of housing in the cool region:[2]

i) Maximize the warming effects of solar radiation:
- utilize south to southeast facing slopes as much as possible;
- orient active living areas to the south of the dwelling to take advantage of the winter sun;
- create protected sun pockets;
- utilize darker colours which absorb radiation;
- utilize exterior walls and fences to capture the winter sun and reflect warmth into the living zones;

ii) Reduce the impact of cold winter winds:
- locate buildings on the lee side of hills;
- utilize evergreens, earth mounds, and exterior walls to protect the home's northern exposure;
- use shallow-pitched roofs to hold snow for added insulation;
- build home into hillside along north wall to take advantage of natural insulation of the earth.

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[1]The location of Olgyay's "cool region" was actually Minneapolis, Minn. see pp. 153-159, ibid.

[2]Cost Effective Site Planning: Single-Family Developments, (National Association of Home Builders, Washington DC, 1976) p. 45.

TABLE 3-4:[1] Energy Conservation in Site Planning: Olgyay's "Cool Region"

a) Housing Layout

1. Site Selection: SSE slope for sun gain is desirable; middle of slope is preferable to prevent excessive wind effects;
2. Town Structure: Sheltering effect against winds; larger buildings may be grouped together but spaced to utilized sun heat effects;
3. Public Spaces: Wind sheltered, open, with periodically shaded areas;
4. Landscape: Generally varying topography shapes street layouts and space utilization into an irregular character;
5. Vegetation: Evergreen windbreaks in NE-SW direction at a distance of twenty times the three height; deciduous shade trees near house; avoid dense planting too close to structure because of dampness effect;

b) Shelter Design

1. House types: Row houses or attached housing result in reduced heat loss; compact arrangements of apartment houses;
2. Arrangement: Conservation and economy of heating is about three times as important as summer comfort; winter and summer extremes suggest separated use zones within houses; entrance spaces;
3. Plan: Determined by conditions prevailing in cool and cold months; indoor living represents seventy percent of annual hours; summer comfort provided through additional living areas or utilization of outdoor spaces;
4. Orientation: Optimum sun orientation lies 12 degrees E of south; prevailing wind pattern may influence orientation of free-standing buildings;
5. Colour: Sun-exposed surfaces in medium colours; recessed surfaces can be of dark absorbent colours if shade in summer can be provided;

c) Building Elements

1. Windows: Sun windows provide good auxiliary heat source; keep windows small except on south and east sides; windows should be shade-protected to prevent overheating; shutters desirable to reduce heat loss during cold periods; double-glazing essential;
2. Roof: Sloping roof is desirable to encourage snow removal;
3. Materials: High heat capacity mass in house interior to balance extreme heat variations is desirable; vapour seal on warm (interior) side of outer walls is important;
4. Shading Devices: Summer shading is desirable, but should not interfere with solar impact during cold months; horizontal shading devices towards the south; deciduous trees to the southeast and west sides of the house.

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[1]Based on Olgyay, ibid., pp. 155-156.

Simon lists many site and design factors which are important to energy conservation in housing.[1] Many of the factors listed agree with Olgyay's conclusions:

i) Site:
- Solar radiation highest on south-facing slopes; however, an orientation several degrees east of south may be optimum because mornings are cooler than afternoons;
- Plant and grass-covered ground surfaces reduce temperature in summer; asphalt and brick surfaces significantly increase temperatures and reradiate heat;
- Deciduous vegetation provides shade in summer and permits sun penetration in winter;
- Vegetation can redirect winds to reduce wind chill factors on the exterior surfaces of buildings and to encourage desirable ventilation;

ii) Building design:
- Compact development, such as clustering and shared party walls, can reduce heat loss through surface wall area, and offer increased protection from winds;
- Compact developments and higher densities can reduce reliance on car travel and make public transportation feasible;
- Temperature zones can be created inside the house, because not all areas of the house need to have the same temperature;
- Maximum solar penetration is desirable in winter, and control of solar radiation desirable in summer;
- Dark-coloured surfaces inside the house can enhance the greenhouse effect to trap solar radiation as heat;

iii) Building materials:
- "Building materials with good heat storage qualities are extremely important in enabling the retention of peak heat loads and their slow release at low temperature periods (these are generally heavy materials of high density)."[2]
- "The two-way transfer of heat through glass..presents a particularly intriguing problem in the design of efficient passive systems."[3]

Similar general site planning principles are discussed in Leckie[4] and the CMHC study of energy conservation in housing. The CMHC study lists

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[1]Charles Simon, "Principles and Examples of the Design of Passive Solar Houses in the Cool Temperature Zone", Proceedings, Solar Energy Update Conference (Solar Energy Society of Canada, Edmonton, 1977).

[2]ibid., p. 10.

[3]ibid.

[4]Jim Leckie, et al, Other Homes and Garbage (Sierra Club Books, San Francisco, 1975); see Chapter 2.

nineteen suggestions to make maximum use of a site's energy-saving potential:[1]

- Choose a site that receives maximum exposure to the sun in fall, winter and spring and also can be shaded in summer;
- Choose a site that receives maximum exposure to cooling breezes in summer and also can be sheltered from winter winds;
- Choose a site on a gentle, south-facing slope, preferably on a street that runs east and west;
- Choose a site that is not surrounded by tall buildings or other man-made obstructions to sunlight, particularly to the south;
- Design subdivisions so that the majority of streets run east and west;
- Space dwellings in a subdivision sufficient distance apart so that they do not obstruct access to sunlight for any site;
- Design the dwelling so that the largest windows face south, and the minimum window area faces north;
- Locate windows so as to provide effective cross-ventilation;
- Shelter windows that are exposed to direct winds during the heating season;
- Minimize total area of the building's exterior surface;
- Incorporate sufficient window area to take advantage of natural light;
- Design the home's interior to make maximum use of sunlight entering the building;
- Plant deciduous shade trees on the south, southeast and southwest sides of the site;
- Retain or plant coniferous trees on the north and northwest sides for wind control;
- Ensure the trees' root systems do not interfere with the building's foundations;
- Plant vines against the building for summer shade;
- Construct sidewalks and patios to reflect radiation in the heating season, and provide shade for these areas in summer;
- Incorporate design features (such as overhangs) to provide effective shading in summer;
- Use free-standing shading devices around the site to provide summer shading.

The CMHC study acknowledges that some of the suggestions may be conflicting with one another with respect to a particular site. It suggests that trade-offs will need to be made between the potential benefits of alternative

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[1]CMHC, ibid., p. 27.

design techniques:

> "The basic principle that should underlie such decisions is that the chosen alternative should be the most cost-effective one with respect to energy conservation over the long-term".[1]

This concludes the summary of solar home heating principles and designs. The following chapters will examine the institutional implications of passive solar housing at each stage of the Winnipeg subdivision delivery system.

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[1]ibid.

CHAPTER IV

SOLAR ENERGY SUBDIVISION DESIGN

4.1 Constraints on the Sunnyvale Design

The major conceptual tool of the present study is a hypothetical solar energy subdivision, Sunnyvale. By submitting its design and other requirements to the Winnipeg subdivision delivery system, it will help clarify institutional implications of solar home heating. However, if the exercise is to be credible and useful, then the solar subdivision design process cannot be carried out in isolation from the realities of site constraints, adjacent land use patterns and the profit motivations of the housebuilding industry. To obtain a sense of realism, Sunnyvale will assume the primary site and economic constraints of a real world conventional subdivision.

The conventional subdivision selected for this purpose is on a 14.1-acre rectangular area in southwest Winnipeg. In the spring of 1978, a Winnipeg housebuilding company, Castlewood Homes, commenced construction at the site. Known as Betsworth, the conventional subdivision was selected for several reasons: it is relatively small, by normal subdivision standards, and it is reasonable to assume that in the early years of solar energy utilization, a housebuilding company would likely choose to undertake a small project to decrease risks. All of the Betsworth property was owned by one company and therefore could be planned as a unit. Betsworth is located on a medium-to-high income area of Winnipeg, with a housing mix dominated by single-family units. Finally, the Betsworth site is on the extreme southern fringe of built-up land in the southwest sector of Winnipeg, with vacant land to its east and south. This eliminated present shading problems for the hypothetical solar homes.

Table 4-1 summarizes the general site and economic constraints of the Betsworth subdivision. These constraints, in turn, become targets or parameters for the Sunnyvale design.

Prior to commencement of construction, the topography of the site was flat, low-lying and poorly-drained. The drainage problem required the clearing of most of the deciduous trees on the site. Land to the east and south was vacant, but is expected to come into use for single-family housing at some future date.

The economic constraints of the housebuilding company are reflected in the zoning and number of lots in the subdivision. The R1-5.5 designates single-family detached housing on 5,500 square feet (510.97 sq. m.) lots. Maximum permitted height of houses is 35 feet (10.67 metres). Six foot (1.83 m.) fences are permitted.[1]

Constraints imposed by municipal needs include 60 feet (18.29 m.) public right-of-ways, an open space dedication for park purposes of approximately 1.5 acres (6,070 sq. m.) and the elimination of one lot on the south border of Betsworth in order to provide future public access to any residential development south of the property.

Figure 4-1 illustrates the shape, orientation and access of the Betsworth subdivision (and therefore, of Sunnyvale). Orientation is due north - south. Access is restricted to two streets entering the property from the north.

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[1]The City of Winnipeg is in the process of converting to metric measurements. Throughout the present study, imperial measurements will usually be listed first, with the metric equivalent in brackets. The following conversion ratios have been used: feet to metres: multiply by .3048; square feet to square metres: multiply by .0920. These ratios are used in J. Leckie, et al, Other Homes and Garbage, ibid.

TABLE 4 - 1

PRIMARY DESIGN CONSTRAINTS
OF BETSWORTH SUBDIVISION

Constraint	Value
Number of dwelling units	72
Zoning	R1-5.5 (single-family detached, lots 5,500 square feet of 511 sq. m.)
Topography	Flat, deciduous tree cover
Public open space	Approximately 1.5 acres (6,070 sq.m.
Public right-of-ways	60 feet (18.29 m.)
House height	Maximum 35 feet (10.67 m.)
Fences	Maximum 6 feet (1.83 m.)
Orientation	Not applicable
Landscaping	None

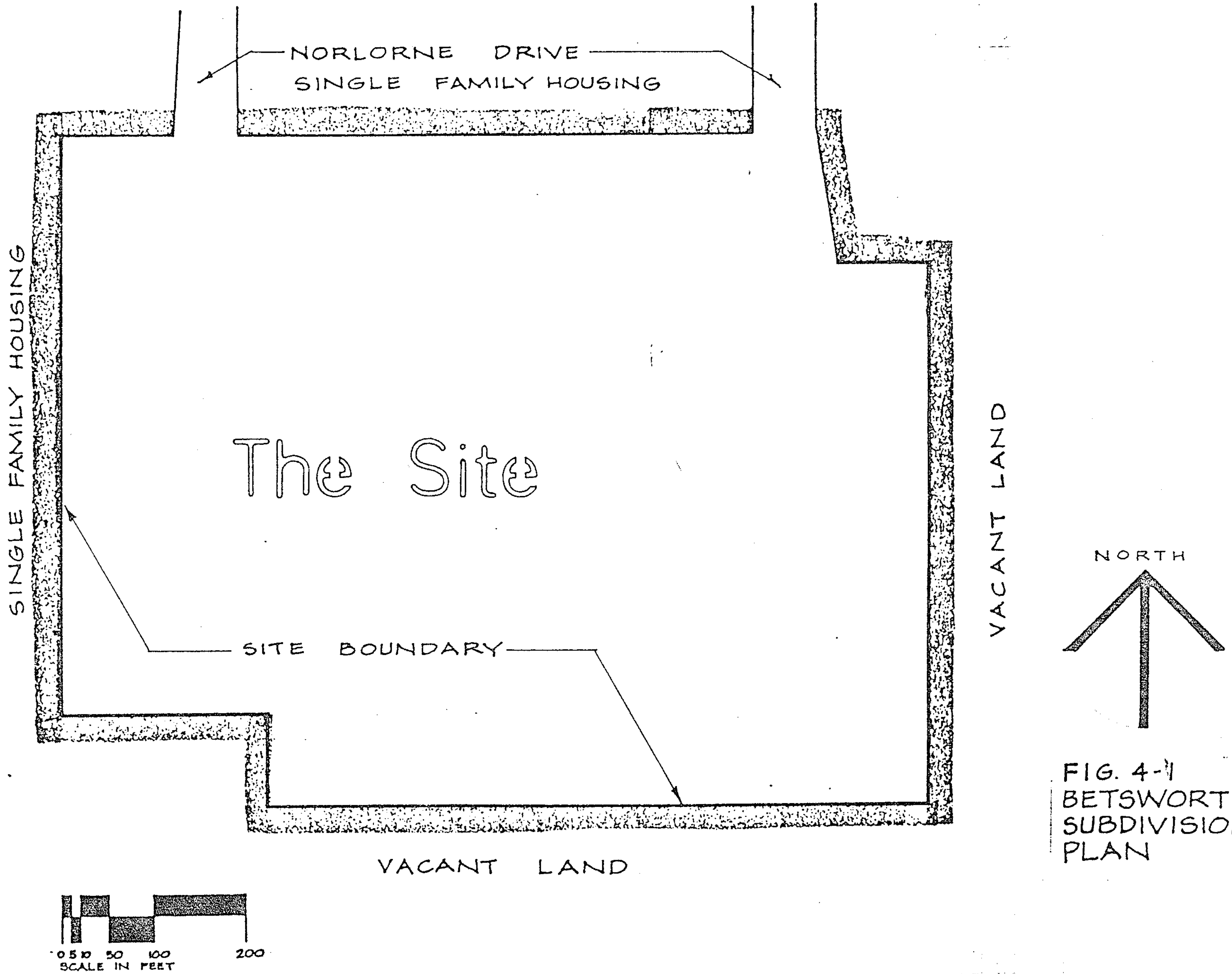
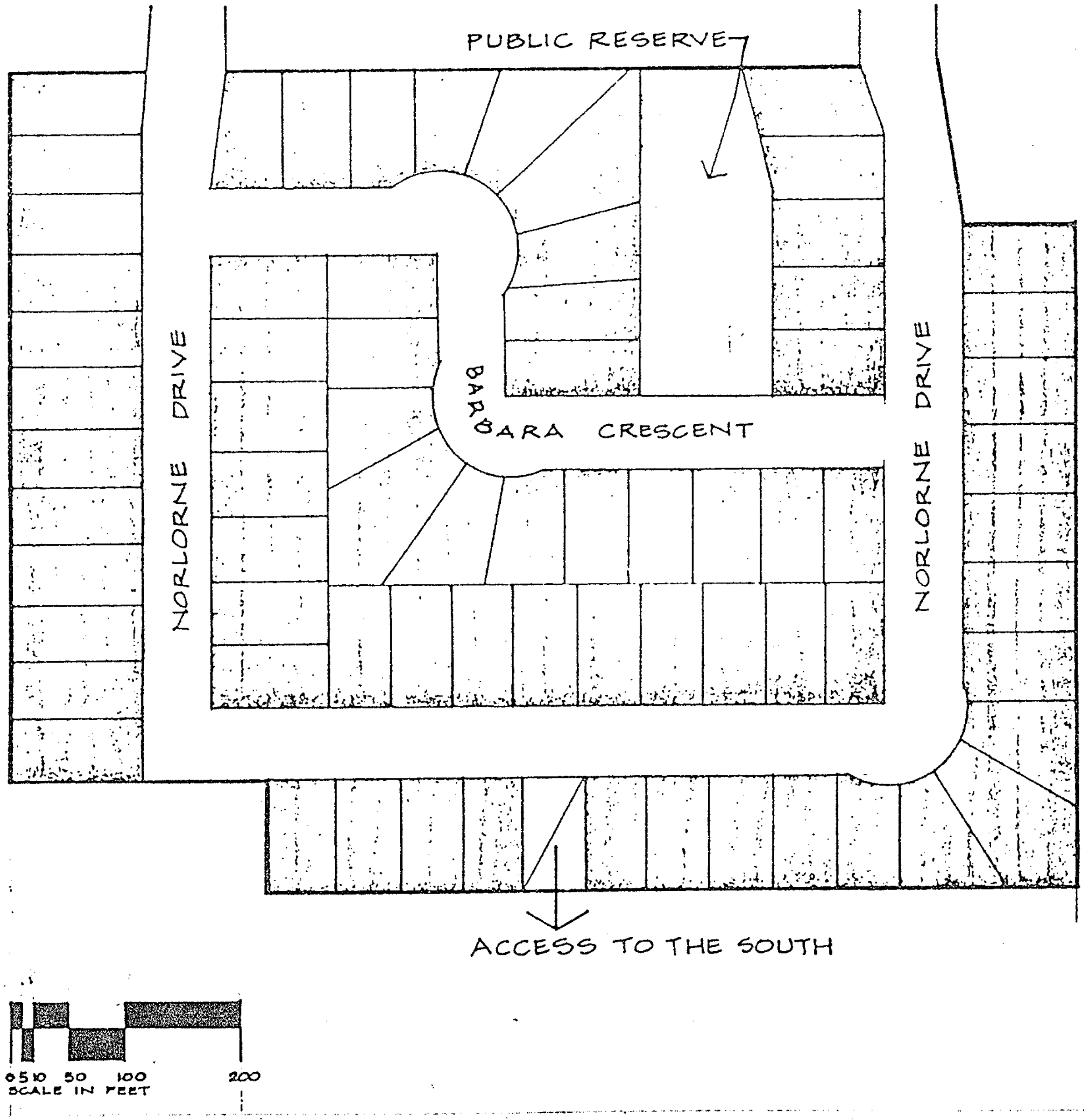


FIG. 4-1
BETSWORTH
SUBDIVISION
PLAN



BASIC ZONING OF THE SITE IS SHOWN AS R1-5.5

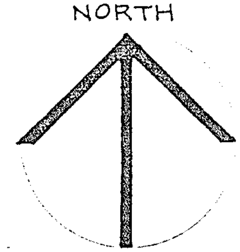


FIG. 4-2
BETSWORTH
PLAN OF
SUBDIVISION

Castlewood Homes designed and received civic approval for a 72-house subdivision on the land in 1978. The Betsworth street pattern and lot orientation is shown in Figure 4-2. Most of the lots are 50 feet by 110 feet (15.24 m. by 33.53 m.) or 55 feet by 100 feet (16.76 m. by 30.48 m.). Note, however, that several lots located on the curve of a street are non-rectangular in shape.

As discussed in Chapter III, an unobstructed southern orientation is essential for the proper functioning of a passive solar home. House or lot orientation is not a criterion in conventional subdivision design, however. Conventional design is the product of compromises between the economic needs of the private developer and the adequate provision of municipal services such as sewer, water, transportation and parks. To an already long list of constraints on the Sunnyvale design, was added the only non-conventional demand: an unobstructed southern orientation for each of its houses. The challenge of the subdivision design process was to meet the essential demand for proper orientation without sacrificing the conventional requirements imposed by the Betsworth subdivision.

The first step was the determination of the scope of the solar-orientation needs of a Sunnyvale home. This is the subject of the following section.

4.2 Solar Access Needs: The Sunscape

There are no suggestions in the literature as to the solar exposure requirements of a passive solar home. The question is rarely raised, with most authors implicitly assuming that once built, a solar home will receive all possible sunlight from sunrise to sunset. However, given the construction of several dozen solar homes in an urban area, and the need to meet certain planning constraints, the assumption is no longer valid. It would be theoretically possible to custom-design a solar home to take advantage of only a small number of sunlight hours a day. However, one of the aims of the Sunnyvale design exercise was to develop a simple, standardized method of determining solar access protection requirements which would eliminate the need to custom-design every house prior to the subdivision design step.

A planning tool had to be developed for this purpose. The product of the exercise, discussed below, is called the sunscape.[1] A sunscape describes the scope of solar access protection needs for each house in terms of angles and distances extending outward and upward from the south wall. Note that an individual sunscape need not be entirely within the property of a homeowner. The sunscape can be considered the energy-gathering zone of a solar home. If the home is to function properly, then the sunscape must be free from shade in the designated hours. To knowingly intrude upon it by placing a building tall enough to cast a shadow on the south windows of another home is equivalent to interrupting the flow of hydro-electricity or natural gas to a conventionally-heated house.

The precise dimensions of a sunscape are a function of five variables:

1. Hours of the day the collector or glazed area is to be shade-free;
2. Winter sun angles for the latitude;
3. Maximum allowable height of buildings and other structures to the southeast, south and southwest of the solar home;
4. Size and placement of glazed area on the solar house;
5. The terrain of the immediate area.

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[1]So far as can be determined, the term sunscape is used for the first time in the present study. Literally, it means "sun shape".

To determine the dimensions of the sunscapes in Sunnyvale, it was necessary to assume a reasonable value for each of the variables:[1]

1. <u>Hours of the day</u>:

Selected Value: From 9 a.m. to 2 p.m.

Ideally, a solar home would be able to collect solar radiation from sunrise to sunset during the winter heating season. But Sunnyvale is not an ideal situation. It must conform to the constraints of economic housebuilding and urban planning. The sunscape implies a restriction on land use, a height limitation so as to prevent a shading of glazed collector area. The longer the shade-free protected time during the day, the greater the size of the sunscapes in the subdivision and the greater the restrictions on land use.

Basic principles of passive solar heating suggest protection of the early morning sunlight. This would begin early the daily process of heating the thermal mass in the solar home. A complicating factor is that early-morning ice crystals and fog are common at sunrise in the Winnipeg winter climate. Therefore, 9 a.m. starting time, about 30 minutes after sunrise on the December 21 winter solstice, was selected.

By 2 p.m., the passive home already has received five hours of sunlight, including the most intense radiation period at noon. To extend the hours of protection would be to increase the size of the sunscape and place further restrictions on subdivision planning and density. In other words, the 2 p.m. selection represents a compromise between the need for

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[1]It should be emphasized that the present study is not an engineering or architectural investigation of solar homes. The values assumed for the variables are merely reasonable, not definitive. Therefore, the dimensions of the sunscapes derived from these values should not be interpreted as being definitive or necessarily sufficient for a solar home in Winnipeg. What the present study wishes to convey is the process by which a sunscape can be determined and applied in subdivision design.

sunscape protection, and the need to achieve the target value for subdivision density.

Two additional factors that may affect a choice of shade-free protected hours for a particular location are the presence of diurnal cloud patterns and anticipated daily living patterns of the solar homeowners.[1] Firstly, if a location regularly experiences a predictable diurnal cloud pattern during the heating season, then designers of passive solar homes should take account of the pattern when selecting the protected hours for the sunscape. Cities in inter-mountain valleys and adjacent to large bodies of water frequently have such diurnal cloud patterns. No significant cloud pattern exists in Winnipeg in winter, and so the factor can be safely ignored in the Sunnyvale case.[2]

Secondly, the patterns of daily use of a solar home may have an effect on the selection of protected hours. If all persons living in the house are away from it from early morning to late afternoon, then it may be beneficial to alter the protected hours so as to take advantage of all the afternoon solar radiation until sunset. Thus, the optimal protected hours in such a case may be from 11 a.m. until 5 p.m.. A different set of protected hours, of course, will create a different pattern of sunscapes within the subdivision, and may allow lesser, or greater flexibility in subdivision design.

2. Winter sun angles:

Selected Values: Minimum solar noon of 22 Degrees, due south;
9 a.m.: 10 Degrees Alt., S 43 Degrees East;
2 p.m.: 17 Degrees Alt., S. 30 Degrees W.

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[1]My thanks to Prof. John Welch for suggesting the potential importance of these two factors.

[2]Personal communication, Prof. A.J.W. Catchpole, Department of Geography, University of Manitoba, March 9, 1979.

Throughout the winter heating season, the sun rises in the south-east, reaches its maximum height for the day at noon, and then sets in the southwest. Sun path diagrams for various latitudes are common in many technical books about solar energy. From such a diagram, it is relatively simple to determine the height of the sun above the horizon (solar altitude) and its position relative to a south-facing wall (solar azimuth) for the 21st day of every month and for any hour of the day.

Ideally, a solar home should be able to receive sunlight on December 21, the winter solstice. This is the "worst case", the day when the sun is lowest in the horizon. If a solar home receives sunlight on this worst day, it will be in a position to receive sunlight every day. Winnipeg is located on approximately 50 degrees n. latitude. The solar noon altitude on the winter solstice is 17 degrees, extremely low to the horizon. A sun-scape based on the "worst case" is extremely large.

The December 21 sunscape angles are unnecessarily protective. They impose severe restrictions on urban planning by requiring a large shade-free zone. In return, they provide sunlight for only a small number of days during the heating system.[1] Based on the work of a professional architect experienced in passive solar design, a solar noon altitude of 22 degrees was selected as the maximum level of protection.[2] An altitude of 22 degrees corresponds approximately to the sun's position at noon on November 21 and January 21. Therefore, a Sunnyvale sunscape will be partially shaded in the mornings and afternoons from November 21 to January 21, although it will

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[1]Late December days are often overcast in Winnipeg, and would be of little use to a solar home even if the sunscape were designed with winter solstice sun angles.

[2]Personal communication, Bill Reid, July 18, 1978, Winnipeg.

never be entirely shaded all day during this period.

Given the selected noon altitude, the corresponding solar altitudes and azimuth angles for 9 a.m. and 2 p.m. were determined from sun path diagrams.[1] These values were previously listed.

3. Height of Other Buildings:

The greater the maximum permitted height of other buildings to the southeast, south and southwest of a solar home, the further apart must be the homes to prevent shading of sunscapes. In the conventional Betsworth subdivision, the maximum height was 35 feet (10.67 m.). However, it was determined that the homes in Sunnyvale would have a maximum height of 25 feet (7.62 m.). There were two reasons for this: firstly, few single-family homes in Winnipeg are built as high as 35 feet. The following are the typical heights of various forms of housing in Winnipeg, based on a survey of homes recently constructed by six large housebuilding companies:[2] bungalows: 14 to 16 feet (4.27 to 4.87 m.); split-levels: 17 to 19 feet (5.18 to 5.79 m.); bi-levels: 18 to 19 feet (5.49 to 5.79 m.); and two storey homes 23 to 25 feet (7.01 to 7.62 m.).

Secondly, a reduced height limit allows houses to be placed more closely together, an essential step in achieving the density target of 72 dwelling units.

4. Size and Placement of Glazed collector area:

The wider the south-facing windows of a passive solar home, the wider will be the sunscape. A value of 25 feet (7.62 m.) was selected as a reasonable figure.

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[1]See for example, Bruce Anderson, Solar Energy: Fundamentals in Building Design, (New York, McGraw-Hill, 1977) p. 316.

[2]Personal communication, Mr. Irwin Torry, Department of Environmental Planning, City of Winnipeg, March 12, 1979.

The height of the top of the glazed area is not relevant to the sunscape. However, the height of the window sill above ground level is an important variable. The higher above ground is the base of the window area, the closer may be the houses. For the Sunnyvale sunscapes, it was assumed that the window area was three feet (0.9 m.) above ground, corresponding to approximate first floor elevation. The low window level is a recognized passive solar energy design technique:

> "Care must be taken with thermal mass to ensure that it is directly irradiated by the sun during the period of interest. In the low sun angles experienced in the winter months, little sun will strike thermal mass in the floor in northern latitudes if the window does not extend almost to floor level."[1]

5. Terrain:

In some cities, the most important factor in determining the dimensions of sunscapes may be the terrain of the subdivision site. A south-facing downward slope would allow the solar houses to be placed closely together, because the sunscape of the house to the north, higher up the slope, would extend above and beyond houses immediately down the slope to the south. Conversely, a north-facing downward slope may eliminate the opportunity for a home to receive sufficient solar radiation for heating purposes. Sloping terrain has a great effect on the intensity of solar radiation received by a site. For example, a site on a ten-degree south-facing slope receives solar radiation equivalent to a horizontal site situated ten degrees latitude closer to the equator.[2]

The terrain variable was ignored in the Sunnyvale design exercise, however, because of the flat terrain of the Betsworth site.

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[1]Robert S. Dumont et al, "Passive Solar Heating: Results from Two Saskatchewan Residences", (Saskatoon, 1978) p. 18.

[2]Personal communication, Prof. John Welch, Winnipeg, February 20,1979.

Table 4-2 summarizes the values selected for the sunscape variables applicable to Sunnyvale.

The next step was to determine, in terms of distances and angles, the dimensions of the sunscapes relevant to Sunnyvale. There were three sunscapes to consider, depending on whether the maximum height of homes to the southwest, south and southeast of the passive solar home was 35 feet (Sunscape 1), 25 feet (Sunscape 2) or 20 feet (Sunscape 3).

Sunscape dimensions were determined by means of scale drawings and simple geometry. For 9 a.m., noon and 2 p.m. on the selected days, calculations were made of the minimum distances required to prevent shading of the solar-exposed window area. Figures 4-3 to 4-5 illustrate the calculations. Note the importance of the solar altitude variable in affecting the minimum separation distances among homes.

Table 4-3 summarizes the dimensions of the three sunscapes relevant to the Sunnyvale design exercise.

For each sunscape, the three distances and angles corresponding to 9 a.m., noon and 2 p.m. were combined to create a picture of the entire sunscape. Figures 4-6 to 4-8 illustrate the asymmetric boomerang-shaped sunscapes, seen in only a two-dimensional, overhead view. Recall, however, that the sunscape is a three-dimensional zone extending upward and outward from the solar home's south wall.

Following determination of its dimensions, the sunscape was able to be used as a solar subdivision design tool. Once the 35-foot sunscape had been drawn in for a particular lot in the subdivision, for example, an area was outlined in which no 35-foot (10.67 m.) building could be placed. It is important to recall that the sunscape does not extend to ground elevation. The greater the sunscape's distance from its solar home, the

TABLE 4 - 2

SUMMARY OF SELECTED VALUES FOR SUNSCAPES

IN SUNNYVALE

Variable	Selected Value
Daily duration	9 a.m. to 2 p.m.
Winter sun angles[1]	9 a.m.: 10 Degrees Alt. S. 43 Degrees E. noon: 22 Degrees Alt. due south 2 p.m.: 17 Degrees Alt. S. 30 Degrees W.
Maximum Heights of buildings	25 feet (7.62 m.)
Size and placement of south-facing windows	25 feet (7.62 m.) wide; 3 feet (0.9 m.) above grade
Terrain	Level

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[1]As the text notes, the selected winter sun angles correspond to the approximate position of the sun on November 21 and January 21.

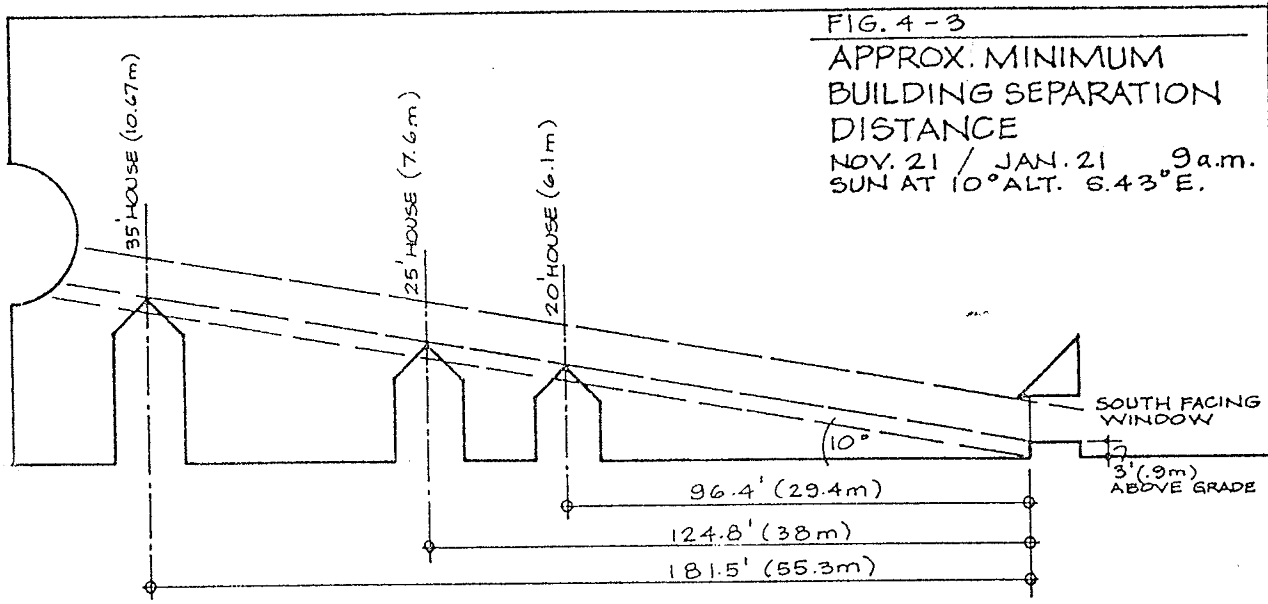

FIG. 4-3
APPROX. MINIMUM BUILDING SEPARATION DISTANCE
NOV. 21 / JAN. 21 9 a.m.
SUN AT 10° ALT. S. 43° E.

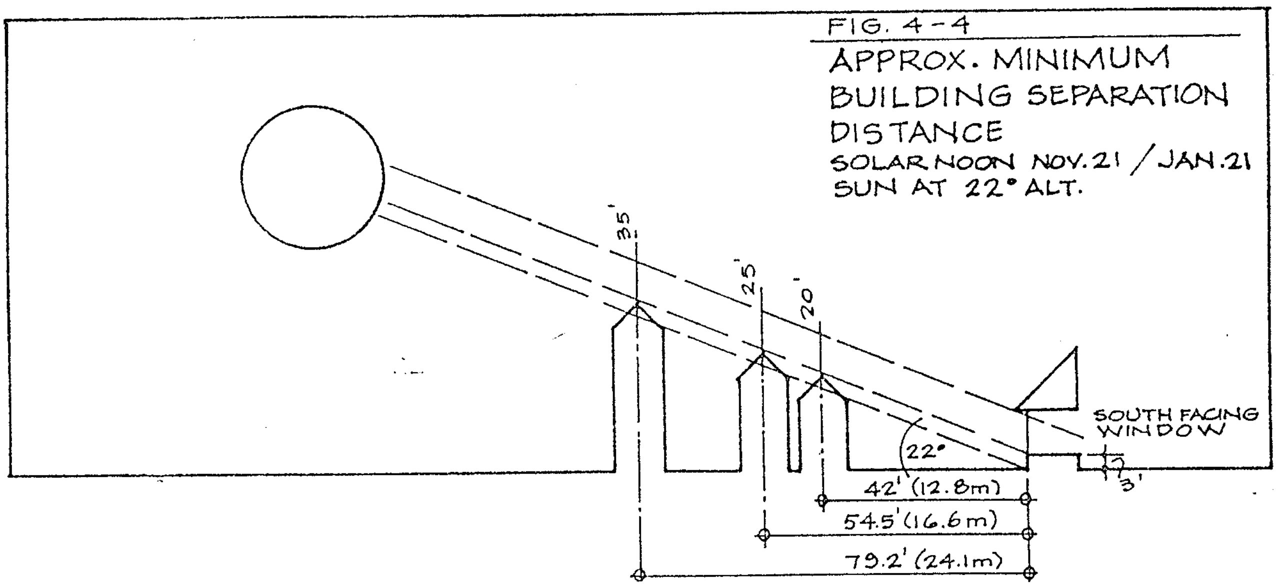

FIG. 4-4
APPROX. MINIMUM BUILDING SEPARATION DISTANCE
SOLAR NOON NOV. 21 / JAN. 21
SUN AT 22° ALT.

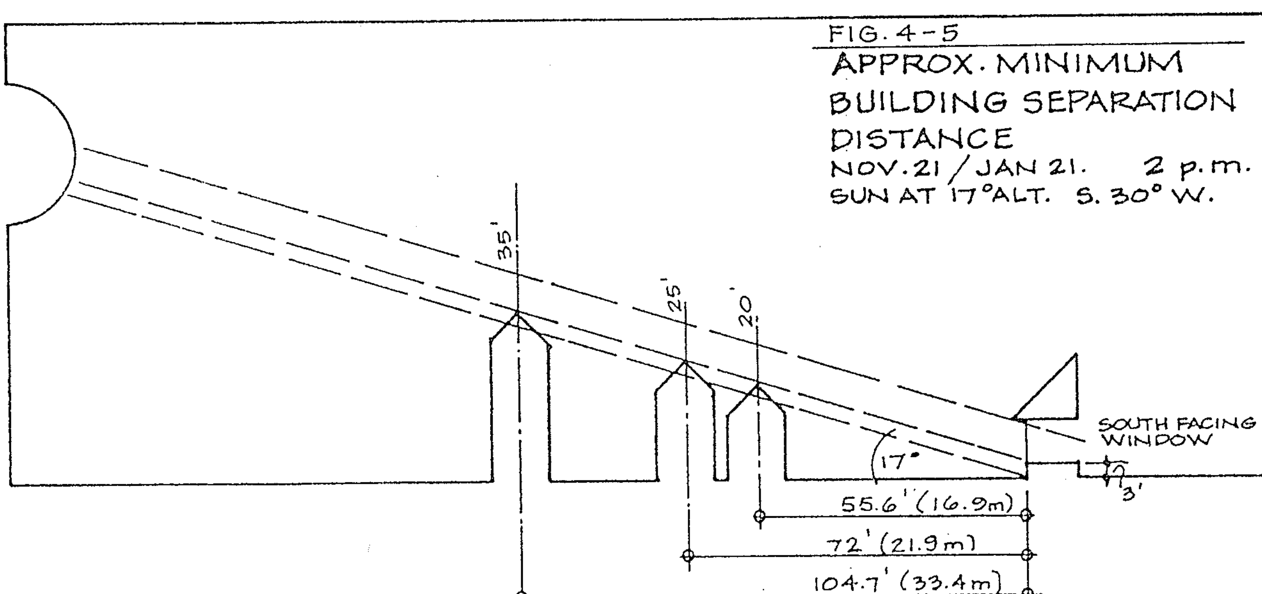

FIG. 4-5
APPROX. MINIMUM BUILDING SEPARATION DISTANCE
NOV. 21 / JAN 21. 2 p.m.
SUN AT 17° ALT. S. 30° W.

DRAWN AT 1" = 40'0"

TABLE 4-3

DIMENSIONS OF THE THREE SUNSCAPES

IN THE SUNNYVALE DESIGN EXERCISE

Height of Houses to Southeast, South or Southwest of Solar Home	Time of day		
	9 a.m.	Noon	2 p.m.
35 feet (10.67 m.)	181.5 feet (55.32 m.)	79.2 feet (24.14 m.)	104.7 feet (31.9 m.)
25 feet (7.62 m.)	124.8 feet (38.0 m.)	54.5 feet (16.6 m.)	72 feet (21.9 m.)
20 feet (6.1 m.)	96.4 feet (29.4 m.)	42 feet (12.8 m.)	55.6 feet (16.9 m.)

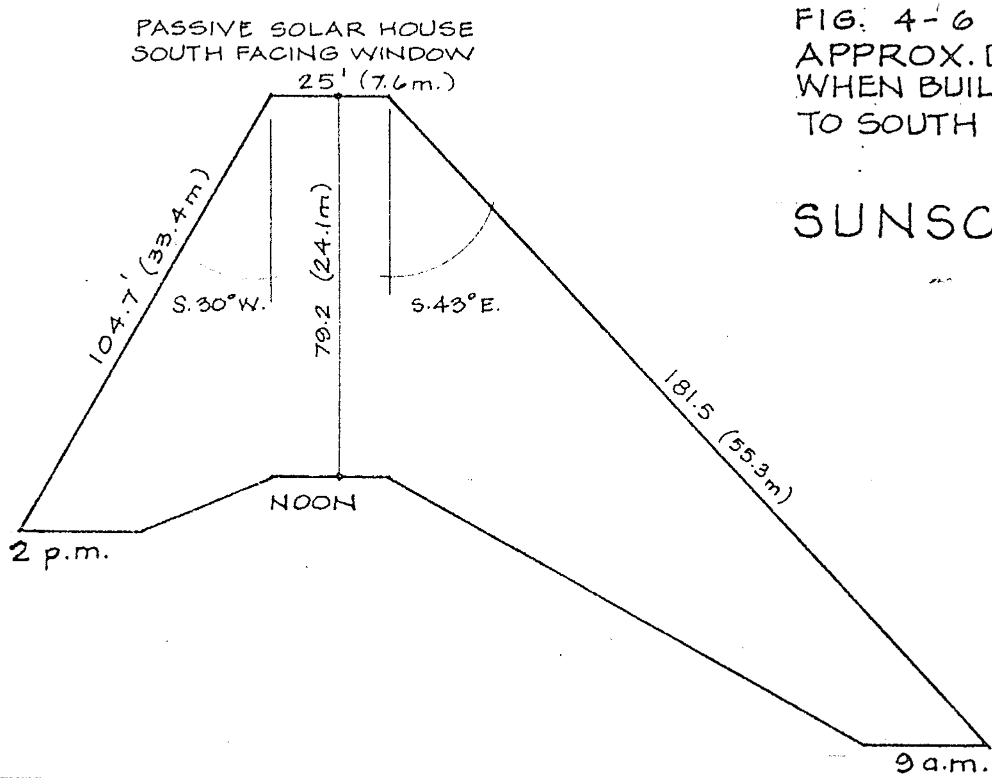

FIG. 4-6
APPROX. DIMENSIONS WHEN BUILDING HEIGHT TO SOUTH IS 35'(10.67m)

SUNSCAPE 1

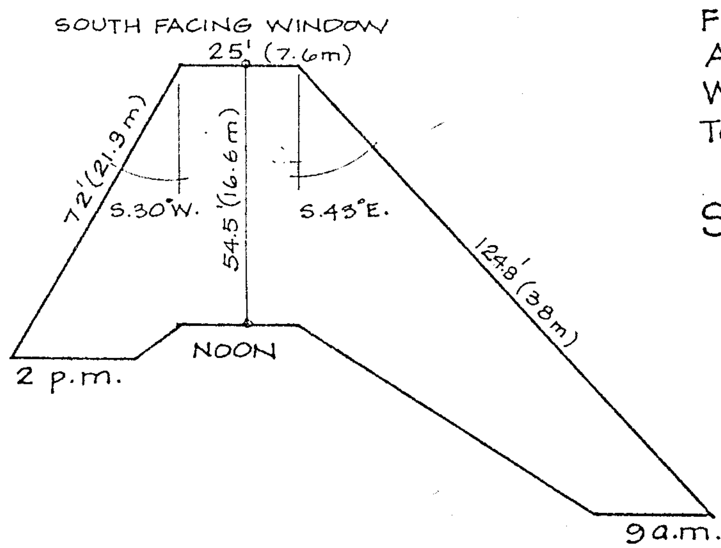

FIG. 4-7
APPROX. DIMENSIONS WHEN BUILDING HEIGHT TO SOUTH IS 25'(7.6m)

SUNSCAPE 2

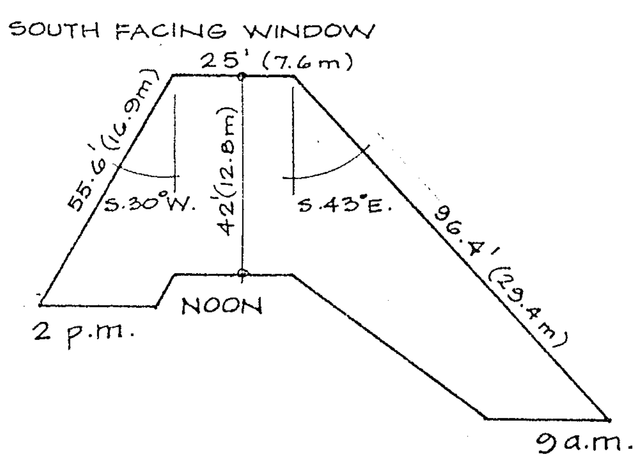

FIG. 4-8
APPROX. DIMENSIONS WHEN BUILDING HEIGHT TO SOUTH IS 20'(6.1m)

SUNSCAPE 3

DRAWN AT 1"=40'-0"

greater its above-ground elevation. Consequently, consideration of sunscapes alone eliminated the need to consider the shading effects of other houses in the subdivision. Calculations of the sunscape's dimensions already accounted for possible shading from other subdivision buildings from 9 a.m. to 2 p.m.

4.3 Design of Sunnyvale

The sunscape tool permitted a simple, standardized method of determining appropriate placement of houses of various heights so that all houses in the subdivision would have an unobstructed solar access.

The first stage in determining the design of Sunnyvale was to apply sunscape analysis to the Betsworth subdivision plan. If the sunscape protection criterion were able to be met in the conventional plan, then solar subdivision planning would likely be compatible with many features of conventional subdivision designs. Subdivision planning would therefore not represent a significant barrier to the subdivision delivery system. However, if sunscape protection were not provided for all lots in Betsworth, then design changes would have to be made. Results from the sunscape analysis of Betsworth would provide clues to more appropriate street patterns and lot configurations.

Figure 4-9 illustrates the sunscape analysis of the Betsworth plan. The three major sunscapes are shown in various parts of the subdivision. Several conclusions can be drawn from the results:

i) Firstly, note that if the houses are built to the maximum allowable height under the zoning bylaw, 35 feet, then most of the lots in Betsworth would not receive sunscape protection. The intrusion of buildings into sunscape space is most noticeable along the north-south streets. However, even if the lots are back-to-back fronting onto east-west streets, sunscape

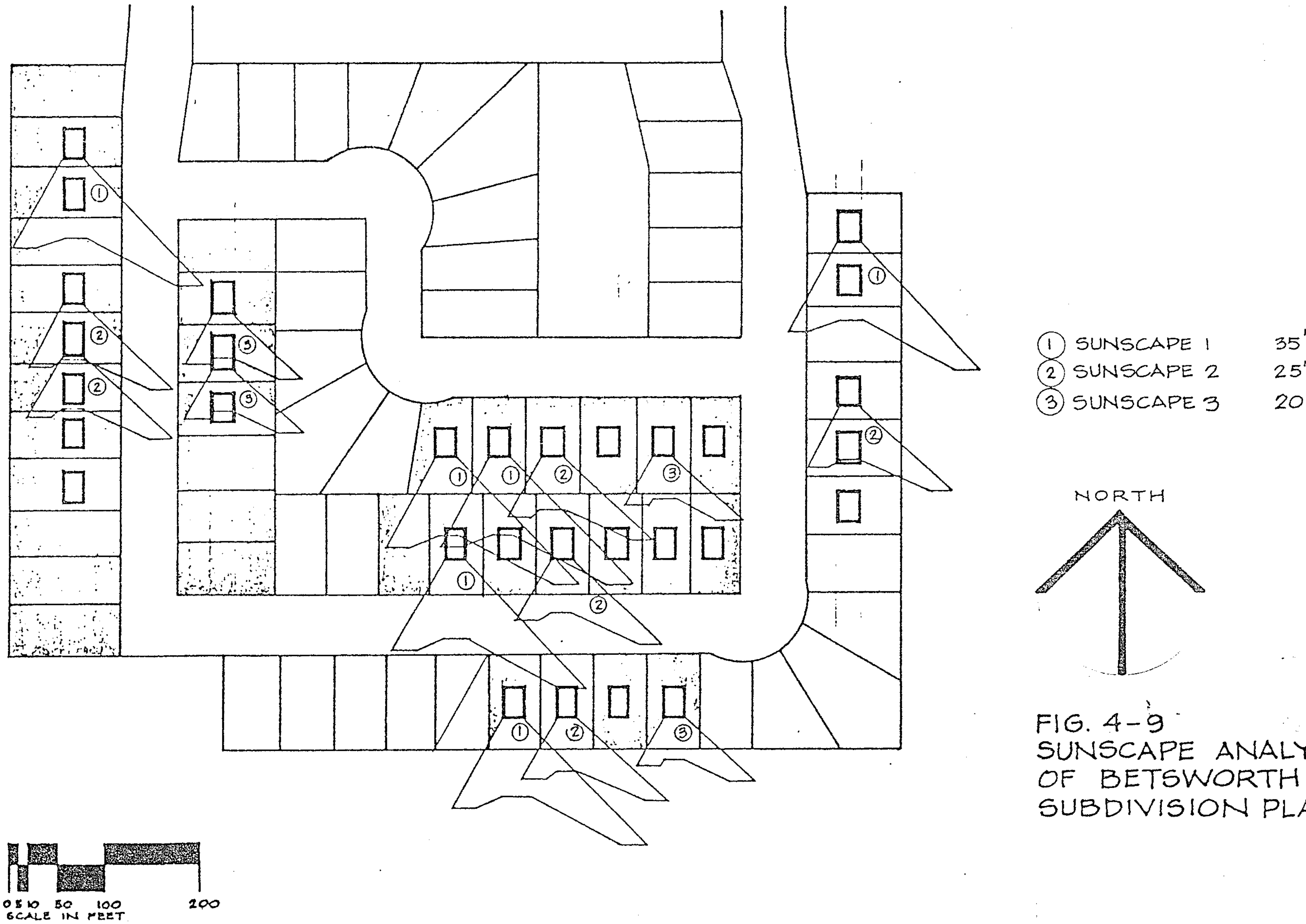

FIG. 4-9
SUNSCAPE ANALYSIS
OF BETSWORTH
SUBDIVISION PLAN

protection would not be provided for most of the houses along the northern row. A house height of 35 feet imposes severe restrictions on the subdivision plan.

ii) If house heights in the subdivision are 25 feet, a common height of two-storey homes in Winnipeg, then sunscape protection is provided for all of the homes on back-to-back lots fronting onto east-west streets. However, homes fronting onto north-south streets still fail to receive adequate sunscape protection, as was the case with 35 feet high houses.

iii) Finally, note that a reduction of house heights to 20 feet, further reduces the land-use restrictions imposed by the sunscapes. (As noted previously, the 20-foot height limit would still be high enough to accomodate most bungalows, split-levels and bi-levels built in Winnipeg). As was the case with houses 25 feet in height, sunscape protection will be provided for all lots on east-west streets. However, most homes fronting onto north-south streets would still experience sunscape shading from homes to the south of them. The extent of the shading is not as severe as with 25-foot or 35-foot houses and it may be possible, in isolated cases, to protect some of the sunscapes through careful siting of the houses on the lots. Generally, however, part of the 20-foot home to the south will intrude into the sunscape of the neighbouring home to the north.

Another important aspect to note of the sunscape analysis in Figure 4-9 is the intrusion of sunscapes along the eastern and southern subdivision borders into adjacent vacant land. Future use of the vacant land is beyond the control of the developer of the subdivision. Therefore, future sunscape protection for homes along the eastern and southern borders is not assured. For example, townhouses may be built at some future date on the vacant property, shading the south-facing walls of the solar homes and reducing the effectiveness of the solar heating systems.

The previous analysis suggested several design changes that could be accomodated in the hypothetical Sunnyvale subdivision in order to satisfy the sunscape protection criterion for all lots.

Firstly, a solar subdivision would attempt to maximize the number of east-west streets and reduce the number of lots fronting onto north-south streets to a minimum. The latter generally fail to provide sunscape protection even if a 20-foot height limit is imposed on the houses. Recall that in Chapter III, the suggestion was noted that "on north-south streets (houses) may be staggered on their respective sites, so that adjacent structures do not fully obstruct the southern horizon."[1] However, conventional R1 zoning in Winnipeg provides for standard setback requirements, and could not accomodate the staggered lots on north-south streets.

Secondly, a solar subdivision could not permit homes as high as 35 feet to be built. Few lots in Betsworth were provided sunscape protection with 35-foot houses. Instead, limits of 25 feet and 20 feet would need to be accepted for solar subdivisions. Given the common heights of one and two-storey homes recently built in Winnipeg, a 25-foot limit would not be a significant disruption to established design practices of the private house-building sector. Single-family homes are rarely 35 feet high; the 35-foot value obtains its significance only because it is the maximum permissible height under conventional single-family housing zoning.

Finally, note that in Figure 4-9, few sunscapes extend into the public park space in the northeast area of Betsworth. From a solar energy perspective, the park is an unproductive area. A solar energy subdivision would try to put the park to use in order to protect some of the sunscapes.

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[1]CMHC, The Conservation of Energy in Housing, p. 21.

The open space could provide sunscape protection in the hypothetical Sunnyvale design if it had an east-west orientation and were located further south in the subdivision property. The altered location may allow an increase in the number of lots along east-west streets, and a consequent decrease in lots fronting onto north-south streets.

Two of these three design changes, imposing a 25-foot house height limit and relocating the park space, could be accomodated easily within the conventional zoning and design constraints of the Winnipeg subdivision delivery system. However, the third change, concerning the staggered placement of houses on lots fronting onto north-south streets, required a change in zoning for the solar subdivision. The standard setback requirements of the R1 zoning in Betsworth could not accomodate the staggered placement of houses.

Therefore, a review was made of the residential zoning bylaws of the City of Winnipeg in order to determine whether sufficient flexibility in lot configuration and siting of houses existed under another form of zoning. It was concluded that the R-PL Planned Residential District zoning bylaw[1] provided the desired flexibility. (The entire bylaw is reprinted in Appendix 1). The R-PL form of zoning was introduced:

> "...to provide for a comprehensive approach to the development of single-family housing where the location and design of the individual dwelling units is an integral part of the planning and design of the overall district, which also includes vehicular and pedestrian circulation systems, services, recreation areas, open spaces, and public and private landscaping."[2]

Special orientation requirements of the dwelling units are more easily accomodated under the R-PL zoning than under R1 zoning. This

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[1]City of Winnipeg Bylaw 1431/76; amended by Bylaw 1967/78.
[2]ibid., p. 3.

flexibility makes the bylaw useful in the siting of houses in a solar subdivision, where the "location and design of the individual dwelling units is an integral part of the planning and design of the overall district...."

The R-PL zoning permits the placement of dwelling units along the property line, without setback requirements, providing certain minimum yard and private space requirements are met.[1] Minimum lot size is 2,500 square feet (232.25 square m.). Lots may be oddly-shaped, providing all the yard requirements are met. Maximum height of the houses is 35 feet (10.67 m.). Six feet high (1.83 m.) fences are allowed.

It was determined that R-PL zoning would be used in the design of Sunnyvale for those lots where conventional house orientation did not provide sufficient sunscape protection. However, consistent with lot sizes in Betsworth, the R-PL designated lots were assumed to have an area of 5,500 square feet rather than the minimum of 2,500 square feet permitted under the R-PL bylaw.

The next stage in designing Sunnyvale was to experiment with various street patterns and lot configurations using the sunscape tool.

Figure 4-10 illustrates how the R-PL zoning provisions were put to use in the solar subdivision design. Along north-south streets, the houses were sited in a staggered manner as suggested by the CMHC study, resulting in L-shaped lots. However, it was determined that the L-shaped lot configurations failed to provide adequate sunscape protection if all the houses were assumed to be 35 feet (10.67 m.) in height.

It was determined that if all houses along a north-south street were to receive complete sunscape protection, then a lower height limit would need

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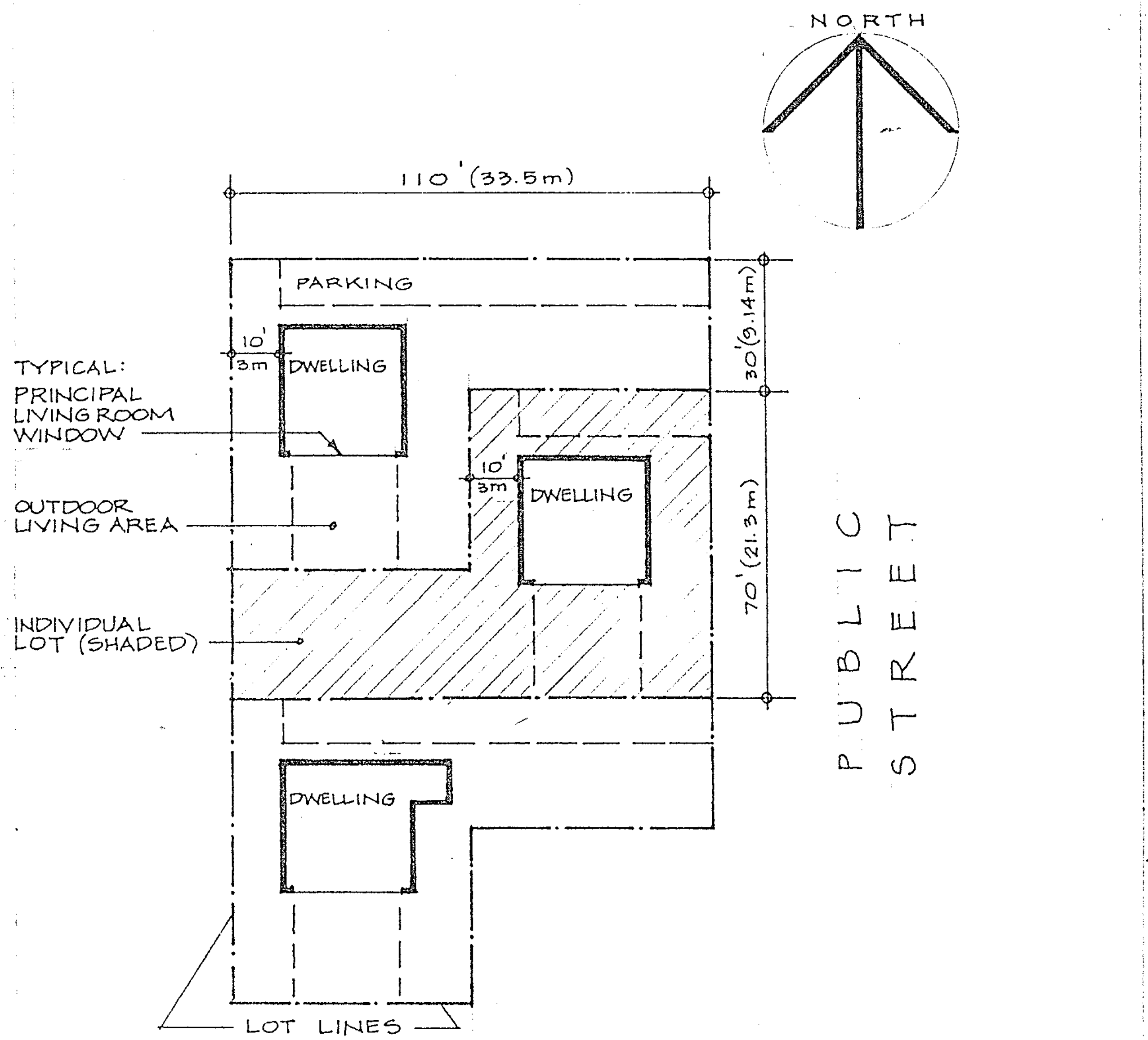
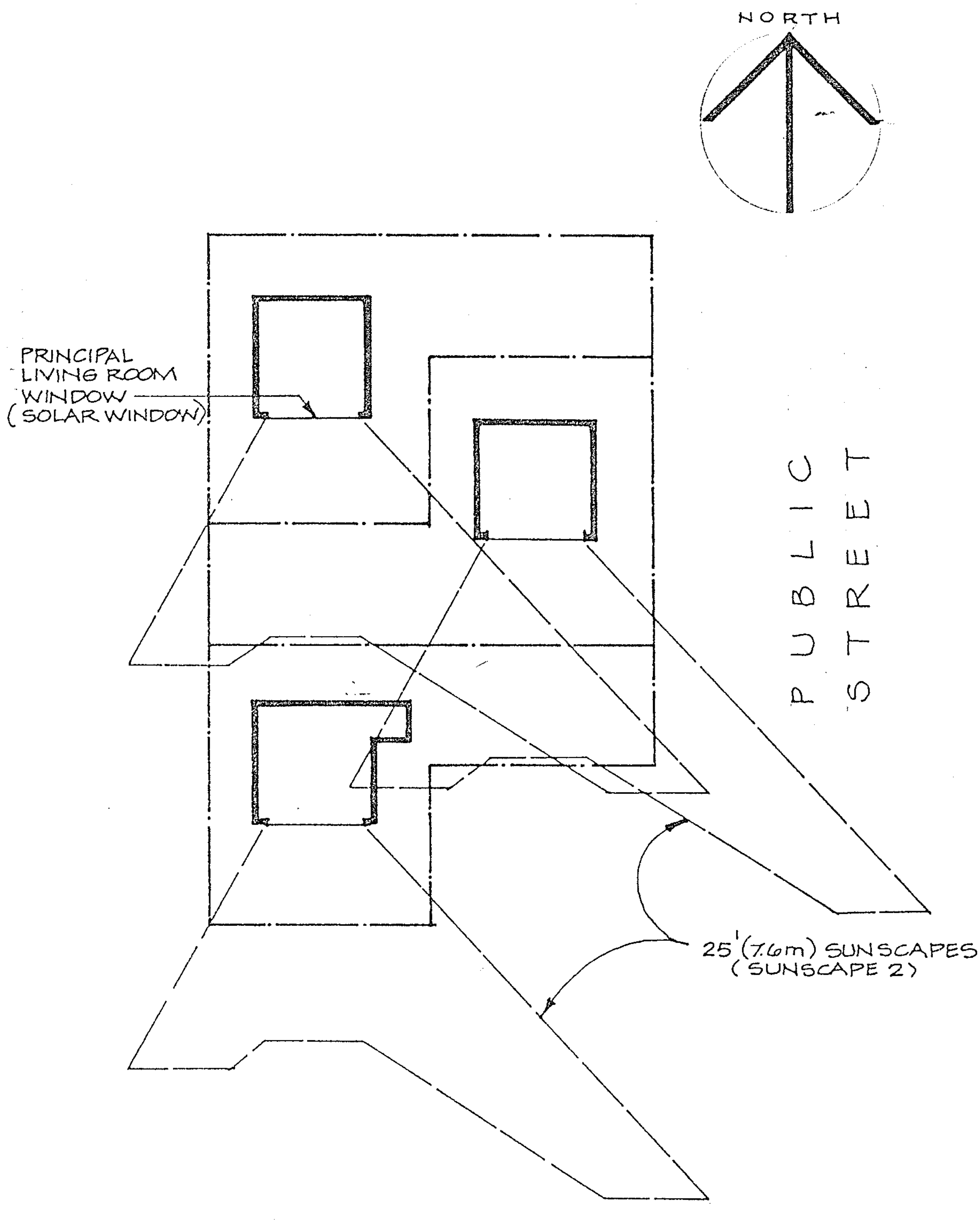
[1]For this reason, the zoning is also known as Zero-lot line zoning.

FIG. 4-10
USE OF R.P.L. ZONING ALONG NORTH-SOUTH STREETS



SCALE: 1" = 40'0"
1 cm = 4.8m

FIG. 4-11
SUNSCAPE ANALYSIS OF PROPOSED R.P.L. ZONED LOTS



SCALE: 1" = 40'-0"
1cm = 4.8 m

to be imposed. A limit of 25 feet (7.62 m.) was selected for these cases. Figure 4-11 illustrates the pattern of 25 feet sunscapes on the L-shaped lots fronting onto north-south streets. Adequate sunscape protection is provided. Note than in Figure 4-11, one sunscape extends over a corner of a home to the southwest. The sunscape will be protected from shading only if that corner of the house is somewhat lower than 25 feet.

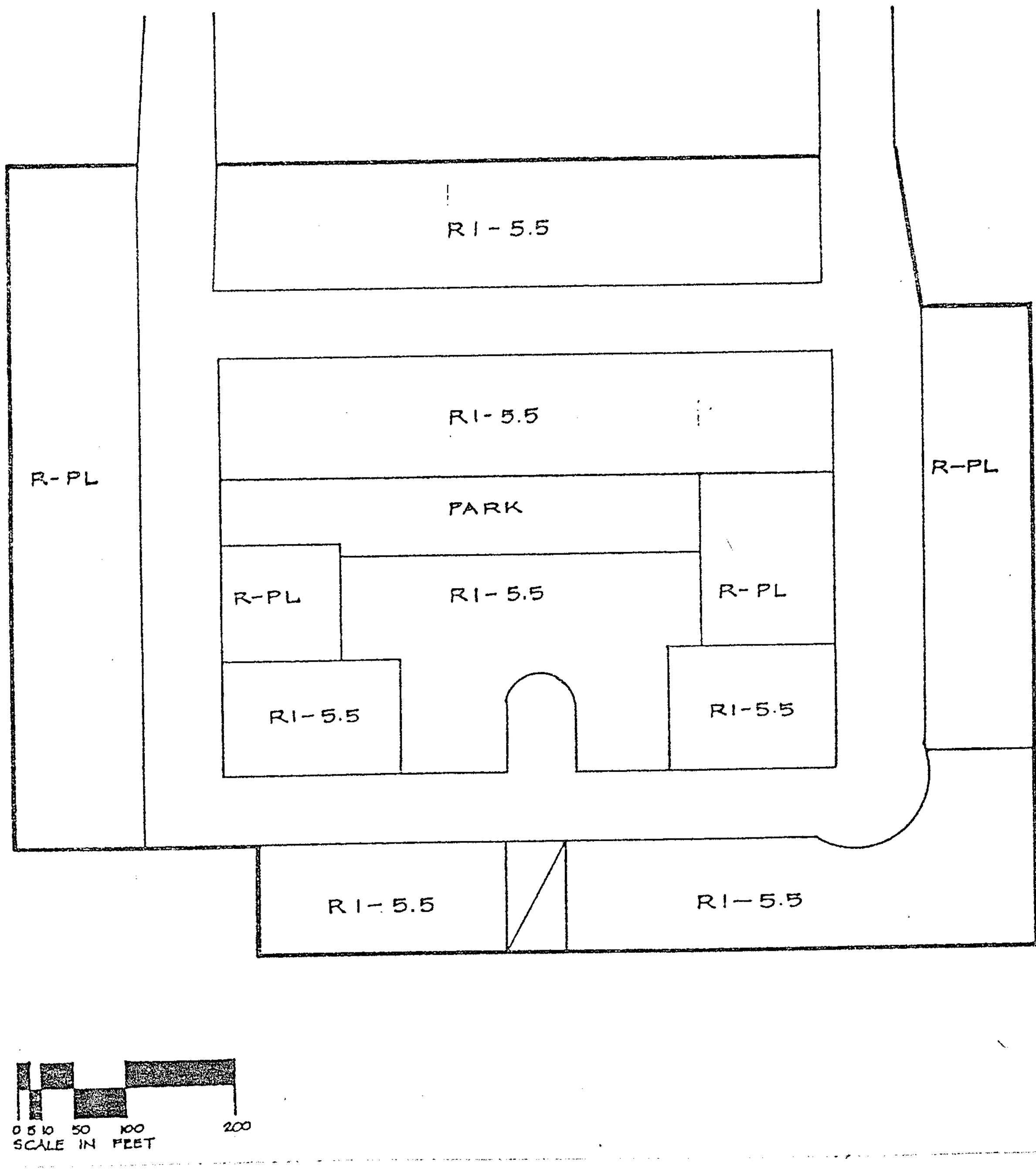
Following a sunscape analysis of various street patterns and lot configurations, one design was derived that satisfied both the primary constraints imposed by the Betsworth plan and the sunscape protection constraint. This design was selected to be the Sunnyvale design. The proposed street pattern and zoning are indicated in Figure 4-12. Lot lines for the subdivision are illustrated in Figure 4- 13. Houses on all lots have a maximum height of 25 feet (7.62 m.). All lots may have a six foot (1.83 m.) fence along their property lines.

Figure 4- 14 illustrates the pattern of 25-foot sunscapes on the Sunnyvale plan.

4.4 Analysis of the Sunnyvale Design

Table 4-4 summarizes the Sunnyvale design features and compares its design with the target values of the conventional subdivision plan of Betsworth. Most of the target values have been met. The densities of each subdivision plan are the same: 72 dwelling units with minimum lot size of 5,500 square feet (511 sq. m.). Sunnyvale was also able to satisfy constraints of the Betsworth design regarding area of public park space, the width of public right-of-ways and the height of private fences.

The proposed zoning for the solar subdivision differed by the addition of R-PL designation for 25 lots. It was determined that the R1-5.5 zoning of Betsworth failed to provide sufficient flexibility in lot configurations for



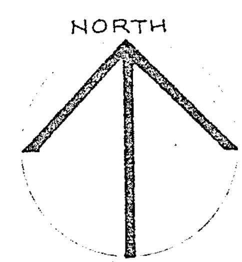
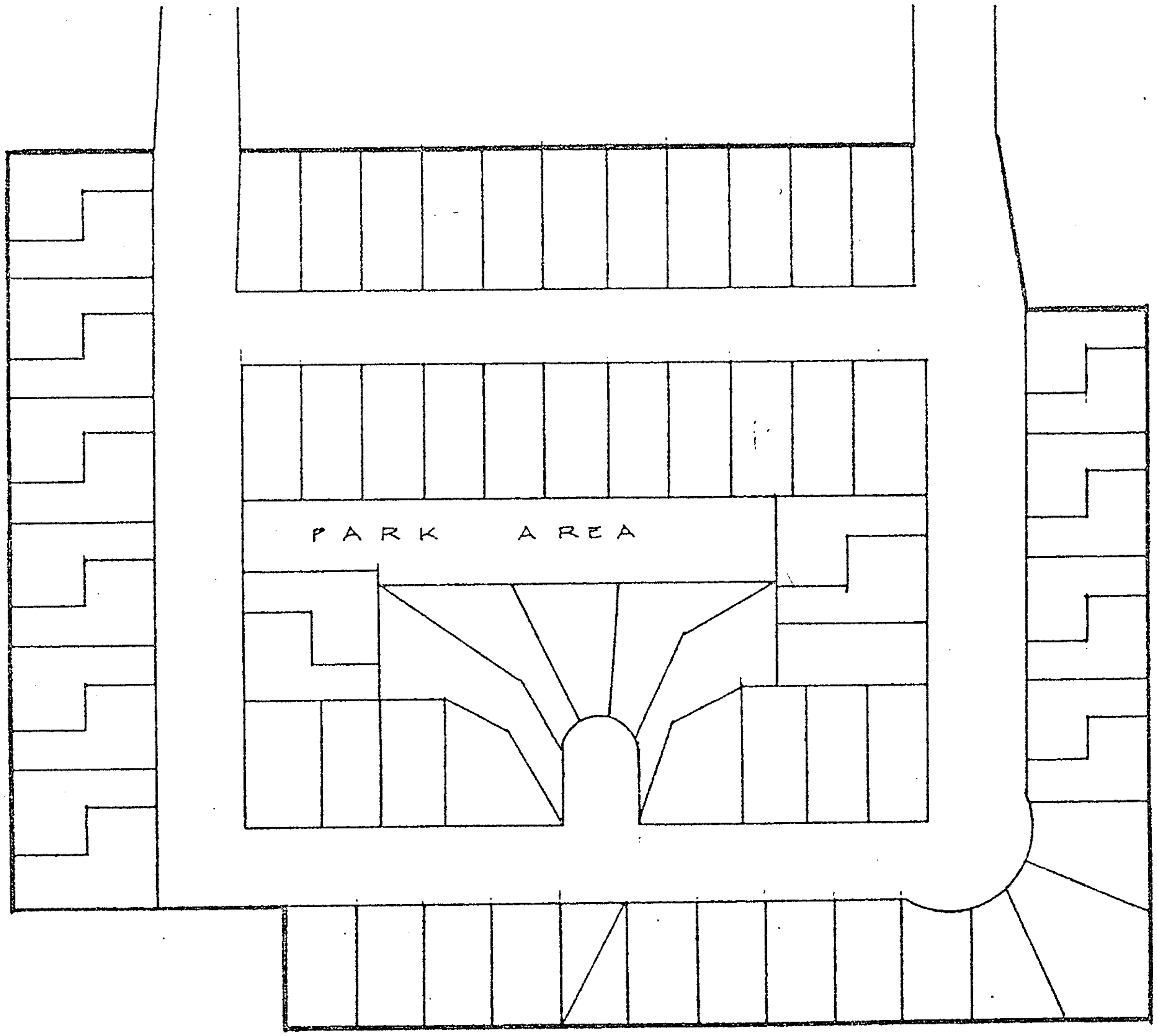


FIG. 4-12
SUNNYVALE
PROPOSED DESIGN
AND ZONING



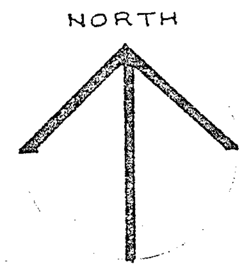
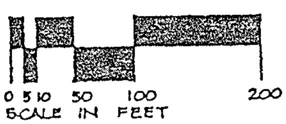
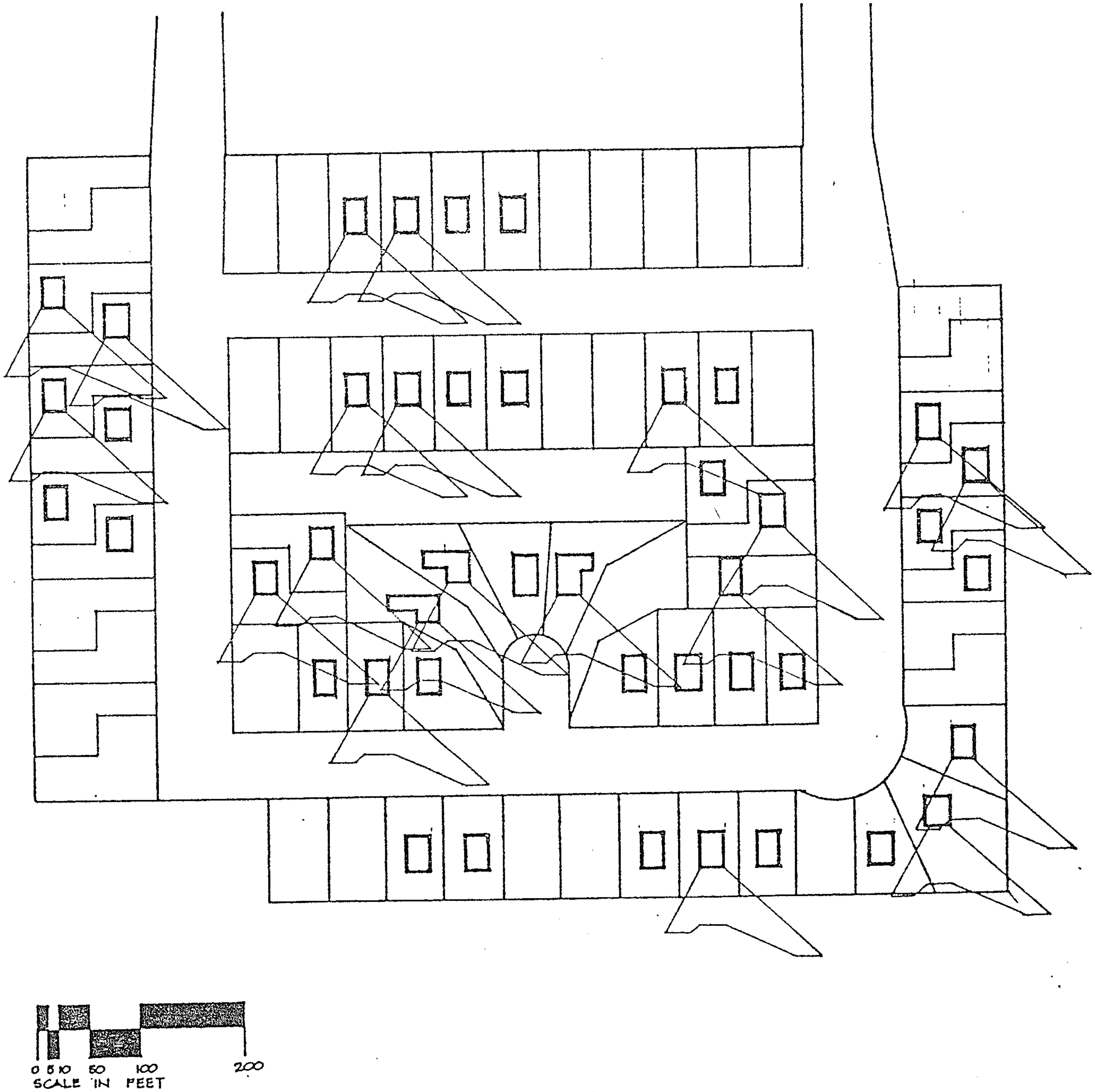


FIG. 4-13
SUNNYVALE
PROPOSED LOT LINES





ANALYSED USING
SUNSCAPE 2 ONLY

25' MAX. BUILDING HEIGHT

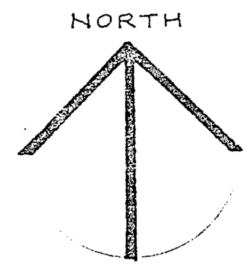


FIG. 4-14
SUNSCAPE PATTERNS
IN PROPOSED
SUNNYVALE
SUBDIVISION

TABLE 4-4

COMPARISON OF SUNNYVALE AND BETSWORTH

SUBDIVISION PLANS

Constraint	Betsworth	Sunnyvale
Number of dwelling units	72	72
Lot size	5,500 sq. ft. (511 sq. m.)	5,500 sq. ft. (511 sq. m.)
Zoning		
Zoning	R1-5.5	R1-5.5 (47 lots) R-PL (25 lots)
House height	Max. 35 feet (10.67 m.)	Max. 25 feet (7.62 m.)
Public open space	1.5 acres (6,070 sq. m.)	1.5 acres (6,070 sq. m.)
Public right-of-ways	60 feet (18.29 m.)	60 feet (18.29 m.)
Fences	Max. 6 feet (1.83 m.)	Max. 6 feet (1.83 m.)
Orientation	Not applicable	Adequate sunscape protection for all 72 dwelling units
Landscaping	None	Restrictions on planting of conifers

sunscape protection along north-south streets. The R-PL zoning bylaw of the City of Winnipeg, with its emphasis on the relationship between the design and orientation of an individual house, and the planning of the overall district, provided the required flexibility.

A maximum height limit of 25 feet (7.62 m.) was also introduced for all 72 lots in Sunnyvale. The lower limit was of particular importance for houses along north-south streets. It was determined that the 25-foot height limit imposed no serious barrier to the housebuilding company, because even two-storey houses can be built within the limit.

Sunnyvale also required restrictions on landscaping within the subdivision. Coniferous trees would not be permitted where they would intrude, either presently or in the future, into a sunscape.

Figure 4-14 illustrates that the sunscapes of homes along the eastern, southern and western borders of the subdivision intrude into adjacent property. The problem of protecting these sunscapes against future development of the adjacent property was ignored at the design stage. It is considered in detail in Chapter VII.

It was further determined that the street pattern and lot configurations proposed for Sunnyvale would not increase costs relative to Betsworth of installing services such as sewer and water lines.[1]

Despite favourable comparison between the Sunnyvale and Betsworth plans on the above design variables, significant design problems remained in the central area of the Sunnyvale plan. In figure 4-14, the central area is bounded on all sides by streets, and contains the park space. Firstly,

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[1]Personal communication, Harry Cochran, Sept. 6, 1978. Mr. Cochran is a municipal engineer with Underwood McLellan Ltd., consulting engineers on the Betsworth subdivision project.

consider the shape and access of the Sunnyvale park. Although it is approximately the same area as required by the Betsworth target value, the Sunnyvale park has been moved to the central area and given an elongated shape in an east-west orientation. The new location and shape provides sunscape protection for the eleven lots immediately to the north. However, the long,narrow shape places severe restrictions on the use of the open space. Its width of about 70 feet (21.3 m.) eliminates its use as a football field or baseball diamond. The open space would likely remain as a passive park, with no sports facilities other than a children's playground. The Sunnyvale park also has poor access, with only one narrow entrance on its west side. The Sunnyvale park, therefore, compares unfavourably with the park in Betsworth, which has good access and a shape that permits a variety of uses.

Secondly, consider the five oddly-shaped lots fronting the cul-de-sac in the central area of the Sunnyvale subdivision. It is likely these lots are not as marketable as others in the subdivision because of their unconventional, and perhaps unattractive shape.

As a result of these design difficulties which detracted from the appearance of the central area, later efforts were made to re-design the central portion of the Sunnyvale subdivision. Figure 4-15 presents the results of one realistic option.[1] In this case, the developer of the subdivision has made a cash dedication payment to the City of Winnipeg in lieu of a land dedication. The cash dedication eliminates the need for a park space in the Sunnyvale subdivision, and allows greater flexibility in designing the central area. The cul-de-sac and oddly-shaped lots of the original Sunnyvale plan have been replaced by a T-shaped rectangular block, a relatively common feature in conventional subdivision design. The new design

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[1]Dr. John Welch and Irwin Torry of the Department of Environmental Planning, City of Winnipeg, suggested versions of the design shown in Fig.4-15

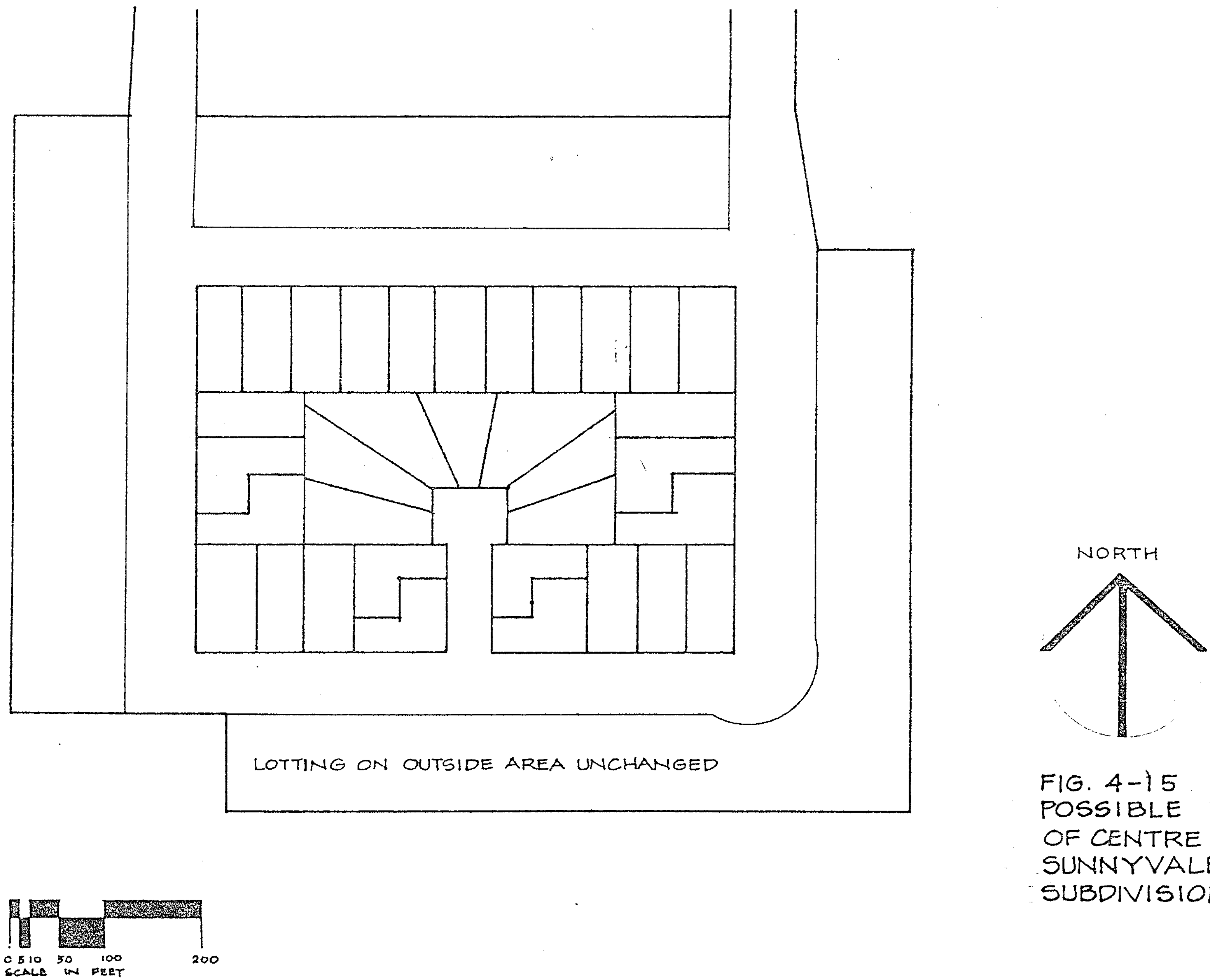

FIG. 4-15
POSSIBLE RE-DESIGN
OF CENTRE AREA
SUNNYVALE
SUBDIVISION

allows for more conventional pie-shaped lots, without sacrificing sunscape protection for any of the homes.

The re-design shown in Figure 4-15 allows for a total of 34 lots in the central area, five more than in the original Sunnyvale plan. It was estimated that the cash dedication for the 14.1-acre subdivision would cost the developer approximately $5,000 per undeveloped acre or $70,500 in total.[1] If the lots in the subdivision were selling at a relatively conservative level of $18,000 each, then the additional four lots would provide $90,000 in revenue for the developer, more than offsetting the costs of the cash dedication payment.

Figure 4-15 suggests that subdivision designers need not necessarily be burdened with the design weaknesses of the original Sunnyvale plan. Instead, there exists within present institutional practices such as the cash dedication, methods of providing a more aesthetically pleasing and marketable subdivision design that will not sacrifice sunscape protection nor reduce the profit margin of the private developer.

4.5 Sunscape Analysis of Urban Planning

The exercise of the present study was to design a hypothetical solar subdivision as a test case under real circumstances. However, the sunscape design tool derived in this chapter can also be applied to more general urban planning pattersn. This section will briefly examine sunscape analysis of typical planning patterns, again using the three sunscapes: for house heights of 35 feet, 25 feet and 20 feet.

4.5.1 Low Density Housing

It was determined in section 4.3 that in low-density house districts such as the Betsworth subdivision, sunscape protection is provided for all lots along east-west streets if the height of the house is limited to 25 feet

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[1]Personal communication, Mr. Stan Bailie, Development Agreements Officer, City of Winnipeg, April 18, 1979.

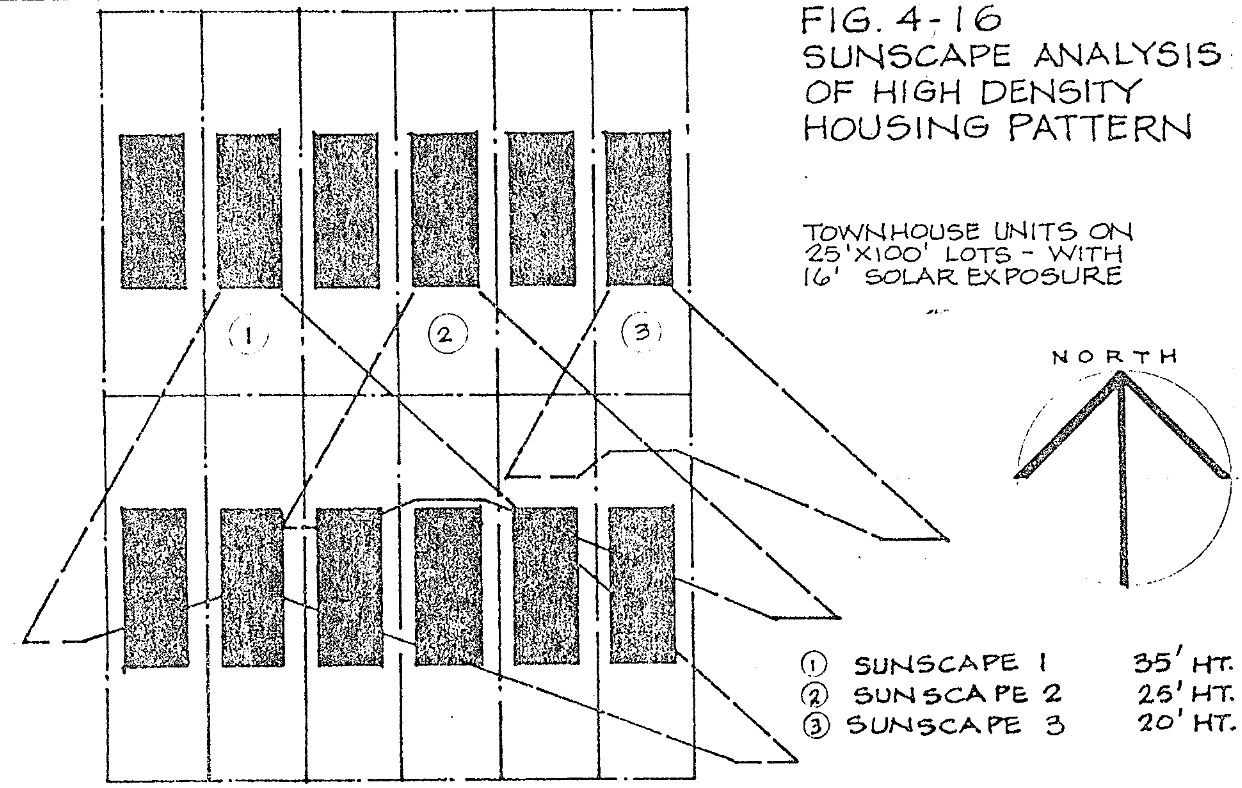

FIG. 4-16
SUNSCAPE ANALYSIS OF HIGH DENSITY HOUSING PATTERN

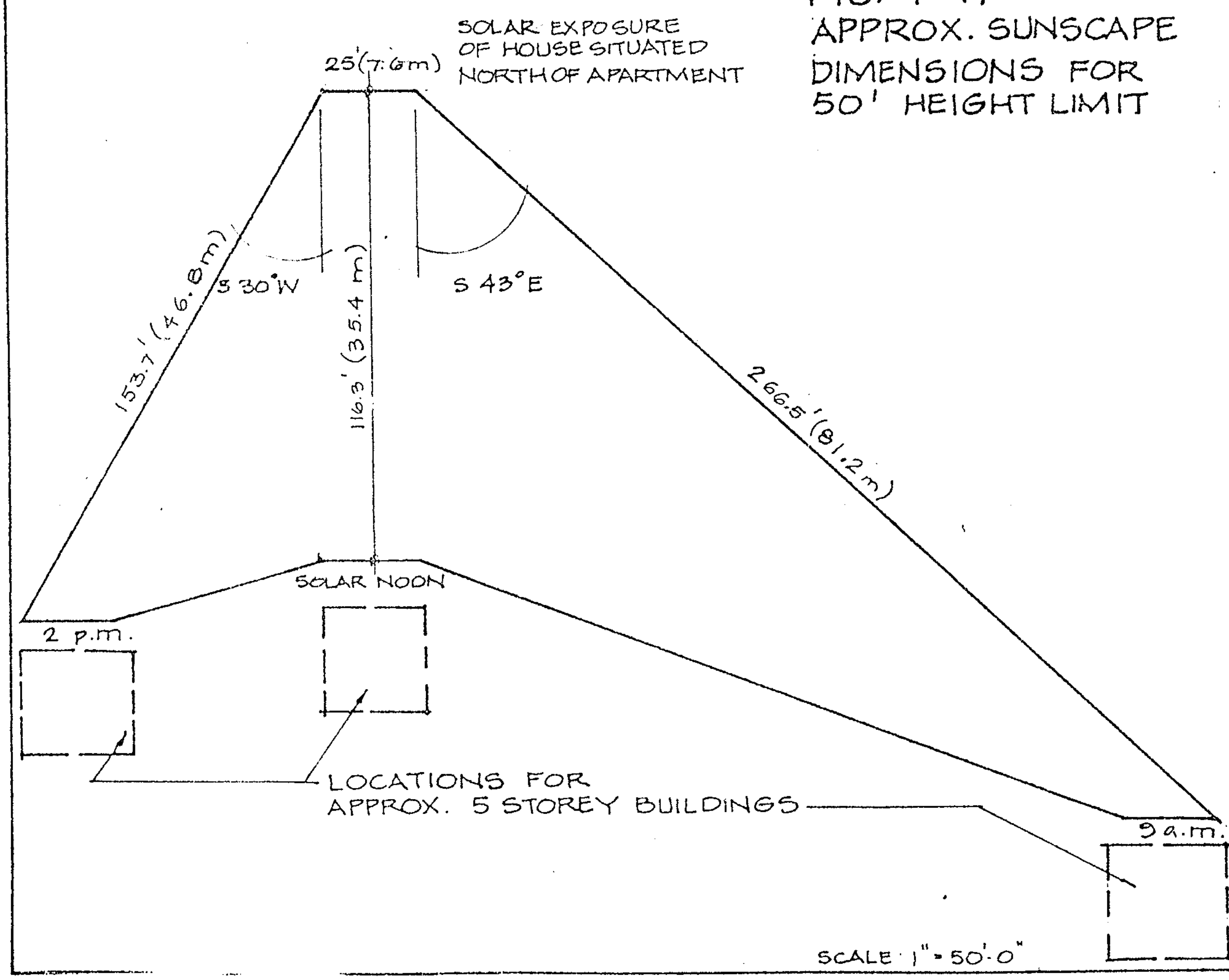

FIG. 4-17
APPROX. SUNSCAPE DIMENSIONS FOR 50' HEIGHT LIMIT

or less. If houses are built to the present legal maximum of 35 feet, then the sunscapes of homes along the northern row of back-to-back lots will not be protected. Along north-south streets, staggered siting of houses is required if the houses are to be built as high as 25 feet.

4.5.2 High Density Housing

Figure 4-16 illustrates the application of the three sunscapes on a high-density housing pattern. A lot size of 18 feet by 100 feet (5.5m. by 30.5 m.), typical for townhouses in Winnipeg, is assumed. Note that sunscape protection is not provided, unless the dwelling along the southern row is 25 feet or less in height. Sunscape analysis suggests, therefore, that when planning a relatively high density subdivision, consideration should be given to siting one-storey homes along the southern row of east-west streets, and placing the taller, two-storey houses and townhouses along the northern row.

A similar conclusion is drawn from the illustration in Figure 4-17 of the sunscape of a home located north of a 50 foot (15.24 m.) high building. Note the extensive separation distances required in this case. Clearly, such distances would impose severe design limitations on a sub-division plan. The extensive shading effects of tall buildings require that any apartment blocks within a solar subdivision be placed along the north side of the subdivision property.

4.5.3. Subdivision Orientation

The roads in the conventional Betsworth subdivision had a north-south, east-west orientation, typical of the southern area of Winnipeg. However, in the northern area of the city, the general street pattern is northwest-southeast, a pattern that dates back to the years of the first settlements in Winnipeg. River lots ran off the Red River in long narrow strips simi he seigneurial land pattern in Quebec.

FIG. 4-18
SUNSCAPE ANALYSIS:
SUBDIVISION WITH
NORTH-WEST—SOUTH EAST
ORIENTATION

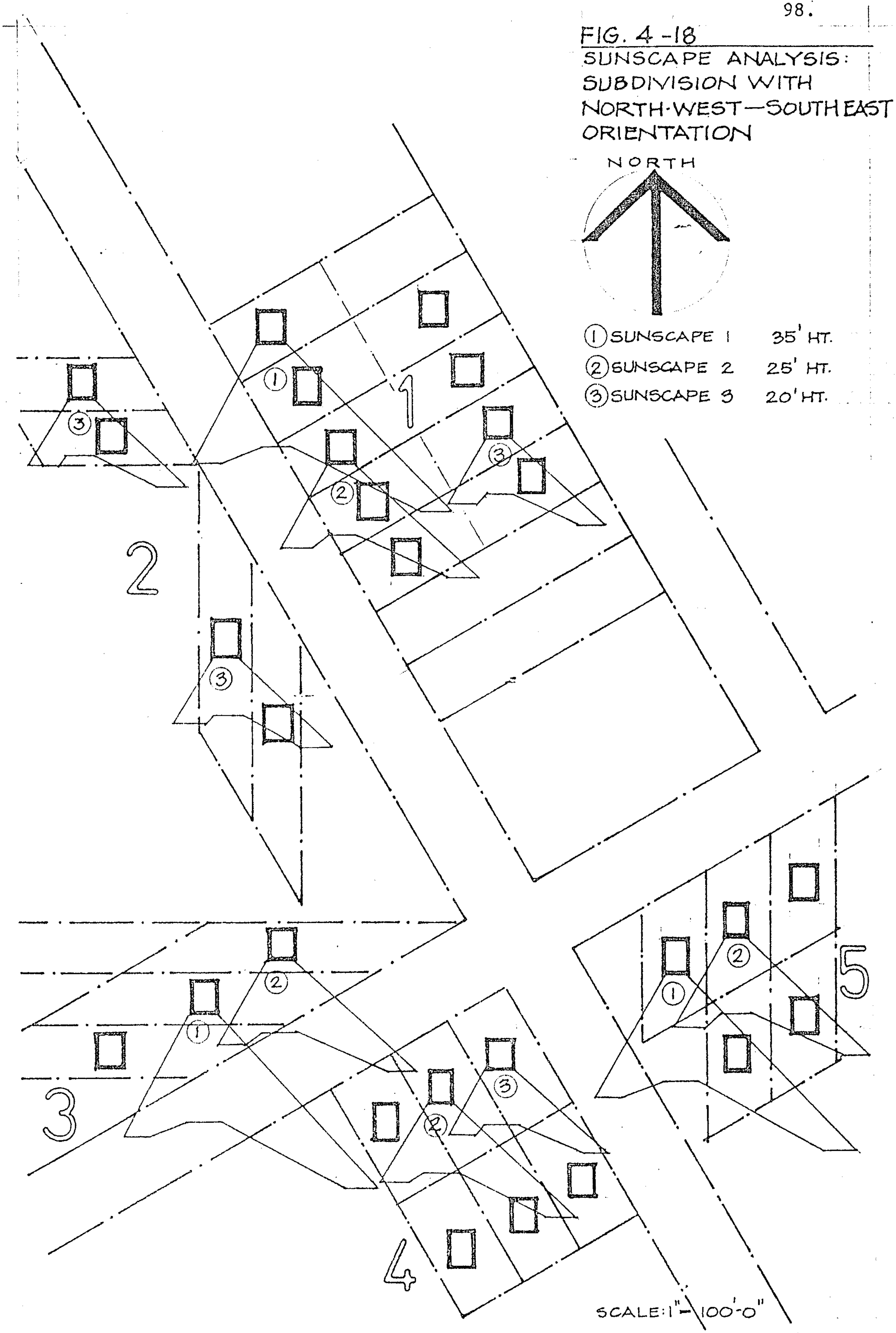

Figure 4-18 illustrates a sunscape analysis of a subdivision with a northwest-southeast orientation. Low density housing, similar to Betsworth, is assumed. The diagram illustrates five general cases:

i) When lots are perpendicular to the street, sunscape protection is not provided if all the houses have a standard setback, even with a height limit of 20 feet. To accomodate passive solar housing in such a pattern, staggered siting of houses, making use of the design flexibility of the R-PL zoning designation, would need to be adopted.

ii) Sunscape protection will not be provided for lots running at an angle off the street, even when the height limit is 20 feet.

iii) Lots in a pattern as shown in case (iii) also fail to provide sunscape protection for houses 20 feet high.

iv) When lots are perpendicular to a northeast-southwest street, sunscape protection is provided if the houses are 25 feet or less in height, but not if the height is 35 feet.

v) Lots with a north-south orientation as shown in case (v) will provide sunscape protection for homes along the northern row only if the homes along the southern row are 20 feet or less in height.

This brief sunscape analysis of a subdivision plan with a northwest - southeast orientation has suggested several desirable design features to accomodate passive solar housing. Lots perpendicular to the street, or with a north-south orientation have a better chance of providing sunscape protection than other lot configurations. Use of the design flexibility inherent in the R-PL zoning bylaw could allow the staggering of houses to provide sunscape protection, as was the case in the Sunnyvale design. As well, the height of homes along the southern row in cases (iv) and (v) should be 20 feet or less, so as to provide sunscape protection of homes to the north or northwest. That is, consideration should be given to siting bungalows along the southern row and two-storey homes to the north and north-east.

4.6 Conclusions

The exercise of designing a hypothetical solar energy subdivision has clarified several institutional implications of introducing solar housing in urban areas:

1. Sunscape

The protection of the sunscape, or energy-gathering zone for each home is the only non-conventional design constraint of a solar subdivision. However, little attention has been given in the literature to the scope of the solar access requirements of a passive solar home. The development of the sunscape, the dimensions of which outline the required shade-free area for each house, provides a simple, standardized design tool for solar subdivision planning. Once calculated, the sunscape enables a planner to determine easily, without resorting to complex calculations of various building shadows, which lots are suitable for solar housing, and which design alterations yield favourable results.

Sunscape analysis of various lot patterns illustrated how sunscapes "consume" land. That is, sunscapes impose restrictions on the uses to which the affected land may be put. The greater the height of houses in the subdivision, the greater the separation distances required to prevent shading of the solar-facing walls of the solar homes. A house height of 35 feet, the maximum allowed under single-family housing zoning bylaws in the City of Winnipeg, requires substantial separation distances among homes north and south o each other. The 35-foot height imposes severe restrictions on solar subdivision planning. However, although the 35-foot height limit is legal under the zoning bylaws, data on the actual height of homes constructed recently in [illegible] suggest that the 35-foot value in unrealistic. Few, if any, single-family homes in Winnipeg subdivisions are built to a height of 35 feet. The value is given significance in the present study only because it is a legal maximum stated in existing zoning bylaws. At some future date, the owner of a home in Sunnyvale could choose to add another storey onto the dwelling, up to the 35-foot limit, and possibly infringe upon the sunscape of another home.

The Sunnyvale design exercise, however, indicated that a house-building company can achieve sunscape protection for all subdivision lots, and still construct conventional two-storey houses, if it accepts a maximum house height of 25-feet. Data presented on the average heights of homes recently constructed in Winnipeg, suggest that the 25-foot limit would not represent a significant disruption to existing subdivision planning practices or to the marketing of homes in the Winnipeg market.

Finally, although sunscape analysis suggested that passive solar housing is most easily accomodated in the large lots of low-density housing, solar housing can also be introduced into higher density areas with careful planning. Two design constraints noted in this chapter were the siting of townhouses and apartment blocks along the north side of the subdivision and the placement of one-storey houses along the southern row of back-to-back lots fronting onto east-west streets.

2. Solar Access Rights

At the design stage, appropriate street patterns and lot configurations can ensure the protection of sunscapes for most of the solar homes. However, no protection is given to sunscapes extending beyond the boundaries of the subdivision. Nor is sunscape protection guaranteed into the future. There must be a mechanism to guarantee sunscape protection against any future development, within or outside of the subdivision itself.

Legal protection of solar access is considered in detail in Chapter VII.

3. Zoning

Inflexible zoning bylaws are frequently mentioned in the literature as a major institutional barrier to solar energy utilization. The Sunnyvale design exercise indicated that the R-PL zoning designation in the City of Winnipeg can be extremely useful in providing the design flexibility required in a solar subdivision. Solar housing, although not intended as such, is an ideal example of the stated purpose of the R-PL bylaw:

> "..to provide for a comprehensive approach to the development of single-family housing where the location and design of the individual dwelling units is an integral part of the planning and design of the overall district..."[1]

In the Sunnyvale plan, use was made of the R-PL zoning to provide flexibility in siting houses along north-south streets so that one house would not shade its neighbour to the north.

4. Public open space

Public open spaces, such as parks, streets, school yards and parking lots, can perform a valuable function in a solar subdivision by providing sunscape protection space for private homes to the north. However, this function may be at the expense of better uses of the public open space. The original Sunnyvale park, for example, was the same size as the Betsworth park and served as sunscape protection space for a row of houses. However, its elongated shape detracted from the overall subdivision, because of its poor access and the severe restrictions on its development as a park. It is a pattern which neither homeowners nor planners would want to see repeated in other solar subdivisions.

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[1]City of Winnipeg, ibid., p. 3.

CHAPTER V

SUBDIVISION APPROVAL

5.1 Introduction

A civic government exercises control over the delivery of housing to the market. Control is expressed primarily through the subdivision approval process, a set of formal administrative and public reviews of the subdivision plan proposed by the housebuilding company. A subdivision approval process may hinder or encourage the introduction of innovative housing:

> "If solar energy is going to gain national prominence, much of the progress will be due to the work of local government...without some confidence about local governmental attitudes and laws towards the new technology, it is going to be difficult to find inventors and developers to take advantage of it."[1]

The exercise of submitting the proposed Sunnyvale plan to the City of Winnipeg approval process will clarify institutional implications of solar housing at the subdivision approval stage of the delivery system.[2]

5.2 Subdivision Approval Process Of the City of Winnipeg

The City of Winnipeg has developed a 20-step approval process for proposed subdivision plans. Its purpose is to allow all civic departments with an interest in a new housing project to review the plans and raise concerns relevant to their sphere of expertise. A proposed plan is circulated among the civic engineering, transportation, waterworks and

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[1] R. Robbins, "Fiscal Impediments and Inducements" Proceedings of the Workshop on Solar Energy and the Law, ed W. A. Thomas (NTIS, March, 1975) p. 15.

[2] It should be made clear, however, that none of the responses of civic officials concerning the present study are necessarily City of Winnipeg policy.

waste, parks, police and fire departments. As well, institutions outside the civic government are asked for their comments. The outside institutions include school divisions, utilities and provincial and federal government housing authorities.[1]

Following the administrative review, a series of public meetings are held so that interested citizens may comment on the proposed plan. The product of the approval process is a formal development agreement between the applicant and the City of Winnipeg.

Recall from Chapter I that considerations of public and political approval are beyond the scope of the present study. Therefore, only the first four steps of the approval process are of concern. Figure 5-1 illustrates the four steps. The diagram indicates that the Administrative Co-ordinating Group (ACG) is the important co-ordinating institution within the administrative review process.

5.3 The Sunnyvale Plan

In Chapter IV, the design and planning constraints were determined for Sunnyvale. Much of the plan was similar to the conventional subdivision plan of Betsworth, which received formal civic approval in a development agreement. It was determined that potential approval problems for the Sunnyvale plan would arise only for those aspects of the plan differing from the Betsworth plan. From the analysis of Chapter IV, it

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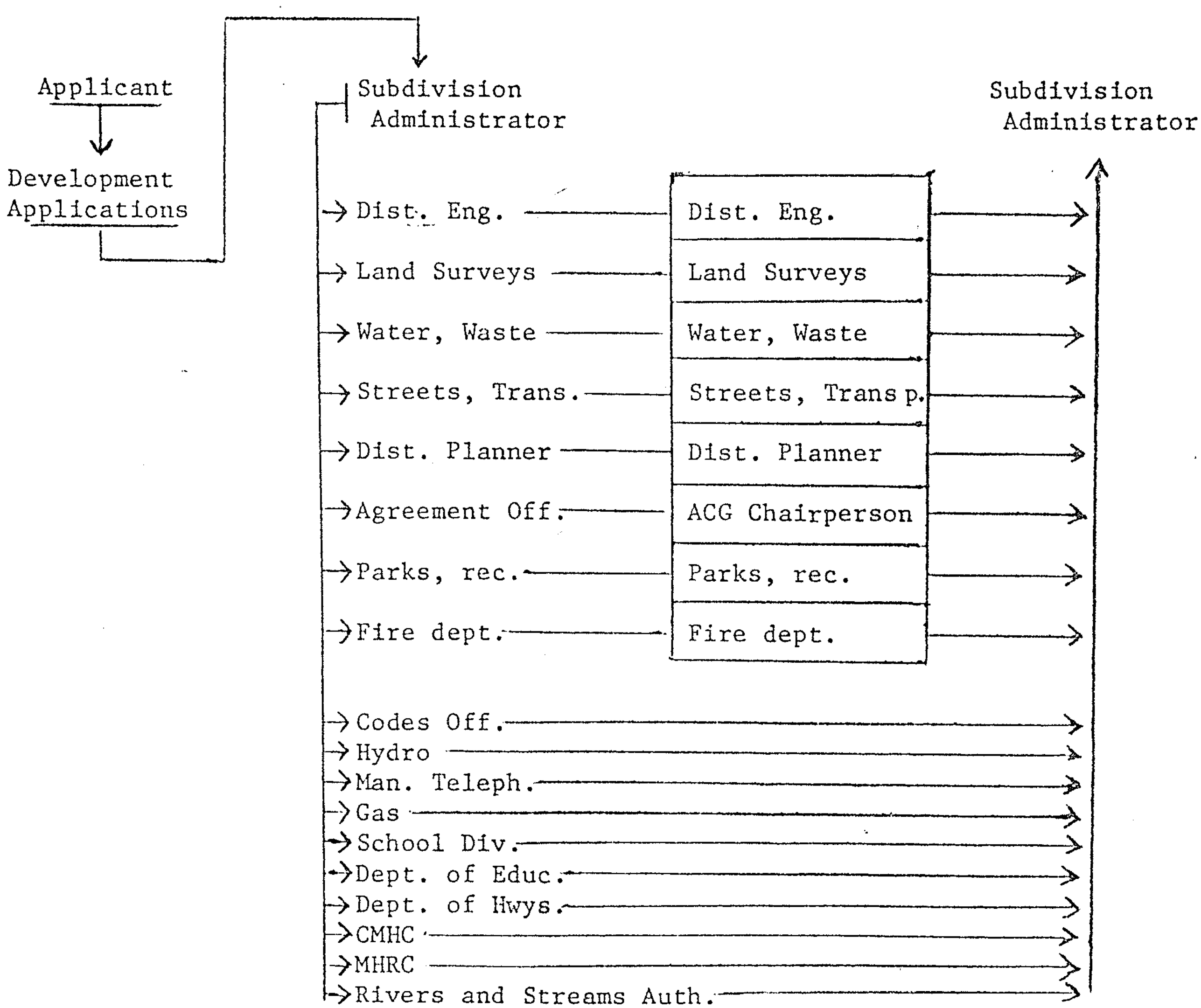
[1]Central Mortgage and Housing Corporation (CMHC) is itself an important approval institution in the subdivision delivery system. However, at the civic approval stage, CMHC has no real influence. The Corporation's influence and response to Sunnyvale's proposed plan will be examined in the following chapter.

Figure: 5-1

STEPS ONE TO FOUR: CITY OF WINNIPEG

SUBDIVISION APPROVAL PROCESS

Step 1	Step 2	Step 3	Step 4
Subdivision and rezoning application submitted	Circulation initiated by Subdivision Administrator	Design and Servicing review by Administrative Co-ordinating Group (ACG)	ACG recommendation to subdivision administrator; circulation completed



(Source: City of Winnipeg, The Approval Process, 1977; for study purposes only) was determined that the significant differences between the two subdivision plans were:

1. Street Pattern: The Sunnyvale plan proposed a slight modification to the Betsworth street pattern that resulted in roads having a more east-west alignment.

2. Zoning: Whereas the Betsworth plan was zoned entirely R1-5.5, Sunnyvale required R-PL zoning for 25 lots. The R-PL zoning allowed a greater flexibility in lot configuration and siting of houses on lots, particularly along north-south streets.

3. Sunscapes: The Sunnyvale plan required that the sunscape of each home be protected into the future against shading. Proper subdivision design provided adequate sunscape protection for most houses at the time of construction. However, there were no guarantees that future development would respect the sunscape space. Nor were the sunscapes extending beyond the boundaries of Sunnyvale protected from the shadow effects of future developments.

4. Public open space: Public open space is used to provide sunscape protection space for housing in the Sunnyvale subdivision plan. The public park space required to be donated to the city by the subdivision developer was given a central location and elongated rectangular shape in Sunnyvale. The new location and shape were extremely useful for protecting sunscapes of homes to the north, but severely limited the uses to which the land could be put. The park space also had poor access.

5. House heights: Whereas the Betsworth plan and zoning allowed a maximum house height of 35 feet (10.67 m.) for all 72 houses, the Sunnyvale plan proposed restricting the house height to 25 feet (7.62 m.). It was determined that the reduced house heights were required to provide

adequate sunscape protection for certain lots, particularly along north-south streets.

6. Landscaping Restrictions: In the Sunnyvale plan, it was necessary to impose restrictions on the planting of coniferous trees in order to prevent future shading of sunscapes during winter heating seasons. Betsworth required no landscaping restrictions.

5.4 Response of the Approval Process

The proposed plan of subdivision for Sunnyvale and its special planning requirements were submitted to the City of Winnipeg subdivision approval process during the summer of 1978. It was determined that for reasons of time, the proposed plan would be reviewed only by the Chairman of the Administrative Co-ordinating Group, Mr. Stan Bailie.[1]

Based on the review by the ACG chairman, the City of Winnipeg approval process response to Sunnyvale's proposed plan was:

1. Street pattern: The ACG had no objections to the proposed street pattern. Transportation patterns would likely be no different than under the Betsworth plan. There would be no problem with installation of underground services because Sunnyvale, like Betsworth, proposed 60 feet (18.3 m.) public right-of-ways. As well, problems of snow clearing in Sunnyvale would be no different than in Betsworth.

2. Zoning: The ACG had no objections to the proposed zoning. Sunnyvale did not propose a change from the relatively low density housing in

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[1]The formal approval process normally requires six months or more before a development agreement is signed. Through discussions with Mr. Bailie, it was decided that if the ACG chairman believed the Sunnyvale plan and requirements were likely to meet with opposition by any of the participating civic departments, then the entire plan would be formally submitted for ACG review. As related in this chapter, a complete formal review was not required.

Betsworth. The R-PL lots were to be 5,500 square feet in size (511 sq. m.), rather than the 2,500 square feet (232.25 sq. m.) minimum area permitted under the R-PL designation. Therefore, density in Sunnyvale would be consistent with adjacent low-density neighbourhoods. Finally, no zoning variances would be required in the Sunnyvale plan, because all lots in the subdivision satisfied the provisions of their designated zoning.

3. Sunscape protection: The ACG recognized the importance of protecting the sunscape of each home and agreed that the sunscape concept was a useful tool in subdivision design. There was a suggestion that the sunscapes be formally registered as part of the development agreement signed by the developer and the city of Winnipeg.

However, there was significant concern expressed over the extension of sunscapes beyond the boundaries of Sunnyvale. Recall that the sunscapes of homes along the east, south and west sides of the subdivision extended into vacant land adjacent to Sunnyvale. Protecting these sunscapes required land-use restrictions on the vacant land. The city of Winnipeg has no zoning or expropriation mechanism which would enforce the protection of sunscapes extending beyond these boundaries.[1]

In the absence of such enforceable mechanisms, the ACG would be unable to guarantee future sunscape protection outside of Sunnyvale. The ACG was not prepared to recommend that the required land-use restrictions be imposed on the vacant land along the eastern, southern and western borders.

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[1]There are private legal mechanisms, such as purchasing an easement, which would provide the required sunscape protection. These mechanisms are discussed in Chapter VII.

4. Public open space: The ACG had no objections to the concept of using public streets and parks as sunscape protection for private homes. However, there was concern expressed over the shape of the Sunnyvale park. It was recognized that the park would not be suitable for conventional sports fields, and would have to remain an undeveloped open space, or passive park.

It was determined that the ACG would not request a change in shape of the Sunnyvale park. However, it was made clear that the shape was not a pattern which would be acceptable to the City of Winnipeg in future solar subdivision designs.

5. House heights: No objections were made concerning the imposition of reduced house heights. The proposed house height changes were within the relevant zoning provisions. Therefore, the decision to limit the heights of certain houses was a self-imposed limit on the part of the developer of the subdivision. The ACG would have been concerned only if proposed house heights exceeded the maximum heights allowed under the zoning bylaws.

6. Landscaping restrictions: The ACG was prepared to accept and recommend landscaping restrictions required in Sunnyvale. It was recognized that these restrictions were necessary for the proper functioning of solar homes, and that the necessary restrictions concerned only the siting of coniferous trees.

Following review of the Sunnyvale plan, the ACG chairman concluded that the ACG would be prepared to recommend approval. Further, the ACG would attempt to assist its passage through the 20 step approval process in order to decrease the amount of time required to obtain a development agreement and begin construction.[1]

5.5 Analysis

Generally, the formal approval process of the city of Winnipeg was not a barrier to Sunnyvale. The ACG, the most important administrative group within the approval process, expressed a positive attitude towards the concept of a solar subdivision and its special requirements.

The exercise of submitting the proposed plan to the ACG indicated two problem areas in the approval process: restrictions placed on the use of the public park; and the extension of sunscapes into property beyond the subdivision and beyond control of the developer of the subdivision.

The former problem illustrates that the civic approval process confronts a trade-off of two public interests in the solar subdivision. On one hand is the public interest derived from protecting sunscapes of private homes and thereby helping society to conserve non-renewable energy. The other public interest is the recreational and aesthetic values attached to a well-designed, well-utilized public park. In the Sunnyvale design, the public interest attached to the park is sacrificed for the sake of sunscape protection. The trade-off was acceptable to the ACG for the hypothetical Sunnyvale case, but may not be acceptable in future plans. The benefits and costs to the city of either option may have to be determined on a case-by-case analysis.

The lack of future protection for sunscapes extending beyond the boundaries of Sunnyvale illustrates a major institutional barrier to solar

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[1]Personal communication, Mr. Stan Bailie, development agreements officer, City of Winnipeg, August 14, 1978, Winnipeg.

energy in the Winnipeg subdivision delivery system.[1] The lack of zoning or planning mechanisms to guarantee future solar access prevents the use of many lots in the subdivision for solar housing. As well, the fact that future developments within the subdivision may at one point intrude upon the sunscape of a home increases the risk of the subdivision project to the developer. Without an adequate mechanism with the zoning and planning regulations of the City of Winnipeg, widespread utilization of solar home heating is unlikely. Chapter VII will discuss various mechanisms which would allow the City of Winnipeg to guarantee sunscape protection into the future.

Finally, the Sunnyvale exercise suggests there is value in the housebuilding company familiarizing members of the ACG with all aspects of the solar subdivision. The special requirements of a solar subdivision will be new to most administrative officials. If the officials are familiar with the justifications of the special requirements, then they will be less likely to withhold approval while they seek an explanation for a particular design feature.

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[1]It is a barrier in the subdivision delivery system of every other Canadian city, as well.

CHAPTER VI

SUBDIVISION CONSTRUCTION

By this stage, Sunnyvale has been designed and received formal civic approval. The solar subdivision confronts another set of institutions in the construction stage of the subdivision delivery system. If mortgage financing is sought from Central Mortgage and Housing Corporation, then Sunnyvale must meet a set of lending codes. Building permits need to be obtained from civic building inspectors. Contractors hired to do construction work may be unfamiliar with solar housing. New products used in Sunnyvale's homes may lack performance standards.

6.1 Central Mortgage and Housing Corporation

6.1.1. The Institution

The federal Central Mortgage and Housing Corporation (CMHC) is an important source of subdivision construction financing through National Housing Act loans. The corporation maintains regional and local offices in Winnipeg.

By virtue of its federal charter, CMHC is required to act on a commercial basis. It can finance conventional housing projects determined to be profitable. Its financing of untested, experimental housing is restricted to that part of the experimental project demonstrably profitable.

CMHC officials use three related set of codes in determining a project's suitability for financing:

i) The National Building Code;
ii) Residential Standards, which contains requirements for buildings of residential occupancy from part 9 of the National Building Code, and

requirements going beyond the scope of the national code.[1]

iii) and, "Builders' Bulletin", a periodical publication of the corporation which publishes new lending policy requirements revising requirements in the Residential Standards.

It was indicated in Fig. 5-1 that CMHC is on the initial circulating list when a subdivision application is made. CMHC subdivision approval officials may make general comments at the initial stage. However, the lending policies of the corporation are not brought into effect until the subdivision's developer has received formal civic approval and applied for NHA financing.

6.1.2 Relevant considerations

When reviewing any subdivision application, CMHC officials attempt to determine the economic viability of the project. The proposed density, lot size and zoning are examined. Proximity to railroads or airports is considered. Heating systems to be used in the homes must be proven efficient and meet code standards. Construction materials must also meet standards set out in the lending codes of the corporation.

The Sunnyvale application would be subject to the conventional considerations. In addition, it was determined that the following solar energy considerations would be relevant to the review by CMHC:

i) That the solar heating system of the homes will function efficiently;

ii) That the sunscape of each home will be protected;

iii) That house design changes required to incorporate the solar

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[1]National Research Council, Residential Standards 1977 (Ottawa, 1977) p. vii.

heating system comply with building code standards;

iv) That the capital costs of the solar heating systems be identified.

6.1.3. CMHC Response to Sunnyvale

In the October, 1978 Builders' Bulletin, CMHC announced its general lending policy guildelines for solar-heated homes.[1] The policy stated:

> "Systems will be evaluated and their lending value determined by the ability of the systems to supply energy over the expected life of the system. It is expected that the lending value established for the system will normally be substantially less than the installed cost of the system."[2]

The policy stated CMHC would make or insure loans for solar housing provided the application met five criteria:[3]

i) Dwelling units-including the solar heating equipment, meet all applicable lending requirements;
ii) Solar heating is designed for space heating and/or domestic hot water heating only;
iii) The solar heating system is designed or verified by a professional engineer skilled in such design;
iv) Changes to the building fabric to incorporate the solar heating system are designed or verified by a qualified professional engineer;
v) The solar collector performance has been verified by an independent testing agency acceptable to the corporation.

With respect to solar collector performance, four tests are required:[4] collector performance, costing $600; health and safety assessment, $250; durability test, $250; systems test, $250. Only two testing centres are acceptable to CMHC: The Ontario Research Council for the

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[1]CMHC, "Builders' Bulletin" No. 296, October 3, 1978.
[2]ibid., p. 2.
[3]ibid., p. 1.
[4]Personal communication, Mr. Charles Sims, regional inspections coordinator, CMHC, Winnipeg, August 8, 1978.

first three tests; and the Waterloo Research Institute for the fourth test.

Under the new lending policy, Sunnyvale's developer would also have to file with CMHC five copies of the following information with its loan application:[1]

i) solar heating system design drawings and installation details;
ii) verified solar collector performance data;
iii) calculations of the solar heating system's thermal performance and building heating requirements;
iv) estimates of life of the heating system, and its annual maintenance and operating costs;
v) site layout drawing details;
vi) placement and orientation of collectors;
vii) location and height of existing buildings, fences, trees and other obstructions to the south of the collector panel;
viii) and, zoning of land in the immediate vicinity.

Within the general CMHC lending policy, regional and local corporation office personnel assess applications. The Sunnyvale proposal was submitted to the chief subdivision approval officer in the Winnipeg office, and to the chief regional inspections officer, as part of the exercise of determining the response of the subdivision delivery system to a solar energy subdivision.[2]

The subdivision approval officer had no objection to the proposed street pattern, lot configuration or zoning. CMHC would expect to receive complete information on the capital costs of the solar homes, the calculated performance of the solar heating system, and some practical demonstration that the system will perform to the calculations. Concern was expressed over the future protection of the sunscapes, particularly those sunscapes

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[1]CMHC, "Builders' Bulletin" p. 2.

[2]Mr. Ron Clough and Mr. Charles Sims, respectively. Again, it should be emphasized that the opinions expressed by CMHC personnel do not necessarily reflect corporation policy.

extending beyond the boundaries of Sunnyvale. The officer stated that the developer would have to demonstrate that each sunscape is legally protected. The legal mechanisms for achieving sunscape protection are discussed in Chapter VII.

With respect to construction of the homes, the regional inspections officer emphasized the need for the house-building company to supply as much information as possible on the calculated and tested performance of the solar heating systems. CMHC recognized that conventional building codes will not always be applicable to solar homes. However, the corporation would not be inflexible in such cases. CMHC response to the use of preserved wood house foundations was suggested as a useful example which could be used for solar housing. Existing building codes do not mention the use of preserved wood foundations. CMHC recognized the potential value of the foundations, agreed to accept for purposes of lending, design standards established by the Canadian Wood Council.

6.1.4. Analysis

CMHC is still in the formative stages in establishing a lending policy for solar housing. The policy guidelines announced in the October, 1978 "Builders' Bulletin" clarified that the corporation was not inflexibly opposed to lending for solar housing. Still, the obligation of the corporation to function on a profitable basis restricts its freedom to finance experimental, innovative housing projects.

Corporation policy on solar housing implicity assumes that active solar heating systems are used in the houses. Policy towards passive systems is unclear at the present time. The performance tests required, for example, apply to active systems. Performance standards applicable to passive systems are not specified.

CMHC response to the Sunnyvale proposal suggested that its primary concern was that the proposed solar heating system function adequately. This concern has two aspects. Firstly, the housebuilding company would need to furnish evidence that the passive design techniques will perform according to their theoretical calculations. In the absence of performance tests required under the October, 1978 policy guidelines, the company would need to rely on performance results of actual homes already built elsewhere. Secondly, the housebuilding company would need to demonstrate that each sunscape is protected into the future. Without protection, the solar heating system cannot function. Sunscape protection within the subdivision may be relatively easy to achieve through proper subdivision design techniques and caveats registered with the property. However, conventional mechanisms may not provide future protection of sunscapes beyond the boundaries of the subdivision. Without such a mechanism, it is unlikely the housebuilding company could obtain CMHC financing for those homes whose sunscapes extend beyond the subdivision's borders.

CMHC lending policy guidelines also suggest that financing would be available for homes in Sunnyvale only up to the level which would be provided for conventional houses of similar size. It is unlikely that financing would be available for the additional house costs attributable to the solar heating system. Such a restriction may not be of importance to a housebuilding company in the case of a passive solar home costing only $1,500 more than its conventional counterpart. But it serves as a significant barrier to the housebuilding industry in cases of active solar systems which may cost $10,000 to $20,000 more than a conventional house of similar size.

The present uncertainty over corporation financing for solar housing increases the uncertainty, risk and possibility of delay for a housebuilding company wanting to build a solar subdivision. There is an incentive for the housebuilding company to provide as much information as possible to appropriate CMHC officials from the earliest design stages of the subdivision project. With greater knowledge of the special requirements of solar subdivision, corporation personnel may better respond to an unfamiliar situation, and have more time to determine the CMHC response. The chances of a delay in the progress of Sunnyvale through the subdivision delivery system would consequently decrease.

6.2 City Building Codes

6.2.1. Relevant codes

Before construction can begin on the solar homes, building permits must be obtained from the building permits department of the City of Winnipeg. House construction techniques and materials must conform to standards established in the municipal building code. The code is based on the National Building Code. Part 9 of the national code, applicable to residential dwelling units, is relevant to the present study.

A proposed building code concerning energy conservation in new buildings, is also of interest.[1] Although it has not been established as policy, it is instructive as an indicator of possible future building code provisions applicable to solar housing.

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[1]National Research Council, Canadian Code for Energy Conservation in New Buildings; Draft for Public Comment, June 1977 (Ottawa)

6.2.2. Requirements of Sunnyvale

It was determined that potential building code barriers to solar houses will arise only where the requirements of solar energy gathering and storage within the home have led to changes in conventional design and construction practices. Recall from Chapter III that a passive solar home is relatively similar to a conventional home, whereas an active solar heating system requires substantial design alterations and incorporation of new mechanical equipment.

Requirements of a passive solar home relevant to building codes were:

i) Glazing: Increased glazed area on south side of home and minimum window area on north side;

ii) Thermal mass, either in the form of heavy wall and floor construction (concrete, stone, brick), or in the form of a Trombe wall;

iii) Increased insulation and improved vapour barrier.

An active solar system would require, in addition to the above three considerations:

i) Placement of solar collectors on roof at the appropriate angle;

ii) Pipes and ducts to convey the heat storage fluid moving through the system;

iii) A large storage tank in the basement, filled with water or rocks; and,

iv) An electrical control mechanism to automatically operate the active system.

6.2.3 Review of Codes and Analysis

A review of the building codes relevant to the Sunnyvale homes revealed that the codes are silent with respect to solar heating system components. The relevant sections in the Residential Standards 1977[1] are:

i) Glazing area: S. 7 establishes minimum window areas for various rooms in a house. No maximum area is specified. However, in a CMHC "Builders' Bulletin" issued in August, 1977, revisions were introduced to encourage energy conservation.[2] S. 7 was changed with the addition of a specified maximum window area:

> "7 A (6) The total glazed area (including glazing in windows and door(s)) in all exterior surfaces of a dwelling unit shall not exceed 20 percent of the total floor area of all finished spaces within the dwelling unit."[3]

The revisions also reduced the minimum window areas permitted in bedrooms to five percent from ten percent.

The new glazing provisions, if strictly enforced by building inspectors would restrict the use of windows as a passive solar design technique in solar homes. A solar home 1,000 square feet in area (92.9 sq. m.) would be limited to 200 square feet (18.58 sq. m.) of window area. However, the passive solar system may require 200 square feet of glazing on the south wall in order to function properly. The existing code does not recognize that the south-facing window area of a home can be a net heat gain source. The value of a south-facing passive solar window design is recognized in the draft proposal of the Canadian Code for Energy Conservation in New Buildings. Section 3.3.7 of the proposed

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[1]National Research Council, Residential Standards 1977.
[2]CMHC "Builders' Bulletin" No. 267, August 10, 1977.
[3]ibid., p. 3.

code states that south-facing glass used as part of a passive solar heating system is counted at only one-half of its actual area in calculating the total permitted window area of a home.

ii) Thermal mass: no provisions.

iii) Insulation and vapour barrier: Section 26 of the Residential Standards code establishes minimum standards. Homes in Sunnyvale would exceed the minimum values required.

iv) Solar collectors on roof: Section 27 establishes the permitted roof slopes. For the roofs applicable to Sunnyvale homes, no maximum slope is specified. Therefore, if the solar homes incorporate an active solar system with rooftop collectors, roof slope provisions of the building codes will not be a barrier.

Appendix B of the Residential Standards establishes the minimum load support for various kinds of roof materials. Rooftop collectors would place an increased weight upon the roof beams. Consequently, greater structural support would need to be incorporated into the building's design. The Sunnyvale homes would therefore exceed the minimum values established in the code.

v) Piping and duct system to convey fluid through an active solar heating system: no provisions.

vi) Storage tank in basement: Section 15 establishes minimum support requirements for footings and foundations. A storage tank would place an increased load upon the foundation. Support would need to be improved accordingly. Homes in Sunnyvale would therefore exceed the minimum values established by the code.

vii) Automatic electrical control mechanism for active solar heating system: no provisions.

To summarize, the hypothetical homes in Sunnyvale more than meet building code provisions for insulation, vapour barrier, roof and foundation support. Code approval would be given for components of the solar heating system not specified in the codes providing they conform to "good engineering practice."[1]

6.2.4. Review of recent Canadian and American experience

A 1978 report published by the United States' Housing and Urban Development department reported results from a survey of 25 civic code inspections departments which have had experience with solar houses.[2] It was found that most local ordinances did not mention solar housing. Six localities in which a HUD solar demonstration project had been built later adopted several specific code requirements for other solar homes to be built in their area. However, only one of the localities had adopted requirements "containing extensive solar provisions, including specific standards for heat loss, glazing, roof overhang and solar easements."[3] Of the 25 departments surveyed, seven had adopted energy conservation building codes without specifically mentioning standards for solar housing.

The HUD report also discussed the code inspection process in 23 of the cities. In nine of the cases, inspectors' approval took a longer

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[1]The term "good engineering practice" is a widely-used term in building codes applicable to cases in which codes are silent on a particular building practice. It is usually taken to mean certification by a professional engineer.

[2]HUD, Selling the Solar Home (April, 1978).

[3]ibid., p. 34; the name of the city and the code requirements cited are not given in the report.

period of time than for a conventional home. However, much of the additional time was apparently due to the curiosity of the inspector and desire to learn more about solar housing, rather than difficulties in code enforcement. After inspection, nine of the 23 code departments requested alterations in the house design, or more information on which to base a judgement. Two departments required the developer to submit complete engineering drawings of the homes. In three cases, the roof structural support of a solar home had to be reinforced in order to support the weight of solar collectors.

Code officers surveyed in the HUD report expressed concern over the potential hazards of active solar heating systems. Hazards cited included the freezing of fluid within the collector or pipes; excessive roof loads and water-glychol fluid from the system leaking into domestic water pipes.

The HUD report concluded that with the lack of experience with solar housing, building code inspectors must rely on manufacturers' specifications in assessing reliability and safety of a component. This reliance, in turn, suggests a need to establish independent quality and performance standards for solar heating equipment.

There has been little code department experience with solar housing in Canada. What experience has occured reinforces the results and conclusions of the HUD study.

In 1977, the environmental planning department of the City of Winnipeg presented a report on several solar heating issues.[1]

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[1]City of Winnipeg Environmental Planning Department, "Re: Solar Space and Water Heating", (Winnipeg, Feb. 17, 1977).

The department had been requested, in part, to examine how the City of Winnipeg could encourage solar heating, "with special attention to building orientation, roof slope, landscaping and other shadow-producing features and the building code.[1]" The departmental report concluded that:

> "As yet, no regulations have been developed for solar energy installations in building codes (national, provincial, municipal) but while there are no specific standards covering solar installations, conversely, there are no restrictive clauses which would prohibit solar installations providing they are designed in accordance with good engineering practice."[2]

The City of Winnipeg building code inspections department has had experience with only one solar house. A house incorporating an active system, with collectors on the roof and a rock-filled storage tank in the basement, was built in 1977. After discussion with code offiers, modifications were made to increase rooftop support strength and increase foundation support.

In Saskatchewan, two solar demonstration homes confronted only minor code difficulties. Designers of Conservation House in Regina proposed a method of heat recovery from used water (greywater). Inspectors expressed concern over the safety of the plan, suggesting greywater could leak into the fresh water supply. Approval was given only after the designers argued that the heat recovery method was an experimental component in a demonstration house.[3] In Saskatoon, Concept Construction was able to build a passive solar home with only slight delay when code inspectors requested more information on the proposed cantilevers and foundation support.[4]

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[1]ibid., p. 4.

[2]ibid.

[3]Personal Communication, Mr. Dave Eyre, Saskatoon, Sask., July 26, 1978.

[4]Personal Communication, Mr. Keith Funk, Saskatoon, Sask., July 25, 1978.

6.2.5. Conclusions

Building codes applicable to the Sunnyvale homes are silent with respect to solar housing. Before a housebuilding company could obtain a building permit, code inspectors would have to be convinced that the solar heating features of the homes conform to "good engineering practice." Passive solar homes incorporate relatively simple design changes from a conventional home, and few code provision difficulties would be expected. Homes incorporating active solar heating systems, however, involve a significant amount of new equipment beyond the scope of present codes. Code enforcement problems with such homes would be correspondingly greater than for passive solar homes. With reliance on "good engineering practice", the solar homes are likely to be "overbuilt", in the sense that they more than meet minimum standards established by the codes for important home features such as insulation, vapour barrier and double-glazing of windows.

Building codes, by themselves, are unlikely to be a significant barrier to a solar energy subdivision. However, enforcing the codes during the construction phase could create delays and increase the costs of a project. Inspectors would not be concerned with only one solar house, but 72 houses at various stages of construction. A housebuilding company cannot afford the delays caused by leisurely, self-educational attitude which has characterized code inspections of individual solar homes in the United States.

In the absence of a City of Winnipeg policy to eliminate the code inspection barrier, the housebuilding industry must take steps to familiarize building code officials with solar home heating technology. Code inspectors who understand the principles of solar energy and solar design and construction techniques, are less likely to cause delays during house construction. The housebuilding company which involves code inspectors at the earliest design stage of the subdivision would be better able to anticipate and solve potential code-related problems before they occur.

6.3 Labour Skills and Jurisdiction

6.3.1. Potential barriers

Labour plays an important role in the subdivision delivery system. Until the construction phase, Sunnyvale exists only on paper, in the designs and blueprints of architects, planners and engineers. Construction tradespersons transform the blueprints into physical dwelling units. If Sunnyvale is to be a profitable investment for the housebuilding company, the solar homes must be built well, and delivered according to the construction schedule.

Two aspects of labour involvement with solar housing have been identified as potential institutional barriers. Firstly, construction trades may lack the special skills required for proper construction of solar homes, particularly homes incorporating active solar heating systems. Secondly, the potential for inter-union or inter-trade jurisdictional disputes over the new jobs created by solar housing is consistently identified as an institutional barrier. A 1978 Canadian study stated:

> "Innovation can undermine the necessity for various skills and certain trades while removing status from others... It seems likely that the diffusion of solar home heating would have differential effects on various trades.... Some, such as those involved in glass manufacture, pipe installation or the provision of insulation, might well witness a considerable increase in the need for their services. Others, such as those concerned with oil or gas furnace maintenance, or oil delivery, might experience a slackened demand."[1]

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[1] Foster and Sewell, Solar Home heating in Canada, p.66.

6.3.2. Construction Practices

The construction trades involved in the residential housebuilding industry in Winnipeg are not unionized. Several large housebuilding companies have their own construction branch of the company. Other companies concentrate on assembling land for development and marketing homes after construction, and choose to contract out home construction work. In the latter case, the building company will employ only supervisory personnel for the construction phase. The contractors sub-contract work to plumbers, electricians and other trades.

A typical construction timetable, applicable to Sunnyvale, is:[1] obtain tenders from contractors, either for the entire year or for a single project of 30 homes; obtain building permits from the City of Winnipeg; marketing division of housebuilding company schedules which lots in the subdivision will be built on first; construction manager sites the houses on the lots; construction begins.

Construction of homes in a subdivision is staggered to maintain an efficient utilization of various tradespersons. In Sunnyvale, an initial block of 30 homes would be started. When these homes are approximately 50 percent completed, another group of 15 homes would be started. Construction of a home in the subdivision normally takes about 90 days, although late completion several days beyond the 90-day target is not considered significant.

The construction manager of the housebuilding company co-ordinates the construction schedules and the work of various trades. Trades normally

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[1]Personal communication, Mr. Al Rupps, construction manager, Castlewood Homes Ltd., Winnipeg, July 6, 1978.

involved in house construction, in the approximate order required are:[1] excavation contractors; basement contractors; framing; electrical; plumbing; heating; drywall and insulation; ceiling insulation; painting; flooring; cabinet finishing; roofing; finishing carpentry; basement flooring; glazing; landscaping.

6.3.3 Construction requirements

Construction problems were likely to occur in Sunnyvale on those components of the solar homes that differ from conventional houses. Passive solar homes differ only moderately from a conventional home. Insulation and vapour barriers are improved; the window area on the south-facing wall is increased. The new or unusual components in the passive solar house could be the heavy masonry walls and floor, the Trombe mass wall behind part of the glazed area, a movable shutter system, and an air-to-air heat exchanger.

Solar homes incorporating active systems involve several new components: rooftop collectors; storage tanks in the basement; piping to convey the fluid moving through the system; and electrical controls to automatically operate the system.

Solar house construction has an additional constraint. A solar-heated house must be constructed well in order to function properly. To a greater extent than a conventional house, a solar house has a close relationship with the outside environment. Windows and walls are designed to take advantage of the environment, rather than separate the environment from the

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[1]ibid.

interior living space. A solar house is therefore a more fragile building in the sense that it is more vulnerable to mistakes in construction. An accidental hole in the vapour barrier of a conventional home has a negligible impact on the home's heating system. A similar accident in a passive solar home would seriously affect the efficiency of the solar heating system.[1]

To summarize, construction of the Sunnyvale homes would require a familiarity with a small number of new building components, and, most importantly, a high degree of workmanship in construction.

6.3.4. Analysis

The introduction of solar home heating technology will alter established construction practices in the subdivision delivery system. By anticipating the changes, the housebuilding industry can take steps to prevent the changes from becoming barriers to solar energy utilization. A solar subdivision project would magnify construction difficulties experienced with a single solar house. Active solar heating systems involve more new components and design changes than a passive solar home. Construction difficulties would be more likely to occur with the former.

Lack of special skills would not present a significant barrier.[2]

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[1]An example of this kind of accident occured during construction of Regina's Conservation House in 1977; Personal communication, Mr. Dave Eyre, Saskatoon, Sask. July 26, 1978.

[2]Based on experiences of designers, manufacturers and contractors. Personal communications J.H. Michell, Solco Energy Systems Ltd., Weston, Ontario, May 29, 1978; Mr. Eric Piitz, Watershed Energy Systems Ltd., Toronto, May, 1978; Mr. Dave Eyre, Saskatoon, July 26, 1978; Mr. Keith Funk, Saskatoon, July 25, 1978; Mr. Jim Phimister, Mecanitec Ltd., Winnipeg, July 10, 1978; Mr. Frank Watts, Mikkelsen-Coward and Co., Plumbers, Winnipeg, August 4, 1978.

For passive solar homes, tradespersons are already familiar with insulation and vapour barrier installation and glazing work.[1] The Trombe mass wall is a simple new component easily constructed on site with familiar materials. For homes incorporating active solar heating systems, construction skills required are those already found in the conventional plumbing, heating, electrical and roofing trades.

More important than the acquisition of new construction skills is familiarity with, and appreciation of, the principles of solar home heating.[2] A tradesperson can better undertake a new task if the reasons for the change are understood.

A solar home functions, rather than exists, on a site. It is affected by the outside environment much more than a conventional house. Construction mistakes have a greater impact on the performance of the heating system of a solar home. High standards of workmanship and proper timing of the activity of tradespersons become the most important requirements of solar home construction.

The construction manager therefore becomes the most important individual in the construction phase. The manager must ensure that each home is oriented according to its blueprints, so that each sunscape will be adequately protected. It will also be the responsibility of the construction manager to schedule the activities of various tradespersons in order to reduce the possibility of accidental damage to the insulation and vapour barriers, glazed areas and Trombe mass walls of the solar homes.

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[1]Although they may not be fully aware of the implications of a poorly sealed or punctured vapour barrier.

[2]For example, electricians and heating contractors could be instructed as to the implications of cutting the vapour barrier to make a hole for a pipe or to obtain access to a conduit.

There has been insufficient experience with solar housing in Canada to determine which trades expect to receive the additional construction work required by solar houses. Inter-union jurisdictional disputes will not be a factor in the Winnipeg subdivision delivery system. The plumbing and heating trades would logically be involved in active solar heating technology. In passive solar home construction, a new on-site supervisory role may need to be given to insulation and vapour barrier installation tradespersons.[1] The importance of the vapour barrier to the proper functioning of the solar house, and its vulnerability to accidents, suggests the vapour barrier trade should supervise construction of the solar components of the home. Development of new trades as a result of construction innovations is common in the house-building industry. The innovation of drywalling replaced the plasterers with the new drywallers' trade twenty years ago.[2]

To conclude, labour is unlikely to present significant institutional barriers to solar energy over the long-run. In the short-term, the house-building industry can anticipate two problems: trades unfamiliar with solar home heating technology and its special construction requirements; and insufficient consideration given to workmanship and timing of tradespersons' activities. A brief training course designed to instruct the building trades on solar home heating principles and requirements would help reduce the impact of the two short-term problems.[3] A housebuilding company planning to build a

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[1]Personal communication, Mr. Dave Eyre, Saskatoon, July 26, 1978.

[2]Personal communication, Mr. Al Rupps, Winnipeg, July 6, 1978.

[3]Saskatchewan Research Council has proposed a three-day certificate course on solar house construction, designed specifically for the building trades. Personal communication, Mr. Dave Eyre, Saskatoon, July 26, 1978.

solar subdivision should also give particular attention to the role of the construction manager. The construction manager would need to be knowledgeable about solar heating in order to properly co-ordinate the work of various trades, and to solve on-site construction difficulties when they occur.

6.4 Solar Heating Standards

The lack of Canadian standards for solar heating systems is of limited importance to the present study. A task force of the Canadian Standards Association was established in 1977 to propose standards.[1] No standards have been proposed to date. The group has selected solar collectors as the top priority component for standards development.[2] Standards are to be developed for the technical performance, durability and health and safety of solar collectors.

Standards applicable to the passive solar heating systems are not mentioned in the report of the Canadian Standards Association. Lack of standards for passive solar systems would not appear to be a barrier to solar housing, providing the systems conformed to good engineering practice.

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[1]Canadian Standards Association, "A Strategy for the Development of Appropriate Canadian Solar Heating Standards" (Toronto, 1977).

[2]ibid., p. 3.

CHAPTER VII

SUBDIVISION MARKETING

Examination of potential institutional barriers in the marketing stage of the subdivision delivery system was restricted to two: uncertainty over property tax assessment of solar houses; and the lack of legal guarantees of solar rights for a homeowner.

7.1 Property Tax Assessment

7.1.1. Present Policy

Property tax assessment policy in the City of Winnipeg is a combination of two assessment methods: housing costs; and comparative sales or "fair market value."[1] Construction costs serve as a starting point in the assessment of a new house, and would normally provide an upper limit to the possible range of assessed values. Whenever possible, assessors will use data on comparative sales in order to check the fairness of the assessed value determined by the cost method. Property assessment of a new house is therefore a result of the experience and judgment of the assessor and not a product of definitive rules.

Three basic manuals are used in the assessment department of the City of Winnipeg. The manuals apply to houses built before 1920, between 1920 and 1940, and since 1940. When new types of housing appear on the market, new assessment guidelines are gradually developed and placed in the manual. For example, the construction of bi-level homes in Winnipeg 20 years ago required new assessment guidelines that today are part of a departmental manual.[2]

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[1] Personal communication, Mr. Dave Schmidt, chief assessor, City of Winnipeg, Winnipeg, August 11, 1978.

Under the British North America Act, property tax assessment is a responsibility of the provincial government. The Province of Manitoba passed legislation in 1977, Bill 87, providing annual property tax exemptions for solar heating equipment used in residences.[1] (See appendix 2). The legislation requires a municipal assessor to make "the normal assessment" of the house with its solar equipment. A special assessment is also made, an amount "in the opinion of the assessor" that would be the assessed value of the house if it were heated solely by conventional heating equipment. The difference between the two values represents the added assessed value to the house attributed to the solar equipment. The municipality assesses the homeowner on the basis of the lower, special assessment value. The provincial government compensates the municipality for the difference between the normal and special assessments.

7.1.2. Sunnyvale's homes

It was determined that the Sunnyvale homes would be similar in size to the conventional homes built in Betsworth. The solar homes would be built at a cost of about $3,500 more than a conventional house of similar size. Passive solar design techniques incorporated in the homes included: large south-facing windows; Trombe mass walls, insulated shutters and improved insulation. No solar heating machinery such as solar collectors or storage tanks were used.

Analysis in Chapter IV determined that the sunscape, or solar radiation collection zone, was an important component of each home's solar heating system.

7.1.3. Response to Sunnyvale

The Sunnyvale proposal and data on its solar homes were

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[1]Province of Manitoba, Bill <u>87</u>, 1977; see Part II "Tax Reductions for Solar Heating".

submitted to the chief assessor of the City of Winnipeg. The assessment department has had limited experience with solar houses. In 1977, one house incorporating an active solar heating system was built for approximately $40,000 more than similar houses in the same subdivision. An assessment value based only on construction costs would have been considerably higher than the conventional homes. But the market value assessment method established a lower value when the solar house sold for a price between the sale prices of two similar conventional homes.[1]

It was determined that in assessing the solar homes, the assessment department would request an itemized list of construction costs. The list would indicate costs of each component of the house. Wherever the component costs exceeded the amounts specified in the manual, the assessed value would increase against the value of a conventional home. Assessors would also consider the prices at which the Sunnyvale homes are sold, in order to provide a check against the assessed value determined by the construction cost method.

There was uncertainty whether provincial government legislation exempting "solar heating equipment" from municipal property taxes applied to passive solar homes.

Finally, there was concern expressed over the land-use restrictions imposed upon a property by the sunscapes of other homes. Property values could be decreased if the sunscapes prevented a homeowner from building a garage, for example. It was determined that the effect of the restrictions would need to be considered on a case-by-case basis.

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[1]Personal communication, Mr. Dave Schmidt, Winnipeg, August 11, 1978.

7.1.4. Analysis

The total amount of money in any property tax exemptions for the solar homes of Sunnyvale is not large. Assuming the homes are passive solar homes costing $3,500 more than a conventional home of similar size, and assuming a property tax mill rate for municipal purposes of 50 mills[1], the increased taxes would be no more than $175 a year for a Sunnyvale home, and $12,600 for all 72 homes in the subdivision.[2] Alternatively, if the homes instead incorporated $10,000 worth of solar equipment, the increased taxes would be $500 a year for a house, and $36,000 for the subdivision.

Eventually, the assessment department of the City of Winnipeg will have a separate manual for assessing solar homes. Until that time, two measures would help reduce uncertainty over the assessment of passive solar homes.

Firstly, the provincial government would need to clarify definition of "solar heating equipment" in Bill 87. There is no ambiguity applying the exemptions to a house with the solar collectors, storage tanks and special pipes of an active system. Less certain is the applicability of the legislation to passive solar design features incorporated into the design and construction of a home. Would south-facing windows, Trombe mass walls, insulated shutters and improved vapour barriers qualify as "solar heating equipment" and entitle the homeowner to a property tax exemption?

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[1]One mill equals $1 in taxes for every $1,000 in assessed value; Bill 87 does not exempt the homeowner from paying school taxes.

[2]This assumes that all of the cost differential is reflected in an increased assessed value of the same amount. Normally, the difference in assessed value would be smaller than the difference in costs.

Secondly, tax assessors would need to be trained to better understand solar heating principles. The housebuilding industry could perform this educational role by familiarizing assessors with design and costs of the solar homes. In the existing subdivision delivery system, assessors are involved only in the final stage. The housebuilding company could help clarify the response of the assessment department by supplying house design and cost information to the assessors at an earlier stage in the delivery system.

7.2 Solar rights

7.2.1. Need

Sunscape protection is essential for the proper functioning of the Sunnyvale homes. The direct rays of the sun are fuel to the heating systems of the homes and "the right to receive these rays without interruption must be legally secure or a solar system can be reduced to uselessness".[1]

To this point in the Sunnyvale development exercise, it has been implicitly assumed that the City of Winnipeg has some legal mechanism by which sunscape protection can be guaranteed into the future. No such mechanism actually exists in civic zoning bylaws or planning regulations at the present time. Yet without a prior guarantee that each of the sunscapes in the solar subdivision would be protected into the future, it is unlikely that the housebuilding company developing Sunnyvale would ever have begun the project.

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[1]Barry Lee Myers, "Solar Acess Rights in Residential Developments", pp.13-20 in The Practical Lawyer V.2 No. 2, March 1978.

A 1977 City of Winnipeg report acknowledged the significance of the solar rights barrier:

> "It is obvious...that if a developer is to be persuaded to invest a substantial amount of money in solar heating equipment, he has to be confident that there is no possibility that at some future date a building will be built on a neighboring lot blotting his access to the sun."[1]

Proper site planning can ensure sunscape protection for each home initially, as was demonstrated in the Sunnyvale design discussed in Chapter IV. One appropriate design was achieved through the flexible zoning provisions of the R-PL zoning bylaw. A recent United States study emphasizes the importance of proper site planning:

> "Necessary (subdivision) design flexibility can be provided by the decreased use of traditional lot subdivisions with setbacks and bulk and height restrictions, and the increased use of land management tools such as planned unit developments coupled with energy performance standards. Proper building orientation and collector location, the protection of solar rights, and other potential constraints have been demonstrated to be surmountable within the context of these more flexible planning techniques. ...If buildings are designed in relationship to one another rather than relative to fixed lot lines, they can be located in order not to infringe upon one another's solar rights..."[2]

However, by itself site planning cannot protect against future developments within the subdivision, nor against eventual development of the vacant land along the eastern and southern borders

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[1]City of Winnipeg, Department of Environmental Planning, "Re; Solar Space and Water Heating", February 17, 1977.

[2]Pat Smith, Peter Pollock and Robert Twiss, "Residential Solar Energy Systems: On-Site versus District" pp. 4-6 in "Solar Energy and Land Use", Environmental Comment (Urban Land Institute, Washington DC) May, 1978, p.4.

of the subdivision. Even if a sunscape is not obstructed by other buildings at the time of construction, the possibility that it could be obstructed in the future may be enough to deter investment.[1]

The scope of sunscape protection is also greater for a passive solar home than for a house incorporating an active solar heating system with a rooftop collector. Figure 7-1 illustrates the different sunscapes of the two systems. The sunscape of a rooftop collector extends outward and upward from the roof. Other buildings can be located quite close to the active solar house without shading the collector. In a passive solar system, the sunscape extends from the south-facing windows of the home. Sunscape analysis in Chapter IV indicated the extensive separation distances required to prevent shading of the windows. As one recent study concluded:

> "The (passive system's) surface area exposed to solar radiation may not be much larger (and could even be smaller) than the square footage of roof collectors. But it is more 'expensive' sunshine as more energy is absorbed from sunlight that passes over adjacent land (as opposed to sunlight coming from directly overhead)."[2]

Most studies in the literature on solar rights have assumed that active solar heating systems are used. For example, "several communities have studied aerial photographs of themselves and found that the roofs of nearly all homes are free of shadows during crucial periods."[3] The conclusions of such studies about the scope of solar rights requirements will tend to understate the scope of protection relevant for passive solar housing.

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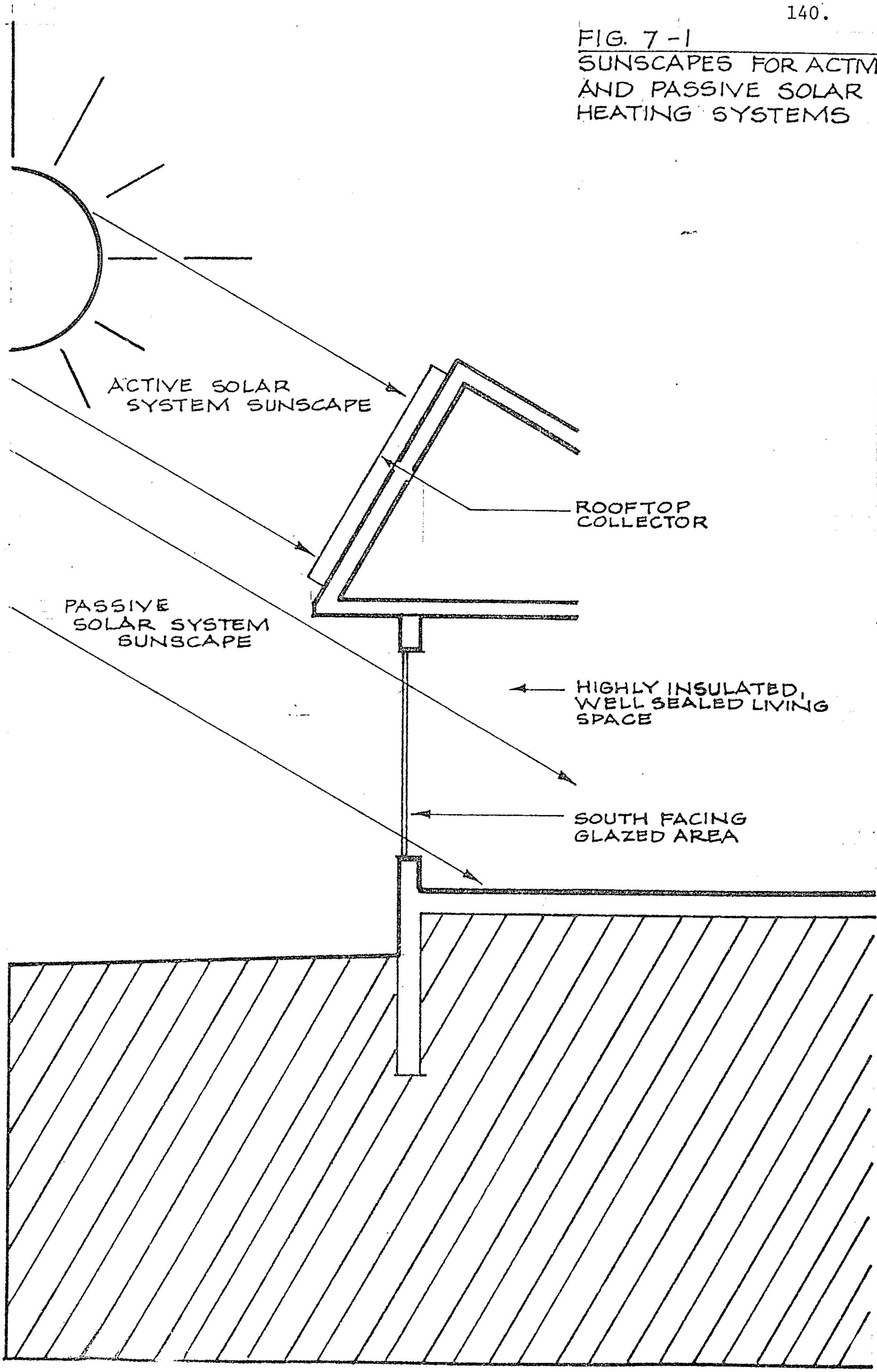
[1] Mary Schiflett and John V. Zuckerman, "Solar Heating and Cooling: State and Municipal Legislation, Impediments and Incentives" pp. 313-336 in Natural Resources Journal V. 18, No. 2, April, 1978.

[2] Alan S. Miller, Gail B. Hayes and G.P. Thompson, "Solar Access and Land Use: State of the Law, 1977", (Environmental Law Institute, Washington DC, 1977) p. 5.

[3] [illegible] p. [illegible]: see also Schiflett and Zuckerman, ibid., p. 318.

FIG. 7-1
SUNSCAPES FOR ACTIVE AND PASSIVE SOLAR HEATING SYSTEMS



7.2.2. Existing Legal Mechanisms[1]

Present common laws that may be applied to solar rights are:

(i) Doctrine of Ancient Lights: This is an old English common law which allows a landowner to obtain a right to light providing the light has been used without interruption for a certain number of years. However, the Doctrine is of no use for solar rights protection. Firstly, the landowner must have been using the light for twenty years before a prescriptive right can be obtained. Secondly, the right is restricted to light necessary for ordinary living purposes such as lighting a room, and would not apply to the direct radiation required by a solar heating system. Finally, the common law right to acquire by prescription the right to access and use of light was abolished in Manitoba in 1970.[2]

(ii) Nuisance: Nuisance refers to "an indirect, unreasonable interference by one landowner of another landowner's use of land or any interference with public rights."[3] The determination of what is "unreasonable" generally "depends upon a decision that the harm caused is greater than the utility of the conduct causing the harm."[4] However, the courts in England, Canada and the United States have never judged the interference with light as unreasonable. The courts have held that "the erection of new buildings is a more important public and private

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[1]This section is based largely on pp. 3-7 in Ontario Ministry of Energy, Perspectives on Access to Sunlight (Toronto, 1978)

[2]Law of Property Act of Manitoba R.S.M. 1970 c. 190 s. 30: "No person shall acquire a right, by prescription, to the access and use of light to any building, structure or work."

[3]C. Harvey, "Materials for Natural Resource Administration and Law" (Winnipeg, 1975) p. 26.

[4]Ontario Ministry of Energy, ibid., p. 3.

interest than the competing desire for unobstructed light and air to existing buildings."[1] Such an interpretation clearly restricts the use of nuisance common law in solar rights protection. The owner of a solar home would have no actionable cause under nuisance common law if a neighbour built a structure that blocked sunlight access to the solar system's collector or grazed area.

(iii) Easements: An easement is a right, usually arranged by a contract, of one landowner to make use of another landowner's land for a special purpose.[2] Present "right to light" easements exist, but are restricted to light used for ordinary living purposes such as admitting light through a window, Legally, there is nothing to stop an owner of a solar home from extending the easement tool to provide sunscape protection. However, there are several disadvantages from the perspective of the individual homeowner.[3] A sunscape of a passive solar home will extend over several other properties; several property owners would have to be included in the easement negotiations, resulting in increased expense for the solar home owner. Easements are also voluntary and the courts cannot force their sale. Enforcing the easement may involve costly court proceedings. An easement for sunscape protection purposes may give "an unjustified windfall to an owner of 'burdened' property who never had any intention of using his land in a manner that would block sunlight."[4] Finally, the easement mechanism would put the entire cost of sunscape protection on the owner of the solar home.

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[1] ibid.
[2] C. Harvey, ibid., p. 35.
[3] Based on Miller, Hayes and Thompson, ibid., p. 11.
[4] ibid. Burdened, or servient, land is that property being used for the benefit of another landowner.

(iv) Restrictive Covenant: A restrictive covenant "is a contractual promise...by one landowner that he will or will not use his land in a certain way for the benefit of the other landowner."[1] It is usually employed on an individual basis between landowners. However,

> "...they are also on occasion found today employed as 'building restrictions' attached to the lots being sold by residential developers within a building scheme for the purpose of attempting to provide a gloss on, to provide additional amenities over and above those which are preserved by, the general governing land use regulations."[2]

Restrictive covenants are a significant land use control because court injunctions can be obtained to enforce their observance providing certain conditions are met. Among the conditions is that the covenant must be registered on the burdened property in the land titles office. The disadvantage of using restrictive covenants for solar users is their expense, if the covenant is acquired from individual neighbors, and the possibility of costly court proceedings to seek enforcement.[3]

(v) Trespass: The tort, or civil wrong, of trespass concerns the direct interference with land possession or use. "With trespass, uniquely, there is strict liability, ie. no damage has to be established in order for the plaintiff to be entitled to at least an injunction."[4] However, under common law, a homeowner has a legal right to control only the air space vertically above the property.[5] The owner of a solar home therefore would be legally able to prevent the interruption of sunlight

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[1]Harvey, ibid., p. 35.
[2]ibid., p. 163.
[3]Ontario Ministry of Energy, ibid., p.6.
[4]Harvey, ibid., p. 26.
[5]"Cujus est solum, ejus est usque ad coelum et ad infernos"; He who owns the soil also owns to the heavens and to the depths; cited in Ontario Ministry of Energy, ibid., p. 7.

falling vertically upon the property, but not the interruption of sunlight passing through air space above the property of others.[1] However, at Canadian latitudes,

> "no sunlight ever falls from directly overhead and the number of properties crossed by a ray of sunlight below the height of potential obstructions increases in the winter, when the demand for solar energy for space heating would be highest."[2]

The law of trespass is therefore of no use for sunscape protection of passive solar homes in Sunnyvale.

In conclusion, the existing legal mechanisms of prescriptive rights to light, nuisance and trespass fail to guarantee that the sunscape of a solar home will be protected into the future. Easements and restrictive covenants are more promising mechanisms and will be examined in greater detail in section 7.2.4.

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[1] ibid.
[2] ibid.

7.2.3. Evaluation Criteria

If sunscape protection is to be guaranteed by a new mechanism or mechanisms, then what qualities should the new law incorporate? The literature offers two lists of evaluation criteria. A 1978 Ontario Ministry of Energy[1] report suggests fourteen principles by which to judge proposed solutions to the sunscape protection problem:

(i) Timeliness: A solar right should be able to be obtained before the homeowner or builder makes the investment in a solar house;

(ii) Cost: The new law should not increase greatly the use of solar home heating; "The high first cost of solar equipment is already the major barrier to its use and this must not be exacerbated by a costly legal procedure."[2]

(iii) Delay: Excessive delay in obtaining a solar right may discourage builders from investing in solar homes;

(iv) Simplicity: The new mechanism must be clear and comprehensible to use and enforce, "or the complexity of the process would itself be a barrier to solar use."[3]

(v) Certainty: The scope of the solar right, or sunscape, must be known with certainty, so that the solar home may be properly sited and so that neighbouring landowners can determine the exact impact of the sunscape upon their land;

(vi) Scope: Adequate protection is needed at appropriate times of the day;

(vii) Equity: "The need of one party for solar energy should be balanced against the inconvenience and restrictions which it would cause to his neighbours."[4]

(viii) Impact: The mechanism should encourage solar users to avoid unnecessary impact on other landowners;

(ix) Termination: Solar rights must not be allowed to permanently freeze land use; it should be possible to terminate the solar right upon fair compensation to the solar user;

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[1] Ontario Ministry of Energy, ibid., pp. 10-13.
[2] ibid., p. 10.
[3] ibid.,
[4] ibid., p. 11.

x) Notice: "Natural justice requires that landowners whose property may be adversely affected by a solar right should have notice and an opportunity to be heard before the right is made binding upon them."[1]

xi) Municipal Planning: Provision of solar access should be integrated with municipal land use planning, because sunscape protection will require amendments to existing municipal controls in zoning bylaws and building codes;

xii) Flexibility: The new mechanism must be able to accomodate the requirements of different solar heating systems in different localities;

xiii) New and Retrofit: Separate mechanisms may be required for new and retrofit installations of solar equipment;

xiv) Enforcement: Sunscape protection must be legally enforceable.

A 1977 United States publication[2] suggests twelve qualities of a good sunscape protection law:

i) Maximum protection from shadows during hours of high solar insolation for solar collectors in an active system in new structures;

ii) Similar protection to passive systems in new developments;

iii) Maximum protection for homeowners retrofitting their homes with solar heating, where "the use is in accord with existing zoning and where due process has been given affected nearby landowners."[3]

iv) Deny protection in retrofitting cases where the burden that would be imposed on a neighbor clearly outweighs the potential benefit to the solar user;

v) Be flexible to adapt to changing solar technologies;

vi) Minimize administrative expense to the building's developer, builder and owner, and to the enforcing jurisdiction;

vii) Minimize delay;

viii) Arbitrate differences between neighbors to reduce the possibility of litigation between landowners;

ix) Allow private, alternative agreements to be made among landowners;

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[1]ibid., p. 12.
[2]Miller, Hayes and Thompson, ibid., p. 14.
[3]ibid.

x) "Be politically acceptable"; [1]

xi) Provide for all forms of property zones;

xii) Include standards for zoning boards "telling them when variances or special uses should be allowed".[2]

The two lists may assist City of Winnipeg administrative and political decision-makers in establishing their own evaluation criteria. Principles common to both lists include: a desire to minimize costs to all parties; the need for a simple mechanism to reduce misunderstanding and avoid delays; flexibility to accommodate changing conditions; and a concept of equity, balancing the benefits to the solar user against the restrictions imposed upon other landowners.

The following section will evaluate possible sunscape protection mechanisms according to these general criteria common to both lists.

7.2.4 Possible Sunscape Protection Mechanisms

i) Solar Easements

As was noted in section 7.2.2, existing common law right to light easements are restricted to light for ordinary living purposes. New provincial legislation could extend the easement concept to allow the acquisition of solar rights by private agreements:

> "Clear legislative sanction to private agreements for 'solar rights' would authorize their creation, registration and enforcement by private parties, and cut away the technicalities of the common law."[3]

Solar easement laws exist in at least four American states: Colorado, Illinois, North Dakota and Kansas.[4] The relevant Colorado legislation is

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[1]ibid.
[2]ibid.
[3]Ontario Ministry of Energy, ibid., p. 14.
[4]Colorado Ch. 326 Laws of 1975, Colorado Statutes Ch. 38; Illinois Statutes Ch. 96.5; Kansas Ch. 227 Laws of 1977; North Dakota Statutes Ch. 425 Laws of 1977; cited in ibid., p. 77 and in Nancy M. Williams, "Solar Easements" (Research Mc raph, State of Oregon, July 27, 1978) p.5.

reprinted in Appendix 3. Each of the state laws provides a framework for the creation of solar easements. Each state requires the easement to be described in writing and include the vertical and horizontal angles at which the solar easement extends over the real property subject to the easement. Such a description would be equivalent to describing a sunscape. The solar easement laws usually require the easement to state the terms of compensation and termination. The easements are usually to be filed with the county clerk or recorder.

In terms of the evaluation criteria discussed above, there are both advantages and disadvantages to provincial legislation guaranteeing solar easements the legal status of regular easements.[1] The costs of obtaining the solar easement would be borne entirely by the solar user. Costs may be high because a sunscape of a passive solar home extends over several other properties, requiring several sets of negotiations and compensations. However, the easement is a relatively simple and familiar mechanism. Sunscapes described according to the provisions of the Colorado legislation would eliminate the possibility of misunderstandings about the scope of the solar right. As well, "a simple form provided by regulation could minimize or eliminate legal fees in obtaining such rights....if the standard form were well drawn, the nature and extent of the solar right would be clear and comprehensible, both to the solar user and his neighbour."[2]

The solar easement is also a flexible mechanism, because it would be determined by private negotiations in individual cases. There is a sense of equity about the solar easement method, as well:

> " Other landowners could not be unfairly affected, as they would be subject to a solar right only if they so agree, or purchase property which is

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[1]Based largely on Ontario Ministry of Energy, ibid., pp.15-18.
[2]ib . pp. 15,16.

already bound. They could bargain for compensation for any loss."[1]

In a solar energy subdivision such as Sunnyvale, the potentially high costs of purchasing solar easements may be avoided by exchanging them among neighbours.[2] All homeowners in the subdivision would have a mutual interest in protecting all of the sunscapes.

Other disadvantages of the solar easement concept were noted in 7.2.2. Included are the voluntary nature of negotiations and the possibility of costly court proceedings to obtain enforcement.

To conclude, legislative authority of privately transferred solar rights already exists in several North American jurisdictions. It would provide a clear, simple, flexible mechanism that would balance private interests through private negotiations. Once the legislation was in place, solar rights acquisitions would cost the provincial and civic governments nothing to administer. Solar easements would appear to be particularly useful in new solar subdivisions where solar rights could be exchanged among neighbours.

However, a significant disadvantage of the solar easement mechanism is that all of the costs of obtaining the sunscape protection would be borne by the solar user, adding to the high first cost of solar home heating. The time and money costs involved in negotiating solar rights with other landowners could prove to be a significant barrier to marketing solar homes, at least in the initial stages of solar energy utilization.

ii) <u>Restrictive Covenants</u>

As discussed in section 7.2.2, restrictive convenants are

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[1]ibid., p. 16.
[2]ibid., p. 15.

relatively common means of controlling private development activities within new developments.[1] Such convenants, if properly designed, could provide for sunscape protection. For example, the covenant could prevent construction on the affected land of any building which would cast shadows on the south-facing window area of a passive solar home.

Restrictive covenants have already been used in several American cities by solar home builders:

> "Typically, the covenant provisions state that no solar energy collector shall be shaded by any building, vegetation or obstruction between certain hours on a certain day (usually winter solstice, December 22, of any year). Some covenants also state that solar energy collectors shall not be visible from the street or from the front of the lot."[2]

The convenant could also be worded like the description of sunscape dimensions in a solar easement, or it could specify setback requirements and height limits.[3]

Restrictive covenants are familiar mechanisms in the building industry and covenants protecting solar access could be established without legislative authorization. Use of the mechanism for solar rights control should not increase costs to the builder or homeowner. Covenants are already understood and used by the building industry; they cost nothing to write and do not require individual homeowners to draw up legal documents; "the developer's lawyer has only to add a clause or two to the deeds."[4] Use of restrictive covenants would also simplify the task of protecting sunscapes:

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[1]Martin Jaffe, "Protecting Solar Access" in Environmental Comment, ibid., p. 13.

[2]ibid.

[3]Miller, Hayes and Thompson, ibid., p.11

[4]ibid., p. 12.; the same argument is expressed in Ontario Ministry of Energy, ibid., p. 26.

> "The nature and extent of the solar right could be very clear both to potential solar users and to landowners affected by it. Restrictive covenants must be set out in writing and registered on the title of the land affected and they are also usually described in the Agreement of Purchase and Sale. Thus, all purchasers should obtain adequate notice."[1]

No unfairness could arise in the use of restrictive covenants because the covenant cannot affect any property other than that owned by the developer.[2]

Use of restrictive covenants for protecting most of the Sunnyvale sunscapes is an inexpensive, simple, flexible and fair mechanism requiring only private-sector decisions and expense. Several articles in the literature specifically recommend the use of restrictive covenants for solar rights acquisition in new subdivisions[3].

The major weakness of the mechanism is that no control can be exercised on land outside the boundaries of the subdivision. Thus, "tall buildings on adjacent properties may render the protection within the subdivision ineffective."[4]

Restrictive covenants would also be of little value in established neighbourhoods. Delay and cost increases would likely be experienced if the subdivision were being developed by several property owners rather than by one owner.[5] Finally, the provisions of a covenant are enforceable by injunctions, but such action involves time-consuming and costly court proceedings.

iii) <u>Solar Zoning and Land Use Planning</u>

Solar zoning, integrated with land use planning for solar access,

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[1]Ontario Ministry of Energy, ibid., pp.26-27.

[2]ibid., p. 28.

[3]see ibid., p. 30; Miller, Hayes and Thompson, ibid., p. 12; and Jaffe, ibid. p. 13.

[4]Ontario Ministry of Energy, ibid., p. 29.

[5]ibid.

represents a significant public sector involvement in sunscape protection. In solar zoning:

> "...municipalities define 'solar zones' in which solar use is encouraged. As solar use may be compatible with a variety of neighbourhoods, including commercial, industrial or residential areas, solar zones may be 'overlaid' on existing zoning. In other words, existing zoning categories such as 'General Commercial' or 'R1' are not altered or replaced, but defined portions of appropriate zones are given an additional classification...All new construction in solar zones could be subjected to strict height and spacing controls to minimize shading of neighbouring properties, whether or not solar collectors were yet in use on those properties."[1]

Solar zoning in the City of Winnipeg would require enabling provincial legislation. The State of Oregon in 1977 passed SB 846 which authorizes local planning commissions to recommend ordinances which would provide for "protecting and assuring access of incident solar energy."[2] The relevant Oregon legislation is reprinted in Appendix 3. The Oregon statute gives planning commissions the power to "recommend zoning ordinances, building height restrictions, setback lines, and other factors which may affect solar access."[3]

As a sunscape protection mechanism, solar zoning would transfer the costs of solar rights acquisition from the homeowner to the municipal government. The Ontario Ministry of Energy study argues that such a transfer would not significantly increase the administrative costs:

> "Zoning is a common and well-understood mechanism for land use planning. The addition of 'solar zones' would not differ substantially from existing zoning bylaws and would not add significantly to either municipal or administrative burdens."[4]

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[1] ibid., pp.31-32.
[2] Oregon Statutes 215.110 (g).
[3] Williams, ibid., p. 6.
[4] Ontario Ministry of Energy, ibid., p. 38.

However, solar-oriented land use planning would represent a significant change from existing planning policies. Civic planners likely lack the technical knowledge required to determine optimal sites for solar zones, and the extent of solar access protection required within the zones. There is likely to be a learning process during the early years of solar energy utilization, as civic planners acquire the skills needed to intelligently select and administer solar zones. The same Ontario Ministry of Energy study acknowledges this possibility:

> "The technical demands of effective solar zoning may be beyond the capacity of most smaller municipalities. Even larger municipalities would have difficulty in the early years, as solar-oriented municipal design is still embryonic in Canada."[1]

Another disadvantage of the zoning mechanism is that a zoning bylaw can be changed at any time by the city council. Solar zoning would not provide an absolute guarantee of sunscape protection into the future. Unlike the private sector agreements of easements and covenants, zoning is a public action, and requires the favourable opinions of public bodies such as an elected council.

In conclusion, solar zoning has the potential to be a clearly-understood equitable and flexible sunscape protection mechanism. However, it would require complex, and probably costly administrative examination of existing zoning designations throughout the city. Zoning may eventually become a useful mechanism for solar access protection. But it would be unable to offer immediate protection for sunscapes in a solar subdivision.

Integrated with solar zoning would be a revision of existing land use planning practices that would encourage good site planning at the subdivision design stage:

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[1]Ibid., p. 41.

> "Many solar access issues arise because the value of solar energy was not considered at the design stage... By careful consideration of solar access issues before buildings are completed and vegetation planted, many conflicts could be avoided without resort to new legal theories for the protection of solar energy systems."[1]

The review of land use controls undertaken in Davis, Calif., was discussed in Chapter II.

Flexibility in zoning bylaws and in subdivision regulations are cited in the literature as being the most important land use planning practices related to sunscape protection.[2] Zoning ordinances can allow flexible siting practices in solar zones by means of building height and setback modifications. Subdivision regulations in solar zones can permit planned unit developments in which a builder proposes a street pattern, building design and uses as one package proposal.[3] Planned unit developments, or PUDs, "are flexible enough to incorporate any design objective, including solar access."[4]

In Chapter IV it was determined that the R-PL zoning designation in Winnipeg permits a significant degree of flexibility in building siting. The same zoning bylaw also allows a builder to designate an R-PL parcel of land as a "planned building group".[5]

As a sunscape protection mechanism, proper site planning played an important role in the design of Sunnyvale. However, as discussed above in 7.2.1., site planning, by itself, will not guarantee against loss of solar rights in the future as a result of new developments within and outside the subdivision.

iv) Municipal Certification of Solar Sites

Zoning would restrict shading of sunscapes in a large area as

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[1]Miller, Hayes and Thompson, ibid., p. 23-24.
[2]See ibid., pp. 23-24 and Environmental Comment, ibid.
[3]Miller, Hayes and Thompson, ibid., p. 24.
[4]ibid.
[5]See Appendix I, part H. [illegible] " was added to the bylaw in June 1978.

a matter of public policy. Municipal certification, if authorized by enabling provincial legislation, would "vest in individuals the right to protection of a specific site."[1] Upon registration of the certificate against neighbouring lands,

> "the site owner would become entitled for a specific period (eg. 30 years) to unobstructed solar access through a defined three-dimensional space, subject only to existing buildings and to such conditions that are set out in the certificate."[2]

Certification would compel the restraint of neighbouring landowners, unlike the voluntary nature of easements. "To avoid excessive cost, compensation could be restricted to cases of hardship, or limited in amount."[3]

The principal disadvantage of the site certification mechanism is its administrative costs and complexity. A high degree of technical expertise would be required of the municipal certifying administration. Hearings would be needed to determine compensation for neighbouring landowners. "Ill-conceived certificates or those insufficiently integrated with municipal planning could cut unreasonably restrictive swaths through the municipality."[4]

Equity considerations could argue against site certification. Although neighbouring owners would be provided notice and a hearing for compensation, certification implies significant publicly-imposed restrictions for the benefit of private individuals.[5] "This may be difficult to justify as a contribution to public welfare."[6]

v) Municipal Expropriation of Solar Rights[7]

Municipal expropriation or purchase of solar rights for private

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[1] Ontario Ministry of Energy, ibid., p. 47.
[2] ibid.
[3] ibid.
[4] ibid., p. 53.
[5] ibid.
[6] [illegible].
[7] [illegible] p. 54.

benefit would require enabling provincial legislation. Compensation would need to be paid to the landowners burdened by the solar rights of another landowner. The mechanism would be subject to the regular public hearings and arbitration of compensation for all municipal expropriations.

The Ontario Ministry of Energy study suggests that the mechanism would be useful when a single large development threatened to shade a large area of potential or actual solar use.[1] However, the costs to the municipal government, and the "dubious political wisdom of using the power of the state to benefit a few individuals,"[2] make it an unsuitable mechanism of sunscape protection. The results of expropriation can be achieved at a lower cost, and with less administrative complexity, by solar zoning and other mechanisms previously discussed.

vi) Natural Solar Rights

New provincial statutes could declare the right to use light for solar heating as a natural right or property right. The State of New Mexico has enacted a Solar Rights Act which declares "that the right to use the natural resource of solar energy is a property right, the exercise of which is to be encouraged and regulated by the laws of this state."[3] The relevant New Mexico legislation is reprinted in Appendix 3.

The concept of a solar right as a property right is similar to the Doctrine of Ancient Lights discussed in 7.2.2. It would allow a solar user the right to use whatever sunlight was necessary to operate the solar heating system, and it would provide legal redress if a neighbour obstructed the solar access.[4]

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[1] ibid.
[2] ibid., p. 55.
[3] New Mexico Statutes, Laws of 1977 Ch. 169 S.4A.
[4] Williams, ibid., p. 6.

A declaration of natural solar rights would represent a major re-ordering of land use priorities in Manitoba, and would increase the cost and complexity of most urban construction.[1]

Given the present low utilization level of solar home heating, natural solar rights does not represent a necessary or a reasonable sunscape protection mechanism. Other mechanisms could achieve similar results without its expense, administrative complexity, and potential interference in other urban development.

7.2.5. Subdivision Delivery System Response to Sunnyvale

The sunscape protection needs of Sunnyvale were submitted to two participants in the Winnipeg subdivision delivery system: a member of the legal department of the City of Winnipeg, who also is a member of the administrative co-ordinating committee in the approval process; and the general manager of the housebuilding company developing the conventional Betsworth subdivision.[2]

It was determined that the civic legal department has not given consideration to the question of solar rights. It was suggested by Mr. Thomas that the easiest method of sunscape protection was by means of the zoning agreement signed by the developer and the City. The sunscape patterns could be registered with the titles to the subdivision property and imposed on all lots in the subdivision. The City could enforce the caveats at the time a building permit application is made through an examination of the shadow effects of the proposed building. Zoning agreement protection would

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[1]Ontario Ministry of Energy, ibid., p. 57.

[2]Mr. Trevor Thomas, City of Winnipeg legal department, personal communication July 7, 1978, Winnipeg, and Mr. Morley Ringstrom, General Manager, Castlewood Homes, personal communication, July 12, 1978, Winnipeg.

provide adequate sunscape protection initially, but there is a possibility that they can be changed at some future period. A second method proposed by the legal department representative was the use of restrictive covenants registered on the titles to each of the lots in the subdivision. However, it was noted that neither the zoning agreement nor covenants would provide protection for the sunscapes extending beyond the borders of Sunnyvale. At present, the only recourse for the owner of a home whose sunscape extended into vacant land outside the subdivision would be to argue against re-zoning at community hearings if a future development threatened to shade the sunscape.

The response of the general manager of the housebuilding company was that the building industry attempts to avoid using restrictive covenants. Prospective homeowners dislike being told what they can and cannot do with their property. Restrictive covenants, for whatever purpose, are therefore perceived by the housebuilding company as a psychological barrier at the marketing stage.

7.2.6. Conclusions:

i) Sunscape protection would be an important feature of marketing Sunnyvale's solar homes:

> "Developers of solar subdivisions may...be expected to have models and drawings of the solar access displayed in their 'model homes'. The solar rights will presumably be a selling point for the protected lots and it will, therefore, be in the developer's interest to ensure that they are well publicized."[1]

ii) Political and administrative decision-makers must establish evaluation criteria for assessing new legal mechanisms proposed for sunscape protection. A review of the literature suggested the criteria of cost, effectiveness, simplicity and equity considerations are most important for

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1Ontario Ministry of Energy, ibid., p. 27.

any proposed mechanism.

iii) Various proposed legal mechanisms, six of which were examined in this chapter, involve either private sector or public sector decision-making.

iv) An analysis of the six proposed mechanisms indicated that no single mechanism is ideal for sunscape protection. The optimal solution is therefore likely to be some combination of two or more proposed mechanisms.

v) Three of the mechanisms, municipal site certification, municipal expropriation and a declaration of natural solar rights are inappropriate mechanisms at the present time. The first two would require municipal governments to bear the full costs of an action that will primarily benefit private landowners.[1] Administrative complexities and a high degree of technical expertise would also be required in using these mechanisms. A declaration of natural solar rights is an unnecessary mechanism at the present time, because other mechanisms can achieve similar results without the declaration's potential for disrupting other urban development and its administrative complexity.

vi) The optimal solution would appear to be a combination of the remaining three mechanisms: restrictive covenants registered on all lots in the subdivision by the developer; privately negotiated solar easements by individual homeowners; and revised, more flexible zoning ordinances and subdivision regulations and solar zone designations by the civic government. The three mechanisms complement rather than conflict with one another. Initially, a developer could use restrictive covenants within the subdivision.

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[1]Although there are social benefits to privately-owned solar housing, in the form of decreased consumption of society's finite fossil fuel resources. See Chapter VIII.

The covenant registered with each lot would describe the extent to which various sunscapes within the subdivision extend over the property. As discussed in 7.2.4., use of restrictive covenants would not likely increase costs to the private developer. No public sector decisions or expenditures are required.

However, restrictive covenants could not protect the sunscapes extending beyond the subdivision boundaries. Use of privately-negotiated solar easements would fill this gap. The developer, or the owners of homes along the eastern, southern and western borders, could negotiate the purchase of solar easements from the adjacent landowners. New provincial enabling legislation similar to the Colorado solar easement law would be required. Political reluctance to enact such legislation is unlikely. Solar easement acquisition would be strictly a private sector negotiation. Once the general enabling legislation is in force, no administrative supervision or enforcement would be required. Acquisition of solar easements could also be made simple and inexpensive through use of the standard forms discussed in 7.2.4., and throug the use of standardized sunscapes as derived in Chapter IV.

Therefore, in the short term, the legal mechanisms of restrictive covenants and solar easements are sufficient to satisfy the sunscape protection needs of Sunnyvale. Up to this point, no significant public sector involvement has been required. Eventually, however, the City of Winnipeg will need to decide if it is to actively encourage energy conservation in housing and solar home heating. If the answer is affirmative, then solar zoning and land use planning can be put into effect. Expertise could be gradually acquired within the civic planning and building approval departments. An examination of potentially suitable solar zones within Winnipeg could begin. As an experiment, one small subdivision area could be designated a solar zone, and flexible site planning practices encouraged. The existing R-PL zoning designation provides an excellent foundation for solar land-use planning practices. The City government could give consideration to requiring developers to submit energy impact statements within subdivision applications. The impact statement, already required in several American states, requires the developer to discuss the effect of the project on energy consumption, and the degree to which energy-conserving practices will be used in the development.[1]

Solar zoning and land use planning would represent a significant shift in the existing subdivision delivery system. All groups involved in the system, builders, the civic government and the public, would incur costs and benefits by such a shift. There is not an urgent need for implementing solar zoning and land-use planning in Winnipeg at the present time. All parties in the subdivision delivery system could use the present period to examine the costs and benefits of solar-oriented land-use planning.

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[1]See, for example, Miller, Hayes, and Thompson, ibid., pp. 23-24.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

8.1. Summary

Solar energy cannot make an impact on energy consumption patterns in Canada until solar homes are available in the general housing market. Most housing is made available on the market through an institutional framework involving the interactions of a private housebuilding industry and public planning and approval administrations. The study has named this institutional framework the subdivision delivery system.

The response of the subdivision delivery system in a given city will be critical to the level of solar home heating utilization. Solar housing, like all innovations, can be expected to cause changes in the status quo. Anticipating the changes and examining the probable institutional implications for the subdivision delivery system can suggest policy strategies to encourage the adoption of the home heating innovation.

A hypothetical solar energy subdivision was used to help clarify institutional implications of solar housing for the Winnipeg subdivision delivery system. Sunnyvale, a subdivision of passive solar homes, assumed the primary site and economic constraints of an actual conventional subdivision. A design tool, the sunscape, was derived in order to determine the scope of solar access requirements of each home. The sunscape was used to determine appropriate siting of houses within the subdivision. One subdivision design was derived for Sunnyvale that satisfied both the constraints imposed by the conventional subdivision and the sunscape protection constraint of the solar homes. Sunscape analysis was also used to derive general conclusions about the suitability of solar housing under several common urban planning patterns and densities.

The Sunnyvale design and its special requirements were then submitted to appropriate officials of institutions at each stage of the Winnipeg subdivision delivery system. The responses of the officials helped identify which institutional considerations are likely to be a barrier for solar housing in Winnipeg and which policy actions would prove useful in eliminating the barriers.

8.2. Conclusions

A solar energy subdivision could be delivered to the housing market through the Winnipeg subdivision delivery system with only minor institutional changes at each stage.

i) Design

The primary design constraint of solar housing is the provision of unobstructed southern exposure for all homes in the subdivision. The sunscape concept can be used to determine the scope of solar access requirements of each home and the suitability for solar housing of various lot configurations.

Conventional subdivision design practices, such as standard setbacks and rectangular lots fronting onto north-south streets, are often unsuitable for solar housing because they fail to provide adequate sunscape protection. Solar energy subdivision design requires, and can be assisted by, more flexible zoning provisions and subdivision regulations. The R-PL zoning designation of the City of Winnipeg was found to provide much of the required design flexibility. Its emphasis on the relationship between the location of individual dwellings and the design of the overall district, makes it highly suited for solar subdivision planning. The R-PL bylaw could form the foundation of broader energy-conserving planning practices in the City of Winnipeg.

Two additional institutional changes which would assist solar subdivision planning are; the private housebuilding industry accepting reduced height limits on certain lots within the subdivision in order to ensure sunscape protection for other houses[1]; and willingness on the part of civic authorities to allow public open spaces, such as parks and school yards, to serve an additional purpose of providing sunscape protection for homes to the north.

ii) Formal Approval

The formal approval process of the City of Winnipeg was not a barrier to Sunnyvale. The Sunnyvale design and requirements were "approved" by the Administrative Co-ordinating Group (ACG), with the exception of sunscape protection for those sunscapes extending beyond the subdivision boundaries. There was recognition, on the part of the ACG, of the benefits of solar home heating and an expression of support for assisting Sunnyvale through the approval process.

The concern of the ACG chairman over the shape and restricted use of the park space in Sunnyvale illustrated the trade-off of public interests in a solar subdivision. There is the public interest derived from protecting sunscapes of private homes and thereby helping society conserve non-renewable energy; there is also the public interest attached to a well-planned, useful park. As suggested in Chapter V, the City of Winnipeg approval process will hav to weight the two public interests on a case-by-case basis.

Solar housing would require an approval process well-informed about solar heating principles and requirements, so that the two public interests can

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[1]Although the discussion in Chapter IV suggested that given the height of homes built recently in Winnipeg (substantially lower than the allowable 35 feet limit) the reduced height limit requirements would not appear to be a significant change from present housebuilding practices in the city.

be judged fairly. This knowledge and expertise may be best developed in a cooperative effort between the private housebuilding industry and the civic government.

iii) Construction

Present uncertainty over Central Mortgage and Housing Corporation policy for solar housing, particularly passive solar housing, would increase the uncertainty, risk and delay for a builder seeking CMHC financing. The builder would need to emphasize the technical feasibility of the passive solar heating system by relying on engineering calculations and the successful experience of similar homes elsewhere. The builder would also need to emphasize the economic profitability of the solar homes through life-cycle costing analysis. Under existing CMHC policy, the builder would expect to receive financing at a proportion of project costs somewhat less than for a conventional project.

Building codes would not be an institutional barrier to Sunnyvale, because the solar homes would exceed minimum standards for most house components. Components not included in building codes, such as mass Trombe walls and movable insulated shutters, would be approved if they were designed according to "good engineering practice". However, inspection by code officers during actual construction may be a barrier if inspectors, unfamiliar with solar house design and construction, delay a project while they seek more information from the builder.

Lack of labour skills and inter-union jurisdictional disputes would not be barriers to a solar subdivision. However, proper timing of the activities of various trades and greater attention to quality workmanship are important requirements during actual construction. A solar home functions, rathern than exists, on a site. It does not block out the external environmental and protect an internal heat source, as does a conventional home; rather a solar home functions according to external environmental conditions in a constantly-changing relationship. A solar home, therefore, is a more "sensitive" dwelling[1] than a conventional home, and is more vulnerable to construction mistakes.

To summarize: a common theme in the construction stage is that for each aspect of construction -- CMHC lending, building codes, and labour -- the only significant barrier is likely to be lack of familiarity with solar housing, and consequent delays in responding to unfamiliar demands. In the present subdivision delivery system, CMHC officials, building code inspectors and contractors, are not involved in the project until the third stage. There is an incentive for the housebuilding company to inform the three groups at an earlier stage of the delivery system. CMHC officials and code inspectors informed beforehand of the special design and requirements of a solar home would have more time to determine policy and respond to unfamiliar situations. Problems could be anticipated before they arise, and the building company could take appropriate steps to solve them before they result in project delays and cost increases.

Brief training courses for construction tradespersons would help contractors become more famililar with special requirements of solar housing. Increased awareness of potential on-site problems would reduce actual on-site construction mistakes and delays.

iv) Marketing

Only minor institutional changes are required to remove the potential barrier presented by uncertainty over property tax assessment of solar housing. The Manitoba provincial government would need to clarify the applicability of Bill 87, 1977, to passive solar heating systems. Secondly, city tax assessors could need to become more familiar with the designs, costs and performance of solar homes in order to determine the fair assessed value. Again, the housebuilder could assist the tax assessment department

[1]"Sensitive" in terms of responding to external environmental conditions.

and clarify assessment uncertainties for potential homebuyers, by involving assessors at an earlier stage of the delivery system.

The most significant institutional change required to accomodate Sunnyvale within the Winnipeg subdivision delivery system is the use of various legal mechanisms to protect the sunscapes of solar homes. Future development within and outside the subdivision could shade the south-facing glazed area of the homes and reduce the effectiveness of the passive solar heating systems.

New legal mechanisms need to be evaluated according to criteria established by political and administrative decision-makers. A review of the literature suggested the criteria of cost, simplicity, effectiveness and equity are important. The optimal solar rights strategy was determined to be a combination of two short-term private sector actions and a longer-term public sector commitment to solar land-use planning. A builder could initially guarantee protection of sunscapes within the subdivision by registering restrictive covenants on titles to the lots. The sunscape tool would be of use in determining the scope of the restrictions; the convenants could describe the extent to which other sunscapes extend over the lot. The reluctance of the building industry to use restrictive covenants would need to be overcome, given the need to provide solar access protection and the ease with which restrictive covenants may be put into effect. Presumably, guaranteed solar access would become an important marketing feature of the homes in Sunnyvale, restrictive covenants would then be perceived by the homebuying public as positive, rather than negative features of the subdivision.

Secondly, privately-negotiated solar easements would enable sunscapes extending beyond the borders of Sunnyvale to be protected. Solar easements would require relatively simple provincial enabling legislation. Similar legislation used in Colorado was cited as an instructive example.

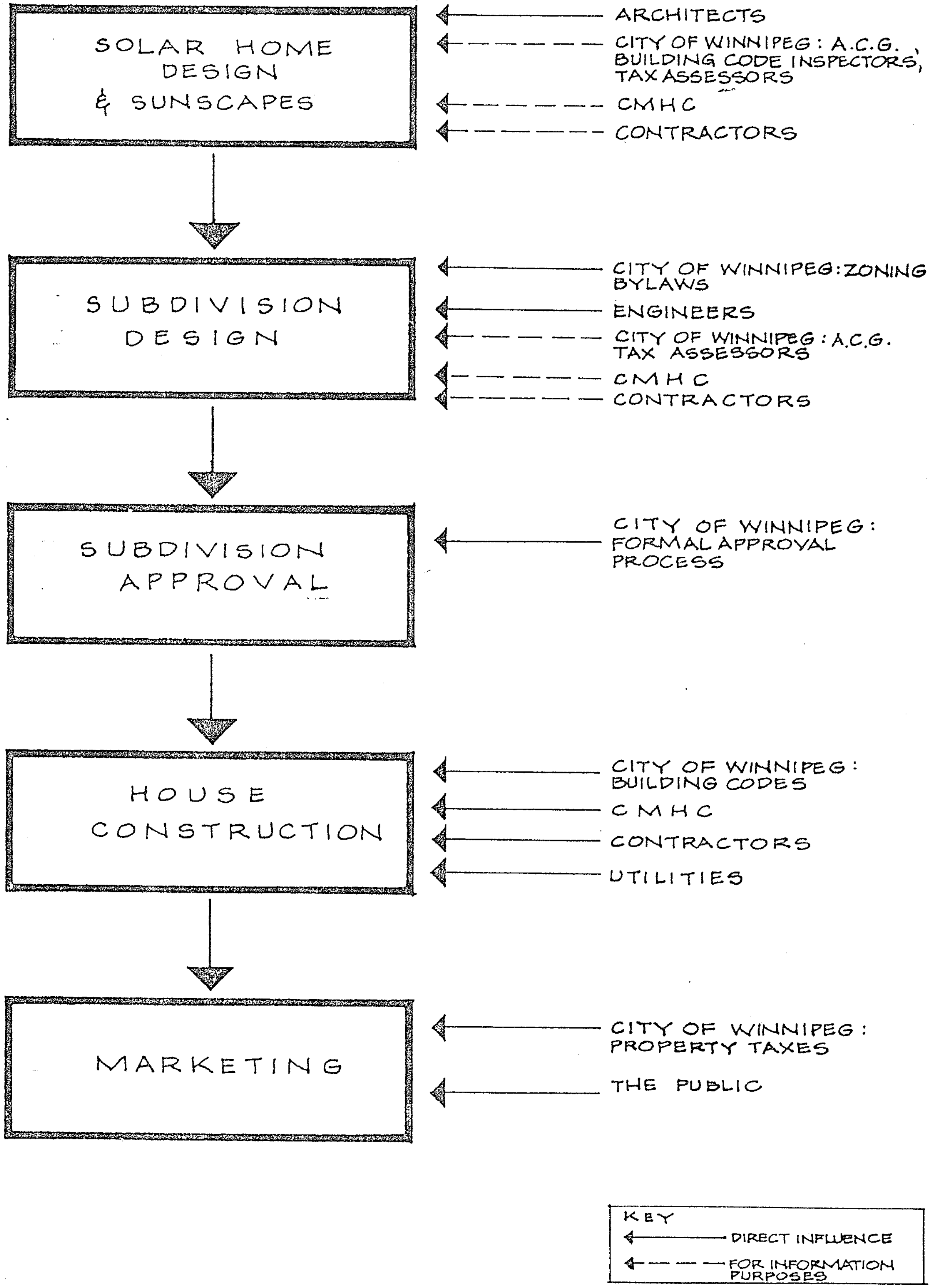
The final stage of the optimal solar access strategy would be the introduction of solar zoning and solar land-use planning by the civic government. The experience of Davis, Calif., cited in Chapter II, is a useful example. The purpose would be to develop zoning ordinances and subdivision regulations that encourage builders to consider at the design stage, solar housing and other energy-conserving planning measures. However, such a policy is likely to involve considerable administrative expense for the civic government. Given the design flexibility inherent in the R-PL zoning designation, there does not appear to be an immediate need for a revision of existing planning regulations. Solar land-use planning, therefore, is seen to be a long-term mechanism which complements, rather than conflicts with, the other two components of the solar access protection strategy.

The discussion has identified various strategies for the private housebuilding industry and civic government in order to better accomodate solar housing. To summarize the suggested strategies for each group:

i) Housebuilding industry:

1. The building industry could reduce the possibility of delay and uncertainty with a solar subdivision project by altering the existing subdivision delivery system. Officials of the public planning and approval administrations, who presently are brought into the system in the later stages, could be supplied with information at the design stage about the special requirements of the project. Problems could be anticipated before they arise, and steps taken to resolve them. Figure 8-1 illustrates the altered subdivision delivery system that would be useful in accomodating solar housing. Compare Figure 8-1 to Figure 1-2 on page 10, which illustrates the existing subdivision delivery system. There are two significant differences in the modified system. Firstly, the activity of house design has

FIG. 8-1
MODIFIED SUBDIVISION DELIVERY SYSTEM



been shifted from the third stage to the first stage. In a conventional subdivision delivery system, the builder can wait until formal approval has been given to the proposed plan before designing the houses. House design may occur several months after the subdivision plan has been established. The builder is allowed the maximum degree of freedom in choosing house designs before having to make a commitment. In the modified delivery system, accomodating solar housing, the builder loses the freedom to choose house designs after the subdivision plan has been established. The first stage in the modified delivery system must be the design of the basic features of the solar homes. The information is required by engineers to calculate the dimensions of the sunscapes so that the subdivision can be properly planned.

The second significant difference in the modified system is the participation of several groups at the initial stage of the system. The dashed lines in Figure 8-1 indicate the groups supplied by the builder with design, cost and performance information. The modified participation would apply to: the civic Administrative Co-ordinating Group (ACG), city building code inspectors; civic tax assessors; CMHC lending code officials; and contractors. The actual influence of each of these groups over the housing project remains as before in the existing subdivision delivery system.

The housebuilding industry may be reluctant to accept the modifications to the existing subdivision delivery system. Designing homes prior to the design and approval of the subdivision could increase the risk and costs to the building company: the civic approval process may require subdivision design alterations that would necessitate a re-design of the homes; rapidly-changing trends in the local housing market may not be able to be accomodated under the modified system, if the building company has committed itself to a particular house design. There is also the strong possibility that the competitors of the building company will learn of the solar house designs and enjoy unearned benefits from the knowledge.

Each building company confronts similar problems of increased risk and costs with the modified subdivision delivery system. Consideration could be given to an educational effort involving all local housebuilders. The Housing and Urban Development Association of Manitoba would appear to be a suitable forum for such a co-operative venture. The association could perform the on-going task of informing the various officials within the subdivision delivery system about the particular requirements of solar housing projects; this would help spread the risks and costs to an individual company that could arise from the modifications suggested in Figure 8-1.

2. The housebuilding industry could make use of the sunscape concept as a design tool for solar housing projects. The sunscape allows a standardized approach to the siting of houses within a subdivision, without the need to resort to complicated calculations of shadow effects for all other nearby structures.

3. Solar subdivision planning also requires an acceptance by the builder of increased design constraints and modifications in existing design practices: reduced height limits for some houses, particularly along north-south streets; careful attention to actual siting of houses on lots so as to ensure adequate sunscape protection; use of public open space in the subdivision for sunscape protection; greater attention given to the siting of vegetation and trees within the subdivision, particularly conifers.

4. The housebuilding industry could find the R-PL zoning bylaw of the City of Winnipeg highly useful in providing the flexibility required in solar subdivision design.

5. The construction manager would be the critical individual on the construction phase of a solar subdivision. The manager would be responsible for proper scheduling of the activities of various trades, and for solving on-site construction problems. A housebuilding company could give consideration to having its construction manager develop an expertise in the special construction requirements of solar housing.

6. The housebuilding industry could give consideration to organizing brief training courses for contractors so that tradespersons can become more familiar with the special construction requirements of solar housing. Particular attention could also be given to developing the insulation or vapour barrier trade as the supervisory trade for construction of the solar components of the homes.

7. Restrictive covenants would be the simplest, least expensive means of guaranteeing solar access for sunscapes within the subdivision. The restrictive covenants could be displayed in the model homes of the subdivision as an important marketing feature of the solar homes.

ii) City of Winnipeg

1. The City of Winnipeg could formally request the provincial government to clarify the applicability of the 1977 Bill 87 to passive solar housing; clarification would remove the present uncertainty over whether the definition of "solar heating equipment" in the legislation includes passive solar design techniques.

2. The City of Winnipeg could also formally request the provincial government to enact legislation allowing private individuals to negotiate solar easements. The legislation could become part of the City of Winnipeg Act. It would require no administrative expense by the civic government, because solar easements involve only private sector negotiations and decisions.

3. The City would also state publicly its intention to help enforce restrictive covenants and easements imposed on land to be used for solar access protection. Such an enforcement policy could logically be added to the existing Development Agreement Parameters[1] which allow the city and developer to establish all rules prior to the commencement of the project.[2] Section 15 of the parameters concerns easements[3]: the requirement of the developer to provide easements for the installation of utility lines and other public purposes. An additional paragraph could state the requirement of the city to enforce registered covenants and easements established for the purpose of solar energy home heating purposes. Enforcement by city officials would be made primarily at the time other development proposals are reviewed, and when building permit applications are made.

4. The City of Winnipeg could give consideration to familiarizing its planning and inspections departments with solar housing. Consideration could also be given to an education program undertaken jointly with the local housebuilding industry.

5. The Administrative Co-ordinating Group would be the critical institution within the civic government in determining the response of the civic government to a proposed solar housing project. Particular attention could be given to developing solar housing expertise within the ACG. In this way, the ACG would be in a better position to understand the special requirements of a solar housing proposal, and in a better position to determine whether the solar project is well-planned. Solar expertise in

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[1]City of Winnipeg, Development Agreement Parameters (Amended and Adopted by the City of Winnipeg Council, May 5, 1976)

[2]ibid., p. 6.

[3]ibid., p. 18

the ACG would also protect homebuyers, and the City of Winnipeg as a whole, from poorly-designed solar housing projects.

6. Consideration could be given to undertaking, jointly with the housebuilding industry, development of ideal energy-conserving planning practices. Recall that Sunnyvale assumed the planning constraints of the conventional subdivision, such as 60 feet public-right-of-ways and specified lot sizes. No attempt was made to plan an ideal energy-conserving subdivision, regardless of existing planning reulations. However, home heating is only one of several energy consumption patterns within a subdivision. An ideal energy-conserving subdivision would consider: the energy impacts of transportation (both within the subdivision and from the subdivision to the central business district); the potential for reducing street widths and asphalting within the subdivision and the energy impacts of reducing street lighting. Other jurisdictions are undertaking a similar comprehensive study[1]; the experience of Davis, Calif., cited in Chapter II, may serve as an instructive example.

The fourth objective of the present study concerned the identification of private and social consequences of a solar energy subdivision. Three major consequences can be identified:

1) Manufacturing of new components for solar houses

Discussion of the designs, costs and performance of passive solar homes in Chapter III, suggested that a small number of new housing components will be required by future solar housing projects. Opportunities for mass manufacturing may exist for movable insulated shutter systems, mass Trombe walls and air-to-air exchangers. At least one housebuilding company

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[1] See Section 1.7, footnote 1.

in Saskatchewan is actively investigating participation in the manufacture of shutter systems and air-to-air exchangers.[1] Large-scale solar housing projects such as Sunnyvale would also increase the general demand for existing house components, particularly double-glazing, insulation and vapour barriers. Mass manufacturing will reduce the capital cost differences between solar houses and conventional homes.

ii) Greater sense of "Neighbourhood"

The sunscape of a passive solar home is not confined to the property lines of a house lot, but extends outward and upward into other privately-owned lots in the subdivision. To a greater extent than in a conventional subdivision, individual homeowners share the land in a solar subdivision. Each imposes restrictions on others. Homeowners have a mutual interest in preventing future developments, within or outside the solar subdivision, from infringing on any sunscape: if one sunscape is lost to a future development, then none are secure against loss. Among the homeowners in a solar subdivision, there may also be a pride that comes from being part of a unique venture, and a mutual recognition that their participation in a solar subdivision is a personal expression of their commitment to energy conservation.

In the light of these considerations, it may be reasonable to suggest that a solar subdivision could foster a greater sense of neighbourhood and co-operation than exists in conventional tract housing developments. The experience of solar subdivisions in the United States supports this tentative conclusion,

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[1]Keith Funk, Concept Construction, Saskatoon, Sask.; personal communication, Sept. 22, 1978. The Saskatchewan Research Council is also investigating various shutter systems in order to determine suitability under Canadian winter conditions; personal communication, Dave Eyre, July 26, 1978, Saskatoon, Sask.; For information on the design and construction of air-to-air exchanger, see R.W. Besant, R.S. Dumont and D. Van.Ee, "An Air-to-Air Heat Exchanger for Residences" Engineering Bulletin, (Extension Division, University of Saskatchewan, Saskatoon, Undated).

but the subject deserves greater study, beyond the scope of the present study.[1]

iii) Energy Savings

Perhaps the most significant private and social consequences of a solar subdivision would be the energy savings of its homes compared to a conventional subdivision of similar size. Recall the analysis in section 3.2.3, which determined the present value costs of home heating for a conventional house and two passive solar houses. Three different future energy price scenarios were assumed and three social discount rates were used to provide a sensitivity analysis of the relationship between present value and the discount rate. Table 3-2 provided an indication of the comparative net present value of future home heating costs for three different time periods: a 5-year horizon, to suggest the time perspective of a prospective home buyer; a 25-year horizon, covering the life of the mortgage; and a 50-year time frame to cover the assumed life of the houses. Table 8-1 converts the previous results listed in Table 3-2 into a comparison of two subdivisions. It is assumed the conventional Betsworth subdivision has 72 homes that have an average energy consumption pattern identical to the conventional home described in section 3.2.3. Two versions of a 72-home solar subdivision are considered, corresponding to the less expensive Solar home A and more expensive Solar Home B described in section 3.2.3. As was the case with the analysis in section 3.2.3., substantial net present value savings, compared to the conventional subdivision, accrue to the solar subdivision in many of the combinations listed in Table 8-1. Energy savings in the solar subdivision are greater when: the solar homes are of the less

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[1] See, for example, Hunt and Bainbridge, ibid., and DePrato, ibid., cited in Chapter II, section 2.2.

TABLE 8 - 1

SUMMARY OF PRESENT VALUE COSTS (PVC)

FOR HOME HEATING

CONVENTIONAL SUBDIVISION AND SOLAR ENERGY SUBDIVISION

(See text for assumptions)

CALCULATED OVER A PERIOD OF 5 YEARS

Annual Energy Price Increases	Social Discount Rate	CONVENTIONAL SUBDIVISION	SOLAR SUBDIVISION A		SOLAR SUBDIVISION B	
		Total PVC of Home Heating	Total PVC of Home Heating & Additional Mortgage Payments	P.V. Costs(–) or Savings (+)[1]	Total PVC of Home Heating & Additional Mortgage Payments	P.V. Costs (–) or Savings (+)
15%	.09	$190,798.56	$ 170,426.16	+$ 20,372.40	$ 251,317.44	–$ 60,518.88
	.14	166,312.80	149,794.56	+ 16,518.24	221,191.20	– 54,878.40
	.18	150,055.20	136,015.92	+ 14,039.28	201,049.92	– 50,994.72
10%	.09	166,513.68	163,110.24	+ 3,403.44	244,001.52	– 77,487.84
	.14	145,724.40	143,618.40	+ 2,106.00	215,015.04	– 69,290.64
	.18	131,881.68	130,564.08	+ 1,317.60	195,598.08	– 63,716.40
6%	.09	149,104.80	157,918.32	– 8,813.52	238,809.60	– 89,704.80
	.14	130,922.64	139,105.44	– 8,182.80	210,502.38	– 79,579.44
	.18	118,787.04	126,635.76	– 7,848.72	191,669.76	– 72,882.72

[1] "PVC Savings" lists the difference between total PVC of space heating for the Conventional Home and PVC of total solar costs of the Solar Home. A positive sign indicates savings for the solar home compared to the Conventional Home.

(continued)

TABLE 8 - 1 (continued)

SUMMARY OF PRESENT VALUE COSTS (PVC)

FOR HOME HEATING

CONVENTIONAL SUBDIVISION AND SOLAR ENERGY SUBDIVISION

(See text for assumptions)

CALCULATED OVER A PERIOD OF 25 YEARS

Annual Energy Price Increases	Social Discount Rate	CONVENTIONAL SUBDIVISION	SOLAR SUBDIVISION A		SOLAR SUBDIVISION B	
		Total PVC of Home Heating	Total PVC of Home Heating & Additional Mortgage Payments	P.V. Costs (-) or Savings (+)	Total PVC of Home Heating & Additional Mortgage Payments	P.V. Costs (-) or Savings (+)
15% /8%	.09	$ 925,619.04	$ 563,515.20	+$ 362,103.84	$ 767,790.72	+$ 157,828.32
	.14	557,451.36	367,233.12	+ 190,218.24	510,166.08	+ 47,285.28
	.18	400,505.76	234,218.16	+ 166,287.60	347,911.20	+ 52,594.56
10%	.09	914,085.36	560,057.76	+ 354,027.60	764,329.68	+ 149,755.68
	.14	526,183.92	357,853.68	+ 168,330.24	500,786.64	+ 25,397.28
	.18	368,478.00	269,627.76	+ 98,850.24	383,320.80	- 14,842.80
6%	.09	575,011.44	458,331.84	+ 116,679.60	662,610.96	- 87,599.52
	.14	359,671.68	307,900.08	+ 51,771.60	450,833.04	- 91,161.36
	.18	266,599.44	239,063.76	+ 27,535.68	352,756.80	- 86,157.36

TABLE 8 - 1 (continued)

SUMMARY OF PRESENT VALUE COSTS (PVC)

FOR HOME HEATING

CONVENTIONAL SUBDIVISION AND SOLAR ENERGY SUBDIVISION

(See text for assumptions)

CALCULATED OVER A PERIOD OF 50 YEARS

Annual Energy Price Increases	Social Discount Rate	CONVENTIONAL SUBDIVISION	SOLAR SUBDIVISION A		SOLAR SUBDIVISION B	
		Total PVC of Home Heating	Total PVC of Home Heating & Additional Mortgage Payments	P.V. Costs (-) or Savings (+)	Total PVC of Home Heating & Additional Mortgage Payments	P.V. Costs (-) or Savings (+)
15%/8%	.09	$1,715,775.10	$800,559.36	+$915,215.76	$1,004,834.80	+$710,940.24
	.14	719,100.72	415,726.56	+ 303,374.16	558,659.52	+ 160,441.20
	.18	451,450.80	294,517.44	+ 156,933.36	408,210.48	+ 43,240.32
10%	.09	2,062,613.50	904,615.92	+1,157,997.60	1,108,891.40	+ 953,722.08
	.14	741,628.08	422,490.96	+ 319,137.12	565,423.92	+ 176,204.16
	.18	432,183.60	288,739.44	+ 143,444.16	402,432.48	+ 29,751.12
6%	.09	861,205.68	544,194.72	+ 317,010.96	748,470.24	+ 112,735.44
	.14	418,006.80	325,401.12	+ 92,605.68	468,334.08	- 50,327.28
	.18	284,857.92	244,541.52	+ 40,316.40	358,234.56	- 73,376.64

expensive type A; when energy prices rise by 15 percent in the first five years; or 10 percent over 50 years and when the discount rate used to calculate present value is lowest.

The savings indicated in Table 8-1 can be interpreted as representing social benefits to the City of Winnipeg. Benefits accrue to the public because of reduced consumption of conventional home heating fuels in the solar subdivision.[1] Determination of the social benefits of Sunnyvale provides a justification for a reasonable level of public expenditure by federal, provincial and civic governments in order to better accommodate solar housing projects in the future. An extremely high level of public expenditures, of course, could be criticized as public spending for private benefit. However, equally indefensible is the argument that no public expense is justified, because all benefits accrue to private homeowners.

Despite the calculated savings in the present value of future home heating costs in a solar subdivision, it must be kept in mind that residential space heating is only one category of energy use in a subdivision. Transportation, street and home lighting, building materials and road construction are other important forms of energy consumption on housebuilding sector. Further research would be needed to determine the total energy impact of any subdivision, be it conventional or solar. Some of the design requirements of a solar subdivision such as Sunnyvale may conflict with energy-conserving practices in one or more of the other categories of energy use. For example, it has been seen that passive solar housing is most easily accomodated in low-density

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[1]Converting the equivalent energy savings of a single passive solar home as listed in Table 3-3, the total equivalent energy savings for a 72-home passive solar subdivision over 50 years would be: 378 million cubic feet of natural gas; 64,260 barrels of oil; 13,608 metric tons of coal, and 110.75 million kilowatthours.

areas, far from tall buildings. It is likely that a solar subdivision would be built on the fringe area of a city to provide for the required protection of sunscapes. However, the energy demands for transportation would increase if the subdivision were on the fringe area. Residents would need to travel long distances to and from their workplaces, and rely on private automobiles because convenient public transportation would be too costly in such a low-density fringe area. Increased energy consumption in transportation may more than offset any social benefits derived from decreased fuel consumption for home heating in the subdivision. Comprehensive studies of the energy impacts of various planning and building practices, such as suggested previously for the City of Winnipeg and the local house-building industry, would indicate the energy-use trade-offs involved in low-density solar subdivisions.

A final objective of the present study was to generate increased awareness of solar housing among members of the Winnipeg housebuilding industry and the City of Winnipeg government staff. The study has attempted to achieve this objective in several ways:

i) through personal interviews with public and private sector officials involved in the Winnipeg subdivision delivery system;

ii) a solar housing workshop was organized by the researcher in Winnipeg on September 21, 1978. More than 20 members of the private housebuilding industry and various civic, provincial and federal planning and approval departments participated in the one-day workshop. Material presented included: principles of solar heating; passive solar home design; costs and performance; potential institutional barriers within the Winnipeg subdivision delivery system and the preliminary design of Sunnyvale, including sunscape derivation and analysis;

iii) partly as a result of interest generated by the present study, a task force on solar housing and solar land-use planning, made up of representatives of the local house-building industry and the civic government, is to be formed in the spring of 1979;

iv) also partly as a result of interest generated during the course of research towards the present study, several planners in the department of environmental planning, City of Winnipeg, are actively developing an expertise in solar housing and solar land-use planning.

v) Finally, the study is to be distributed to members of the Housing and Urban Development Association of Manitoba and to various departments in the City of Winnipeg government.

8.3 Recommendations for Further Research

Research into the potential problems of implementing solar home heating technology should continue at all levels: economic, technical and institutional. The scope of the present study was limited by considerations of time and available resources. Several institutional or social aspects of solar housing, referred to briefly in the present study, await further analysis:

i) Detailed market-studies are required to determine the attitudes of various segments of the public towards solar housing. Living in a solar home or a solar subdivision represents a significant change from present attitudes: heat in a home is not necessarily available at the turn of a dial; a homeowner must protect the passive solar heating system at night or on cloudy days by moving the insulated shutter system into place;[1] the homeowner may need to accept subdivision design alterations such as staggered lots; restrictive covenants, imposed for sunscape protection, must be accepted as positive attributes of the solar subdivision, rather than as limitations on what uses can be made of the property; restrictions on landscaping, particularly the siting of coniferous trees, also need to be accepted. Market studies would help the housebuilding industry determine

[1]The problem of having to remember to move the shutter system may be eliminated if designers succeed in developing an automatic shutter system which responds to temperature or light levels.

which kinds of people are likely to be first to buy solar houses, and therefore allow the industry to better plan its designs and marketing strategy.

ii) The present study assumed that conventional financing was available for the hypothetical solar subdivision. However, banks and other lending institutions may be reluctant to make loans and mortgages available for solar housing at the same rates as for conventional housing. Further research is needed to determine more precisely the extent of this potential barrier, and which institutional or economic changes are required in financial institutions to accomodate solar housing.[1]

iii) Further attention could also be given to the market potential for new housing components demanded by solar housing. Opportunities for small-scale, labour-intensive manufacturing may exist for several components, and may represent a significant benefit of a large-scale shift to energy-conserving solar houses.

iv) Utilities and private companies which supply conventional home heating fuels such as natural gas, heating oil and electricity, may be expected to oppose solar housing, Solar homes may contribute to traditional peak demand problems of a utility; when the sun is shining, the solar home does not draw on conventional sources of heat; however, during a lengthy cloudy period, or a severe winter storm, the solar home uses the natural gas or electricity during peak demand periods, as do conventional houses. The utilities may respond to the problem created by the infrequent,

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[1]For further discussion, see Charles Cartee, "Solar Energy Installations: Trends and Lender Attitudes, Journal of Property Management, pp. 21-27, January/February 1976.

but untimely use of conventional energy by imposing rather high rates for the solar homes. Such a pricing policy would tend to discourage the adoption of solar home heating technology. Further research could suggest possible rate structures or other methods that would eliminate the need for the utilities to maintain a costly peak-demand capacity or to impose higher rates on solar homes.[1]

v) Further research into the implications of solar housing for the construction trades would also be useful. Several American unions have funded studies into the potential job-creation prospects of solar housing.[2] The present study has suggested that the vapour barriers and insulation trades would be logical construction supervisors on a solar housing project, and that there may be value in organizing short training courses about solar house construction at the community college level. Individual trades or unions in Winnipeg could investigate how best to implement these suggestions.

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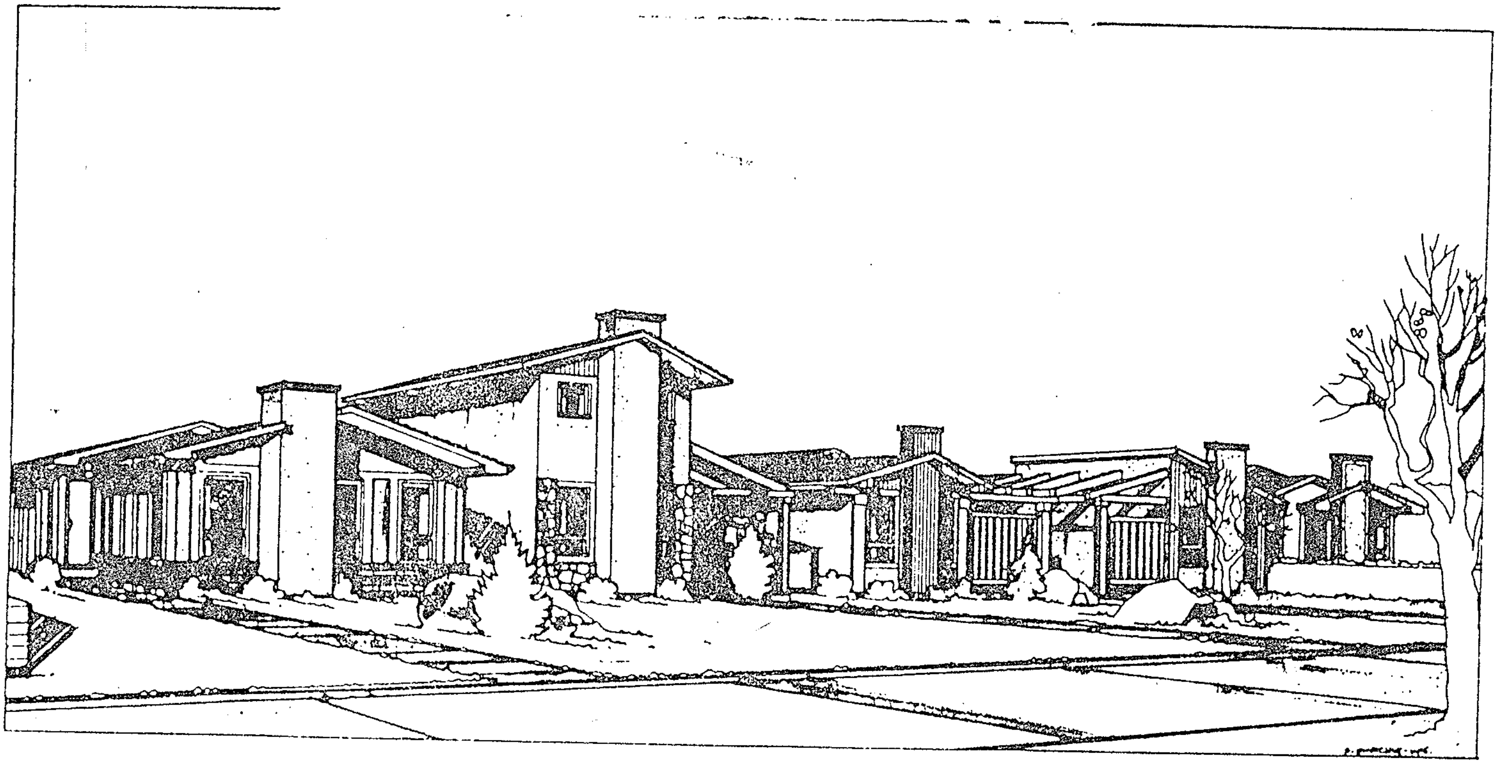
[1]For further discussion on the utility interface issue, see Charles Dickson, et al, "Solar Energy and U.S. Public Utilities: The Impact on Rate Structure and Utilization", Energy Policy, September 1977, pp. 195-210.

[2]See, for example, S. Laitner, Impact of Solar Energy and Conservation Technologies on Employment (Critical Mass, Washington, DC) May, 1976 and Strategic Implication of Solar Energy for Employment of Sheet Metal Workers (prepared for Sheet Metal Workers International Association, by Stanford Research Institute, June 1975).

APPENDIX 1

City of Winnipeg's R-PL Zoning Bylaw, Bylaw 1431/76, as amended by Bylaw 1967/78



R-PL

PLANNED RESIDENTIAL DISTRICT

"R-PL"

PLANNED RESIDENTIAL DISTRICT

A. PURPOSE AND INTENT

The purpose and intent of this District is to provide for a comprehensive approach to the development of single-family housing where the location and design of the individual dwelling units is an integral part of the planning and design of the overall district, which also includes vehicular and pedestrian circulation systems, services, recreation areas, open spaces, and public and private landscaping.

B. DEFINITIONS

Notwithstanding anything elsewhere contained in this By-law or Town Planning Scheme, the following definitions shall apply to the text of this Chapter:

(a) Dwelling Unit means one (1) or more rooms in a building for the use of one or more persons as a housekeeping unit with cooking, eating, living, sleeping and sanitary facilities.

(b) Gross Floor Area means the sum of the gross horizontal areas of the several floors within the dwelling unit measured from the exterior faces of the exterior walls or from the centre line of party walls, when such walls are fire walls separating two buildings, excepting thereout attached garages, carports, exterior storage facilities and non-habitable cellars.

* (c) Habitable Room means a room or enclosed space used or usable for human occupancy, including but not limited to kitchens, bedrooms, living rooms, family rooms, dens, bathrooms, water closet compartments, laundries, pantries, foyers, communicating corridors, entry ways, storage rooms, and rooms in basements or cellars used only for recreational purposes.

* (d) Maintenance access means an area of land a minimum of 600 mm [two (2) feet] in perpendicular width along an exterior blank wall of a dwelling unit extending for a distance of 1.5 m [five (5) feet] from the ends of said blank wall and may be partially or entirely on an abutting lot or lots.

* (e) Outdoor Living Area (OLA) means an uninterrupted open area immediately adjacent to one of the walls of the dwelling unit, being an area, a minimum of one-half (½) the gross floor area of the dwelling unit, and shall not be overlapped by any separation space from any adjacent dwelling unit.

* (f) Public open space means any open land for public use including but not limited to a public street, public lane, walkway, tot lot, and public park."

* (g) Screening means planting, fencing, walls or berms, which are used alone or in combination with one another to minimize noise and/or visual nuisance.

* Amended by By-law No. 1967/78 1978 06 14

. . . . . /4

* (h) Separation Space is the open space provided around a dwelling unit to ensure adequate light, air, and privacy, for activities undertaken within the dwelling unit, and a view from the unit. A separation space may be partially or entirely outside the lot boundaries of a dwelling unit within the development being approved except that said separation space may be partially or entirely outside the development boundaries into a public open space.

* (i) A Single-Family Attached Dwelling means a building designed and used or designed to be used for one (1) family and which has two (2) or more party walls.

* (j) A Single-Family Detached Dwelling means a building designed and used or designed to be used for one (1) family and which does not have a party wall.

* (k) A Single-Family Semi-Detached Dwelling means a building designed and used or designed to be used for one (1) family and which has one (1) party wall.

* (l) Yard means an open area within the minimum separation space which is not used for communal or public activities, and is entirely contained within the lot boundaries for the dwelling unit to which the yard applies.

C. USE

(a) No land shall be used or occupied and no building or structure shall be erected, altered, used or occupied except for the following uses:

(i) a single-family detached dwelling,

(ii) a single-family semi-detached dwelling,

(iii) a single-family attached dwelling,

(iv) public utility,

(v) accessory uses including, but not limited to the following:

(1) home occupations, subject to approval as a conditional use;

(2) the home office of a physician, dentist or other person authorized by law to practise medicine or healing, when located in a room in the dwelling unit occupied by that person;

(3) one (1) private garage, either attached or detached; and/or one (1) private carport with or without an integrated storage structure.

* Amended by By-law No. 1967/78 1978 06 14

D. LANDSCAPING

In respect of application for subdivision and/or re-zoning to or under "R-PL" zoning, landscaping will be required to reflect the purpose and intent of this District. In the selection and siting of trees, shrubbery and fencing, the need for privacy, control, separation and a view from the principal living room window shall be recognized.

E. BULK REGULATIONS

Notwithstanding anything else in this By-law or Town Planning Scheme, no building or structure nor the enlargement of any building or structure shall be hereafter erected unless the following are provided and maintained in connection with such building, structure or enlargement:

(a) Outdoor Living Area for Dwelling Units

(i) Dwelling units shall be provided with an outdoor living area (OLA) entirely contained within the lot boundaries and immediately adjacent to one of the sides of the dwelling unit for use by its occupants.

* (ii) The outdoor living area (OLA) shall be not less than one half (½) the gross floor area of the dwelling unit. (See Illustration A)

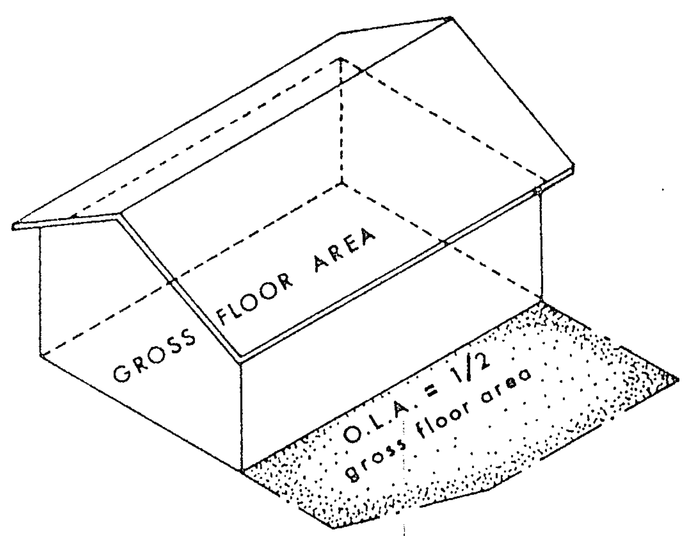


illustration A

* Amended by By-law No. 1967/78 1978 06 14

(iii) The outdoor living area (OLA) shall consist of one (1) uninterrupted space. (See Illustration B)

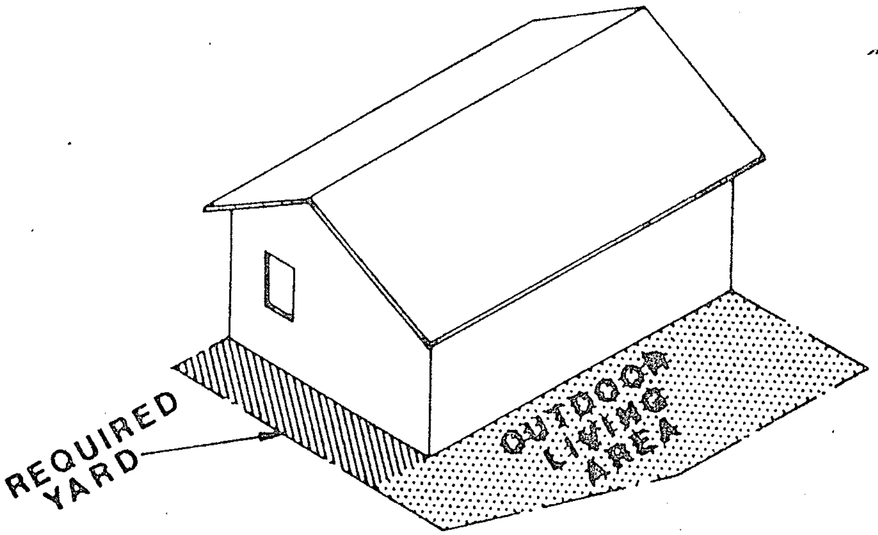


illustration B

(iv) The Director of Environmental Planning may require that the outdoor living area (OLA) be established and defined legally, as an area to the possession of which the residents of the dwelling unit are entitled.

(b) Yards for a window

* (i) Yards for a window in a dwelling unit shall be provided as hereinafter set forth, and shall be entirely contained within the lot boundaries for said dwelling unit extending across the length of the exterior wall in which the window is located. (See Illustration C)

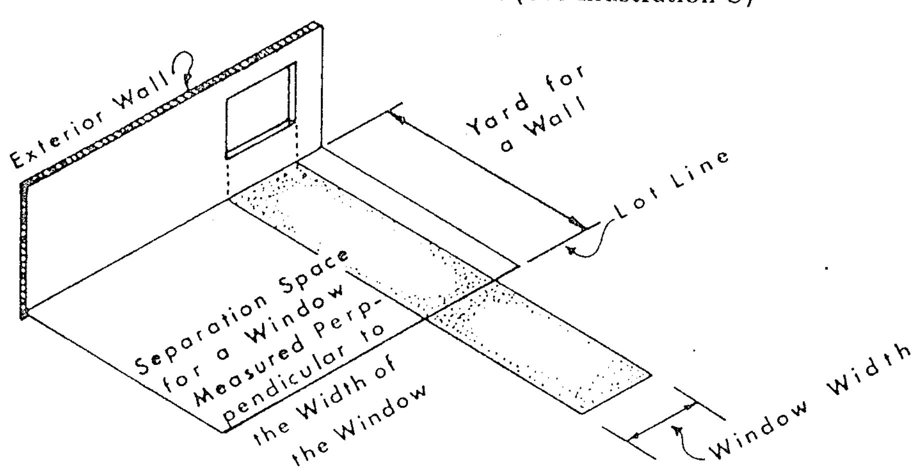


illustration C

* Amended by By-law No. 1967/78 1978 06 14

(c) Separation space for a window

* (i) A separation space for a window in an exterior wall of a dwelling unit shall be provided along the full width of the window as hereinafter set forth and shall not overlap the separation space of a window in another building or in another dwelling unit. (See Illustrations D and E)

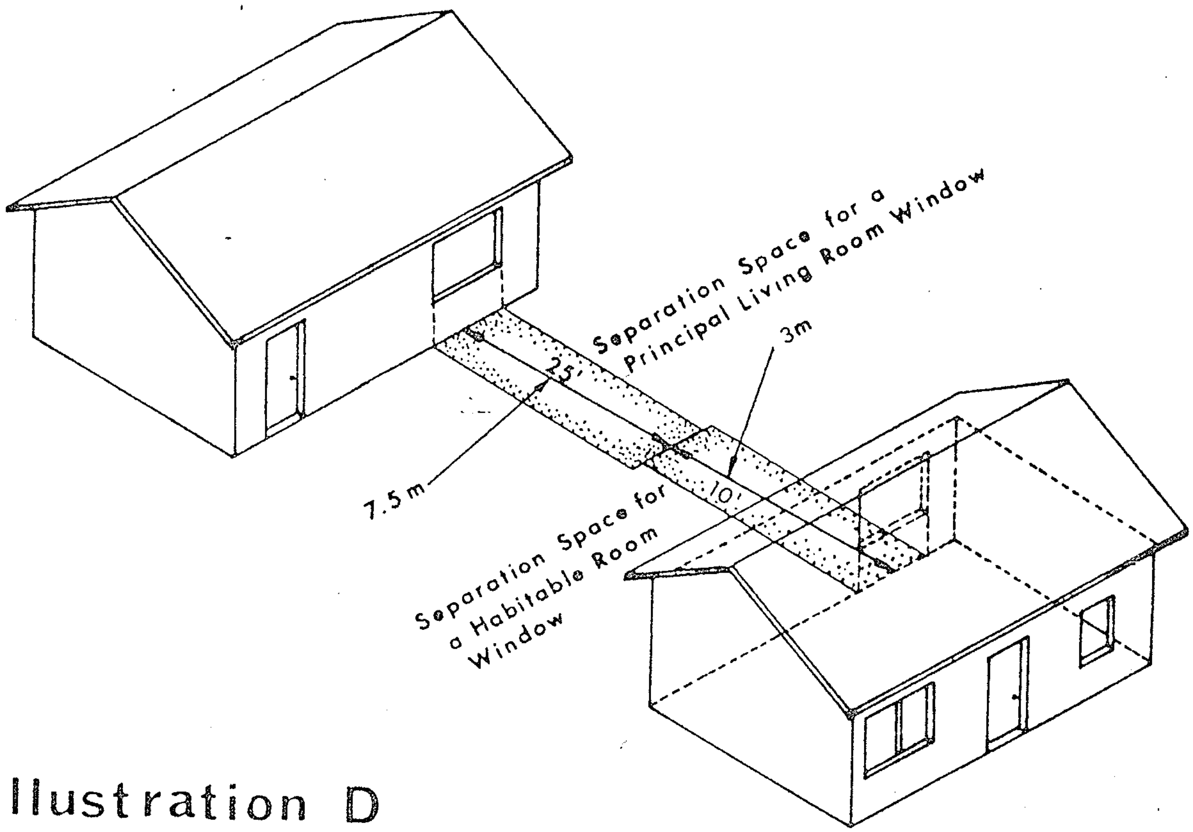


illustration D

* Amended by By-law No. 1967/78 1978 06 14

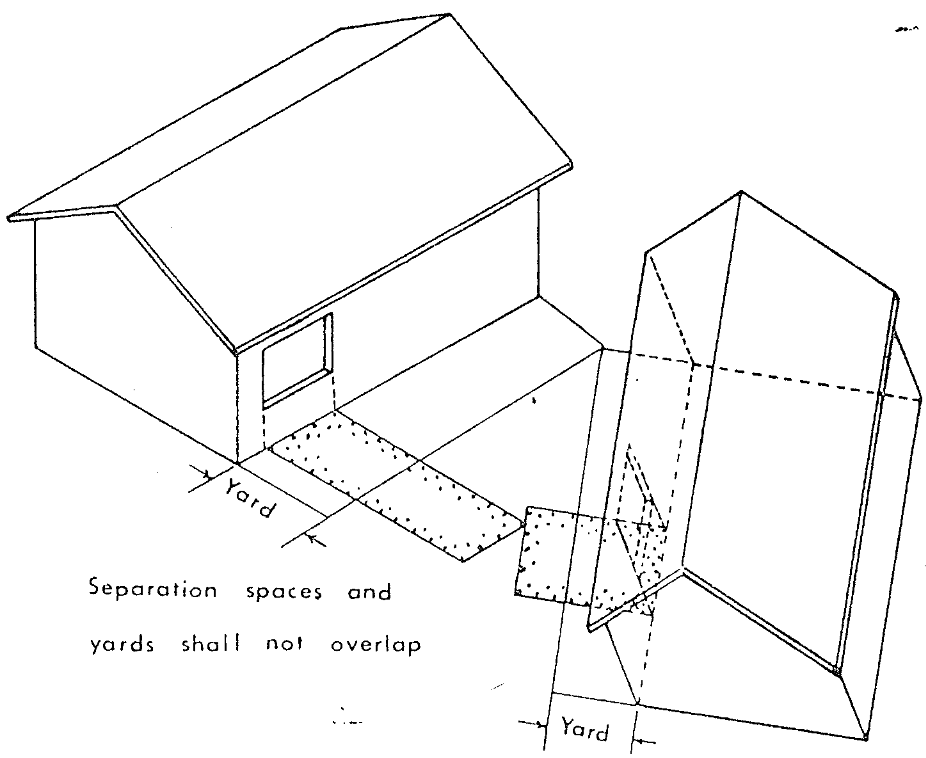


illustration E

* (ii) Windows in exterior walls of the same dwelling unit that face each other shall not require separation spaces.

(d) Principal living room window

* (i) The minimum separation space for a principal living room window shall be twenty-five (25) feet [7.5 m] and the minimum yard shall be fifteen (15) feet [4.5 m]. (See Illustration F)

* Amended by By-law No. 1967/78 1978 06 14

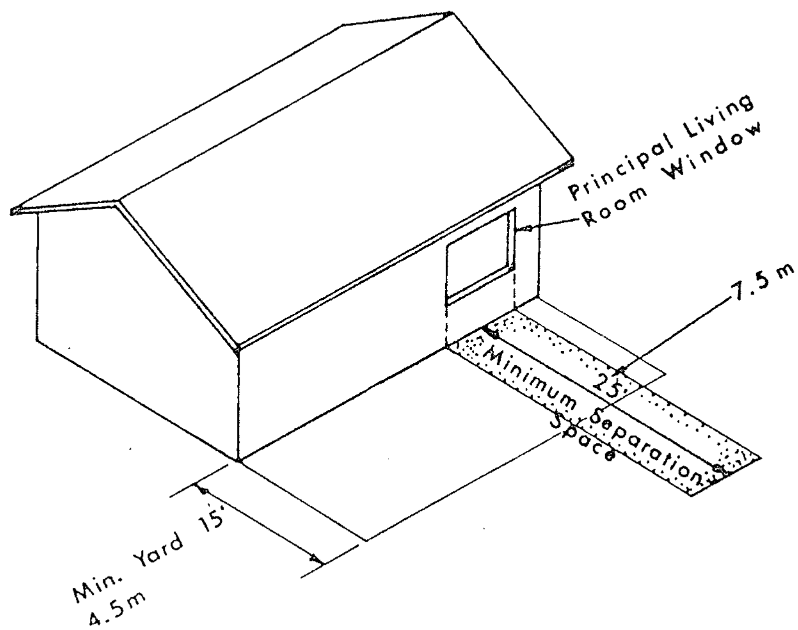


illustration F

(e) Habitable room window

(i) For a habitable room window other than a principal living room window the minimum separation space shall be ten (10) feet [3 m] and the minimum yard shall be four (4) feet [1.2 m]. (See Illustration G).

* Amended by By-law No. 1967/78 1978 06 14

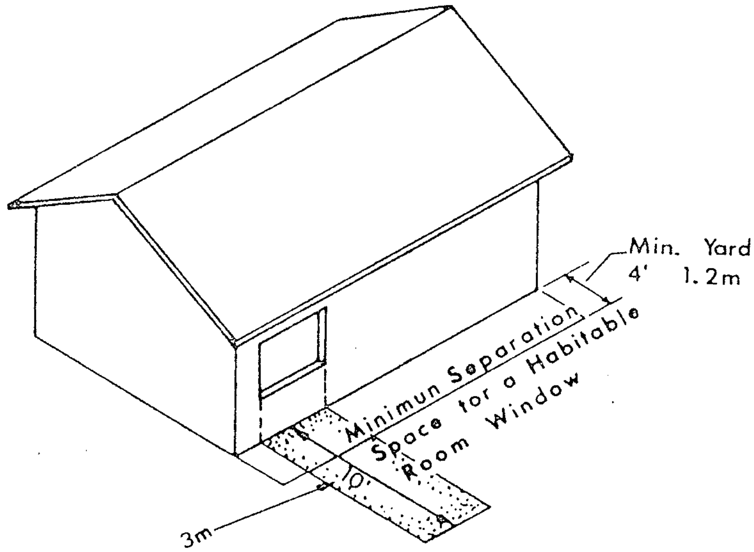


illustration G

(f) Blank walls

* (i) For an exterior blank wall, the minimum separation space shall be five (5) feet [1.5 m] and the minimum yard zero (0) [0 m] (See Illustration H)

* (ii) The separation space for a blank wall may overlap any other separation space.

* (iii) Where an exterior blank wall has a yard of less than two (2) feet [600 mm] maintenance access shall be provided along the exterior blank wall by legal agreement recorded where possible by caveat.

* Amended by By-law No. 1967/78 1978 06 14

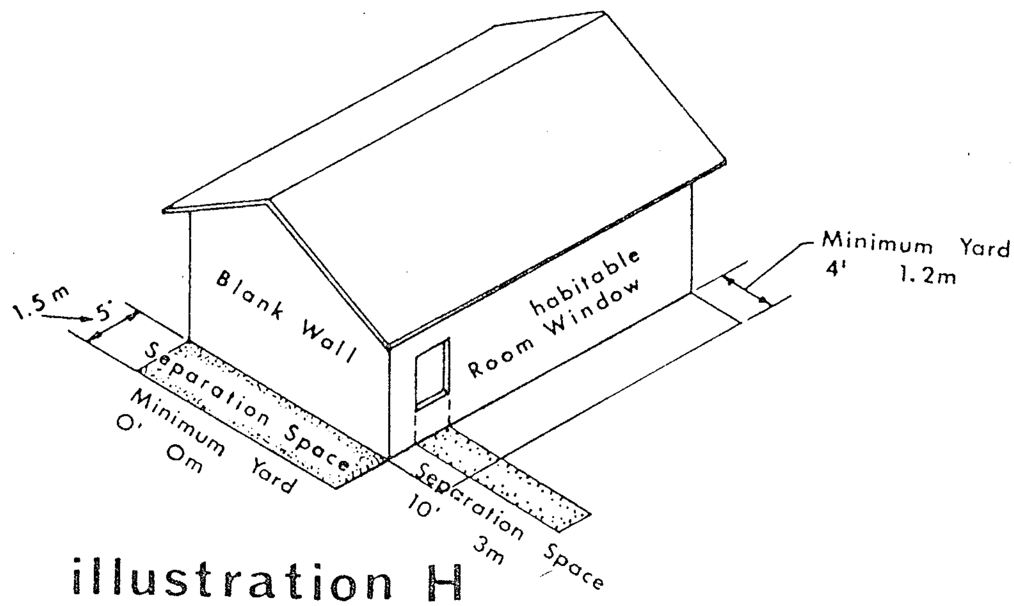


illustration H

(g) Doors

* (i) An accessory open off-street parking space shall not be located within a four (4) foot [1.2 m] radius from the perpendicular centre line of an entrance door to a dwelling unit.

* (ii) An exterior door shall have a minimum yard of four (4) feet [1.2 m].

* Amended by By-law No. 1967/78 1978 06 14

(h) Accessory off-street parking

(i) A minimum of two (2) accessory off-street parking spaces shall be provided for each dwelling unit.

(ii) An accessory off-street parking space shall not be located in the separation space provided for a principal living room window. (See Illustration I)

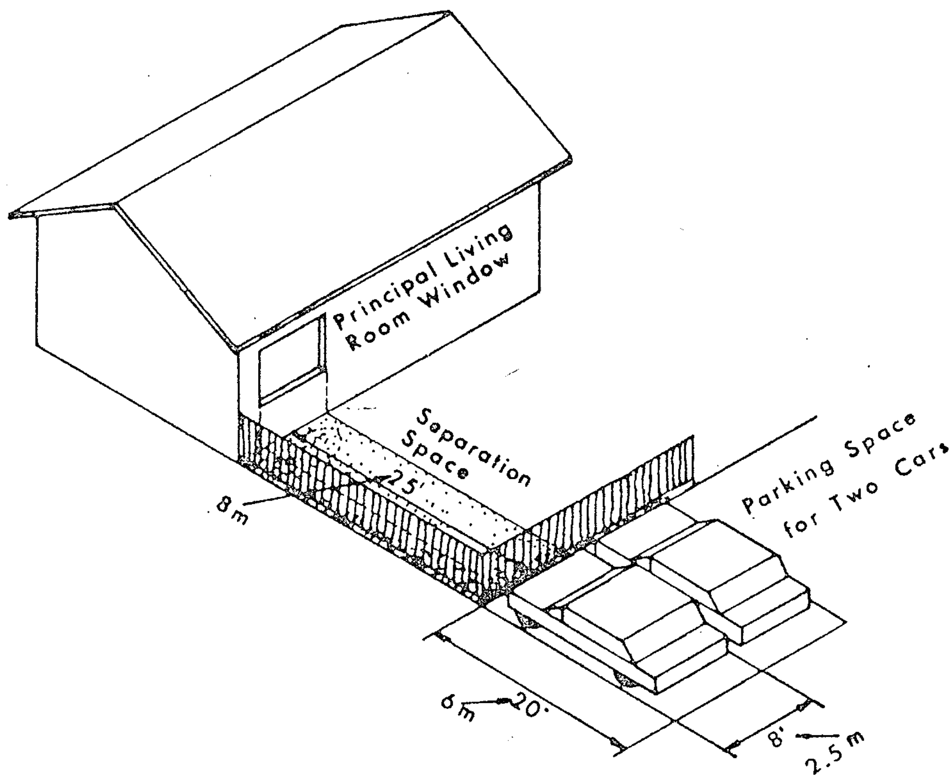
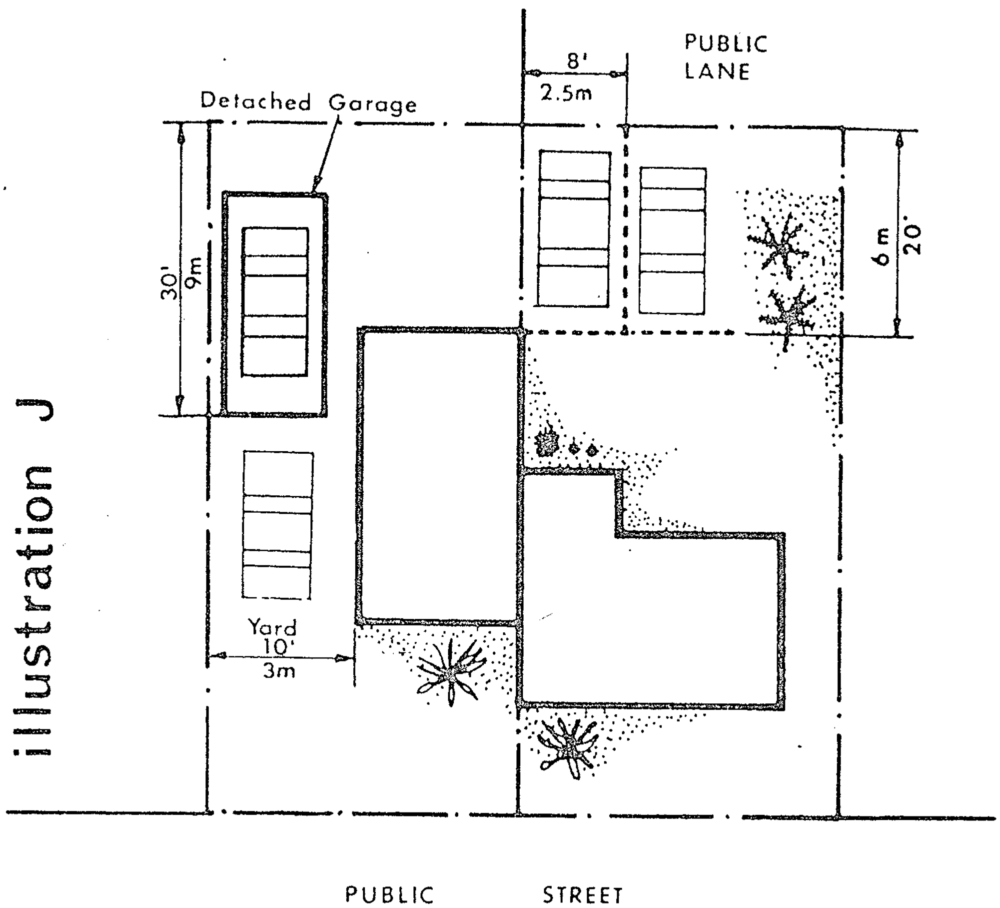


illustration I

* (iii) An accessory off-street parking space shall be a minimum eight (8) feet [2.5 m] in width by a minimum of twenty (20) feet [6 m] in length, exclusive of the aisle or driveway thereto, and shall have a vertical clearance of at least six (6) feet, six (6) inches [2 m]. (See Illustration J)



(iv) Accessory off-street parking spaces may be grouped together provided that they open directly upon an aisle or driveway, that provides vehicular access to a street or public lane.

(v) Accessory off-street parking areas, shall have vehicular access to a street or public lane.

(vi) Accessory off-street parking areas, including access aisles and driveways thereto, shall be paved with an asphaltic or concrete surfacing.

* Amended by By-law No. 1967/78 1978 06 14

* (vii) A detached garage shall be located to the rear of a line adjacent to and parallel with the rear wall of the single-family dwelling except on a lot that has a lot depth of ninety (90) feet [27 m] or less, in which case the maximum distance permitted for any part of the detached garage to the rear lot line shall be thirty (30) feet [9 m]. In addition thereto, a detached garage shall provide and maintain the following set backs:

(a) To an interior lot line, zero (0) feet [0 m] clear to the sky;
(b) To a corner lot line, ten (10) feet [3 m] clear to the sky; and
(c) To a rear lot line, zero (0) feet [0 m] clear to the sky, except where the rear lot line abuts a public lane in which case the set back shall be twelve (12) feet [3.6 m] measured to the centre line of the public lane. (See Illustration J)

(i) Dwelling unit access

* (i) A dwelling unit shall have exterior access to the outdoor living area (OLA), the pedestrian circulation system, and the vehicular circulation system.

(ii) A dwelling unit shall have convenient access for fire and other emergency vehicles.

(j) Grouping of dwelling units

(i) No building shall be erected, altered, or enlarged to contain therein more than five (5) dwelling units.

(k) Storage facilities

(i) Exterior storage facilities when provided for a dwelling unit shall have individual means of access and control and shall be screened from the normal view of the adjacent dwelling units.

(l) Refuse storage facilities

(i) Exterior refuse storage facilities when provided for a dwelling unit shall be screened from the normal view of the dwelling unit and adjacent dwelling units.

(m) Lot area

(i) The lot area per dwelling unit shall be not less than twenty-five hundred (2500) square feet [$230\ m^2$]

* Amended by By-law No. 1967/78 1978 06 14

* (n) Lot width

(i) Minimum lot width per dwelling unit
(a) Serviced by a public lane - twenty (20) feet [6 m]
(b) Not serviced by a public lane - thirty (30) feet [9 m]

(o) Height

* (i) No building or structure nor the enlargement of any building or structure shall be hereafter erected to exceed thirty-five (35) feet [10.5 m] in height.

(p) Special yard provisions

(i) Where a side lot line in an "R-PL" District abuts a side lot line of an adjacent "A", "RA", "R1" or "R2" District, the front yard requirement of the adjacent District shall extend into the "R-PL" District for a minimum distance of twenty (20) feet [6 m] from the district boundary, and a minimum yard of five (5) feet [1.5 m] shall be provided along the side lot line in the "R-PL" District.

(ii) Where a side lot line in an "R-PL" District abuts a rear lot line in an adjacent "A", "RA", "R1", or "R2" District, a minimum yard of five (5) feet [1.5 m] shall be provided in the "R-PL" District along said side lot line.

(iii) Where a rear lot line in an "R-PL" District abuts a side or rear lot line in an adjacent "A", "RA", "R1", or "R2" District, a minimum yard of five (5) feet [1.5 m] in depth shall be provided along the side or rear lot line.

* (iv) A lot for a dwelling unit which does not have an attached garage and is not serviced by a public lane shall provide thereon, one (1) side yard a minimum of ten (10) feet [3 m] in width, to a line adjacent to and parallel with the rear wall of the dwelling unit except on a lot that has a lot depth of ninety (90) feet [27 m] or less, in which case said side yard shall extend to a point distant thirty (30) feet [9 m] from the rear lot line.

* (v) Along the lot line abutting a flankage street to an "R-PL" site there shall be provided and maintained a yard of ten (10) feet [3 m] in width.

* Amended by By-law No. 1967/78 1978 06 14

(q) Fencing

(i) Fencing when provided shall be not less than two (2) feet [600 mm] or greater than six (6) feet [2 m] in height.

(ii) Fencing when provided adjacent to an outdoor living area (OLA) shall be at least 50% opaque.

F. The uses set forth in clause C above are permitted subject to the submission and approval of plans establishing compliance with this By-law including thereon the following information:

(a) The location and use of each existing and proposed building or structure and the use or uses to be contained therein;

(b) The location of all doors and windows, and the type thereof;

(c) The location of all exterior refuse storage facilities and the screening thereof;

(d) The location of all exterior storage facilities, and the screening thereof;

(e) The location of all curb cuts, driveways, accessory parking areas, accessory loading areas, public transportation points and the illumination facilities for same;

(f) The location of all pedestrian walks, malls and open space areas;

* (g) The location, type and height of all proposed walls, fences, and landscaping.

(h) The types of surfacing, such as paving, turfing, or gravel, to be used at various locations;

(i) Floor plans and elevations of all proposed buildings and structures;

(j) The location of all outdoor living areas (OLA) showing their access to the dwelling units, their landscaping, and their screening;

(k) The total number of dwelling units and the gross floor area;

(l) The location and dimensions of all maintenance easements; and

(m) The location of all encroachments.

* Amended by By-law No. 1967/78 1978 06 14

G. Notwithstanding anything elsewhere contained in this By-law or Scheme, the Designated Officer of Zoning may in his discretion allow after an approved "R-PL" project, has been completed, additions or alterations to dwelling units therein, provided the addition or alteration shall not vary an "R-PL" regulation by more than five percent (5%).

* H. PLANNED BUILDING GROUP

(a) An "R-PL" parcel of land to contain thereon two or more principal buildings may be approved as a planned building group.

(b) A planned building group shall comply with the requirements of the "R-PL" regulations except that lot lines for dwelling units need not be shown.

* Amended by By-law No. 1967/78 1978 06 14

APPENDIX 2

Manitoba Bill 87, 1977: Property Tax Exemptions for Solar Heating Equipment

PART II

TAX REDUCTIONS FOR SOLAR HEATING

Special assessment.

9 Where the principal residence of a taxpayer is equipped with solar heating equipment used for heating the principal residence, the assessor of the municipality in which the principal residence is situated shall, in addition to making the normal assessment in respect of the principal residence, make a special assessment of the principal residence which shall be the amount that, in the opinion of the assessor, the assessment of the residence would be if the house was not equipped with solar heating equipment but was heated solely with the type of heating equipment that is most usual in the neighborhood of the municipality in which the principal residence is situated.

Note of special assessment on assessment roll.

10 The assessor of the municipality shall make a note on the assessment roll of each principal residence in respect of which he has made a special assessment under section 9 indicating the amount of the special assessment.

Levying of tax against special assessment.

11 Where the special assessment of the principal residence of a taxpayer is less than the normal assessment for the principal residence, the municipality in which the principal residence is situated shall assess and levy taxes on the principal residence on the basis of the special assessment and shall, on or before November 30 in each year, notify the minister of the difference between the taxes assessed and levied in that year against principal residences in the municipality on the basis of special assessments and the amount of taxes that would have been assessed and levied in that year against those principal residences if taxes had been assessed and levied against them on the basis of the normal assessment.

Compensation by government.

12 Where the minister receives notice under section 11 of the difference between taxes assessed and levied by a municipality in a year against the principal residences on the basis of special assessments and the amount of taxes that would have been assessed and levied by the municipality in that year against the principal residences if the taxes had been assessed and levied against them on the basis of normal assessment, he shall request the Minister of Finance, to pay, and the Minister of Finance shall pay, the amount of that difference to the municipality.

p.4

APPENDIX 3

SOLAR RIGHTS LEGISLATION IN THE UNITED STATES

Appendix 3 contains examples of three types of solar rights legislation in the United States:

i) Colorado Statutes Chapter 326, Laws of 1975:
Solar easements;

ii) Oregon Statute 215.110, 1975:
Solar land-use planning;

iii) New Mexico Statutes, Laws of 1977, Chapter 169:
Declaration of Natural Solar Rights.

CHAPTER 326

PROPERTY — REAL AND PERSONAL

SOLAR EASEMENTS

SENATE BILL NO. 95. BY SENATORS Schieffelin, Allshouse, Anderson, Bishop, Cooper, DeBerard, Holme, Hughes, Kadlecek, McCormick, Minister, and Stockton; also REPRESENTATIVES Burrows, Cantrell, Elliott, Flanery, Frank, Gaon, Hilsmeier, Orten, Shoemaker, and Taylor.

AN ACT

CONCERNING SOLAR EASEMENTS, AND PROVIDING FOR THE CREATION AND CONVEYANCING THEREOF AND THE RECORDATION AND CONTENTS OF THE INSTRUMENT RELATING THERETO.

Be it enacted by the General Assembly of the State of Colorado:

Section 1. Title 38, Colorado Revised Statutes 1973, as amended, is amended BY THE ADDITION OF A NEW ARTICLE to read:

ARTICLE 32.5

Solar Easements

38-32.5-101. Solar easements — creation. Any easement obtained for the purpose of exposure of a solar energy device shall be created in writing and shall be subject to the same conveyancing and instrument recording requirements as other easements.

38-32.5-102. Contents. (1) Any instrument creating a solar easement shall include, but the contents shall not be limited to:

(a) The vertical and horizontal angles, expressed in degrees, at which the solar easement extends over the real property subject to the solar easement;

(b) Any terms or conditions or both under which the solar easement is granted or will be terminated;

(c) Any provisions for compensation of the owner of the property benefitting from the solar easement in the event of interference with the enjoyment of the solar easement or compensation of the owner of the property subject to the solar easement for maintaining the solar easement.

Capital letters indicate new material added to existing statutes; dashes through words indicate deletions from existing statutes and such material not part of act.

326

Section 2. Safety clause. The general assembly hereby finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

Approved: July 18, 1

(ii) Oregon: Solar land-use planning

215.110 Preparation of ordinances by commission; submission to county governing body; retroactive ordinances prohibited. (1) A planning commission may recommend to the governing body ordinances intended to implement part or all of the comprehensive plan. The ordinances may provide, among other things, for:

(a) Zoning,

(b) Official maps showing the location and dimensions of, and the degree of permitted access to, existing and proposed thoroughfares, easements and property needed for public purposes,

(c) Preservation of the integrity of the maps by controls over construction, by making official maps parts of county deed records, and by other action not violative of private property rights,

(d) Conservation of the natural resources of the county,

(e) Controlling subdivision and partitioning of land,

(f) Renaming public thoroughfares,

(g) Protecting and assuring access to incident solar energy, and

(h) Numbering property.

(2) The governing body may enact, amend or repeal ordinances to assist in carrying out a comprehensive plan. If an ordinance is recommended by a planning commission, the governing body may make any amendments to the recommendation required in the public interest. If an ordinance is initiated by the governing body, it shall, prior to enactment, request a report and recommendation regarding the ordinance from the planning commission, if one exists, and allow a reasonable time for submission of the report and recommendation.

(3) The governing body may refer to the legal voters of the county for their approval or rejection an ordinance or amendments thereto for which this section provides. If only a part of the county is affected, the ordinance or amendment may be referred to that part only.

(4) An ordinance enacted by authority of this section may prescribe fees and appeal procedures necessary or convenient for carrying out the purposes of the ordinance.

CHAPTER 169

AN ACT

RELATING TO SOLAR ENERGY; PROVIDING DECLARATIONS AND FINDINGS CONCERNING SOLAR RIGHTS; PROVIDING A DECLARATION OF SOLAR RIGHTS.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF NEW MEXICO:

Section 1. SHORT TITLE.--This act may be cited as the "Solar Rights Act".

Section 2. DECLARATION AND FINDINGS.--The legislature declares that the state of New Mexico recognizes that economic benefits can be derived for the people of the state from the use of solar energy. Operations, research, experimentation and development in the field of solar energy use shall therefore be encouraged. While recognizing the value of research and development of solar energy use techniques and devices by governmental agencies, the legislature finds and declares that the actual construction and use of solar devices, whether at public or private expense, is properly a commercial activity which the law should encourage to be carried out, whenever practicable, by private enterprise.

Section 3. DEFINITIONS.--As used in the Solar Rights Act:

A. "solar collector" means any device or combination of devices or elements which rely upon sunshine as an energy source, and which are capable of collecting not less than twenty-five thousand Btu's on a clear winter solstice day. The term also includes any substance or device which collects solar energy for use in:

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(1) the heating or cooling of a structure or building;

(2) the heating or pumping of water;

(3) industrial, commercial or agricultural processes; or

(4) the generation of electricity.

A solar collector may be used for purposes in addition to the collection of solar energy. These uses include, but are not limited to, serving as a structural member or part of a roof of a building or structure and serving as a window or wall; and

B. "solar right" means a right to an unobstructed line-of-sight path from a solar collector to the sun, which permits radiation from the sun to impinge directly on the solar collector.

Section 4. DECLARATION OF SOLAR RIGHTS.--

A. The legislature declares that the right to use the natural resource of solar energy is a property right, the exercise of which is to be encouraged and regulated by the laws of this state. Such property right shall be known as a solar right.

B. The following concepts shall be applicable to the regulation of disputes over the use of solar energy where practicable:

(1) "beneficial use". Beneficial use shall be the basis, the measure and the limit of the solar right, except as otherwise provided by written contract. If the amount of solar energy which a solar collector user can beneficially use varies with the season of the year, then the extent of the solar right shall vary

likewise;

(2) "prior appropriation". In disputes involving solar rights, priority in time shall have the better right except that the state and its political subdivisions may legislate, or ordain that a solar collector user has a solar right even though a structure or building located on neighborhood property blocks the sunshine from the proposed solar collector site. Nothing in this paragraph shall be construed to diminish in any way the right of eminent domain of the state or any of its political subdivisions or any other entity that currently has such a right; and

(3) "transferability". Solar rights shall be freely transferable within the bounds of such regulation as the legislature may impose. The transfer of a solar right shall be recorded in accordance with Chapter 71, Article 2, NMSA 1953.

C. Unless singular overriding state concerns occur which significantly affect the health and welfare of the citizens of this state, permit systems for the use and application of solar energy shall reside with county and municipal zoning authorities.

Section 5. PRIOR RIGHTS UNAFFECTED.--Nothing in the Solar Rights Act shall be construed to alter, amend, deny, impair or modify any solar right, lease, easement or contract right which has vested prior to the effective date of the Solar Rights Act.

Section 6. EFFECTIVE DATE.--This act shall become effective on July 1, 1978.

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